Stock Forecasting Using Artificial Neural Network

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1. Introduction

Stock values prediction is a widely concerned issue. The choice which is made today will lead to some consequences some time in the future. Thus, it is seen necessary to forecast the consequences from the historical data available in order to facilitate the decision making step.

In the stock market, every investor certainly would like to be able to precisely forecast stock prices in order to maximize their profit. To get a very accurate forecast, highly sophisticated and expensive methods have been called for [Salvatore, 1996]. However, in general, investors do have the limitations on time and money available for forecasting. Consequently, they tend to use the forecasting method that can minimize the total cost of making the forecast and the cost of an inaccurate forecast (cost of making a wrong decision) as shown in Figure 1. However, the investors have to compromise the accuracy for the lower cost.

The forecasting methods can be divided into four categories [Turban and Meredith, 1994]: judgment methods, counting methods, time-series methods, and causal methods. Judgement and counting methods are used in the cases where quantitative methods, i.e. causal methods and time-series, are inappropriate or cannot be applied. In this study where tremendous historical data of the stock market are available, quantitative forecasting methods are more appropriate. Even though, the causal methods have proved to be more powerful than the time-series methods, they are more complex, and their total cost is considerably high. From all limitations discussed above, investors

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might have no better choice than time-series methods. However, the standard time-series methods, such as moving average and exponential smoothing, cannot be able to provide the investors with the reasonable accuracy.

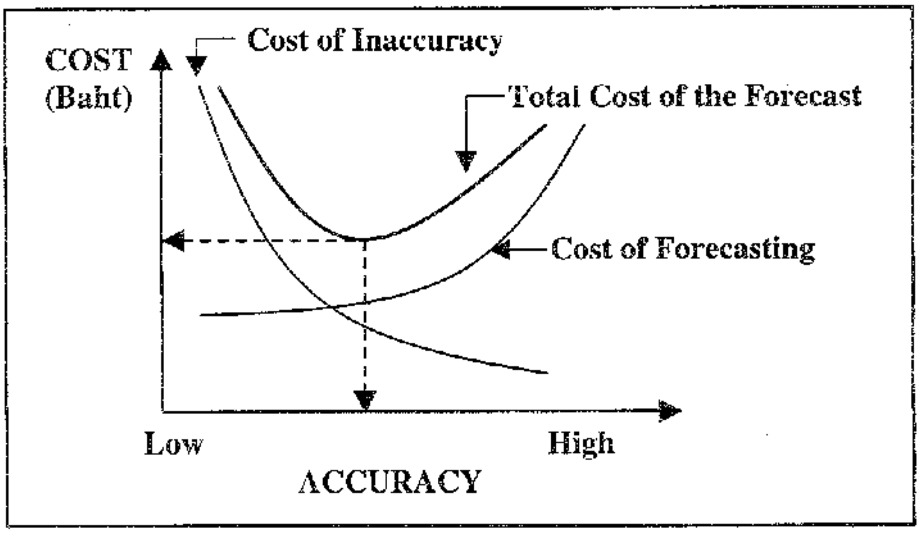

Figure 1 The Costs of Forecasting

Therefore, the purpose of this paper is to provide an alternative forecasting technique called "artificial neural network," which is easy, inexpensive yet very effective. This technique enables investors to easily create their own forecasting model using the data collected in the past.

2. Artificial Neural Network

Artificial neural networks (ANNs) are new information processing techniques that simulate biological neurons using mathematical models. ANNs utilize a parallel processing structure that has a large number of simple processing elements. Each processing element is connected to many of its neighbors, thus there are more interconnections among processors than the number of processors itself. The damage to a few nodes or interconnections does not significantly affect the overall performance. ANNs provide a greater degree of robustness or fault tolerance thanks to the massive parallelism in their design. They are used in the situations where only a few decisions are required from a massive amount of data, or a complex nonlinear mapping needs to be learned. In an artificial neural network, there are three main components: processing elements, interconnection, and learning rules.

Processing elements (PEs) are the basic components of artificial neural networks. They handle many basic functions such as input signal evaluation, summation of signals, and comparison to a threshold value to determine the output value.

One processing element provides the data to another processing element, or even to itself, by transferring through the interconnection. A weight is assigned to each interconnection. A connection is unidirection. There are three primary interconnection schemes (Figure 2): intra-field, inter-field, and recurrent connections. Intra-field connections connect PEs in the same layer, while inter-field connections connect them in different layers. Recurrent connections loop and connect back to the PE itself.

