

## NEURAL NETWORK APPLICATIONS IN STOCK MARKET PREDICTIONS

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### ABSTRACT

The traditional mathematical model cannot effectively explain stock market behaviors and has often proved to be baffling for investors due to unreasonable hypotheses on which these models exist. Moreover, the fluctuation of market makes its prediction difficult. Even whilst considering its unpredictability, some patterns do exist which can assist in making proximate predictions. Hence to analyze and better interpret these patterns, we need to employ a form of intelligence smarter than average human intellect. The idea of a machine with learning capability has been one of the driving forces behind artificial intelligence and the same can be a boon for stock traders.

As of 2012, approximately 60% of world stock trades are driven by artificial intelligence-based software. The paper presents the effective use of artificial neural network (ANN) model which is applicable in predicting market behavior by using the present and past financial data. The artificial neural networks can be trained by feeding time series data and investment data which includes statistical information about the variations in stock prices and number of investors, past and current market status of the company and the companies associated with this stock or commodity. It can be trained using backpropagation algorithm or similar techniques over a period of time due to which it can provide investors with short time range predictions of stock and commodity prices and market behavior. Thus, this prediction can help investors make more precise investment decisions which, in turn could lead to higher monetary returns.

**KEYWORDS:** Artificial Intelligence, Backpropagation Algorithm, Artificial Neural Network, Stock Market, Prediction

### INTRODUCTION

Predictions in financial market have been based on traditional statistical forecasting methods for many decades. Linear models have been the basis of such traditional statistical forecasting. However, traditional methods have rarely proved helpful owing to the presence of noise and non-linearity in the time series data. To begin with the relation of past prices to future prices will not be linear, but nonlinear. This non-linearity implies that past price change can have wide ranging effects on future prices.

There are several motivations for trying to predict stock market prices. It is a practically interesting and challenging topic to predict the trends of a stock price. Fundamental and technical analyses are the first two methods used to forecast stock prices. Various technical, fundamental, and statistical indicators have been proposed and used with varying results. With the development of neural networks, researchers and investors are hoping that the market mysteries can be unraveled.

Although it is not an easy job due to its nonlinearity and uncertainty, many trials using various methods have been proposed, for example, artificial neural networks, fuzzy logic, evolutionary algorithms, statistic learning, Bayesian belief networks, hidden Markov model, granular computing, fractal geometry, and wavelet analysis.

An ANN model is a computer model whose architecture essentially mimics the learning capability of the human brain. Many simple interconnected linear or nonlinear computational elements are operating in parallel processing at

multiple layers. In some applications it has been specified that ANNs have limitations for learning the data patterns. They may perform inconsistently and unpredictable because of the complex financial data used.

The very power of neural network modeling lies in its ability to adjust itself according to the information given in order to optimize some pre-determined objective. The novelty of neural network lies in their ability to model nonlinear processes with few (if any) assumptions about the nature of generating process. This is particularly useful in financial prediction applications where much is assumed and little is known about the nature of the processes determining asset prices.

In this paper we discuss about the ANNs used to predict stock performance. To make prediction, ANN needs to be trained. For training ANN, we have used backpropagation algorithm to train ANN on weekly basis. Backpropagation is widely used algorithm to train ANN.

## **TRADITIONAL APPROACH**

A share of stock is literally a share in the ownership of a company i.e. a small fraction of the assets and earnings of that company. Assets include everything the company owns and earnings are all of the money the company brings in from selling its products and services. A company shares its assets and earnings with the general public because it needs the money, of course. Companies only have two ways to raise money to cover start-up costs or expand the business: It can either borrow money (a process known as debt financing) or sell stock (also known as equity financing).

The disadvantage of borrowing money is that the company has to pay back the loan with interest. By selling stock, however, the company gets money with fewer strings attached. There is no interest to pay and no requirement to even pay the money back at all. Even better, equity financing distributes the risk of doing business among a large pool of investors (stockholders). If the company fails, the founders don't lose all of their money; they lose several thousand smaller chunks of other people's money.

