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TÍTULO: Selección de aeropuertos en ciudades con múltiples aeropuertos, caso de estudio de Teherán.

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RESUMEN: Los autores comparan los resultados del modelado de la selección de aeropuertos por pasajeros del Aeropuerto Internacional Imam Jomeini con los pasajeros del Aeropuerto Mehrabad (en Teherán) utilizando el Modelo Binary Logit. Se realizaron encuestas de preferencia establecida como entrevista a los pasajeros de los aeropuertos. Los cuestionarios para los aeropuertos fueron 240 y 681, respectivamente. Los resultados del modelado para los aeropuertos mencionados fueron algo diferentes. Factores tales como la experiencia de usar el aeropuerto en el pasado, la edad de los pasajeros y sus ingresos mensuales fueron significativos. Factores como las instalaciones del aeropuerto y la calidad del acceso terrestre fueron efectivos para elegir el aeropuerto por los pasajeros de dos aeropuertos.

PALABRAS CLAVES: Elección del aeropuerto, modelo logit binario, preferencia indicada, aeropuerto internacional Imam Khomeini, aeropuerto internacional Mehrabad.

TITLE: Airport selection in cities with multiple airports, Case study of Tehran.

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ABSTRACT: Authors compare the modeling results of airport selection by passengers of Imam Khomeini International Airport with passengers of Mehrabad Airport (in Tehran) by using Binary Logit Model. Surveys in the form of Stated Preference have been carried out as the interview of the Imam Khomeini and Mehrabad airports passengers. The questionnaires for Imam Khomeini and Mehrabad Airport were 240 and 681, respectively. The results of modeling for mentioned airports were somewhat different. Factors such as experience of using the airport in the past, the age of passengers and their monthly income were significant. Factors such as facilities of the airport and ground access quality were effective to choose the airport by passengers of two airports.

KEY WORDS: airport choice, Binary Logit Model, stated preference, Imam Khomeini International Airport, Mehrabad International Airport.

INTRODUCTION.

With the increase in number of air passengers, as well as the expansion of cities, many problems for major airports, especially the metropolises of the world are created, like capacity, air and noise pollution for residents around the airport and so on.

Management systems have been used for various applications, such as increase of airport capacity and reduce of density of traffic; however, airports become crowded and dense rapidly. Airport selection by passengers in regions with some airports is one of the important research topics related to the transportation demand studies. The areas with some airports are the main areas for Airlines

trafficking, which some of them have at least 10 million passengers per year (Loo, 2008). Hence, due to the large volume of air traffic in these areas, understanding the ways to make them efficient is very important.

It is very important to plan air travels and airport development to know how air travelers select airports and airlines and analyze these behaviors. Tehran, based on the existing potential in the aviation sector, is one of the most important areas in the Middle East that needs to study the choice behavior of passengers faced with available airports and airlines for more efficient development of their airports. On the other hand, since such studies in the Asian cities with some airports, including Tehran has rarely been done, the modeling, and analysis of the choice behavior of passengers, can be very helpful for future researches. In addition, by using this model, the comparative study of choice behavior of passengers in Iran with travelers in other countries, can lead to improvement of future planning which is consistent with the characteristics of that country.

In relation to the selection of airport by travelers, numerous studies have been done and different papers have been presented, in most of them, the Logit models (Binary Logit Model, Multinomial Logit Model, and Nested Logit Model) has been used for modeling (Suzuki 2005).

There are many useful studies in this field all around the world (Loo et al., 2005; Hess and Polak, 2005; Basar and Bhat, 2004; Pels et al., 2001, 2003). One of the first studies have been done on the modeling of the airport selection, was in 1976 by Skinner, in the area with three airports in the Washington – Baltimore (Skinner, 1976). One year later, Lin (1977) studied the ways of choosing the airport in areas with low demand in the north of New York, and indicated that they want to travel a long distance to get better flight services, in relation to the better services can mention to number of flights.

Innec and Doucet (1990) presented one of the most important articles in the field of airport choice. They discussed about determination of the importance of being close to the airport, as well as level of service-factors on passengers' choices. They also showed that the level of service of airport have had much impact on behavior of passengers. Therefore, air travelers participating in this study had great desire to make use of jet aircraft, and for this reason, they were willing to travel longer to get to the airport with jet aircraft.

