

A Comparison of Stock Price Prediction with ANN and ARIMA

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Abstract. Nvidia is one of the most competitive companies in the semiconductor industry, whose stock has risen a remarkable 5,427% in the past decade. Forecasting its stock price has always been one of the most important topics for investors, as its stock price fluctuates dramatically with the release of new products and the rising price of cryptocurrencies worldwide. This paper compares the degree of accuracy of ANN and ARIMA, which are considered to be the most commonly used and accurate models in stock price forecasting for the past 20 years, in predicting Nvidia's stock price. The time period chosen for the prediction is from June 2020 to June 2021, when Nvidia's stock price rises sharply, and the data is obtained from Kaggle and Yahoo Finance. According to the analysis, the ANN model is clearly capable of predicting the sharp fluctuations in Nvidia's stock price between 2020 and 2021, which also indicates the potential of artificial neural network-based models for stock price predictions. These results shed light on guiding further exploration of stock price prediction.

Keywords: Price prediction; Nvidia; ARIMA; ANN; Machine learning.

1. Introduction

Nvidia is a fabless semiconductor company that designs and sells graphics processors in the United States. The company also designs processors for game consoles, e.g., the Xbox and PlayStation. Nvidia is best known for the GeForce series for individuals and gamers, the Quadro series for professional CGI workstations, and the Tesla series for server and college computing. Nvidia is moving into the market for artificial intelligence and machine vision. However, Nvidia has had its fair share of critics, who have focused on abusive business partnerships, marketing practices, and a rejection of the industry's open standards and free software movements [1, 2].

Graphics cards were called display adapters in the early days. In the DOS era, the computer's display requirements were extremely low. However, with the popularity of various software applications, people's demand for PC graphical interface is becoming more and more intense, so color display has emerged. The earliest display type was EGA, which could only recognize black and white. These early display adapters were very simple and generally integrated with 16K video memory [3].

There were some graphics related software appeared in PC, and companies have begun to design some graphics on the PC, the earliest is CAD. Programmers began writing small games for their own leisure time, or porting games from consoles to PCs. Therefore, there's a four-color adapter that can distinguish between three colors and black and white. This adapter was very bad. Since this is the first color display adapter, which is called as CGA. In the era of CGA, the requirements of graphics cards have been greatly improved, but the production process at that time is still far higher than the demand of graphics card chips, hence the CGA display adapter is still integrated in the motherboard, in a single chip way to achieve.

The graphics card interface also restricts the development of graphics card technology and gradually becomes a bottleneck. In order to speed up the transmission between the display chip and the bus, it is imperative to use the interface bus with high bandwidth. Subsequently, 3DFX has

introduced the Voodoo speedup card, which allows more focus on 3D graphics. Since then, 3D graphics processing technology has advanced by leaps and bounds with the participation of companies such as Nvidia and AMD.

Contemporarily, the worldwide demand for graphics cards and the semiconductors in which they are built is growing rapidly as the value of Bitcoin continues to soar. Hence, more and more people want to use high-performance graphics cards to get bitcoin faster. As a result, sales prices of graphics cards increased by nearly 20% in 2020. With the decline of bitcoin price and the standardized management of virtual currency mining projects by the regulatory authorities of various countries, the graphics card industry is gradually returning to rationality. Under the recovery of the production capacity of graphics card manufacturers, the graphics card and its semiconductor industry are gradually restored to order.

Nvidia Corporation is one of the major American software companies which is imposing an impact on the global scope. As a multinational technology company, Nvidia Corporation has undergone more than 20 years which enables it to shape and consolidate its unique organizational structure and distinguished corporate culture which maintains its competitive edge in the current highly competitive business environment. According to Lindholm, et al, Nvidia has established collaboration with other top companies in other industries by providing them with smart and advanced technological solutions [4]. For example, Nvidia has helped Tesla to develop its programmable graphics and other computing technologies which feature high and forceful performance [5]. Besides, Moon, et al. also found out that the inner system of Nvidia has evolved into a highly autonomous stage which allows its organizational structure and management dynamic to be methodical and systematic, further enhancing its management efficiency [6].