Learning in an artificial neural network is considered as a change in the weight matrix. It can be categorized into two groups: supervised and unsupervised learning.

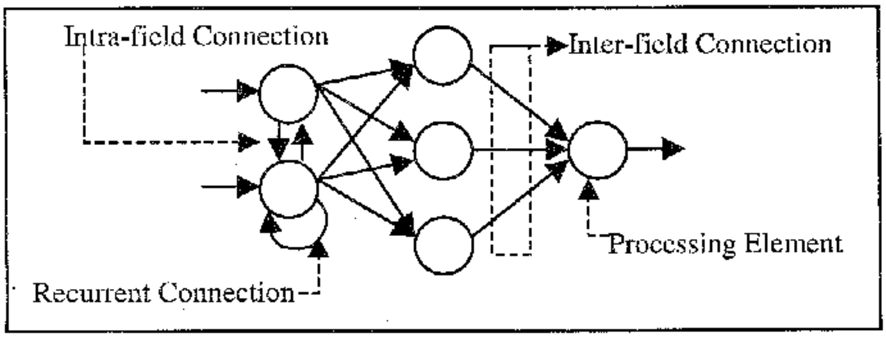

Figure 2 The Three-Layer Artificial Neural Network Architecture

Supervised learning uses the data set that contains input vectors and corresponding output vectors to train the network. The weight matrix of the network is updated as long as the total network error is greater than ε (acceptable range of error).

Such updated techniques as error-correction learning, reinforcement learning and stochastic learning are always included in this type of learning. Error-correction learning adjusts the whole weight matrix in proportion to the different between the desired and the actual values of the output neuron. Reinforcement learning is a technique which the weights are reinforced for properly performed actions and punished for inappropriate actions. Stochastic learning makes a random change in the weight matrix then determines a property of the network (the resultant energy). If the resultant energy is lower than the previous one, the change is accepted, otherwise the change is accepted under a pre-chosen probability distribution.

Unsupervised learning does not incorporate external teacher. It relies only on local information and internal control. This is also known as competitive learning.

3. Genetic Algorithms

Genetic algorithms (GAs) are biologically influenced by theories of evolution. According to those theories, individuals in a population naturally compete with one another for resources such as food, water, and shelter for their survival. Also, members of the same species often compete to attract a mate. Those individuals which are most successful in surviving and attracting mates will have relatively larger numbers of offspring. On the other hand, poorly performing individuals will produce few or even no offspring at all. This means that the genes from the highly adapted, or "fit" individuals, will spread to an increasing number of individuals in each successive generation. The combination of good characteristics from different ancestors can sometimes produce "superfit" offspring, whose fitness is greater than that of either parent. In this way, species evolve to become more and more well suited to their environment.

The basic principles of GA can be represented as shown in Figure 3. The mechanism of a simple genetic algorithm is nothing more than a copying strings and swapping partial strings [Goldberg, 1989]. A simple genetic algorithm composes of the following operators: reproduction, crossover, and mutation.

Reproduction is a process in which individual strings are copied according to their fitness values, which are calculated from the objective function. This means that the chromosomes (strings) with a higher value have a higher probability of contributing one or more offspring in the next generation.

