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AN ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM FOR FORECASTING AUSTRALIA'S DOMESTIC LOW COST CARRIER PASSENGER DEMAND

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Abstract. This study has proposed and empirically tested two Adaptive Neuro-Fuzzy Inference System (ANFIS) models for the first time for predicting Australia's domestic low cost carriers' demand, as measured by enplaned passengers (PAX Model) and revenue passenger kilometres performed (RPKs Model). In the ANFIS, both the learning capabilities of an artificial neural network (ANN) and the reasoning capabilities of fuzzy logic are combined to provide enhanced prediction capabilities, as compared to using a single methodology. Sugeno fuzzy rules were used in the ANFIS structure and the Gaussian membership function and linear membership functions were also developed. The hybrid learning algorithm and the subtractive clustering partition method were used to generate the optimum ANFIS models. Data was normalized in order to increase the model's training performance. The results found that the mean absolute percentage error (MAPE) for the overall data set of the PAX and RPKs models was 1.52% and 1.17%, respectively. The highest R^2-value for the PAX model was 0.9949 and 0.9953 for the RPKs model, demonstrating that the models have high predictive capabilities.

Keywords: adaptive neuro-fuzzy inference system (ANFIS); air transport; Australia; forecasting methods; low cost carriers.

1. Introduction

Forecasting is the process of making projections about future performance based on the existing historic data. An accurate forecast assists firms in decision-making and planning for the future. Forecasts empower people to modify existing variables at the current time to predict the future in order to achieve a favorable scenario (Hadavandi *et al.* 2011).

Forecasting passenger transport demand is of critical importance for airlines as well as for investors since investment efficiency is greatly influenced by the accuracy and adequacy of the estimation performed (Blinova 2007). Air traffic forecasts are therefore one of the key inputs into an airline's fleet planning and route network development, and are also used in the preparation of the airline's annual operating plan (Ba-Fail *et al.* 2000; Doganis 2009). Furthermore, analysing and forecasting air travel demand may also assist an airline in reducing its risk through an objective evaluation of the demand side of the airline business (Abed *et al.* 2001; Ba-Fail *et al.* 2000).

Classical modelling such as multiple linear regression (MLR) has been used extensively in forecasting air traffic demand for several decades (see, for example, Abed *et al.* 2001; Aderamo 2010; Ba-Fail *et al.* 2000; International Civil… 2006; Kopsch 2012; Sivrikaya, Tunç 2013). However, traditional regression techniques are not able to capture the non-linear structure of a specific process as effectively as the artificial intelligence-based models. Consequently, artificial intelligence-based modelling techniques have become more popular in diverse disciplines over the past decade (Kar *et al.* 2014) because of their robustness, high predictive capabilities and flexible behaviours to handle the multi-objective criteria in a straightforward manner (Yetilmezsoy *et al.* 2011).

Jang (1993) and Jang *et al.* (1997) introduced the adaptive network-based fuzzy inference system (ANFIS), which is a system using a hybrid learning rule to optimize the fuzzy system parameters of a first order Sugeno system (Giovanis 2012). This approach has been applied to a growing range of disciplines, including transport mode choice (Andrade *et al.* 2007), economics (Fang 2012; Giovanis 2012), electricity demand forecasting (Zahedi *et al.* 2013), financial markets forecasting (Bagheri *et al.* 2014; Kablan 2009), gold price forecasting (Makridou *et al.* 2013), oil consumption forecasting (Senvar *et al.* 2013), stock market forecasting (Atsalakis, Valavanis 2009; Chen *et al.* 2013; Cheng *et al.* 2013; Svalina *et al.* 2013; Wei 2013), tourism demand forecasting (Atsalakis *et al.* 2014; Chen *et al.* 2010; Hadavandi *et al.* 2011), and ordering policy in supply chains (Latif *et al.* 2014).

Following the deregulation of Australia's domestic airline market in 1990, which permitted other airlines to compete with the established carriers (Forsyth 2003; Nolan 1996), a number of low cost carriers (LCCs) have entered the market. The LCCs now hold around a 35 per cent market share, with the two major incumbent LCCs being "Jetstar Airways" and "Tiger Airways" (Srisaeng *et al.* 2014). Despite the reported advantages of the ANFIS in the literature together with acknowledged critical importance of forecasting for airline and airport management, to the best of the author's knowledge there has been no previously reported study that has developed and empirically examined ANFIS models for forecasting Australia's domestic quarterly LCCs air travel demand and revenue passenger kilometres performed[1] (RPKs). Thus, the key objective of this study is to address this apparent research gap in the literature. Furthermore, the study is intended to provide both a theoretical perspective on the development of an ANFIS for forecasting airline passenger demand, and also to provide a practical application of the ANFIS to forecast Australia's quarterly domestic LCC passenger demand and revenue passenger kilometres performed (RPKs).

[1] Enplaned passengers and revenue passenger kilometres performed (RPKs) are the recognised measures of airline passenger traffic (Belobaba 2009; Holloway 2008).