Considering the financial performance, especially the performance of its share price of Nvidia, Tavares states that the share price of Nvidia has been volatile in the past decades, yet it is still underestimated by investors [7]. It draws the conclusion that it would be a good opportunity to possess the shares of Nvidia in around 2020, which further supports the prosperity of the financial condition of the company at that time period. Nvidia, found in 1993, has undergone a relatively long operational and developmental process, which allows the company to establish its unique corporate culture and practice [8]. Nvidia has been making constant efforts in enhancing its competitive advantage of the company by making investments in research and development and launching new products to attract market attention. It also aims to maintain its competitive edge by acquiring intellectual property rights and enhancing the originality of its products. Upon the date of research, Nvidia has gained its space in the digital and high-tech market. It is also a well-established fact that Nvidia purchasing and acquisition is one of the major approaches through which Nvidia keeps its competitive advantages in the fiercely competitive market. In the meanwhile, the purchasing and acquisition activities would also have an impact on the inner structure and corporate practice of the company as a whole, which might further impose an impact on the stock price of the company in the short term.

The stock price is one of the major indexes of evaluation of the financial performance of an organization as it is directly perceivable, and the trend is obviously noticeable. The stock price has also been used as one main indicator by Nvidia to evaluate its financial healthiness and trend. This research project aims to evaluate the financial and market performance of Nvidia through its stock price. The choice of the stock price as the key aspect is well justified as the stock price of Nvidia has increased constantly from 2020 to 2022 as it is noticed. It is also noticed that the stock price of Nvidia did not rise continuously in the period of 2020 to 2022 as there was a fluctuation from 2020 to 2021. Based on the market research and the observation of the stock price of the company, it is reasonable to claim that Nvidia can be used as an effective case to research the stock price of a commercial corporate using different models. To be more exact, this research project takes the motivation to use Nvidia as an example to analyze and predict its stock price using two different models. The aim of this research project is to evaluate the usefulness and effectiveness of the two different models being applied in the prediction of the stock price of Nvidia. The accuracy of prediction will be taken as the core index to assess the effectiveness of the two different models. As for the framework of this report,

the basic company description will be made on Nvidia, which will be followed by the introduction of the data collection method. Then, the two models that are going to be used in the analysis of Nvidia's stock price will be introduced in terms of their nature and features so as to lay a theoretical foundation for the research. Subsequently, empirical analysis based on quantitative evidence will be conducted and will be used for comparison of the two models. Eventually, limitations of the research will be acknowledged which leads to the outlook of future research in this field.

2. Data & Method

The source of data is crucial for the empirical research to be conducted and for the results to be as accurate as possible. The source of the data will be determined by the research objective which is to use the stock price of Nvidia to evaluate to test the effectiveness of two models in terms of the accuracy of the prediction of stock price. The key data that will be collected to form the base of this empirical study will be the closing price of the stock of Nvidia from 2020 to 2022. The closing price of Nvidia in the period of three years is going to be collected as the major data source because the three years' duration would be sufficient for researchers to apply the two different stock price analyzing models to make a prediction. Besides, the data from this three years period is collected also because this duration would be long enough for the megatrend of the stock price to be reflected. The key source of data will be taken from the site of Kaggle. Kaggle is evaluated to be a credible source of data because it is an online community of data scientists which further justifies the practical aspect of its data source. Nvidia's closing stock price from 2020 to 2022 will be collected to be assessed by the two models from an artificial intelligence perspective and a statistical perspective respectively to draw a conclusion on the effectiveness and the applicability of the two models in stock price prediction for Nvidia in this research report. In addition, the annual report of Nvidia which contains the internal financial information will also be collected as another supplemental data source for better accuracy and wider applicability of the result of this research.

2.1 Data

Nvidia was founded in California in April 1993. Nvidia kept a low profile until 1997-1998, when it released its RIVA line of graphics processors for personal computers. It was listed on Nasdaq in January 1999. In May of that year, it sold its 10 millionth graphics processor. Nvidia acquired 3DFX's intellectual property rights in 2000. Since then, Nvidia has developed close relationships with many OEMs and other organizations, most notably TSMC. In February 2002, Nvidia sold its first billionth graphics processor.

Nvidia and AMD supply most of the standalone graphics cards on the market today. Nvidia's best known line of GeForce graphics processors debuted in 1999. The GeForce product line has now expanded to include desktop and laptop computers. For mobile devices, Nvidia has the Tegra product line. It provides high efficiency while maintaining low energy consumption. Such products are commonly used in wireless communication devices.