If you issue a lot of shares, that would lower the price of each individual share, perhaps making the stock more attractive to lone investors. Another consideration is ownership. Each person who buys a share of stock essentially owns a piece of the company and has a say in how the company is run.

Stock prices aren't fixed. From the second a stock is sold to the public, its price will rise and fall based on free market forces. It is these ever-shifting market forces that make short-term movements of the stock market so difficult to predict. And that is precisely the reason why short-term stock market investing is so risky. If there are a fixed number of shares in circulation, then the price of the stock will rise as more people want to buy it, and fall as more people want to sell it.

Since decades, people have tried to find out the optimal method for analyzing the stock market and its behavior. A few have been accepted as standard techniques or methods to predict the behavior of stock market which are Fundamental analysis or Technical analysis.

Fundamental Analysts are concerned with the company that underlies the stock itself. They evaluate a company's past performance as well as the credibility of its accounts. Many performance ratios are created that aid the fundamental analyst with assessing the validity of a stock, such as the P/E ratio.

Technical analysts or chartists are not concerned with any of the company's fundamentals. They seek to determine the future price of a stock based solely on the (potential) trends of the past price (a form of time series analysis). Numerous patterns are employed such as the head and shoulders or cup and saucer. Alongside the patterns, statistical techniques are

utilized such as the exponential (EMA). Also the other approaches involve prediction based on the profit and loss of the company in the current quarter, the status of company, the number of investors in the company, the new products or offers proposed by the company

Stock exchanges have an interesting side effect. Because all the buying and selling is concentrated in one place, and since it's all done electronically, we can track the constantly fluctuating price of a stock in real time. Investors can watch, for example, how a stock's price reacts to news from the company, media reports, national economic news and lots of other factors.

The stock prices can be very well analyzed and predicted based on the transaction and deals made by the company with other companies. These transactions decide the volume of money transferred between the market and company. This money actually comprises of investment made by the stock holders. Thus in a way the success transactions or the deals made with other companies decide the overall profit and loss of the company. So more investment made by investors more money is available for the company to make transactions which will in turn result in more profit for the company or loss if the deals don't work as expected.

The status of company plays an important role to make the investors invest more in their company. The better is the past record of the company the more is the chances for an investor to suggest and recommend the stock to other people, who are in a dilemma whether to invest in this company or not. Also the risk involved in investing in such company is very less due their past record and also the less variation in their stock prices.

Number of investors depicts the faith people have in the company. This faith is instilled in people due the benefits or the profits made by them by investing in the company in the past years. It a general herd mentality that if a person is buying a particular stock and if the person just tips about it in the market, indicating about the probability of the profit they would get by investing in this stock, people generally tend to invest in the stock. Thus more the number of stock holders more is the information about the variation in the prices of the stock is spread in the market.

If a particular company makes a deal with another company there are many who benefit from it. These are the investors in the companies, the companies themselves and lastly the consumers or the customers buying commodities manufactured by them or the service provided by them.

All News Related to the markets and about the company can predict whether it will have a positive or negative impact on the stock price. In case of good news for a stock, positions can be made in advance and also on intra-day basis to make good profits.

Studying stock chart patterns is very important for all interested in stock trading. Some chart patterns are bullish while some others are bearish in nature. In case of a bullish chart formation, positions can be made for a few trading sessions and then profits can be booked. In case of a bearish pattern, exiting the stock immediately before the huge free fall would be the right strategy. Chart patterns help to understand weakness and strength in the stock thus enabling us to predict future price targets.

Generally, it has been observed that there is a substantial volume growth in the stocks of companies before they start their run up. Increasing volumes can mean that there is growing trader interest in the stock due to some positive news. However, on the other hand, if a stock is continuously breaking down with heavy volumes, then it is a sign that it is going down to a great extent.

## RELATED WORK

Although a lot of research has been done in this field, there are some factors which should be considered to make the output more accurate. The most important part of the neural network is input. The more efficient inputs are, the more accurate the results would be.

