Chapter 6

Conclusion and Future Directions

6.1 Conclusion

For many decades, financial time series forecasting have been studied using conventional and traditional statistical linear models. They have seldom proved successful due to the presence of noise and non-linearity in the time series data. Successful application of non-linear methods in numerous areas of research has kindled the hopes of financial researchers. It was observed that the past values of the time series will help to determine the future values. But the relation of past values to future values is non-linear and non-linearity implies that any change in the past values can have wide range effects on future values. Recent studies have revealed that wavelet analysis has shown a tremendous performance in the area of financial time series analysis due to its litheness to handle very irregular time series data. On the other hand, artificial neural networks have ability to approximate any discontinuous function by formalizing unclassified information without requiring any prior assumption about the characteristics of the data series contrasting the traditional forecasting methods which assume linear relationship between inputs and outputs have also shown significant efficiency in forecasting time series data.

In recent years, there has been considerable interest shown by researchers for forecasting financial time series using hybrid models and there is no reason to invalidate that hybrid models provides reasonable performance for different forecasting horizons. In this study, we use an integrated approach of wavelet analysis and neural networks to investigate different aspects of financial time series with economically meaningful variables. We observe that optimal forecasting is achieved by using the hybrid model of wavelet and neural networks than conventional models and this study further reveals the efficiency and significance of wavelets and artificial neural networks in forecasting financial time series. We observe that combined model of wavelet and neural network overcomes the deficiency of traditional forecasting models which seems to be limited to linear system for forecasting. The main findings of this study can be summarized as
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follows:

1. We analyze the ability of yield spread for forecasting IIP (Index for Industrial production) growth using hybrid model of wavelet and neural network. The study demonstrated that both the approaches i.e., individual ANN and WNN can effectively forecast the IIP growth than other conventional models as improved results are obtained in both the cases. The spread provides superior recession forecasts, especially up to 1 year ahead and that spread is a dependable predictor of output growth. The improved forecasting efficiency is achieved when lagged IIP growth values are used. Wavelet neural network model gives slightly superior forecasting results than individual artificial neural network model.

2. A hybrid wavelet network that comprise of a Daubechies wavelet and a simple MLPPN (Multi-layer Perceptron Neural Network) model is used to analyze the relationship between real effective exchange rate and crude oil prices. The study for India specify that crude oil prices do influence the real effective exchange rate and the hybrid model better untangle the relationship between real effective exchange rate and crude oil prices than individual ANN model or wavelet based approach. The crude oil price is a dependable predictor of real effective exchange rate and provides superior forecasts.

3. We propose a hybrid wavelet and neural network model which consist of a simple MLPNN and wavelet based decomposition to analyse the relationship between 5 stock markets which includes NIFTY from India, SHCOMP from China, DAX from Germany, FTSE-100 from United Kingdom and NKY from Japan. These stock markets are studied in relation to NASDAQ from U.S. stock market independently. The study reveals the hybrid model of wavelet and neural network better unravel the relationships between financial institutions and can provide a valuable alternative to the existing conventional methods in testing financial contagions.

4. One more study evaluates the effect of 16 mother wavelet functions on the performance of the hybrid wavelet Multilayer Perceptron Neural Network (MLPNN) model for forecasting IIP Growth with Yield spreads by using DWT technique. It further investigates the selection of a suitable decomposition level for the DWT. The results of this hybrid model are compared with artificial neural (ANN) model for gauging its
performance. The wavelet based neural network models for IIP Growth–Yield Spread modeling performed better when approximation is done with Daubechies wavelet than other wavelets. The hybrid model has better performance when time lagged yield Spread is used for modeling for producing better IIP growth forecasts. The yield spread in general is a dependable predictor of output growth like IIP growth and spreads provide better recession forecasts than other conventional models.

