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Forecasting stock market with neural networks

Hua Jiang
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Hua Jiang, B.Eng., China, 1995

A dissertation

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In partial fulfillment of the

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ABSTRACT

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The objective of this project is to use neural networks to forecast next day's stock closing price. In the past, researchers used different methods to forecast stock price such as technical analysis, fundamental analysis, and economic analysis. Forecasting stock prices is a problem that has been usually approached in terms of weekly, monthly, or quarterly forecast. This project aims at finding a feasible way, by using neural networks, to make daily forecasts.

Most methods proposed so far, such as technical, fundamental and economic analysis, are limited to solving the problem as a long term trend analysis. Thus, these methods either lack accuracy or add extra expenses to the forecasting task, especially if a company's fundamental statistics are out of date. Therefore it is difficult to forecast day-to-day close price as a nonlinear problem.

In this study, three portfolios are created. Portfolio #1 is based on subjective forecasts, Portfolio #2 uses a neural network to forecast, and Portfolio

#3 using CAPM optimizer forecast. A comparison of these portfolios showed that the CAPM optimization based on neural network forecast (Portfolio #3) achieved the highest return. The degree of accuracy is compared in three economic periods: the beginning of recession; the middle of recession; and the beginning of recovery. Stock forecasting example cases are given to illustrate this neural network approach to solve nonlinear problems. It is observed, indeed, that next day closing prices are forecast with better accuracy within a one-year period than other methods.

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NOMENCLATURE

NOTATION

B_i	Adjusted close price of i day
B_{i+1}	Adjusted close price of i+1 day
e_i	Some residual value on asset i
f	Some function
E^k	Mean square error at node k
$E(r_i)$	Expected return on asset i
N_i	Node i
r_i	Return on asset i
r_f	Risk free rate
R^2	Measurement of unsystematic risk
T^j	Targeted value at node j
w	Connection weight
y^j	Value to be estimated at node j
α_i	Vertical axis intersection value
β_i	Beta coefficient
ε_i	Some residual value on asset i
θ_j	Output action function at node j
σ	Risk value
σ_i	Rick value on asset i
σ_m	Risk value on stock market

ACRONYMS

#i	Hidden neuron number i
BPN	Back propagation neural network
CAPM	Capital Asset Pricing Model
CPI	Consumer price index

DD/DD'	Daily data
DJIA	Dow Jones Industrial Average
E	Sum of activated excitory inputs
HPR	Holding period return
I	Sum of activated inhibitory inputs
MIA	Market index average
MS	Money supply
MD	Monthly data
NASDAQ	National Association of Securities Dealers Automated Quotation System
PDC	Predict daily close price
P#1	Subjective forecast portfolio
P#2	Neural network forecast portfolio
P#3	CAPM forecast portfolio
R^2	System risk/Total risk
SPTSE	TSE 300 index/S&P TSX composite index
T (tse)	AT&T company symbol
T	Threshold
TR	T-bill rate
TSE	Toronto Stock Exchange
UR	Unemployment rate

ACKNOWLEDGEMENT

During the course of the project, Dr. El-Bouri and Dr. Zolfaghari gave much help and after numerous corrections, this project report is ready to be presented. I would like to give special thanks to their supervision and to the Mechanical Engineering Department at Ryerson University.

CHAPTER 1. INTRODUCTION

According to Carter [3], a survey conducted by the Toronto Stock Exchange in 1989 revealed that “Twenty-three percent of all Canadians owned stocks or mutual funds. This means that over 5.5 million Canadians invest in the stock market. Well over 4 million of them own shares directly in their own name rather than through mutual funds. Of the 4 million-plus Canadians who invest in the market only about eight percent have accounts over $50, 000, but most are less than $10,000”. The significance in collecting the right data and identifying the type of investors is the key to the analysis of stock market where more and more Canadians invest. An important tool for making investment decisions is forecasting.

Forecasting is a common activity in stock market investment. There are several methods (techniques) such as statistical methods, mathematical modeling, fundamental analysis, technical analysis etc. In the 1990s, techniques based on artificial intelligence approaches began to be used. One such technique uses artificial neural network for forecasting.

Neural networks have many features as a data analysis tool, and a relatively efficient implementation scheme in terms of computation speed and computer memory requirements. The advent of such a powerful technique naturally attracted the interest of the finance community and economists.

The objective of this project is to develop a neural network for forecasting next day prices using seven input factors believed to influence prices. The seven factors are as follows:

1. T-bill Rate (TR);
2. Consumer Price Index (CPI);
3. Money Supply (MS);
4. Market Index Average (MIA);
5. Unemployment Rate (UR);
6. Monthly Data (MD);
7. Daily Data (DD);

The rationale for choosing these specific factors is explained in detail in Section 3.5. The stock data is quoted in dollars. The value of money works directly on the quotation of stock, and thus forecast results are quoted in dollars. Industry generally uses the 3 months T-Bill rate as an equivalent indicator of interest rate. This is because the Treasury bill rate is calculated according to the currency reserve in the Central Bank and interest rate is calculated according to the currency reserve in the Central Bank too. Therefore when the reserve changes, the T-Bill rate and the interest rate move proportionally according to the same factor. In this project, T-Bill rate is considered as an essential indicator of economic health. Concerning stock market, the stock prices respond directly to the limit of credit controlled by the Federal Reserve. Therefore, stocks are priced for their value.

Stocks as financial instruments have their fair value and limits. According to Kenneth [6], "Price limits are artificial boundaries established by market regulators to confine daily movements of security prices. Price limits are currently used in the U.S. futures market and in many stock exchanges around the world including: Austria, Belgium, France, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Spain, Switzerland, Taiwan, and Thailand". Therefore, it is reasonable to believe that stock price can't go beyond this limit in this project.

According to Schulz [10], "The market is always to be considered as having three movements, all going on at the same time. The first is the narrow movement from day to day. The second is the short swing, running from two weeks to a month or more; the third is the main movement, covering at least four years in its duration." This project is concerned with day to day movement. Therefore, daily adjusted close price is used as an indicator in forecasting the following day close price. During this project, the Dow Jones Industrial Average lost 18% and the TSE300 index lost 13%. The DJIA closed at 10073.4 and the TSE300 Index closed at 7646.8 in January. At the end of year 2002, DJIA closed at 8341.63 and TSE300 Index closed at 6614.5.

Three portfolios are created to compare three forecasting techniques. In Portfolio #1, buying and selling are based on random decisions. Portfolio # 2 uses a Neural Network with input factors to make buy/sell decisions. Finally, buying and selling in Portfolio # 3 is based on daily Beta. There are ten stocks in each portfolio. The results of the comparison showed that portfolio #2 outperformed both portfolio #1 and the market indices. However, the highest return among the three was still achieved by portfolio #3, with daily Beta.

CHAPTER 2. LITERATURE REVIEW

In this chapter, the history of Neural Networks and its use in forecasting the stock market using generalization is reviewed. Then the CAPM model widely used in the security analysis industry is reviewed.

2.1 REVIEW OF BPN FORECAST ON STOCK MARKET

In the past decade, neural network prediction models attracted many enthusiastic researchers. The literature within our research scope include Ahmadi [1], Choi et al [4], Kohara et al [7]. They concluded that neural network models outperformed the benchmark models in index return. In this project, the factors considered are generally economic and market variables and we feed these selected data to the BPN neural network under study.

2.2 ADVENT OF NEURAL NETWORK MODEL

The study of human brain has never stopped. Nowadays, scientists can basically understand the function of nerves and neurons in the human brain and the functional allocation of each physical part. On the path, the advancement of computer technology has allowed computer scientists to use computer program to simulate the single neuron firing process and organize it in a complex way to carry out the basic tasks that the human brain does.

According to Wilde [12], "A human brain consists of about 10 to the power of 11 nerve cells. The protrusions of the soma are of two different kinds, called axons and dendrites. There are about 10 to the power of 9 meters of axons, axon branches and dendrites. This is about 25 times the circumference of the earth." Further, Wilde [12] points out that "Neurons communicate through the exchange of ions. The ions carry electric charges. Because of the changing ion concentration inside the neurons, voltage spikes will travel in the neuron. When the spike arrives at the synapse, neurotransmitters (complex molecules) are released. A neuron that has not fired, because it did not reach the threshold for firing, loses its potential to fire gradually. This is sometimes called leakage, in analogy with an electric current leaking away." Based on the understanding of these logic, Neural Networks were developed.

2.3 MAJOR CONTRIBUTORS TO NN MODEL

The major milestones in the BPN model development, according to Fu [5] are:

- McCulloch and Pitts introduced the first abstract neuron model – 1940.
- Hebb proposed a learning law that explained how a network of neurons learned- 1949.
- Rumelhart and McClelland published "Parallel Distributed processing- 1985.
- Rumelhart, Hinton, and Williams developed backpropagation learning algorithm as a powerful solution to training a multiplayer neural network- 1986.

2.4 ARTIFICIAL NEURON AND MLP

This section describes the Multi-Layer Perceptron (MLP) network model that has been developed as an effective and powerful model for performing supervised learning tasks. Through adjusting the weights of connections between neurons, the MLP can be trained to solve non-linear optimization problem i.e. stock price data. The remainder of the project is concerned with input data selection procedure and the training and forecast examples.

The Backpropagation algorithm is carried out by presenting input data at the input layer and assigning weights to inter neuron connections. The input data is then propagated through the hidden layers until it reaches the output layer. The resulting output is compared with the desired output, and the difference is propagated back to the first layer (backpropagation). The weights are adjusted in a way to minimize the error and a new value is calculated as the output in the second epoch. In this way, data is propagated forward, and errors are propagated backward through the network thousands of times (epochs) until, the output error is minimized. The connection weights can be compared to the synaptic strength of biological neuronal networks. Details on the BP algorithm are found in Chapter 6 of "Artificial Neural Networks" by Schalkoff [9].

Artificial neurons are based on the all-or-nothing property of neuron firing, in a discrete time scale.

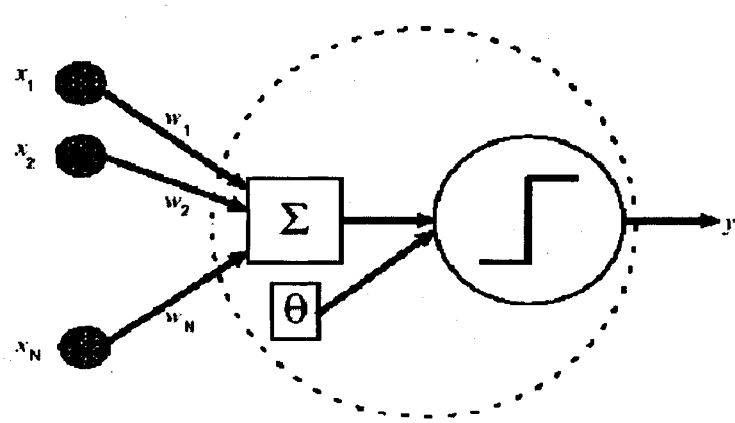

Figure 1. MLP Artificial Neuron Model [9]

T: Threshold

E: Sum of activated excitory inputs

I: Sum of activated inhibitory inputs

The MLP Neuron has the following characteristics [9]:

Table 1: Neuron Firing

E =>T	I=0	Firing (1)
E=>T	I>0	Not firing (0)
E<T	I=0	Not firing (0)
E<T	I>0	Not firing (0)

The figure below shows the general architecture of the MLP.

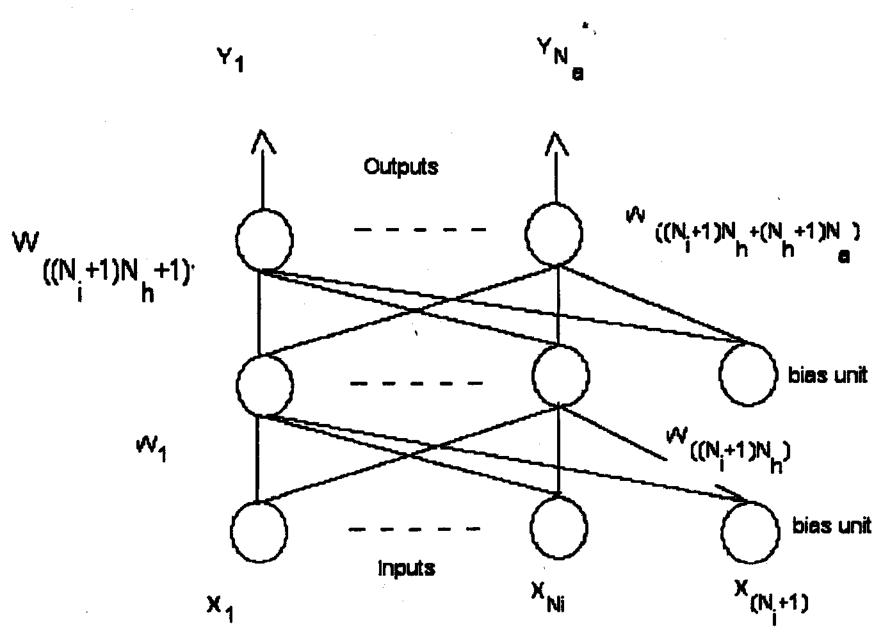

Figure 2. MLP General Architecture

2.5 COMPUTATION USING MLP'S SUPERVISED LEARNING

The MLP architecture feeds activation forward along the network and it feeds the error back along the network. Thus it is a non-recurrent network. In recurrent networks, the activation of the output layer is fed back to the network. In neural network, some commonly used activation functions are the sigmoid functions, such as the logistic $f(a) = \frac{1}{1+e^{-a}}$ and the hyperbolic tangent $f(a) = \tanh(a) = \frac{e^{a} - e^{-a}}{e^{a} + e^{-a}}$. When the network is fully trained, the input domain and the output domain are mapped through the weight matrix that can be saved and used for later forecast. This project is concerned with using MLP to perform supervised learning tasks. We use Mean Squared Error (MSE) $E^{k} = \frac{1}{2}\left\| y^{j} - \theta^{j}(T^{j}, w)) \right\|^{2}$ as the error function.

2.6 GENERALIZATION AND MODEL COMPLEXITY

In practice, generalization means that a trained NN can generate correct outputs for new input data patterns that were not part of the training set. According to Tamura and Tareishi [11], "The goal of supervised learning is not to learn an exact representation of the training data itself, but rather to build a statistical model of the process which generates the data".

The study of neural network generalization is directly related to the complexity of the model. Tradeoffs are often made for the particular tasks of the network. According to the readings, a simpler neural network generalizes better than a more complex neural network, and forecasts better result in cases where the output data has not been included in the input data set. Thus these kinds of neural networks are more robust. On the other hand, to increase the accuracy of the network, a more complex network is needed. The requirements of generalization vs. accuracy are compared in Table 2.

Table 2: Generalization vs. Accuracy

General, robust				Accurate, brittle
Low	←	Complexity resolution (Required level of accuracy).	→	High
A general model will interpolate incorrectly in this case	← Yes	Is the problem well posed?	→ No	Problem must be restarted so that it is well posed.
		Data Coding		
Dimensionality reduction				Many dimensions
		Network architecture		
Low	←	Number of network units	→	High
		Data collection		
Less data Sparse data Even distribution Noisy data				More data Dense data Uneven distribution No noise in data
		Network training		
Stop early	←	Independent validation set error rate monitoring	→	Over train
		Test criteria		
Performs well on unseen data				Reaches required level of accuracy

From the table represented in Kevin's book, we conclude that a simpler network structure is essential to take advantage of the generalization of neural networks. We can also avoid to over train the neural network and extract rules of noise data that doesn't belong to the mapping process.

2.7 MATH MODEL ON STOCK PRICE

According to Kohara et al. [7], there are two approaches in determining stock price with mathematical models. These are traditional statistical analysis and dynamic system. Market decisions are based on the agent's personal strategy, learning availability, availability of information [7].

2.8 CAPM MODEL ON STOCK PRICE

Capital Asset Pricing Model is a single factor model in determining stock price based on the risk averse value. In this model, investment return, r_i, is based on the expected return plus the level of response (β_i) to the single factor.

$$r_i = E(r_i) + \beta_i f + \varepsilon_i \tag{1}$$

Given $E(r_i)$ is known, β_i can be predicted and thus the return on asset i.e. stock price can be determined correspondingly. In a stock market, the single factor is the market index, and thus a single index model can determine the stock price.

$$r_i - r_f = \alpha_i + \beta_i (r_m - r_f) + e_i \tag{2}$$

The risk is composed of systematic risk and the unsystematic risk in terms of variance.

$$\sigma_i^{\ 2} = \beta_i^{\ 2} \sigma_m^{\ 2} + \sigma^2(\varepsilon_i) \tag{3}$$

Total variance = Systematic variance + Unsystematic variance

The measurement of unsystematic risk is given by $R^2 : \dfrac{SystematicRisk}{TotalRisk}$. For example, Air Canada $R^2 = 0.3$ means there is big firm specific risk, not much influenced by market, which means stock price doesn't fluctuate as much as the market index does.

2.9 SUMMARY OF REVIEW

Success in designing a neural network depends on a clear understanding of the problem. Knowing which input variables are important in the market being forecasted is critical. This is easier said than done because the very reason for relying on a neural network is for its powerful ability to detect complex nonlinear relationships among a number of different variables. However, economic theory can help in choosing variables that are likely important predictors. At this point in the forecasting process, the concern is about the raw data from which a variety of indicators will be developed. These indicators will form the actual inputs to the neural network. The financial researcher interested in forecasting market prices must decide whether to use both technical and fundamental economic inputs from one or more markets. Technical inputs are defined as lagged values of the dependent variable or indicators calculated from the lagged values. Fundamental inputs are economic variables that are believed to influence the dependent variables or their first difference as inputs.

A more popular approach is to calculate various technical indicators that are based only on past prices (and occasionally volume and /or open close price) of the ticker being forecasted. As an additional improvement, inter market data can be used since the close link between all kinds of markets, both domestically and internationally, suggests that using technical inputs from a number of interrelated markets should improve forecasting performance. For example, the price of Nortel Networks in NYSE and in TSE could be used as neural network inputs when forecasting the NT ticker. Fundamental information such as the yield, P/E ratio, volatility, or overvalue and undervalue effects may also be helpful.

