International Journal of Soft Computing 12 (2): 120-131, 2017
ISSN: 1816-9503

Forecasting the Stock Index Movements of India: Application of Neural Networks

Sigo Marxiaoli, Murugesan Selvam, Kasilingam Lingaraja and Vinayagamoorthi Vasanth
Department of Commerce and Financial Studies, Bharathidasan University,
620024 Tiruchirappalli, Tamil Nadu, India

Abstract: Prediction of financial markets, especially prediction of highly volatile stochastic stock market indices, plays a crucial role in identifying profitable investment avenues by the financial investors at large. The investing community encompasses retail investors, financial institutions, investment banks and Foreign Institutional Investors who look for the creation of wealth in the form of capital appreciation and earning the title of ownership of business enterprises by investing in the securities market, through buying and selling of shares of stock exchange listed corporate entities. The forecasting of dynamic financial market movements is one of the scientific endeavours which demands a great deal of market intelligence, financial acumen and domain knowledge of the characteristics of behavioural finance in a wider spectrum. This paper aims to discuss the non-linear movement pattern/trend of the most active two stock indices of India, namely, the Sensex and Nifty, during the study period from 2009-2015 by applying the traditional logistic regression method and one of the neural network tools, namely, k-nearest neighbourhood algorithm. This study would help the investors to streamline their investment patterns and strategies in order to take well informed investment decisions and optimize their stock returns by using the relevant market information.

Key words: Artificial intelligence, behavioural finance, capital market, forecasting, investment, neural network, predictive analytics, regression, stochastic and stock index

INTRODUCTION

The forecasting of stock price/value and stock indices movement is difficult due to the existence of a higher rate of volatility in stock markets. There are two types of analysis which investors usually undertake before investing their hard earned money in a company stock. The foremost of this kind is the fundamental analysis and the next one is the technical analysis. Under fundamental analysis, investors assess the intrinsic value of company shares, performance of the industry and economy to decide whether to invest or not in a particular stock or stock index. On the other hand, the technical analysis is the evaluation of stocks by means of studying the statistics generated by market activities such as past prices and volumes (Patel *et al*., 2015a, b). The technical analysts do not attempt to measure the intrinsic value of the share of a listed company but instead use stock charts to identify price movement patterns and trends that may suggest how a stock will behave in the future.

The efficient market hypothesis, propounded by Malkiel and Fama (1970), states that prices of stocks are informationally efficient which means that it is possible to predict stock prices based on the daily trading data. It is quite possible that many uncertain factors like political scenario of the country, public image of the company, etc., would affect the stock prices. Hence, if the information obtained from stock markets is pre-processed efficiently and appropriate algorithms are applied, then the trend of a specific stock or stock index may be predicted for a future time period.

In the highly globalized, market-driven, free flowing business, capital, trade and economic environment, the probabilities of financial crises are unavoidable. Many financial crises have led to the existing economic system getting better because in the absence of financial flux, people may become complacent. The governments frequently collapse and rebuild. Like companies failing, the nations also have to learn to adapt to the new economic world order so as to grow stronger in a sustainable manner (Taleb, 2016).

Scientific methods of forecasting facilitate the investors to take well-informed and timely investment decision which encompasses factors such as timing of investments, stock selection, quantum of investments, portfolio management and maximizing the stock returns. Many techniques have been developed to predict the stock market trends accurately. Different statistical tools

Corresponding Author: Sigo Marxiaoli, Department of Commerce and Financial Studies, Bharathidasan University, 620024 Tiruchirappalli, Tamil Nadu, India

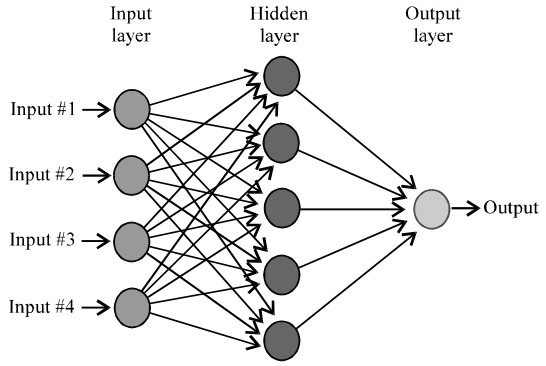

Fig. 1: Neural network data processing module; wikipedia

have been applied to predict the stock prices. In order to assess the nature of the application and the strength of the internal data patterns, the network approaches are used to address the problems of relationships which may be quite dynamic or non-linear like stock market price movements. Some of the neural network methods which are widely used for prediction of stock market movements, are Artificial neural networks, Back propagation algorithm, Support vector machine, Fuzzy logic and k-nearest neighbourhood algorithm (Schmidhuber, 2015).

The pictorial representation of a simple neural network is exhibited in Fig. 1. A gamut of preprocessed data collected from various sources, are fed through different input layers as input. The input data is processed in the spectrum of multiple layers in the hidden layer module. The well processed, refined data derived in this process is the final output which signifies the research result of a business problem/scientific phenomenon.

Literature review: An extensive review of literature in the area of prediction of stock indices was done by the Researchers, so as to improve the level of understanding of the predictive analytics of markets. The following reviews were based on many sources and they include the research articles published in reputed professional journals.

Etzioni (1976) delineated the prediction of stock market indices and the price movements of individual stock values and explained the difficulties in making specific predictions. The unexpected vectors would intervene to throw off all the forecasts. It was pointed out that buying a stock, exactly when the price is at the lowest and making a sale when the market price of the share is at the highest, would make the investors to benefit the most. In the study, Kohzadi *et al.* (1996) compared the methodology, advantages and demerits of artificial neural network and time series models which are used for analyzing and forecasting the highly volatile commodity price movements. The mean squared error, absolute error and mean absolute percent error were all lower on an average for the neural network approach than for the time series models like Auto Regressive Integrated Moving Average (ARIMA). Walczak (1999) forecasted the fluctuations of financial markets which vary on chronological time and geographical space across the economies of the globe. The rate of financial literacy was considered as one of the crucial factors which influence the investment decisions of the investors. Hansen and Nelson (2003) applied a time-delay neural network which receives the resulting components as inputs and the outputs of this neural network are then became the input to a back propagation algorithm which synthesizes the processed components into a single forecast. Kuo (2006) classified the networks into linear, passive, reciprocal, causal and time invariant and each one of the network approaches has different characteristic properties accordingly. Jasic and Wood (2004) calculated the profitability of stock indices, based on daily trades, by applying neural network for the highly volatile stock index movements of S and P 500, the DAX, the TOPIX and the FTSE. Single hidden layer models were built using a time-delay embedding technique for input units with varying number of nodes. Carvalhal and Mendes (2008) analyzed the forecast performance of emerging market stock returns, using standard Auto Regressive Moving Average (ARMA) and more elaborated Auto Regressive Conditional Heteroskedasticity (ARCH) models and the results indicated that the ARMA and ARCH specifications generally outperformed than the random walk models. Zhu *et al.* (2008) explained the technicalities of predicting stock index movements, by using different neural networks, the role and influence of trading volume under different time horizons of various stock market indices like DJIA and STI. According to Hanson and Oprea (2009), the novelty, complexity and anonymity of forecasting the stock markets influenced some observers to fear that prediction of stock price would be misused. Boyacioglu and Avci (2010) predicted the return on stock price/index value of the Istanbul Stock Exchange (ISE) with the help of Adaptive Network-Based Fuzzy Inference System (ANFIS) and by using six macroeconomic variables and three indices as input variables. The experimental results revealed that the model successfully forecasted the monthly return of ISE national 100 Index with an accuracy rate of 98.3%. Robert Snigaroff and Wroblewski (2011) ran two regressions, involving the price-to-dividend ratio and squared-error processes of both the Shiller model and the NV model, to gauge the forecasting abilities of each model. Simon and Raoot (2012) applied Artificial Neural Network (ANN), one of the

