Study on Methods of Determining an Airport's Catchment Area

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ABSTRACT: The article will outline a method of determining an airport's catchment area on the basis of passengers' airport choice behavior. In our opinion, the most important factor influencing a passengers' airport choice is the total trip cost taking into account the time cost. The article will clarify the concept of the total trip cost taking into account the time cost and provide a method to determine this factor. Determining the exact total trip cost taking into account the time cost is the basis for determining the airport's catchment area and this is also the main content of the method described in this article. This method will be applied to determine the catchment area of Noi Bai International Airport.

KEYWORDS: Airport's catchment area, airport choice model, competition from neighboring airports, time of trip, total trip cost.

1. INTRODUCTION

In fact, there are many experimental as well as theoretical studies on the factors influencing passengers' airport choice. However, there are not many studies on determining which be an attractive object for a certain airport, that is, there are not many studies on determining the airport's catchment area.

The airport's catchment area is a geographic area around the airport where it can reasonably expect to draw commercial air service customers. The airport customers are those who want to use the airport to make their trips and can afford to pay for their trips. It should be noted that the customers' affordability should be taken into account in the future, not just at the present time.

The airport's catchment area is still determined on the basis of travel time from the departure point to the airport. Accordingly, the airport's catchment area is an area around the airport, in which travel time from the farthest point to the airport is approximately 2 hours. This method is very simple and easy to apply. However, the biggest disadvantage of this method is that it ignores the factors influencing the passengers' airport choice behavior. According to this method, the size of the airport's catchment area is always fixed. However, when a certain factor influencing the passengers' airport choice behavior changes, the size of the airport's catchment area will change.

In order to overcome such shortcomings, the article will introduce a method of determining the airport's catchment area on the basis of the passengers' airport choice behavior. This method shows that the size of the airport's catchment area will change when there is a change in a factor influencing the passengers' airport choice behavior.

Contents of this article are divided into five sections. After the introduction, the 2nd section will introduce some literature related to determining the size of an airport's catchment area in the world. The 3rd section will be about the method of determining the airport's catchment area from our point of view, the 4th section will present the results of applying our method at Noi Bai International Airport and the last section will point out some comments on the above method.

2. LITERATURE REVIEW OF DETERMINING THE AIRPORT'S CATCHMENT AREA

There is extensive literature concerning passengers' travel mode choice behavior for their trips. Most of the published literature used the logit model to determine the market shares of different travel modes (Kroes et al., 2005). However, there is no literature that suggests a method to determine the airport's catchment area, only a little literature mentions the need to determine the size of the airport's catchment area and there is some literature that just implies that we should pay attention to determine the catchment area of a given airport.

Most of the literature addressing the airport choice showed that the factors influencing the airport choice decision-making include: airport access time, flight frequency and airfare (Ashford and Bencheman, 1987; Bradley, 1998; Humphreys and Francis, 2002; Lian and Ronnevik, 2011; Pels et al., 2001, etc.). However, the roles of these three factors in passengers' decision-making are very different in different studies.

The literature shows that business trips are often very sensitive to airport access time and flight frequency. Meanwhile, other purpose trips are very sensitive to the airfare (Harvey, 1987; Pels et al., 2003; Hess and Polak, 2005; Loo, 2008; Zhang and Xia, 2005). Hence, business

trips tend to give priority to the use of airports with shorter access time and higher flight frequencies. In addition, a lot of passengers with business trips are willing to choose longer flights to reduce travel costs and it has been shown clearly in studies of Franke (2004), Mason (2000) and Pantazis and Liefner (2006). Trips with other purposes, the airport access time and flight frequency are less important. Therefore, low-cost airlines will attract customers in a larger area than traditional airlines (Gillen and Lall, 2004; Geifenstein and Weib, 2003). This means that airports with low-cost airlines can expand their catchment area (Lian and Ronnevik, 2011).

In fact, there have been some studies on passengers' behavior. They have also discovered the factors influencing the passengers' airport choice but they only stop at the passengers' behavior not to determine the airport's catchment area.

3. METHODOLOGY FOR DETERMINING THE AIRPORT'S CATCHMENT AREA.

3.1. Concept

Intrinsic factors influencing passengers' behavior are the ones mentioned in our method. These factors include the airport access time, flight frequency at the studied airport and airfare. It should be noted that when the frequency at a certain airport increases to a certain extent, the above factors may interfere and interact with each other. In addition, customers are willing to accept longer airport access time for higher quality airline products. This effect has a stronger impact on non-business trips.

In this article, the airport's catchment area will be determined on the basis of a number of principles as follows:

- Focusing on competition among airports in the region, in the area and in the country.
- The factor influencing the passengers' airport choice is the total cost of their trip.

