Neuro Fuzzy Modeling

ABSTRACT

The modeling of stock market behaviour is one of the key areas of present financial research as stock market is the main determinant of economic development of a country. Worldwide a number of researches have been conducted on the modeling of relationship between macroeconomic indicators and stock market behaviour. But in the context of India not many researches can be traced in the literature. These are primarily based on statistical and econometric analysis, which are not much reliable because of lack of accuracy and non-linearity in the system. In the present study the researchers have made an attempt to develop the neuro fuzzy model, which is not been previously done by researchers in India. The model is based on the data for the period from April 1999 to March 2010. The study considered daily index of S&P CNX Nifty as an indicator of stock market behaviour and the real macroeconomic indicators (Gross Domestic Product, Index of Industrial Production and Inflation) as determining variables. The study finds that neuro fuzzy model developed for stock market behaviour is quite suited for this application.

Keywords: *Stock Market behaviour, Real Economic Indicators, Fuzzy Logic, Adaptive Neuro-Fuzzy*

of

The Impact Of Real Economic Indicators on Stock Market Behaviour:

Some Reflections From National Stock Exchange of India

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INTRODUCTION

The behaviour of stock market has been studied for many years and number of stylized facts have been applied. Since stock market is a complex dynamic system, it is difficult to deal with normal analytical methods. Many researchers (Abhyankar A et al., 1997) claim that the stock market is a chaotic system as it is a nonlinear process which can't easily be expressed. The existence of nonlinearity of stock market is propounded by many researchers and financial analysts. Most of them feel that to deal with system nonlinearity, non-conventional methods like artificial neural networks (ANN), fuzzy logic are considered best.

The impact of real macroeconomic indicators on stock market volatility has been studied extensively in finance literature. An illustrative list of studies includes Famma EF (1981), Ibrahim HM (1999), Ahmed MF (1999), Charkravarty S (2005), Mehr (2005), Chowdhary SS et al. (2006), Adam et al. (2008) etc. These studies identified macroeconomic factors such as gross domestic product, industrial production, inflation, trade balance, money supply and so on as being important in explaining stock market volatility.

In view of Corradi V & Distaso W (2009) studying the impact of real macroeconomic indicators on stock market volatility has important implications for both market practitioners and policy makers. Policy makers are interested in the main determinants of volatility and in its effects on real activity to conduct national macroeconomic policies without the fear of influencing capital formation and the stock trade process. Moreover, economic theory suggests that stock prices should reflect expectations about future corporate performance, and corporate profits generally reflect the level of economic activities. If stock prices accurately reflect the underlying fundamentals, then the stock prices should be employed as leading indicators of future economic activities, and not the other way around. Market practitioners are mainly interested in the direct effects time-varying volatility exerts on the pricing and hedging of plain vanilla options and more exotic derivatives.

Present research is focused on developing a neuro fuzzy model (a combination of fuzzy logic and artificial neural networks) for predicting stock market behaviour due to variations in real macroeconomic determinants. With a view to make the study specific and focused, researchers used only the real economic determinants. This paper consists of seven sections. First the introduction states the motivation and goal of the research by describing the importance of nonlinear modeling of stock market behaviour. In the second section, specific studies conducted on impact of macroeconomic variables on stock market behaviour are presented. Then a brief introduction of selected real economic indicators is described in section three. The fourth section deals with the aspects concerned with database and the neuro fuzzy modeling. The fifth section is the model development phase and comparison of results. In the last section conclusions are derived on the basis of developed models.

ITERATURE REVIEW

The relationship between macroeconomic variables and stock market returns is, by now, well-documented in the literature. Maysami RC et al. (2004) examined the long-term equilibrium relationships between selected macroeconomic variables and the Singapore stock market index. He concluded that the causal relations and dynamic interactions among macroeconomic determinants of the economy and stock prices are important in the formulation of the nation's macroeconomic policy. Leblebicioglu K & Aksoy H (2004) implemented a rule based fuzzy logic model to forecast the monthly return of the ISE100 Index by combining technical analysis, financial analysis and macroeconomic analysis.