proven methods of neural network and data mining to predict the stock price movements. The selection of appropriate number of hidden layers, number of neurons in each layer, size of the training set, initial values for weights, inputs to be included, activation function are the key issues in designing a network model. Subha and Thirupparkadal Nambi found that research on predictability of stock indices was significant owing to the dynamic nature of the stock markets and used k-nn algorithm, a data mining technique, to increase the accuracy of prediction of stock index movement of BSE-Sensex and NSE-Nifty. According to Wang and Shang (2014), an accurate prediction of stock index movement may not only provide reference value for the investors to make effective strategy but also for policy makers to monitor the stock markets, especially in the emerging economies. Least Square Support Vector Machine method outperformed Linear Discriminant Analysis (LDA) and Quadratic Discriminant Analysis (QDA) in both training and testing accuracy. Wu and Lee (2015) analyzed the Box-Jenkins model which requires the underlying time series to be stationary so as to make a successful prediction. Other statistical methods, like spectral analysis and Markov process, are based on the probability theory which needs prior knowledge of the underlying time series. According to Patel *et al.* (2015a), many techniques have been developed to predict stock movement trends of listed business enterprises. Initially, the classical regression methods were used to predict the trends. Uncertainty makes the forecasting of stock market a difficult function. Prediction performance of both indices and individual stocks, namely BSE-Sensex, NSE-Nifty, Reliance Industries and Infosys Limited were measured by using four predictive models, namely, artificial neural network, support vector machine, random forest and naive-bayes and the respective values were compared in a group. Patel *et al.* (2015b) assessed the movement of stock prices and the statistical validity of the volatility in index movements, by using various technical parameters. The predictions were made for 1-10, 15 and 30 days in advance by applying a combination of network approaches, artificial neural network and random forest methods.

It is inferred from the review of related research articles that most of the studies empirically supported the forecasting of stock index movements. Based on the above reviews, the researchers applied both traditional time-series approach (logistic regression) and neural network (k-nn algorithm) method in this study so as to predict the high growing Indian stock market.

MATERIALS AND METHODS

Statement of the problem: The prediction of individual stock prices and index stock movements is one of the classic problems of the stock market behaviour (Patel *et al.*, 2015b). Minimizing the risk and maximizing the stock return on investment are some of the issues concerning the capital market. There are a number of studies to forecast the movement of stock indices and to assess the stock returns of various stock markets of the world economies for different time horizons. It is a known fact that investors normally find it difficult to earn profits by buying and selling of shares. Investors lose their hard-earned money in the stock market due to lack of adequate financial literacy about the stock market movements which are highly non-linear in nature (Boyacioglu and Avci, 2010). But the forecasting of stock indices, especially prediction of highly stochastic, key stock indices of the ever growing Indian economy, like BSE-Sensex and NSE-Nifty has become a daunting task since only a few studies focused on the prediction of Indian stock indices by using the proven tools like regression, autoregressive integrated moving average and artificial neural network that do exist in this regard (Patel *et al.*, 2015a). The absence of proven forecasting techniques, to exactly predict the movement of stock index values, signifies the magnitude and severity of this issue. The forecasting of stock price/index movement is difficult due to the presence of uncertainties and risk of return on invested capital in the context of highly globalized free flowing capital, trade and business market environment of the world order. Against this background, an attempt has been made in this study, to forecast two stock indices viz., BSE-Sensex and NSE-Nifty, by using proven forecasting techniques, namely, logistic regression and k-nearest neighbourhood algorithm.

Need of the study: The prudence of forecasting of stock price and index movement is the prime motive from the point of view of investors who are really interested in maximizing their financial wealth, by making investments in financial assets like equity shares, preference shares, bonds and debentures which are normally traded in the stock exchanges. This study would help the investors, ranging from domestic retail investors, financial institutions, mutual funds, investment banks, overseas corporate bodies to Foreign Institutional Investors (FIIs), to take well-informed investment decisions, based on scientific thinking and rational approach (Etzioni, 1976). Besides, this study would be useful to develop an approach, based on proper assessment of fundamentals, operational efficiency, investor's sentiments, market

performance and probable future business prospects of the stock market behaviour. In light of the study, the investors could probably reap a higher rate of returns on their capital market investment. The traders could earn more by leveraging the high growth rate-driven stock market environment of any developing economy.

Objective of the study: The main objective of the study is to assess the historical price movements of stock index value and to forecast the probable future index movements of two major stochastic stock indices, namely, BSE-Sensex (www.bseindia.com) and NSE-Nifty (www.nseindia.com) which represent one of the rapidly developing vibrant economies of the globe, India for the study period starting from 1st January, 2009 to 31st December, 2015 (in the post global financial crisis 2008, scenario).

Hypotheses of the study: The present study aims at testing the following null hypotheses, relating to the movements of sample stock indices which were framed to test the validity of such stochastic movements.

