Chapter 1

General Introduction

1.1 Introduction

Financial sector plays a very crucial role in the well-being and economy of developed countries having highly privatized economy. It helps to reduce the vulnerability and risk. And also enhance the ability of people to access basic amenities, such as education, food and health easily, hence affects poverty reduction positively. Stock Market forecasting and portfolio optimization are two important building blocks of the financial sector. Time series analysis helps to construct forecasting models and portfolio designing.

For decades, time series study was the prerogative of statistics. This custom was broken with the introduction of advanced techniques of data analysis such as fuzzy sets, rough sets, neural networks, genetic algorithms, etc. These non-statistical techniques are particularly important in the circumstances, where time series are short and cannot be characterized as stochastic processes, i.e. time series observations are vague and do not show regular behavior (Perfilieva et al. [79]). The most common examples are financial and medical time series.

The main areas of this research are the study and depiction of financial time series, to propose self-evolving trading systems and design portfolios for stock market investors using soft computing techniques. These techniques are used to determine the underlying behavior of complex financial time series. The trading systems are consequently used to establish whether stock returns are predictable to some degree,
so that profitable trading systems can be designed after applying realistic transaction costs. Before attempting to apply prediction models to financial time series, an analysis of the underlying nonlinear systems is carried out to derive appropriate model parameters.

1.2 Stock Market Prediction

In the modern world, stock market prediction has become an important part of the world economy. Forecasting of the stock market involves a development of techniques to predict the future values of stock indices. An accurate prediction helps in decision making and designing for the future stocks. The main goal of forecasting is to find a better way to get high profits with the help of well-defined schemes. The fundamental idea of successful forecasting is to achieve best results employing least complex prediction models. However, stock market investment is always risky due to it’s uncertain and unpredictable nature (i.e. market volatility). Market Volatility always needs to be expressed in simple and user-friendly models. Among other components, prediction modeling needs consideration of characterized phenomena, for example, expansion and recession periods, low and high volatile periods. The volatility in market prices come up because required returns are in themselves very volatile, driven by short-term and other cyclical variations. To capture this volatile nature of the stock market, a tremendous amount of research work has been published.

The selection and implementation of a prediction model has always been an important planning issue for most firms, researchers and agencies. The financial and organizational stability of an organization depends upon accurate forecasting of the stock market. Such information will most likely to be used in making key decisions in the field of capital financing, marketing, purchasing, human resource and advertising. The difficulty of prediction depends on an enormous number of factors. Most significantly, the historic patterns of variables and the complexity of a prediction task may be increased by underlying input factors that affect the variables. The volatile nature of historical patterns may suggest that the variables to be predicted
have a numerous underlying factors. Some of these factors may not be discoverable and hence needs to be identified with the help of expert knowledge, which is gained over time to be built into the prediction models.

Prediction of the stock market would be a very crucial step when evaluating prudence of an investment. This step is quite difficult due to the presence of a multitude of factors and complexity that may affect the value of a certain variable (Baba and Kozaki [9]). Following are the major challenges that have been identified in the field of forecasting:

1. In some cases, it may be very difficult to ascertain a future scenario during prediction. Regardless of the technique that may be used, it is always assumed that there will be a variable measure of uncertainty.

2. Forecasting variables for which there are no existing paradigms or historical data is often prone to errors, primarily due to the lack of ability to understand underlying factors which could affect the forecast (Agarwal [4] and Weckman [91]).

3. Selection and implementation of an accurate prediction model are very important because different prediction problems must be addressed using different tailor-made models (Elman [39]).

