Air Passenger Distribution Model in Chinese Multiple-airport Regions

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Abstract: Passenger distribution is a crucial factor in determining airports' success or failure. Chinese travelers have their own choice characteristics. Application of existing models of passenger choice behavior developed by foreign countries has not obtained obvious effect in China. In this paper, a multinomial logit (MNL) model is constructed to predict air passenger distribution in multi-airport regions. Parameters in this model are estimated by maximizing the log-likelihood function. Based on the survey data from two airports in Beijing and Tianjin, the proposed model is calibrated. The results indicate that the important airport-choice variables in Chinese multi-airport choice are airfares, flight frequency, experience and access time, orderly. Travelers in developing countries have higher airfare elasticity than those in developed countries, while travelers in developed countries have higher access time elasticity than those in developing countries. In addition, a passenger's experience is significant in the air passenger distribution in both developed and developing countries. Airport managers may be benefits of attracting nonusers and providing high-quality service.

Keywords: Multiple-Airport Region; Passenger Distribution; Multinomial Logit Model

1 Introduction

Airports in a multiple airport region may have to compete with other airports for departing passengers. Passengers take a number of decisions; they have to choose the departure airport, the airline and the airport access mode. These choices depend on a number of explanatory variables such as airport access times, frequency of service offered by the airline and the airfare, and availability and cost of the access mode [1]. Many of the world's largest cities are served by more than one commercial airport, no exception to Chinese metropolitan area. Therefore, air passenger distribution is an important air travel-related decision in multiple airport regions.

Several earlier studies have examined airport choice in a multi-airport region. Some of these studies have focused on airport choice in isolation [2-6], while others have examined airport choice along with other dimensions of air travel [7-8]. These earlier studies have focused on different urban areas and, sometimes, different population groups (such as business travelers versus leisure travelers and residents versus nonresidents). However, a common finding in all these studies is that access time to the airport and service frequencies are the dominant factors affecting airport choice. Several of these studies also suggest that a simple measure of access time to the airport; i.e., auto access time; performs as well as more complex formulations that consider multiple modes and both access time and access cost. In addition, many earlier studies find that airfare is not a significant factor in airport choice for business travelers, though a few studies find airfare to affect airport choice for non-business passengers.

Nowadays, a number of papers have modeled air passenger distribution in multi-airport regions. Most studies used the discrete choice models, such as the binomial or multinomial logit approach to investigate the primary determinants of passengers' airport-choice decisions, e.g. airfare, airport access time, airport access cost, and flight frequencies. Some of these studies have focused on airport choice in isolation [2-5], while others have examined airport choice along with other dimensions of air travel [9-12].

This paper aims to provide insight into passenger sensitivity to fare, frequency, airport access time and passenger experience in Chinese multi-airport regions. Prior researchers generally studied the airport choice in developed countries. They are seldom concerned with the multi-airport regions in developing countries. As a developing country, Chinese travelers have their own choice characteristics. Application of existing models of passenger choice behavior developed by foreign countries has not obtained obvious effect in China. We extend the research on airport choice to developing countries. A multinomial logit (MNL) model is constructed to predict air passenger distribution in multi-airport regions. Parameters in this model are estimated by maximizing the log-likelihood function. Based on the survey data from two airports in Beijing and Tianjin, the proposed model is calibrated. The modeling results indicate that, Travelers in developing countries have higher airfare elasticity than those in developed countries, while travelers in developed countries have higher access time elasticity than those in developing countries.