- NH_1: there exists no non-linear movement in BSE-Sensex and NSE-Nifty, during the study period.
- NH_2: there is no corresponding linear relationship between BSE-Sensex and NSE-Nifty movements in terms of growth or downfall, during the study period

Sampling design of the study: Stock markets play a vital role in the economic growth and industrial development of any country and India, being one of the highly growing economies is not an exception to this phenomenon. India has become a robust developing economy, propelled by an average annual growth rate of >6% in terms of Gross Domestic Product (GDP) for the last 15 years, i.e. from 2001-2015 (The Economic Survey, Ministry of Finance, Government of India in 2015). Both Sensex and Nifty are the first ever and the prime stock indices of BSE and NSE of Indian Stock Market, respectively. These two stock indices, namely, BSE-Sensex and NSE-Nifty, represent the top market leadership position of listed business firms in their respective industrial sector/business domain. The S and P BSE SENSEX (S and P Bombay Stock Exchange Sensitive Index) is a free-float, market-weighted stock market index of top 30 financially sound companies, listed in the Bombay Stock Exchange (www.bseindia.com). Similarly, the CNX NSE-Nifty (CNX National Stock Exchange of India Fifty) is an index of top 50 financially strong companies, listed in the National stock exchange which represents 22 sectors of the Indian economy (www.nseindia.com). Both the stock indices, namely, BSE-Sensex and NSE-Nifty are categorized as the largest in terms of value of trades, volume of transactions and market capitalization of the respective stock exchanges. SENSEX and NIFTY signify the overall direction of the stock/index price movements of Indian capital market in general (Patel *et al*., 2015b). Hence, these two stock indices, namely, BSE-Sensex and NSE-Nifty were taken as the sample for this study.

Sources of data: The required secondary data, relating to the daily closing trading values of BSE-Sensex and NSE-Nifty were collected from the respective websites of Bombay stock exchange (www.bseindia.com) and the national stock exchange of India (www.nseindia.com). The other relevant information and required data were collected from reputed books, professional journals and industry reports.

Period of the study: The study mainly focuses on the behaviour of historical stock/index price movements. The global financial crisis which occurred in the year, 2008 is considered by many economists as one of the worst ever financial crisis the global economies experienced since the Great Depression of the 1930s (ILO, 2011). For the purpose of the study, it has been decided to cover a period of seven whole years after 2008 (the post global financial crisis period starting from 2009 onwards) from 01-01-2009 to 31-12-2015 to examine the BSE-Sensex and NSE-Nifty index values.

Statistical tools used in the study: In order to forecast the movements of BSE-Sensex and NSE-Nifty index, the following statistical tools were used. For the prediction of stock market index movements, the traditional time series method (simple regression, logistic regression and ols regression) and neural network method (artificial neural networks, back propagation algorithm, support vector machine, fuzzy logic and k-nearest neighbourhood algorithm) are normally used depending upon the nature and scope of the study (Schmidhuber, 2015). In this study, both the traditional and network driven approaches, namely logistic regression and k-nn algorithm were used to validate the research data.

Logistic regression (to measure mean absolute error, root mean squared error, root absolute error and root relative squared error) and k-nearest neighbourhood algorithm (to measure true positive rate, false positive rate and precision value).

Table 1: Dataset of the study

Factor	Descriptions
Period of the study	1st January, 2009 to 31st December, 2015
In sample ratio: out sample ratio	80:20
In sample period	1st January, 2009 to 31st July, 2014
In sample period observations	1388
Out sample period	1st August, 2014 to 31st December, 2015
Out sample period observations	347
Data variant	Daily closing values of the stock indices
Stock indices	BSE-Sensex and NSE-Nifty
Market movements	Bear and bull (Growth/Downfall)
Statistical techniques	Logistic regression and k-nn algorithm

Collected from www.bseindia.com and www.nseindia.com

Limitations of the study: While carrying out this study, the Researchers observed the following limitations. The study was based upon only the daily closing trading values of BSE-Sensex and NSE-Nifty index of past seven calendar years from 1st January, 2009 to 31st December, 2015. The study tried to forecast only the probable daily trading index values of BSE-Sensex and NSE-Nifty, for the time period from 1st August, 2014 to 31st December, 2015. The study was based only on secondary sources of data. All the limitations of logistic regression and k-nn approach are applicable to this study also.

RESULTS AND DISCUSSION

Prediction analysis of stock index movements: As stated earlier, the main aim of this study was to predict and analyze the index movements of BSE-Sensex and NSE-Nifty during the study period. Table 1 signifies the details of the dataset defined and used, to forecast the movements of BSE-Sensex and NSE-Nifty. The global financial crisis of 2008 heavily shattered the financial markets, especially the stock market of global economies (ILO, 2011). The study covered seven calendar years in the aftermath of the global crisis from 2009-2015. For the purpose of this study, the entire study period was divided into two periods, i.e., training period (from 1st January, 2009 to 31st, July, 2014) and testing period (from 1st August, 2014 to 31st December, 2015). In other words, the ratio between the training dataset and test dataset used in this study was 80:20. It is to be noted that the observations used during the in-sample period, i.e., training period (from 1st January, 2009 to 31st July, 2014) were 1388 which constituted 80% of the total observations whereas during the out-sample period, i.e., the testing period (from 1st August, 2014 to 31st December, 2015), the observations made were 347 which worked out to 20% of the total observations. The total observations used were 1735 for the whole study period. The daily trading index values in terms of opening price, minimum value, maximum value and the closing index value were taken as the inputs for the purpose of the predictive analysis. The stock market movements are generally influenced by both the bull and bear factors

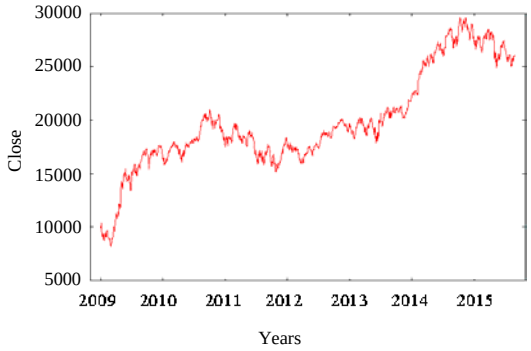

Fig. 2: Movements of BSE-Sensex (Actual) for the whole study period from 01.01.2009 to 31.12.2015; www.bseindia.com

and this explains the sharp increase/ decrease from the previous market position/movement of an individual stock/index, respectively (Wolfers and Zitzewitz, 2004). The analysis of prediction of movements of BSE-Sensex (30 Stocks) and NSE-Nifty (50 Stocks) indices is presented as follows:

- The movement of BSE-Sensex and NSE-Nifty during the whole study period from 01-01-2009 to 31-12-2015 (Actual)
- The movement of BSE-Sensex and NSE-Nifty during the study period from 01-08-2014 to 31-12-2015 (Predicted and Actual)
- The prediction of BSE-Sensex and NSE-Nifty using predictive model
- The prediction of BSE-Sensex and NSE-Nifty using predictive model using comparison of classifier
- The prediction of BSE-Sensex and NSE-Nifty using prediction classifier
- The prediction of BSE-Sensex and NSE-Nifty using error report
- The prediction of BSE-Sensex and NSE-Nifty using accuracy by class

