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Using artificial neural network models in stock market index prediction

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ABSTRACT

Forecasting stock exchange rates is an important financial problem that is receiving increasing attention. During the last few years, a number of neural network models and hybrid models have been proposed for obtaining accurate prediction results, in an attempt to outperform the traditional linear and nonlinear approaches. This paper evaluates the effectiveness of neural network models which are known to be dynamic and effective in stock-market predictions. The models analysed are multi-layer perceptron (MLP), dynamic artificial neural network (DAN2) and the hybrid neural networks which use generalized autoregressive conditional heteroscedasticity (GARCH) to extract new input variables. The comparison for each model is done in two view points: Mean Square Error (MSE) and Mean Absolute Deviate (MAD) using real exchange daily rate values of NASDAQ Stock Exchange index.

1. Introduction

Forecasting simply means understanding which variables lead to predict other variables (Mcnelis, 2005). This means a clear understanding of the timing of lead-lag relations among many variables, understanding the statistical significance of these lead-lag relations and learning which variables are the more important ones to watch as signals for predicting the market moves. Better forecasting is the key element for better financial decision making, in the increasing financial market volatility and internationalized capital flows.

Accurate forecasting methods are crucial for portfolio management by commercial and investment banks. Assessing expected returns relative to risk presumes that portfolio strategists understand the distribution of returns. Financial expert can easily model the influence of tangible assets to the market value, but not intangible asset like know-how and trademark. The financial time series models expressed by financial theories have been the basis for forecasting a series of data in the twentieth century.

Studies focusing on forecasting the stock markets have been mostly preoccupied with forecasting volatilites. There has been few studies bringing models from other forecasting areas such as technology forecasting.

To model the market value, one of the best ways is the use of expert systems with artificial neural networks (ANN), which do not contain standard formulas and can easily adapt the changes of the market. In literature many artificial neural network models are evaluated against statistical models for forecasting the market value. It is observed that in most of the cases ANN models give better result than other methods. However, there are very few studies comparing the ANN models do among themselves, where this study is filling a gap.

Objective of this study is to compare performance of most recent ANN models in forecasting time series used in market values. Autoregressive Conditional Heteroscedasticity (ARCH) model (Engle, 1982), generalized version of ARCH model Generalized ARCH (GARCH) model (Bollerslev, 1986), Exponential GARCH (EGARCH) model (Nelson, 1991) and Dynamic Architecture for Artificial Neural Networks (DAN2).

Ghiassi and Saidane (2005) will be analyzed in comparison to classical Multi-Layer Perceptron (MLP) model. Despite the popularity and implementation of the ANN models in many complex financial markets directly, shortcomings are observed. The noise that caused by changes in market conditions, it is hard to reflect the market variables directly into the models without any assumptions (Roh, 2007). That is why the new models will also be executed in hybrid combination with MLP. The analysed models will be tested on NASDAQ index data for nine months and the methods will be compared by using Mean Square Error (MSE) and Mean Absolute Deviation (MAD).

The remaining sections of this paper are organized as follows: Section 2 gives the background of the related studies; Section 3 introduces the models used in this study and Section 4 provides results of each model using daily exchange rates of NASDAQ index. Final section gives the conclusion and recommendations for future researches.

This study will not only make contribution to the ANN research but also to the business implementations of market value calculation.

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2. Background

2.1. Time series forecasting and ANN

The financial time series models expressed by financial theories have been the basis for forecasting a series of data in the twentieth century. Yet, these theories are not directly applicable to predict the market values which have external impact. The development of multi layer concept allowed ANN (Artificial Neural Networks) to be chosen as a prediction tool besides other methods. Various models have been used by researchers to forecast market value series by using ANN. A brief literature survey is given in Table 1.

Gooijer and Hyndman (2006) reviewed the papers about time series forecasting from 1982 to 2005. It has been prepared for the silver jubilee volume of international journal of forecasting, for the 25th birthday of International Institute of Forecasters (IIF). In this review statistical and simulation methods are analyzed to include exponential smoothing, ARIMA, seasonality, state space and structural models, nonlinear models, long memory models, ARCH-GARCH. Gooijer and Hyndman (2006) compiled the reported advantages and disadvantages of each methodology and pointed out the potential future research fields. They also denoted existence of many outstanding issues associated with ANN utilisation and implementation stating when they are likely to outperform other methods. Last few years researches are focused on improving the ANN's prediction performance and developing new artificial neural network architecture.

Engle (1982) suggested the Autoregressive Conditional Heteroscedasticity (ARCH) model, Bollerslev (1986) generalized the ARCH model and proposed the Generalized ARCH (GARCH) model for time series forecasting. By considering the leverage effect limitation of the GARCH model, the Exponential GARCH (EGARCH) model was proposed by Nelson (1991). Despite the popularity and implementation of the ANN models in many complex financial markets directly, shortcomings are observed. The noise that caused by changes in market conditions, it is hard to reflect the market variables directly into the models without any assumptions (Roh, 2007).