The inputs that are considered so far focus more on technical factors. But in case of stock market predictions there are a lot of indirect factors that affects the stock prices. Focusing only on past stock performance is not enough to predict stock market performance. Factors such as Market sentiment, inflation, rumours are also important in predicting stock market performance. The Neural network designed so far does not put emphasis on these factors. Hence we consider direct and indirect factors in our design to make the prediction accurate.

## NEURAL NETWORK ARCHITECTURE

A neural network is a massively parallel distributed processor that has a natural propensity for storing experiential knowledge and making it available for use. Artificial neural networks are computers whose structure is modelled after the brain. It resembles the brain in two respects: knowledge is acquired by the network through a learning process and inter-neuron connection strengths known as synaptic weights are used to store the knowledge. They typically consist of many hundreds of simple processing units, which are wired, together in a complex communication network. Each unit or node is a simplified model of a real neuron, which fires (sends off a new signal) if it receives a sufficiently strong input signal from the other nodes to which it is connected. The strength of these connections may be varied to enable the network to perform different tasks corresponding to different patterns of node firing activity. The basic element of a neural network is the perceptron. Frank Rosenblatt first proposed it in 1958 at Cornell University. The perceptron has 5 basic elements: n-vector input, weights, summing function, threshold device and an output. Outputs are in the form of  $-1$  and/or  $+1$ . The threshold has a setting, which governs the output based on the summation of input vectors. If the summation falls below the threshold setting,  $-1$  is the output. If the summation exceeds the threshold setting,  $+1$  is the output. A more technical investigation of a single neuron perceptron shows that it can have an input vector  $X$  of  $N$  dimensions. These inputs go through a vector  $W$  of Weights of  $N$  dimension. Processed by the Summation Node, 'a' is generated where 'a' is the 'dot product' of vectors  $X$  and  $W$  plus a bias. It is then processed through an activation function, which compares the value of 'a' to a predefined threshold. If 'a' is below the threshold, the perceptron will not fire. If it is above the threshold, the perceptron will fire one pulse whose amplitude is predefined.

Neural networks itself represents a collection of artificial intelligence models which include, multilayer perceptron neural network, recurrent neural network, modular neural network, radial basis network. Each of these models has its own specific structure, training method and area of application. A thorough understanding on each of them is necessary to make the best choice of network structures for financial forecasting tasks. The choice of relevant inputs for the networks would essentially be based on the expert knowledge in finance field. However, the best set of inputs is constrained by time factor and market factor thereby, demanding sufficient human expertise to choose the best inputs for a specific market at a specified time. Certain systematic methods give a helping hand to select a best sub-set of inputs from a large collection of possible inputs, including pruning of network, mutual information and embedding dimension. Equally important is the choice of outputs from the network to generate meaningful financial forecasting. This again rests on the expert financial knowledge. Neurons are all fundamentally the same, though may differ in specific details, such as connections and functions used to analyse data. When neurons are combined in such a way, they often take one of three roles: input, hidden, and output neurons. Input neurons are ones that are fed data from an external source, such as a file,

rather than other neurons. Hidden neurons accept their information from other neurons' outputs. Output neurons are like hidden neurons, but rather than passing the processed information to a new set of neurons, they save the information and allow it to be read and interpreted by an external actor. For explanatory purposes, a neuron may be broken down into, input connections, summing and activation functions, output connections

### Input Connections

Unless the artificial neuron is an input neuron, a neuron is connected to other neurons and depends on them to receive the information that it processes. There is no limit to the amount of connections a neuron may receive information from. The information that a neuron receives from others is regulated through the use of weights. When a neuron receives information from other neurons, each piece of information is multiplied by a weight with a value between -1 and 1, which allows the neuron to judge how important the information it receives from its input neurons is. These weights are integral to the way a network works and is trained: specifically, training a network means modifying all the weights regulating information flow to ensure outputs are correct.