2 Model

Disaggregate or discrete-choice modelling is now far more common for air passenger distribution research in multi-airport regions. Made possible by micro data (data on individual decision-making units), this approach explains behavior directly at the level of a person, household, or firm. The most widely used theoretical foundation for disaggregate models is the additive random-utility model of Mcfadden. Suppose a air passenger n facing discrete alternatives (airports) $j=1,2,\ldots,J$ chooses the one that maximizes utility as given by

$$U_{jn} = V\left(z_{jn}, \beta\right) + \varepsilon_{jn} \tag{1}$$

where $V(\cdot)$ is a function known as the systematic utility, z_{jn} is a vector of attributes of the alternative airports. β is a vector of unknown parameters, and ε_{jn} is an unobservable component of utility functions. Based on preliminary survey, the deterministic component of utility may be specified as a nonlinear function of explanatory variables as follows:

$$V_{jn} = \beta_0 + \beta_1 \cdot \ln fare_{jn} + \beta_2 \cdot \ln freq_{jn} + \beta_3 \cdot time_{jn} + \beta_4 \cdot expe_{jn} \tag{2}$$

In Equation (2), $freq_{jn}$ is the daily frequency of service, included in logarithmic form, as it is an indication of the size of an airline in a market to a certain destination, $\beta_2 > 0$; the airline fare, the access time and passenger experience are also included; $\beta_1 < 0$, $\beta_3 < 0$, $\beta_4 > 0$.

The air passenger choice is probabilistic because the measured variables do not include everything relevant to the individual's decision. This fact is represented by the random terms ε_{jn}. Once a functional form for V is specified, the model becomes complete by specifying a joint cumulative distribution function for the random terms, $F(\varepsilon_{1n},\ldots,\varepsilon_{Jn})$. Denoting $V(z_{jn},\beta)$ by V_{jn}, the passenger choice probability for airport i is then

$$\begin{aligned} P_{in} &= \Pr(U_{in} > U_{jn}, \textit{for all } j \neq i) \\ &= \Pr(\varepsilon_{jn} < V_{in} - V_{jn} + \varepsilon_{in}, \textit{for all } j \neq i) \\ &= \int_{-\infty}^{+\infty} F_i\left(V_{in} - V_{1n} + \varepsilon_{in}, \ldots, V_{in} - V_{jn} + \varepsilon_{in}\right) d\varepsilon_{in} \end{aligned} \tag{3}$$

where F_i is the partial derivative of F with respect to its ith argument. F_i is thus the probability density function of ε_{jn}.

The multinomial logit model which can be used in passenger distribution model arises when the J random terms are iid with the extreme-value distribution, sometimes called the Gumbel or double-exponential distribution. This distribution is defined by

$$F(x) = \Pr\left(\varepsilon_{jn} < x\right) = \exp\left(-e^{-\mu x}\right) \tag{4}$$

for all real number x, where μ is a scale parameter. Here the convention is to normalize by setting $\mu = 1$.

Suppose passenger n has decided to fly to a particular airport. The passenger then has to choose a departure airport. Using the standard multinomial logit (MNL) function, the probability that passenger n chooses airport i (i=1,2,…,J) can be obtained:

$$P_{in} = \frac{\exp\left(\beta_0 + \beta_1 \cdot \ln fare_{in} + \beta_2 \cdot \ln freq_{in} + \beta_3 \cdot time_{in} + \beta_4 \cdot expe_{in}\right)}{\sum_{j=1}^{J} \exp\left(\beta_0 + \beta_1 \cdot \ln fare_{jn} + \beta_2 \cdot \ln freq_{jn} + \beta_3 \cdot time_{jn} + \beta_4 \cdot expe_{jn}\right)} \tag{5}$$

3. Survey

Data for estimating the parameters in the MNL model were collected in Beijing-Tianjin region from the passenger survey conducted by several college students during the summer of 2008. In the survey, the interview consisted of the following parts. (a) General information about type of trip and flight taken. (b) Details of the flight taken (airline, flight number, etc.) and the ticket price. (c) Details of the trip origin and the trip to the airport (ground access mode, access time, and access cost, etc.). (d) Airport choice, e.g., primary reasons for choosing airport over other airports and other airports considered. (e) Experience, that is, whether or not a

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passenger has ever used a candidate airport in the past and the times every year, and his/her satisfaction degree in the airport, and (f) Information about the respondent and his or her household. The survey was distributed to the passengers in the study area by the intercept survey. Only those passengers who lived in the study area were surveyed.