The analysis performed in this study clearly showed that the most important factor for air passengers to select a particular airport is tendency to use the jet. Another important factor in airport selection in this study can be the fly time and direct fly availability.

De Luca and Di Pace (2012) discussed the choice behavior of passengers using the various models and determined the advantages and disadvantages of each of them. De Barros et al. (2007) found that quality of the flight information display and curtesy of the security check staff are important factors for airport choice. Usami et al. (2017) indicated that the flight connectivity is a crucial variable in choosing between Narita or Haneda airports by Japanese. Paliska et al. (2016) explored not only passengers' airport choice but also the airports' catchment area size in Upper Adriatic region. Chung et al. (2017) concluded that the airport brand associated with the airport service quality could be an important factor for choosing between three airports in Northeast Asia.

In another study, some variables such as minimum connection time, service quality of flight connection, travel time and airfares are affecting passengers' airport choice (Choi et al., 2019; Parvizian et al, 2015). Jung and Yoo (2016) used hybrid choice model to explore passengers 'airport choice behavior in South Korea. The results indicated that frequency, flight time, fare, access time, access cost and airport access convenience are effective variables in decision-making.

Despite of importance of level of airport services, access time and access quality to the airport (by land) in determining the airports and airlines by the passengers, their relative importance in the different geographical conditions varies (Bradley and Daly 1991; Adler et al. 2005; Hess et al. 2007; Haghshenas et al, 2015; Gadge et al, 2019). In each study, according to questionnaires and analyst perspective on how to model, different results may be achieved. Therefore, the results obtained in an area and a specific statistical society cannot be generalized to other countries and regions, and if it is necessary to determine and analyze the choice behavior of passengers on a specific statistical area, we need to model the behavior of passengers in that area.

Tehran is the first city with several airports in Iran. Tehran like all cities with several airports needs to identify the reasons people have in choosing the airport for its future planning for air passengers. Since, there are two airports in Tehran, in order to create a hub airport and the center of the area activity, air transport and development programs intended to Imam Khomeini airport. Therefore, study the potential of the air sector in the region is essential.

One of the key issues in urban and suburban transport planning is determination of factors related to the selection of airports, which is also an important factor in airport management. Since, domestic and Hajj flights are conducted by Mehrabad airport and international flights are conducted by Imam Khomeini airport, passengers are limited in choosing the airport.

In this research, stated preference method (SP) is used to estimate the contribution of selecting two one of the existing airports. The advantage of the stated preference method is its flexibility, which can reflect a wide range of factors determining the levels of aviation services for the strategic objectives. Proper design of SP solves Multi-Being problem and makes researchers able to study the effects of changes in the factors (Loo, 2008; Murasheva et al, 2018; Rajavenkatesan et al, 2017).

DEVELOPMENT.

Methodology.

The simplest and most used models for choice models are logit models. The reason of this popularity is formulation of these models and their simple interpretation. Logit model by Luce (1959) is obtained from one of the assumptions of the theory of decision-making named independence of irrelevant alternatives (IIA).

Marschak (1960) showed the consistency of model with the model utility maximization. Marley has obtained relationship between logit model and unobserved utility distribution, which were introduced, by Luce and Suppes (1965). This relationship showed that the logit model is based on the distribution of Extreme Values. McFadden (1973) confirmed previous results by inverse analysis and expressed that in the logit formula (Louviere et al., 2000).

In these models, the decision maker n has j alternatives. The utility gained by the person that is obtained from alternative j has two parts. A part, which is shown as V_{nj} and is observable by researchers as the parameters affecting the behavior of decision-maker. The unknown and unobservable part, which is shown as ε_{nj}, and researcher considers it randomly.