6.2 Future Directions

The highly effective hybrid model based on wavelets and artificial neural networks presented in this study can also be applied to other real world problems to forecast different types of variable such as foreign exchange rates, inflation rates, spillover effect among different countries, gold prices, prediction of bankruptcy, prediction of hydrology and water resources, renewable energy, wind energy, electric load forecasting, software reliability, software cost estimation, pattern recognition, weather forecasting and so on. Therefore, in future work we plan to investigate the applications of hybrid wavelet neural networks for the above mentioned problems. In particular, we will try to apply our hybrid model to the below mentioned real world problems because of the following reasons:

1. **Forecasting foreign exchange rates**

   In recent years, a great deal of effort has been made in order to gain advantages in foreign exchange (FX) rate predictions., however most existing techniques seldom excel the simple random walk model in practical applications. Therefore, the model described in our thesis formed by coupling the wavelets and neural networks may be a good candidate to describe and model non-stationary, nonlinear time series.

2. **Gold price forecasting**

   It has been a hot issue in economics recently. Actually, in ancient times, gold has been recognized as a symbol of wealth and a frontier-less currency that can be easily exchanged among different monetary systems but in recent times, gold has gradually become a popular nonmonetary tool in the financial market, which is characterized by high yield and high-risk. Gold price is partly regarded as a reflection of investors’
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expectations and the world’s economic trends. Thus, gold price forecasting is a vital issue in economics and we believe that our prescribed model will provide better and most accurate results.

3. **Prediction of bankruptcy**

   For financial firms especially banks it has been the extensively researched area from many decades. Actually, creditors, auditors, stockholders and senior management are all interested in bankruptcy prediction because it affects all of them in the same way. Therefore, it very difficult to forecast bankruptcy as there are many other variable on which it depends such as capital adequacy, asset quality, management expertise, earnings strength, liquidity, and sensitivity to market risk. We expect better forecasting results by using the hybrid approach of wavelet and neural networks.

4. **Software reliability**

   It deals with behaviour of a software system and is defined as the probability of working without failure for a specified period of time. Software reliability prediction is a task where we try to predict the future failures and their cost using the past failure data of the software. We believe that the approach used in this study will provide better and most accurate results.

5. **Electric load forecasting**

   Accurate electric load forecasting could prove to be a very useful tool for all market participants in electricity markets because it cannot only help power producers and consumers make their plans but also can maximize their profits. In addition, the electric load is always influenced by various factors, including weather conditions, social and economic environments, dynamic electricity prices and more. Therefore, in the power system, the electric load is difficult to forecast and remains an enormous problem. The goal of electric load forecasting is to take advantage of every model used and find a balance between production and consumption. In the electricity market, precise electricity demand forecasting is often needed and is fundamental in many applications. With an accurate, quick, simple and robust electric load forecasting method, essential operating functions such as load dispatch, unit commitment, reliability analysis and unit maintenance can be operated more
effectively. Thus, developing a method to improve the accuracy of electric load forecasting is essential and we expect our approach to be suitable in this case.

6. **Forecasting of hydrology variables**

   The accuracy prediction of hydrology and water resource can give important information for the city planning, land use, the design of civil project and water resource management. Hydrology system is influenced by many factors, such as weather, land with vegetal cover, infiltration, evaporation and transpiration, so it includes the good deal of stochastic dependent component, multi-time scale and highly nonlinear characteristics. It is recommended that future studies should explore the use of the WAVELET–ANN method in groundwater level forecasting and other watersheds in different geographical regions.

   Other application areas include forecasting lead times (such as daily, weekly, or yearly forecasting) for economical variables; comparing the forecasting performance of the wavelet based noise removal method to other filtering methods; comparing the use of different types of continuous (Morlet and Mexican Hat) and discrete (Daubechies) mother wavelets in the wavelet decomposition phase of the wavelet neural network forecasting method; comparing the wavelet neural network method with other new methods such as support vector regression with localized multiple kernel learning; and ensemble forecasting via the use of the bootstrap method to develop wavelet–bootstrap–neural network models.