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A new hub and spoke system proposal: A case study for Turkey's aviation industry

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ABSTRACT

In this paper, we are proposing a multi-objective mathematical model for the selection of a newly constructed hub and spoke system. The objectives of this model are maximizing aircraft utilization and revenue whilst reducing the commercially infeasible network detour factor. The sensitivity analysis of the model is tackled using weights related to the objectives as well as the network detour factor. The number of available aircraft and the range that an aircraft can reach are also considered in this model. Since Istanbul has already got a hub and spoke system with busy airports on both sides of the city, the model is applied to three other major cities of Turkey, Ankara, Antalya, and Izmir. The test data consists of over 90 cities in Europe and in the Middle East. The data includes unit passenger revenues and operating costs for the segments, distances between cities and hubs, expected load factors and flying times of segments. The scenarios are tested under specific expectations of airline network experts and the results are visualized by using Pareto front graphs. Compared to other candidates, Antalya stands out as a good choice for a new hub and spoke system in Turkey. The results of this model could be helpful for airlines and other airports in Turkey in order to identify their potential and competitive position in relation to their counterparts.

1. Introduction

Turkish Airlines (THY) was the only carrier dominating domestic and international flights in Turkey until 2003. Then other carriers were allowed to enter the domestic airline market. At the same time, second and third public offerings of THY occurred. Thus, THY became 50.1% public and began to operate as a private airline company rather than a state-owned airline. Following this, THY started to launch new routes with more flexibility. Not only as a result of these internal positive factors, but also external factors such as the strong tourist appeal and robust economic growth of Turkey, THY has been experiencing substantial growth at Istanbul Ataturk Airport (CAPA, 2013). As shown in Fig. 1, international passenger numbers in Turkey grew at a compound average growth rate of 11.9% per annum from 2003 to 2013 and domestic passenger numbers at 23.3% per annum (General Directorate of State Airports Authority of Turkey (DHMI), 2014).

When the Ataturk Airport slot volume rose above its standard levels, a second runway was constructed to accommodate the huge growth and need for additional capacity. However, the second runway also became inadequate and, as of April 2013, Turkish Airlines moved some of its operations to the Anatolian side of Istanbul, to Sabiha Gokcen Airport (THY, 2013). According to the Official Airline Guide (OAG) data, Pegasus Airlines (PGS), which utilizes Sabiha Gokcen airport as its hub, was Europe's fastest growing airline in 2011 and 2012 (Pegasus, 2013). THY accounts for 76% of seats and 55% of movements offered from Istanbul Ataturk Airport whereas the seat ratio at Sabiha Gokcen Airport is 24% by THY and 67% by PGS and 9% by other carriers. Ataturk Airport served 56 million passengers at 2014. When investor presentations of THY are reviewed, growth rate targets for the following four years are 18%, 13%, 0% and 8% respectively (THY, 2014a). At a rough estimate, on the assumption that the overall load factor and distribution of seats will be maintained, Ataturk Airport will have to serve nearly 85 million passengers. TAV, the operator of the Ataturk Airport, is investing 136 Million USD on capacity improvements in 2015 to reach this growth target.

Management and regulation of Turkish airports and control of Turkish airspace are performed by DHMI which is a state-owned enterprise. These regulations include inviting tenders for

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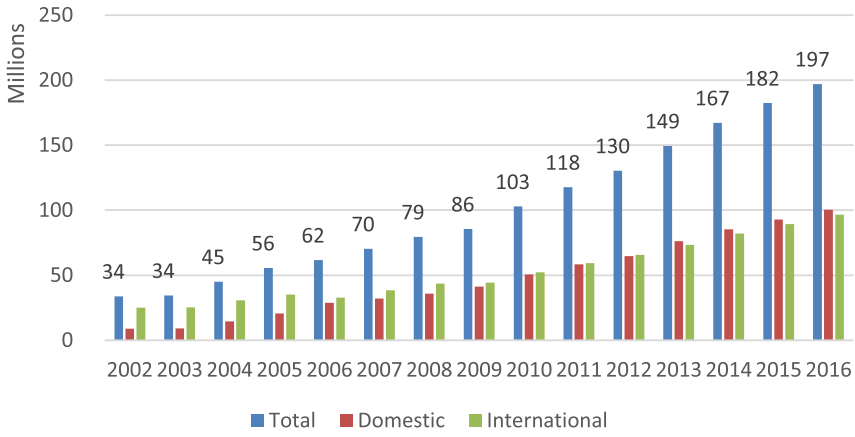