Chowdhury SSH (2006) examined how the macroeconomic risk associated with industrial production, inflation, and exchange rate is related and reflected in the stock market return in the context of Bangladesh. He concluded that there is relation between stock market volatility and macroeconomic volatility. Engle RF & Rangel JG (2006) developed a model that allows long horizon forecasts of volatility to depend on macroeconomic developments, and delivers estimates of the volatility to be anticipated in a newly opened market.

Aguiar RA et al. (2006) presented empirical tests for the overreaction and under reaction hypothesis for petrol/petrochemical and textile firms in the Brazilian stock market. While, Humpe A & Macmillan P (2007) examined whether selected macroeconomic variables influenced stock prices in the US and Japan, Adam et al. (2008) in his study found that there is co-integration between macroeconomic variable and stock prices in Ghana indicating long run relationship.

Hassan R (2009) presented a novel combination of Hidden Markov Model (HMM) and Fuzzy model for forecasting stock market data. The experimental results clearly showed the improved forecasting accuracy compared to other HMM based forecasting model such as ARIMA and ANN. Hung JC (2009) derived a new application of fuzzy systems designed for a GARCH model and showed results by applying the method of functional fuzzy systems to analyze the clustering in the case of a GARCH model by using data from the Taiwan weighted index (Taiwan) and the NASDAQ composite index (NASDAQ). From the simulation results, researcher determined that the performance is significantly improved if the leverage effect of clustering is considered in the GARCH model. Othman et al. (2010) presented the use of fuzzy if-then rules for a decision support system in stock trading with the help of three linguistic variables namely view from the expert, earning per-share and price to earnings ratio. The purpose of the study was to assist investors in making a decision on their shares as the investors need to make a right decision to gain a high profit in stock trading. The study concluded that using the artificial intelligence application with the fuzzy logic can make it simpler as well as beneficial to investors. Most of the above reviewed research works show that fuzzy logic can work successfully within stock market environment.

JUSTIFICATION OF INDICATORS SELECTION

As, the present research is focused only on the real macroeconomic determinants of stock market environment, researchers have been selected various macroeconomic indicators from seven different published researches in order to find which were considered the most significant. The sources of selecting the variables and the variables used in them are listed below in the table 1.

Variables used by above studies belong to different sections of economy as FX Reserves, FX Rate, Balance of payments belong to forex economy. Repo Rate, Treasury Bills Rate, Interest rate are the money market indicators. But, researchers want to focus only on the Real economy, which is the physical side of the economy dealing with goods, services and resources. This side is concerned with using resources to produce the goods and services that make the satisfaction of wants and needs possible. For the present study the researchers have selected following indicators from several real macroeconomic indicators that reflect the stock market performance.

Table 1: Justification of Variables Base

S. No.	Source	Variables Used
1.	Ali I et. al. (2010)	Inflation, Money Supply, Industrial Production, Exchange Rate, Balance of Trade
2.	Corradi V & Distaso W (2009)	Inflation, Industrial Production
3.	Adam et. al. (2008)	Exchange Rate, Inward FDI, Oil Prices, Inflation, Interest Rate
4.	Diebold FX and Yilmaz K (2008)	GDP, Inflation, Real Consumption Expenditure
5.	Humpe A & Macmillan P (2007)	Industrial Production, Inflation, Money Supply, Interest Rate
6.	Maysami RC et. al. (2004)	Interest Rate, Inflation, Exchange Rate, Industrial Production, Money Supply
7.	Leblebicioglu K&Aksoy H (2004)	Gross National Product, Industrial Production, Capacity Utilization, Balance of Payments, FX Reserves, FX Rate, Budget Deficit, Repo Rate, Treasury Bills Rate

- Gross Domestic Product (GDP): GDP is the value of all goods and services produced in the economy in the given period.
- Index of Industrial Production (IIP): Index of Industrial Production is indices prepared by the government that provides a fixed weight measure of the physical output of the nation's factories, mines and utilities.
- Inflation Rate / Wholesale Price Index (WPI): Inflation rate is the percentage rate of increase of the level of prices during a given period, usually measured by the Consumer Price Index (CPI) and the Wholesale Price Index (WPI). WPI is considered as much better indicator of inflation rate because CPI measures monthly change in the prices of a defined basket of consumer goods, whereas WPI measures changes in prices in the manufacturing and distribution sector of the economy that tends to lead the consumer price index by 60 to 90 days. Researcher selected the data on WPI as the indicator of inflation for modeling.