### Summing and Activation Functions

The second portion of a neuron is the summing and activation functions. The information sent to the neuron and multiplied by corresponding weights is added together and used as a parameter within an activation function. In a biological context, a neuron becomes activated when it detects electrical signals from the neurons it is connected to. If these signals are sufficient, the neuron will become "activated" - it will send electrical signals to the neurons connected to it. An activation function is similar: the artificial neuron will output a value based on these inputs. It is almost always the case that a neuron will output a value between  $[0, 1]$  or  $[-1, 1]$ , and this normalization of data occurs by using the summed inputs as a parameter to a normalizing function, called an "activation function". Numerous activation functions exist, but within this project, three types of activation functions were explored:

- **Threshold Function:** a simple function that compares the summed inputs to a constant, and depending on the result, may return a -1, 0, or 1.
- **Piecewise-Linear Function:** if the summed inputs are in the range  $[-0.5, 0.5]$ , the value is kept as before, while anything else will return a -1 or 1
- **Hyperbolic Tangent Function:** a continuous function with a domain of  $(-\infty, \infty)$  and a range of  $(-1, 1)$ .

### Output Connections

Finally, once the activation function returns a corresponding value for the summed inputs, the values are sent to the neurons that treat the current neuron as an input. The process repeats again, with the current neuron's output being summed with others, and more activation functions accepting the sum of these inputs. The only time this may be ignored is if the current neuron is an output neuron. In this case, the summed inputs and normalized sum is sent as an output and not processed again.

### Feed Forward Networks

While each neuron is, in and of itself, a computational unit, neurons may be combined into layers to create complex and efficient groups that can learn to distinguish between patterns within a set of given inputs. Indeed, by combining multiple layers of such groups, it is theoretically possible to learn any pattern. There are many combinations of neurons that allow one to create different types of neural networks, but the simplest type is a single-layer feed forward

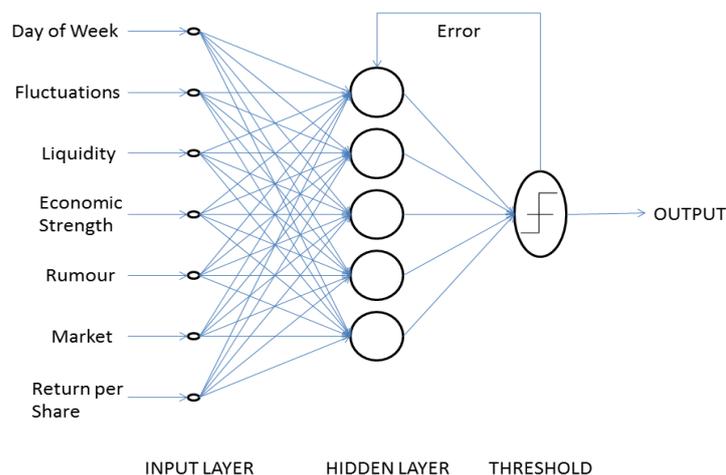
network. In this case, a network is composed of three parts: a layer of input nodes, a layer of hidden neurons, and a layer of output nodes. Within this network, there is a neuron for each input variable in an input pattern, which is then propagated to the layer of hidden neurons. As mentioned earlier, each neuron in the hidden layer has the inputs multiplied by a weight, and all inputs are summed. After this is done, the value is passed to an activation function, and each neuron in the hidden layer then passes the output on to neurons in an output layer, which also multiply the values by weights and sum them. A multilayer feed forward network is similar to a single-layer one. The main difference is that instead of having a hidden layer pass its calculated values to an output layer, it passes them on to another hidden layer. Both types of networks are typically implemented by fully connecting each layer's neurons with the preceding layer's neurons. Thus, if *Layer A* has  $k$  neurons and sends its information to *Layer B*, with  $n$  neurons, each neuron in *Layer A* has  $n$  connections for its calculated output, while each neuron in *Layer B* has  $k$  input connections. Interestingly, such a network can be represented mathematically in a simple manner. Supposing there are  $k$  neurons in *Layer A*, let  $a$  represent a vector, where  $a_i$  is the  $i$ th neuron's activation function output. Let  $b$  represent the input values to neurons in *Layer B*, with  $b_j$  be the  $j$ th neuron. Let  $W$  be an  $n$  by  $k$  matrix where  $w_{ji}$  represents the weight affecting the connection from  $a_i$  to  $b_j$ . Keeping this in mind, we can see that for a single-layer feed forward network, we can mathematically represent the flow of information by,  $W_a = b$ , and the learning thus becomes a modification of each  $w_{ji}$  in  $W$ . A similar mathematical analogy applies to multilayer feed forward networks, but in this case, there is a  $W$  for every layer and  $b$  is used as the value for  $a$  when moving to subsequent layers. The most popular type of learning within a single-layer feed forward network is the Delta Rule, while multilayer feed forward networks implement the Back Propagation algorithm, which is a generalization of the Delta Rule.