On April 27, 2020, Nvidia announced that it had completed the sale of Mellanox Technologies, Ltd. for \$7 billion. In July 2020, it was reported that Nvidia was in talks to buy Arm Holdings from SoftBank Group for \$32 billion, subject to the usual scrutiny and with the latter retaining a 10% stake in Nvidia. However, despite Nvidia's repeated assertions that ARM would remain open source and customer-neutral after the acquisition, the proposal has faced stiff opposition from regulators and large corporations. They were worried that after the acquisition, it would cause serious competition problems and make it impossible for ARM to remain neutral. Finally, on February 7, 2022, Nvidia and SoftBank agreed to terminate their previously agreed ARM share deal, officially ending the acquisition and allowing SoftBank to push ARM to go public.

On June 11, 2021, Nvidia announced the acquisition of DeepMap, Inc., a developer of high-definition maps for autonomous vehicles. In January 2022, Nvidia announced that Bright Computing

had joined Nvidia. On March 7, 2022, Nvidia announced that Excelero, a storage solution provider, has joined Nvidia.

2.2 Models

Between the organizational competitive advantage and financial performance, financial performance is obviously a topic of major interest to investors and researchers. The stock price is also an important indicator of Nvidia's financial position and, as mentioned earlier, 2020 would be a good opportunity to possess the shares of Nvidia, evidenced by the strong rise in its share price from 2020-2022. In this paper, two models commonly used by researchers in stock forecasting, Artificial Neural Network and the autoregressive integrated moving average, are employed to forecast Nvidia's stock price in the next few years from an artificial intelligence perspectives and a statistical perspective respectively, and the results of the two models are also compared. Artificial Neural Network, proposed by Tang and Fishwick [9]; Wang and Le in 1993, was the first application of ANN to predict stock prices on the Tokyo Stock Exchange Kimoto et al. [10]. In the past 20 years, ANN stock price prediction has been more maturely applied in stock exchange market index. Haider Khan et al. use Back propagation method for training the Neural Network and Multilayer Feed forward network to forecast the Bangladesh Stock Exchange market index [11]. Qiu et al. Introduced genetic algorithm (GA) and simulated annealing (SA) to overcome back propagation (BP) learning algorithm significantly improved prediction accuracy [12]. The Autoregressive Integrated Moving Average (ARIMA) model has also been widely used for stock price forecasting, Mondal et al. by using the ARIMA model for the New York Stock Exchange (NYSE) and Nigeria Stock Exchange (NSE) using the ARIMA model and demonstrates the strong potential of ARIMA in forecasting stock prices in the short term [13]. In contrast, Ariyo et al., Mar the ARIMA model was found to be more than 85% accurate for 56 stocks in India, given different sectors [14]. Moreover, in the last two decades, many researchers have compared ANN and ARIMA models Adebisi et al., comparing the forecasting effectiveness of the two models, clarify and confirmed contradictory opinions in literature about superiority of each of the model over one another in stock price prediction [15]. Kapila Tharanga Rathnayaka, R. M et al. developed hybrid models of three layer feed forward back propagation artificial neural network (ANN) and autoregressive integrated moving average (ARIMA) hybrid models to predict the future index values and trends of SENSEX, BSE IT, BSE Oil & Gas, BSE 100 and S&P CNX Nifty Indian stock markets and to compare with the traditional index values and trends and compare them with the traditional ANN and ARIMA models [16].

Artificial Natural Network, a computational system that simulates a biological neural network, is a framework for machine learning algorithms, consisting of multiple neurons, each representing a specific (activation function). The output results change according to the way the neurons are connected and the activation function changes. In the field of stock price prediction, ANN model contains an input layer, a hidden layer and an output layer. The data of opening price (open), high price (high) and low price (low) of the stock are input to the input layer to generate weights, then weights are multiplied with the data and then passed to each neuron of the hidden layer. It is notable that in this paper, the data in the output layer are processed in the same way as in the hidden layer. In this paper, we use 5373 data from the Nvidia stock data set since 1985 to train this model, and use the trained model to predict the data from 5373 to 5673 i.e., (August 15, 2021) and compare it with the actual stock price data (test). Error signal(e) is calculated by

$$e = \frac{\text{Actual Output} - \text{ANN Output}}{\text{Actual Output}} \quad (1)$$