An intelligent prediction model for stock market forecasting would be highly desirable and of wider investment interest. A tremendous amount of research work has been published in recent times and continues to find an optimal prediction model for the stock market. Most of the research work involving forecasting has employed statistical time series analysis techniques, such as Autoregressive (AR) model by Champernowne [19], the Autoregressive Moving Average Model (ARMA) by Avci [8] and the Autoregressive Integrated Moving Average Model (ARIMA) by Box [16]. These linear models are not adequate in stock market prediction. Later on non-linear techniques, such as Autoregressive Conditional Heteroskedasticity (ARCH) by Engle [40] and Generalized Autoregressive Conditional Heteroskedasticity (GARCH) by Bollerslev [15] were proposed to surmount their shortcomings. Random Walk (RW) model (Cootner [33], Fama [42] and Fama et al. [43]) has been widely used
in financial literature to predict the stock market. A growing body of researchers (Butler and Malaikah[18], Gallagher and Taylor [47], Kavussanos and Dockery [63] Qian and Rasheed [80]) have closely analyzed RW model and they have shown that stock market prices do not follow a RW model but can be forecasted to some extent.

In recent years Artificial Intelligence (AI) techniques such as Artificial Neural Networks (ANNs), Fuzzy Logic, and Genetic Algorithms (GAs) became popular research topics since they can deal with complex problems which are difficult to solve by classical methods (Chang et al. [22]). These techniques have been successfully applied by many researchers (Ansari et al. [6], Chang et al. [22], Keles et al. [64], Kumar and Thenmohzi [68], OConnor and Madden [77], Wilson et al. [93], Yang et al. [97], Yudong and Lenan [99]) to replace complex mathematical models which were previously used to forecast stock markets.

Each of the AI-based techniques has advantages as well as disadvantages. One approach to deal with complex real-world problems is to integrate several AI techniques, combining their strengths to generate hybrid models. These models provide better results than the ones achieved with the use of each of these isolated techniques. Using hybrid models or combining several models have become a common practice to improve forecasting accuracy (Aldag et al. [5], Boyacioglu and Avci [17], Khashei et al. [65]). Development in forecast modeling may promise attractive benefits to investors. Adaptive Neuro Fuzzy Inference System (ANFIS) is one among several hybrid models for stock forecasting. Jang [56] said that ANFIS is a fuzzy inference system implemented in the framework of adaptive networks. ANFIS can be used with more than one variable and does not rely on assumptions. The rules mined from ANFIS are also easily understandable. ANFIS has been successfully used in fields as diverse as engineering, education, medicine and financial investment (OConnor and Madden [77], Trinkle [87], Afolabi and Olatoyosi [3], Abbasi and Aboueic [1], Cheng et al. [30])
1.3 Portfolio Theory

Portfolio designing is not a simple task that comes in handy. It rather involves a deep understanding of the financial products available and their best use for the investors. Thus it needs expertise which is developed over the years. There are different types of investors depending on their style of investment, mandates, horizon and assets under management and may have a different goal for which they want to invest. For example, for an individual, the goal may be retirement, children’s education and buying a home, etc. For institutional investors, goals may vary from pension funds to investment policy and others. So it becomes very difficult to decide an investment strategy; here comes the role of portfolio designing.

Portfolio theory describes the problem of how to allocate one’s capital to a different number of securities so that profitable returns can be obtained from the investment (Qin et al. [81]). The concept behind portfolio selection is to diversify the investment risk instead of centering overall risk in any single object (Chen et al. [24]). Selection of investment and securities is not an easy task, it needs not only profit optimization but most significantly require minimizing the potential risk of investment (Hui et al. [55]). Nevertheless, with the existence of an immense number of investment securities in the present world, it has become more difficult for investment managers/investors to scrutinize each and every stock on the market (Quek et al. [82]). The appropriate portfolio selection process can be separated into two steps. In the first step, experience and observation play a vital role in the starting and it ends with faith in the future performance of usable products. The second step begins with beliefs regarding the future performance of several investment securities and ends with the selection of a portfolio strategy (Shyng et al. [85]).