3.2. Method of determining the airport's catchment area

The method of determining the airport's catchment area for cargo and passengers is the same. This article only focuses on determining the airport's catchment area for passengers.

To determine the size of the airport's catchment area, we can use one of the following four criteria:

1. The total trip length
2. The total trip time
3. The actual total trip cost
4. The total trip cost taking into time cost.

Although the 4th criterion is very difficult and complex in data collection and computation and investment in new construction, even just upgrading an airport, is very costly and affects socio-economic development of the region, the area, even the whole country, careful calculation is an almost mandatory requirement. Therefore, we will choose the 4th criterion to be the basis for our method.

To calculate the 4th criterion, we need to do the following two tasks first:

- **Dividing passengers into 2 categories based on trip purpose (business and other)**
- **Basing on the nature of trips, they are divided into 2 categories.**

1) Trips which can only be made by air travel mode. In this case, determining the size of the airport's catchment area is only based on the competition among airports. These trips are international trips with long or very long distances, or are domestic trips but to regions with very specific geographical locations or terrain conditions with complicated difficulties. These trips are called non-substitution trips.

2) Trips which are made by different travel modes. These are trips to regions of the country or international trips but usually to points relatively close together. In this case, when determining the airport's catchment area of an airport, in addition to considering the competition of that airport with neighboring airports, there must also be consideration of competition between the air travel mode with the others. They are called substitution trips.

In general, the airport's catchment area size is calculated by the following steps:

- Step 1: Identifying all possible destinations of all flights departing from the studied airport.
- Step 2: Classifying passengers in the entire studied region according to the trip purpose.
- Step 3: Calculating the airport's catchment area size based on type of passenger.
- Step 4: Comparing the total trip cost of the passenger to determine the studied airport's catchment area size.
- Step 5: Making a conclusion and putting into practice.

These are the overall steps and they will be adjusted accordingly when applied in practice.

3.3. Determining the airport's catchment area for non-substitution trips

Determining the airport's catchment area for non-substitution trips is also carried out according to the procedure described above.

After step 1 and step 2, we will calculate the total trip cost for each type of passenger in the step 3. It should be noted that the total trip cost for a passenger from departure point to the end point is the total actual cost he/she must pay for the entire itinerary plus his/her time value.

We call: TP: A collection of all types of passengers in the studied region

ST: A collection of vehicles that the passengers may use

NR: A collection of subzones in the studied region

AP: A collection of airports that the passengers can use

We determine the direct cost of a certain passenger as:

$$cd: TP \times ST \times NR \times AP \rightarrow \mathbb{R}_+ \quad (1)$$

Where: $cd(p,s,r,a)$ is the direct cost (airfare) paid by the p-type passenger in the subzone r and paid for using the vehicle s to travel to the airport a during his/her trip.

Similarly, we determine the passenger's indirect cost (parking costs, etc.) by the function:

$$ci: TP \times ST \times NR \times AP \rightarrow \mathbb{R}_+ \quad (2)$$

Total cost of any passenger is determined as follows:

$$cj: TP \times ST \times NR \times AP \rightarrow \mathbb{R}_+ \quad (3)$$

Where: $cj(p,s,r,a)$ is the total cost of the p-type passenger when he/she comes from region r and uses the vehicle s to travel to the airport a during his/her trip.

Next, we determine the passenger's time cost.

The time value of p-type passenger in subzone r is calculated by the following function:

$$w: TP \times NR \rightarrow \mathbb{R}_+ \quad (4)$$

The function that determines the amount of direct time a passenger has lost while using vehicle s is:

$$td: ST \times NR \times AP \rightarrow \mathbb{R}_+ \quad (5)$$

Where: $td(s,r,a)$ is the amount of time that a p-type passenger spent at subzone r when he/she used vehicle s to travel to the airport during his/her trip.

Similarly, the function that determines the amount of indirect time (e.g. arrival time to the waiting point, time for waiting vehicle, etc.) of the above passenger is:

$$ti: ST \times NR \times AP \rightarrow \mathbb{R}_+ \quad (6)$$

Finally, the function to determine total cost $tc(p,r,$ which a p-type passenger at subzone r spent to use different vehicles s to travel to the airport a and from the airport a, he/she uses air travel mode for his/her trip as follows:

$$tc: TP \times NR \times AP \rightarrow \mathbb{R}_+ \quad (7)$$

This value can be determined by the formula:

$$tc(p,r,a) = \sum_{s=1}^{st}(cd(p,s,r,a) + ci(p,s,r,a)) + w(p,r) \cdot \sum_{s=1}^{st}(td(s,r,a) + ti(s,r,a)) \quad (12)$$

If the p-type passenger in subzone r uses the vehicle s to travel to the airport a or the airport b, then we have $tc(p,r,a) > tc(p,r,b)$, this indicates that this passenger will be in the catchment area of the airport b and vice versa. In case of $tc(p,r,a) \cong tc(p,r,b)$, this means that this passenger lies on the boundary line between the two catchment areas of the airport a and airport b.