Movements of BSE-Sensex and NSE-Nifty during the whole study period from 01-01-2009 to 31-12-2015 (Actual): As stated earlier, one of the prime objectives of this study was to assess the movements of more vibrant stock indices of India, namely, BSE-Sensex and NSE-Nifty, during the whole study period. Figure 2 shows the actual movement of BSE-Sensex (Top 30 stocks) for the whole study period from 1st January, 2009 to 31st December, 2015. The actual value of BSE-Sensex was recorded at 9903.46 points on 1st January, 2009. Both the bull and bear factors such as growth/downfall, widely influenced the movements of BSE-Sensex throughout the study

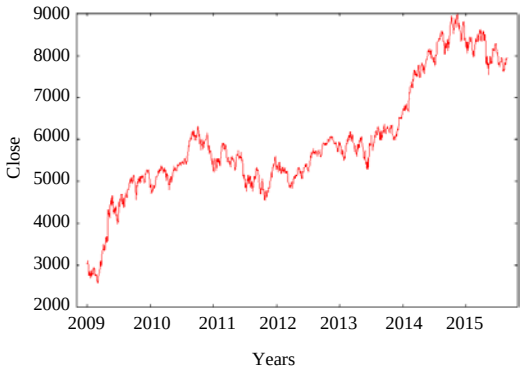

Fig. 3: Movements of NSE-Nifty (Actual) for the whole study period from 01.01.2009 to 31.12.2015; www.nseindia.com

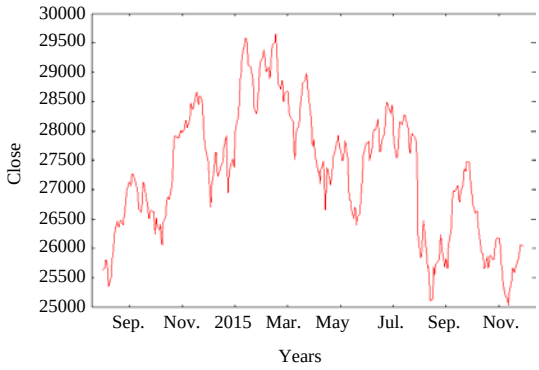

Fig. 4: Movements of BSE-Sensex (Predicted) for the time period from 01.08.2014 to 31.12.2015; Predicted using Gretl 2016a

period (Wang and Shang, 2014). The lowest value of this index was recorded at 8160.4 points on 9th March, 2009 while the highest value of BSE-Sensex was recorded at 29681.77 points on 29th January, 2015. As on 31st December, 2015, the actual closing value of BSE-Sensex was recorded at 26117.54 points with an annual growth rate of 23.38%, during the study period.

The actual movements of NSE-Nifty (Top 50 Stocks) for the whole study period (1st January, 2009 to 31st December, 2015) are exhibited in Fig. 3. The closing value of NSE-Nifty was recorded at 3033.45 points on 1st January, 2009 and it varied widely due to both bull and bear factors throughout the study period. The lowest value of this index was recorded at 2573.15 points on 9th March, 2009 while the highest value of NSE-Nifty was recorded at 8996.25 points on 3rd March, 2015. As on 31st December, 2015, the closing value of NSE-Nifty was recorded at 7946.35 points with an annual growth rate of 23.13%, during the study period.

Movements of BSE-Sensex and NSE-Nifty during the study period from 01-08-2014 to 31-12-2015 (Predicted and Actual): Figure 4 depicts the predicted values of BSE-Sensex movement for the study period from 1st August, 2014 to 31st December, 2015. The closing value of BSE-Sensex was observed as 25639.14 points on 1st August, 2014. It is a known fact that both bull and bear factors, namely, growth and downfall, influenced the variations in movements of BSE-Sensex. The closing value of BSE-Sensex was observed as 26046.99 points on 31st December, 2015 with an annual growth rate of 1.28%, during the study period.

The actual movement of BSE-Sensex, during the study period from 1st August, 2014 to 31st December, 2015 is given in Fig. 5. The actual closing value of sensex was recorded at 25480.84 points on 1st August, 2014. It is

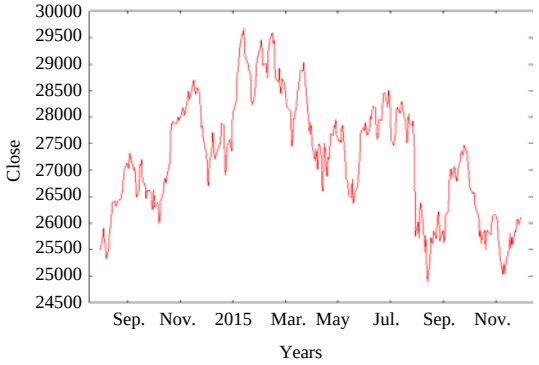

Fig. 5: Movements of BSE-Sensex (Actual) for the time period from 01.08.2014 to 31.12.2015; www.bseindia.com

worth noting that the variation in movements happened due to both bull and bear factors. The lowest value of BSE-Sensex was recorded at 25150.35 points on 9th March, 2009 while the highest value was registered at 29681.77 points on 14th December, 2015. The closing value of BSE-Sensex on 31st December, 2015 was observed as 26117.54 points with an annual growth rate of 1.66%, during the study period.

Figure 6 portrays both the predicted and actual values (combined effect) of pictorial representation for BSE-Sensex movement, during the study period from 1st August, 2014 to 31st December, 2015. It clearly indicates that the two non-linear trend lines which overlapped, exhibit the existence of deviation between the predicted values and actual values. The annual growth rate, for both the predicted and actual index values of BSE-Sensex was calculated as 1.28 and 1.66%, respectively which signified the presence of deviation in the accuracy of prediction for the Sensex during the study period. Figure 7 denotes the predicted movements of

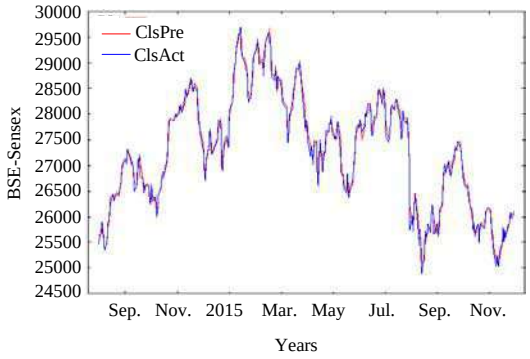

Fig. 6: Combined Movements of BSE-Sensex (Predicted and Actual) for the time period from 01.08.2014 to 31.12.2015; combined effect of Fig. 3 and 4 using Gretl 2016a