In this paper, to study the choice behavior of passengers of the Imam Khomeini Airport, in relation with the choice between Imam Khomeini and Mehrabad airport, the survey conducted in the form of the stated preference and binary logit model is used. Binary logit model is simplified as shown in the following equations:

$$u_n = \beta_n x + \varepsilon_n \qquad (1)$$

$$P_n = \frac{\exp(\beta_n x)}{\sum_{n=1}^{N} \exp(\beta_{\acute{n}} x)} \qquad (2)$$

Where, U_n desired function of n^{th}, the x vector of descriptive variable (including Select coordinates, travel details, and passenger profile), β_n the matrix of unknown parameters, ε_n the random part of utility function, N the total number of choices for travelers, P_n the probability that the n^{th} option is

selected. To evaluate the logit models, the t-test to determine the significance of each of descriptive variables provided in confidence level of 10% was used, as well as a fitness indicator of the model ρ^2, which have similar characteristics is presented in the following form:

$$\rho_c^2 = 1 - (L(\beta)/ L(c) \qquad (3)$$

$$\rho_0^2 = 1 - (L(\beta)/ L(0) \qquad (4)$$

Where, L(β) is log-likelihood function, in the case that coefficients in the utility functions are selected on the basis of maximum likelihood. L(c) is log-likelihood function when the utility function of options is defined as constant. L(0) is log-likelihood function when all the coefficients in the model are zero and the contribution of all options to be considered.

It should be noted that the fitness indicator in the logit model and regression models are not equal. The following figure shows the difference between these two terms (Hensher et al. 2005).

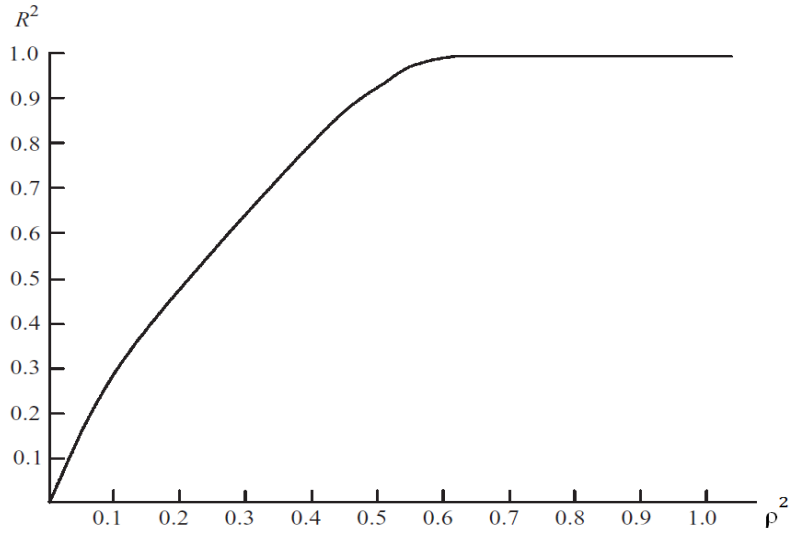

Fig. 1 The difference of the fitness index between logit and Linear regression models (Hensher et al., 2005).

Data collection.

In this study, the data required for modeling passenger's choice behavior of Imam Khomeini airport were collected through questionnaires and interviews. Questionnaires were adjusted in such a way

that individual and social characteristics of the passengers and choice behavior of passengers on airport choice derived. In general, the collected data can be divided into three categories:

1) Information relating to socio-economic status of travelers.

2) Information relating to passenger's travel.

3) Information relating to travelers answer to considering policies.

Twenty Questionnaires with 20 questions were designed using the XLSTAT software. Eighteen questions were related to personal and social characteristics of the passengers, which were similar in all 20 questionnaires, and two questions were about the choice between Mehrabad and Imam Khomeini International airport with respect to the given characteristics for each Airport. Details about the airlines that were examined in this study include:

• Flight time: flight time of airport which is considered in two ways: 1. unlimited flight time (24 hours) 2. limited flight time (from 8am to 10pm).

• Public access: This factor shows the type of public land access to the airport which include subway, bus, shuttle airline, Van and so on.

• Facilities: This indicator shows the facilities in the airport of origin, and includes play space for children, ADSL, proper and high-quality rest seats, the variety of stores, restrooms and the special room for the watching movies.

• Airport tax: Complications which is received from passengers at the airport.

