Chapter 6
Using the Continuum Equilibrium Approach to Solve Airport Competition Problems: Computational and Application Issues

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ABSTRACT
This chapter presents a computational method using the continuum equilibrium approach to solve airport competition problems. The mathematical formulation and solution algorithm are given. The Hong Kong-Pearl River Delta region is used as a case study to demonstrate the effectiveness of the approach in solving real-life large-scale airport competition problems. Behavioral choices of both international and domestic air travelers in the region are modeled. The results show the distinctive value of the continuum approach in understanding the spatial dynamics of air passenger flows in multi-airport regions.

INTRODUCTION
If one considers airports to be facilities providing services (rather than just intermediate stops), the delimitation of market areas of competitive airports becomes similar to the classical location problems of von Thunen’s isolated states, Christaller’s central place theory, and Hotelling’s traveling salesman or retail locations. Airports constitute part of the movement space of air passengers (Borgstrom, 1974), and airport services generate utility to air passengers. When airports are viewed as service points, air passenger turnover is the result of aggregated personal decisions to use those facilities. On the demand side,
the decision to choose a particular airport is no longer purely the (shortest) Euclidean distance between a passenger’s home (or the origin of the freight) and the departure airport, or the distance between the final destination and the arrival airport. On the supply side, airports are differentiated by facility attributes including a set of primary level-of-service (LOS) factors, which are related to the price and frequency of flights, and a set of secondary LOS factors, which are related to the quality of airports and airlines. Secondary LOS factors tend to dominate in a multi-airport context where differences among primary LOS factors and distances among airports are not great (Bradley, 1998; Rubin & Fagan, 1976). In a multi-airport region (MAR), the choice of an airport facility is no longer peripheral to an individual’s decision to travel, and services at different airports are differentiated products. Consequently, the delimitation of the market areas of airports becomes much more complicated than a simple case of nearest-center assignment (Bryan & O’Kelly, 1999). In the pioneer study of Ndoh et al. (1990), preference data were used to examine the choice of departing air travelers among four airports in central England: the East Midlands, Birmingham, Manchester and Liverpool airports. Specifically, Bradley (1998) found that the choice of air travelers among competitive departure airports in Europe was affected by at least twelve LOS factors. In light of these findings, there is a need to reconsider airport LOS attributes (rather than considering only an airport’s physical location in relation to demand) to reflect real airport choices.

Apart from MARs in Europe, there has been a growing interest in airport competition in the southern part of China. In 1979, only two international airports operated in the Hong Kong and Pearl River Delta region (hereafter, the HK-PRD region). After two decades, four international airports were operating in this 48,000-sq.-km. region (Loo, 1999). Before 1997, the Hong Kong International Airport operated and thrived under British colonial rule. On the one hand, it faced virtually no competition from airports across the border. On the other hand, few people and little freight from across the border passed through the airport facilities of the Hong Kong International Airport. Since 1997, the situation has gradually changed under the “one country, two systems” policy. The Hong Kong International Airport now faces competition from three other international airports in the region at Guangzhou, Shenzhen and Zhuhai. It is easy for Hong Kong people to use airport facilities in Mainland China and for Mainland Chinese people to use airport facilities in Hong Kong. Most importantly, the demand for air travel in a large part of the region has greatly expanded because of the rapid income growth. With these four international airports, the HK-PRD region represents an ideal case study for analyzing airport competition problems.

In the context of an MAR, traditional air traffic forecasting techniques based on national forecasts and local market shares are far from satisfactory because “it is unusual for airport service areas to overlap and even more unusual for an overlap to be considered in the forecasting process” (Rubin & Fagan, 1976, p. 1). Such forecasts are often made for single-airport regions with well-defined and fixed market areas. In reality, however, the simplified assumption of a single-airport region is unrealistic. The continuum equilibrium model offers an alternative in understanding air traffic distribution in MARs, where the market areas of airports are not well-defined and immutable. Taguchi and Iri (1982) were among the first to develop a promising numerical procedure to solve the problem of continuous transportation systems for a general city configuration. They used the finite element method (FEM) (Zienkiewicz & Taylor, 1989) to solve three continuum network problems: the maximum flow problem, shortest route problem and minimum-cost flow problem. For user equilibrium problems, a dual-based formulation was given by Sasaki et al. (1990), in which the user equilibrium problem in a continuous system was solved by minimizing an objective