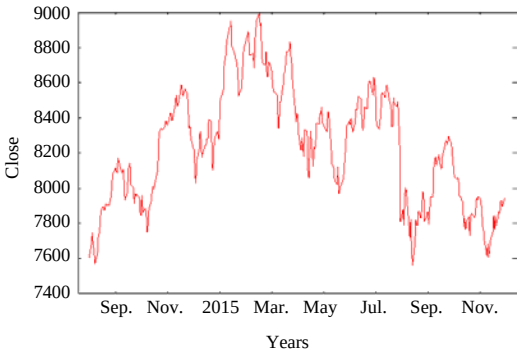

Fig. 7: Movements of NSE-Nifty (Predicted) for the time period from 01.08.2014 to 31.12.2015; Predicted using Gretl 2016a

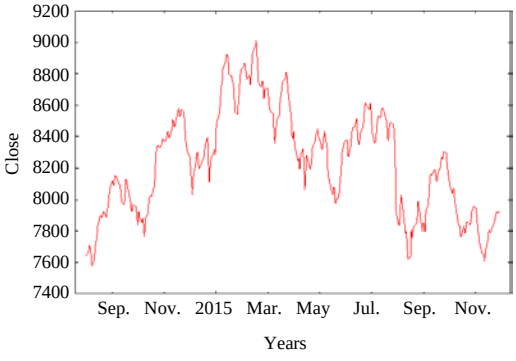

Fig. 8: Movements of NSE-Nifty (Actual) for the time period from 01.08.2014 to 31.12.2015; www.nseindia.com

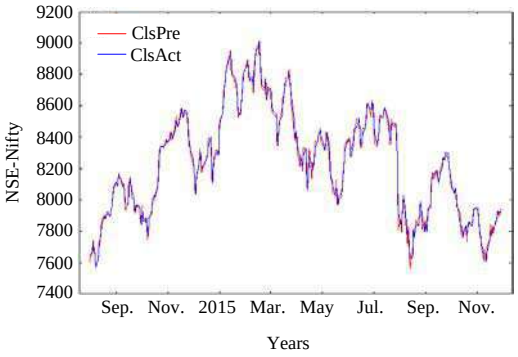

Fig. 9: Combined movements of NSE-Nifty (predicted and actual) for the time period from 01.08.2014 to 31.12.2015; combined effect of Fig. 6 and 7 using Gretl 2016a

NSE-Nifty, during the study period, starting from August, 2014 to December, 2015. The predicted closing value of NSE-Nifty was observed at 7643.93 points on 1st August, 2014. Snigaroff and Wroblewski (2011) stressed that the index movements varied due to both bull and bear factors such as growth (positive) and downfall (negative) phenomenon. The closing value of NSE-Nifty was observed at 7922.71 points on 31st December, 2015 with an annual growth rate of 3.64%, during the study period.

The actual movements of NSE-Nifty for the study period from 1st August, 2014 to 31st December, 2015 are presented in Fig. 8. The actual closing value of Nifty was at 7602.6 points on 1st August, 2014 and both bull and bear factors influenced the variation in movements. The lowest value of this index was recorded at 7558.8 points on 7th September, 2014 while the highest value of NSE-Nifty was recorded at 8996.25 points on 3rd March, 2015. The closing value of Nifty was registered at 7946.35 points on 31st December, 2015 with an annual growth rate of 3.95%, during the study period. Figure 9 shows both the predicted and actual values (combined effect) of NSE-Nifty movement, during the study period from 1st August, 2014 to 31st December, 2015. It is to be noted that there are two non-linear trend lines which are superimposed and these trend lines exhibited the existence of deviation between the predicted and actual values of NSE-Nifty. The annual growth rate of predicted and actual values were calculated as 3.64 and 3.95%, respectively for NSE-Nifty which denotes the presence of deviation in the accuracy of prediction of the Nifty during the study period. It is found from the analysis that both the BSE-Sensex and NSE-Nifty had experienced highly volatile non-linear movements which indicated that the starting value of SENSEX was at 9903.46 points on 1st January, 2009, the lowest value was at 8160.4

points on 9th March, 2009, the highest value was at 29681.77 points on 29th January, 2015 and the closing value of Sensex was at 26117.54 points on 31st December, 2015. Simultaneously, the starting value of NIFTY was at 3033.45 points on 1st January, 2009, the lowest value was at 2573.15 points on 9th March, 2009, the highest value was at 8996.25 points on 3rd March, 2015 and the closing value of Nifty was at 7946.35 points on 31st December, 2015. These values were influenced by market fluctuations and the market fluctuations were influenced by various macro-economic factors which included the bull and bear characteristics in the stock market. Hence, the Null Hypothesis (NH_1) namely, there exists no non-linear movement of individual stock indices, namely BSE-Sensex and NSE-Nifty, during the study period is rejected. This finding is in line with the findings of Subha and Thirupparkadal Nambi.

It is interesting to note that the BSE-Sensex had grown by 163.72% (with an average annual growth rate of 23.38% per year) for a period of seven calendar years (whole period) from 1st January, 2009 to 31st December, 2015. The Sensex had increased from 9903.46 points on 1st January, 2009 to 26117.54 points, on 31st December, 2015. The NSE-Nifty had grown by 161.95% (with an average annual growth rate of 23.13% per year) for a period of seven calendar years, from 1st January, 2009 to 31st December, 2015. The Nifty had increased from 3033.45 points on 1st January, 2009 to 7946.35 points on 31st December, 2015. It is significant to note that the growth rate of BSE-Sensex and NSE-Nifty ran close to each other, i.e., the annual growth rates of SENSEX and NIFTY were 23.38 and 23.13%, respectively. Hence, the Null Hypothesis (NH_2) namely, there is no corresponding linear relationship in terms of growth or downfall in the index movement between BSE-Sensex and NSE-Nifty during the study period is not rejected. The findings of this study confirmed the findings of Patel *et al.* (2015b).

The above statistical observation indicated that both the BSE-Sensex (top 30 Stocks) and NSE-Nifty (top 50 Stocks) had shown wide variations in terms of both upward and downward movements, propelled by bull and bear factors of the stock markets, i.e., the value of BSE-Sensex was 8160.4 points on 9th March, 2009 which increased to 29681.77 points (the highest) on 29th January 2015 and NSE-Nifty was 2573.15 points on 9th March, 2009 which increased to 8996.25 points (the highest) on 3rd March, 2015, during the post global crisis period of 7 years from 1st January, 2009 to 31th December, 2015. The investors who had invested their hard-earned money in these stock indices, would have benefitted hugely by earning profits since these two indices had grown positively in a significant way, i.e., BSE-Sensex had grown by 163.72% with an annual growth rate of 23.38% while NSE-Nifty had grown by 161.95% with an annual growth rate of 23.13%, during the study period from 1st January, 2009 to 31st December, 2015.

