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An intelligent decision making approach for identifying and analyzing airport risks

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ABSTRACT

Airport is a main infrastructure with the risk of danger and catastrophic damages throughout its activities. These dangers can lead to heavy financial damages and casualties. Thus, identification and prioritization of airport risks and their impact on the system are issues by which the airport management can plan control measures in order to increase safety and to improve system performance. In this regard, this study tries to provide a new decision-making approach to prioritize airport risks in order to consider the cause-effect relationships between risks and their relationships with system objectives that indeed reflect the performance of the airport. Proposed decision-making approach uses fuzzy cognitive map (FCM) method and slack-based data envelopment analysis (SBDEA). So that, at first, cognitive map is drawn for airport risks and system objectives (measurement factors); Then, the impact of each risk on measurement factors is evaluated using learning algorithm based on extended Delta rule and risks are prioritized using SBDEA model without outputs. In the proposed decision-making approach, airport risks are considered as alternatives and the impact of each risk on measurement factors (the output of learning algorithm) are considered as evaluation criteria. Results of using proposed approach in Urmia International Airport located at northwestern in Iran show that risks including: "Lack of staff training", "Inappropriate ground handling" and "Inoperable navigation aid (NAVAID)" are the main risks in this airport.

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1. Introduction

In today's world, where the pace of life is increasing every day; solving problems related to rapid and easy transportation is the focus of attention of all people concerned. The transportation industry is an important part of economy and sustainable development of each country. As many other industries, this industry is composed of several sections including road transportation, rail transportation, maritime transportation and air transportation. In the meantime, air transportation, is a key motive for economic and social development and demand for it is growing constantly each year (Wilke et al., 2014). Safety is the most basic element of transportation in all forms and models. Because without it, any attempt and action will fail and the aims of transportation services will not be achieved. Therefore, providing safety in air travels is a key element of this industry and designing processes affecting flights, monitoring proper implementation of these processes and

assessing the risks of flights are some substantial measures, which are recommended to ensure the safety of flights.

In this industry, passenger, airport and aircraft, all need each other to achieve a desirable cyclic in order to achieve safe and fast transportation. Airports are organizations with specific commercial, logistic, safety and security features and basic infrastructures for regional development (Fernandes and Pacheco, 2007) and there are high risks for catastrophic damages in its activities. These dangers and risks impose heavy financial losses and casualties to the airport, which are sometimes irreparable. Hence, reducing the probability of risks is a strategic discussion in airports, which can be managed in order to further increase safety and to reduce costs and delays. So, it is necessary to implement the risk management process including identifying and prioritizing risks, defining control tools and allocation of resources needed to implement these control measures (Neubauer et al., 2015). However, in the real world, each risk has complicated relations with other risks; so that, it is affected by many of them and affects many others. Therefore, we try to use an intelligent decision-making approach to prioritize risks.

Decision-making process, especially at the management level is

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very important. In most cases, the decision is favorable and satisfactory for decision maker when the decision is based on several criteria examined. Multi criteria decision-making (MCDM) problems is interesting for researchers in recent decade. They often have a conflict of intended criteria with together so that increasing utility of one can reduce utility for others. That is why MCDM methods, especially multiple attribute decision-making (MADM) have been developed to help such this problems solving. In this method, several options (decision alternatives) based on several different criteria are compared and the best option or the appropriate options are selected based on mathematical reasoning (Hwang and Yoon, 2012). Some of these methods are analytic hierarchy process (Saaty, 1990, 2008), analytic network process (Saaty, 1996), PROMETHEE (Brans and Vincke, 1985), ELECTRE (Roy, 1991), VIKOR and TOPSIS (Opricovic and Tzeng, 2004), and best worst method (Rezaei, 2015, 2016). In general, MCDM methods widely use in prioritizing problems with limited number of options along with a number of criteria. By integrating several experts opinion and taking into account qualitative and quantitative criteria, they prioritize predetermined options. The weakness of these methods is often their inability to determine causal relationships between characteristics. However, in the real world, each characteristic is affected on other characteristics and conversely. Ignoring of this issue will lead to uncertainty in the results. Among the MADM methods, the nearest method that able to consider the interaction between the criteria and options is analytic network process (ANP) method. But the disadvantages of this method such as the inability to consider relations from higher levels to lower levels, complexity in network design in ANP model, non-intelligent, dependence of this method to experts opinion, the use of it is limited.