Fig. 1. 2002–2014 yearly airline passenger figures and 2015–2016 forecast for Turkey (DHMI, 2014).

construction of new terminals, runways, and airports. DHMI invited tenders for a third airport of Istanbul in May 2013. The project is being constructed using a Build-Operate-Transfer model and deal with secured EUR26.1 billion including value added tax. It will be located on the European Side of Istanbul near the Black Sea coast and expected to be completed in four phases. The first phase which is now under construction is planned to open in October 2017 with a 90 million passenger capacity which is close to the THY passenger targets. It will have six runways and a 150 million passenger capacity when phase four is completed. When scheduled services commence at this airport, Ataturk Airport will be closed to scheduled flights due to the conditions of the contract between the government and bidder who won the deal. Thus, it can be inferred that THY will be a dominant player at the third airport and capacity will be limited.

On the Anatolian Side of Istanbul, a second runway will be constructed at Sabiha Gokcen. However, the bidding process has not even started yet. Notwithstanding THY and PGS would like to dominate the capacity in order to keep market shares for the future growth of the capacity at Sabiha Gokcen (CAPA, 2014; THY, 2014b).

The main purpose of this study is to identify a new hub and spoke city and network model in Turkey other than that of Istanbul. The capacities of both Istanbul Ataturk and Sabiha Gokcen have nearly reached their limits in terms of aircraft movements, slots, parking areas and so on. The third airport is under construction to overcome the capacity shortage of Istanbul but when it opens as discussed Ataturk airport will be closed down. Passenger numbers are increasing every year, but the capacity of Istanbul airports is not growing to meet demand. However, other major cities in Turkey have room for growth, namely Ankara, Antalya, and Izmir. A new airline or existing airlines could have a competitive advantages by carrying both local and transfer passenger at a new hub built elsewhere.

The remainder of the paper is organized as follows: Section 2 introduces a brief literature review of the hub location problem, hub and spoke airline networks, and the detour factor. Section 3 then presents the multi-objective mathematical formulations of the problem. Section 4 provides the results of the application of the model for Turkey. In Section 5, the paper is concluded.

2. Literature survey

Several studies in the literature have focused on the problem of the discrete formulation of airline hub location. O'Kelly (1987) presented a single assignment model that minimizes the total network cost. A single assignment model is one where all flows in the network must move from their origin points to their destinations over at least one hub, and all nodes are assigned to a single hub. O'Kelly also came up with two heuristic models to solve the single assignment model. Campbell (1994) presented the first multiple assignment model. In a multiple assignment model, nodes can have flows over multiple hubs. Jaillet et al. (1996) proposed three different models based on the network strategy of the airline, namely the one-stop model, two-stop model and all-stop model. Moreover, other researchers have contributed to the literature with other heuristic models to solve this problem (Ernst and Krishnamoorthy, 1996; Klincewicz, 1991; Skorin-Kapov and Skorin-Kapov, 1994; Smith et al., 1996). Bryan and O'Kelly (1999) presented a literature review of the hub location problem and categorized hub location models into two classes, namely single assignment models and multiple assignment models.

Through a review of the hub location problem literature, it becomes clear that most of the studies adopt restricted models of the problem. They assume that each point in the network must be connected to at least one hub. However, there are several empirical studies that assess hub locations. Maertens et al. (2014) examined the potential for an international hub in Libya from both economic and geographic perspectives. Carlos Martın and Román (2003) analysed the new potential hubs in the South-Atlantic market for a future liberalization process. GDP per capita and population were found to be the most important factors for choosing a hub location in an earlier study by Bailey et al. (1985). Saberi and Mahmassani (2013) proposed continuous approximation models for single hub systems with one transfer. They concluded that the optimal location of a hub depends more on its geographical position than on the air travel demand to and from the hub.

Martın and Román (2004) reported that the factors which affect the network structure of an airline are as follows: number of hubs, potential traffic at the hub cities, location of the hub in order to minimize flying costs, good airport facilities, good weather facilities and strategy of competitors. Discussions of airline competition analysis and network strategies in a hub and spoke system can be found in Adler (2001), Hansen (1990) and Hong and Harker (1992).

Hub and spoke network systems have significant advantages for network carriers (Brueckner and Spiller, 1994; Caves et al., 1984). These include:

- consolidating passenger numbers and creating economies of density;
- decreasing the number of routes required to connect each pair of cities in a network;
- increasing the demand for frequent flights;