Table 2: Results of predictive model for BSE-Sensex during the study period

Evaluation on test dataset for BSE-Sensex (k = 5)	Values
Correlation coefficient	0.9926
Mean absolute error	21.1854
Root mean squared error	32.7822
Relative absolute error	3.11%
Root relative squared error	3.47%

Collected from www.bseindia.com and computed by using Gretl 2016a

Table 3: Results of predictive model for NSE-Nifty during the study period

Evaluation on test dataset for NSE-Nifty (k = 5)	Values
Correlation coefficient	0.9912
Mean absolute error	10.2518
Root mean squared error	13.278
Relative absolute error	4.15%
Root relative squared error	5.18%

Collected from www.nseindia.com and computed by using Gretl 2016a

Prediction of BSE-Sensex and NSE-Nifty: As pointed out earlier, one of the main aims of the study was to forecast the stochastic stock price movements of high volatile stock indices of India namely, BSE-Sensex which represents highly active and top market capitalization value of 30 stocks of BSE. Similarly, the NSE-Nifty represents a robust and top market capitalization value of 50 stocks of the NSE of India.

Prediction of BSE-Sensex and NSE-Nifty using predictive model: Table 2 exhibits the results of predictive model for BSE-Sensex, during the study period from 01.01.2009 to 31.12.2015. It is inferred that the correlation coefficient for the BSE-Sensex movement (actual values), under the prediction model was found to be at 0.9926 points, implying a high level of dependency under the predictive model. The forecasting error of the model was low which is denoted by the Mean Absolute Error (MAE) with a value of 21.1854 and Root Mean Squared Error (RMSE) with a value of 32.7822. This clearly confirms the fact that the predictive model also displayed a low error rate of prediction as measured by Relative Absolute Error (RAE) of 3.11% and the Root Relative Squared Error (RRSE) of 3.47% in respect of BSE-Sensex during the study period. The investors who had invested their financial resources by using this forecasting model, would have earned better return (Etzioni, 1976).

The results of predictive model for NSE-Nifty during the study period, from 01.01.2009 to 31.12.2015 are given in Table 3. It is to be noted that the value of correlation coefficient for NSE-Nifty index movement (actual and predicted values) was found to be at 0.9912, implying a very high level of dependency of the predictive model. The forecasting error of the model was very low as

Table 4: Results of comparison of classifier for BSE-Sensex during the study period

	k-nn algorithm		Logistic regression	
Total instances (347)	Instances	Accuracy (%)	Instances	Accuracy (%)
Correctly classified instances	253	72.91	196	56.48
Incorrectly classified instances	94	27.09	151	43.52
Kappa statistics	0.7183		0.1851	

Table 5: Results of comparison of classifier for NSE-Nifty during the study period

	k-nn algorithm		Logistic regression	
Instances (347)	Instances	Accuracy (%)	Instances	Accuracy (%)
Correctly classified instances	248	71.46%	189	54.43 %
Incorrectly classified instances	99	28.54%	158	45.57 %
Kappa statistics	0.6312		0.1328	

denoted by the Mean Absolute Error (MAE) 10.2518 and Root Mean Squared Error (RMSE) 13.278. Besides, the predictive model displays a very low error rate of prediction as measured by Relative Absolute Error (RAE) of 4.15% and the Root Relative Squared Error (RRSE) of 5.18% of NSE-Nifty during the study period.

The analysis of predictive model, used in respect of BSE-Sensex and NSE-Nifty, during the study period, ensured high level of dependency. The investors may take note of this information, before making investments in stock indices and may use such forecasting in future too.

Prediction of BSE-Sensex and NSE-Nifty using comparison of classifier: Table 4 shows the results of comparison, under classifier models, on the test dataset of BSE-Sensex, during the study period from 01.08.2014 to 31.12.2015. It is important to note that the k-nn algorithm rightly classified the next day's movement of BSE-Sensex for 253 instances out of 347 total instances with an accuracy rate of 72.91% and misclassified 94 instances with the accuracy rate of 27.09% during the study period. It is to be noted that the kappa statistics is a measure that can ranges from -1 to +1 and it implies a perfect agreement or disagreement of the stock index prediction. The analysis of k-nn predictive model indicates a higher degree of acceptance rate of 0.7183, when compared with the acceptance rate of 0.1851 in the case of the logistic regression model for BSE-Sensex prediction during the study period. This analysis confirms a high degree of acceptance rate.

The results of comparison, under classifier models, on the test dataset of NSE-Nifty, during the study period, from 01.08.2014 to 31.12.2015 are indicated in Table 5. It is understood from the analysis that the k-nn algorithm correctly classified the next day's movement of Nifty for 248 instances out of the total instances of 347 with an accuracy rate of 71.46% and misclassified 99 instances with the accuracy rate of 28.54%. The analysis of k-nn predictive model shows relatively a higher degree of acceptance rate of 0.6312 when compared with the acceptance rate of 0.1328 in case of the logistic regression model for NSE-Nifty prediction, during the study period.

Table 6: Results of prediction classifier for BSE-Sensex during the study period

	k-nn classifier		Logistic regression	
Predicted class	Bull	Bear	Bull	Bear
Bull	157	18	119	56
Bear	68	104	80	92

Table 7: Results of prediction classifier for NSE-Nifty during the study period

	k-nn classifier		Logistic regression	
Predicted class	Bull	Bear	Bull	Bear
Bull	131	37	98	70
Bear	62	117	83	96

Prediction of BSE-Sensex and NSE-Nifty using prediction classifier: Table 6 denotes the results of prediction classifier for BSE-Sensex (30 Stocks), during the study period from 01.08.2014 to 31.12.2015. It is found that the analysis of k-nn classifier correctly classified 157 instances out of 175 total bull movements and 104 instances correctly out of 172 total bear movements in respect of BSE-Sensex. But in the case of logistic regression model, out of the total movements of 347, only 119 bull movements out of 199 total bull movements and 92 bear movements out of 148 total bear movements were rightly predicted. This shows that the k-nn approach was more accurate than logistic regression method in terms of prediction in respect of BSE-Sensex, during the study period.

The results of prediction classifier for NSE-Nifty (50 Stocks), during the study period, from 01.08.2014 to 31.12.2015, are demonstrated in Table 7. It is seen that the k-nn classifier correctly classified 131 instances out of 168 total bull movements and 117 instances correctly out of 179 total bear movements in the case of NSE-Nifty. It is to be noted that out of the total movements of 347, only 98 bull movements out of 181 total bull movements and 96 bear movements out of 166 bear movements were rightly predicted, under the logistic regression model. This indicates that the k-nn approach was more accurate than logistic regression method in terms of prediction in respect of NSE-Nifty, during the study period.

