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Airport classification criteria based on passenger characteristics and terminal size

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A B S T R A C T

This paper introduces classification criteria for airports that focus on the comparability of passenger terminal facilities. The variables used to define the criteria include terminal size in terms of number of gates, passenger characteristics in terms of international/domestic passenger volumes and transfer passenger volume. The study utilizes passenger data collected from the T-100 and airport origin/destination-survey databases of the US Bureau of Transportation Statistics. Cluster analysis is used as the technique to identify similar airport groups using passenger volumes as multiple variables. Finally, a set of criteria is defined, to differentiate airports based on the variables used.

1. Introduction

The motivation to classify airport terminal systems is mainly due to its relevance for passenger terminal service quality evaluation, standard setting and performance benchmarking. There is a growing body of literature on the evaluation of terminal service quality performance. A major barrier faced when attempting to apply these measures over a large number of airports is the difficulty in collecting comparable data and defining standard performance criteria applicable to all airports. Evaluating individual scenarios can be extremely difficult when considering a large heterogeneous mix of airports in the world or a particular region. This problem, however, can be simplified by classifying airports into more homogeneous groups.

Service quality benchmarking is another area that requires the ability to define comparable groups to develop more effective benchmarks. Institutions such as the International Air transport Association (IATA) and the Airport Council International (ACI) separately carry out their regular airport service quality surveys (IATA's Global Airport Monitor and ACI Airport service quality benchmarking) and rank them based on a set of performance indicators (Airport Council International, 2004, 2011). However, there is no standard method of classification adopted when selecting airports for such surveys. This is a lapse in the evaluation process, which may lead to making unrealistic conclusions and recommendations. Furthermore the evaluations and recommendations can be made more useful if generalized based on a proper classification of airports.

We develop criteria to identify airport categories with comparable passenger terminal systems. Detailed data on characteristics defining a terminal, such as passenger facilities are extremely difficult to collect for a sample of airports large enough for analysis. Therefore, it is necessary to use a set of characteristic variables that accurately approximates the magnitude and configuration of terminal elements. Furthermore, data must be readily available so that they can be collected in a uniform format across a large number of airports.

2. Airport classification

Airports are classified in a number of ways based on a variety of criteria. The type of classification varies depending on the particular purpose for which the classification is made. The following list contains classifications and criteria:

1. Current operational capacity, in terms of annual passenger traffic (European Union, 2005; US Federal Aviation Administration, 2010)
2. Functional role (intercontinental hub, regional, leisure destinations) (Graham, 1998; Malighetti et al., 2009)
3. Geographical location (national or regional capital) (Transport Canada, 2010)
4. Airport competition (Air Transport Group, 2002).

Most classifications use a combination of region/location or annual enplane/deplane passenger volumes as variables for clustering. Total passenger volumes may relate to the overall magnitude of the airport, but it lacks relevance to the facilities and configuration of the passenger terminal system.

Cluster analysis has been used to examine airports in previous studies, Malighetti et al. (2009) For example, looked at 467

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European airports, to identify strategic groups by considering their position in the network. They classified each airport into clusters by employing traditional clustering tools and then into modules by employing the innovative simulated annealing methodology. Madas and Zografos (2008) used the technique on 52 European airports to define types of variables related to airport capacity with the objective of examining alternative slot allocation strategies that vary with the identified airport clusters.

Sarkis and Talluri (2004) used cluster analysis in benchmarking airports based on operational efficiency. Relative efficiency of airport operations was used as the basis for clustering variable with the method being hierarchical using average linkage. The best performing airports in each category were selected as potential benchmarks. Burghouwt and Hakfoort (2001) also looked at the European aviation network and clustered a broad sample of airports by average seat capacity, average number of destinations and average number of intercontinental destinations.

3. Methodology

Airports are clustered using basic variables such as the number of gates, annual volume of international passengers, annual volume of domestic transfer passengers and annual volume of domestic origin-destination passengers. It is not possible to break down international passengers further into origin/destination and transfers due to data not being available. The average percentage of international passengers at US airports is, however, 2%, making the effect from international transfers likely to be neglected.

The number of gates is to represent the overall capacity of the terminal system and three passenger types are used to define passengers served at the terminal; there is correlation, however, between number of gates and passenger types but they are both retained for classification because of the need to differentiate these characteristics. Therefore the cluster analysis is done in two steps separating number of gates and passenger types.

