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Airport Choice Model in Multiple Airport Regions

Claudia Muñoz, Jorge Cordoba, Iván Sarmiento

National Universtiy of Colombia (Colombia)

chmunozb@unal.edu.co, jecordob@unal.edu.co, irsarmie@unal.edu.co

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Abstract

Purpose: This study aims to analyze travel choices made by air transportation users in multi airport regions because it is a crucial component when planning passenger redistribution policies. The purpose of this study is to find a utility function which makes it possible to know the variables that influence users' choice of the airports on routes to the main cities in the Colombian territory.

Design/methodology: This research generates a Multinomial Logit Model (MNL), which is based on the theory of maximizing utility, and it is based on the data obtained on revealed and stated preference surveys applied to users who reside in the metropolitan area of Aburrá Valley (Colombia). This zone is the only one in the Colombian territory which has two neighboring airports for domestic flights. The airports included in the modeling process were Enrique Olaya Herrera (EOH) Airport and José María Córdova (JMC) Airport. Several structure models were tested, and the MNL proved to be the most significant revealing the common variables that affect passenger airport choice include the airfare, the price to travel the airport, and the time to get to the airport.

Findings and Originality/value: The airport choice model which was calibrated corresponds to a valid powerful tool used to calculate the probability of each analyzed airport of being chosen for domestic flights in the Colombian territory. This is done bearing in mind specific characteristic of each of the attributes contained in the utility function. In addition, these probabilities will be used to calculate future market shares of the two airports considered in this study, and this will be done generating a support tool for airport and airline marketing policies.

Keywords: airport choice model, multinomial logit, passenger demand .

1. Introduction

This article is a way to approach passenger air transportation based on demand management. It is a key tool in transportation planning and helps to expand knowledge regarding the factors that affect each airport's passenger demands. It will allow better control of mobility policy results, and it will help to obtain greater knowledge regarding what they want to manage.

Discrete Choice Models based on a random utility theory have been widely used to analyze choice situations in different means of transportation to travel. In this study, the choice scenario corresponds to two airports in the metropolitan area of Aburrá Valley from where a user can start a trip towards the main cities in the Colombian territory. Thus, knowing the variables that passengers consider when choosing which air terminal, they will use to travel becomes a crucial component in transportation planning. Furthermore, this has been a topic which has become important recently for airport planners. In this article, state-of-the-art modeling is implemented in making an airport choice using multinomial logit models (MNL) which make it possible to capture the variables that are statistically significant in choosing an airport and which may permit an analysis of individuals' behavior regarding the two available alternatives.

Data collecting is done for the inhabitants of the metropolitan area of Aburrá Valley (3.5 million inhabitants). It includes the city of Medellin (2.4 million inhabitants), which is the second most inhabited city in Colombia, and it is the only one that is served by 2 airports in the country. The airports chosen to implement the research are Enrique Olaya Herrera (EOH) and Jose Maria Cordova (JMC); they are in the metropolitan area of Aburrá Valley, and the common routes to evaluate for the two airports are Medellin-Bogota and Medellin-Cali. Bogota is the capital of the country and has over 7 million inhabitants, and Cali is the third city in Colombia with more than two million inhabitants, in 2015.

In chapter 2, the study presents a theoretical framework for discrete choice models. In chapter 3, it presents data collecting and a choice scenario. In chapter 4, the study presents the methodology and the specification of the proposed choice model. In chapter 5, it presents the results of the analysis which revealed a significant influence of the variables like airfare, the price to travel to the airport, and the time to get to the airport, among others. In the airport choice made by air transportation users, several MNL models and the mixed logit models (ML) were produced, and the MNL model was chosen as the best in this case study through statistical items that permit model ranking. In chapter 6, the conclusions highlight the most important findings.

2. Theoretical framework

A field which is of special interest is the analysis of decisions made by passengers who travel from regions that have several airports and where there is a choice to go to a common destination from either of the two airports relatively close to each other. Modeling these choices is appealing from a research perspective because of choice process. In addition, this modeling is of great importance for airport and airline expansion policies (Jung & Yoo, 2014). As a matter of fact, an increase in air transportation has caused severe congestion problems in regions that have several airports, and this leads to an urgent increase in capacity. (Hess & Polak, 2006).

In discrete choice models, also named qualitative response models, the conditional probability of a choice is related to a series of self-explanatory factors. These factors gather the characteristics of the individuals who make decisions and the attributes of the alternatives, which also make it possible to calculate the probability that an individual with determinate characteristics will make a given choice. These transportation models represent a planning process nucleus in the region, and they make it possible to quantify any future scenario which decision-makers may consider. Accordingly, this tool must be very transparent, and it must inspire confidence in the results so that decision-making may be the most adequate for the city.