Prediction of BSE-Sensex and NSE-Nifty using error report: Table 8 presents the class-wise error report of the prediction of BSE-Sensex, during the study period from 01.08.2014 to 31.12.2015. It is vividly clear that the k-nn classifier incorrectly classified 18 bull instances out of 175 bull movements with an error rate of 10.28% and incorrectly classified 68 bear instances out of 172 bear

Table 8: Details of error report of classifiers for BSE-Sensex during the study period

		k-nn classifier		Logistic regression	
Class	No. of cases	No. of errors	Error (%)	No. of errors	Error (%)
Bull	175	18	10.28	56	32.00
Bear	172	68	39.53	80	46.50
Overall	347	86	24.90	136	39.25

Table 9: Details of error report of classifiers for NSE-Nifty during the study period

		k-nn classifier		Logistic regression	
Class	No. of cases	No. of errors	Error (%)	No. of errors	Error (%)
Bull	168	37	22.02	70	41.66
Bear	179	62	34.63	83	46.36
Overall	347	99	28.32	153	44.01

Table 10: Accuracy of logistic classifier for BSE-Sensex during the study period

Class	TP rate	FP rate	Precision	F-measure	ROC area
Bull	0.54	0.46	0.54	0.42	0.785
Bear	0.59	0.41	0.62	0.60	0.813

movements with an error rate of 39.53%. Under the logistic regression model which is used to classify movements, it is evident that 56 bull and 80 bear movements were incorrectly predicted with the error rate of 32 and 46.5%, respectively. It is clear that the error rate was comparatively lower under the k-nn approach than under the logistic regression method, during the study period.

The class-wise error report of the prediction of NSE-Nifty, during the study period, from 01.08.2014 to 31.12.2015 is shown in Table 9. It is found that the k-nn classifier incorrectly classified 37 bull instances out of 168 bull instances with an error rate of 22.02% while 62 bear instances were incorrectly classified out of 179 bear movements with an error rate of 34.63%. It is shocking to note that under the logistic regression model, 70 bull and 83 bear movements were incorrectly predicted with the error rate of 41.66 and 46.36%, respectively. It is found that the error rate was relatively lower under the k-nn approach than under the logistic regression method, during the study period (Hanson and Oprea, 2009).

Prediction of BSE-Sensex and NSE-Nifty using Accuracy by Class: Table 10 reveals the evaluation of accuracy, for BSE-Sensex, by using logistic classifier, during the study period from 01.08.2014 to 31.12.2015. It is clear from the Table that the True Positive Rate (TPR) of bull and bear movements of logistic regression classifier were valued at 0.54 and 0.59, respectively while the False Positive Rate (FPR) of bull and bear movements were registered at 0.46 and 0.41, respectively. The precision values for bull and bear classification were at 0.54 and 0.62, respectively. The F-Measure was recorded as 0.42 and 0.60 in respect of bull and bear behaviour, respectively. The receiver operative curve area under k-classifier was at 0.785 and 0.813 for bull and bear market behaviour, respectively for Sensex movement of BSE, during the study period. The evaluation of accuracy for NSE-Nifty, by using the logistic classifier, during the study period from 01.08.2014 to 31.12.2015 is depicted in Table 11. The True Positive Rate (TPR) of bull and bear of logistic regression classifier were recorded at 0.51 and 0.57, respectively. The False Positive Rate (FPR) of bull and bear movements observed at 0.48 and 0.41, respectively. It is also noted that the precision values recorded at 0.52 and 0.54 for bull and bear classification, respectively. F-Measure was measured as 0.55 and 0.52 for bull and bear, respectively. According to the results of table, the receiver operative curve area under the k-nn classifier, registered values at 0.589 and 0.594 for bull and bear market behaviour, respectively at NSE of Nifty movement, during the study period.

Table 11: Accuracy of logistic classifier for NSE-Nifty during the study period

Class	TP rate	FP rate	Precision	F-measure	ROC area
Bull	0.51	0.48	0.52	0.55	0.589
Bear	0.57	0.41	0.54	0.52	0.594

Table 12: Details of accuracy of k-nn classifier for BSE-Sensex during the study period

Class	TP rate	FP rate	Precision	F-measure	ROC area
Bull	0.87	0.08	0.90	0.84	0.897
Bear	0.91	0.13	0.87	0.89	0.914

Table 13: Details of accuracy of k-nn classifier for NSE-Nifty during the study period

Class	TP rate	FP rate	Precision	F-measure	ROC area
Bull	0.72	0.14	0.72	0.67	0.815
Bear	0.84	0.25	0.68	0.71	0.824

Collected from www.nseindia.com and computed by using Gretl 2016a

Table 12 displays the evaluation of prediction accuracy of BSE-Sensex, measured by using the k-nn classifier, during the study period from 01.08.2014 to 31.12.2015. It is understood from the analysis that the True Positive Rate (TPR) of bull and bear of k-nn classifier were recorded at 0.87 and 0.91, respectively. On the other hand, the False Positive Rate (FPR) of bull and bear movements observed at 0.08 and 0.13, respectively during the study period. The precision values were recorded at 0.90 and 0.87 for bull and bear classification, respectively in respect of BSE-Sensex. It is interesting to note that F-Measure was recorded at 0.84 and 0.89 for bull and bear behaviour in respect of Sensex. The value of Receiver Operative Curve area was measured at 0.897 and 0.914, for BSE-Sensex movement, during the study period.

The evaluation of accuracy of NSE-Nifty (50 Stocks), by using the k-nn classifier, during the study period from 01.08.2014 to 31.12.2015 is given in Table 13. It is seen that the True Positive Rate (TPR) of bull and bear movements,

under the k-nn classifier were recorded at 0.72 and 0.84, respectively. The False Positive Rate (FPR) of bull and bear movements were measured at 0.14 and 0.25, respectively during the study period. The precision values were recorded at 0.72 and 0.68 for bull and bear classification, respectively. It is interesting to note that F-Measure was recorded as 0.67 and 0.71 for bull and bear behaviour in respect of NSE-Nifty. The value of Receiver Operative Curve was recorded at 0.815 and 0.824 for bull and bear market behaviour, respectively for NSE-Nifty movement, during the study period.

From the analysis of Table 10-13, it is clearly evident that k-nn algorithm forecasted the movements of stock indices (both the BSE-Sensex and NSE-Nifty) more accurately than the logistic regression approach. This indicates the fact that the Neural Network Approach, k-nearest neighbourhood algorithm had outperformed the traditional time series-regression prediction model in terms of various predictive parameters of evaluation, during the study period in respect of the sample indices, namely, BSE-Sensex and NSE-Nifty of India.