The frequency of the data depends on the objective of the researcher. A typical off-floor trader in the stock or commodity futures markets would most likely use daily data if designing a neural network as a component of a overall trading system. An investor with a longer-term horizon may use weekly or monthly data as inputs to the neural network to formulate the best asset mix rather than using a passive buy and hold strategy. An economist forecasting the GDP, unemployment, or other broad economic indicators would likely use monthly or quarterly data.

CHAPTER 3. DESIGN OF A BPN FOR FORECASTING

To narrow down our training data frequency and to consider the possible effects and limits on forecasting results, daily data is selected. The data frequencies such as seasonal, quarterly, monthly and weekly are not considered in this project, which uses only daily data. However, because of their potential impact on the performance of the neural network, a brief explanation of each effect is given next.

3.1 SEASONAL EFFECT

Some stocks react to seasonal changes very much. It is so significant to consider stocks such as farming, leather, tourism, and hotel industry. The weather changes, road conditions, icing condition all can affect the stock price given other factors to be constant. Seasonal changes affect the profits of many industries, especially those whose sales depend heavily on weather or holiday influences. For example, if the summer is abnormally hot, the soft drink, air conditioning, leisure-time equipment and related industries may naturally be expected to benefit. But if the summer is colder than usual, their earnings may be disappointing. Likewise, Christmas and Easter bestow their seasonal blessings on the retail industry, while farm equipment makers benefit from early spring and summer. Seasonal market cycles such as these do not apply to the scope of this project due to the lack of data. Most stocks that are listed in Exchanges are less than five years in history; therefore to collect data on a seasonal basis is not feasible.

3.2 MONDAY EFFECT

The term "Black Monday" refers to the market crashes of Monday October19, 1987 and Monday October28, 1929. The Monday in 1929 was the beginning of the ten years great depression, in which the stock market basically collapsed and bankers and stock investors lost everything in their investment. Moreover, on the Monday of October28, 1929, DJIA dropped 508 points about 22.6% and S&P 500 lost 20.5% while NASDAQ Composite lost 11.3%. Not surprisingly, Black Monday still affects investors' psychology.

3.3 WEEKEND EFFECT

According to Miller [8], the negative returns over weekends are caused by a "shift in broker to investor balance". Miller argues that individuals focus on current needs on weekends, while market tends toward buy recommendations during the week. His hypothesis has been observed by the increasing number of odd lot orders in decrease number of institutional round log orders. Even if it is interesting to test the weekend effect, it is not considered because the scope of the project is limited to day traders and pattern day traders.

3.4 QUARTERLY EFFECT

Quarterly earnings play an important role in determining the stock price. When the quarterly earnings are published, good earnings often drive the stock price up and bad earnings generally drive the price down given the same market condition. However, the firm's specific risk is also influenced by market risk. For stocks that have positive Beta value, the market price generally moves in the same direction as the intra-day market direction. For stocks that have negative Beta value, the market price generally moves in the opposite direction to the market index. Should we use the quarterly effect as an input neuron, the duration of the project may last up to ten years to test the validity and collect the data. Thus the quarterly market cycle does not fall into the scope of this project due to the lack of data. Most stocks that are listed in Exchanges are less than five years in history; therefore to collect seasonal data is not feasible.

3.5 INPUTS SELECTION

Interest Rate Factor

The 91days Treasury bill rate as the interest rate is an input to the neural network. According to bank of Canada's report, substantial changes in the volatility of stock market returns are capable of having significant negative effects on risk averse investors. Such changes can impact on corporate capital budgeting decisions, investors' consumption decisions, and other business cycle variables. At the same time, it has been widely accepted that interest rate has immediate and direct impact on the stock market performance [2].

Consumer Price Index Factor

The CPI, calculated by the Bureau of Labor Statistics, is called an inflation indicator. The Consumer Price Index is an estimation of the price changes for a typical basket of goods. In other words, the prices of everyday goods such as housing, food, education, clothing, etc., are compared from one month to the next and the difference represents the CPI. The goods are weighted appropriately in order to get an accurate measure. The CPI carries important factors of cost of living and is used by the Federal Reserve when deciding the changes that need to be made to the interest rates as well as by investors when trying to predict the future price of securities. Indeed, when inflation is rising, it causes people to buy fewer goods, therefore reducing the profits of companies. This earning reduction may cause the company to become short of cash or to suffer a quarterly loss. Therefore, share price goes down.

Money Supply Factor

Money supply is used as an input neuron to the neural network model. There are two types of money supply, M1 & M2. M1 includes all coins and currency held by the public, traveler's checks, checking account balances, NOW accounts, automatic transfer service accounts, and balances in credit unions. M2 includes M1, plus savings and small time deposits, overnight repos at commercial banks, and non-institutional money market accounts. A key economic indicator used to forecast inflation, it is widely accepted that the M2 is an important gauge of Federal Reserve strategy and economic potential. If the annual rate of change in money supply is running under 3% stocks will typically struggle [2]. The money supply, M2, is the third input factor for the neural network.

Market Index Average Factor

In the exchange, MIA is designed to measure price changes of an overall market, such as the stock market or the bond market. An example is Vanguard's Total Bond Market Index. In this project, the DJIA and TSE are considered. These two factors are statistical indicators providing a representation of the value of the securities. They often serve as barometers for a given market or industry and benchmarks against which financial or economic performance is measured. The special effect of political news on MIA is taken in these data sets, e.g., War effect and the September 11 effect are all reflected in the TSE and DJIA indices. [2]

Unemployment Rate Factor

Unemployment news carries two primitive types of information relevant for valuing stocks: information about future interest rates and future corporate earnings and dividends. According to bank of Canada's report, an announcement of rising unemployment is good news for stocks during economic expansions and bad news during economic contractions. Stock prices usually increase on news of rising unemployment, since the economy is usually in an expansion phase. A rise in unemployment rate typically signals a decline in interest rates, which is good news for stocks, as well as a decline in future corporate earnings and dividends, which is bad news for stocks. According to bank of Canada's report, there is a strong relationship between stock prices and macroeconomic news, such as news about unemployment rate. According to bank of Canada's report, monthly stock returns are negatively correlated with the per capita labor income growth rate. They argued that since most of the variation in per capita labor income arises from variation in hours worked and not the wage rate, their findings are consistent with the unconditional positive correlation between unemployment rate and stock returns. Therefore unemployment rate is used as an input factor [2].

Monthly Data Factor

This is the past five-year's stock monthly-adjusted close. These data are easily available from Internet open sources and carry a firm's specific risk and nature of business performance result under the past economic environment. A five-year period is used in this project because industry widely accepts five years as an economy business cycle. The close price is adjusted based on stock dividends and the pre and after market hour trading data. Details can be found at http://finance.yahoo.com

Daily Data Factor

This data set contains the 60 days adjusted close price of a particular stock under testing. The method of using adjusted close price to forecast next day closing price is called Predict Day Close (PDC). PDC can catch the movement and trend of a particular stock on a daily basis. News happening during market hours is not considered in this factor.

3.6 DATA COLLECTION

The data required for training and testing the BPN are collected as follows:

Interest Rate

Interest rate data were collected based on 91 days T-bill rates. Cansim database is used as a source. There were 60 data value collected from March1997 to March2002. Five-year data were used to get the rules of how interest rate affects a particular stock.

Consumer Price Index

Consumer Price Index data were collected from Cansim as well. There were 60 data values collected from March 1997 to March 2002. Five-year data were used to get the rules of how CPI affects a particular stock.

Money Supply

M2 nominal money supply data were collected from Cansim as well. There were 60 data values collected from March 1997 to March 2002. Five-years data were used to get the rules of how M2 affect a particular stock.

Market Index Average

Market Index Average data were collected from Cansim as well. There were 60 data values collected from March 1997 to March 2002. Five-year data were used to get the rules of how MIA affects a particular stock.

Unemployment Rate

Unemployment rate data were collected from Cansim as well. There were 60 data values collected from March 1997 to March 2002. Five-year data were used to get the rules of how UR affects a particular stock.

Monthly Data

Monthly Trading Data of the stock being forecasted were collected base on adjusted price of each month. There was 60 data values collected from March 1997 to March 2002. Five-year data were used to get the rules of how the particular stock reacts to the five-year's economy cycle.

Daily Data

This is the daily-adjusted close price of the past 60 days. It is collected on each of the stocks in the portfolio and used as the main neuron input data in the PDC method. Because these data are adjusted, any dividend and split or reverse split of stocks are considered.

3.7 BPN PREDICTION OF NEXT DAY PRICE

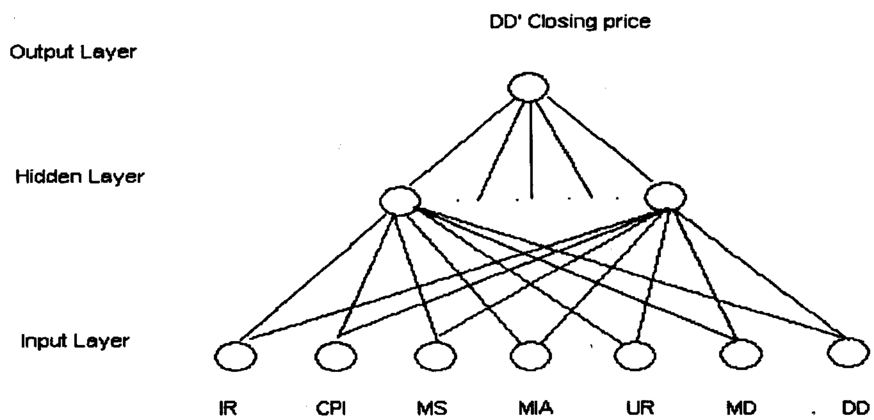

Figure 3. BPN Structure

A backpropagation neural network (BPN) was designed for the predict day close (PDC) method. This BPN network (see figure 3), has three layers with seven input neurons and a number of hidden neurons that is determined according to the volatility of the stock data in the past 60 trading days. If the stock price deviation from the two-month mean price is over 20%, there should be less hidden neurons i.e. five neurons. If the stock price deviation from the two-month mean price is less than 20%, we use fifteen neurons. This method of selecting the number of hidden layers is based on trial and error observation, and is described in the following section. Network connections are initialized with random weight matrix. The procedure for obtaining the values for the input neurons is discussed in details in the following chapter. The input data is applied to the NN at the end of a business day. Its output, DD' is the forecast change (%) in the closing of the stock in the following business day. The value of DD' ranges between –1.0 and +1.0. For example, a value of DD'= 0.0062 means a 0.62% increase in the stock price. An illustrative example of an actual input pattern is: TR= -0.049, CPI= -0.0496, MS=0.0397, MIA= 0, UR= -0.0147, MD= 0.0216, DD= 0.0108. Using a trained network with 15 hidden neurons, and using the intermediate weights to forecast the next day's close price DD'= 0.0062 is obtained.

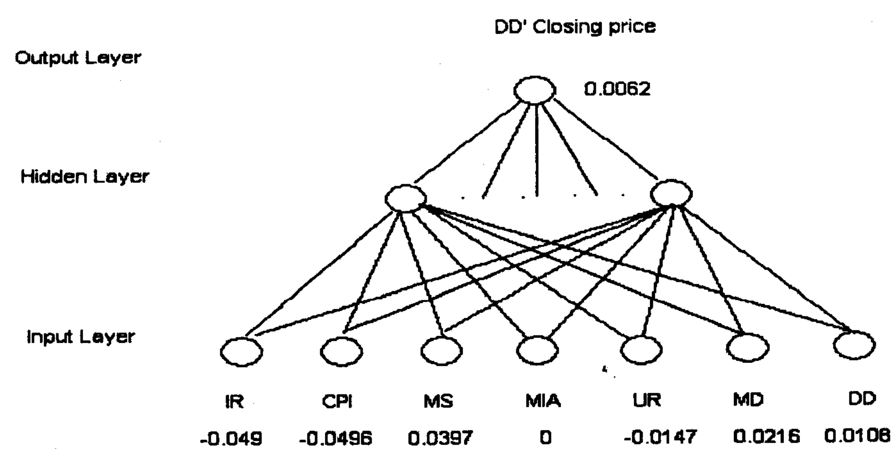

Figure 4. BPN Structure With Data

3.8 TRAINING THE NEURAL NETWORK

The purpose of training is to minimize the output error and reach the closest forecast result. In the process of training, we compare each trail in terms of rate of convergence. First, use five hidden neurons, and stop training at 10000 epochs, record error 0.078256. Second, use six hidden neurons, and stop training at 10000 epochs, record error 0.078023. Third, use seven hidden neurons, and stop training at 10000 epochs, record error 0.077332. Fourth, calculate the rate of convergence between trial 1 and 2 that is (0.078023 - 0.078256), rate of convergence between trial 2 and 3. Fifth, increase the number of hidden neurons. Sixth, when the rate of convergence decreases, that is the optimal hidden layer point. The determination of hidden neurons is done in the initial stage and the number stays the same afterwards.

CHAPTER 4 CASE STUDIES

Ten experiments were repeated in 250 trading days using a trained BPN neural network model. In this project, the market was tested at the start of recession; in the middle of the recession, and finally at the start of recovery. In this section, the statistical data of neural network implementation on a single stock is provided. Then, implementation on a portfolio of 10 stocks on one day is done. Finally, the result of one year's investment return is summarized.

4.1 SINGLE STOCK EXAMPLE

The trading simulation with the neural network involves making investment decisions based on the neural network model. The forecasted result of Portfolio #1, Portfolio #2, and Portfolio #3 is compared. The purpose of this section is to illustrate the model implementation by brining it to real-world data.

4.2 COLLECTION OF INPUT-TARGET PATTERN PAIRS

In this section procedures and data used in predict day close (PDC) testing are described. First, topics such as the origin of the data, their description in statistical terms as well as their quality are covered. Second, the procedure of their integration in order to create the output patterns for the training and for the forecasting is described. Third, data that will be compatible with the models we use are described.

The data considered in PDC method is obtained from Yahoo Inc. These prices have to be easily reachable and updated everyday. In order to avoid data discrepancy, data period verification, frequency check and scaling is done when the factors such as split or reverse split is involved. Briefly, one stock with symbol T is chosen, and forecasts for three portfolios is obtained. The intra day close price using the forecasted results is calculated. The dynamic Beta is obtained for the trading day from the neural network's output. Ordinary least squares regression is run on the data to find the slope that is the Beta and achieve the intra day close price.

Suppose B_i is the value of the rate or index in month i. The following steps for testing on three portfolios are used. The flow chart of the three portfolios is described in figure 5 below:

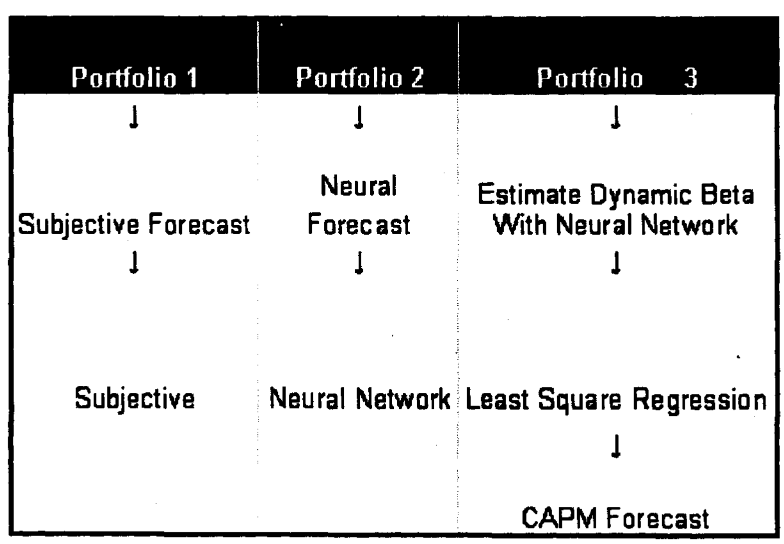

Figure 5. PDC Procedure Flow Chart

The input patterns are generated by the following procedure, the results of which are given in Tables 3 and 4. The data for TR, CPI, MS, MIA, and MD were collected monthly between March 1997 and February 2002 (i.e. 60 months). The DD data is collected, for demonstration purposes, from July 22, 2002 to October 15, 2002. Sixty days were used to get the rules of how the particular stock reacts to the daily factors.