Thus, unlike most previous studies, in the present study airport risks are prioritized by considering cause-effect relationships between these risks. This prioritization is done via using a decision-making approach, based on cognitive map method and data envelopment analysis (DEA) model without outputs. Cognitive map by connecting facts, values, processes objectives and policies, allows researchers to anticipate and analyze mutual interactions and mechanism of complex events through using what-if analysis (Dickerson and Kosko, 1994). Fuzzy cognitive map method may have many different characteristics and variables. FCM method also consider cause-effect relationships between characteristics as backward-forward relations at the same time. Also, use of learning algorithms in the cognitive map, cause to increase reliability in decision-making, making intelligent system, increase accuracy in obtained weights and reduce dependence on experts opinion, as well as planing and reviewing various scenarios (Papageorgiou et al., 2004; Papageorgiou and Kannappan, 2012). It is worth noting that to develop a good fuzzy cognitive map; knowledge, experience and scenarios can be applied to reduce dependence on individual comments and achievement useful results. For this reason, in present study, scenarios defined to evaluate the effect of any concept on the system objective (in this study the cost, time and risk of flight) assuming being active any risk in system in order to investigate by the learning algorithm. Then using SBDEA based on learning algorithm output, the risks are prioritized. DEA method in this study is combined with cognitive map, the weight of each criterion is determined based on mathematical programming models and independent expert opinion.

Using the proposed intelligent decision-making based on FCM and SBDEA methods can providing an accurate, comprehensive and understandable definition of complex systems for decision-makers in the area of airport management. So that, in the first phase, available risks are identified and cause-effect relationships between these risks are determined. Then, using the outputs of the first phase, the impact of risks on system is evaluated using learning

algorithm based on extended Delta rule and risks are prioritized using data envelopment analysis. So that, airport management through allocation of limited financial resources and limited time can fix the negative effects of the root risks and can obtain the best result. In the present study, second section reviews the previous researches on risk management and applications of MCDM methods in airline industry and also applications of FCM and DEA methods in other fields. Cognitive map method is introduced in the third section. In fourth section explanations on DEA method are presented. Then, research methodology and proposed approach are presented in the fifth section. In the sixth section, the case study is introduced, results obtained from case study are analyzed in the seventh section. Summary and conclusion are presented in the final section.

2. Literature review

As mentioned, most studies conducted on risk management in airline industry have not considered cause-effect relationships between risks. In the following, some of these studies are reviewed. Lee (2006) evaluated safety risk factors by a developed quantitative model. The model integrated fuzzy linguistic scale method, failure mode, effects and criticality analysis principle used in order to increase the effectiveness of risk management system. The model developed by assessing estimation factors according to their importance. Netjasov and Janic (2008) studied models for safety evaluating. The investigated models categorized into four type: causal for aircraft and air traffic control/management operations, collision risk, human factor error and third-party risk. Kim and Yang (2012) evaluated risk frequency of hazards associated with Gimpo International Airport runway incursion. Fifteen hazards causing runway incursion verified, the weights determined through analytic hierarchy process. Then, fault tree analysis was performed. Chang and Wong (2012) determined human risk factors related to pilots in runway incursions. In order to categorize risk factors, they applied a model based on opinions of 112 pilots. Taiwan's airlines, civil aviation authority, and expert opinions was focused in order to reduce runway incursions. Feng and Chung (2013) by using Fuzzy Logic-Based Failure Modes Effect and Criticality Analysis (FMECA) evaluated risks of airport airside. 14 risk items of airports was identified and then FMECA applied to define decision factors of probability, severity and detectability of airport risks and the risks prioritized.

Čokorilo et al. (2014) considered some characteristics including the aircraft, environmental conditions, route, and traffic type to compare aircraft accidents. Data were collected by using database of over 1500 aircraft accidents, occurring between 1985 and 2010, then cluster analysis were used. Wilke et al. (2014) proposed an integrated framework for holistic risk evaluation. First, a process model developed to attain triangulation. Second, causal factors are determined based upon a data set that combined 12 databases. Finally, they introduced a macroscopic scenario tool. Chang et al. (2015) used a two-stage process in order to assess the performance of safety management system (SMS) operations at three international airports. First stage was to determine and ranking SMS components and elements using ANP. Second stage was to assess and rank their performance. Hu and Hsiao (2016) designed a model in order to quality risk assessment. The model measures quality risk for airline services. The model integrating Kano model, importance degree and satisfaction. Rong et al. (2016) specified key modules affecting the airport operational safety. Then 165 airport operational risk monitoring indicators were designed using system and job analysis method, fault tree analysis, expert brainstorming etc. indicators divided into 3 main laval. Da Cunha et al. (2017) by considering the context of small to medium airports analyzed

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