According to the proposed ACRP, the sequential selection method is one of the technique methods proposed for the site survey of airport passengers (Ashford and Bencheman**,** 1987). The method is done so that, first, of those who are in check-in, a person randomly is chosen as the first person. All subjects selected, one person who questioned, asks all the questions respondents, and in any case, there is a need for greater clarity, and when the respondent does not know how to answer questions, give him further description. Questioning conducted for three days (24 hours) at Imam Khomeini

International Airport, and five days at Mehrabad Airport in the summer of 2018. After questioning, some of the incomplete questionnaires removed, 240 questionnaires of Imam Khomeini International Airport and 681 questionnaires of Mehrabad Airport analyzed. About 10% of the questionnaires was separated before the construction of the model, to use at the end to validate the model.

The collected data were analyzed by SPSS software. Table 1 shows socio-demographic characteristic (age and gender) of respondents in Imam Khomeini and Mehrabad Airport. As seen in this table, more travelers are in the age range between 26 and 35 years and the minimum frequency is related to the range of 51 to 72 years.

Table 1. The distribution of passenger's age and gender in Imam Khomeini and Mehrabad Airport.

	Imam Khomeini Airport		Mehrabad Airport	
	Frequency	Percent	Frequency	Percent
Male	121	50.4	462	67.8
Female	119	49.6	205	30.1
SUM	240	100	667	97.9
VALID	0	0	14	2.1
TOTAL	240	100	681	100
less than 25 years	53	22.1	104	15.2
between 26 and 35 years	92	38.3	241	35.4
between 36 and 50 years	72	30	231	33.9
between 51 and 72 years	23	9.6	81	11.9
SUM	240	100	657	96.4
VALID	0	0	24	3.6
TOTAL	240	100	681	100

Modeling.

As mentioned earlier, binary logit model was used in this paper to model the choice behavior of the travelers. For this purpose, first, the correlation between the variables was calculated by SPSS

software, variables with high correlation were removed, and variables with acceptable correlation were used. Correlations between all variables used in this model are less than 0.5. In the modeling process conducted in this study, we have tried to complete the definitions. Types of the variables used in this model are shown in Table 2.

Table 2. The Airport Binary Logit Model variables used in this study.

Variable	Types of Variables	Describe and how the coding
CONST	Special person (Dummy)	Constant
R-U18	Special person (Ordinal)	Number of household members over 18 years 5 years
EXP	Special person (Dummy)	The experience of the use of the airport in the past (equal=1, Otherwise=0)
TIME	Special person (Dummy)	Flight time (8am-10pm=1, Unlimited=0)
H_GROUP	Special person (Dummy)	passengers traveling companions-Group (equal=1, Otherwise=0)
AGE_25	Special person (Dummy)	The Age group less than 25 years (equal=1, Otherwise=0)
AGE_2535	Special person (Dummy)	The Age group 26-35 years (equal=1, Otherwise=0)
AGE_3550	Special person (Dummy)	The Age group 36-50 years (equal=1, Otherwise=0)
SAL1	Special person (Dummy)	Income (less than 40 million Rials=1, Otherwise=0)
FAC_CHI	Special Airport (Dummy)	Facilities-play space for children (equal=1, Otherwise=0)
FAC_CHA	Special Airport (Dummy)	Facilities- comfortable chairs (equal=1, Otherwise=0)
ACC_MET	Special Airport (Dummy)	Public access – Metro
ACC_BUS	Special Airport (Dummy)	Public access – Bus
ACC_VAN	Special Airport (Dummy)	Public access – Van

More than 100 models were developed by NLOGIT4 software. Investigation of the causal relationship between the variables and control variables for choice of Airport modeling by passengers in Imam Khomeini International Airport are presented in Table 3.

Table 3. Results of an investigation of choice of airport using Binary Logit Modelling (Imam Khomeini Airports).

Variable	*Coefficient*	*Standard Error*	*b/St.Er*	*P[|Z|>z[*
Const.	-1.93557***	0.51986	-3.723	0.0002
R_U18	0.28425***	0.09360	3.037	0.0024
EXP	-0.77397**	0.30071	-2.574	0.0101
TIME	-0.56086***	0.20932	-2.679	0.0074
AGE_25	1.29212***	0.43901	2.943	0.0032
AGE_2535	1.37938***	0.42477	3.247	0.0012
AGE_3550	.99030**	0.43550	2.274	0.0230
O_SA1	0.37434*	0.20844	1.796	0.0725
FAC_CHI	1.00697***	0.33543	3.002	0.0027
ACC_MET	-1.93557***	0.33543	1.772	0.0765