**Back Propagation**

The back propagation algorithm is one of the most common learning methods within neural networks. While widely used, the algorithm has its pros and cons, and it helps to understand how it works. The back propagation algorithm is useful in that it generalizes the Delta Rule for single-layer feed forward neural networks to multilayer feed forward ones. One of the biggest problems in training neural networks is the Credit Assignment Problem: how does one assign credit to individual neurons for errors in the final outputs of a neural network? The Delta Rule is one solution to this problem, but only applies to single-layer feed forward networks.

**MODEL ANALYSIS**

We used feed forward neural network which has an input layer with seven inputs, a hidden layer which has 5 neuron sand an output layer with single neuron. The back propagation algorithm has been used for training the network.



**Figure 1**

- **Training Phase**

There are two phases 1st is the training phase and 2nd is the prediction phase. The training phase can be divided into two parts, the propagation phase and the weight update phase. In the propagation phase 1st the input data is normalized for feeding the network into the input nodes. The normalized input data are fed into the input layer, and then the weights are multiplied with the each input data and enter into the neurons of hidden layer. The hidden layer neurons have the same functions as the input layers neurons .After that each neuron passes the output to the next neuron of the output layer. The output layer calculate the in the same way as the hidden layer neuron and generate the final out put which is the compared with the real output and calculate an error signal. The error is generated from the Propagation Phase is used to update the weight.

This process is done in every weight matrix in the network for updating weight. The Phase 1 and Phase 2 procedure repeatedly used until the sum of square error is zero or close to zero.

- **The Prediction Phase**

When the neural network is trained then it is ready for prediction. After training with acceptable error the weights are set into the network then we give the trained network the input data set of the day which price we want to predict. The trained network then predicts the price using the given input data set.

- **Input Data**

Here is a brief description about the inputs that affect the share price:

### **Day of the Week**

Day of the week effect phenomenon is one of the most important anomalies that have been observed in many stock markets in all over the world and thus investors can adjust their buying and selling accordingly to increase their returns based on days. This specific phenomenon has been observed and studied by many researchers for many years and as a consequence there are a lot of different results. It has been observed that average market return in the first trading day and in some countries in the second trading day is negative or at least lower than the rest of trading days.

E.g. for BSE, the highest and lowest returns are observed on Wednesday and Monday, the highest and the lowest volatility are observed on Friday and Wednesday, respectively.

Thus day of the week can have a value ranging from 0 to 1. Zero indicates the returns on that day are not so good compared to other days whereas one indicates a strong return expectation for that day.

### **Fluctuation**

The range of fluctuations of a stock price determines the stability of the stock price. Thus the fluctuations help us determine whether investment should be made for long term or short term. If the stock price of the company varies very frequently i.e the fluctuation is high that kind of stocks are preferred for short term investment whereas if the fluctuations is very low it indicates that the stock prices are fairly stable and changes only over a period of time which means that long term investment is preferable for such kind of stocks The fluctuation can be calculated by considering the range of the lowest and the highest value of the stock for a period of time and keeping that as the normalizing parameter fluctuation can be calculated. Fluctuation thus can be ratio of the net increase or decrease of a stock price in a given small period of time to that of the difference in the lowest and the highest value of the stock for a comparatively larger period of time.

