Predictive Analysis of Exchange Rates Using Hybrid Models

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Abstract

In this paper an attempt is made to develop hybrid models using Artificial Neural Network (ANN) and Autoregressive Integrated Moving Average (ARIMA) for predicting the future exchange rate for US dollar. Simulation results of hybrid models were compared with results of ANN based models and ARIMA based models. Results show that the model ANN – ARIMA - ANN gives a better performance than the other models. The performance of the two methods were compared based on standard statistical measures such as MAPE, MAE, RMSE and MSE. Validity of the models were tested and the future exchange rate was predicted.

Keywords: Hybrid Models, Autoregressive Integrated Moving Average, Artificial Neural Network, prediction

1. Introduction

The Financial Market is the most complex area in an investment business in which prediction often misfires. The reason is that there are too many variables that cause a price change. Knowing when to sell and when to buy a particular share is one of the toughest parts of the investment business. Shares should be sold when their investment potential has deteriorated to the extent that they no longer merit a place in the portfolio. Many people believe that a typical investor sells the winners too soon and hangs on to the losers too long (Hersh. S and Meir.
The investors are torn between the desire to protect profits or minimize further losses and the protection of price appreciation. There are many theories that provide partial answers, but most of them depend on a market framework as utility curves or consumption decision change.

Financial time series forecasting is an important area of forecasting in which past observations of the same variables are collected and analyzed to develop a model to describe the underlying relationship. One of the most important and widely used time series model is the Auto-Regressive Integrated Moving Average (ARIMA) model. The popularity of ARIMA model is due to its statistical properties as well as the well-known Box Jenkin's methodology in the model building process. The major limitation of the ARIMA model is the pre-assumed linear form of the model. Hence no non-linear pattern can be captured by an ARIMA model.

In recent years, Artificial Neural network has become a popular modeling tool. Complex real world problems in which non-linearity is present can be successfully modeled using this technique (Refenes 1995, Kate et. al 2000, Abu - Mostafa et. al 2001). Also it has been suggested that two or more computational models can be synergically combined to give a better approach for prediction problems. Each model’s unique capability can be used to model different patterns of data (Zhang, G 2003).

The advantages of the relatively easy-to-tune ARIMA models and the computational power of ANN has been combined to give the time series prediction for the hybrid ARIMA–ANN model. The literature review shows that the combination of ANN and ARIMA are much better than individual model and the results are more substantial when dealing with non-stationary series (Priestley 1988).

2. Prediction of Exchange Rates Using Hybrid Models

The data for analysis is taken from the average monthly foreign exchange rates for US Dollar from the January 2001 to September 2013 (Source: RBI). The exchange rates were predicted for this time period using ARIMA, ANN, ANN-ARIMA, ANN – ARIMA - ARIMA, ANN – ARIMA - ANN. In this study, time delay moving average is used as technical data. The predictors chosen are two yearly moving average, one yearly moving average, six monthly moving average and three monthly moving average (Joarder and Ruhul 2003). The main objective in this work is to develop models using hybrid models of ANN and ARIMA and to compare their performance to ANN and ARIMA models by calculating the error measures.
3. ANN-ARIMA Modeling of Exchange Rates

The model consists of two stages. In the first stage ANN is used to predict the exchange rates using four predictors, namely two yearly moving average, one yearly moving average, six monthly moving average and three monthly moving average. Then the generated residuals are provided to give the forecast. In the second stage, the predicted price by ANN is summed with the error forecast generated by ARIMA which produces the final forecasted value. The input series is the residual or error generated from the difference of actual and predicted exchange rates of the indices from ANN model during the same time period. First stage is to verify the normality and the stationarity of the residual.

The tentative values of three parameters $p$, $d$ and $q$ of ARIMA ($p$, $d$, $q$) are got by performing various iterations. The residual plot generated indicated that ARIMA $(0, 1, 1)$ is the model that fits the residuals generated by the ANN. Finally the integrated forecast is made by adding the predicted rates by ANN with the error forecast by ARIMA.

4. ANN-ARIMA-ARIMA and ANN-ARIMA-ANN Modeling

This model consists of three main procedures which involve ANN modeling, ARIMA modeling and again ARIMA modeling in sequential order. Firstly Artificial Neural Network (ANN) is used to fit the data, then ARIMA is fitted to the residuals.

The integrated values are again compared with the actual values and once again the residuals obtained in the process are forecasted using ARIMA and ANN modeling. Finally these values are integrated with the previously forecasted values to give the final forecasts.

5. Error Estimates of the Models

Hybrid model developed using ANN and ARIMA were compared with the conventional models using ARIMA, ANN techniques and the error measures Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Mean Square Error (MSE) and Root Mean Square Error (RMSE).
Table 1: Error Measures for Exchange Rates using ANN, ARIMA, Hybrid ANN-ARIMA, Hybrid ANN-ARIMA-ARIMA, Hybrid ANN-ARIMA-ANN

<table>
<thead>
<tr>
<th>Error Measures</th>
<th>ARIMA</th>
<th>ANN</th>
<th>ANN-ARIMA</th>
<th>ANN-ARIMA</th>
<th>ANN-ARIMA-ANN</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE</td>
<td>0.491</td>
<td>0.439</td>
<td>0.270</td>
<td>0.364</td>
<td><strong>0.168</strong></td>
</tr>
<tr>
<td>MAPE</td>
<td>1.0697</td>
<td>0.9563</td>
<td>0.5935</td>
<td>0.7960</td>
<td><strong>0.3689</strong></td>
</tr>
<tr>
<td>MSE</td>
<td>0.628</td>
<td>0.444</td>
<td>0.148</td>
<td>0.252</td>
<td><strong>0.048</strong></td>
</tr>
<tr>
<td>RMSE</td>
<td>0.793</td>
<td>0.666</td>
<td>0.385</td>
<td>0.502</td>
<td><strong>0.219</strong></td>
</tr>
</tbody>
</table>

Figure 1: Bar chart showing the Mean Absolute Percentage Error (MAPE) for the various models

Figure 2: Actual and Predicted Chart for various models (Exchange Rates)
6. Conclusion

From the various techniques used to model the US Dollar Exchange Rates, it can be seen that ANN-ARIMA-ANN superseded all the other methods in all the error estimates (Table 1). This can also be confirmed from Figure 1, that the MAPE value for ANN-ARIMA-ANN is very low compared with all other estimates. Comparative graph plotted between actual and predicted values for all the models (Figure 2) shows the superiority of the hybrid model ANN-ARIMA-ANN. Hence it can be concluded that the hybrid models using ARIMA and ANN is the best alternative model for forecasting non-stationary time series data as it gives the lowest values for RMSE, MSE, MAE and MAPE compared to other models.

References


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