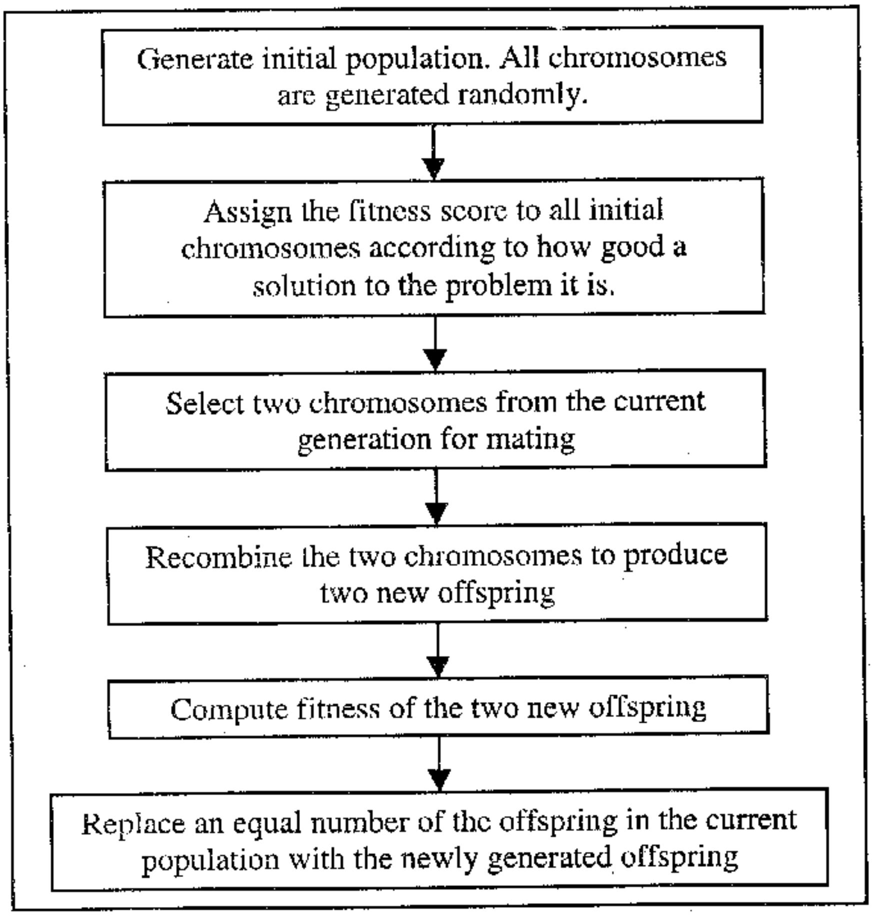

Figure 3 The Basic Principles of a Genetic Algorithm

After the reproduction, all the newly produced strings in the mating pool are mated at random. Each pair of strings is put in the crossover process. The crossing position, k, is selected from a uniform random distribution between [1, L-1], where L is the length of the strings. New strings are created by swapping all characters between position k+1 and L as shown in Figure 4.

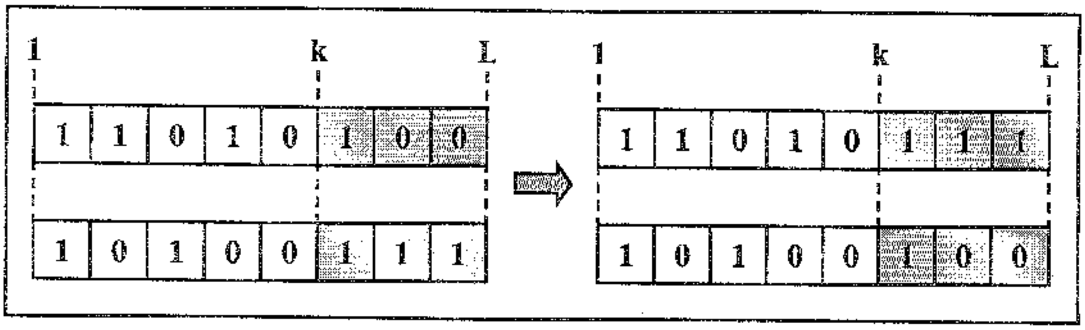

Figure 4 Single-Point Crossover

Mutation is not directly responsible for producing new offspring. It arbitrary alters one or more components of a selected structure increasing the variability of the population (Figure 5). Each position of each solution string in the population undergoes a random change with a probability equal to the mutation rate.

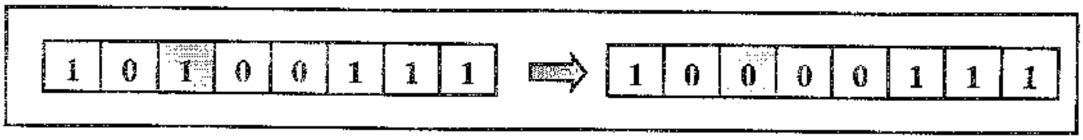

Figure 5 Mutation

4. Process Description

The history stock prices of Krung Thai Bank (KTB) from January 2538 to March 2541 are used in this study. All the data is downloaded from the Stock Exchange of Thailand web page, except the bank's financial indices which are derived from the balance sheet and income statement published in KTB's annual report.

5. Model Description

In this study, both one of the standard time-series techniques called moving average and artificial neural network are used to forecast the stock price at the end of the month using historical data available. Four different models shown in Table 1 have been used in this paper.