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

By using the equations, three values of the log-likelihood function for zero LL(0), the log-likelihood function for constant parameters LL(C), and the log-likelihood function for the estimated coefficients of LL(B) are obtained.

$$\rho_c^2 = 1 - \frac{LL(\widehat{\beta})}{LL(C)} = 0.0852$$

$$\rho_0^2 = 1 - \frac{LL(\widehat{\beta})}{LL(0)} = 0.0894$$

The log-likelihood function for zero coefficients: LL(0) = -299.440

The log-likelihood function grape seed fixed parameters: LL(c) =-298.100

The log-likelihood function for the estimated coefficients: LL(β) =-272.568

The results of the final model from the modeling of Airport selection in Mehrabad airport are provided in Table 4.

Table 4. Results of an investigation of choice of airport using Binary Logit Modelling (Mehrabad Airports).

Variable	*Coefficient*	*Standard Error*	*b/St.Er*	*P[|Z|>z[*
Const.	1.21188***	0.13019	9.309	0.0000
R_U18	-0.00033*	0.00018	-1.782	0.0747
H_GROUP	0.00054***	0.00021	2.590	0.0096
FAC_CHI	0.86455***	0.16667	5.187	0.0000
FAC_CHA	1.07942***	0.27806	3.882	0.0001
ACC_MET	0.45166**	0.17799	2.538	0.0112
ACC_BUS	0.54852**	0.24105	2.276	0.0229
ACC_VAN	0.71556***	0.18752	3.816	0.0001

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

By using the equations, three values of the log-likelihood function for zero LL(0), the log-likelihood function for constant parameters LL(C), and the log-likelihood function for the estimated coefficients of LL(B) are obtained.

$$\rho_c^2 = 1 - \frac{LL(\widehat{\beta})}{LL(C)} = 0.0738$$

$$\rho_0^2 = 1 - \frac{LL(\widehat{\beta})}{LL(0)} = 0.1400$$

The log-likelihood function for zero coefficients: LL (0) = -844.25327

The log-likelihood function grape seed fixed parameters: LL (c) =-783.9746

The log-likelihood function for the estimated coefficients: LL (β) =-726.0539

After modeling, 24 (of 240 questionnaires) and 68 (of 681 questionnaires) questionnaires used in model calibration and validation of Imam Khomeini International and Mehrabad airport survey respectively. Validation percentages of the model for Imam Khomeini International and Mehrabad airport were 56% and 46% respectively.

Discussion.

Many variables can affect the desirability and probability of an airport selection. The information about effective variables in utility function were used for statistical analysis after identifying and

gathering and the right choice was made after considering the level of significance of these variables. Some results of model and their interpretation are discussed as following. In this study, the final model for the Imam Khomeini airport is $\rho_c^2 = 0.0852$, and Mehrabad airport is $\rho_c^2 = 0.0738$. The results of the validation show that the data that has been used for modeling are consistent with actual sample (56% for Imam Khomeini International Airport and 46% for Mehrabad Airport). The interpretations of some of the variables used in the model of Imam Khomeini and Mehrabad airport, which are significantly higher than the 90% level, are shown in Table 5 and 6, respectively.

Table 5. Significant variables in binary Logit model for Imam Khomeini International Airport.

Significant variable	Significant percent	Significant amount	Interpretation
Number of household members over 18 years	99%	-3.723	Families whose members have more than 18 years are more likely to choose the Imam Khomeini airport.
The experience of the use of the airport in the past	99%	3.037	Passengers who have experience of using Imam Khomeini airport in the past are less likely to use again
Flight time	99%	-2.574	Travelers tend to this issue that Imam Khomeini Airport has Unlimited flight (24).
Age (less than 25 years)	99%	-2.679	Travelers aged less than 25 years, prefer Imam Khomeini airport.
Age (between 25 and 35 years)	99%	2.943	Travelers who are aged between 25 and 35 years prefer Imam Khomeini airport.
Age (between 35 and 50 years)	95%	3.247	Travelers who are aged between 35 and 50 years old are more likely to use the Imam Khomeini airport.
Income	90%	2.274	Travelers whose monthly income is less than 4 million Rials are more willing to use the Imam Khomeini airport.
Facilities (play space for children)	99%	1.796	Create a special space for children to play can encourage passengers to use the Imam Khomeini airport.
Public access (Metro)	90%	-3.002	Create subway service to Imam Khomeini Airport increases passenger's tendency to the use of this airport.