Moreover, the error signal is used to update the weight by using the formula:

$$\begin{aligned} \text{Updated Weight} = & \text{weight}(\text{old}) + \text{learning rate} \times \text{output error} \times \text{output}(\text{neurons } i) \\ & \times \text{output}(\text{neurons } i + 1) \times (1 - \text{Output}(\text{neurons } i + 1)) \end{aligned} \quad (2)$$

Arima model is a statistical model used to analyze and predict time series data. It explicitly caters to a standard set of structures in time series data and thus provides a simple and powerful way to make skilled time predictions. In this model, AR stands for autoregression, A model that uses the

dependent relationship between an observation and some number of lagged observations. Here, i stands for integrated, i.e., the use of differencing of raw observations in order to make the time series stationary; MA stands for Moving Average, A model that uses the dependency between an observation and a residual error from a moving average model applied to lagged observations. The variables of this model is p , meaning the number of lag observations included in the model, also called the lag order; the variable d , meaning the number of times that the raw observations are differenced, also called the degree of differencing; the variable q means that the size of the moving average window, also called the order of moving average.

To evaluate the models, we use the data of MSE, MAE and RMSE to determine the degree of fitting of the model. The root mean square error (MSE) is a measure of the deviation between a predicted value and an observed value.

$$MSE = \frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2 \quad (3)$$

Root Mean Square Error (RMSE), which represents the sample standard deviation of the difference between the predicted and observed values.

$$RMSE = \sqrt{MSE} \quad (4)$$

Mean Absolute Error (MAE), represents the average of the absolute error between the predicted value and the observed value.

$$MAE = \frac{1}{n} \sum_{i=1}^n |y_i - \hat{y}_i| \quad (5)$$

The smaller the three sets of data, the more accurate the model.

3. Empirical analysis

We used Nvidia's open price, highest price, and lowest price data, totaling 5373 samples from 1999/1/22 to 2020/5/29, to build the neural network model. In Figure 1, the leftmost three data are the Input layer, the middle is the Hidden layer, and the rightmost close price is the Output layer. These three layers make up the neuron network model. Through R code, the data obtained are used to predict the trend of close price in the next 300 days. The prediction results are illustrated in Fig. 2, where the green line represents the trend predicted by our ANN model, and the gray line represents the actual data. It can see that the predicted trend is generally upward, but compared with the actual data, the trend is relatively slow.

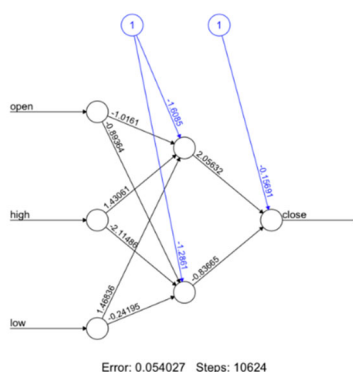


Fig. 1 Neural network model.

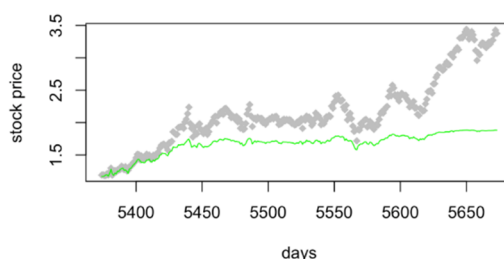


Fig. 2 Stock price prediction by ANN.

Through R code, the results for ARIMA model prediction are obtained as shown in Fig. 3. The blue line is the forecast 300 days after 2020/5/29, while the dark gray area is the 95% confidence interval for the forecast data, and the light gray area is the 80% confidence interval. We can see that our forecast trend is also overall upward.

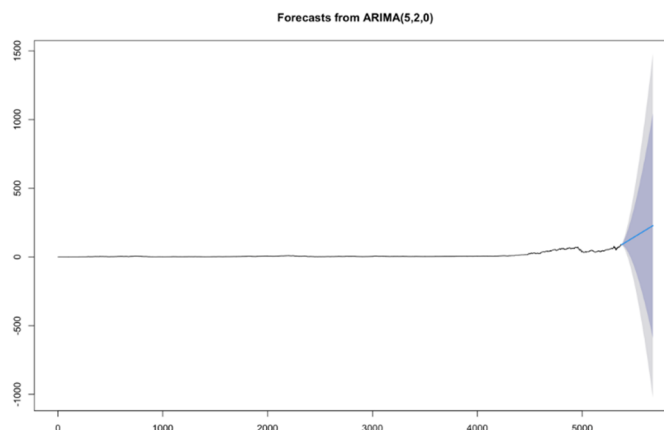


Fig. 3 Stock price prediction by ARIMA.