2.1 Discrete Choice Models

The discrete Choice models based on the theory of random utility model substantiate themselves on the probability that an individual, q, will choose alternative, *j*. This is a function of an individual's social economic characteristics and the variables associated to some choice options (Ortúzar & Willumsen, 2011). The idea behind the theory is that while the alternative of each choice may be known by an individual during a decision-making process, it is not totally known by the observer or the modeler, and so this uncertainty must be considered. Even though transportation demand models have been developed based on aggregate approaches, it is a very common practice to disaggregate models for discrete choices to calibrate choice models. The approach establishes an indirect utility of an alternative, *j*, for an individual, *q*, U_{jq} is represented in equation (1) times the sum of the term known by the modeler V_{jq} and a random one ε_{jq} (Domencich & McFadden, 1975).

$$U_{jq} = V_{jq} + \varepsilon_{jq} \qquad (1)$$

Equation 1. Utility function

For each alternative, which in this case study will be the two available airports for the metropolitan area of Aburrá Valley, the deterministic component V_{jq} of the utility is specified as a function of attributes X like flight time and airfare, and an individual's characteristics (age, reason for traveling, and occupation, among others). Thus, the deterministic component also called systemic is described in equation (2) as a function of X_{ikq}, which represents the value of a k attribute of alternative, j, for an individual, q

$$V_{jq} = \Sigma\theta_{ikq} X_{ikq} \qquad (2)$$

Equation 2. Deterministic component

The random term, ε_{jq}, contained in the utility function, U_{jq}, in equation (1) reflects the modeler's measurement and observation errors, and they are random variables with a 0 mean and a probability distribution which will be specified. The model used depends on the type of distribution. The individual, q, chooses the maximum utility alternative; in other words, chooses alternative, j, if, and only if, the inequality is fulfilled in equation (3)

$$U_{jq} \geq U_{iq} \qquad \forall\ A_i \in A(q) \qquad (3)$$

Equation 3. Highest utility alternative

The multinomial logit model (MNL) is a generalization of the binary logit model, and it is used to describe how an individual chooses from among a finite number of alternatives (Domencich & McFadden, 1975). This model is used in this study, and it has been the most used discrete choice model in airport choice studies. This model is obtained based on the assumption that the error terms of the equation (1) are distributed independently and distributed identically (iid) and follow a Gumbel distribution, so the probability that an individual, q, chooses alternative, j, is given by equation (4) (Domencich & McFadden, 1975)

$$P_{jq} = \frac{\exp(V_{jq})}{\sum_{A_i \in A(q)} \exp(V_{iq})} \qquad (4)$$

Equation 4. choice probability

2.2 Airport choice demand modeling

The implementation of econometric models in an airport choice has provided valid powerful tools to find future passenger market shares. Knowing choice decisions becomes a factor that is every time more important in airport marketing policies, and consequently for airline companies. (Pels, Nijkamp & Rietveld, 2003; Loo, 2008; Marcucci & Gatta, 2011; Fuellhart, O'Connor & Woltemade, 2013; Yang, Lu, & Hsu, 2014).

Skinner (1976) conducted the first airport choice studies. Skinner (1976) used the multinomial logit model (MNL) to describe the behavior in and airport choice when there were 3 available air terminals. The results revealed and effect of frequencies and accessibility conditions. Windle and Dresner's (1995) studies concluded that the effects of passengers' time to get to the terminal and flight frequency were statistically significant in the choice model.

In the Bay Area of San Francisco, several airport choice studies have been conducted. Harvey (1987) found that regarding the different motives users had to travel, flight frequency and the time to get to the airport were significant variables in the airport choice MNL model. Basar and Bhat (2002, 2004) established a multinomial logit model for business travelers who resided in the Bay Area, and they found that the time to get to the airport and frequencies were significant variables in airport choice. Recent studies conducted by Hess and Polak (2006) analyzed airport choice in the Bay Area of San Francisco using a mixed logit model (ML), which had a better fit compared to the produced MNL models, and just like in previous studies, the variable of time to get to the airport was statistically significant in the model. Ishii, Jun, and Van Dender, (2009) calibrated mixed logit models for the San Francisco – Los Angeles route bearing in mind the variable like time to get to the airport, airport delays, and flight frequency, among others. In addition, they generated models for two groups of travelers, leisure and business.

