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Airline new route selection based on interval type-2 fuzzy MCDM: A case study of new route between Turkey- North American region destinations

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ABSTRACT

Conditions of global competition in the aviation sector force airlines to be internationally-minded instead of competing only in their domestic markets. Thus, airlines are interested in potential international markets instead of domestic markets. This study focuses on the process of new route selection, which has a high impact on the revenue and passenger numbers of airlines. An airline company in Turkey plans to launch a new route at an airport in the North American region. Any suboptimal decision has a huge effect on the outcomes of airlines in the market. Therefore, making an optimal decision, which is compatible with the airline company's goal, is highly important. In this study, a decision analysis is applied in terms of the selection of a new route from five different destinations by using an interval type-2 fuzzy TOPSIS method. A multi-criteria decision-making (MCDM) method is used in order to identify the aspects of the new route's feasibility. Finally, a real case study is shown to verify the proposed method and to demonstrate its practicality and feasibility. The results show that the MCDM approach is a useful tool for decision-makers in terms of selecting potential airports for route analysis.

1. Introduction

The sector of aviation has been on the rise, especially after the second half of the 1980s. During this period, it has been observed that some airline companies have started a modernization and standardization process in an effort to improve and elevate service standards. The emphasis has been on international flights, which are more economically advantageous than domestic ones. At the same time, a substantial increase in the number of airline companies, their fleet capacities, and their share in the market has been observed (DPT, 2001).

In Turkey today, air travel has drawn more attention than other modes of traveling. The aviation sector has experienced constant progress and change since the early years, when air travel started in earnest. Since 2003, the progress and change have gained momentum, and an increase in the number of private airline companies has been noted. In recent years, low-cost airlines have started to join the sector globally (THY, 2009). The aviation industry, which plays a key role in the development and competitiveness of countries, has developed around the world in parallel with economic growth, globalisation, and liberalization. Since 2002, world air traffic has increased by 49% in terms of revenue passenger miles. Turkey has been among the four fastest-growing countries in the world in terms of civil aviation for the last eight years (THY, 2011).

Managing and regulating Turkish airports and controlling Turkish airspace are carried out by DHMI, a state-owned enterprise operating under Ministry of Transport, Maritime Affairs and Communications. Inviting tenders for construction of new terminals, runways, and airports is among the regulations of this enterprise. DHMI invited tenders for the third airport of Istanbul in May 2013. It will be one of the greatest international airports in the world when the fourth and final phase is finished by 2028. It will be also one of the busiest airports in the world with six runways, flights to nearly 350 destinations and an eventual annual capacity of 200 million passengers. When first phase is completed in 2018, Istanbul's new airport will have the world's largest terminal under one roof, including a gross floor area of nearly 11 million square feet with the ability to serve 90 million passengers annually.

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Constructed on the Black Sea coast on the European side of Turkey, the airport will be 22 miles outside Istanbul. Istanbul's new airport will become Turkey's main airport and a hub for connecting flights between Europe and Asia (Çiftçi and Şevkli, 2015; http://www.dailymail.co.uk).

Hub and spoke network systems provide important benefits for network carriers (Brueckner and Spiller, 1994; Caves et al., 1984; Jaillet et al., 1996; Çiftçi and Şevkli, 2015). The following are some of these benefits: aggregation of passenger numbers and providing economies of density; minimizing the number of routes needed to connect cities in a network; increasing the demand for frequent flights; combining the activities of staff, maintenance, and operations; decreasing costs; and raising customer loyalty with airport domination.

The airline company subject to consideration in this paper also utilizes hub and spoke network systems. This company feeds its network with long routes. Besides, the company inaugurates the operation of either two or three new long routes each year (due to fleet expansion). While opening new routes, the effect of the new destinations in terms of passenger flow on current route network is also considered. For example, it is important to examine whether opening a new route to North American region also increases the passenger demand of other regions like South American, African or Asia Pacific regions.

Fuel expenses stand out as the most important and volatile cost item for airline companies. Apart from this, passenger costs (meal, inflight entertainment etc.), station costs, gate costs and parking costs are among the variable costs as the company realizes additional operations. Pilot and crew salaries, aircraft leasing costs can be regarded as the fixed costs. Finally, administrative costs that are not related with operations includ office rents, marketing and sales costs, distribution channel costs, managers and office personnel salaries comprise the indirect costs. By dividing the available seat kilometer with the total costs, cost per available seat kilometer can be found. Airline companies utilize new and productive fleet especially wide-body aircraft for inaugurating long-haul new destinations in order to minimize the effect of fixed and indirect costs and increase profitability.