Procedure:

1. Take a stock of Canadian company AT&T.
2. Get 60 days adjusted stock closing price beginning from the previous day.
3. Calculate rate of change with formula $(B_{i+1}-B_i)/\ B_i$
4. Get interest rate
5. Calculate rate of change with formula $(B_{i+1}-B_i)/\ B_i$
6. Get consumer price index
7. Calculate rate of change with formula $(B_{i+1}-B_i)/\ B_i$
8. Get Money Supply
9. Calculate rate of change with formula $(B_{i+1}-B_i)/\ B_i$
10. Get market index average

11. Calculate rate of change with formula $(B_{i+1}-B_i)/ B_i$

12. Get unemployment rate

13. Calculate rate of change with formula $(B_{i+1}-B_i)/ B_i$

14. Get past five years' monthly adjusted close price

15. Calculate rate of change with formula $(B_{i+1}-B_i)/ B_i$

16. Consolidated all data into one matrix and data set (see table 3)

17. List the daily data (see table 4)

18. Determine DD' for each day. DD' in day i is equal to DD for day i+1

19. Train the network and save the weights

20. Perform least squares regression (95% confidence level)

21. Record the regression result (for use in determining the Betas for Portfolio #3)

Table 3: Source Data for AT&T

Date	TR	Change	CPI	Change	MS	Change	MIA	Change	UR	Change	MD	Chan
1997M03	3.052		107.4		450155		5850.22		9.3		23.42	
1997M04	3.173	0.039646	107.4	0	449494	-0.14684	5976.63	0.216077	9.4	0.107527	22.25	-0.049
1997M05	3.045	-0.04034	107.5	0.09311	450366	0.193996	6382.12	0.678459	9.3	-0.10638	24.41	0.097
1997M06	2.899	-0.04795	107.7	0.186047	450362	-0.00089	6437.74	0.08715	9.2	-0.10753	23.29	-0.045
1997M07	3.227	0.113142	107.7	0	449217	-0.25424	6877.68	0.683376	8.9	-0.32609	24.45	0.049
1997M08	3.148	-0.02448	107.9	0.185701	448608	-0.13557	6611.79	-0.3866	8.9	0	25.91	0.0597
1997M09	3.034	-0.03621	107.8	-0.09268	447372	-0.27552	7040.23	0.647994	8.8	-0.11236	29.4	0.134
1997M10	3.464	0.141727	107.9	0.092764	447983	0.136575	6842.36	-0.28106	8.9	0.113636	32.47	0.104
1997M11	3.602	0.039838	107.7	-0.18536	447511	-0.10536	6512.78	-0.48168	8.9	0	37.12	0.143
1997M12	4.129	0.146308	107.6	-0.09285	445502	-0.44893	6699.4	0.286544	8.5	-0.44944	40.73	0.0972
1998M01	4.175	0.011141	108.2	0.557621	447100	0.358696	6700.2	0.001194	8.8	0.352941	41.61	0.021
1998M02	4.546	0.088862	108.3	0.092421	446208	-0.19951	7092.49	0.58549	8.6	-0.22727	40.52	-0.02
1998M03	4.597	0.011219	108.4	0.092336	439258	-1.55757	7558.5	0.657047	8.4	-0.23256	43.68	0.077
1998M04	4.69	0.020231	108.3	-0.09225	441779	0.573922	7664.99	0.140888	8.3	-0.11905	39.95	-0.085
1998M05	4.746	0.01194	108.7	0.369344	443350	0.355608	7589.78	-0.09812	8.3	0	40.44	0.012
1998M06	4.778	0.006743	108.8	0.091996	443487	0.030901	7366.89	-0.29367	8.4	0.120482	37.95	-0.061
1998M07	4.863	0.01779	108.8	0	445573	0.470363	6931.43	-0.5911	8.3	-0.11905	40.28	0.061
1998M08	4.972	0.022414	108.8	0	447265	0.379736	5530.71	-2.02082	8.1	-0.24096	33.3	-0.17
1998M09	5.242	0.054304	108.6	-0.18382	448852	0.354823	5614.12	0.150812	8.1	0	38.82	0.165
1998M10	4.708	-0.10187	109	0.368324	449571	0.160186	6208.28	1.058331	8	-0.12346	41.52	0.069
1998M11	4.838	0.027613	109	0	450255	0.152145	6343.87	0.218402	8	0	41.32	-0.00
1998M12	4.694	-0.02976	108.7	-0.27523	448995	-0.27984	6485.94	0.223948	8.1	0.125	50.32	0.217
1999M01	4.632	-0.01321	108.9	0.183993	450335	0.298444	6729.56	0.375612	7.9	-0.24691	60.29	0.198
1999M02	4.788	0.033679	109.1	0.183655	451173	0.186084	6312.69	-0.61946	7.9	0	54.56	-0.09
1999M03	4.875	0.01817	109.5	0.366636	454232	0.67801	6597.79	0.45163	7.9	0	53.02	-0.02
1999M04	4.531	-0.07056	110.1	0.547945	452383	-0.40706	7014.7	0.631893	8.1	0.253165	50.32	-0.05
1999M05	4.36	-0.03774	110.4	0.27248	454242	0.410935	6841.8	-0.24648	7.9	-0.24691	55.31	0.099
1999M06	4.582	0.050917	110.5	0.09058	454694	0.099506	7010.07	0.245944	7.5	-0.50633	55.62	0.005
1999M07	4.621	0.008512	110.8	0.271493	455748	0.231804	7081.03	0.101226	7.6	0.133333	51.95	-0.06
1999M08	4.811	0.041117	111.1	0.270758	461726	1.31169	6970.81	-0.15566	7.6	0	44.84	-0.13
1999M09	4.712	-0.02058	111.4	0.270027	463548	0.394606	6957.72	-0.01878	7.4	-0.26316	43.35	-0.03
1999M10	4.792	0.016978	111.5	0.089767	462436	-0.23989	7256.22	0.42902	7.2	-0.27027	46.59	0.074
1999M11	4.856	0.013356	111.4	-0.08969	465268	0.612409	7523.23	0.367974	6.9	-0.41667	55.69	0.195
1999M12	4.82	-0.00741	111.5	0.089767	471777	1.398979	8413.75	1.183694	6.8	-0.14493	50.63	-0.09
2000M01	5.034	0.044398	111.4	-0.08969	474524	0.582267	8481.11	0.080059	6.7	-0.14706	52.57	0.038
2000M02	5.12	0.017084	112	0.5386	477365	0.598705	9128.99	0.763909	6.8	0.149254	49.21	-0.06

Table 3: Source Data for AT& T (Continued)

Date	TR	Change	CPI	Change	MS	Change	MIA	Change	UR	Change	MD	Change
2000M03	5.219	0.019336	112.8	0.714286	480427	0.641438	9462.39	0.36521	6.8	0	56.11	0.140215
2000M04	5.4	0.034681	112.4	-0.35461	485376	1.030125	9347.61	-0.1213	6.7	-0.14706	45.72	-0.18517
2000M05	5.707	0.056852	113	0.533808	482796	-0.53155	9251.99	-0.10229	6.7	0	34.82	-0.23841
2000M06	5.579	-0.02243	113.7	0.619469	489634	1.416333	10195.45	1.019737	6.7	0	31.7	-0.0896
2000M07	5.588	0.001613	114.1	0.351803	494339	0.960922	10406.31	0.206818	6.8	0.149254	30.83	-0.02744
2000M08	5.642	0.009664	113.9	-0.17528	495180	0.170126	11247.91	0.80874	7.1	0.441176	31.51	0.022056
2000M09	5.582	-0.01063	114.4	0.438982	495340	0.032311	10377.92	-0.77347	6.9	-0.28169	28.9	-0.08283
2000M10	5.62	0.006808	114.6	0.174825	498582	0.6545	9639.57	-0.71146	7	0.144928	23.11	-0.20035
2000M11	5.706	0.015302	115	0.34904	498581	-0.0002	8819.92	-0.8503	6.9	-0.14286	19.55	-0.15405
2000M12	5.553	-0.02681	115.1	0.086957	501972	0.68013	8933.68	0.128981	6.8	-0.14493	17.19	-0.12072
2001M01	5.274	-0.05024	114.7	-0.34752	501576	-0.07889	9321.87	0.434524	6.9	0.147059	23.91	0.390925
2001M02	4.967	-0.05821	115.2	0.43592	505389	0.760204	8078.72	-1.33358	6.9	0	22.92	-0.04141
2001M03	4.634	-0.06704	115.6	0.347222	507212	0.360712	7608	-0.58267	7	0.144928	21.23	-0.07373
2001M04	4.452	-0.03927	116.4	0.692042	509833	0.516746	7946.63	0.445097	7	0	22.2	0.04569
2001M05	4.357	-0.02134	117.4	0.859107	510738	0.177509	8161.87	0.270857	7	0	21.1	-0.04955
2001M06	4.28	-0.01767	117.5	0.085179	512431	0.331481	7736.35	-0.52135	7.1	0.142857	21.92	0.038863
2001M07	4.186	-0.02196	117.1	-0.34043	513910	0.288624	7689.69	-0.06031	7.1	0	20.15	-0.08075
2001M08	3.878	-0.07358	117.1	0	515421	0.29402	7399.22	-0.37774	7.3	0.28169	18.98	-0.05806
2001M09	3.194	-0.17638	117.4	0.256191	520366	0.95941	6838.56	-0.75773	7.2	-0.13699	19.24	0.013699
2001M10	2.748	-0.13964	116.8	-0.51107	523723	0.645123	6885.7	0.068933	7.4	0.277778	15.2	-0.20998
2001M11	2.244	-0.18341	115.8	-0.85616	529073	1.021532	7425.65	0.784161	7.6	0.27027	17.43	0.146711
2001M12	2.022	-0.09893	115.9	0.086356	531227	0.407127	7688.41	0.353855	8	0.526316	18.08	0.037292
2002M01	1.926	-0.04748	116.2	0.258844	534496	0.615368	7648.49	-0.05192	7.9	-0.125	17.64	-0.02434
2002M02	2.035	0.056594	116.9	0.60241	534856	0.067353	7637.5	-0.01437	7.9	0	15.49	-0.12188

Table 4: DD Data for AT&T

Date	DD	Change	Date	DD	Change
22-Jul-02	40.35		3-Oct-02	48.47	-0.0548
23-Jul-02	37.3	-0.07559	4-Oct-02	49.15	0.014029
24-Jul-02	38.4	0.029491	7-Oct-02	48.18	-0.01974
25-Jul-02	37.21	-0.03099	8-Oct-02	46.05	-0.04421
26-Jul-02	38.74	0.041118	9-Oct-02	45.71	-0.00738
29-Jul-02	41.28	0.065565	10-Oct-02	48.13	0.052942
30-Jul-02	42.38	0.026647	11-Oct-02	50.9	0.057552
31-Jul-02	43.15	0.018169	14-Oct-02	50.73	-0.00334
1-Aug-02	40.99	-0.05006			
2-Aug-02	40.69	-0.00732			
5-Aug-02	36.83	-0.09486			
6-Aug-02	39.46	0.071409			
7-Aug-02	39.46	0			
8-Aug-02	41.54	0.052712			
9-Aug-02	42.38	0.020221			
12-Aug-02	43.44	0.025012			
13-Aug-02	42.38	-0.0244			
14-Aug-02	43.02	0.015101			
15-Aug-02	44.72	0.039517			
16-Aug-02	44.29	-0.00962			
19-Aug-02	45.61	0.029804			
20-Aug-02	47.39	0.039027			
21-Aug-02	51.62	0.089259			
22-Aug-02	52.47	0.016466			
23-Aug-02	51.79	-0.01296			
26-Aug-02	53.36	0.030315			
27-Aug-02	51.29	-0.03879			
28-Aug-02	51.16	-0.00253			
29-Aug-02	52.39	0.024042			
30-Aug-02	51.79	-0.01145			
3-Sep-02	47.47	-0.08341			
4-Sep-02	49.59	0.04466			
5-Sep-02	49.97	0.007663			
6-Sep-02	51.71	0.034821			
9-Sep-02	52.13	0.008122			
10-Sep-02	53.62	0.028582			
11-Sep-02	53.74	0.002238			
12-Sep-02	52.73	-0.01879			
13-Sep-02	53.91	0.022378			
16-Sep-02	52.22	-0.03135			
17-Sep-02	53.53	0.025086			
18-Sep-02	53.57	0.000747			
19-Sep-02	51.88	-0.03155			
20-Sep-02	52.68	0.01542			
23-Sep-02	51.92	-0.01443			
24-Sep-02	50.65	-0.02446			
25-Sep-02	50.52	-0.00257			
26-Sep-02	53.58	0.06057			
27-Sep-02	53.45	-0.00243			
30-Sep-02	51.07	-0.04453			
1-Oct-02	52.73	0.032504			
2-Oct-02	51.28	-0.0275			

4.3 ILLUSTRATION BPN CASE TESTING

BPN is illustrated using AT&T stock. Company information is obtained from www.yahoo.com.

Company profile:

"AT&T Corp. is engaged in providing voice and data communications services to large and small businesses, consumers and government entities. AT&T and its subsidiaries furnish domestic and international long distance, regional, local and Internet communications services. The Company's primary lines of business are AT&T Business Services and AT&T Consumer Services. AT&T Business Services offers a variety of global communications services to over four million customers, including large domestic and multinational businesses, small and medium-sized businesses and government agencies. AT&T Consumer Services is a provider of domestic and international long distance and transaction-based communications services to residential consumers in the United States."

Industry: Communications Services
Employee: 71,000

Stock information from www.att.com

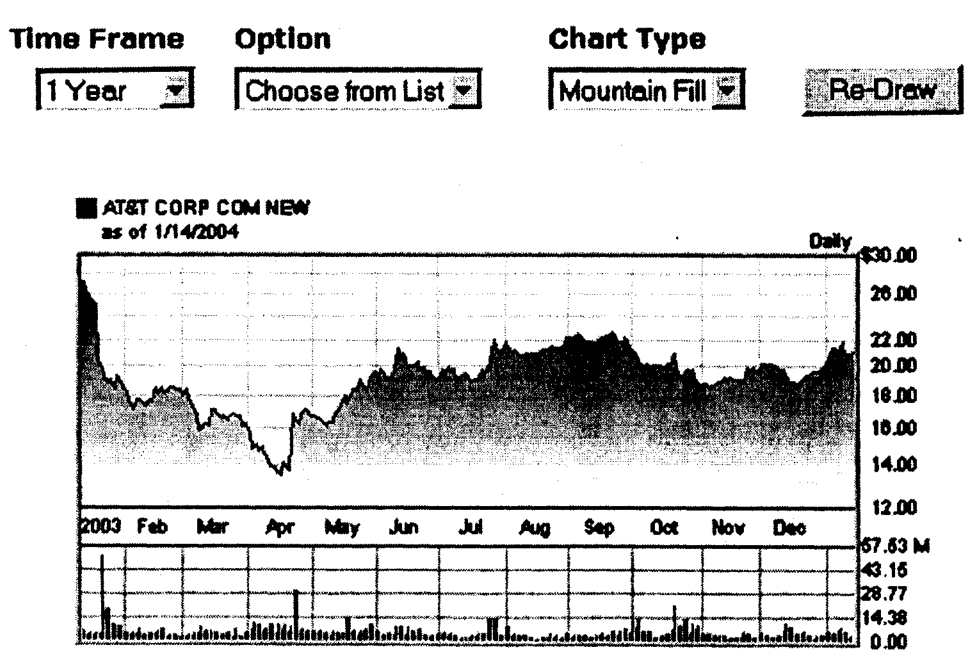

Figure 6. Chart of Middle Recession

4.3.1 FORECAST IN MID-RECESSION

The weeks from September 5, 2002 to August 27, 2003 are chosen in this example. The following is the mixed data that is used to train the neural network and forecast the neural network. It starts from the date to forecast and select 60 days' data to do the training. One more row i.e. another day's data to do the forecast is obtained. The actual rate of price change and comparison with the forecasted results are listed afterwards.

Table 5: Input-Target Patterns

	Inputs							Target
Date	DD	MD	TR	CPI	MS	MIA	UR	DD'
3-Jun-02	-0.049	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	0.0086
4-Jun-02	0.0086	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.0298
5-Jun-02	-0.0298	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.043
6-Jun-02	-0.043	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.0476
7-Jun-02	-0.0476	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.0406
10-Jun-02	-0.0406	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	0.0413
11-Jun-02	0.0413	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.0193
12-Jun-02	-0.0193	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	0.0117
13-Jun-02	0.0117	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	0.0155
14-Jun-02	0.0155	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.0439
17-Jun-02	-0.0439	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.055
18-Jun-02	-0.055	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	0.037
19-Jun-02	0.037	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	0.053
20-Jun-02	0.053	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.0318
21-Jun-02	-0.0318	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.0362
24-Jun-02	-0.0362	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	0.0289
25-Jun-02	0.0289	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	0.0807
26-Jun-02	0.0807	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.0625
27-Jun-02	-0.0625	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	-0.0629
28-Jun-02	-0.0629	-0.0496	0.0397	0	-0.0147	0.0216	0.0108	0.0235
1-Jul-02	0.0235	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0591
2-Jul-02	0.0591	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0079

Table 5: Input-Target Patterns (Continued)

	Inputs							Target
Date	DD	MD	TR	CPI	MS	MIA	UR	DD'
3-Jul-02	0.0079	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.0255
5-Jul-02	-0.0255	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.0228
8-Jul-02	-0.0228	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0387
9-Jul-02	0.0387	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0276
10-Jul-02	0.0276	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0105
11-Jul-02	0.0105	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.0341
12-Jul-02	-0.0341	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0254
15-Jul-02	0.0254	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.0162
16-Jul-02	-0.0162	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.0349
17-Jul-02	-0.0349	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.0405
18-Jul-02	-0.0405	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.0755
19-Jul-02	-0.0755	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0295
22-Jul-02	0.0295	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.031
23-Jul-02	-0.031	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0412
24-Jul-02	0.0412	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0656
25-Jul-02	0.0656	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0266
26-Jul-02	0.0266	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	0.0181
29-Jul-02	0.0181	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.05
30-Jul-02	-0.05	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.0074
31-Jul-02	-0.0074	0.0969	-0.0403	0.0093	0.0194	0.0679	-0.0106	-0.0947
1-Aug-02	-0.0947	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0712
2-Aug-02	0.0712	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0
5-Aug-02	0	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0526
6-Aug-02	0.0526	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0204
7-Aug-02	0.0204	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.025
8-Aug-02	0.025	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	-0.0244
9-Aug-02	-0.0244	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.015
12-Aug-02	0.015	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0394
13-Aug-02	0.0394	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	-0.0095
14-Aug-02	-0.0095	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0298
15-Aug-02	0.0298	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0389
16-Aug-02	0.0389	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0896
19-Aug-02	0.0896	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0164
20-Aug-02	0.0164	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	-0.0131
21-Aug-02	-0.0131	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0304
22-Aug-02	0.0304	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	-0.0389
23-Aug-02	-0.0389	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	-0.0026
26-Aug-02	-0.0026	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.024
27-Aug-02	0.024	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	-0.0114
28-Aug-02	-0.0114	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	-0.0833
29-Aug-02	-0.0833	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0446
30-Aug-02	0.0446	-0.0434	-0.048	0.0186	-0.0001	0.0087	-0.0108	0.0077
3-Sep-02	0.0077	0.0499	0.1131	0	-0.0254	0.0683	-0.0326	0.0347
4-Sep-02	0.0347	0.0499	0.1131	0	-0.0254	0.0683	-0.0326	0.0082
5-Sep-02	0.0082	0.0499	0.1131	0	-0.0254	0.0683	-0.0326	

Desired output vs. forecasted output

Table 6: Comparison of Middle Recession

Middle	27-Aug-03	28-Aug-03	29-Aug-03	2-Sep-03	3-Sep-03	4-Sep-03	5-Sep-03
Actual	0.024	-0.0114	-0.0833	0.0446	0.0077	0.0347	0.0082
[redacted]							

On Day 6, intra-day company news is the main factor to shift market up from –0.03447 to 0.0347.

In the next case study, AT&T stock is used as an example, the following taking company information into consideration.