DATABASE AND NEURO FUZZY MODELING

Database

It is generally said that data selection must be performed judiciously to avoid the "garbage-in, garbage-out" syndrome often associated with computers. So, the performance of fuzzy logic is also highly dependent on the quality & appropriateness of its input data. If relevant data inputs are not included, the performance will suffer needlessly. For modeling purpose, the daily S&P CNX Nifty daily index is taken as dependent variable. The data are collected from the website of the National stock Exchange (NSE) (www.nseindia.com). S&P CNX Nifty is a well-diversified 50-stock index accounting for 23 sectors of the economy (Saxena SP & Bhadauriya S, 2012). Three real macroeconomic variables, viz; Gross Domestic Product (GDP), Index of Industrial Production (IIP) and Inflation (Wholesale Price Index, WPI) are taken as the independent variables. Data of these variables are collected from the website of Reserve Bank of India (www.rbi.org). With a view to develop model for measuring the impact of selected macroeconomic indicators on variations in S&P CNX Nifty, eleven year data from 1999-00 to 2009-10 is taken. For training and testing purpose, data is divided into two sets. The first set is training set consisting of eighty percent of data, and the second one is testing set consisting of remaining twenty percent data. Data for testing is selected from the data series of selected variables by separating the value of every fifth item from the series. Keeping in mind the weaknesses of conventional analytical techniques and to measure the appropriateness of non-conventional analytical techniques, researchers applied neuro-fuzzy based model as a forecasting tool to predict the behavior of the stock market. To judge the accuracy of models on different points of time, researchers developed long term and short term models simultaneously. Annual and monthly mean average of variables is used respectively for long term and short term models. Detailed description of data compilation is mentioned in table 2.

Table 2: Data Compilation

Variable Name	Collected Data Cycle (Data Source)	Data Compiled for Short Term Model	Data Compiled for Long Term Model
S&P CNX Nifty (Base: 1995)	Daily (www.nseindia.com	Mother Average $=\frac{N_1+N_2+...N_k}{K}$ Where, n=S&P CNX Fifty	Yearly Average $=\frac{N_1+N_2+...N_k}{K}$ Where, n=S&P CNX Nifty
GDP (In Thousand Crore Rupees)	Quarterly (www.rbi.org)	Constant for all three months, we considered quarterly data	Yearly Average $=\frac{Q_1+Q_2+Q_3+Q_4}{4}$ Where, Q= Quarterly GDP
IIP (Base: 1993-94)	Monthly (www.rbi.org)	Monthly	Yearly Average $=\frac{M_1+M_2+M_{12}}{12}$ Where, M= Monthly IIP
WPI (Base: 1993-94)	Monthly (www.rbi.org)	Monthly	Yearly Average $=\frac{M_1+M_2+M_{12}}{12}$ Where, M= Monthly WPI

EURO FUZZY MODELING

Fuzzy Logic was initiated in 1965 by Zadeh A Lotfi, professor for computer science at the University of California in Berkeley. Basically, Fuzzy Logic is a multi-valued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth - truth values between "completely true" and "completely false". But, it requires a sufficient expert knowledge for the formulation of the rule base, the combination of the sets and the defuzzification. In general, the employment of fuzzy logic might be helpful, for very complex processes, when there is no simple mathematical model, for highly nonlinear processes or if the processing of expert knowledge is to be performed. One another latest non-linear modeling technique, which is significantly applied by the financial researchers, is Artificial Neural Networks (ANN). An ANN model self discovers nonlinear relationship in the nonlinear relationship in the input data set without a priori assumption of thenknowledge of relation between the input and the output. They independently learn the relationship inherent in the variables (Hagen MT et al., 1996).So, neural network is also a better model than others for instudying the stock market behaviour.

