1. Introduction

Deregulation of air transport industry significantly changed market conditions all over the world and permanently affected airline competition (Morrison and Winston, 1986; Burghouwt and Hakfoort, 2001). Since market forces did not affect airline service during the period of regulation, airline service was shaped by bilateral agreements negotiated between the countries involved. Nowadays, in most parts of the world air transport policy and regulation programs aim to provide that prices and capacities are set by market forces of supply and demand. However, sustainability of airline business models was questioned once the market became open and competition began to strengthen. Only those airlines that were able to react promptly and adjust to the emerging conditions had a chance to sustain profitably and retain their market position.

Through adequate network structure and pricing policy, airlines can gain higher profit and still increase/maintain their market share. Given the freedom to manage traffic and price more proactively, airlines are able to influence the demand by maximizing the value provided to consumers and to charge prices which are most rewarding in relation to its goals. This added value is reflected in better scheduled times, better connectivity, higher frequencies, higher probability of booking a seat on a flight, etc.

Network designing implies that an airline has to make decisions about markets that will be served and the routing policy between those markets. From passengers’ point of view, it would be ideal if the airline offers the nonstop services between any points that correspond to O & D demand matrix. In reality, many markets do not have sufficient demand to support nonstop service or high frequency nonstop service. Making these decisions means finding a good balance between serving different market segments and meeting economic interests of the airline. However, the impact of the competition should not be neglected either.

On the other hand, pricing policy denotes how an airline sets the price of its service regarding costs, demand, quality of service and different implications on their profitability. Integrating pricing policy into network strategy development enables airlines to set sustainable, profitable prices in the market or to discard services that cannot be produced cost-effectively. Achieving efficiency in operating costs is one of the most important requirements for air carriers in order to be competitive. It is noteworthy that almost all carriers significantly reduced their costs compared to the period twenty years ago (Oum and Yu, 1995; Tsoukalas et al., 2008). Strong competition from low cost carriers (LCCs) has forced traditional carriers to change their former way of business performance, or to withdraw from the market. However, achieving efficiency in operating costs does not mean that the carrier has the lowest operating costs, it is more important that the level of costs reflects the level of quality offered to passengers.

**Keywords:** Airline network structure, Competition, Product differentiation

**ARTICLE INFO**

**ABSTRACT**

This paper deals with modeling the selection of airline network structures for airlines operating in a competitive environment. In order to capture interactions between competing airlines when choosing the structure of their networks, the effects of product differentiation based on prices, flight frequencies, seat accessibility and route length have been considered. Competing airlines are supposed to be able to choose either point-to-point (PP) or hub-and-spoke (HS) network structure. Each choice is expected to have different implications on their profitability (i.e., costs and revenues) strongly influenced by different products offered to passengers. The main results indicate that there are direct benefits to users/passengers due to the simultaneous increase of flight frequencies and unchanging prices, which leads to the socially-optimal choices of prices and flight frequencies. In addition, modeling which includes route lengths opens new perspectives on coexistence between the two different business models. Integration of these parameters results in selecting an airline network structure model in a competitive environment which enables passengers to differentiate among the offered transport services.
This research aims at finding an appropriate choice for network structure that would enable an airline to position itself in the market and to offer a service required to sustain the chosen position. In this paper, we study whether and how price, frequency, load factor and route length affect optimal network structure chosen by airlines. In particular, we attempt to gain some insight about network structure equilibrium when an airline creates more value to its customers by increasing the service quality. Moreover, we analyze how inclusion of load factor and route length affects network efficiency. This paper is organized as follows. In Section 2 the background of this research is provided. In Section 3, three mathematical sub-models with formulations are proposed. The results obtained from the sub-models are then used in Section 4 to study the equilibrium in airline networks. Section 5 provides welfare analysis and network efficiency analysis. Finally, the outcomes and conclusions are summarized in Section 6.

2. Literature review

In the academic literature, one could find many research papers related to the network optimization problem in airline industry and solutions proposed could be divided into two groups: analytical models with economic approach and transportation models with heuristic approach in network designing. This paper belongs to the first group of publications, thus our focus will be only on those publications that deal with analytical models. Oum et al. (1995) analyze the effects of strategic interaction between deregulated airlines on their network choice and establish that demand-side network effects of HS network together with reduced costs make it a dominant strategy for airlines. Hendricks et al. (1995, 1999) provide a general approach by considering the social optimum. Moreover, we analyze how inclusion of load factor and route length affects network efficiency. This paper is organized as follows. In Section 2 the background of this research is provided. In Section 3, three mathematical sub-models with formulations are proposed. The results obtained from the sub-models are then used in Section 4 to study the equilibrium in airline networks. Section 5 provides welfare analysis and network efficiency analysis. Finally, the outcomes and conclusions are summarized in Section 6.

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