The two foremost stock indices of India, namely, BSE-Sensex and NSE-Nifty had grown significantly, during the study period. The Sensex had grown by an annual growth rate of 23.38% while Nifty had grown by an annual growth rate of 23.13%, throughout the whole study period of seven calendar years, i.e., from 1st January, 2009 to 31st December, 2015. The investors who made investments in these stock indices, namely, BSE-Sensex and NSE-Nifty would have earned better profits since the leading indices of the two stock markets, namely, Bombay Stock Exchange and National Stock Exchange had shown increasingly an upward movement (on an average), during the study period from 01.01.2009 to 31.12.2015. It is suggested that the use of predictive instruments/methods like time series-regression methods, neural network-artificial neural network, fuzzy logic and support vector machine, need to be taken into account by the investors in respect of forecasting the accuracy of the markets while taking the investment decisions.

CONCLUSION

The study found that the stock market movements in India were highly stochastic (Patel *et al*., 2015a) in nature which followed a non-linear pattern/trend of index movements during the study period from 1st January, 2009 to 31st December, 2015. The two key stock indices, namely, BSE-Sensex (Top 30 Stocks) and NSE-Nifty (Top 50 Stocks) had experienced both upward and downward mobility, i.e., growth and downfall in terms of daily closing index values. This phenomenon shows a disagreement with the Efficient Market Hypothesis but in confirmation of the existence of Random Walk Theory in respect of capital market movements (Malkiel and Fama, 1970) in this study.

On an average, the capital market in India had shown increasingly a positive growth trend, especially the BSE-Sensex had grown by 163.72% with an annual growth rate of 23.38% and NSE-Nifty had grown by 161.95% with an annual growth rate of 23.13%, during the study period, from 1st January, 2009 to 31st December, 2015. This phenomenon shows an agreement/correlation in terms of Compounded Annual Growth Rate (CAGR) between the two sample stock indices of both BSE and NSE, during the study period (Zhu *et al*., 2008). It is found that the stock market movements were greatly influenced by various macro-economic factors which included the investment climate, government policies on tax, investment and dividends, inflows/outflows of foreign institutional investors, interest rates (lending rates and deposit rates), credit policy, industrial policy, foreign trade policy and the growth of annual gross domestic product to name a few (Walczak, 1999). Moreover, the investor's sentiments and investment pattern of different constituents of stock market participants like retail investors, overseas corporate bodies, domestic and foreign institutional investors.

It is imperative that savings and capital formation which propells the investment pattern/trend, plays a crucial role in the growth of any developing economy. India, an emerging economy is not an exception to this phenomenon. India has also attained a formidable economic development, endowed by the contribution of financial markets, especially stock markets which helped the business enterprises to augment the financial resources for the promotion of industrial growth and development (Wolfers and Zitzewitz, 2004). The investors could maximize their stock returns, by taking advantage of timely and prudent investments in these stock indices.

SUGGESTIONS

The following are some of the broader areas which are identified as the scope for future research. The Researchers can venture into the following areas to explore in depth, the existing knowledge base of behavioural finance, especially in the field of predictive market analytics:

- The researchers can extend their research endeavours, to forecast different sectoral indices and individual share price movements of BSE and NSE

- Other techniques of network approach such as artificial neural network, support vector machine and back-propagation algorithm to predict the price/value movements of stocks/stock indices for a future study period
- The efforts can be made to study the movements of the highly volatile global stock indices of developed economies such as the DJIA and S and P-500 (USA), Nikkei-225 (Japan) and FTSE-100 (UK) (Jasic and Wood, 2004)
- A comparative analysis of global stock indices with the Indian stock indices can also be made, by applying the neural network methods

REFERENCES

Boyacioglu, M.A. and D. Avci, 2010. An Adaptive Network-Based Fuzzy Inference System (ANFIS) for the prediction of stock market return: The case of the Istanbul Stock Exchange. Expert Syst. Appl., 37: 7908-7912.

Carvalhal, A. and B.V.D.M. Mendes, 2008. Evaluating the forecast accuracy of emerging market stock returns. Emerging Markets Finance Trade, 44: 21-40.

Etzioni, A., 1976. Future analysis. Analysen Prognosen, 1: 19-20.

Hansen, J.V. and R.D. Nelson, 2003. Forecasting and recombining time-series components by using neural networks. J. Oper. Res. Soc., 54: 307-317.

Hanson, R. and R. Oprea, 2009. A manipulator can aid prediction market accuracy. Econ., 76: 304-314.

ILO., 2011. The global crisis, causes, responses and challenges. International Labour Organisation, Geneva, Switzerland.

Jasic, T. and D. Wood, 2004. The profitability of daily stock market indices trades based on neural network predictions: Case study for the S&P 500, the DAX, the TOPIX and the FTSE in the period 1965-1999. Applied Finan. Econ., 14: 285-297.

Kohzadi, N., M.S. Boyd, B. Kermanshahi and I. Kaastra, 1996. A comparison of artificial neural network and time series models for forecasting commodity prices. Neurocomputing, 10: 169-181.

Kuo, F., 2006. Network Analysis and Synthesis. John Wiley & Sons, New Delhi, India,.

Malkiel, B.G. and E.F. Fama, 1970. Efficient capital markets: A review of theory and empirical work. J. Finance, 25: 383-417.

Patel, J., S. Shah, P. Thakkar and K. Kotecha, 2015a. Predicting stock and stock price index movement using trend deterministic data preparation and machine learning techniques. Expert Syst. Appl., 42: 259-268.

Patel, J., S. Shah, P. Thakkar and K. Kotecha, 2015b. Predicting stock market index using fusion of machine learning techniques. Expert Syst. Appl., 42: 2162-2172.

Schmidhuber, J., 2015. Deep learning in neural networks: An overview. Neural Networks, 61: 85-117.

Simon, S. and A. Raoot, 2012. Accuracy driven artificial neural networks in stock market prediction. Intl. J. Soft Comput., 3: 35-44.

Snigaroff, R. and D. Wroblewski, 2011. A network value theory of a market and puzzles. Financial Analysts J., 67: 69-85.

Taleb, N.N., 2016. Volatility is not such a bad thing. Econ. Times, 23: 1-18.

Walczak, S., 1999. Gaining competitive advantage for trading in emerging capital markets with neural networks. J. Manage. Inf. Syst., 16: 177-192.

Wang, S. and W. Shang, 2014. Forecasting direction of China security index 300 movement with least squares support vector machine. Procedia Comput. Sci., 31: 869-874.

Wolfers, J. and E. Zitzewitz, 2004. Prediction markets. J. Econ. Perspect., 18: 107-126.

Wu, S.F. and S.J. Lee, 2015. Employing local modeling in machine learning based methods for time-series prediction. Expert Syst. Appl., 42: 341-354.

Zhu, X., H. Wang, L. Xu and H. Li, 2008. Predicting stock index increments by neural networks: The role of trading volume under different horizons. Expert Syst. Appl., 34: 3043-3054.