The value of the fluctuation will range from 0 to 1 zero indicating less fluctuation and one indicating very high fluctuations

### **Liquidity**

Liquidity is an important and sometimes under-appreciated factor. It refers to how much investor interest and attention a specific stock has and thus can be deciding factor for the evaluation of the supply and demand of that particular stock.

Liquidity refers to the probability of converting the stock or an asset to money. If the stock is highly liquid it means that the stock is in demand and thus can be sold easily to convert them into money on the other hand if the stock is not that much in demand then the chances of finding a potential buyer and earning good amount of profit from it is less. It is safer to invest in liquid assets than illiquid ones because it is easier for an investor to get his/her money out of the investment.

Trading volume is a direct indicator for liquidity. It indicates the number of buyers and sellers for that stock thus determining the probability of selling and buying of that stock. It is also a function of corporate communications i.e. the degree to which the company is getting attention from the investor community and hence its goodwill and stock performance can be interpreted. Large-cap stocks have high liquidity because they are well followed and heavily transacted due to the fact that such stocks are proven to perform well and give high returns when the stock is sold. Many small-cap stocks suffer from low liquidity because the stock performance is fairly average and the stock prices change is not that large thus giving a low return value whilst selling it.

Liquidity can have a value between 0 and 1 where zero indicates that the stock is illiquid and one indicates that the stock is highly liquid.

### **Economic Strength**

The Company's operations and performance depend significantly on worldwide economic conditions. Uncertainty about current global economic conditions poses a risk as consumers and businesses may continue to postpone spending in response to tighter credit, unemployment, negative financial news and/or declines in income or asset values, which could have a material negative effect on demand for the Company's products and services

If the economy is forecast to enter into a recession, then stock markets will generally fall. This is because a recession means lower profits, less dividends and even the prospect of firms going bankrupt, which would be disastrous for shareholders.

However, in a recession, stock markets can sometimes increase this is because stock markets are forward looking.

A country with consistent economic growth performs better than a country with lower rates of growth. The link may not be perfect but there is definitely some correlation. For example, the Indian stock market has done well in the past couple of years due to improved performance of Indian economy.

The various factors that affect the economy and thus the stock prices are

- Interest rates
- Economic outlook
- Inflation

- Deflation
- Economic shocks
- Changes of government
- The international value of oil and other major raw products

The value of economic strength can range from 0 to 1 where zero indicates that the economy is going through a bad phase and market is probably not going to perform well and thus the investments will not be beneficial .one indicates that the economy of the country is strong and is very likely to be affected by other country's economy and ensures that the market is stable and companies will make large profits.

### **Rumour**

News and rumours are something that affects stock prices. It affects both long-term investment and short term investment. It's important to review the news headlines periodically as the market and company's conditions change very frequently and any major declaration made by the company or the government can have a major and immediate effect on stock prices. There may be positive news, negative news or news to which investors may not react at all. These news and rumours are seldom stated officially by the company and have a direct or indirect implication. The investor has to be smart enough to decode these news and rumours and quickly decide whether it will affect his stocks in anyway and if yes, the degree to which the news can have an impact. In today's world of multimedia and internet these inside facts and knowledge about a company's performance spread very quickly which results in a chain reaction of one investor suggesting his circle to invest in the same stock and so on. This chain reaction can result in sudden demand for a particular stock, increasing its value. These rumours sometimes also indicate a selling pattern when a tip is circulated that the company's return is not going to be high for a particular quarter.

These rumours are very frequently out in the market and are large in numbers so it is very difficult to identify a genuine fact and respond to it.

The rumours can have a value between 0 and 1. Zero indicates that strength of the rumour or the support for the rumour is very low and the probability for that to turn true is less. One indicates that the information contained in the rumour or news is almost true and there is strong following and responses by the investors.