Network development can be helpful in order to provide credible analysis of profitable new route opportunities for airline decision makers. For this reason, the airlines are looking for viable and profitable markets (http://www.aviationeconomics.com).

In recent years, new route analysis has become an important measure of success and it informs strategic decisions. However, this decision is usually complicated and is based on many considerations. Many qualitative and quantitative criteria need to be taken into account at the same time. Fuzzy multi-criteria decision-making methods have been developed as a solution to deal with these problems. These methods reflect a new aspect of the selection made by decision-makers and they evaluate numerous criteria simultaneously. The airline company examined in this study plans to incorporate three new wide-body aircraft into its fleet. With these new three aircraft, due to network structure, one far east and one westbound trip can be scheduled rotationally. For this reason, five alternative destinations from North American region are deemed available.

The objectives of this study are to: (1) Construct a methodology for destination selection problem for network carrier airlines (2) To identify a real life airline industry case (3) To provide a solution to this case by TOPSIS method, one of the multi-criteria decision-making methods, which has been integrated with the interval type-2 sets. During this process, five different airports have been evaluated according to eleven criteria by five decision-makers and have been sorted according to the calculated indices. This study shows that the interval type-2 fuzzy TOPSIS method can be utilized effectively in the decision-making process of new route analysis. Furthermore, a sensitivity analysis has been conducted by changing the priorities of the criteria for this model.

The rest of the paper is organized as the following. Section 2, provides an overview of the relevant work. Section 3, presents the basic steps of the interval-valued type-2 fuzzy and the proposed integrated method based on interval type-2 fuzzy TOPSIS. Section 4, presents a case study of new route selection between Turkey-North American region destinations. Section 5 discusses the results. Finally, Section 6 concludes this study.

2. Literature review

Multi Criteria Decision Making, is the process of making the best decision from a group of decisions involving more than one criterion and decision maker. In fact, MCDM is the process of decision maker's choosing between more than one alternative according to certain criteria (Mardani et al., 2015a, 2015b; 2015c; Deveci et al., 2015; Yavuz and Deveci, 2014; Demirel et al., 2016).

A vast number of very successful fuzzy MCDM have been applied to a variety of problems, like the selection of outsourcing providers in the airline industry (Liou and Chuang, 2010), strategic alliance partner selection (Liou et al., 2011; Liou, 2012; Prakash and Barua, 2015; Garg, 2016), third-party reverse logistics partner selection (Prakash and Barua, 2016a, 2016b), ranking of the airports (Prakash and Barua, 2016c), evaluating service quality of airlines (Chang and Yeh, 2002; Chen et al., 2011) and investigating an efficiency assessment of airlines (Barros and Wanke, 2015; Wanke et al., 2015).

In recent years, interval type-2 fuzzy sets together with multi criteria decision-making techniques have been applied on various kind of problems. Mendel et al. (2006) present a novel method that makes an interval type-2 fuzzy logic system much more accessible to all readers of this study. Wang et al. (2012) investigate multi-attribute group decision making models under interval type-2 fuzzy sets. Gong (2013) presents a fuzzy multi-attribute group decision making method based on ınterval type-2 fuzzy sets and applications to global supplier selection. And global supplier selection problem is given to illustrate the feasibility and effectiveness of the proposed method. Hu et al. (2013) proposes a new approach based on possibility degree to solve MCDM problems in which the criteria value takes the form of interval type-2 fuzzy number. This method is applied to a case study on the overseas minerals investment for one of the largest multi-species nonferrous metals companies in China and the results show the feasibility of the method. An overview of previous work on relevant MCDM studies is provided in Table 1.

3. Methodology

The proposed methodology consists of three basic stages: (1) Identification of the criteria, alternatives and linguistic variables to be used in the model (2) Analysis of method using these selected criteria, alternatives and linguistic variables (3) Ranking the alternatives using interval type-2 fuzzy TOPSIS. The schematic diagram of the proposed methodology for the selection of new route is shown in Fig. 1. The stages are as follows: