Abstract

Demand information is a major tool for decision makers and sports administrators. It is also required by dynamic ticket pricing models of sports events, which have been an increasingly popular research topic. It can be inferred that the accuracy of the demand forecasting plays a crucial role on critical decisions. Considering this point, soft computing techniques, artificial neural networks and adaptive neuro-fuzzy inference system (ANFIS), are utilized to forecast attendance demand of sports games in this study. Classical regression models have been used in almost all of the studies conducted for the same purpose. It is aimed to propose competitive alternative forecasting approaches. To do so, multiple models are developed to forecast attendance demand rate of sports events. To generalize the use of the proposed approaches, as a general term, the demand rate is considered. By multiplying the demand rate by the total number of tickets offered for sale, the number of spectators (attendance demand) is obtained. The proposed approaches can be used for almost all sports disciplines by making some modifications. Demand factors of indoor and outdoor sports games may differ. Therefore, the determinants of demand are selected accordingly. The real data of the sports clubs are used to evaluate the forecasting results of the models. The mean absolute percentage error (MAPE) is used for that purpose. As a result, the MAPE values of the proposed models are below %10 that means the proposed models can be utilized for demand forecasting purposes. The proposed models may be utilized in other industries as well.

Keywords: soft computing techniques, demand forecasting, neural networks, ANFIS
INTRODUCTION

An accurate estimation affects a firm’s economic decisions and plans for the future (Srisaeng, Baxter, & Wild, 2015). This is relevant for sports clubs either since estimation demand of games is vital for sports clubs. Decision makers and policy makers in the sports industry benefit from demand estimation while deciding on various matters that are investment in stadium reconstruction, pricing strategies and so on (Borland & Macdonald, 2003). There has been a considerable economic growth of the professional sports sector. Spectator attendance is a prominent source of revenue for sports organizations, and understanding the determinants of demand in terms of decision makers and government is vital. Therefore, the topic of sports demand has attracted substantial attention in sports economics and marketing areas (S. Dobson & Goddard, 2011). There have been many studies about attendance at sports events or demand for tickets of sports events. The majority of them are econometric studies that try to reveal the determinants of the demand. By using data sets of different sports disciplines, the usual approach is based on estimation of a demand equation that is linear or can be linearized. Some of them are as follows: Martins and Cró (2016) concentrate on the determinants of stadium demand in the Portuguese First Division League for five seasons. Cost, habit persistence, expected quality, team performance, and outcome uncertainty variables are highlighted. Lemke, Leonard, and Tlhokwane (2009) estimate the demand using censored normal regression with home team fixed effects by considering MLB games of 2007 season. According to the results, attendance increases as the chance of home game winning the game increases. S. Dobson and Goddard (2011) consider English football clubs. According to the results, the duration of a team’s league membership, hometown population and the degree of competition are significant determinants on the demand. As the duration of a club in the season gets longer, the demand of that team is higher too. Reilly (2015) considers Ireland Football league by using three season data. Game and seasonal outcome uncertainty, team performance, derby games and fixture quality are found to be significant factors. Borland and Macdonald (2003) consider international studies about professional sport demand. The determinants of the demand are presented. The prominent factors that affect the demand are uncertainty of outcome and quality of the game.

Soft computing techniques generally perform better than regression methods. In this study, an ANFIS model is proposed to predict demand of sports games. The ANFIS combines the advantages of both artificial neural network and fuzzy inference system. The ANFIS has some advantages including ability of capturing the nonlinear structure of a process, adaptation capability, and rapid learning capacity. The ANFIS has been applied to many areas including economics (Lotfi, Darini, & Karimi-T, 2016), passenger demand forecasting (Srisaeng et al., 2015), energy (Panapakidis & Dagoumas, 2017), environment (Prasad, Gorai, & Goyal, 2016). However, it has not been utilized enough in sports. It is only used in simulated soccer agents. Neural networks, by using a supervised learning approach, learn from training data, adjust weights to reduce the error between the actual data and the forecasting result produced by the model (McCullagh, 2010). Since the feed-forward neural network models are adaptable extensions to the standard regression models, they are an alternative for use in prediction and exploratory analysis in larger data sets (Liestbl, Andersen, & Andersen, 1994). Neural networks can be an alternative to linear regression or time-series analysis (Tu, 1996). Neural networks have been used in sports areas and have produced better results than the regression models (Condon, Golden, & Wasil, 1999; Maszczyk et al., 2014). Thus, they are utilized in this study.

LITERATURE REVIEW

There are different types of neural networks that have been used in many areas. Since models of neurological networks by McCulloch and Pitts (1943), there have been hundreds of different
models developed considered as neural networks. Besides, research regarding the sports demand carries high importance for sports economics. Therefore, there has been abundance of studies about attendance at sports games or demand of sports games. The studies regarding neural networks in sports and sports games attendance are stated in two sections as follows:

1. NEURAL NETWORKS IN SPORTS

Neural network studies in sports are used for predicting a game’s winner or winning rate of a team, sports results and success for different sports disciplines. Purucker (1996) examines the use of neural networks to predict the winner in National Football League. Condon et al. (1999) develop neural network and OLS linear regression models to predict success of countries at the Summer Olympic Games. The data of 1996 Summer Games is used. According to the comparisons of the model results, the best neural network model provides better results than the best regression model. Rotshtein, Posner, and Rakityanskaya (2005) benefit from neural networks for predicting football game results. Fuzzy logic, neural network and genetic algorithm are combined for that purpose. Loeffelholz, Bednar, and Bauer (2009) design neural networks to estimate the success of basketball teams in the National Basketball Association (NBA). The data of 620 NBA games was analyzed and used for training neural networks. 74.33% of the time prediction accuracy on average is achieved compared to 68.67% of the time prediction accuracy of experts. Huang and Chang (2010) design a neural network model based on multi-layer perception (MLP) with back propagation learning rule to predict the game’s winning rate of home and away teams. 2006 World Cup data is used for that purpose. 76.9% prediction accuracy is achieved. Maszczyk et al. (2014) compare the accuracy of regression and artificial neural network models over estimating sports results. The data of a group of 116 javelin throwers is used. Based on the results, the neural network model provides better estimates for sports results than regression models.