FOR RELEASE TUESDAY, SEPTEMBER 3, 2002 from www.att.com

AT&T Broadband Offers New Faster Speed To Cable Internet Users

Company plans to trial lower speed service later in the year

Pittsburgh, PA -- Internet power users who have a need for more cable Internet speed now can subscribe to UltraLink service, a new level of AT&T Broadband Internet, the company announced today. The faster broadband Internet residential service is being launched September 3 in Pittsburgh, PA; Cleveland, OH; and Richmond, VA. The service was previously launched in Dallas, Denver, Salt Lake City, San Francisco Bay Area, Seattle, St. Paul and communities in the company's Michigan and Rocky Mountain markets.

The UltraLink service is a faster cable Internet speed that will be offered in addition to the company's current service. The new tier will allow customers to surf at maximum speeds capped at 3 Mbps downstream and 384 kbps upstream for $79.99 per month. The service costs $82.99 per month for customers who lease a modem from the company.*

4.3.2 FORECAST AT BEGINNING OF RECESSION

Table 7 shows the input-output training patterns, and the NN forecast for the 7-day period of interest is given in Table 8. Stock information is obtained from www.att.com.

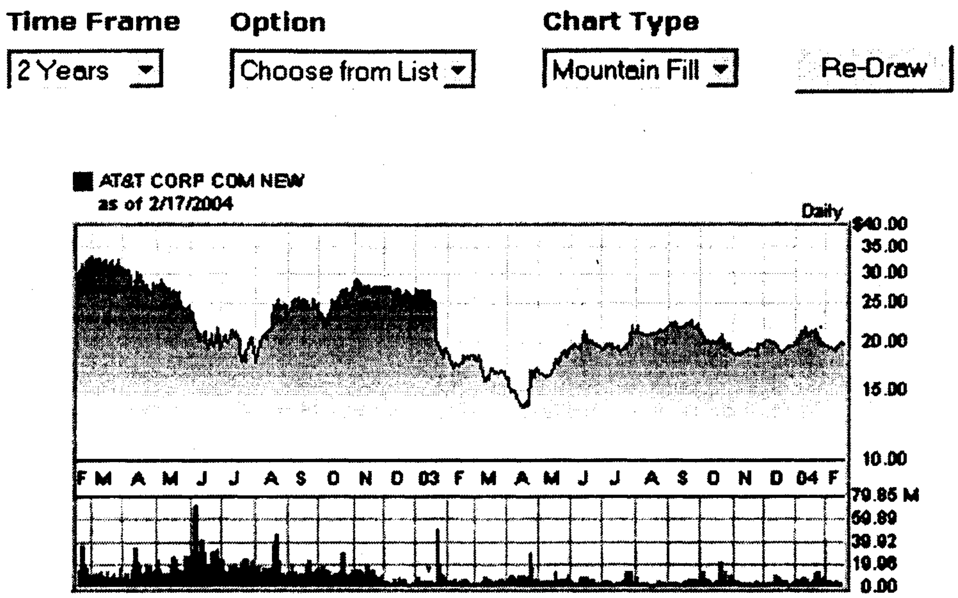

Figure 7. Chart of Beginning Recession

Input neurons:

Table 7: Input-Target Patterns

	Inputs							Target
Date	DD	MD	TR	CPI	MS	MIA	UR	DD'
8-Oct-01	0.0164	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0078
9-Oct-01	-0.0078	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	0.0306
10-Oct-01	0.0306	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	0.0142
11-Oct-01	0.0142	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	0.005
12-Oct-01	0.005	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0395
15-Oct-01	-0.0395	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	0
16-Oct-01	0	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0297
17-Oct-01	-0.0297	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0393
18-Oct-01	-0.0393	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0084
19-Oct-01	-0.0084	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	0.031
22-Oct-01	0.031	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0328

Table 7: Input-Target Patterns (Continued)

	Inputs							Target
Date	DD	MD	TR	CPI	MS	MIA	UR	DD'
23-Oct-01	-0.0328	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0767
24-Oct-01	-0.0767	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0209
25-Oct-01	-0.0209	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	0.0006
26-Oct-01	0.0006	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.015
29-Oct-01	-0.015	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0018
30-Oct-01	-0.0018	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0312
31-Oct-01	-0.0312	-0.2098	0.0444	-0.0897	0.5823	0.0801	-0.1471	-0.0138
1-Nov-01	-0.0138	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0418
2-Nov-01	0.0418	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0148
5-Nov-01	0.0148	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0157
6-Nov-01	0.0157	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0074
7-Nov-01	-0.0074	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0217
8-Nov-01	0.0217	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0115
9-Nov-01	-0.0115	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0093
12-Nov-01	-0.0093	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0261
13-Nov-01	0.0261	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0036
14-Nov-01	-0.0036	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0353
15-Nov-01	0.0353	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0124
16-Nov-01	0.0124	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0051
19-Nov-01	-0.0051	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0036
20-Nov-01	-0.0036	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0064
21-Nov-01	-0.0064	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0065
23-Nov-01	0.0065	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0042
26-Nov-01	0.0042	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0164
27-Nov-01	-0.0164	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0309
28-Nov-01	0.0309	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0157
29-Nov-01	0.0157	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0074
30-Nov-01	-0.0074	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0029
3-Dec-01	-0.0029	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	0.0086
4-Dec-01	0.0086	0.1469	0.0171	0.5386	0.5987	0.7639	0.1493	-0.0011
5-Dec-01	-0.0011	0.0375	0.0193	0.7143	0.6414	0.3652	0	0.029
6-Dec-01	0.029	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0221
7-Dec-01	-0.0221	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0441
10-Dec-01	-0.0441	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0148
11-Dec-01	-0.0148	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.009
12-Dec-01	-0.009	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0212
13-Dec-01	-0.0212	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0013
14-Dec-01	-0.0013	0.0375	0.0193	0.7143	0.6414	0.3652	0	0.0553
17-Dec-01	0.0553	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0217
18-Dec-01	-0.0217	0.0375	0.0193	0.7143	0.6414	0.3652	0	0.009
19-Dec-01	0.009	0.0375	0.0193	0.7143	0.6414	0.3652	0	0.0624
20-Dec-01	0.0624	0.0375	0.0193	0.7143	0.6414	0.3652	0	0.028
21-Dec-01	0.028	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0055

Table 7: Input-Target Patterns (Continued)

	Inputs							Target
Date	DD	MD	TR	CPI	MS	MIA	UR	DD'
26-Dec-01	-0.0055	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0149
27-Dec-01	-0.0149	0.0375	0.0193	0.7143	0.6414	0.3652	0	0.0117
28-Dec-01	0.0117	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0022
31-Dec-01	-0.0022	0.0375	0.0193	0.7143	0.6414	0.3652	0	0.0309
2-Jan-02	0.0309	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0032
3-Jan-02	-0.0032	0.0375	0.0193	0.7143	0.6414	0.3652	0	-0.0144
4-Jan-02	-0.0144	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	0.006
7-Jan-02	0.006	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	0.0238
8-Jan-02	0.0238	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0117
9-Jan-02	-0.0117	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	0.0107
10-Jan-02	0.0107	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	0.0111
11-Jan-02	0.0111	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0105
14-Jan-02	-0.0105	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0047
15-Jan-02	-0.0047	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0149
16-Jan-02	-0.0149	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0091
17-Jan-02	-0.0091	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	0.0087
18-Jan-02	0.0087	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0216
22-Jan-02	-0.0216	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0017
23-Jan-02	-0.0017	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	0.0216
24-Jan-02	0.0216	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0017
25-Jan-02	-0.0017	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0021
28-Jan-02	-0.0021	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0331
29-Jan-02	-0.0331	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	-0.0203
30-Jan-02	-0.0203	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	0.0143
31-Jan-02	0.0143	-0.0242	0.0347	-0.3546	1.0301	-0.1213	-0.1471	

Recession started from January 2002.
Desired output vs. forecasted output.

Table 8: Comparison at Beginning of Recession

Recession	23-Jan-02	26-Jan-02	27-Jan-02	28-Jan-02	29-Jan-02	30-Jan-02	31-Jan-02
Actual	-0.0017	0.0216	-0.0017	-0.0021	-0.0331	-0.0203	0.0143
[redacted]							

4.3.3 FORECAST AT BEGINNING OF RECOVERY

On January 26, 2004, the Dow surged pushed AT&T close price shift up higher than forecasted.

Source:
http://www.thestreet.com/_yahoo/markets/marketstory/10139178.html

Stocks Surge to New Highs

By Joshua A. Krongold

TheStreet.com Staff Reporter

01/26/2004 04:05 PM EST

Updated from 3:52 p.m. EST

Stocks rallied Monday afternoon with the major indices closing at two-and-a-half-year highs, following several strong earnings releases.

Based on early tallies, the Dow rose about 132 points to 10,701, its highest close since June 2001; the S&P 500 added almost 14 points to 1155; and the Nasdaq climbed 30 points to 2153, passing its recent 30-month high.

Input neurons:

Table 9: Input-Target Patterns

	Inputs							Target
Date	DD	MD	TR	CPI	MS	MIA	UR	DD'
7-Oct-03	0.0075	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.0165
8-Oct-03	-0.0165	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	0.0137
9-Oct-03	0.0137	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.0025
10-Oct-03	-0.0025	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.002
13-Oct-03	-0.002	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.003
14-Oct-03	-0.003	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.0035
15-Oct-03	-0.0035	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	0.0131
16-Oct-03	0.0131	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.008
17-Oct-03	-0.008	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	0.0473
20-Oct-03	0.0473	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.0509
21-Oct-03	-0.0509	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.0243
22-Oct-03	-0.0243	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.0182
23-Oct-03	-0.0182	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	0.0386
24-Oct-03	0.0386	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.0056
27-Oct-03	-0.0056	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	0.0077
28-Oct-03	0.0077	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.0437
29-Oct-03	-0.0437	-0.1372	-0.0989	0.0864	0.4071	0.3539	0.5263	-0.009
30-Oct-03	-0.009	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0161
31-Oct-03	-0.0161	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.0147-0.0161

Table 9: Input-Target Patterns (Continued)

	Inputs							Target
Date	DD	MD	TR	CPI	MS	MIA	UR	DD'
3-Nov-03	0.0147	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0038
4-Nov-03	-0.0038	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0059
5-Nov-03	-0.0059	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.0043
6-Nov-03	0.0043	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.0086
7-Nov-03	0.0086	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.008
10-Nov-03	0.008	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0005
11-Nov-03	-0.0005	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.0159
12-Nov-03	0.0159	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0084
13-Nov-03	-0.0084	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.0032
14-Nov-03	0.0032	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0053
17-Nov-03	-0.0053	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0016
18-Nov-03	-0.0016	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.0042
19-Nov-03	0.0042	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0063
20-Nov-03	-0.0063	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.0472
21-Nov-03	0.0472	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0101
24-Nov-03	-0.0101	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.0087
25-Nov-03	0.0087	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0096
26-Nov-03	-0.0096	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.0026
28-Nov-03	0.0026	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	0.026
1-Dec-03	0.026	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0035
2-Dec-03	-0.0035	0.0664	-0.0475	0.2588	0.6154	-0.0519	-0.125	-0.0025
3-Dec-03	-0.0025	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.0045
4-Dec-03	0.0045	0.0362	0.0566	0.6024	0.0674	-0.0144	0	-0.008
5-Dec-03	-0.008	0.0362	0.0566	0.6024	0.0674	-0.0144	0	-0.006
8-Dec-03	-0.006	0.0362	0.0566	0.6024	0.0674	-0.0144	0	-0.0086
9-Dec-03	-0.0086	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.001
10-Dec-03	0.001	0.0362	0.0566	0.6024	0.0674	-0.0144	0	-0.0132
11-Dec-03	-0.0132	0.0362	0.0566	0.6024	0.0674	-0.0144	0	-0.0325
12-Dec-03	-0.0325	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0
15-Dec-03	0	0.0362	0.0566	0.6024	0.0674	-0.0144	0	-0.0005
16-Dec-03	-0.0005	0.0362	0.0566	0.6024	0.0674	-0.0144	0	-0.0037
17-Dec-03	-0.0037	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.0187
18-Dec-03	0.0187	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.0084
19-Dec-03	0.0084	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.0052
22-Dec-03	0.0052	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.0119
23-Dec-03	0.0119	0.0362	0.0566	0.6024	0.0674	-0.0144	0	-0.0031
24-Dec-03	-0.0031	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.0036
26-Dec-03	0.0036	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.0225
29-Dec-03	0.0225	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.0035
30-Dec-03	0.0035	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.0135
31-Dec-03	0.0135	0.0362	0.0566	0.6024	0.0674	-0.0144	0	0.0281
2-Jan-04	0.0281	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	0.0297
5-Jan-04	0.0297	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0019
6-Jan-04	-0.0019	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0089
7-Jan-04	-0.0089	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	0.0339

Table 9: Input-Target Patterns (Continued)

	Inputs							Target
Date	DD	MD	TR	CPI	MS	MIA	UR	DD'
8-Jan-04	0.0339	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0419
9-Jan-04	-0.0419	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0019
12-Jan-04	-0.0019	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	0.0014
13-Jan-04	0.0014	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	0.0157
14-Jan-04	0.0157	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0103
15-Jan-04	-0.0103	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0057
16-Jan-04	-0.0057	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	0.029
20-Jan-04	0.029	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0185
21-Jan-04	-0.0185	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.04
22-Jan-04	-0.04	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0343
23-Jan-04	-0.0343	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	0.0228
26-Jan-04	0.0228	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0119
27-Jan-04	-0.0119	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.007
28-Jan-04	-0.007	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0091
29-Jan-04	-0.0091	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	-0.0066
30-Jan-04	-0.0066	-0.0414	0.1047	0.6843	-0.1331	0.2802	-0.2532	

Recovery started from January 2004. Desired output vs. forecasted output.

Table 10: Comparison of Beginning Recovery

Recovery	22-Jan-04	23-Jan-04	26-Jan-04	27-Jan-04	28-Jan-04	29-Jan-04	30-Jan-04
Actual	-0.04	-0.0343	0.0228	-0.0119	-0.007	-0.0091	-0.0066
[redacted]							

4.4 DESCRIPTION OF FORECAST RESULT

Through the above forecast, one week's result is obtained at the beginning of the recession, middle of the recession and beginning of the recovery. The result comparison shows that at the beginning of the recession and the recovery, the BPN Neural Network achieved a better result than in the middle of the recession.

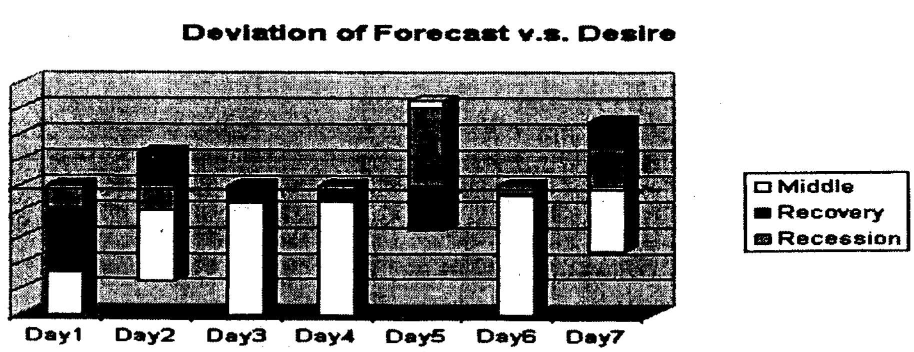

Figure 8. Comparison Chart

In the sample given in this section, there are no missing values. However very often, there may be missing data of one day without trade, or one day stock price went out of range such as 3 times because of 1:3 reverse split. The next step is to investigate the outliers. The first (Q1) and third quartile (Q3) distribution is calculated, i.e. 25-th and 75-th percentiles respectively. Any value that is greater than Q3 + 5(Q3 –Q1) or lower than Q1 –5(Q3-Q1) is an outlier. The price change is defined as $\frac{B_{i+1} - B_i}{B_i}$ where B_i is the adjusted close price of day i. In this project, we chose to transform data to neural network ready decimals. In this way, our neural network can be used to stock of any type, i.e. from penny stocks under the $5 value to stocks of $500 in value.

4.5 INTERMEDIATE WEIGHTS

In order to estimate the importance level of each factor, we illustrate the 3D graph of the weights matrix extracted beginning from Tuesday and ended in Monday. Note, the training in this example used 7 hidden units in the Neural Network.

The following is an example of one random week's descriptive data of weight matrix extracted from the daily training data and that is used to forecast the daily close price.