Chaturvedi DK (2005, 2009) observed that neural networks and fuzzy systems have their own advantages and disadvantages. Both the systems are very different but they have a close relationship because both of them can work with imprecision in a space that is not defined by crisp, deterministic boundaries. The shortcomings of neural networks and of fuzzy systems may be overcome if both operate competitively and co-operatively. Fuzzy model requires large power in representing linguistic and structured knowledge by fuzzy sets and usually rely on the domain experts to provide the required knowledge for a specific problem. On the other hand, artificial neural networks models are particularly good for nonlinear mappings because these models are developed via training. Combination of fuzzy systems and neural networks is known as neuro fuzzy model. So, the neuro fuzzy approach of modeling has also been applied by the researcher to make the study more scientific, accurate, and logical. For developing fuzzy and neuro-fuzzy model of stock market behaviour, Fuzzy toolbox of MATLAB (7.0) is used. Steps followed by the researcher in the present study for developing neuro fuzzy modeling are as follows:

1. Identification of key variables and their ranges
2. Development of fuzzy knowledge base
3. Development of fuzzy rule base
4. Results of fuzzy logic modeling
5. Development of neuro fuzzy logic based model
6. Training and testing of neuro fuzzy model

Financial Modeling

In this phase of the study, researchers developed fuzzy logic based and neuro fuzzy logic based models for prediction of stock market behavior using previously stated six steps.

Step 1: The first step in model development is the identification of key variables and their ranges. Justification of selected real macroeconomic indicators (GDP, IIP, WPI) and

the selection of dependent variable (S&P CNX Nifty) is already discussed. To identify the range of selected variables, simply the minimum and maximum value of the data have been traced and the ranges have been decided and presented in table 3.

Table 3: Data Compilation

Variable Name	Variable Type	Range
S&P CNX Nifty (Base: 1995)	Dependent	830–6310
GDP (In Thousand Crore Rupees)	Independent	386–1546
IIP (Base: 1993-94)	Independent	128-368
WPI (Base: 1993-94)	Independent	116-276
Source: Researcher Own Experience (Judgement)		

Step 2: The second step in model development is concerned with development of fuzzy knowledge base, to divide the range of selected variables in several membership functions. First the researchers divide the data into five membership functions (very low, low, medium, high, very high) by taking the reference of Leblebicioglu K & Aksoy H (2004), they also divide the data in five membership functions (very bad, bad, neutral, good, very good). But the data set is too long in comparison to Leblebicioglu K and Aksoy H (2004), so the researchers decided to increase the number of membership functions of the variables for constructed a better model. And the allotted linguistic terms for these membership functions are: Extremely Low, Very Low, Low, Lowly Medium, Medium, Highly Medium, High, Very High and Extremely High. Membership values given to these membership functions are shown in following Figure 1. Zero denotes the minimum value of the input variables and one indicates the maximum value of the variables.

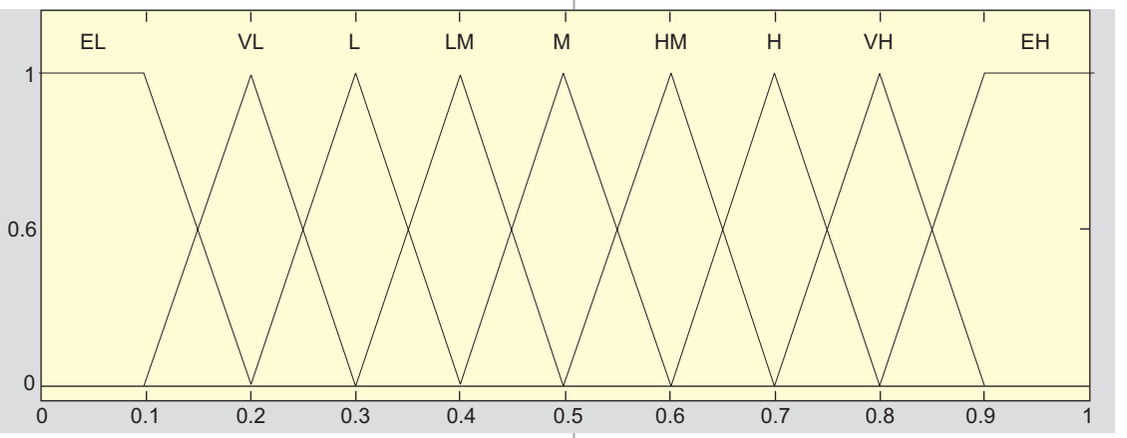

Figure 1 : Fuzzy Membership Functions of Input Variables

There are two important methods for developing fuzzy modeling viz. Mamdani Method introduced by Mamdani and Assilian, 1975 and Takagi-Sugeno-Kang Method introduced by Sugeno, 1985, which is popularized as Sugeno Method (Sivanandam SN et al., 2007). The main difference between these two is that the Mamdani output membership functions are also allotted by the model developer but the Sugeno output membership functions are established itself through the linear dependency of each fuzzy rules on the input variables. Sugeno method is considered ideal for acting as an interpolating supervisor of multiple linear controllers that are to be applied, respectively to differed operating conditions of a dynamic nonlinear system because of the linear dependence of each rule on the input variable of the system. The researchers used Sugeno method of fuzzy inference for fuzzy modeling because it has guaranteed continuity of the output surface.