Table 1 The Input and Output Parameters of the Models Used in this Study

Model	Technique	Input	Output
1	Moving Average	P(t), P(t-1), P(t-2)	P(t+1)
2	ANN + GA	P(t), P(t-1), P(t-2), P(t-3)	P(t+1)
3	ANN + GA	P(t), P(t-1), P(t-2), P(t-3), ROA, ROE, P/E	P(t+1)
4	ANN + GA	P(t), P(t-1), P(t-2), P(t-3), ROA, ROE, P/E, C	P(t+1)

Note: P(t) = Stock Price at the End of the t^{th} month

ROA = Return on Asset

ROE = Return on Common Equity

P/E = Price/Earning Ratio

C = The Subjective Comment from the Market Expert

The first model uses the three-period moving average method. The input of this first model are the closing prices of KTB stock at three different lags: current month (P(t)), last month (P(t-1)), and the last two months (P(t-2)). The second, third, and fourth models employ the technique which is the combination of artificial neural network and genetic algorithm. The second model uses only the closing prices of the stock at four different lags as the input, while the third model uses both the closing prices of the stock at four different lags and the financial ratio data, i.e. ROA, ROE, and P/E. ROA measures a firm's performance in using assets to generate income. ROE measures the rate of return earned on the common stockholders' investment. P/E is equal to the market price per share of stock divided by the earning per share. The fourth model uses the qualitative information, such as surveys and opinion polls, for supplementing the forecast. Therefore, the fourth model requires the following input parameters: the closing prices of the stock at four different lags, the financial ratio data, and the subjective comment from the market expert.

In this study, the three-layer network (1 input layer, 1 hidden layer, and 1 output layer) is implemented for all three neural network models (model 2, 3, 4). Before training the neural network models, the weight vectors are initialized by genetic algorithm. The intention of using the genetic algorithm is to make a wide search for the global minimum. The genetic parameters used in this study are: the probability of mutation = 0.0001, the probability of crossover = 0.8, and the number of generations = 3.

6. Results and Discussion

The result of the three-period moving average method (model 1) is shown in Figure 6. From Figure 6, the moving average does not give a satisfactory forecast because moving average technique are useful when the time series exhibit little trend or seasonal variations but a great deal of irregular or random variation [Salvatore, 1996]. However, Thailand economy in the time period used in this study (January 2538 – March 2541) is in a recession. Moreover, there are a lot of random variations, such as A (January 24: U.S. interest-rate cut), B (February 28: cabinet reshuffle), C (September 30: dissolution of parliament), D (June 27: BoT temporarily closed 16 financial institutions; July 2: devaluation of the Thai baht), E (August 5: Thai government's commitment to an IMF rescue plan and BoT temporarily closed another 42 financial institutions).