Table 11: Tuesday Rules Extracted

Hidden Neuron	TR	CPI	MS	MIA	UR	MD	DD
#1	0.481836	-0.6047	-1.17946	2.09661	1.72983	0.030101	-0.07048
#2	1.09091	4.23752	8.36444	-4.86742	-2.52176	0.338833	-2.18673
#3	0.637937	0.303776	0.015657	-1.40163	-3.84104	-2.46732	0.7784
#4	0.260846	-0.4913	-0.9268	0.405234	-0.0612	-0.26359	-0.09974
#5	0.312993	-0.1885	0.361328	0.453693	0.172569	-0.22581	0.096525
#6	0.266097	-5.51553	-10.1198	6.33131	5.52548	-0.33232	-2.24828
#7	0.021223	-0.10925	0.006167	-0.08799	0.030626	-0.04819	0.00086
Output Neuron	0.23169	3.2304	0.610798	-0.1747	-0.07443	3.10551	-0.02836

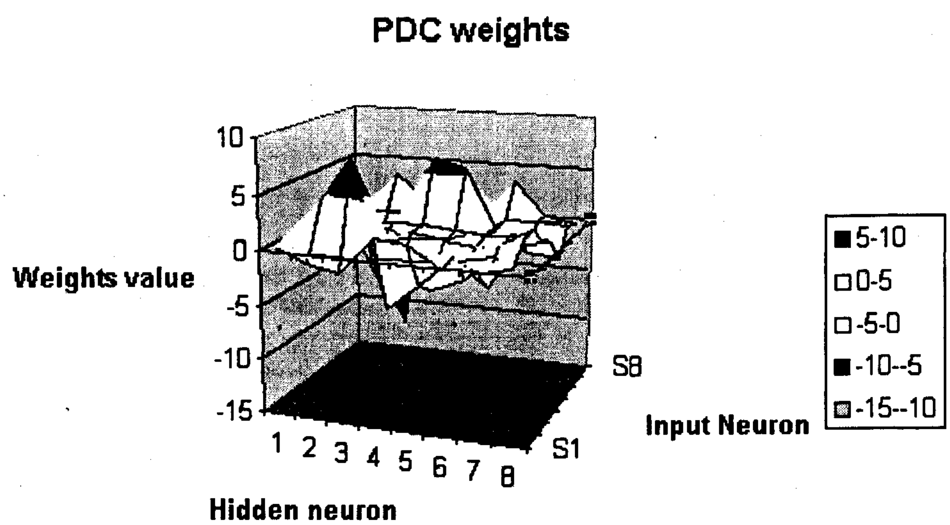

Figure 9. Tuesday 3D Weights

Table 12: Wednesday Rules Extracted

Hidden Neuron	TR	CPI	MS	MIA	UR	MD	DD
#1	-12.2168	-8.93131	-7.42711	20.6976	-3.7037	17.3282	-1.68834
#2	-1.47452	1.77715	-1.13391	0.947118	19.1783	-2.33181	-2.53968
#3	14.2537	3.99002	11.1921	-1.82428	16.7259	16.5284	-0.06256
#4	-3.1363	-5.79747	-16.2886	14.6681	-12.0303	-26.7685	-18.8794
#5	1.42962	18.8824	11.3915	-16.5518	12.4828	-11.5641	-1.53404
#6	-14.7617	0.019865	-10.4117	1.78158	37.5286	-15.6606	0.407079
#7	2.51967	-3.56169	-8.05337	1.67518	14.2182	-13.825	-6.49107
Output Neuron	-1.11672	-0.76444	1.69572	1.068	-1.02891	1.23694	-0.73457

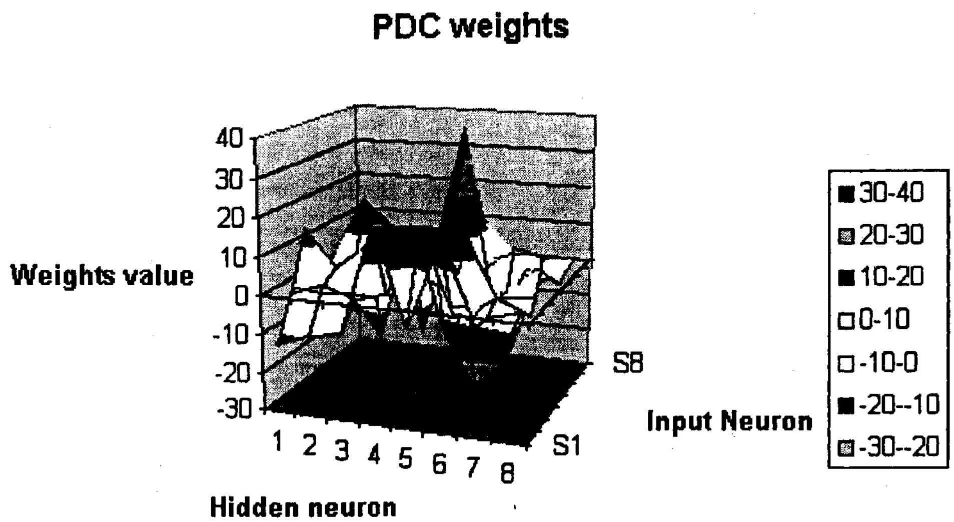

Figure 10. Wednesday 3D Weights

Table 13: Thursday Rules Extracted

Hidden Neuron	TR	CPI	MS	MIA	UR	MD	DD
#1	2.04441	1.35105	2.77535	1.87311	-1.99349	-3.98078	-7.04171
#2	0.235733	-1.71533	-15.6753	-14.9382	-0.342	-11.6289	27.8493
#3	9.63429	33.6149	3.1069	19.7447	17.8264	-26.6905	26.2399
#4	-11.8317	-25.4227	5.4913	-21.5548	-6.42322	-0.10572	-0.88473
#5	-14.7212	14.474	-11.161	-4.17326	-2.84225	-6.57632	2.41107
#6	13.649	-7.88144	14.34	7.67803	11.0392	14.3241	6.53109
#7	-6.00227	-0.60784	11.433	-3.5682	-5.03349	-7.99865	-10.027
Output Neuron	1.01958	1.24527	-1.98144	-2.05624	1.87397	1.64772	1.31047

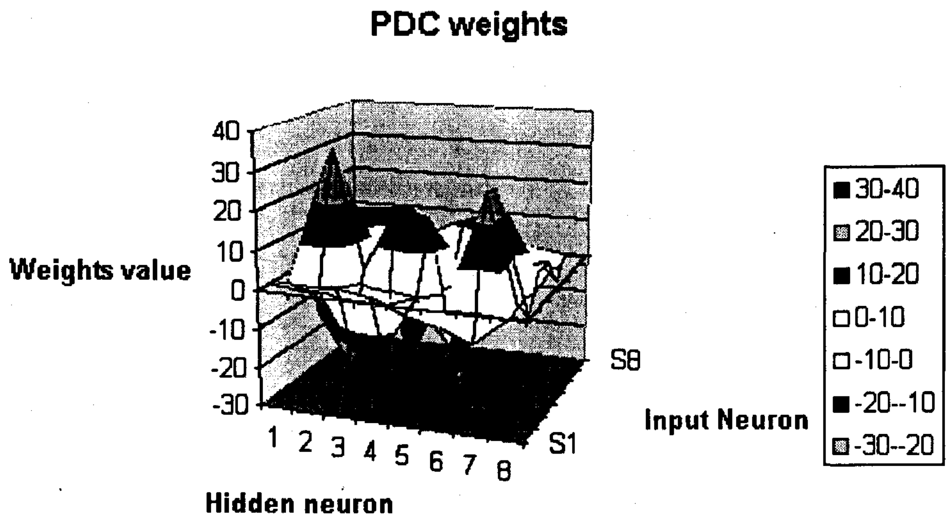

Figure 11. Thursday 3D Weights

Table 14: Friday Rules Extracted

Hidden Neuron	TR	CPI	MS	MIA	UR	MD	DD
#1	3.04759	-1.45201	7.13346	0.819701	-0.02718	-9.63123	6.50241
#2	-7.06779	-4.44646	5.19325	10.4773	22.3339	3.76575	4.34926
#3	-8.22273	14.2858	-6.95988	-0.50287	2.72345	-1.33294	6.68527
#4	-7.95351	14.3162	-38.9097	-8.84243	-0.12385	-9.46424	15.1829
#5	0.870886	3.76879	2.86373	3.02841	-2.93558	-12.3014	6.47592
#6	0.144388	-9.72898	0.874429	6.00892	16.784	4.35555	5.15953
#7	-0.4482	-2.31023	-1.68585	1.7862	-1.91094	-0.02513	1.90246
Output Neuron	0.58587	1.33022	-0.87224	1.34509	-1.01194	-1.31639	-0.09455

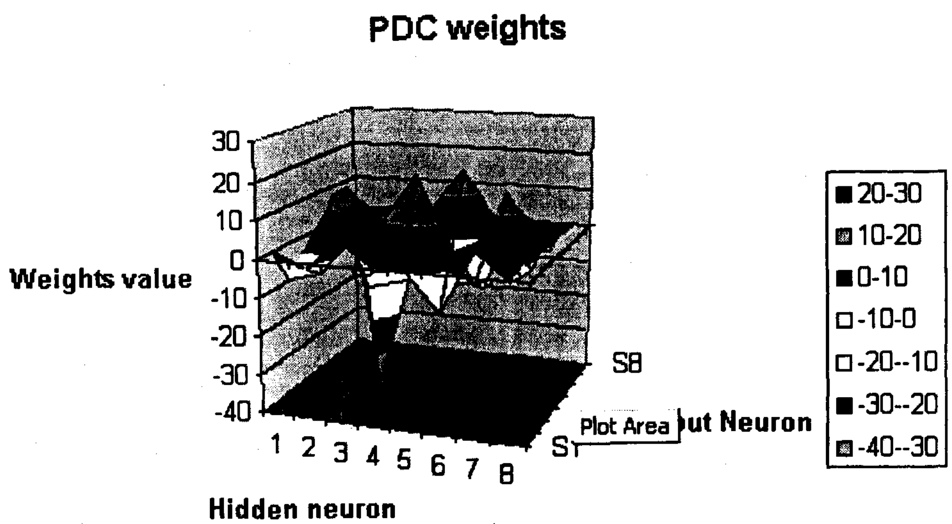

Figure 12. Friday 3D Weights

Table 15: Monday Rules Extracted

Hidden Neuron	TR	CPI	MS	MIA	UR	MD	DD
#1	21.8458	-0.20184	-13.585	-13.2053	11.8761	-3.75971	13.7784
#2	11.2876	21.2974	2.58194	6.83214	-0.12841	0.387722	7.75116
#3	3.25835	7.68435	5.65079	-8.0997	-1.28767	-5.78979	1.43651
#4	-12.2446	5.91422	-3.18246	-5.97747	-4.23804	-5.16948	-11.0393
#5	-3.43308	0.603312	29.1331	16.5558	-4.3258	-11.1506	1.39378
#6	7.70478	6.82058	3.28653	6.61287	-11.549	6.63074	3.21597
#7	-6.28858	-11.0738	-4.77701	8.46411	-8.88334	-14.7633	-2.81099
Output Neuron	-1.55789	0.965962	1.32529	-0.57956	-1.52161	-0.61104	1.01705

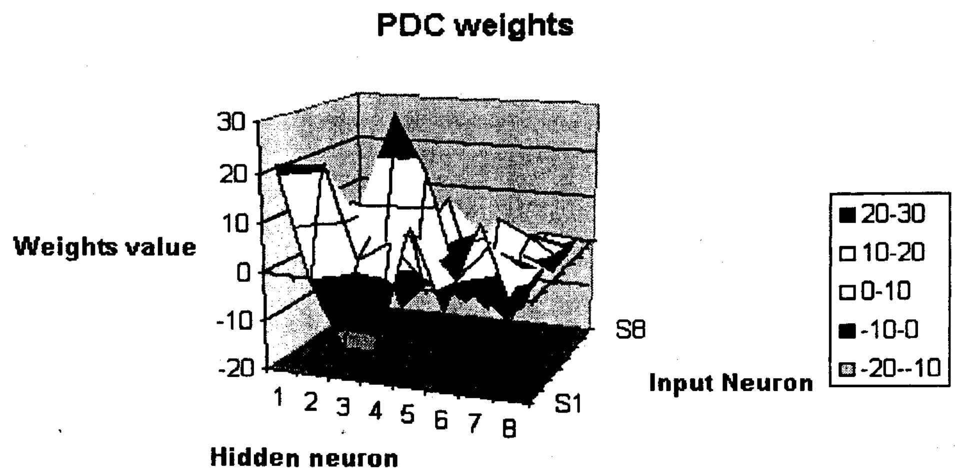

Figure 13. Monday 3D Weights

Table 16: Tuesday Rules Extracted

Hidden Neuron	TR	CPI	MS	MIA	UR	MD	DD
#1	-11.8785	16.6129	10.2571	-16.2271	16.4668	9.08855	-12.2204
#2	10.2527	-15.3734	-6.96857	8.54461	-10.3306	2.64699	-7.3611
#3	-8.9129	9.39881	1.25995	8.47404	-8.91604	-30.2112	10.0014
#4	-15.8368	8.48571	-3.00142	8.918	-9.07617	0.079068	-1.84868
#5	-8.3218	0.505948	8.34965	12.4901	3.80585	-3.832	-12.828
#6	-1.89383	-0.35906	-4.95121	-8.4729	-3.15831	3.95745	4.89479
#7	-4.84001	0.386734	-0.7006	0.869146	-1.67497	-1.11152	2.62745
Output Neuron	1.2898	1.77662	0.960093	-1.18914	-0.8219	-0.89041	0.839952

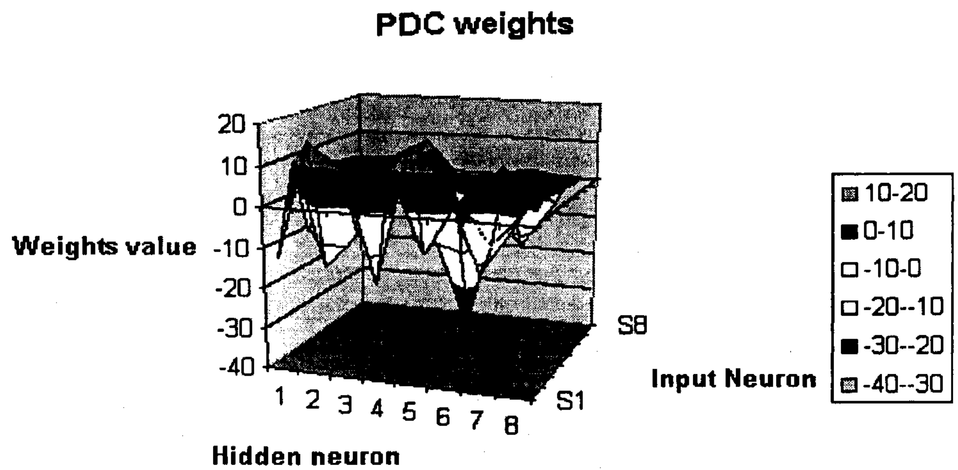

Figure 14. Tuesday 3D Weights

The overall importance level of input neurons from high to low sequence is MD, MS, MIA, CPI, TR, and UR from the 12 months average of weights recorded on 10 stocks. Neural Networks can be used to make short-term or long-term forecasts. The data can be intraday, daily, weekly or monthly and the patterns can be as short as one day or as long as many years.

4.6 OUTPUT DATA OPTIMIZATION

The optimized results are based on the following selection process. From the regression result of each stock on a testing day, the daily Beta is obtained and the forecast to achieve the maximum return is observed in our Portfolio #3. For example, for the September 5, 2003 forecast, a regression for the past 7 days is performed and results are presented. The regression data are shown in Table 17. Next the daily Beta is computed using EXCEL. The daily Betas in the forecasts of the 3 AT&T case studies described earlier are given in Table 18, along with the corresponding CAPM.

Table 17: Regression Data Source

31-Jan-02				6-Sep-03				31-Jan-04			
Date	T	Date	SPTSE	Date	T	Date	SPTSE	Date	T	Date	SPTSE
11-Oct-01	83.46	11-Oct-01	7060.1	15-May-03	16.88	15-May-03	6758.4	8-Oct-03	19.97	8-Oct-03	7569.3
12-Oct-01	83.88	12-Oct-01	7031	16-May-03	17.54	16-May-03	6742	9-Oct-03	20.24	9-Oct-03	7604.5
15-Oct-01	80.57	15-Oct-01	6955.6	20-May-03	17.58	20-May-03	6732.1	10-Oct-03	20.19	10-Oct-03	7633.6
16-Oct-01	80.57	16-Oct-01	7026.9	21-May-03	17.85	21-May-03	6726.4	14-Oct-03	20.09	14-Oct-03	7749.4
17-Oct-01	78.18	17-Oct-01	6956.8	22-May-03	17.96	22-May-03	6779.3	15-Oct-03	20.02	15-Oct-03	7783.2
18-Oct-01	75.11	18-Oct-01	6900	23-May-03	18.63	23-May-03	6782.9	16-Oct-03	20.28	16-Oct-03	7792.8
19-Oct-01	74.48	19-Oct-01	6911	27-May-03	18.3	27-May-03	6840.2	17-Oct-03	20.12	17-Oct-03	7717.5
22-Oct-01	76.79	22-Oct-01	6905.2	28-May-03	17.82	28-May-03	6836.2	20-Oct-03	21.07	20-Oct-03	7719.9
23-Oct-01	74.27	23-Oct-01	6904.2	29-May-03	18.42	29-May-03	6836.6	21-Oct-03	20	21-Oct-03	7768
24-Oct-01	68.57	24-Oct-01	6896.9	30-May-03	18.86	30-May-03	6859.8	22-Oct-03	19.51	22-Oct-03	7711.2
25-Oct-01	67.14	25-Oct-01	6943.7	2-Jun-03	19.12	2-Jun-03	6940.2	23-Oct-03	19.16	23-Oct-03	7650.2
26-Oct-01	67.18	26-Oct-01	7004.9	3-Jun-03	18.82	3-Jun-03	6931.3	24-Oct-03	19.9	24-Oct-03	7614.4
29-Oct-01	66.17	29-Oct-01	6896.3	4-Jun-03	19.2	4-Jun-03	7001.3	27-Oct-03	19.79	27-Oct-03	7664.2
30-Oct-01	66.05	30-Oct-01	6825.4	5-Jun-03	18.99	5-Jun-03	7034.9	28-Oct-03	19.94	28-Oct-03	7719.2
31-Oct-01	63.99	31-Oct-01	6885.7	6-Jun-03	18.75	6-Jun-03	7046.9	29-Oct-03	19.07	29-Oct-03	7730.5
1-Nov-01	63.11	1-Nov-01	6984.6	9-Jun-03	18.66	9-Jun-03	6972.4	30-Oct-03	18.9	30-Oct-03	7739.4
2-Nov-01	65.75	2-Nov-01	7024	10-Jun-03	18.68	10-Jun-03	7042.7	31-Oct-03	18.59	31-Oct-03	7772.7
5-Nov-01	66.72	5-Nov-01	7079.3	11-Jun-03	19.84	11-Jun-03	7100.8	3-Nov-03	18.87	3-Nov-03	7843.5
6-Nov-01	67.77	6-Nov-01	7145.5	12-Jun-03	20.84	12-Jun-03	7106.9	4-Nov-03	18.8	4-Nov-03	7863.7
7-Nov-01	67.27	7-Nov-01	7147.3	13-Jun-03	20.19	13-Jun-03	7010.5	5-Nov-03	18.68	5-Nov-03	7867.7
8-Nov-01	68.73	8-Nov-01	7140.8	16-Jun-03	20.38	16-Jun-03	7099.3	6-Nov-03	18.77	6-Nov-03	7870.9
9-Nov-01	67.94	9-Nov-01	7209.7	17-Jun-03	19.41	17-Jun-03	7121	7-Nov-03	18.93	7-Nov-03	7860.4
12-Nov-01	67.31	12-Nov-01	7223.9	18-Jun-03	19.58	18-Jun-03	7103.5	10-Nov-03	19.08	10-Nov-03	7815.5
13-Nov-01	69.07	13-Nov-01	7324.4	19-Jun-03	19.59	19-Jun-03	7078.5	11-Nov-03	19.07	11-Nov-03	7772.2
14-Nov-01	68.82	14-Nov-01	7349.5	20-Jun-03	19.77	20-Jun-03	7070.9	12-Nov-03	19.37	12-Nov-03	7797.3
15-Nov-01	71.25	15-Nov-01	7262.9	23-Jun-03	19.19	23-Jun-03	7014.7	13-Nov-03	19.21	13-Nov-03	7767.6
16-Nov-01	72.13	16-Nov-01	7315.3	24-Jun-03	19.33	24-Jun-03	6988.9	14-Nov-03	19.27	14-Nov-03	7752.4
19-Nov-01	71.76	19-Nov-01	7422.8	25-Jun-03	18.97	25-Jun-03	6970.6	17-Nov-03	19.17	17-Nov-03	7766
20-Nov-01	71.5	20-Nov-01	7381.2	26-Jun-03	19.28	26-Jun-03	6991.4	18-Nov-03	19.14	18-Nov-03	7737.4
21-Nov-01	71.04	21-Nov-01	7330.9	27-Jun-03	18.93	27-Jun-03	6979.1	19-Nov-03	19.22	19-Nov-03	7801.1
23-Nov-01	71.5	23-Nov-01	7382.5	2-Jul-03	19.43	30-Jun-03	6983.1	20-Nov-03	19.1	20-Nov-03	7809.8
26-Nov-01	71.8	26-Nov-01	7432.4	2-Jul-03	19.43	2-Jul-03	6990.3	21-Nov-03	20	21-Nov-03	7783.6
27-Nov-01	70.62	27-Nov-01	7466.4	3-Jul-03	18.98	3-Jul-03	6999.8	24-Nov-03	19.8	24-Nov-03	7850.1
28-Nov-01	72.8	28-Nov-01	7462.6	7-Jul-03	19.53	4-Jul-03	7001.9	25-Nov-03	19.97	25-Nov-03	7822.3
29-Nov-01	73.94	29-Nov-01	7358.2	8-Jul-03	19.28	8-Jul-03	7089.6	26-Nov-03	19.78	26-Nov-03	7860.4
30-Nov-01	73.39	30-Nov-01	7400.5	9-Jul-03	19.4	9-Jul-03	7117.3	28-Nov-03	19.83	28-Nov-03	7859.4
3-Dec-01	73.18	3-Dec-01	7425.6	10-Jul-03	18.71	10-Jul-03	7071.5	1-Dec-03	20.35	1-Dec-03	7924.6
4-Dec-01	73.81	4-Dec-01	7374.8	11-Jul-03	18.95	11-Jul-03	7077.6	2-Dec-03	20.27	2-Dec-03	7927.6
5-Dec-01	73.73	5-Dec-01	7450.1	14-Jul-03	19.03	14-Jul-03	7116	3-Dec-03	20.22	3-Dec-03	7959.9
6-Dec-01	75.87	6-Dec-01	7620.2	15-Jul-03	19.15	15-Jul-03	7116.1	4-Dec-03	20.31	4-Dec-03	7993.3
7-Dec-01	74.19	7-Dec-01	7613.7	16-Jul-03	18.8	16-Jul-03	7082	5-Dec-03	20.15	5-Dec-03	7990.3