### **Market**

A particular company's stocks follow the market conditions and their sector and other companies involved in similar line of business or companies that are indirectly related to it e.g. a company manufacturing raw goods for the company. A company's individual performance is determined by majority of a stock's movement. The economic conditions account for about 90% for evaluation of a company's growth and thus the stock performance.

The value of market can range from 0 to 1. Zero indicates that the market conditions are not so good and thus the sector in which the company operates and the associated companies are performing poorly and thus it is not preferable to invest in such companies because the returns will not be high if the stock is sold in near future but if the investment is made for a long term there is a possibility that the market might recover and the corresponding sector in which company is categorized may as well recover thus giving good returns but in such a case the risk factor is high and is generally avoided. One indicates that the market conditions are stable and the sector in which the company operates is healthy and thus investment can be made.

## Return per Share

Expected return is simply an estimate of how an investment will perform in the future. Return on an investment is the total value derived from that investment over a specified period of time. Actual return consists of the profit or loss made when the stock is sold plus whatever dividend income is received during the time the stock was held. If the stock pays no dividend, return is simply positive or negative depending on whether the stock was sold for more or less than its cost. Return is arrived at by dividing the total return by the cost of the investment.

The return of a share is directly related to the company's performance. If the company announces a big contract then the stock prices will go up and hence the profit margin or net profit for the investment will be high. Similarly if the company has gone through losses and have had a split or any major law suit has been filed against them for which they have to pay a huge penalty the profit made by that company will decrease drastically thus the dividend given can be minimal or even zero. In such a case the return per share or the profit earned will be low or it can even be a loss.

The value of the return per share is an indicator of the profit that can be made and is relative for investors as it depends on the quantity of stocks purchased and the initial investment made. Thus it can have a value between 0 and 1 where zero indicates that the return per share is going to be less and will incur a loss to the investor. One indicates that the returns will be high. 0.5 indicates that the investment won't return anything which is very rare case because an investment generally results in a profit or loss.

## CONCLUSIONS

In this paper, an attempt is made to explore the use of neural network to predict the daily returns of the Stock Market. Neural networks are basically experimental methods where lot of trial and error is involved. Neural network with different structures can be used to predict the stock market behaviour and a compare is on can be made of the predictive power of the different architectures. Global financial market players, institutional investors and generic software developers should consider developing stock market trading strategies using neural networks. Probably, further experimentation is required for producing better prediction of stock prices and further work has to be done by testing it for weekly or monthly returns, as well as by including other micro and macro-economic variables as inputs. Further, the influence of macroeconomic variables such as interest rates, stability of the government, GDP, trend in global stock market, etc., have to be considered to obtain a better network structure. The network may also be developed using technical indicators apart from fundamental data. Better network structure could be obtained by varying the parameters of the training algorithm and different trading strategies can be developed for different market players. Neural networks have the capability to forecast financial markets and if properly trained, the individual and institutional investors could benefit from the use of this forecasting tool.

Different types of investors depend on different factors. Short-term investors and traders tend to incorporate and may even prioritize technical factors. Long-term investors prioritize fundamentals and recognize that technical factors play an important role. Investors who believe strongly in fundamentals can reconcile themselves to technical forces with the following popular argument: technical factors and market sentiment often overwhelm the short run, but fundamentals will set the stock price in the long-run. In the meantime, we can expect more exciting developments in the area of behavioural finance since traditional financial theories cannot seem to explain everything that happens in the Stock market.

SINCE NNs are relatively new methods and still not adequately examined, they open up many possibilities for combining their methods with new technologies, such as intelligent agents, Active X, and others. Those technologies could help in intelligent collecting of data that includes searching, selecting, and designing the large input patterns. Furthermore,

with its intelligent user interfaces, those methods could improve the explanation of NNs results and their communication with user. NNs researchers improve their limitations daily, and that is the valuable contribution to their practical importance in the future.

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