Step 3: For the development of fuzzy rule based model the researcher established 93 rules on the basis of their intuition and collected data of variables. A large number of rules are framed because of high degree of variations in the stock market indices. These rules are defined on the basis of causal relationship between identified variables (Chaturvedi DK 2010). Causal links between the variables have been developed by System Dynamic methodology in the software Vensim PLE. The developed causal loop diagram is shown in Figure 2. The figure clearly shows positive causal links between the input variables and the output. So, some of the rules developed by the researchers are listed below:

- If GDP is EL, IIP is EL, WPI is EL then S&P CNX Nifty is EL.
- If GDP is VL, IIP is VL, WPI is VL then S&P CNX Nifty is VL.
- If GDP is L, IIP is L, WPI is L then S&P CNX Nifty is L.

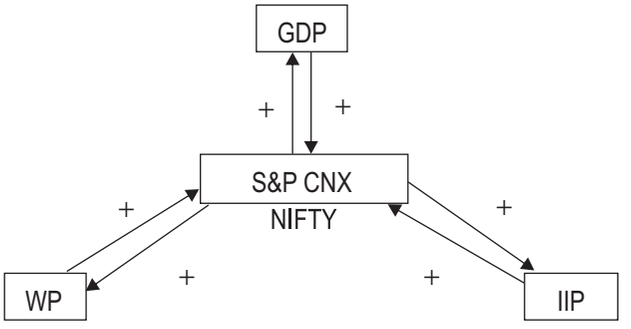

Figure 2 : Causal Loop Diagram for Stock Market Indices and Macroeconomic Determinants

Step 4: After developing fuzzy knowledge base and fuzzy rule base, the next step is to check the results by the defuzzification of the rules (get the value of output variable from the construct rule base). The weighted average method is adopted for defuzzification. The comparison of actual output and the fuzzy results are presented in Figure 7 and 8 for long-term and short-term models respectively. The results are very close to the actual outputs on some points of time but on some points it is far away from the actuals. In spite of, making a large number of fuzzy rules, the model is still failed in predicting actual output value. Because the fuzzy knowledge base developed in previous steps is fixed and does not have adaptability. Hence, the researchers used Neuro-Fuzzy approach to make it more flexible and adaptive.

Step 5: The Adaptive neuro fuzzy logic inference system (ANFIS) model is developed by Grid partition Method in the fuzzy logic toolbox of MATLAB. Block diagram of ANFIS model of Stock Market behaviour is depicted in following figure 3, which simply shows the combinations of fuzzy logic and artificial neural networks.