The K-means clustering technique is used here. The number of clusters and their initial centers for the K-means method are specified using an initial hierarchical classification based on Ward's method (Everitt et al., 2001). Passenger data for the analysis was obtained from the Bureau of Transportation Statistics (BTS) of the US Department of Transportation (US Research and Innovative Technology Administration, 2011). The annual domestic and international passengers, for all US airports with commercial passenger services were obtained from the BTS' T-100 Domestic Market (All Carriers) and T-100 International Market (All Carriers) data libraries, Domestic transfer passenger data for the same airports were computed from the data libraries of DB1B Coupon and DB1B Market.

Airports with an annual passenger volume of less than two hundred thousand were excluded from the analysis. These are very small airports that have none or very few transfer passengers and international passengers. Information on airport facilities, such as the number of gates and the horizontal arrangement of terminals, was collected using data posted on airport websites.

Past studies have identified the number of gates as a key factor in determining the facility size and configuration of passenger terminals (Bandara and Wirasinghe, 1992a, 1992b; de Barros and Wirasinghe, 2003; De Neufville et al., 2002; Hanaoka and Saraswati, 2011; Transportation Research Board, 2010). Airport terminal design guidelines identify proportions of passenger types as factors determining terminal configuration and facilities (Transportation Research Board, 2010). Studies by Wirasinghe et al. (1987) and De Neufville et al. (2002) on the optimal configuration of passenger terminal buildings show the presence of transfer passengers and higher transfer ratios affecting the choice of terminal configurations based on the distribution of passenger walking distances.

Data were collected on the number of gates, the number of terminals, and the terminal concepts at each airport. Then number of gates showed a strong association with terminal concepts, as expected. A cluster analysis can assist to divide the data set based on the greatest average differences between groups and least differences within a group. A cluster analysis was done using Ward's method, and the results suggested that the population can be divided into four clusters based on the number of gates. The resulting cluster centers were used in a k-means cluster analysis to optimize the membership. The resulting distributions of cluster membership are shown in Fig. 1.

Cluster boundaries and their respective membership are given in Table 1.

4. Classification using passenger data

The classification determined above differentiated terminal systems based on overall capacity. However, it is equally necessary to determine a classification based on the type of passengers served by the terminal system. Higher level terminal concept development and detailed facility requirements are closely related to whether a terminal system is serving predominantly domestic or international and origin/destination or transfer passengers (Transportation Research Board, 2010).

Cluster analysis can be performed using multiple variables to examine the average similarity of the entities under investigation. The variables selected for analysis are:

a. Annual domestic origin/destination passenger volume,
b. Annual domestic transfer passenger volume, and
c. Annual international passenger volume.

A scatter plot can be used to generate an initial visualization of clusters (Fig. 2).

Following the scatter plot, there is a large concentration of small airports with a dominant proportion of domestic origin/destination passengers. These airports have extremely low international and transfer traffic. The remaining airports failed to show tight clustering in terms of passenger volumes.

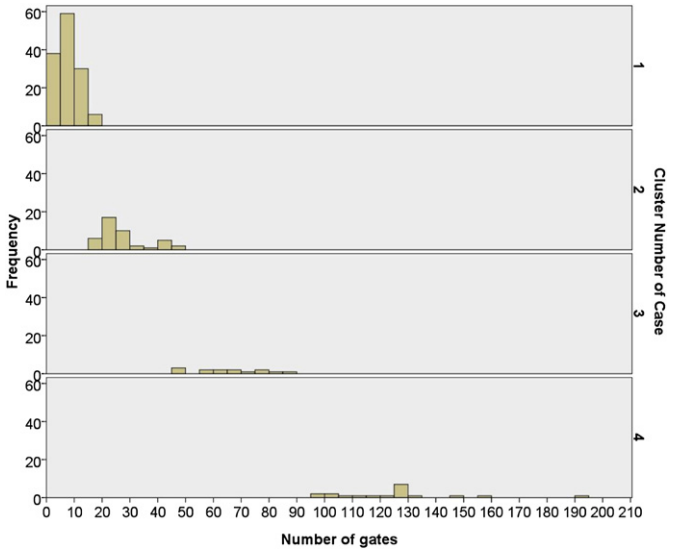

Fig. 1. Distribution of cluster membership – number of gates.