Modeling joint airport and route choice behavior for international and metropolitan airports

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Chih-Wen Yang [a],[*], Jin-Long Lu [b], Chun-Yen Hsu [a]

[a] Department of Distribution Management, National Taichung University of Science and Technology, 129 Sec. 3, Sanmin Road, Taichung 40401, Taiwan, ROC
[b] Department of Shipping and Transportation Management, National Kaohsiung Marine University, 142, Haijhuan Road, Nanzih Dist., Kaohsiung 81157, Taiwan, ROC

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ABSTRACT

The main objective of this study is to model the airport and route choice behavior for a direct flight from Taiwan to Shanghai. We adopt a stated preference approach to design choice scenarios and evaluate the effects of airport operating strategy. Further, we formulate a nested logit model that combines the choice of airport and flight route and analyze the trade-off between airport characteristics, access factors, and flight attributes. Our empirical findings indicate that access time and access cost are both important aspects in airport choice, while air fare and flying time significantly influence the route choice of travelers. Further, a fast check-in service at airports have an impact on the travelers with high personal income, while frequent fliers on business trips are more concerned with the daily frequency of flights. In particular, the travelers prefer to arrive at a metropolitan airport than an international airport but no significant difference in departure airport. Finally, this study is the first of its kind to propose a two-dimensional strategy map to help operators develop a price strategy.

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1. Introduction

Trends such as open sky policies, low-cost airline growth and airport financial autonomy accelerate airport competition in multi-airport regions. Therefore airport planners and managers must be aware of the factors influencing traveler preferences for departure airports. Such an analysis can help airport authorities plan long-term development policies regarding airport location, capacity expansion and faster ground access and implement short-term operating strategies, such as reducing check-in time, improving flight punctuality or adjusting airport fees. In addition, airline operators need to be aware of the sensitivity of travelers to routes when developing marketing strategies related to fares or flight frequency. Moreover, an accurate demand forecast is important to determine whether establishing a new route is actually worthwhile.

Taoyuan International Airport (TPE) is the major international gateway of Taiwan. Civil air transport statistics (Civil Aeronautics Administration, 2011) show that 86% of Taiwan's incoming and outgoing passengers pass through TPE. However, following the

introduction of cross-strait direct flights and the establishment of the "golden aviation circle" in Northeast Asia, Songshan International Airport (TSA) has been upgraded from a secondary to primary airport. The most vital advantage of TSA is its location in Taipei, the capital city of Taiwan. However, TPE is Taiwan's major international gateway and the scale, capacity, and frequencies of this airport render it attractive. For short trips within the Asia region (i.e., trips of approximately three hours), both TPE and TSA are competitive departure airports since they are merely one hour apart by road. Furthermore, in addition to these airport and geographic characteristics, the corporatization of the airport authority and the introduction of ground transit systems between the two airport cities would intensify the competition between the two airports. Hence, modeling the travelers' airport choice behavior for these two airports and examining the importance of the factors influencing their preferences could help airport managers and airline operators adopt more effective competitive strategies.

In the airport choice behavior literature, the first concern is choice dimension. One approach is to consider airport choice as single dimensional but with specific attributes of different choice dimensions (Basar and Bhat, 2004; Hess and Polak, 2005; Zhang and Xie, 2005; Hess, 2010). Another is the multidimensional approach, combining airport choice with other choice dimensions such as airline choice, flight choice or access choice. Bondzio (1996)

* Corresponding author. Tel.: +886 4 22196764; fax: +886 4 22196161.
E-mail addresses: cwyang@nutc.edu.tw, cwyang1210@gmail.com (C.-W. Yang).

formulated a two-level nested construct to model the access and airport choice behaviors of travelers. The same nesting structure was used by Pels et al. (2003) in a study of the San Francisco Bay area. Pels et al. (2009) also used the nested logit (NL) model to combine the airport and airline choice dimensions and analyze low-cost airlines. Multidimensional specifications help, in not only theoretically investigating the interdependent relationships between different choice dimensions, but also in gaining more significant results than single-dimensional specifications. For example the studies of Bondzio (1996), Pels et al. (2003); Hess and Polak, (2006b) and de Luca and Di Pace (2012) all proved that two-level NL models provide more significant results than multinomial logit (MNL) models in modeling airport choice behavior.

The specific joint choice behavior for departure airport and flight route has rarely been discussed during the last two decades, but the following three studies have addressed this issue. Ndoh et al. (1990) use an NL model to construct the joint choice of departure airport and route for air passengers in Central England whilst Furuichi and Koppelman (1994) use such a model for departure and destination airport choice in Japan. Bradley (1998) adopts an MNL model to consider the airport and route choice simultaneously. However, both the trend of open skies agreements and the development of low-cost airlines in multi-airport regions have led to air travelers having more diverse flight alternatives by combining multiple departure airports and flight routes, and hence the need for more research in this area.