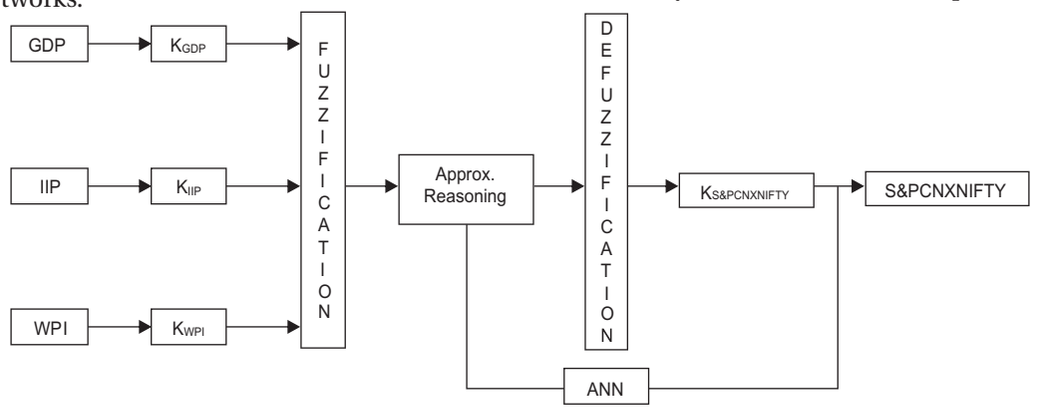

Figure 3 : Block Diagram of ANFIS Model of Stock Market Behaviour

In the figure GDP, IIP and WPI are the inputs, K is any value taken from the data series, and fuzzification means to use the fuzzy rule base. At the stage between fuzzification and the defuzzification the adaptability of ANN is also applied. Then the values of output are traced.

Step 6: In the above process, the researchers developed long-term and short-term models for predicting stock market behavior. For verification purpose, these models are trained and tested. The models are trained by using Hybrid method of measuring the deviation between the model responses and the actual responses. The training results are shown in figures 11 and 12, which show the diminishing value of the training error with the increasing number of epochs. The results of testing are presented in table 4.

Table 4: Testing Results

Model	Average
Long Term ANFIS Model	0.000004
Short Term ANFIS Model	0.076

The average testing errors for Adaptive neuro fuzzy models are very low as 0.000004 for Long term and for short term 0.076. So, the output results have been compared with the actual values of output with a view to recognize deviation between the results of simple fuzzy logic models and the adaptive neuro fuzzy logic models as shown in figure 9 and 10. Figures show that the ANFIS model proved much better of stock market behavior than the simple fuzzy logic based model for both the long-term and short-term model.

CONCLUSIONS

In nutshell, there is a positive causal links between the real macroeconomic indicators and the stock market indices, meaning that real macroeconomic fundamentals / news can be used to predict stock market behavior. Moreover, stock market indices can also be used to assess the macroeconomic movements in India. The graphical effects of Gross Domestic Product (GDP), Index of Industrial Production (IIP), and Inflation Rate (WPI) on S&PCNX Nifty are shown in Figure 4 to 6. The fuzzy and neuro-fuzzy based models developed for predicting stock market behavior due to real economic indicators show that both these models are quite suitable for application. However, the adaptive neuro-fuzzy model is more successful in predicting the stock market behavior, as it minimizes deviation between model responses and the actual responses.

The results of the study also indicate that both the modeling approaches are perfect for complex problems, which are highly nonlinear in nature and both the modeling techniques have their advantages and limitations. As a fuzzy logic based model possesses large brain power and time in representing linguistic and structured knowledge by fuzzy sets and membership functions but the behavior of fuzzy models can be understood easily due to their logical structure and step-by-step inference procedures. On the other hand, a neural network normally acts as a black box, without providing explanation facility but particularly well for non-linear mappings and for providing parallel processing facility to simulate complex system because these models are developed via training. Hence, it is quite natural to consider the possibilities of integrating the two paradigms, in order to utilize the desired strength of both types of models to produce improved results.