Neural network models are also applied to a selection process of players or talents. McCullagh (2010) designs a neural network approach for the selection of players in the annual Australian Football League (AFL) National Draft. According to the results, the neural network model has ability to help recruiting managers in the talent identification process. Maszczyk, Zając, and Rzyguła (2011) use neural networks in a selection process of javelin throwers. Based on the experiments, it is concluded that neural network models provide valuable assistance in the recruiting process of javelin throwers.

It can be concluded that neural network models in sports are generally used for predicting results of games and selecting talented players. In this study, a unique neural network model is proposed for forecasting attendance rate of sports games. It is not limited to any sports discipline since it can be applied to any sports disciplines by making few changes.

2. SPORTS ATTENDANCE

There have been many studies regarding the sports attendance. In this section, studies regarding the sports games will be the major focus. As it will be seen, the majority of them are econometric studies whose goal is to reveal determinants of the demand. Some of the studies are as follows: García and Rodríguez (2002) analyze seasons 1992/93 to 1995/96 data of Spanish Football League to estimate an attendance equation. Weather conditions, day of the game, quality of both home and away teams are found to be significant on the demand. Forrest and Simmons (2002) find that home team performance has greater importance on attendance than away team performance as Bruggink and Eaton (1996) and Rascher (1999) find it for Major League Baseball. Hart, Hutton, and Sharot (1975) construct a model to estimate the attendances of four English First Division clubs. The geographical distance between the stadiums of home and away teams is considered as a significant factor. This factor allows the
local derby effect on attendances. Besides, it is stated that highly placed away teams attract more spectators. S. M. Dobson and Goddard (1992) analyze disaggregated game attendance data of English Football League to investigate the determinants of attendances. The geographical distance between away and home teams and the league position of the home team are considered as significant variables. The number of points gained by home and away teams from their previous five games is taken as a significant factor on the attendance. Differently from others, Brandes, Franck, and Nüesch (2008) investigate the impact of “superstar” players on the attendance of German Bundesliga games. According to the results, superstar players have an increasing effect on the attendance.

In summary, there have been many studies examining the effective factors on attendance of soccer games. The name and number of factors may differ depending on the scope of the study. However, by evaluating the literature overall, the ground distance between home and away teams (Borland & Macdonald, 2003; S. Dobson & Goddard, 2011; Peel & Thomas, 1992), day of the game (Buraimo & Simmons, 2008; Cox, 2015), performance of the home team and performance of the away team (Bruggink & Eaton, 1996; Forrest & Simmons, 2002; Rascher, 1999) are the determining factors to be used to forecast the attendance rate in this study.

METHODOLOGY

1. ADAPTIVE NEURAL-FUZZY INFERENCE SYSTEM (ANFIS)

The ANFIS was introduced by Jang (1991) and since then is has been used for controlling, parameter estimation and modeling in complex systems (Amid & Mesri Gundoshmian, 2017). The ANFIS is a combination of artificial neural network (ANN) and fuzzy inference system (FIS). Combining the ANN and fuzzy-set theory can provide advantages and overcome the disadvantages of both techniques. The ANFIS model can be trained without relying solely on expert knowledge, which can be solely sufficient for a fuzzy logic model. The ANFIS model utilizes the advantage of both numerical and linguistic knowledge. The ANFIS also uses the ANN’s ability to classify data and identify patterns. Compared to the ANN, the ANFIS model is more transparent to the user and causes less memorization errors. Consequently, there are several advantages of the ANFIS including its adaptation capability, nonlinear ability, and rapid learning capacity (Srisaeng et al., 2015).

2. NEURAL NETWORKS

Neural network mimics the human brain behavior (Haykin, 2009). In other words, due to its learning and generalization capabilities, neural network can be expressed as a mathematical representation of the human neural architecture (Amato et al., 2013). There are some advantages of using artificial neural network. First, it is data driven and does not require any restrictive assumptions about the form of the model. Second, it has ability to generalize. After training it by using real data, it responds to new data that has not been used in the training phase. Third, it has ability to detect complex nonlinear relationships between dependent and independent variables (Dumitru & Maria, 2013). There is no certain method to determine the most appropriate neural network structure prior to training, so the neural network model is generally designed after a trial and error procedure (Tiwari & Chatterjee, 2010). In other words, all possible neural network model structures are trained by using training data set and tested by using testing data set. The neural network model structure providing the best results with smallest error is selected eventually.
CONCLUSION

Attendance information is used for decision makers. It is also required for dynamic ticket pricing models. Thus, understanding attendance and forming determinants is vital. Forecasting attendance is as important as understanding it. In this study, a neural network and an ANFIS model based on attendance parameters are developed for forecasting attendance rate of sports games. Neural networks are capable of finding internal representations of interrelations within data. The ANFIS contains the advantages of both neural networks and fuzzy logic. The simulation results demonstrate that the developed neural network model and ANFIS model are able to estimate attendance rate of sports games satisfactorily. It can be utilized by dynamic ticket pricing models in addition to sports managers, administrators and so on. Future research could extend this study by using a larger data set to examine whether better predictions can be obtained. Likewise, the number of inputs (attendance determinants) may be increased for the same purpose.

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