Table 17: Regression Data Source (Continued)

31-Jan-02				6-Sep-03				31-Jan-04			
Date	T	Date	SPTSE	Date	T	Date	SPTSE	Date	T	Date	SPTSE
10-Dec-01	70.92	10-Dec-01	7616.8	17-Jul-03	18.62	17-Jul-03	7069.4	8-Dec-03	20.03	8-Dec-03	7990.8
11-Dec-01	69.87	11-Dec-01	7559.8	18-Jul-03	18.81	18-Jul-03	7114.6	9-Dec-03	19.86	9-Dec-03	7975.9
12-Dec-01	69.24	12-Dec-01	7531.6	21-Jul-03	18.73	21-Jul-03	7136	10-Dec-03	19.88	10-Dec-03	7887.1
13-Dec-01	67.77	13-Dec-01	7577.7	22-Jul-03	19.37	22-Jul-03	7185.2	11-Dec-03	19.62	11-Dec-03	7956.2
14-Dec-01	67.68	14-Dec-01	7451.2	23-Jul-03	19.09	23-Jul-03	7231.3	12-Dec-03	18.98	12-Dec-03	7979.2
17-Dec-01	71.42	17-Dec-01	7425.7	24-Jul-03	19.54	24-Jul-03	7251.4	15-Dec-03	18.98	15-Dec-03	7932.1
18-Dec-01	69.87	18-Dec-01	7515.4	25-Jul-03	19.95	25-Jul-03	7262.6	17-Dec-03	18.9	17-Dec-03	8040.2
19-Dec-01	70.5	19-Dec-01	7586.5	28-Jul-03	21.69	28-Jul-03	7284.5	18-Dec-03	19.25	18-Dec-03	8124.7
20-Dec-01	74.9	20-Dec-01	7501.1	29-Jul-03	21.25	29-Jul-03	7227.4	19-Dec-03	19.41	19-Dec-03	8113.8
21-Dec-01	77	21-Dec-01	7455	30-Jul-03	20.68	30-Jul-03	7205	22-Dec-03	19.52	22-Dec-03	8135.4
24-Dec-01	77	24-Dec-01	7528.3	31-Jul-03	20.78	31-Jul-03	7257.9	23-Dec-03	19.75	23-Dec-03	8138.4
27-Dec-01	75.44	27-Dec-01	7552.6	1-Aug-03	21.6	1-Aug-03	7218.6	24-Dec-03	19.69	24-Dec-03	8136.8
28-Dec-01	76.32	28-Dec-01	7650.6	5-Aug-03	20.79	5-Aug-03	7189.5	29-Dec-03	19.96	29-Dec-03	8260.5
31-Dec-01	76.15	31-Dec-01	7675	6-Aug-03	20.87	6-Aug-03	7139.1	30-Dec-03	20.03	30-Dec-03	8213.8
2-Jan-02	78.5	2-Jan-02	7688.4	7-Aug-03	20.64	7-Aug-03	7180.3	31-Dec-03	20.3	31-Dec-03	8220.9
3-Jan-02	78.25	3-Jan-02	7646.8	8-Aug-03	20.43	8-Aug-03	7252	2-Jan-04	20.87	2-Jan-04	8293.7
4-Jan-02	77.12	4-Jan-02	7774.2	11-Aug-03	20.47	11-Aug-03	7317.8	5-Jan-04	21.49	5-Jan-04	8381.7
7-Jan-02	77.58	7-Jan-02	7833.2	12-Aug-03	20.62	12-Aug-03	7354	6-Jan-04	21.45	6-Jan-04	8405.1
8-Jan-02	79.43	8-Jan-02	7870.3	13-Aug-03	20.52	13-Aug-03	7372.3	7-Jan-04	21.26	7-Jan-04	8388.5
9-Jan-02	78.5	9-Jan-02	7782	14-Aug-03	20.67	14-Aug-03	7393.8	8-Jan-04	21.98	8-Jan-04	8386.4
10-Jan-02	79.34	10-Jan-02	7775.8	15-Aug-03	20.55	15-Aug-03	7390.5	9-Jan-04	21.06	9-Jan-04	8352.2
11-Jan-02	80.22	11-Jan-02	7722.4	18-Aug-03	20.67	18-Aug-03	7411.3	12-Jan-04	21.02	12-Jan-04	8380.4
14-Jan-02	79.38	14-Jan-02	7701.9	19-Aug-03	20.83	19-Aug-03	7474.9	13-Jan-04	21.05	13-Jan-04	8380.3
15-Jan-02	79.01	15-Jan-02	7623.3	20-Aug-03	20.84	20-Aug-03	7491.1	14-Jan-04	21.38	14-Jan-04	8403.8
16-Jan-02	77.83	16-Jan-02	7643.9	21-Aug-03	20.87	21-Aug-03	7516.5	15-Jan-04	21.16	15-Jan-04	8423.9
17-Jan-02	77.12	17-Jan-02	7584	22-Aug-03	21.24	22-Aug-03	7467.2	16-Jan-04	21.04	16-Jan-04	8522.3
18-Jan-02	77.79	18-Jan-02	7652.7	25-Aug-03	21.1	25-Aug-03	7441.1	20-Jan-04	21.65	20-Jan-04	8623.6
22-Jan-02	76.11	22-Jan-02	7604.8	26-Aug-03	21.08	26-Aug-03	7442.8	21-Jan-04	21.25	21-Jan-04	8621.9
23-Jan-02	75.98	23-Jan-02	7559.3	27-Aug-03	21.07	27-Aug-03	7500.6	22-Jan-04	20.4	22-Jan-04	8589.1
24-Jan-02	77.62	24-Jan-02	7598.5	28-Aug-03	21.21	28-Aug-03	7517	23-Jan-04	19.7	23-Jan-04	8604.7
25-Jan-02	77.49	25-Jan-02	7657.6	29-Aug-03	21.79	29-Aug-03	7517	26-Jan-04	20.15	26-Jan-04	8594.9
28-Jan-02	77.33	28-Jan-02	7659.3	2-Sep-03	21.88	2-Sep-03	7566.9	27-Jan-04	19.91	27-Jan-04	8588.2
29-Jan-02	74.77	29-Jan-02	7643.7	3-Sep-03	21.74	3-Sep-03	7580.4	28-Jan-04	19.77	28-Jan-04	8535.7
30-Jan-02	73.25	30-Jan-02	7567.1	4-Sep-03	22.01	4-Sep-03	7594.9	29-Jan-04	19.59	29-Jan-04	8449.4
31-Jan-02	74.3	31-Jan-02	7548.8	5-Sep-03	22.17	5-Sep-03	7612.5	30-Jan-04	19.46	30-Jan-04	8521.4

Regression result are recorded as follows:

Table 18: Regression Result

Date	23-Jan-02	24-Jan-02	25-Jan-02	28-Jan-02	29-Jan-02	30-Jan-02	31-Jan-02
CAPM	-40.3418	-43.2893	-45.2217	-48.7003	-54.4367	-55.932	-53.1916
Daily Beta	0.015185	0.015582	0.015842	0.016306	0.017062	0.017257	0.016895

Date	27-Aug-03	28-Aug-03	29-Aug-03	2-Sep-03	3-Sep-03	4-Sep-03	5-Sep-03
CAPM	-9.45388	-9.53236	-10.1411	-10.6624	-10.6165	-10.6652	-10.813
Daily Beta	0.00409	0.0041	0.004186	0.004259	0.004254	0.004263	0.004285

Date	22-Jan-04	23-Jan-04	26-Jan-04	27-Jan-04	28-Jan-04	29-Jan-04	30-Jan-04
CAPM	-0.39367	1.076263	1.268085	1.762763	2.115627	2.785426	3.8395
Daily Beta	0.002529	0.002342	0.002314	0.002249	0.002201	0.002116	0.001984

The CAPM estimator for forecasting in the periods January 23- January 31, 2002; August 27 – September 5, 2003, and January 22- January 30, 2004 are presented in Table 19.

Table 19: CAPM Optimizer

Date	Estimator
23-Jan-02	-40.3418 + 0.015185 * S&PTSE Composite Index
24-Jan-02	-43.2893 + 0.015582 * S&PTSE Composite Index
25-Jan-02	-45.2217 + 0.015842 * S&PTSE Composite Index
28-Jan-02	-48.7003 + 0.016306 * S&PTSE Composite Index
29-Jan-02	-54.4367 + 0.017062 * S&PTSE Composite Index
30-Jan-02	-55.932 + 0.017257 * S&PTSE Composite Index
31-Jan-02	-53.1916 + 0.016895 * S&PTSE Composite Index

Date	Estimator
27-Aug-03	-9.45388 + 0.00409 * S&PTSE Composite Index
28-Aug-03	-9.53236 + 0.0041 * S&PTSE Composite Index
29-Aug-03	-10.1411 + 0.004186 * S&PTSE Composite Index
2-Sep-03	-10.6624 + 0.004259 * S&PTSE Composite Index
3-Sep-03	-10.6165 + 0.004254 * S&PTSE Composite Index
4-Sep-03	-10.6652 + 0.004263 * S&PTSE Composite Index
5-Sep-03	-10.813 + 0.004285 * S&PTSE Composite Index

Table 19: CAPM Optimizer (Continued)

Date	Estimator
22-Jan-04	-0.39367 + 0.002529 * S&PTSE Composite Index
23-Jan-04	1.076263 + 0.002342 * S&PTSE Composite Index
26-Jan-04	1.268085 + 0.002314 * S&PTSE Composite Index
27-Jan-04	1.762763 + 0.002249 * S&PTSE Composite Index
28-Jan-04	2.115627+ 0.002201 * S&PTSE Composite Index
29-Jan-04	2.785426 + 0.002116 * S&PTSE Composite Index
30-Jan-04	3.8395 + 0.001984 * S&PTSE Composite Index

The CAPM Estimator clearly indicates the trend. There is a bigger Beta with Mean 0.0163 at the beginning of recession and our neural network forecast result should be more influenced by the general stock market performance, however the negative alpha with mean – 48.7305 indicates that T is much more risky than the general market at January 2002. There is a moderate Beta with Mean 0.0042 at the middle of recession and our neural network forecast result should be less influenced by the general stock market performance, and the moderate negative alpha with mean –10.2692 indicates that T is still risky than the general market at September 2003. There is a small Beta with Mean 0.0022 at the beginning of recovery and our neural network forecast result should be less influenced by the general stock market performance, and the positive alpha with mean 1.7791 indicates that T is now a safer stock than the general market performance. This is reasonable since this stock and the market is highly correlated. Thus the data in the output is validated.

Repeating the same forecast and optimization on a portfolio of ten stocks, the everyday dynamic Beta of our portfolio is obtained. The following is an example of daily Beta obtained.

Table 20: Summary of Dynamic Beta

Symbol	TLC	BR	AC	COR	HUM	BRA	RCMB	SCC	PCA	MFI
Beta	0.301	0.673	1.993	0.868	0.824	[illegible]	[illegible]	1.026	0.545	0.588

A higher Beta means the stock has more systematic risk; a lower Beta means the stock has less systematic risk. For example, if MIA changes one percent, AC stock will likely change 1.993 percent.

4.7 ONE-YEAR IMPLEMENTATION RESULT

To summarize the overall result of one-year testing result, the investment return and adjusted stock weights in the portfolio are calculated.

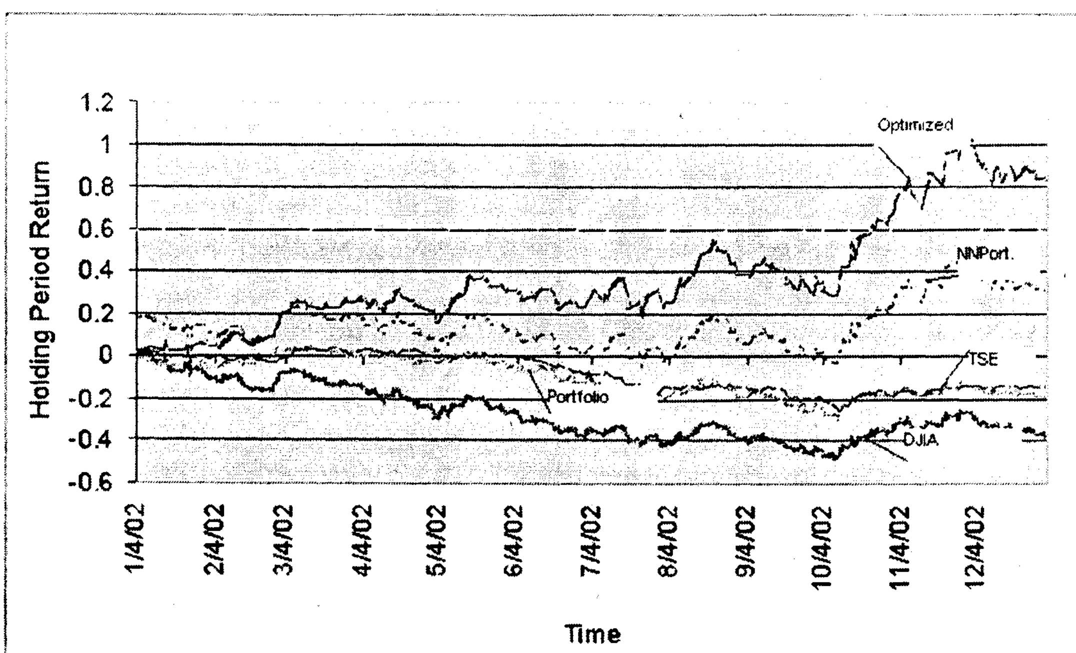

Figure 15. Return Comparison

The negative return on portfolio #1 tells us that unless all the 10 companies are well known, it is very risky to setup the portfolio based on the investor's own choice.

The neural network portfolio tells us that it is possible to do better than the market. The positive holding period return reached 31%, and that is much better than market indexes.

Table 21: Stock Weights In One Portfolio

Symbol	Weight	Value	Share
TLC.TO	0.009	900	192.71949
BR.TO	0.118	11800	[illegible]
AC.TO	0.12	12000	1572.7392
COR.TO	0.025	2500	1329.7872
HUM.TO	0.114	11400	400
BRA.TO	0.092	9200	2628.5714
RCMB.TO	0.111	11100	628.89518
SCC.TO	0.152	15200	646.80851
PCA.TO	0.136	13600	317.75701
MFI.TO	0.124	12400	784.81013
TOTAL	1	100000	

The table lists the optimized neural network portfolio composition and adjusted weights between 10 stocks. With the multi-method neural network model, it is possible to achieve a positive return when the market suffers a loss. The positive holding period return was 83%, which is better than market indices. Using Excel processing correlation function on each input data, we obtained the following correlation.

