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Comparison of two MCDM methodologies in aircraft type selection problem

Slavica Dožić*, Milica Kalić

Faculty of Transport and Traffic Engineering, 305 Vojvode Stepe Street, office 335, Belgrade 11000, Serbia

Abstract

In order to provide a satisfactory choice while dealing with multiple criteria, planners apply some of the multiple criteria decision making (MCDM) methods as an aid to decision making. As the aircraft type selection embodies inherent multi-criteria decision making, two MCDM methods, the Analytic Hierarchy Process (AHP) and the Even Swaps Method (ESM), are applied and illustrated with the case study of a hypothetical regional airline. These methods are compared, as well as solutions they arrived at. Considering the difference between the AHP and ESM, a sensitivity analysis is carried out in different ways. In the AHP, the sensitivity of alternative ratings in respect to different pairwise comparisons of the alternatives is analysed, showing that the AHP is sensitive to this kind of changing. In the even swaps method, the objective ranking across alternatives is varied showing that the ESM is not sensitive at all. The final priority weight for specific aircraft type decreases with the decrease of the domination measure of one aircraft over another with respect to payment conditions, for all aircraft types in the solutions obtained by AHP.

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1. Introduction

In order to match airline capacity and passenger demand in an observed market conditions and economic environment, airline planners need to make fleet-related decisions that will be used in the next decades. Size and structure of a fleet must be determined properly in order to enable the airline to realize the planned schedule and earn money. In order to chose appropriate aircraft type, planners very often have to balance multiple, usually conflicting

* Corresponding author. Tel.: +381-11-3091-264;

E-mail address: s.dozic@sf.bg.ac.rs

criteria. Interests of both the airline and passengers must be considered, as well as operational requirements. In order to provide a satisfactory choice while dealing with multiple criteria, planners apply some of the multiple criteria decision making (MCDM) methods as an aid to decision making. In the relevant literature, the aircraft selection problem is discussed in different ways considering different criteria.

Bharda (2003) find out that it is possible to derive the selection of aircraft and fleet mix for origin and destination pairs based on the passenger demand on considered destinations, as well as that passengers, distance and types of airport hubs can support selection of an aircraft fairly well. A model for selection of aircraft in the case of a Saudi Arabia airline operating on domestic and international routes with the base in Jeddah and Madinah is presented by Harasani (2006, 2008). In the study specific aircraft types are chosen to be considered based on aircraft range and payload for given route network. Aircraft efficiency and its contribution to the net profit of the airline are obtained as a result from Excel application created by the author, helping planers to choose the right aircraft. A systematic evaluation model for selection of an optimal training aircraft for Air Force Academy is proposed by Wang and Chang (2007). An aircraft is selected mainly from the perspective of pilot drillmasters and trainees. The authors employ multi-criteria decision making method to determine the importance weights of evaluation criteria, and TOPSIS to obtain performance ratings of feasible alternatives in linguistic terms described with triangular fuzzy numbers. Ozdemir et al. (2011) use Analytic Network Process (ANP) to choose middle range, single-aisle aircraft for *Turkish Airlines*. They consider cost (purchasing, operation and spare, maintenance and salvage cost), time (delivery time and useful life) and physical attributes and others (dimensions, security, reliability and suitability for service quality) as the main criteria (sub-criteria). Vidović et al (2011) define the criteria applicable to modelling of low-cost airline in the Republic of Croatia. They propose seats, mass (payload, MTOM – maximal take-off mass), operating data (airspeed, flights altitude, range), infrastructure needs (runway length for take-off and landing) as the criteria (sub-criteria) for selecting optimal aircraft type from set of three aircraft types. Gomes et al. (2014) investigate the aircraft selection problem in regional charter flights in Brazil. They use three groups of criteria (financial, logistics and quality) in the multi-criteria decision aiding method named NAIADE (Novel Approach to Imprecise Assessment and Decision Environments).

Due to the global airline industry has been passing through a very turbulent period in the last decade airlines are faced with the inability to respond to the market and demand changes adequately. Therefore some of them will go bankrupt and will be replaced by new ones, while others will maintain their market position. For all airlines, either new ones or airlines that are well positioned in the market, fleet planning and aircraft type selection are problems which are very important and always actual, which has motivated the authors to research them. As the aircraft type selection is recognized as multi-criteria decision making, two MCDM methods, the Analytic Hierarchy Process (AHP) and the Even Swaps Method (ESM), are applied in this paper. In order to enable an airline to respond better to the market changes it is decided to compare two MCDM methods, and to learn their solution sensitivity to different changes. The AHP implies dividing the problem into a hierarchy of issues which should be considered in the work. This methodology considers a set of chosen criteria and a set of alternatives among which the best solution regarding the weights of criteria and alternatives is to be found. The pairwise comparison method is used to compare alternatives and determine their importance over each other. Even swaps method provides a practical way of making trade-offs among any set of objectives across a range of alternatives. The method forces decision-makers to think about the value of one objective in terms of another and to make smart decisions related to aircraft type considering different criteria and making wise trade-offs. It should be noted that both of the methods use quantitative as well as qualitative data (that are translated into numbers). The MCDM methods are illustrated with the case study of a hypothetical regional airline. These methods were compared, as well as solutions they arrived at. Considering the difference between the AHP and ESM, the sensitivity analysis is carried out in different ways. In the AHP, the sensitivity of alternative ratings with respect to different pairwise comparisons of the alternatives is analysed (Dožić and Kalić (2014) analyzed solution sensitivity with respect to different pairwise comparisons of the criteria), while in the even swaps method the objective ranking across alternatives is varied in order to learn solution sensitivity.

2. Model and data

Dožić and Kalić (2015) developed the three stages airline fleet planning model encompassing approximate fleet mix, fleet sizing and aircraft selection, respectively. Passenger demand and distance are the inputs to the first stage

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