A new approach to identify the target market of new gateway airports

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Abstract. Benefiting from the Belt and Road initiative, China experiences the flourishing cross-border trading and tourism. Meanwhile, explosive air transport demand arises in Chinese Bay Area as its strategic position on the Belt and Road. As an important infrastructure in Chinese Bay Area, Hong Kong-Zhuhai-Macao Bridge has connected Zhuhai airport and Hong Kong airport. As a result, we firstly propose a new international transfer mode called “air-bus-air”. In order to identify the target market of “air-bus-air”, a path choice model is established integrating multinomial logit model and latent class model and validated by path choice data. Test results indicate that a latent class model with three segments performs best and this method is effective in improving the accuracy of market segmentation.

1. Introduction

Mega-transport-projects usually create convenient linkages to surrounding airports. For example, in Chinese bay area, Hong Kong-Zhuhai-Macao Bridge has connected Zhuhai and Hong Kong directly, which can shorten the time from Zhuhai airport to Hong Kong international airport significantly. Based on above geographical advantages, Zhuhai airport has operated shuttle bus to Hong Kong international airport, thus providing the opportunity to link its domestic air routes with abundant international flights of Hong Kong airport. Besides, Zhuhai airport may attract more domestic passengers with the support of international air routes resources of Hong Kong airport.

To be specific, passengers can take domestic flights to Zhuhai airport and then transfer to outbound flights at Hong Kong airport by Hong Kong-Zhuhai-Macao Bridge shuttle bus. As shown in figure 1, this international transfer mode can be summarized as “air-bus-air” path, which will make Zhuhai airport a new gateway airport indirectly. It is cheaper than direct flights to Hong Kong because of free taxes. In addition, due to the incomparable sight of Hong Kong-Zhuhai-Macao Bridge, this path may attract passengers who are curious about new things. However, transferring more than once may increase inconvenience for passengers. Therefore, it is reasonable to believe that passengers who prefer this new transfer path differ from those who prefer the traditional “air-air” transfer mode. In other words, existing market segmentation methods are difficult to identify target passengers of the new gateway airport, which may lead to mistakes in airport operation strategies.
Existing market segmentation approaches are represented by cluster analysis such as fuzzy clustering, dynamic clustering and K-means clustering. Besides, latent class model is gradually popular in market segmentation as it can capture segments sizes and segment membership of passengers[1]. Seelhorst and Liu confirmed that latent class model performed well in studying air travel choices[2]. Therefore, this paper aims to establish an integrated path choice model to identity market segments of Zhuhai airport. To validate the model, we design RP and SP survey to obtain passengers’ attitudes toward path attributes. Based on the characteristics of segments, Zhuhai airport can adopt effective strategies to expand the potential market.

2. Literature review
Market segmentation aims to understand the demand diversity of passengers and form the basis of revenue management. Segmentation approaches normally include two types: prior segmentation and post hoc segmentation[3]. The former method needs to pre-determine variables and the number of classes. For example, passengers are usually divided into business and leisure according to the travel purpose in the air transport market. The latter is a statistical classification method represented by cluster analysis. For example, Punel & Ermaguna studied segmentation in airline industry using network clustering[4]. Recently, latent class model is widely used in segmentation researches about travel behavior. Teichert et al. applied latent class model into the segmentation of airlines choice incorporating socioeconomic and airlines characteristics[5]. Chu studied the choices of carriers and routes and pointed out that latent class model was good at exploring individual preference[6].

For the purpose of quantifying the influence of attributes on the path choice, logistic regression is introduced into the latent model to estimate the parameters of variables. At present, latent class regression models are mostly applied in medical and psychological fields but little in transportation. For example, Wong and Maffini used the latent class regression model to study the factors of suicidal tendencies among Asian American teenagers[7].

Present studies explore passengers’ travel behavior from multiple perspectives such as airline choice, airport choice and airport access mode choice[8-9]. It has been confirmed that air passengers’ travel choices are not only affected by socio-demographic characteristics but also attributes of alternatives such as travel time, flight fare and flight frequency[10]. In order to improve the accuracy of market segmentation, we use the latent class regression model incorporating social-demographic characteristics and attributes of new gateway services. According to estimated results, relevant suggestions are proposed to provide reference for airport managers.

3. Modelling approach
The path choice result of passenger $i$ is $y_i$ and the level of the $jth (j=1,\ldots,J)$ attribute in the path is $x_{ij}$. The class probability of the $kth (k=1,\ldots,K)$ latent class is denoted as $\pi_k$ and the sum of all latent class probabilities is 1. $y_i$ and $x_{ij}$ represent the dependent variable and independent variable respectively. The regression model is as shown in equation (1).

$$y_i = \beta_k + x_i \theta_k + \epsilon_k$$

(1)

$\beta_k$ stands for the intercept; $x_i$ is a vector of selected attributes, $x_i=(x_{i1},\ldots,x_{iJ})$; $\theta_k$ is a vector of parameters; $\epsilon_k$ is an error variance following normal distribution.

The density function and the conditional density function of $y_i$ are denoted as $h_i$ and $f$ respectively.
Latent class regression model can be expressed in equation (2) and the log likelihood function is as shown in equation (3).

\[ h_i = \sum_{k=1}^{K} \pi_k f(y_i | x_i, \theta_k) \]  

(2)

\[ LL = \sum_{i=1}^{n} \ln \left( \sum_{k=1}^{K} \pi_k f(y_i | x_i, \theta_k) \right) \]  

(3)

In order to prevent model over-fitting, the fitness of latent class model is tested by \( AIC \) and \( BIC \), which are shown in equations (4) and (5).

\[ AIC = -2LL + 2K \]  

(4)

\[ BIC = -2LL + (\ln(N))K \]  

(5)

\( LL \) is the maximum value of the log-likelihood, \( K \) is the number of parameters in the proposed model, and \( N \) is the sample size. \( AIC \) and \( BIC \) are used to balance the model fitness and the number of parameters. Because \( BIC \) has a greater punishment on coefficients volume, it is generally considered to be more suitable for determining the fitness of the latent class model than \( AIC \) and \( LL \).

4. Survey design and data collection

This survey contains two parts. RP survey is used to collect the social-demographic information including gender, age and education. It also asks respondents about their air travel frequency, transfer times they can accept in one trip and whether or not knowing the Hong Kong-Zhuhai-Macao Bridge.

The second part is SP survey. In this experiment, respondents need to choose a satisfactory travel path from the domestic city to Hong Kong airport. Alternative paths include direct flights, transfer at Zhuhai airport and transfer at Shenzhen airport. According to existing literatures and research background, variables influencing the path choice and corresponding levels are listed in Table 1.

| Variables                                      | Values                      |
|------------------------------------------------|-----------------------------|
| Flight departure time (dpt)                    | 6:00-9:00; 11:00-14:00;     |
|                                                | 16:00-19:00; 21:00-24:00    |
| Air ticket price to Hong Kong airport (prdr), unit: RMB | 1300; 1700; 2100; 2500      |
| Air ticket price to transfer airport (prtsf), unit: RMB | 300; 600; 900; 1200         |
| Luggage delivery service (lgg)                 | Straight up; take by self   |
| Transfer time permitted between two flights (trt), unit: hour | 4; 4.5; 5; 5.5               |
| In-bus time (bust), unit: hour                 | 1.5; 1.8; 2.2; 2.5          |
| Frequency of shuttle bus (budf), unit: times per hour | 3; 4; 6; 12                 |
| Transfer fees (bpr), unit: RMB                 | 100; 250; 500; 1200         |
| Features of transfer path (bsc)                | with Hong Kong-Zhuhai-Macao Bridge; normal road |

Direct flights to Hong Kong are more expensive due to taxes so two fare variables are set for direct flights and flights to transfer airports respectively. Considering that sufficient time should be reserved in the transfer process, the “permitted transfer time” is set to indicate the connecting time between domestic flights and international flights. In addition, we also observe passengers’ attitude towards “luggage delivery service” because of inconvenient transfer.

The survey was conducted at airports and online. The response rate is 85.7%. A total of 994 valid questionnaires were collected, including 3976 selection data. The proportion of women and men in the sample was 45.9% and 54.1% respectively. 72.54% of respondents have air travel experience in the past year, 82.39% of respondents can accept 2–3 times transfer during one trip, and 74.64% of respondents know the Hong Kong-Zhuhai-Macao Bridge, which ensure the reliability of the survey data.
5. Estimation Results
The model is estimated on R platform. In order to obtain an ideal latent class regression model, we have tested four latent class models by gradually increasing the number of segments. The results of different latent class models are shown in Table 2.

| Number of segments | Parameters | LL     | AIC    | BIC    |
|--------------------|------------|--------|--------|--------|
| 1                  | 9          | -7626.50 | 15274.99 | 15356.25 |
| 2                  | 19         | -6427.47 | 12900.94 | 13070.83 |
| 3                  | 29         | -6257.99 | 12585.98 | 12844.51 |
| 4                  | 39         | -6222.45 | 12538.89 | 12886.06 |

In Table 2, AIC and BIC keep decreasing with the number of segments increasing from 1 to 3. When the number of segments increases to 4, BIC begins to increase. Meanwhile, although the AIC decreases slightly, the significant increasing in the number of parameters will increase the difficulty of estimation. Therefore, the model with three segments is ideal for analysis. Estimation results are shown in Table 3.

|                          | segment 1 | segment 2 | segment 3 |
|--------------------------|-----------|-----------|-----------|
| Constant                 | 1.250***  | 1.553***  | 1.810***  |
| dpt                      | 0.001     | -0.022**  | -0.002    |
| prdr                     | -0.046*** | -0.064    | -0.014*** |
| prtsf                    | -0.013*** | -0.027*** | -0.034*** |
| lgg                      | -0.057*** | -0.062**  | -0.111*** |
| trt                      | -0.001    | -0.022*   | -0.037*** |
| bust                     | -0.009    | -0.013    | -0.037*** |
| budf                     | -0.011    | -0.011    | -0.034*** |
| bpr                      | -0.037*** | -0.050*** | -0.037*** |
| bsc                      | 0.211***  | 0.072**   | -0.110*** |

In Table 3, three segments account for 63%, 29% and 8% of the sample respectively. Significant differences in terms of air ticket price, luggage delivery service, permitted transfer time and transfer path indicate that these variables are major factors affecting path choice.

Segment 1 (passengers with high curiosity): they have the strongest positive attitude to the transfer path (bsc) than those of segment 2 and 3. Therefore, it can be inferred that these passengers are curious about the new transfer path. Although coefficients of ticket prices (prdr, prtsf, bpr), time (trt, bust) and the luggage delivery service (lgg) are negative, the strong attraction of the Hong Kong-Zhuhai-Macao Bridge may relieve the inconvenience of transfer. These passengers are early adopters of the new gateway service provided by Zhuhai airport.

Segment 2 (passengers with high price-sensitivity): the coefficient of direct flight price (prdr) indicates that these passengers prefer cheaper tickets. Meanwhile, they show stronger negative attitude to the ticket price (prtsf, bpr) than those of segment 1 and 3. Therefore, these passengers are probably attracted by lower travel cost. In addition, they also focus on luggage delivery service (lgg) and flight departure time (dpt).

Segment 3 (passengers prefer direct flights): these passengers can accept more expensive direct flights (prdr) but show negative attitude to attributes related to the transfer (lgg, bust, budf, bpr, bsc), especially permitted transfer time (trt). It can be referred that these passengers focus on travel time and prefer direct flights. Therefore, this segment is not the target market of new gateway airport service.

According to above analysis, it can be found that passengers with high curiosity or price-sensitivity are the target market of the new gateway airport service at Zhuhai airport. The following operation
strategies are proposed for Zhuhai airport to attract different types of passengers:

1) To focus on developing tourism products about the Hong Kong-Zhuhai-Macao Bridge on the transfer path. Thus promoting the new gateway airport service at Zhuhai airport.

2) To cooperate with airlines actively and adjust domestic flight schedules. Thus ensuring appropriate time between domestic and international flights. Meanwhile, it is better to provide passengers with convenient luggage delivery service and cheap air tickets.

3) To cooperate with shuttle bus companies, so as to obtain lower bus fares and appropriate bus frequency.

6. Conclusion

In the context of the opening of the Hong Kong-Zhuhai-Macao Bridge, surrounding airports are connected as Zhuhai airport has operated shuttle bus to provide new gateway service for domestic passengers through “air-bus-air” path. In order to explore the target passengers of the new gateway service, this paper developed a latent class model integrating logistic regression. The data used to test these models were obtained from the RP and SP survey and empirical results indicated that the three-segment latent class model was optimal. Three segments account for 63%, 29% and 8% respectively. According to segment-specific preferences, passengers who are curious about the new transfer path and sensitive to ticket price can be the target market of new gateway airport service. Therefore, sightseeing of the Hong Kong-Zhuhai-Macao Bridge and cheaper ticket price are important selling points in attracting passengers to “air-bus-air” path.

Future research could apply discrete choice model into latent class model to explore more general latent class structure modelling path choice.

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