ARIMA Model, Discounted Cash Flow Analysis, and Dividend Discount Model for Five Technology Stocks' Pricing and Trading Strategy

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Abstract. This study examines the ability of three widely used financial and econometric models-the Autoregressive Integrated Moving Average (ARIMA), the Discounted Cash Flow (DCF), and the Dividend Discount Model (DDM), to accurately forecast the stock prices of five well-known technological companies. Every theoretical framework offers a unique point of view. DDM places an emphasis on the value of expected future dividends. Collecting historical information on each stock and then applying that information to the relevant models in order to make projections about future stock values was an integral part of the process. In order to evaluate the accuracy, dependability, and applicability of each model in regard to the technology equity, a head-to-head comparison was carried out. Based on the preliminary findings, it appears that while ARIMA can provide valuable insights for price changes in the short term, DCF and DDM can provide a more comprehensive view of the long-term intrinsic worth of a company's stock. However, the effectiveness of each model differed among the several technological stocks that were considered, underscoring the relevance of selecting a model that is adapted to the particular qualities and dynamics of a specific stock as well as the industry in which it operates.

Keywords: ARIMA; DCF; DDM; stock price prediction.

1. Introduction

In the ever-evolving domain of stock market forecasting, numerous models and methodologies have been put out to analyze and predict the seemingly unpredictable nature of stock prices. The fundamental aspects of a company's financial health and trajectory frequently serve as the core determinant of a stock's value for investors with long-term investment goals. In contrast, traders, particularly those with a short-term concentration, frequently depend on previous price patterns and statistical models as a means of predicting stock moves. With the advancement and expansion of computer technology, neural networks and machine learning have become increasingly prevalent [1]. Short-term price fluctuations contribute significantly to the unpredictability of the securities markets. Predicting stock price fluctuations accurately is an enormous economic advantage. Typically, the aforementioned objective is achieved by the examination of the organization, a practice commonly referred to as fundamental analysis. The utilization of machine learning for the development of a predictive algorithmic model has garnered significant attention in recent academic study [2].

The objective of this study is to assess and compare three prominent models, specifically the Autoregressive Integrated Moving Average (ARIMA) model, the Discounted Cash Flow (DCF) Analysis, and the Dividend Discount Model (DDM), in order to forecast the future values of five prominent technology stocks. The five stocks are Apple (AAPL), International Business Machines Corporation (IBM), Nvidia Corporation (NVDA), Microsoft (MSFT), and Intel (INTC). The reason for choosing those five stocks because they are large, prestigious, and world most successful technology companies. Also, they did provide enough data for ARIMA, DCF, and DDM from Yahoo Finance.

The five stocks' data were all from Yahoo Finance, which is an excellent site for getting stocks' data. The three main reasons why using data from Yahoo Finance because their historical depth, frequency and granularity, and dividends and splits. Yahoo Finance provides a comprehensive collection of historical stock price data spanning numerous years, frequently encompassing several

decades, across a diverse range of stocks. The depth provided is of great value when it comes to back testing techniques and carrying out long-term analysis. In addition to its other services, Yahoo Finance provides daily stock data that includes various parameters such as opening and closing prices, high and low prices, as well as trading volume. Certain assets additionally offer intraday data points that can be accessed. And the inclusion of stock dividends and splits in the platform's data is essential for ensuring precise historical analysis. The adjusted close prices, which take into consideration dividends and splits, are presented in conjunction with the unadjusted closing prices.

About the short-term predicting Arima model, ARIMA is supported by an extensive amount of information, tutorials, case studies, and tools due to its widespread use. This makes it an excellent introduction to time series forecasting for beginners. According to Li, the predominant approaches utilized in stock price forecasting with ARIMA involve statistical prediction models and machine learning models [1]. Also, there are three advantages for ARIMA model, simplicity, stationarity, and able to handle different time series components.

Regarding its components, ARIMA is relatively straightforward and easy to comprehend. The AR (autoregressive), I (integrated), and MA (moving average) terms enable users to comprehend and interpret how each component influences the prediction. As with numerous other financial metrics, the statistical properties of stock prices can fluctuate over time. The "I" in ARIMA represents "integrated" and represents the required difference to make the series stationary. After the series has stabilized, it is simpler to model. ARIMA also can manage a variety of time series data components: long-term movement in the data, seasonality is the recurrence of short-term cycles, and noise is arbitrary variation. In Ariyo's investigation on the efficacy of the Arima model, it was observed that the experimental outcomes achieved using the optimal ARIMA model showcased the potential of ARIMA models in accurately predicting stock prices within a short-term timeframe. This has the potential to aid stock market investors in formulating lucrative investment strategies. Based on the acquired findings, it can be argued that ARIMA models exhibit a reasonable level of competitiveness when compared to emerging forecasting methodologies in the context of short-term prediction [3]. Zhu further argued that the ARMA model may be effectively utilized to predict the additional value in the service sector. This approach offers a more precise foundation for establishing planning objectives and conducting evaluations [4].