4. DETERMINING CATCHMENT AREA OF NOI BAI INTERNATIONAL AIRPORT (PASSENGER TRANSPORT)

4.1. Airport system in Vietnam

Population of Vietnam as of December 2019 was 96.2 million people. Vietnam ranks the 15th among the world's most populated countries. The gross domestic product (GDP) per capita is constantly increasing. According to the World Bank, the GDP per capita of Vietnamese people in 1990 was only 295 USD, by 2015 this figure was 2162 USD and by 2019 it was 2715 USD. Moreover, foreign direct investment (FDI) is on the rise (FDI in Vietnam is 20 billion USD in 2019 and this is a record number). The above figures are really worth for aviation managers and it will greatly affect the future aviation demand in Vietnam.

Vietnam currently has 22 airports, including 11 international airports. Over the past six years, the total designed capacity of the entire Vietnamese airport system has doubled, for example, the capacity of Tan Son Nhat Airport has increased from 18 million passengers per year to 28 million passengers per year, Noi Bai Airport has increased from 6 million to 25 million passengers per year. However, the above figure is still not enough compared to the actual needs of the industry.

4.2. Determining catchment area of Noi Bai International Airport for international trips

As mentioned above, Vietnam currently has 11 international airports namely Noi Bai, Cat Bi, Van Don, Vinh, Da Nang, Chu Lai, Cam Ranh, Phu Bai, Tan Son Nhat, Phu Quoc and Can Tho.

To determine the catchment area of Noi Bai Airport for international trips, we will use the formula presented in section 3.3. We will calculate the total trip cost for each type of passenger at each departure point to a certain destination. It should be noted that the calculation will be done according to the following principles:

- The study and calculation are carried out throughout the territory of Vietnam. We divide the studied region into 63 subzones corresponding to 63 provinces in Vietnam.
- The movement within a subzone as well as from subzones to the airport is by road.
- The movement from the last airport to the destination is the same so we ignore this cost part.
- Airfares from Vietnam to Europe, Australia, America as well as to Asian countries are determined as the average fares to these regions.
- Passengers are divided into 3 categories: tourists, business travelers and VIPs. According to a report by Long Thanh International Airport Project in 2014, the time value of passengers traveling for business purposes and VIPs is 1.52 and 3.04 times higher than that of tourists.
- The airports including Cat Bi, Van Don, Vinh, Phu Bai, Chu Lai, Can Tho and Phu Quoc are international airports. However, some of them only have a very small number of international destinations and some of them have no international flights so the competition with Noi Bai airport is very low. In this article, we ignored the competition from the above airports. The competition only takes place among Noi Bai, Da Nang, Cam Ranh and Tan Son Nhat airports. (Long Thanh Airport should be considered in later case study).
- The total trip costs of passengers in subzones to different destinations were calculated by Excel application. After comparing the results, we found that the catchment area of Noi Bai International Airport for non-substitution trips is from Quang Tri to the Northern provinces.

5. CONCLUSION

So far, the airport's catchment area is often determined by drawing a circle around the airport area. The radius of this circle is determined on the assumption that the maximum passenger time to reach the airport is about 2 hours. This theory can fix the catchment area size ignoring the intrinsic factors that influence the passengers' airport choice behavior.

The method we introduce in this article takes into account the intrinsic factors that influence the passengers' airport choice behavior. Since then, we can make a report showing the change of the airport's catchment area size when there is a change in a certain influencing factor. In particular, the method emphasizes that there is a difference

between the motivation of the trip as well as the destination of the passenger in choosing the airport for his/her trip. In addition, the above method allows to estimate the impact of change in airport infrastructure or service quality on the airport's catchment area.

Thus, the above method allows managers and strategists to have an overview of the spatial characteristics of the airport's catchment area. After studying the results, those who are interested in this issue will further understand the reason for the passengers' airport choice and they will see the actual competitive strength of the airport. Through the application of the methodology and review of results, those who are interested in this issue have also identified areas where the market share of the studied airport is low and its causes. Results obtained from this method will become a tool to evaluate the change in the catchment area resulting from the change in airport service quality. Airlines may use the information obtained from this study in their marketing activities. For authorities, this study is also very useful. Through analyzing its results, local managers not only know the competitive position of the airport but also evaluate the effectiveness of investment in infrastructure.

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