Preminger and Franck (2007) used a robust linear autoregressive and a robust neural network model to forecast exchange rates. Their robust models were better than classical models but still are not better than Random Walk (RW). Roh (2007) used classical ANN and EWMA (Exponentially Weighted Moving Average), GARCH and EGARCH models with ANN. NN-EGARCH model outperforms the other models with a 100% hit ratio for smaller forecasting period than 10 days.

Kumar and Ravi (2007) reviews 128 papers about bankruptcy prediction of banks and firms. This review shows that ANN methods outperforms many methods and hybrid systems can combine the advantages of different methods. Ghiassi, Saidane, and Zimbra (2005) evaluated ANN, ARIMA and DAN2 (Dynamic Architecture for Artificial Neural Networks) using popular time series in literature. DAN2, is a new NN architecture first developed by Ghiassi and Saidane (2005), clearly outperforms the other methods. DAN2 is pure feed forward NN architecture and detailed information about this architecture will be given in Section 5.

Menezes and Nikolaev (2006) used a new NN architecture and named it Polynomial Genetic Programming. It is based on Polynomial Neural Network first developed by Ivakhnenko (Menezes & Nikolaev, 2006). This architecture uses polynomials to build an ANN. Menezes and Nikolaev (2006) uses genetic algorithm to estimate ANN parameters such as starting polynomials, weight estimation etc. This study gives better result for some problems. It is a new promising architecture but it needs improvement (Menezes & Nikolaev, 2006).

Zhang and Wan (2007) developed a new ANN architecture Statistical Fuzzy Interval Neural Network based on Fuzzy Interval Neural Network. JPY/USD and GBP/USD exchanges rates are predicted using these methods. These methods are developed to predict only an interval not a point in time. Hassan, Nath, and Kirley (2007) used a hybrid model including Hidden Markov Model, ANN and Genetic Algorithm. They test hybrid model on stock exchange rates. Hybrid model is proven to be better than simulation models.

Yu and Huarng (2008) used bivariate neural networks, bivariate neural network-based fuzzy time series, and bivariate neural network-based fuzzy time series model with substitutes to apply neural networks to fuzzy time series forecasting. Bivariate neural network-based fuzzy time series model with substitutes performs the best. Zhu, Wang, Xu, and Li (2008) used basic and augmented neural network models to show trading volume can improve the prediction performance of neural networks. Leu, Lee, and Jou (2009) compared radial basis-function neural network (RBFNN), random walk, and distance-based fuzzy time series models with daily closing values of TAIEX, and exchange rates NTD/USD, KRW/USD, CNY/USD, JPY/USD. Results show that RBFNN outperformed the random walk model and the artificial neural network model in terms of mean square error. Cheng, Chen, and Lin (2010) used PNN (Prbobabilistic NN), rough sets, and hybrid model (PNN, Rough Set, C 4.5 Decision Tree) to integrate fundamental analysis and technical analysis to build up a trading model of stock market timing. They report that hybrid model is helpful to construct a better predictive power trading system for stock market timing analysis. Chang, Liu, Lin, Fan, and Ng (2009) used an integrated system (CBDWNN) which combines dynamic time windows, case based reasoning (CBR), and neural network (NN). Their CBDWNN model outperformed other compaired methods, and very informative and robust for average investors.

Egrioglu, Aladag, Yolcu, Uslu, and Basaran (2009) introduced a new method which is based on feed forward artificial neural networks to analyze multivariate high order fuzzy time series forecasting models. Khashei and Bijari (2010) compaired autoregressive integrated moving average (ARIMA), artificial neural networks (ANNs), and Zhang's hybrid model. And Hybrid model outperforms the other models. Hamzacebi, Akay, and Kutay (2009) compaired ARIMA and ANN and conclude that direct forecast with ANN is better and noted that before generalizing the conclusion other researchs should be done. Majhi, Panda, and Sahoo (2009) compaired functional link artificial neural network (FLANN), cascaded functional link artificial neural network (CFLANN),and LMS model and observed that the CFLANN model performs the best followed by the FLANN and the LMS models.

Liao and Wang (2010) used stochastic time effective neural network model to shows some predictive results on the global stock indices and their model is showed predictive results. Atsalakis and Valavanis (2009a) used Adaptive Neuro Fuzzy Inference System (ANFIS) to determine the best stock trend prediction model and results show that ANFIS clearly demonstrates the potential of neurofuzzy based modeling for financial market prediction. Chen, Ying, and Pan (2010) also used ANFIS to predict monthly tourist arrivals. And conclude that ANFIS performs better than markov and fuzzy models. Bildirici and Ersin (2009) combined ANNs with ARCH/GARCH, EGARCH, TGARCH, PGARCH, APGARCH. This combined models better perfomred than ANNs or GARCH based models. Guresen and Kayakutlu (2008) used hybrid models like GARCH-DAN2 and EGARCH-DAN2 to forecast Istanbul Stock Exchange Index (ISE XU100). Yudong and Lenan (2009) used bacterial chemotaxis optimization (BCO), and back propagation neural network (BPNN) on S&P 500 index and conclude that their hybrid model (IBCO–BP) model offers less computational complexity, bet-