Chapter 64
Prediction of International Stock Markets Based on Hybrid Intelligent Systems

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ABSTRACT

This paper compares the accuracy of three hybrid intelligent systems in forecasting ten international stock market indices; namely the CAC40, DAX, FTSE, Hang Seng, KOSPI, NASDAQ, NIKKEI, S&P500, Taiwan stock market price index, and the Canadian TSE. In particular, genetic algorithms (GA) are used to optimize the topology and parameters of the adaptive time delay neural networks (ATNN) and the time delay neural networks (TDNN). The third intelligent system is the adaptive neuro-fuzzy inference system (ANFIS) that basically integrates fuzzy logic into the artificial neural network (ANN) to better model information and explain decision making process. Based on out-of-sample simulation results, it was found that contrary to the literature GA-TDNN significantly outperforms GA-ATDNN. In addition, ANFIS was found to be more effective in forecasting CAC40, FTSE, Hang Seng, NIKKEI, Taiwan, and TSE price level. In contrary, GA-TDNN and GA-ATDNN were found to be superior to ANFIS in predicting DAX, KOSPI, and NASDAQ future prices.

INTRODUCTION

Since trading financial assets is a highly risky task, investors and portfolio managers need accurate predicting systems. However, financial assets time series are nonlinear and non-stationary. Therefore, they mostly follow a noisy path. The nonlinearity implies that asset prices do not follow a linear pattern, and non-stationary implies that their dynamics change over time. As a result, sophisticated systems were proposed to model the underlying financial time series by capturing the above patterns in order to provide accurate forecasts (Lahmiri, 2013, 2014a, 2014b, 2014c; Lahmiri & Boukadoum, 2014a, 2014b; Lahmiri, Boukadoum, & Chartier, 2014a, 2014b; Lahmiri & Boukadoum, 2015a, 2015b). In the 2000s, nonlinear and adaptive forecasting models such as artificial neural networks (ANNs) have become popular intelligent

systems widely used in stock market modeling and forecasting (Zimmermann, Neuneier & Grothmann, 2001; Yao & Tan, 2000; Atsalakis & Valavanis, 2009; Huang & Wu, 2010; Hsieh, Hsiaso & Yeh, 2011; Wang et al, 2011). In general, previous works (Zimmermann, Neuneier & Grothmann, 2001; Yao & Tan, 2000; Atsalakis & Valavanis, 2009a) have shown that ANNs were superior to traditional statistical models such as the well known auto-regressive integrated moving average (ARIMA) models (Box & Jenkins, 1970). Indeed, ARIMA models are based on the assumptions that the time series are stationary and that the errors of the model are normally distributed. Unfortunately, financial data do not meet those criteria and, as a result, the techniques based on statistical approaches could not provide accurate financial forecasts. However, the ANN systems suffer several disadvantages, namely dependency on network architecture, type of transfer function, parameters choice, and being considered as a black-box.

To overcome these disadvantages, hybrid soft computing systems were proposed in the literature. These systems combine synergistically ANNs and other soft computing models to obtain complementary hybrid intelligent system models. For instance, genetic algorithms (Goldberg, 1989) were proposed to automatically optimize the topology and parameters of ANNs (Yao, 1999), and fuzzy logic (Zadeh, 1965) was incorporated into ANN resulting in adaptive neuro-fuzzy inference system (ANFIS) (Jang, 1993). In particular, in one hand ANN is capable to recognize patterns and adapt to data. On the other hand, fuzzy inference systems incorporate human knowledge and expertise to make fuzzy inference and decision (Jang, 1993; Atsalakis & Valavanis, 2009b).

This study compares three artificial neural network architectures for the prediction of next day individual stock price using past values. The three soft computing models used are the ANFIS, and two types of recurrent neural networks which are genetically optimized; namely the time delay neural network (TDNN) (Kim, 1998; Saad et al, 1998) and the adaptive time delay neural network (ATDNN) (Kim, 1998; Saad et al, 1998). The ANFIS was chosen thanks to its hybridization of linguistic and numerical techniques, its fast convergence due to its hybrid learning algorithm, and its ability to generate rule-based explicative models. In addition, ANFIS can model non linear functions and has been reported to achieve higher accuracy than classical statistical models (Tan, 1997; Taha & Ghosh, 1999; Yao, 1999; Jang, 1993). The TDNN and ATNN were considered because recurrent feedback in the network is a positive factor to predict financial time series (McCluskey, 1993; Castiglione, 2001) since they have a long memory than the general feed-forward neural network. Indeed, recurrent networks possess two specific features: a rudimentary memory and capability to exhibit internal chaotic behavior (Karray & De Silva, 2004). Therefore, they may capture the chaotic behavior of financial time series and are suitable to be adopted as forecasting systems since empirical finance have found that stock returns time series are chaotic (Brock, Hsieh & LeBaron, 1991; Hsieh, 1991; Blank, 1992; Decoster, Labys & Mitchell, 1992; Frank & Stengos, 1988). Furthermore, a little attention has been given to the use TDNN and ATDNN for financial time series prediction. Indeed, most of previous works dealing with the applications of recurrent networks in finance employed the well known partially recurrent networks such as the Elman network (Elman, 1990) and the Jordan's sequential network (Jordan, 1986). In addition, a comparison with ANFIS has not been considered in the literature. Such comparison may help international investors choose the right ANN type to be used in international portfolio management.

Since choosing the architecture of a neural network is often subjective and depends on the experimenter's experience, a genetic algorithm (GA) is incorporated into the architectures of TDNN and ATDNN to optimize their respective designs. This includes finding the optimal topology in terms of the numbers of hidden layers and processing elements. In this respect, the GA tends to converge to optimal or near-optimal solutions.

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