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APPENDICES

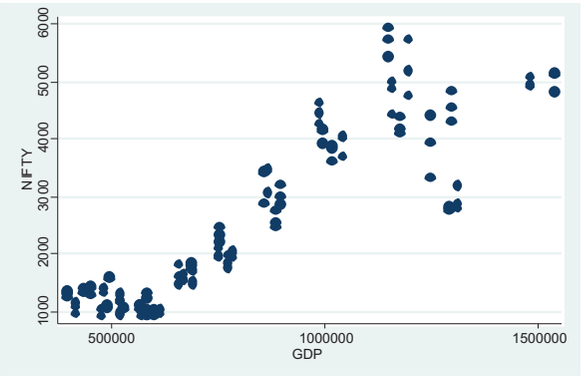

Figure 1 : Effect of GDP on S&PCNXNIFTY

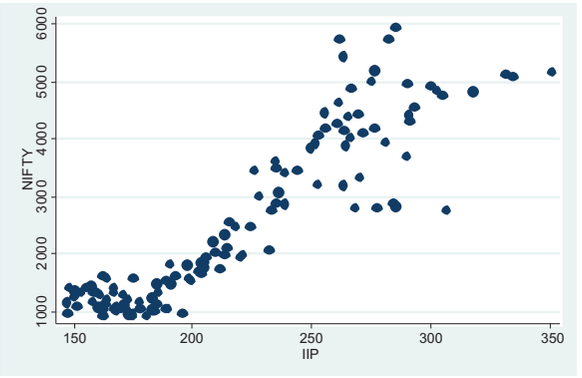

Figure 2 : Effect of IIP on S&PCNXNIFTY

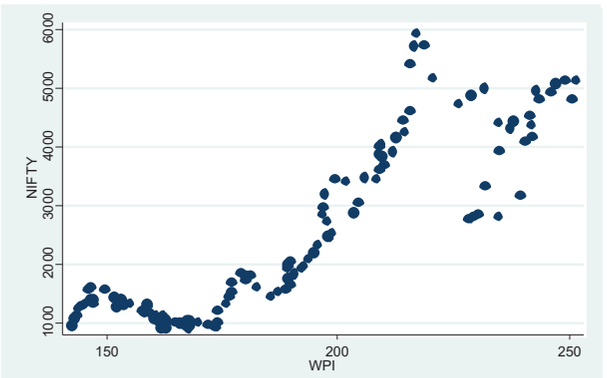

Figure 1: Effect of WPI on S&PCNXNIFTY

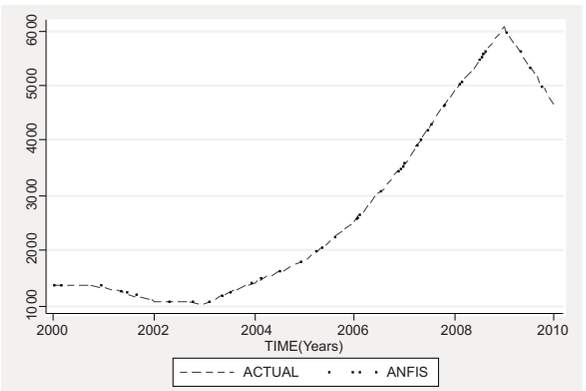

Figure 9: S&PCNXNIFTY (Long Term ANFIS Model)

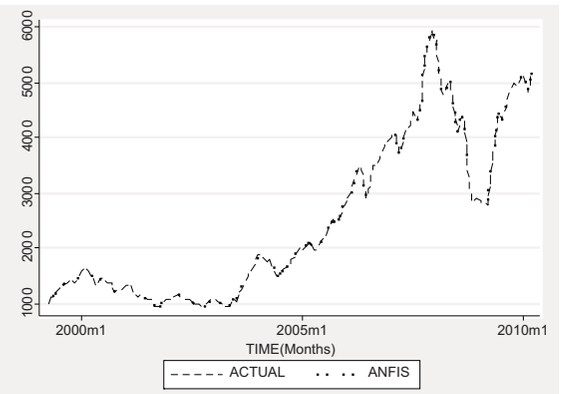

Figure10: S&PCNXNIFTY (Short Term ANFIS Model)

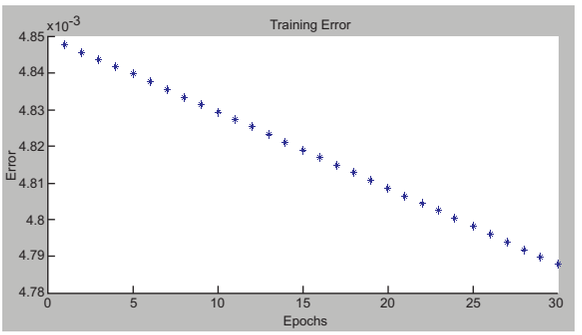

Figure 11: Training of Long Term Model

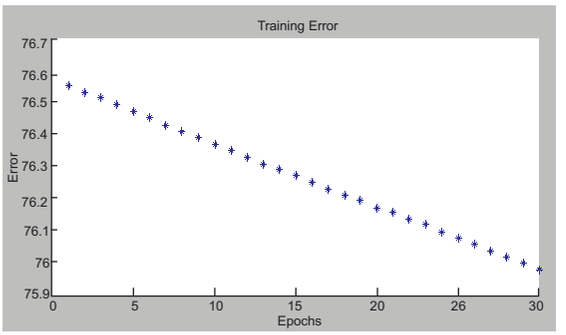

Figure 12: Training for Short Term Model