Table 22: Input Correlation

Correlation	TR	CPI	MS	MIA	ER	MD
TR	1	0.04283	0.15333	0.31679	-0.07359	0.36008
CPI	0.04283	1	0.27006	0.00507	0.23449	0.07319
MS	0.15333	0.27006	1	0.01183	0.2418	0.22965
MIA	0.31679	0.00507	0.01183	1	0.18609	0.44684
ER	-0.07359	0.23449	0.2418	0.18609	1	0.2179
MD	0.36008	0.07319	0.22965	0.44684	0.2179	1

In this project, it is considered that each noise factor works differently on the final forecasted result, it is important to find out the correlation between noise factors and the input factors. The above is a sample correlation matrix for each factor that passed through the network in optimized method.

CHAPTER 5. CONCLUSION

5.1 SUMMARY OF CONTRIBUTIONS

The goal of this project was to forecast next day's stock close price. In this study, three portfolios were created. They were Portfolio #1 using subjective forecast; Portfolio #2 using neural network forecast and Portfolio #3 using CAPM optimized forecast. A comparison of these portfolios showed that the CAPM optimization based on neural network forecast (Portfolio #3) achieved the highest return. The degree of accuracy was compared in three economic periods, i.e. the beginning of recession, the middle of the recession and the beginning of recovery. Stock forecasting example cases were given to illustrate this neural network approach to solve nonlinear problems. Neural networks indeed forecasted next day's closing price with better accuracy within one-year period than other methods.

In the training and forecast process, the following inputs were used: T-bill rate of change, Consumer Price Index rate of change, Money Supply rate of change, Market Index Average rate of change, Unemployment Rate value of change, Daily Stock Price rate of change. These decimals were fed to the input layer of the network and compared with the following day's target change in stock price. After the training, the extracted weights matrices were used as intermediate data to forecast the next day's close price rate of change. This same procedure is repeated on ten stocks continuously for one year.

It was found that neural network forecast can help individual investors to improve their investment return given a free trade environment without commission and trade cost i.e. the test and recommendations in this project assumed zero cost of buy/sell. For a single stock, the neural network achieved better result at the beginning of each economic cycle, such as beginning of recession and beginning of recovery than in the middle of recession.

Results suggested that intra-day stock traders and online investors can achieve better return by using neural network forecast method when compared to economic data forecast, fundamental forecast and technical forecast. They cannot use economic data analysis to forecast stock price because most economic data are not published daily. They cannot use fundamental analysis to forecast stock price because fundamental data available to the public are very limited. They cannot use technical analysis to forecast stock price because chartists are considered as professionals and most investors do not master the techniques of reading stock charts. Finally, it was recommended that they use computers to run the neural network program, take seven inputs and obtain the forecasted next day closing price within minutes.

Based on ten stocks portfolio return, it was concluded that the single neural network portfolio did significantly better than initial portfolio and the market indices. The forecasting model is highly efficient in capitalized free trade market i.e. US and Canada. In sequence of decreasing order of importance, the overall importance level of input neurons from high to low sequence as observed in this study was MD, MS, MIA, CPI, TR, and UR from the 12 months average of weights recorded on 10 stocks.

5.2 DIRECTIONS FOR FUTURE RESEARCH

The goal of forecasting daily closing price allows the investors and users of neural network forecast to do one trade on each stock only. More frequent trading cannot be done because actual commission resulting from frequent trading could be very high. For example, if a user invests $ 10,000, buy and sell the same stock three times a day, the actual commission could be quite significant. Moreover, most stocks are not volatile enough to reach three or more peaks or bottom enough to cover the commission of trades.

However, it is possible that some VIP clients were given fixed rate unlimited trade service by their brokers in the future. If that becomes reality, a more frequent forecast would be very interesting and a research on shorter forecast frequency than one day would be definitely worthwhile to be studied.

APPENDIX: SOURCE DATA FOR STOCKS USED IN THE PORTFOLIOS

Table A.1: TLC.TO Data

TLC.TO		
Date	Adj Close	HPR
1-May-02	4.95	-0.0642722
1-Apr-02	5.29	-0.0203704
1-Mar-02	5.4	0.5697674
1-Feb-02	3.44	-0.0971129
2-Jan-02	3.81	0.0409836
3-Dec-01	3.66	-0.1180723
1-Nov-01	4.15	0.0375
1-Oct-01	4	-0.0123457
4-Sep-01	4.05	-0.3193277
1-Aug-01	5.95	-0.1991925
3-Jul-01	7.43	0.0067751
1-Jun-01	7.38	-0.0428016
1-May-01	7.71	-0.0469716
2-Apr-01	8.09	-0.2543779
1-Mar-01	10.85	-0.0882353
1-Feb-01	11.9	1.2242991
2-Jan-01	5.35	1.547619
1-Dec-00	2.1	-0.475
2-Oct-00	5.05	-0.0471698
1-Sep-00	5.3	-0.3116883
1-Aug-00	7.7	-0.1675676
4-Jul-00	9.25	-0.1590909
1-Jun-00	11	-0.0350877
1-May-00	11.4	0.1457286
3-Apr-00	9.95	-0.3137931
1-Mar-00	14.5	-0.3526786
4-Jan-00	19.45	0.0345745
1-Dec-99	18.8	-0.3138686
1-Nov-99	27.4	0.0682261
1-Oct-99	25.65	-0.2875
1-Sep-99	36	-0.193729
3-Aug-99	44.65	-0.185219
2-Jul-99	54.8	-0.2171429
1-Jun-99	70	0.0727969
3-May-99	65.25	0.2060998
1-Apr-99	54.1	0.1177686
1-Mar-99	48.4	0.7102473
1-Feb-99	28.3	-0.085622
4-Jan-99	30.95	-0.0251969
1-Dec-98	31.75	0.0618729
2-Nov-98	29.9	0.2008032
1-Oct-98	24.9	0.1800948
1-Sep-98	21.1	0.2448378
4-Aug-98	16.95	-0.3081633
2-Jul-98	24.5	0.0208333
1-Jun-98	24	0
1-May-98	24	0
1-Apr-98	24	0.2565445
2-Mar-98	19.1	0.079096
2-Feb-98	17.7	0.0792683
2-Jan-98	16.4	0.2148148
1-Dec-97	13.5	0.1790393
3-Nov-97	11.45	0.0409091
1-Oct-97	11	-0.0598291
2-Sep-97	11.7	-0.0168067
1-Aug-97	11.9	0.012766
2-Jul-97	11.75	0
2-Jun-97	11.75	-0.0208333
		Alpha=0.475270589593318
R=0.0242991627864238	SD=0.329284018724122	Beta=0.300648149462693
Beta <1 insignificant; Alpha>0 Excess return exist but is not significant, it could be compensation for risk factors not captured by the market		

Table A.2: BR.TO Data

BR.TO		
Date	Adj Close	HPR
1-May-02	8	0.4035088
1-Apr-02	5.7	0.0363636
1-Mar-02	5.5	0.1
1-Feb-02	5	0.0204082
2-Jan-02	4.9	-0.02
3-Dec-01	5	0.1764706
2-Nov-01	4.25	-0.0555556
1-Oct-01	4.5	0
4-Sep-01	4.5	-0.0909091
3-Aug-01	4.95	0.0102041
3-Jul-01	4.9	0.0652174
4-Jun-01	4.6	0.010989
2-May-01	4.55	0
2-Apr-01	4.55	0.0963855
1-Mar-01	4.15	-0.0348837
1-Feb-01	4.3	-0.0652174
2-Jan-01	4.6	-0.0107527
1-Dec-00	4.65	-0.0412371
1-Nov-00	4.85	0.0210526
2-Oct-00	4.75	-0.0686275
5-Sep-00	5.1	-0.0555556
1-Aug-00	5.4	-0.0526316
4-Jul-00	5.7	-0.05
1-Jun-00	6	0
1-May-00	6	0.1009174
3-Apr-00	5.45	-0.0438596
1-Mar-00	5.7	-0.1230769
1-Feb-00	6.5	-0.0298507
4-Jan-00	6.7	-0.1625
1-Dec-99	8	0.4814815
1-Sep-99	6	0.1650485
3-Aug-99	5.15	0.1444444
2-Jul-99	4.5	-0.1
1-Jun-99	5	0
3-May-99	5	0.0309278
1-Apr-99	4.85	0.4923077
1-Mar-99	3.25	0
1-Feb-99	3.25	-0.0972222
5-Jan-99	3.6	0.0285714
1-Dec-98	3.5	-0.127182
4-Nov-98	4.01	-0.0886364
1-Oct-98	4.4	-0.1111111
3-Sep-98	4.95	0.1647059
4-Aug-98	4.25	-0.1826923
2-Jul-98	5.2	0.1182796
1-Jun-98	4.65	-0.1388889
1-May-98	5.4	-0.1
1-Apr-98	6	0.0084034
2-Mar-98	5.95	-0.1185185
2-Feb-98	6.75	0.125
2-Jan-98	6	0.0434783
1-Dec-97	5.75	0.0176991
3-Nov-97	5.65	-0.1374046
1-Oct-97	6.55	-0.0642857
2-Sep-97	7	-0.0540541
1-Aug-97	7.4	-0.1030303
3-Jul-97	8.25	-0.0060241
3-Jun-97	8.3	-0.0514286
12-May-97	8.75	
		Alpha=0.113970235377814
R=0.00627881038651584	SD=0.13460949226012	Beta=0.67295812386836
Beta <1 insignificant; Alpha>0 Excess return exist but is not significant, it could be compensation for risk factors not captured by the market		

Table A.3: AC.TO Data

	AC.TO	
Date	Adj Close	HPR
1-May-02	7.08	0.0694864
1-Apr-02	6.62	-0.0419682
1-Mar-02	6.91	0.3959596
1-Feb-02	4.95	-0.0480769
2-Jan-02	5.2	0.0358566
3-Dec-01	5.02	0.1205357
1-Nov-01	4.48	0.6969697
1-Oct-01	2.64	-0.2747253
4-Sep-01	3.64	-0.4374034
1-Aug-01	6.47	-0.1221167
3-Jul-01	7.37	-0.1557847
1-Jun-01	8.73	-0.0761905
2-Apr-01	8.95	0.1329114
1-Mar-01	7.9	-0.1459459
1-Feb-01	9.25	-0.26
2-Jan-01	12.5	-0.0875912
1-Dec-00	13.7	-0.0743243
1-Nov-00	14.8	-0.1084337
2-Oct-00	16.6	0.0993377
1-Sep-00	15.1	-0.1815718
1-Aug-00	18.45	-0.0107239
4-Jul-00	18.65	-0.0435897
1-Jun-00	19.5	-0.0025575
1-May-00	19.55	0.2572347
3-Apr-00	15.55	0.0032258
1-Mar-00	15.5	-0.0962099
1-Feb-00	17.15	0.8641304
4-Jan-00	9.2	-0.1559633
1-Dec-99	10.9	0.2748538
1-Nov-99	8.55	-0.2191781
1-Oct-99	10.95	0.095
1-Sep-99	10	0.1049724
3-Aug-99	9.05	0.3211679
2-Jul-99	6.85	0.1048387
1-Jun-99	6.2	0.0333333
3-May-99	6	-0.0977444
1-Apr-99	6.65	-0.0074627
1-Mar-99	6.7	0.0983607
4-Jan-99	6.65	0.0813008
1-Dec-98	6.15	0.025
2-Nov-98	6	0.0169492
1-Oct-98	5.9	0.0535714
4-Aug-98	6.65	-0.335
2-Jul-98	10	-0.2395437
1-Jun-98	13.15	0.0193798
1-May-98	12.9	-0.0337079
1-Apr-98	13.35	0.0389105
2-Mar-98	12.85	-0.0153257
2-Feb-98	13.05	-0.0474453
2-Jan-98	13.7	-0.0711864
1-Dec-97	14.75	0.0727273
3-Nov-97	13.75	-0.0213523
1-Oct-97	14.05	0.0407407
2-Sep-97	13.5	0.2385321
1-Aug-97	10.9	-0.0954357
2-Jul-97	12.05	0.2956989
2-Jun-97	9.3	0.1625
12-May-97	8	
		0.508025
R=0.0177031829438089	SD=0.212889407994318	Beta=1.99333370272235
Beta >1 significant; Alpha>0 Excess return exist but is not significant, it could be compensation for risk factors not captured by the market		

Table A.4: COR.TO Data

COR.TO		
Date	Adj Close	HPR
1-May-02	1.88	-0.1255814
1-Apr-02	2.15	-0.0315315
1-Mar-02	2.22	-0.0305677
1-Feb-02	2.29	-0.2020906
2-Jan-02	2.87	-0.0528053
3-Dec-01	3.03	-0.2329114
1-Nov-01	3.95	0.0589812
1-Oct-01	3.73	0.130303
4-Sep-01	3.3	-0.3567251
1-Aug-01	5.13	-0.0672727
3-Jul-01	5.5	0.25
1-Jun-01	4.4	0.1891892
1-May-01	3.7	0
2-Apr-01	3.7	-0.0414508
1-Mar-01	3.86	0.2371795
1-Feb-01	3.12	-0.3035714
2-Jan-01	4.48	0.7991968
1-Dec-00	2.49	-0.3926829
2-Oct-00	6	0.0810811
1-Sep-00	5.55	0.0571429
1-Aug-00	5.25	0.1666667
4-Jul-00	4.5	-0.2173913
1-Jun-00	5.75	0.0550459
1-May-00	5.45	-0.455
3-Apr-00	10	-0.3079585
1-Mar-00	14.45	-0.3386728
1-Feb-00	21.85	-0.2111913
4-Jan-00	27.7	0.2648402
1-Dec-99	21.9	-0.1673004
1-Oct-99	9.75	-0.109589
1-Sep-99	10.95	0.2882353
3-Aug-99	8.5	0.2977099
2-Jul-99	6.55	0.1696429
1-Jun-99	5.6	0.3023256
3-May-99	4.3	-0.0337079
1-Apr-99	4.45	-0.0881148
1-Mar-99	4.88	-0.2314961
1-Feb-99	6.35	-0.130137
4-Jan-99	7.3	0.1967213
1-Dec-98	6.1	0.5443038
2-Nov-98	3.95	0.3036304
1-Oct-98	3.03	-0.1488764
1-Sep-98	3.56	1
4-Aug-98	1.78	-0.1909091
2-Jul-98	2.2	-0.2786885
1-Jun-98	3.05	-0.0615385
1-May-98	3.25	-0.1216216
1-Apr-98	3.7	0.3214286
2-Mar-98	2.8	-0.0967742
2-Feb-98	3.1	-0.1014493
2-Jan-98	3.45	0.5
1-Dec-97	2.3	-0.2651757
3-Nov-97	3.13	-0.187013
1-Oct-97	3.85	-0.2803738
2-Sep-97	5.35	-0.3395062
1-Aug-97	8.1	-0.0526316
2-Jul-97	8.55	-0.0604396
2-Jun-97	9.1	0.1165644
12-May-97	8.15	
		0.4056254
R=0.0233035075289627	SD=0.358027120216893	Beta=0.867965737301136
Beta <1 insignificant; Alpha>0 Excess return exist but is not significant, it could be compensation for risk factors not captured by the market		

Table A.5: HUM.TO Data

HUM.TO		
Date	Adj Close	HPR
1-May-02	30.15	0.0307692
1-Apr-02	29.25	-0.1136364
1-Mar-02	33	0.0322177
1-Feb-02	31.97	-0.0968927
2-Jan-02	35.4	0.1815754
3-Dec-01	29.96	0.2129555
1-Nov-01	24.7	-0.05
1-Oct-01	26	-0.0038314
4-Sep-01	26.1	-0.018797
1-Aug-01	26.6	-0.0646976
3-Jul-01	28.44	0.1421687
1-Jun-01	24.9	-0.1487179
1-May-01	29.25	-0.025
2-Apr-01	30	-0.2207792
1-Mar-01	38.5	-0.1675676
1-Feb-01	46.25	-0.0913556
2-Jan-01	50.9	0.018
1-Dec-00	50	0.0893246
1-Nov-00	45.9	0.0222717
2-Oct-00	44.9	0.003352
1-Aug-00	49.4	0.0977778
4-Jul-00	45	-0.2241379
1-Jun-00	58	0
1-May-00	58	-0.1684588
1-Mar-00	62.1	-0.0590909
4-Jan-00	49.3	0.1333333
1-Dec-99	43.5	0.2908012
1-Nov-99	33.7	0.0212121
1-Oct-99	33	0.0030395
1-Sep-99	32.9	0.0734095
3-Aug-99	30.65	0.2235529
2-Jul-99	25.05	-0.0857664
1-Jun-99	27.4	0.2177778
3-May-99	22.5	-0.1
1-Apr-99	25	0.0917031
1-Mar-99	22.9	-0.2302521
1-Feb-99	29.75	-0.0703125
4-Jan-99	32	0.0631229
1-Dec-98	30.1	0.0415225
2-Nov-98	28.9	0.1795918
1-Oct-98	24.5	-0.2109501
1-Sep-98	31.05	0.0114007
4-Aug-98	30.7	-0.0970588
2-Jul-98	34	-0.1359593
1-Jun-98	39.35	-0.0901734
1-May-98	43.25	-0.0951883
1-Apr-98	47.8	-0.039196
2-Mar-98	49.75	0.0226105
2-Feb-98	48.65	0.0883669
2-Jan-98	44.7	-0.0282609
1-Dec-97	46	-0.018143
3-Nov-97	46.85	-0.0676617
1-Oct-97	50.25	-0.0633737
2-Sep-97	53.65	0.0141777
1-Aug-97	52.9	-0.0018868
2-Jul-97	53	0.486676
2-Jun-97	35.65	-0.0997475
12-May-97	39.6	
		Alpha=0.0015242330244446
R=0.00456031097558232	SD=0.140180844833559	Beta=0.824406206296188
Beta <1 insignificant; Alpha>0 Excess return exist but is not significant, it could be compensation for risk factors not captured by the market		