Table 6. Significant variables in binary Logit model for Mehrabad Airport.

Significant variables	Significant percent	Significant amount	Interpretation
Number of household members over 18 years	90%	-1.782	Families whose members have more than 18 years have a low tendency to select Mehrabad airport.
The number of air passengers traveling companions	99%	2.590	At least one passenger who accompanies them on their journey and travel in groups prefers Mehrabad airport.
Facilities (play space for children)	99%	5.187	Create a special space for children to play and use of facilities such as comfortable seats and high quality can encourage passengers to use Mehrabad airport.
Facilities (comfortable chairs)	99%	3.882	
Public access (subway)	99%	2.538	If Create good public services, such as subway, bus and van taxi for the Mehrabad airport, will increase passengers' tendency to the Mehrabad airport.
Public access (bus)	99%	2.278	
Public access (van)	99%	3.816	

Based on Tables 3 and 4, similarities and differences in the factors influencing the choice of Imam Khomeini International and Mehrabad airport by passengers can be seen. Variables such as the number of household members over 18 years, the facilities used in the airport, and public access to the airport are some important factors in choice of the airport by passengers, which are common to both the airport, and only their significant are important. On the other hand, variables such as experience about the use of the airport, the number of travel companions, flight time, traveler's age and income are some effective factors to selected airport, which are seen in the results of the modeling of selection of Airport that they are significant. Based on the results, households with members with more than 18 years old have more willing to use the Imam Khomeini airport.

One of the effective parameters that are seen only in the choice of Imam Khomeini Airport is the experience about the use of the airport, which is mentioned in some previous studies (Suzuki, 2005). The results of this study showed that, this variable is one of the important factors in the selection of the Imam Khomeini Airport, since travelers with experience of Imam Khomeini International Airport do not prefer to use it again. Flight time, age and monthly income of passengers are other

important factors in the selection of airport that is effective in selection of Imam Khomeini Airport which is significant in model. On the other hand, the number of travel companions is only variable that can be seen in Mehrabad Airport model. The results showed that passengers who travel in groups (at least with one person) prefer Mehrabad airport.

Appropriate facilities at airports play a significant role in the selection of airport by passengers. Therefore, the allocation of space for children to play, as well as the use of appropriate and high-quality chairs in the waiting hall of the airport can encourage the passengers to use the airport. As in previous research, the quality of public access is one of the important parameters in selection of airport by passengers (Innes and Doucet, 1990; Adler et al., 2005). The study also showed that subway lines to Khomeini airport, buses and taxis and van for the Mehrabad airport, are effective factors in the choice of the airport by passengers and increase their desire to use this airport.

CONCLUSIONS.

In recent years, with the increase in the number of air passengers, understanding the behavior of passengers for airports selection is very important for aviation industry.

Airport managers need to know how the passengers make decisions to choose airport. Due to the built of the Imam Khomeini airport, Tehran has become the first area with several airports in Iran. In this paper, the results of choice behavior modeling of passengers at Imam Khomeini and Mehrabad Airport are presented.

In relation to choose of airports, binary logit model is compared and effective parameters in the selection of airport have been separately specified by travelers. For this purpose, data collected from the 8-days survey conducted in the summer 2018. About 240 and 681 questionnaires were collected for Imam Khomeini International and Mehrabad Airport respectively and mentioned surveys were in the form of stated preference and conducted as the interviews at the airport. The results show that

factors such as number of household members over 18 years, the facilities used at the airport and public access to the airport are important in choosing airport.

Flight time, age and income of travelers have been effective factors in the choice of the airport by travelers of Imam Khomeini International airport. For future studies, the following cases are suggested:

1) Apart from the selection of airport, it is suggested that selection of the airline and airport modeled simultaneously.

2) It is recommended to design of questions is associated with greater changes in the characteristics of each option to specify the choice behavior of passengers and obtain better significantly.

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