In the present world, the financial portfolio management system is one of the fields of key interest for stock market investors. In highly complicated market conditions financial institutions and individual investors are always trying to find new ways of investment from where they can get maximum returns with minimum risk. As a consequence sometimes individual investors and even professional investment decision makers often make mistakes by allowing their emotions to interfere in making critical investment decisions (Beach and Rose [11]). Following two questions are
very important in making portfolio decisions (Huang [53]):

1. In what kind of stock one wants to invest?

2. How much capital one wants to invest in the selected stocks?

To tackle the above, Harry Markowitz [73] developed Modern Portfolio Theory (MPT), which has been the cornerstone of modern finance theory and is widely accepted by investors. The key attribute of Markowitz theory is to take the expected return of an asset as the investment return and variance of expected return as the risk on the investment. MPT gave the concept of maximizing the expected return for given level of risk, conversely, minimize the risk for a given level of expected return.

Markowitz introduced the concept of efficient frontier, i.e. a portfolio lying on the efficient frontier gives the best-expected return with the given level of risk. MPT has been an interesting topic for researchers and investors, however, in recent years, assumptions of MPT have been criticized. The first criticism is about the efficiency of markets, which is the basic assumption of MPT. However, it is very costly and difficult to get all the information of the markets and each individual stock (Grossman and Stiglitz [49]). Secondly, MPT has not met the real investor’s preferences since, in portfolio optimization, it is found that the investors prefer a portfolio which lies behind the efficient frontier of Markowitz model (Ehrgott et al. [36]). Finally, covariance matrix and quadratic utility function increase the computational complexity of MPT which is very difficult to handle in real life applications because of a large number of stocks (Yunusoglu and Selim [100]). As a consequence, portfolio management is reckoned with Multi-Criteria Decision Making (MCDM).

MCDM not only focuses on two basic criteria, i.e. return and risk but also considers; preferences of investors, stock market behavior, variation of returns in terms of statistical measure etc. (Xidonas et al. [94]). Thus finance portfolio management is relatively an unstructured, uncertain and subjective process. Nowadays AI techniques are widely used in MCDM, because these techniques can easily deal with complex, uncertain and unstructured problems (Bahrammirzaee [10], Mousavi et al. [75]).
Among the wider AI techniques, the rule-based fuzzy expert system is one of the most useful and an important AI technique. The fuzzy expert system is a system which uses fuzzy logic and derives solutions from inputs and fuzzy inference system (Kandel [62]). Earlier Chan et al. [20] proposed an expert system for designing a portfolio for banks. Later on, Lin and Hsieh [70] proposed a Decision Support system (DSS) that incorporates fuzzy theory into strategic portfolio selection. This DSS is an expandable, interactive and flexible system which helps managers to select the most suitable project for portfolio management. Further, a fuzzy expert system for the recommendation of the portfolio was developed by Fasanghari and Montazer [44]. Here the stocks are ranked by using fuzzy Delphi method with the knowledge of experts in the stock market, then fuzzy inference system is used for portfolio construction. This expert system was developed based on the Tehran Stock Exchange and the validation of the proposed expert system has been checked by interviewing users and experts. Gupta et al. [50] have developed a fuzzy multi-criteria decision-making system to design a portfolio for investors. Abiyev and Menekay [2] proposed a fuzzy portfolio model, possibility of a trade-off between risk and return is formulated with the help of fuzzy set theory and optimal values of risky securities are found with the help of genetic algorithms.

Recently, Oh et al. [78] proposed a fuzzy expert system in portfolio management to deal with the uncertainty of the fuzzy front-end product development. To find an optimal project in portfolio development they have used the strategic bucket for resource allocation, portfolio matrices for balancing projects and scoring models for evaluating projects. Finally, the portfolio projects are selected by an expert system which covers the company strategy and operational knowledge in the fuzzy rule-based system. The feasibility of the system has been verified by applying it to a Korean electronic firm. To support portfolio managers in their middle-term investment decisions, Yunusoglu and Selim [100] developed a rule-based fuzzy expert system. This system considers different risk profiles for investors and different investment period lengths. The proposed system is validated by Istanbul Stock Exchange National-100 (ISE) index and the results are compared with the benchmark index of ISE. Results have shown that proposed system is superior to the bench-
mark index. Zeng et al. [103] proposed a multi-objective decision-making model using fuzzy uncertainty for the energy generation portfolio.