Table A.6: BRA.TO Data

BRA.TO		
Date	Adj Close	HPR
1-May-02	4.5	0.125
1-Apr-02	4	-0.2831541
1-Mar-02	5.58	-0.07
1-Feb-02	6	-0.0243902
2-Jan-02	6.15	-0.075188
3-Dec-01	6.65	0.0390625
1-Nov-01	6.4	0.0666667
1-Oct-01	6	-0.1780822
4-Sep-01	7.3	-0.1797753
1-Aug-01	8.9	-0.11
3-Jul-01	10	-0.047619
1-Jun-01	10.5	-0.1025641
1-May-01	11.7	0
2-Apr-01	11.7	0.190234
1-Mar-01	9.83	-0.0090726
2-Jan-01	12.6	0.5365854
1-Dec-00	8.2	-0.2612613
1-Nov-00	11.1	-0.1747212
1-Sep-00	16	0.0596026
1-Aug-00	15.1	0.51
4-Jul-00	10	-0.2592593
1-Jun-00	13.5	0.125
1-May-00	12	0.0714286
1-Mar-00	14.75	-0.2377261
1-Feb-00	19.35	0.5117188
4-Jan-00	12.8	1.245614
1-Dec-99	5.7	-0.0806452
1-Nov-99	6.2	0.5938303
1-Oct-99	3.89	-0.0151899
1-Sep-99	3.95	-0.2752294
3-Aug-99	5.45	0.0582524
2-Jul-99	5.15	-0.0283019
1-Jun-99	5.3	-0.0862069
3-May-99	5.8	-0.0333333
1-Apr-99	6	0.1538462
1-Mar-99	5.2	-0.079646
1-Feb-99	5.65	0
4-Jan-99	5.65	0.1649485
1-Dec-98	4.85	-0.03
2-Nov-98	5	0.8181818
1-Oct-98	2.75	0.1956522
1-Sep-98	2.3	0.15
4-Aug-98	2	-0.3421053
2-Jul-98	3.04	-0.0925373
1-Jun-98	3.35	-0.1410256
1-May-98	3.9	-0.025
1-Apr-98	4	0.1267606
2-Mar-98	3.55	-0.0923077
2-Feb-98	3.25	0.0450161
2-Jan-98	3.11	0.0032258
1-Dec-97	3.1	-0.225
3-Nov-97	4	-0.3162393
1-Oct-97	5.85	-0.1397059
2-Sep-97	6.8	0.1239669
1-Aug-97	6.05	0
2-Jul-97	6.05	-0.1357143
2-Jun-97	7	-0.020979
12-May-97	7.15	
		Alpha=0.485387283263483
R=0.0219079496993124	SD=0.27798916455343	Beta=1.81744653350361
Beta >1 significant; Alpha>0 Excess return exist but is not significant, it could be compensation for risk factors not captured by the market		

Table A.7: RCMB.TO Data

RCMB.TO		
Date	Adj Close	HPR
1-May-02	17.86	0.018244
1-Apr-02	17.54	-0.0309392
1-Mar-02	18.1	-0.0320856
1-Feb-02	18.7	-0.1095238
2-Jan-02	21	-0.0869565
3-Dec-01	23	0.0747664
5-Nov-01	21.4	0.1192469
31-Oct-01	19.12	-0.0487562
3-Sep-01	20.1	-0.2821429
3-Aug-01	28	0.009009
1-Jun-01	26.1	0.4032258
1-May-01	18.6	0.0333333
2-Apr-01	18	-0.1325301
1-Mar-01	20.75	-0.045977
1-Feb-01	21.75	-0.2536033
2-Jan-01	29.14	0.1058824
1-Dec-00	26.35	0.0821355
2-Oct-00	32	-0.3043478
1-Sep-00	46	0.0337079
1-Aug-00	44.5	-0.0283843
4-Jul-00	45.8	-0.0700508
1-Jun-00	49.25	0.1017897
1-May-00	44.7	-0.0345572
3-Apr-00	46.3	-0.208547
1-Mar-00	58.5	-0.1582734
1-Feb-00	69.5	0.0800311
4-Jan-00	64.35	0.2222222
1-Dec-99	52.65	0.1131078
1-Nov-99	47.3	0.1261905
1-Oct-99	42	0.2103746
3-Aug-99	32.5	0.023622
2-Jul-99	31.75	0.3092784
1-Jun-99	24.25	-0.1018519
3-May-99	27	0.0485437
1-Apr-99	25.75	-0.0480591
1-Mar-99	27.05	0.1634409
1-Feb-99	23.25	0.0064935
4-Jan-99	23.1	0.2486486
1-Dec-98	18.5	0.1314985
2-Nov-98	16.35	0.021875
1-Oct-98	16	0.3913043
1-Sep-98	11.5	-0.08
4-Aug-98	12.5	-0.2753623
2-Jul-98	17.25	-0.0547945
1-Jun-98	18.25	0.0735294
1-May-98	17	0.1111111
1-Apr-98	15.3	-0.04375
2-Mar-98	16	0.2075472
2-Feb-98	13.25	0.2801932
2-Jan-98	10.35	-0.2099237
1-Dec-97	13.1	-0.1761006
3-Nov-97	15.9	-0.3234043
1-Oct-97	23.5	-0.0329218
2-Sep-97	24.3	-0.1243243
1-Aug-97	27.75	-0.021164
2-Jul-97	28.35	0.0903846
2-Jun-97	26	0.0358566
12-May-97	25.1	
		0.1262189
R=0.00750184416243219	SD=0.16278317614255	Beta=1.40155594461766
Beta >1 significant; Alpha >0 Excess return exist but is not significant, it could be compensation for risk factors not captured by the market		

Table A.8: SCC.TO Data

SCC.TO		
Date	Adj Close	HPR
1-May-02	24.15	0.0168421
1-Apr-02	23.75	0.1309524
1-Mar-02	21	0.088647
1-Feb-02	19.29	0.0315508
2-Jan-02	18.7	-0.0079576
3-Dec-01	18.85	0.1055718
1-Nov-01	17.05	0.24
1-Oct-01	13.75	-0.0072202
4-Sep-01	13.85	-0.3704545
1-Aug-01	22	0.0045662
3-Jul-01	21.9	0.0045872
1-Jun-01	21.8	-0.0289532
2-Apr-01	20.75	0.0375
1-Mar-01	20	-0.2351816
1-Feb-01	26.15	0.1419214
2-Jan-01	22.9	0.062645
1-Dec-00	21.55	-0.0650759
1-Nov-00	23.05	-0.1383178
2-Oct-00	26.75	-0.2132353
1-Sep-00	34	-0.0215827
1-Aug-00	34.75	0.0131195
1-Jun-00	34.25	0.0073529
1-May-00	34	-0.0555556
3-Apr-00	36	0.0572687
1-Mar-00	34.05	-0.1313776
1-Feb-00	39.2	-0.0224439
4-Jan-00	40.1	0.0025
1-Dec-99	40	0.1267606
1-Nov-99	35.5	0.0923077
1-Sep-99	35.15	0.0882353
3-Aug-99	32.3	0.0521173
2-Jul-99	30.7	-0.022293
1-Jun-99	31.4	-0.0426829
3-May-99	32.8	0.0412698
1-Apr-99	31.5	0.2185687
1-Mar-99	25.85	0.2023256
1-Feb-99	21.5	-0.0732759
4-Jan-99	23.2	0.2888889
2-Nov-98	18.6	-0.1564626
1-Oct-98	22.05	0.26
1-Sep-98	17.5	-0.1025641
4-Aug-98	19.5	-0.271028
2-Jul-98	26.75	-0.0272727
1-Jun-98	27.5	0.0185185
1-May-98	27	0.0093458
1-Apr-98	26.75	0.0573123
2-Mar-98	25.3	0.1526196
2-Feb-98	21.95	0.0138568
2-Jan-98	21.65	0.0962025
1-Dec-97	19.75	-0.0550239
3-Nov-97	20.9	-0.1049251
1-Oct-97	23.35	-0.0390947
2-Sep-97	24.3	0.2089552
1-Aug-97	20.1	-0.0336538
2-Jul-97	20.8	0.1243243
2-Jun-97	18.5	0.1011905
12-May-97	16.8	
		Alpha=0.678665528014017
R=0.0141321683856259	SD=0.125220043016103	Beta=1.22584803942853
Beta >1 significant; Alpha>0 Excess return exist but is not significant, it could be compensation for risk factors not captured by the market		

Table A.9: PCA.TO Data

PCA.TO		
Date	Adj Close	HPR
1-May-02	43	0.0172699
1-Apr-02	42.27	0.0294691
1-Mar-02	41.06	0.0882587
1-Feb-02	37.73	0.0379642
2-Jan-02	36.35	-0.0752989
3-Dec-01	39.31	0.0358366
1-Nov-01	37.95	-0.0709914
1-Oct-01	40.85	0.0482422
4-Sep-01	38.97	-0.000513
1-Aug-01	38.99	-0.015404
3-Jul-01	39.6	0.0993892
1-Jun-01	36.02	-0.1310012
1-May-01	41.45	-0.0247059
1-Mar-01	35.44	-0.0171936
1-Feb-01	36.06	0.0317597
2-Jan-01	34.95	-0.0838794
1-Dec-00	38.15	0.0962644
1-Nov-00	34.8	0.0875
2-Oct-00	32	-0.0447761
1-Sep-00	33.5	0.072
1-Aug-00	31.25	0.0926573
4-Jul-00	28.6	0.034358
1-May-00	28.6	0.1462926
3-Apr-00	24.95	0.0331263
1-Mar-00	24.15	0.1838235
1-Feb-00	20.4	-0.0555556
1-Dec-99	20.45	-0.0072816
1-Nov-99	20.6	-0.0213777
1-Oct-99	21.05	-0.0539326
1-Sep-99	22.25	-0.0089087
3-Aug-99	22.45	0.0112613
2-Jul-99	22.2	0.1044776
1-Jun-99	20.1	0.1166667
3-May-99	18	-0.093199
1-Apr-99	19.85	0.1246459
1-Mar-99	17.65	0.0895062
1-Feb-99	16.2	-0.1
4-Jan-99	18	0.1076923
1-Dec-98	16.25	-0.084507
2-Nov-98	17.75	-0.1012658
1-Oct-98	19.75	0.0313316
1-Sep-98	19.15	0.2766667
4-Aug-98	15	-0.3071594
2-Jul-98	21.65	-0.0826271
1-Jun-98	23.6	-0.0503018
1-May-98	24.85	0.0311203
1-Apr-98	24.1	-0.0474308
2-Mar-98	25.3	-0.0416667
2-Feb-98	26.4	0.019305
2-Jan-98	25.9	-0.0038462
1-Dec-97	26	0.023622
3-Nov-97	25.4	-0.1241379
1-Oct-97	29	0.1439842
2-Sep-97	25.35	0.05625
1-Aug-97	24	-0.0342052
2-Jul-97	24.85	0.109375
2-Jun-97	22.4	-0.0666667
12-May-97	24	
		Alpha=0.86196307319616
R=0.0142418548860091	SD=0.0947229521728042	Beta=0.544668507148688
Beta <1 insignificant; Alpha>0 Excess return exist but is not significant, it could be compensation for risk factors not captured by the market		

Table A.10: MFI.TO Data

MFI.TO		
Date	Adj Close	HPR
1-May-02	15.65	-0.0628743
1-Apr-02	16.7	0.1719298
1-Mar-02	14.25	0.0178571
1-Feb-02	14	0.2444444
2-Jan-02	11.25	0.0693916
3-Dec-01	10.52	0.0223518
1-Nov-01	10.29	-0.0310734
1-Oct-01	10.62	-0.1414713
4-Sep-01	12.37	0.0097959
1-Aug-01	12.25	-0.0429688
3-Jul-01	12.8	0.236715
1-Jun-01	10.35	0.0097561
1-May-01	10.25	0.0301508
2-Apr-01	9.95	0.1055556
1-Mar-01	9	0.0588235
1-Feb-01	8.5	-0.0810811
2-Jan-01	9.25	0.1708861
1-Dec-00	7.9	-0.0481928
1-Nov-00	8.3	-0.0348837
2-Oct-00	8.6	-0.0282486
1-Sep-00	8.85	-0.0432432
1-Aug-00	9.25	0.0882353
1-Jun-00	10.25	0.025
1-May-00	10	-0.0950226
1-Mar-00	10.25	-0.2175573
1-Feb-00	13.1	0.0076923
4-Jan-00	13	-0.0714286
1-Dec-99	14	-0.0508475
1-Nov-99	14.75	0.0535714
1-Oct-99	14	-0.0508475
1-Sep-99	14.75	-0.006734
2-Jul-99	13.5	0.0714286
1-Jun-99	12.6	0.008
3-May-99	12.5	-0.0384615
1-Apr-99	13	-0.0298507
1-Mar-99	13.4	0.046875
1-Feb-99	12.8	-0.0153846
4-Jan-99	13	-0.1186441
1-Dec-98	14.75	0.199187
2-Nov-98	12.3	-0.0538462
1-Oct-98	13	0.1555556
1-Sep-98	11.25	-0.0816327
4-Aug-98	12.25	-0.2898551
2-Jul-98	17.25	-0.0921053
1-Jun-98	19	-0.05
1-May-98	20	0.0126582
1-Apr-98	19.75	-0.0458937
2-Mar-98	20.7	0.29375
2-Feb-98	16	0
2-Jan-98	16	0.0126582
1-Dec-97	15.8	-0.0306748
3-Nov-97	16.3	0.0723684
1-Oct-97	15.2	-0.0440252
2-Sep-97	15.9	0.0258065
1-Aug-97	15.5	-0.0251572
2-Jul-97	15.9	0.0707071
2-Jun-97	14.85	0.0531915
12-May-97	14.1	
		Alpha=0.222349525080144
R=0.00716090453603395	SD=0.105289790154602	Beta=0.588010966506758
Beta <1 insignificant; Alpha >0 excess return exist but is not significant, it could be compensation for risk factors not captured by the market		

Table A.11: TSE Five-year Return

Date	Close	HPR
1-May-02	7656.1	-0.00095
1-Apr-02	7663.4	-0.02396
1-Mar-02	7851.5	0.02802
1-Feb-02	7637.5	-0.00144
2-Jan-02	7648.5	-0.00519
3-Dec-01	7688.4	0.035391
1-Nov-01	7425.6	0.078409
1-Oct-01	6885.7	0.006887
4-Sep-01	6838.6	-0.07576
1-Aug-01	7399.2	-0.03778
3-Jul-01	7689.7	-0.00604
1-Jun-01	7736.4	-0.05213
1-May-01	8161.9	0.027093
2-Apr-01	7946.6	0.044506
1-Mar-01	7608	-0.05826
1-Feb-01	8078.7	-0.13336
2-Jan-01	9321.9	0.043453
1-Dec-00	8933.7	0.012903
1-Nov-00	8819.9	-0.08503
2-Oct-00	9639.6	-0.07114
1-Sep-00	10377.9	-0.07735
1-Aug-00	11247.9	0.080874
4-Jul-00	10406.3	0.020676
1-Jun-00	10195.5	0.101978
1-May-00	9252	-0.01023
3-Apr-00	9347.6	-0.01213
1-Mar-00	9462.4	0.036521
1-Feb-00	9129	0.076393
4-Jan-00	8481.1	0.007999
1-Dec-99	8413.8	0.118931
1-Nov-99	7519.5	0.036286
1-Oct-99	7256.2	0.042902
1-Sep-99	6957.7	-0.00188
3-Aug-99	6970.8	-0.01552
2-Jul-99	7080.7	0.010071
1-Jun-99	7010.1	0.024599
3-May-99	6841.8	-0.02465
1-Apr-99	7014.7	0.063188
1-Mar-99	6597.8	0.045163
1-Feb-99	6312.7	-0.06195
4-Jan-99	6729.6	0.037574
1-Dec-98	6485.9	0.022335
2-Nov-98	6344.2	0.02189
1-Oct-98	6208.3	0.105841
1-Sep-98	5614.1	0.015079
4-Aug-98	5530.7	-0.20208
2-Jul-98	6931.4	-0.05912
1-Jun-98	7366.9	-0.02937
1-May-98	7589.8	-0.00981
1-Apr-98	7665	0.01409
2-Mar-98	7558.5	0.065703
2-Feb-98	7092.5	0.05855
2-Jan-98	6700.2	0.000119
1-Dec-97	6699.4	0.028651
3-Nov-97	6512.8	-0.04817
1-Oct-97	6842.4	-0.0281
2-Sep-97	7040.2	0.064793
1-Aug-97	6611.8	-0.03866
1-Jul-97	6877.7	0.068347
2-Jun-97	6437.7	0.008712
1-May-97	6382.1	

Table A.12: TBILL Five-year Return

Date	3 Month Rate	HPR
2002M05	2.544	0.212
2002M04	2.392	0.199333
2002M03	2.248	0.187333
2002M02	2.035	0.169583
2002M01	1.926	0.1605
2001M12	2.022	0.1685
2001M11	2.244	0.187
2001M10	2.748	0.229
2001M09	3.194	0.266167
2001M08	3.878	0.323167
2001M07	4.186	0.348833
2001M06	4.28	0.356667
2001M05	4.357	0.363083
2001M04	4.452	0.371
2001M03	4.634	0.386167
2001M02	4.967	0.413917
2001M01	5.274	0.4395
2000M12	5.553	0.46275
2000M11	5.706	0.4755
2000M10	5.62	0.468333
2000M09	5.582	0.465167
2000M08	5.642	0.470167
2000M07	5.588	0.465667
2000M06	5.579	0.464917
2000M05	5.707	0.475583
2000M04	5.4	0.45
2000M03	5.219	0.434917
2000M02	5.12	0.426667
2000M01	5.034	0.4195
1999M12	4.82	0.401667
1999M11	4.856	0.404667
1999M10	4.792	0.399333
1999M09	4.712	0.392667
1999M08	4.811	0.400917
1999M07	4.621	0.385083
1999M06	4.582	0.381833
1999M05	4.36	0.363333
1999M04	4.531	0.377583
1999M03	4.875	0.40625
1999M02	4.788	0.399
1999M01	4.632	0.386
1998M12	4.694	0.391167
1998M11	4.838	0.403167
1998M10	4.708	0.392333
1998M09	5.242	0.436833
1998M08	4.972	0.414333
1998M07	4.863	0.40525
1998M06	4.778	0.398167
1998M05	4.746	0.3955
1998M04	4.69	0.390833
1998M03	4.597	0.383083
1998M02	4.546	0.378833
1998M01	4.175	0.347917
1997M12	4.129	0.344083
1997M11	3.602	0.300167
1997M10	3.464	0.288667
1997M09	3.034	0.252833
1997M08	3.148	0.262333
1997M07	3.227	0.268917
1997M06	2.899	0.241583

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