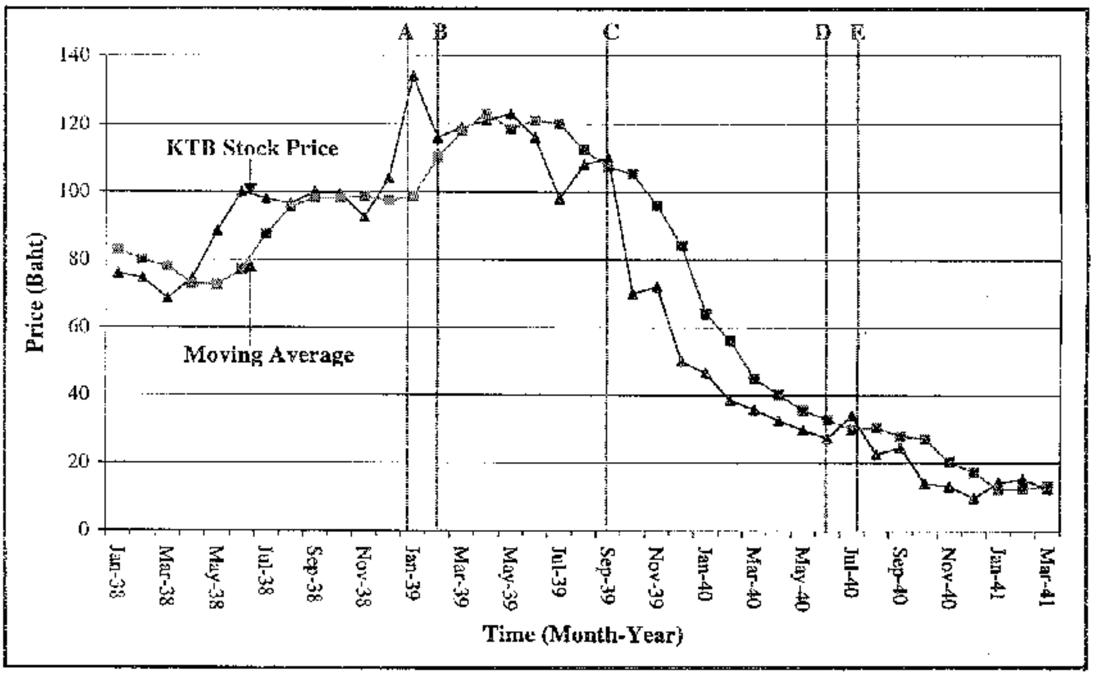

Figure 6 Model 1

The results of the model 2, 3, and 4 are shown in Figure 7, 8, and 9 respectively. It is obvious that the model 4 is the best performer. Finally, the model 1 (the traditional time-series technique) and the model 4 (the best ANN model) are given a task to estimate KTB stock prices on April 2541 and May 2541. The testing results are shown in Table 2.