Airport choice studies have been conducted in the United Kingdom (UK). Ashford and Bencheman (1987) calibrated MNL models to describe airport choices in England bearing in mind the availability of 5 terminals including two airports in London. In the models, they produced, they found that the time to get to the airport and the frequencies were important factors when choosing which terminal to travel from. Furthermore, airfare turned out to be a statistically significant variable for domestic flights, while for business people traveling on international flights, it was not statistically significant. Discrete choice models are also used in hypothetical choice situations. Thompson and Cuevas (1993) used the MNL model to forecast the market share of the new airport in northern England. The time to get to the airport, flight frequency and the size of the aircraft were significant variables within the model. The implementation of airport choice models in the Colombian territory has been null. This study provides a valuable contribution to air terminal choice starting with the definition of a specific market, considering a determinate set of destinations like direct routes from Medellin to the main cities in Colombia (Bogota, Cali).

3. Description of data and choice scenario

The metropolitan area of Aburrá Valley is the only metropolitan region in Colombia that has two airports available for passengers' domestic trips, and it is formed by the city of Medellin as the main hub, and nine other townships. Thus, the choice scenario in which this study is conducted is Enrique Olaya Herrera (EOH) airport and Jose Maria Cordova (JMC) airport. EOH is a Colombian airport in the southwestern part of the city of Medellin, which serves regional and domestic flights as shown in figure 1. The other available air terminal is JMC international Airport in the township of Rionegro 29 kilometers from Medellin. This airport is the most important in the province of Antioquia, and in terms of infrastructure, it is second to El Dorado international airport in Bogota. The two airports in Medellin move more than 6.5 million passengers per year which makes it the second city with the most passenger domestic traffic in Colombia after Bogota, which moved more than 19 million passengers in 2014. (Aerocivil, 2015).

Figure 1. Location of EOH airport and JMC airport in the metropolitan area of Aburrá Valley (Google maps)

The objective of the study is to find a utility function that makes it possible to know the market shares of each of the airports for the routes to the main cities in the Colombian territory. To start the modeling process, it was necessary to gather information, and to do so revealed preference surveys were conducted (RP) on the direct observation of individuals' consumption behavior, and in these surveys, they asked for the social economical characteristics and the airports' attributes. Furthermore, stated preference surveys (SP) were conducted, which asked about the decisions that individuals eventually made regarding a determinate choice alternative based on a series of fictitious attributes proposed by the researcher in accordance with the researcher's objectives (Ortúzar & Willumsen, 2011). This study asked for the different situations regarding traveling from one of the two airports that serve the city of Medellin and its nearby townships. These situations were produced because of the variation in values of studied attributes like airfare (AF), the price of traveling to the airport (PT), and the time to get to the airport (TA).

200 domestic flight users of the two airports were surveyed, and this enabled the gathering of each airport's social economic information, which was useful to explain why EOH airport or JMC airport were chosen to start a trip. This information was complemented with a stated preference survey (SP), which corresponded to users stated choices regarding hypothetical consumption situations in which individuals had to choose and alternative that was the most attractive of a group of two possibilities (EOH or JMC) in a set of 9 cases per respondent, resulting in a total of 1800 observations, which became the primary information to produce choice models.

4. Methodology and model specification

The model to estimate will consider the utilities users assigned to the two available airports. In general terms, this utility will have the basic structure shown in equation (5)

$$U_j = \beta + \theta_{Airfare} CT_j + \theta_{Traveling\,cost} CD_j + \theta_{Time} TV_j + \varepsilon_j \tag{5}$$

Equation 5. Basic structure of the utility function

The database constructed based on the gathered information contains each terminal's own attributes, and includes social economic variables, among others, which are described in table 1, and at the same time are in each airport's utility function.

Variable	Description
AF	airfare
PT	price of traveling to the airport
TA	time to get to the airport
SEX	gender (0 man, 1 woman)
PL	airport where passengers departed from on their last trip (0 EOH, 1 JMC)
AC1	the type of preferred airplane is < 100 passengers
TR1	ticket reservation time in days
MOT1	if the motive for most air trips is work or business (1 if so, 0 if not)
OC	occupation (1 employee, 0 other (student, retiree, home maker)
PC	people choose an airport where they are going to travel from. (1. The respondent, 0 others)
MT	means of transportation used to get to the airport (1 private, 0 public)
SS	social economic strata (1. Medium- low, 0 medium- high)

Table 1. Descripiton of attributes

Several models with different specifications were tested. These models differ in the number of estimated attributes, and they were estimated using Biogeme software which is commonly used in transportation modeling. (Bierlaire, M., 2008)

With the data obtained in the information-gathering stage, Muñoz, C., Sarmiento, I., & Córdoba, J. (2014) calibrated models for each airport and each route, and they obtained two utility functions for EOH airport, one for the Medellin – Bogota route and the other for the scheduled Medellin–Cali route. Likewise, for JMC Airport, two utility functions were obtained, one for the Medellin – Bogota route and the other for the Medellin – Cali route.