Four variables are chosen in the airport-choice studies. They are as follow: (a) airfare at each airport, (b) flight frequency to the passenger's destination from each airport, (c) access time to each airport, and (d) passenger's experience with airports. The airfare variable measures a passenger's perceived level of airfare at each airport. Flight frequency was obtained by counting the number of scheduled flights from each airport to the passenger's destination using the official airline guide. The access time to each airport and experience variables were collected directly from the survey data. The value of passenger experience is a dummy (-4/-2/0/2/4) variable, it is coded 4 if traveler *n* has used airport *j* and had very good experiences with the airport; coded -4 if traveler *n* has used airport *j* and had very bad experiences with the airport, and coded 0 if the traveler *n* has not used airport *j* or had ordinary experiences with the airport. If β_4 is positive and significant (good experience), an individual is more likely to choose the airport than those without prior experiences and with bad experience, if everything else is equal.

4. Estimation and Results

4.1 Estimation Issues

An issue in estimating airport-choice models is the specification of a choice set for each passenger. For a given logit model, data on actual choice, along with traits z_{jn}, can be used to estimate the unknown parameter vector β in Equations (1) and (2) and to carry out statistical tests of the specification. Parameters are usually estimated by maximizing the log-likelihood function:

$$L(\beta) = \sum_{n=1}^{N} \sum_{i=1}^{J} \delta_{in} \log P_{in}(\beta) \tag{6}$$

where N is the sample size. In this equation, δ_{in} is the choice variable, defined as 1 if passenger n chooses airport i and 0 otherwise, and $P_{in}(\beta)$ is the choice probability.

4.2 Estimation Results

Estimation results from the log-likelihood function are shown in Table 1. If we define those variables that are significant at the 90% significance level or above in the models as the 'important' variables, the important airport-choice variables are airfares, flight frequency, experience and access time, orderly.

Table 1.Estimation Results

Variables	Coefficients	*t*-statistics
Airfares	-0.252	8.6
Flight frequency	0.748	3.57
Access time	-0.044	2.91
Experience	2.629	2.13

The results indicate that a passenger tends to choose the airports that have lower average airfares, more flight frequency, prior good experience, and less access time. Prior studies in developed countries [2-6] indicate that access time and flight frequency variables are important, and airfare variable is not significant. In agreement with previous work, it was found that flight frequency is one of the significant variables of airport choice. However, our estimation results indicate that not access time but airfare is another important variable in the competition between airports in a developing country's region. Passengers in developing countries have higher airfare elasticity than those in developed countries, while travelers in developed countries have higher access time elasticity than those in developing countries. Possible explanations for this phenomenon are the difference on economy and standard of living. Passengers in developing countries have lower income than those in developed countries. Therefore, they have higher airfare elasticity than passengers in developed countries.

In addition, a passenger's experience is significant in the airport choice behavior in both developed and developing countries. This would show that passengers who have used an airport and had good experience will tend to continue to use the same airport, all other factors being equal. The study results provide important implications to airport managers. They should identify the primary factors affecting CSD (customer satisfaction degree), and improve the service quality because the studies indicate that a passenger is return after a good experience than a poor experience.

5. Conclusions

This paper has extended the studies of multi-airport passenger distribution into Beijing-Tianjin region using a multinomial logit (MNL) model. Four explanatory variables were investigated, namely, access time to the airports of choice, airline service (mainly flight frequencies) at the regional airports, airfare, and a passenger's experience with an airport. The estimated results show that, expect for flight frequency, not access time but airfare is another important predictor in the competition between airports in a developing country's region. Passengers in developing countries have higher airfare elasticity than those in developed countries, while travelers in developed countries have higher access time elasticity than those in developing countries. In addition, passengers who have used an airport and had a good experience will tend to continue to use the same airport, all other factors being equal. Airport managers may be benefits of attracting nonusers and providing high-quality service.

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