The major contributions of this study can be identified as follows. First, we utilize a two-level nested structure to model the dimensions of joint airport and route choice. This model can investigate the competitive relationship between airports and estimate the potential demand for new routes. Second, we adopt a stated preference (SP) design to examine the trade-off between strategic airport attributes and flight attributes. Furthermore, this study can help airport managers identify the key airport attributes and propose effective strategies to enhance the competitive advantage of a particular airport. Finally, this study is the first of its kind (as far as we know) to adopt an elasticity of attributes to reveal the relative advantages and disadvantages of various flight-route alternatives on a two-dimensional map.

2. Methodology

We examine the interdependence of airports and flight routes with a two-level NL model representing the hierarchical structure of joint choice behavior. In the literature of air travel choice, the dimension of airport choice is frequently specified as the upper nest, and the other dimensions of airline choice, flight choice and access mode are conditional on the lower nest (Ndoh et al., 1990; Furuichi and Koppelman, 1994; Bondzio, 1996; Pels et al., 2000; Hess and Polak, 2006a; Pels et al., 2009). Therefore, the hierarchical structure nested by departure airport is first illustrated as an example to explain the formulation of NL models (Fig. 1). Other
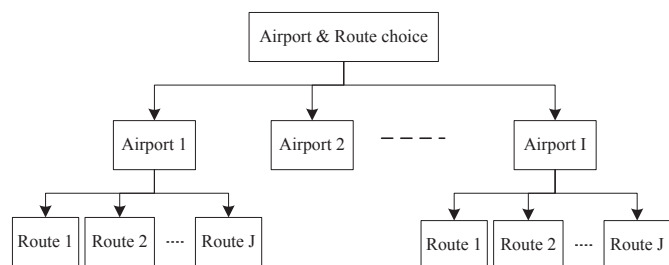
possible specifications of the NL structure, for example, the structure nested by destination airport or airport capacity, follow the same formulation as above.

The NL model is frequently used to model the joint choice behavior of travelers for airport, airline, flight and access mode. We assume a situation when a traveler decides to fly to a specific destination and chooses an airport ($i = 1,2,...,I$) and flight route ($j = 1,2,...J$) simultaneously to maximize their indirect utility. The probable joint choice model (P_{ji}) can be represented as the product of the conditional probability of route choice ($P_{j|i}$) and marginal probability of airport choice (P_i). Hence, the probability of traveler t choosing flight route j and airport i jointly can be expressed as follows:

$$P_{ji} = P_{j/i} \times P_i, \tag{1}$$

$$\text{where} \begin{cases} P_{j/i} = \dfrac{\exp((\alpha_j + \beta_f \cdot X_j)/\mu_i)}{\sum\limits_{j'} \exp((\alpha_{j'} + \beta_f \cdot X_{j'})/\mu_i)} \\[2ex] P_i = \dfrac{\exp(\alpha_i + \beta_a \cdot Y_i + IV_i)}{\sum\limits_{i'} \exp(\alpha_{i'} + \beta_a \cdot Y_{i'} + IV_{i'})} \\[2ex] IV_i = \mu_i \sum\limits_{j'} \exp((\alpha_{j'} + \beta_f \cdot X_{j'}) \end{cases}$$

X_j is the vector for the attributes of flight route j and is specified on the lower-level flight utility, such as air fare, flight time, frequency or departure time; Y_i is the vector for the attributes of airport i and is specified on the upper-level airport utility, such as airport capacity, punctuality, check-in time or access factors; β_f and β_a are the corresponding parameters for vectors X_j and Y_i, respectively; α_j is a route-specific constant; α_i is an airport-specific constant; IV_i is the inclusive value (IV) of the airport nest i; and μ_i is an inclusive value parameter. The NL model is consistent with the theory of utility maximization if $0 < \mu_i < 1$ is statistically significant. Otherwise, the nested choice structure for airport and route choice will reduce to the MNL model with the independence of irrelevant alternatives (IIA) property.

By applying the concept of a competitive map (Cooper, 1988) and analyzing the competitive relationship among flight routes, we can help aviation operators develop appropriate strategies. The two indexes of competitive maps, clout (the impact on other alternatives) and vulnerability (the impact of other alternatives), are defined as follows (Kamakura and Russell, 1989):

$$\text{clout}_j = \sum_{k \neq j} \eta_{kj}^2; \tag{2}$$

$$\text{vulnerability}_j = \sum_{k \neq j} \eta_{jk}^2; \tag{3}$$

where η_{kj} denotes the cross elasticity of the probable route k selected with respect to the attribute of route j. To interpret the implications of the two competitive map indexes, we first apply a two-dimensional strategy map (Yang et al., 2014) to identify the activeness/passiveness of specific operating strategies. We interpret the strategy map and give its complete explanation and empirical results in the fourth section.

3. Data

Our empirical data focus on the direct flight from Taiwan to Shanghai, since this was the first flight route opened in 2008 among

Fig. 1. Structure of model nested by departure airport.