In this study, based on the data obtained from the stated preference surveys for the Medellin-Bogota and Medellin-Cali routes, several expressions of utility functions were tested, and in several of them, the attributes were not statistically significant at a 95% confidence interval. MNL and ML models were tested, and in the latter, it was found that the attributes were not significant in the utility function. After producing some MNL models, a model ranking was established to determine the best model.

5. Results of the modeling

The model produced and described in table 2, establishes that the signs of the variables correspond to what was expected. In addition, when implementing a t-test, it was found that all the variables were statistically significant at a 95% confidence interval.

Attribute	Parameter	Value	T-Test
	BJMC	Fixed (=0)	Fixed (=0)
	BEOH	1.36	4.50
AF	θAF	-0.0000124	-10.30
PT	θPT	-0.0000169	-6.20
TA	θTA	-0.0191	-3.26
SEX	θSEX	334	2.69
PL	θPL	1.09	8.13
AC1	θAC1	0.273	20.3
TR1	θTR1	0.379	3.07
MOT1	θMOT1	0.332	2.16
OC	θOC	0.373	2.41
PC	θPC	0.536	4.27
MT	θMT	0.650	5.15
SS	θSS	0.266	2.23

Table 2. Airport choice MNL Model

Based on the values of the parameters produced in the MNL model, utility functions were constructed for each air Terminal. Thus, for JMC airport, the variables that make up that function are described in equation (6), along with the parameter values, which gives the weight of each one of the attributes in a utility function

$$\begin{aligned} U_{JMC} &= -0.0000124CT_{JMC} - 0.0000169CD_{JMC} - 0.0191TV_{JMC} \\ &+ 0.334SEX + 0.266ES + 1.09LU + 0.536DV + 0.379TR1 \end{aligned} \quad (6)$$

Equation 6. JMC airport utility function

On the other hand, for EOH airport, its utility function is presented in equation (7) and EOH airport's utility function and JMC airport's utility function will make it possible to calculate each terminal's choice probabilities.

$$\begin{aligned} U_{EOH} &= 1.36 - 0.0000124CT_{EOH} - 0.0000169CD_{EOH} - 0.0191TV_{EOH} \\ &+ 0.65MT + 0.373OC + 0.332MOT1 + 0.273AVI1 \end{aligned} \quad (7)$$

Equation 7. EOH airport utility function

This estimated model provides a tool to calculate the market shares of the two airports studied herein. In other words, it refers to the probability that each analyzed airport may be chosen to fly from the metropolitan area of Aburrá Valley to the main cities in the Colombian territory. This is done considering the characteristics of each one of the attributes contained in the utility function.

6. Conclusion

In this article, an approach has been made towards discrete choice models in the passenger air transportation sector to and from capital cities in the Colombian territory, and the article is a contribution to research. Furthermore, it opens the door to many applications not only in air transportation but also in other fields of interest.

Based on the information gathered using stated preference surveys, a series of multinomial logit and mixed logit models were formulated, and when they were all evaluated and compared, it was observed that the MNL model had the best fit. Furthermore, this model evidences the attributes users consider when choosing an air terminal to start a trip to go to any of the Colombian capital cities. In the model established for trips to the main cities in the Colombian territory, it was found that the variables that influence airport choice were airfare (AF), the price of traveling to the air terminal (PT), time to get to the airport (TA), which coincides with the variables found in the airport choice models found in studies conducted in different cities in the world. In addition, the utility function obtained for JMC airport makes it possible to conclude that traveling from JMC airport has a higher utility for users with the following characteristics: Female users, who departed from this airport on their last trip and for travelers from medium and low social economic strata, which is an attribute that is related with income levels.

The utility function produced for EOH airport makes it possible to infer that to travel from this airport has a higher utility for users whose reason for traveling is work or business, and because they can arrive to the airport terminal using private transportation. In addition, it is of higher utility for users who prefer to travel in small aircrafts from this terminal.

The model obtained for EOH airport revealed that business travelers are the least affected by higher airfares, compared to the people that travel for fun. Business Travelers are willing to pay higher airfare because the time to get to the airport is less. In addition, in the model found for JMC Airport, ticket booking time was less than 5 days, and this produced a higher utility for users who fly from this airport, because they find lower airfare rates compared to the rates offered by airlines traveling from EOH airport. These models represent a valuable tool to see air transportation users' decisions. The planner can use the results obtained in the model calibration process for decision-making. This makes it possible not only to calculate the demand of each alternative, but also, it makes it possible to know the sensitivity the demand has when facing changes of the values of the different policy variables included in the model like airfare (AF), the price to travel to the air terminal (PT), time to travel to the airport

(TA), and an intervention in passenger distribution policies for trips to the main cities in the Colombian territory.

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