4. Comparison

According to the data of R code, in the ANN model, RMSE is 0.78 and MAE is 0.63. In the ARIMA model, the obtained RMSE is 0.69 and MAE is 0.26. The smaller the RMSE and MAE data, the higher the accuracy of the model. From this, we can see that the ARIMA model has a better fit in Nvidia's stock forecast for the 300 days after 2020/5/29. Artificial Neural network is a machine learning model that simulates human brain nervous system to process complex information. It has high accuracy and high fault tolerance for noise. It has advantages in dealing with random and nonlinear data. When processing Nvidia data, we also associatively process close price data through open price, highest price, and lowest price. By comparing the above two results, one can also see that the prediction map of ANN model is more refined.

However, the ANN model requires a large number of parameters for training, and it is unable to observe the prediction process, which makes it difficult to interpret our output results. In contrast, the ARIMA model is relatively simple and basically requires only a single variable and does not need to rely on other variables to make predictions. It's an analysis based on time series. The advantage of Arima is even greater when using existing data to predict future data. From the model establishment and obtained results, the longer the prediction time of ARIMA model, the larger the confidence interval, and the relatively less accurate the result. ARIMA by nature can only capture linear relationships. The data used must be stable, and if the data is unstable, the pattern cannot be captured.

Therefore, the reason attributed to the non-ideal results of ARIMA forecasting is that the stock data is unstable and often fluctuated by external influences, such as the promulgation of new policies. However, from the comparison of our two models, we can also see that the results of ARIMA are better than ANN in terms of short-term prediction. In this regard, it is believed that the short prediction time is one reason, and the sample size is not large enough for ANN, hence the results obtained are not accurate enough. Based on the above analysis, ARIMA outperformed ANN in this stock forecast, which does not apply to all data.

5. Limitations & Future outlooks

Although ANN is a frequently used model in stock price prediction, as mentioned in the previous literature review, the accuracy of the original ANN model is relatively low compared to its improved versions, the ANN models that introduced (SA) and (GA). The accuracy of ANN is lower for both long term and short-term stock price prediction for ANN based models such as LSTM or RNN that

use deep learning. Similar to ARIMA, ANN models are less successful than other deep learning-based stock price prediction models such as RNN or LSTM models in predicting special events or turning points. An example of this is the stock price doubling of Nvidia's graphics cards in the early 2020s, where the ANN model's prediction data differed significantly from the original stock price data, making ANN's prediction ability for such events significantly weak. In the future, modified ANN, deep learning models represented by LSTM and RNN or a mixture of these two will be more accurate models for stock price prediction, and ANN-ARIMA hybrid models have also been shown to have great potential for short-term stock price prediction.

Although the ARIMA model only needs the prior data of the time series to generalize the prediction and performs well in the short-term prediction, it still has some defects. To be specific, it is difficult to predict the turning point, and the parameters in the model involve a lot of subjectivity, and the calculation cost is high. These shortcomings further lead to its poor performance in long-term forecasting, and the model cannot be used for seasonal time series. Therefore, Arima models are also generally more difficult to interpret than exponential smoothing

6. Summary

In conclusion, this paper takes the objective to investigate the usability and effectiveness of the Artificial Neural Network (ANN) model and the Autoregressive Integrated Moving Average (ARIMA) model in the prediction of the share price of the Nvidia from 2020 to 2022. According to the analysis, the ANN appears to be more suitable and accurate in the prediction of the stock price of Nvidia thanks to its high accuracy and high fault tolerance for noise, as well as its advantages in dealing with random and nonlinear data. Moreover, the findings also prove that the ARIMA is more practical in the actual analytical context as it requires a simple variable and follows the basic time series which allows it to predict the future trend according to the past data. In the future, the data from a broader time frame and from more companies are suggested to be taken as a base for testing the usefulness of the two models so as to generate the widely applicable result of the two models. Overall, these results offer a guideline for selecting the stock price prediction models in different contexts.

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