1.4 Research Objectives

Recently, the forecasting of the stock market and portfolio designing has become a very interesting issue. Researchers, stock market investors and stock market managers are always trying to find more efficient methods to predict the stocks and design a portfolio. The main aim of this thesis is to help the stock investors in stock market prediction and portfolio designing. Keeping in view of the literature review, my research work is an attempt to overcome the drawbacks in the existing models by using hybrid neuro-fuzzy model. Specifically, the proposed research is designed to achieve the following objectives:

- The first objective is to propose some new forecasting mechanism which is modeled by artificial intelligence approaches specially the neuro-fuzzy hybrid method for Indian stock markets (Bombay Stock Exchange (BSE), National Stock Exchange (NSE)).

- The second objective is to design an ideal portfolio for investors in the stock market.

1.5 Summary

The main goal of this thesis is to predict the Indian stock markets, BSE and NSE using soft computing techniques. The chapter wise summary of the thesis is presented in this section. The work is distributed in five chapters.

In Chapter 2, we have included some of the key theories and methodologies relevant to the thesis. The material presented in this chapter is mostly standard definitions and results obtained from the literature.

Chapter 3 investigates the predictability of stock markets BSE30, Hang Sang China Stock Index (HS), Japan Stock Index (NIKKEI) and Taiwan Weighted Index
(TWI) using ANFIS combined with subtractive clustering technique. In this process, we compare stock markets with variable numbers of data clusters. Optimized subtractive clustering is used to cluster the data and create fuzzy membership functions. Finally, a hybrid learning algorithm has been used to combine least square method and back propagation gradient descent method for training the fuzzy inference system.

Chapter 4 deals with the choice of predictive variables in stock market prediction. We have used financial sectors as predictive variables. Regression analysis has been employed for the selection of sensitive variables and then dimensions of data have been reduced by using principal component analysis. After the selection of input variables, a hybrid model is proposed in which fuzzy c-means (FCM) clustering method and adaptive neuro-fuzzy inference system are used for fuzzification and for defining fuzzy relations. For the evaluation purpose, the proposed model is compared with existing models. The results have shown that the proposed model gives a satisfactory prediction of the stock market index.

In Chapter 5, an attempt has been made to aggregate high dimensional data into one useful forecasting factor. Higher dimensional data can not be easily processed by existing forecasting models because the model will become more complex with the increase of data dimensions. So to tackle this issue, a minimal variability OWA operator has been used to aggregate values of high dimensional data into a single attribute. After that two algorithms have been proposed. In the first algorithm, a hybrid network based fuzzy inference system combined with subtractive clustering is used to forecast BSE30. In the second algorithm, fuzzy inference system combined with fuzzy c-means clustering is used to forecast BSE30. Further, the proposed models have been compared with some existing models. Results have shown that proposed models give better forecasting than existing models.

The goal of Chapter 6 is to help fund managers, investors, portfolio managers and stock market traders in taking their decisions by providing them the investment knowledge for maximizing profit while minimizing risk. We have used financial ratios for the construction of the portfolio. Firstly, more efficient ratios are selected by applying a clustering technique, then a rule-based fuzzy expert system is developed
to rank the stocks and finally, a linear programming model is developed to design a portfolio for investors. The proposed model has been evaluated using two data sets of BSE30. One data set has been taken from recession period and one from growing market. The results have been tested with the benchmark index of BSE30 and compared with another existing approach in literature. It is observed that the proposed expert system gives relatively better results over some existing methods for portfolio design.