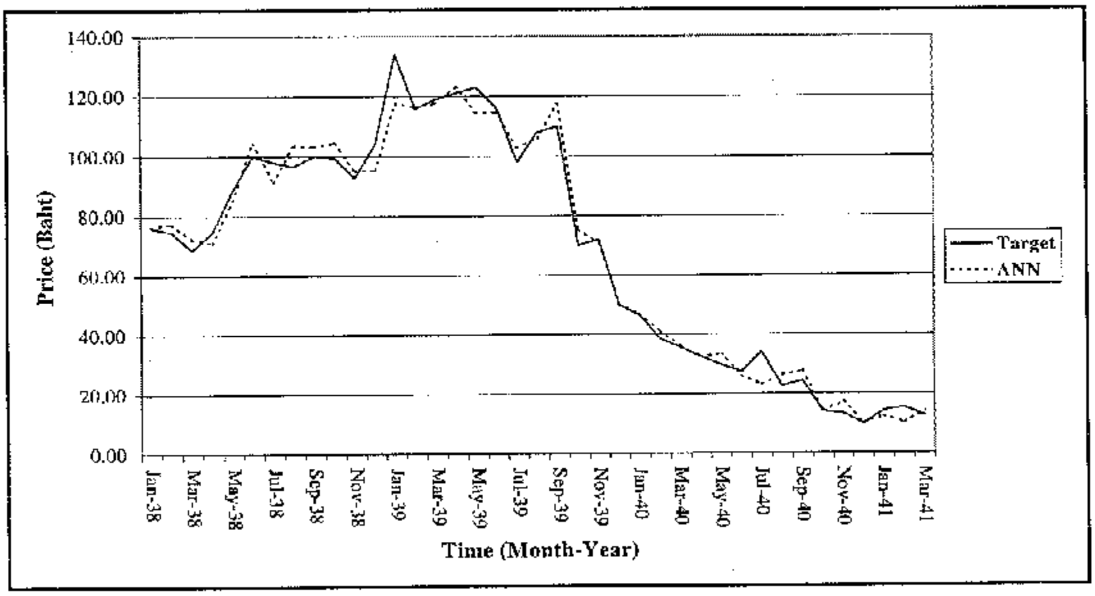

Figure 7 Model 2

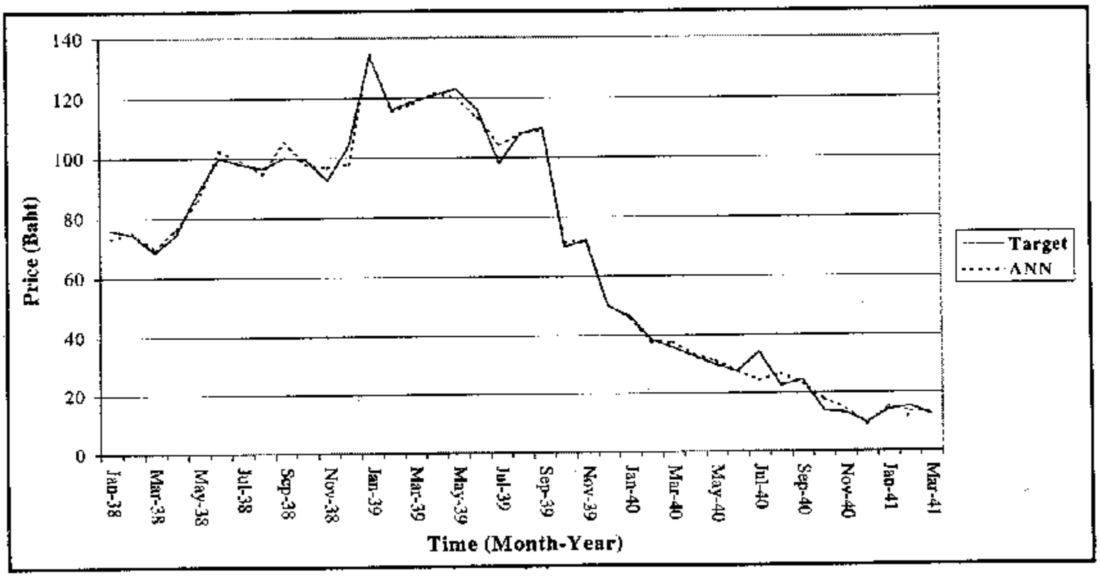

Figure 8 Model 3

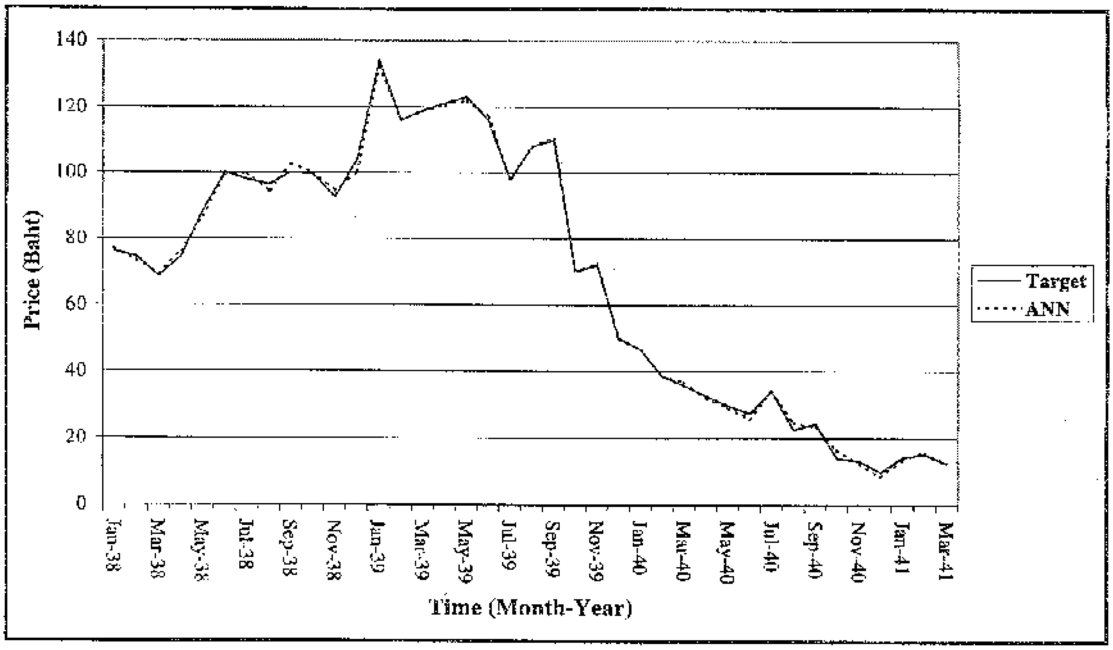

Figure 9 Model 4

Table 2 The Testing Results of the Model 1 and 4

Month	Actual	Model 1	Model 4
April 2541	9.9	14	9.32
May 2541	6.4	12.55	6.0

In conclusion, the artificial neural network model provides financial investors with an alternative forecasting method which is easy yet accurate and cost effective. Moreover, the results confirm that the ANN technique, which utilizes both qualitative and quantitative information, is superior to the one using only the quantitative data. It is also noteworthy that this technique can be applied during the economic downturn when the application of traditional methods do not yield satisfactory results.

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