About other two long-term predicting models used in this research, the DCF (Discounted Cash Flow) Analysis is a method that is firmly grounded in the fundamental aspects of a company. It involves the computation of the current value of anticipated future cash flows generated by the company. By engaging in this practice, it provides an inherent assessment, functioning as a benchmark by which the market value of a stock can be measured. Malafeyev emphasized that the primary objective of the appraisal process is to ascertain the worth of the company by aggregating the free cash flows projected for future periods. This entails summing the present values of the anticipated income streams, while also accounting for the associated risks. As a result, the projected future earnings are discounted to their present value by applying the discount rate, which is determined by the weighted average cost of capital [2]. The Discounted Cash Flow (DCF) model has three sequential steps: (i) The practice of predicting the future free cash flow within a certain projection term, usually ranging from 5 to 10 years, is known as forecasting. (ii) The computation of the projected amount of free cash flow using the simplified model assumptions. (iii) The free cash flow is discounted using the weighted average cost of capital (WACC) [5]. In terms of efficacy, Peng asserts that the use of discounted cash flow (DCF) analysis stands as a highly suitable approach for assessing the value of a firm. Furthermore, esteemed investor Warren Buffett (year) regards DCF as a fundamental technique for evaluating stocks with the intention of making investment decisions [6].

The corresponding model, known as DDM, adopts a narrower scope by concentrating on dividends and making predictions about stock values through the use of expected dividend payouts and an assumption of perpetual growth. This methodology is especially advantageous for companies that exhibit a regular pattern of dividend distributions, since it provides valuable insights into the current

value of all forthcoming dividends. During the 1980s, several academics conducted empirical studies that offered evidence supporting the concept that dividend yields, specifically the ratios of dividend stock prices, has predictive capabilities for future stock prices, particularly in terms of long-term stock returns [7]. Additionally, Gacus highlighted the Discount Dividend Model (DDM) as a straightforward and extensively employed conventional approach for assessing the equitable valuation of a stock's share price [8]. Gottwald posited that the dividend discount model (DDM) is a valuation framework predicated on the underlying assumption that the value of a share is determined by the present value of all forthcoming dividend payments, discounted by the needed rate of return [9]. The technology industry, renowned for its swift expansion and continuous development, poses a distinctive obstacle for any prognostic model. Although corporations may exhibit favorable underlying characteristics, they are also vulnerable to rapid shifts in the market and disruptive technical advancements, resulting in heightened volatility in their stock values [10]. The objective of this study is to test totally three short term and long-term forecasting model for future prices of five specific technology stocks, namely ARIMA, DCF, and DDM models. This study aims to offer investors and scholars a thorough examination and comparison of different approaches in the realm of technology equities. By doing so, this paper aims to provide valuable insights into the respective strengths and potential drawbacks of each strategy, also the result would suggest which prestigious technology stocks are good to invest in future.

2. Methods

2.1. Dataset Collection and Preprocessing

The data pertaining to the five chosen technology stocks was obtained from Yahoo Finance, and covers a time frame ranging from Jan 1st, 2020, to September 21, 2023. The dataset encompasses daily closing prices, dividends disbursed, and essential financial variables necessary for conducting ARIMA, DCF, and DDM including net income, capital expenditures, and variations in net working capital.

The initial phase of data preprocessing encompassed the removal of missing values, outliers, and potential discrepancies from the dataset. Subsequently, the data was partitioned into two distinct sets, namely the training set and the testing set. The training set encompassed 80% of the data, while the remaining 20% was allocated for the purpose of validation.

2.2. The Application of ARIMA

The implementation of the ARIMA model necessitated the determination of the optimal parameters (p, d, q) for each individual stock. The Python programming language's stats model's library was utilized for this specific objective. The optimal parameters were identified using a grid search approach, with the selection based on the Akaike Information Criterion (AIC). Once the model identification process was completed, the ARIMA model was estimated using the training set. Subsequently, the accuracy of the model was tested by employing the testing set. The predictive capability of the model and the result was assessed by comparing it with the intrinsic values obtained from the discounted cash flow (DCF) and dividend discount model (DDM).

2.3. The Application of DCF

The DCF analysis for each stock commenced by predicting the future free cash flows of the company using the prescribed formula,

$$FCF = Net\ Income + \frac{Depreciation}{Amortization} - Changes\ in\ Work\ Capital - Capital\ Expendi \quad (1)$$

The formula for Free Cash Flow (FCF) can be expressed as the sum of Net Income, Depreciation/Amortization, less Changes in Working Capital, and minus Capital Expenditures. The

formula for free cash flow (FCF) can be expressed as the sum of net income, depreciation/amortization, changes in working capital, and capital expenditures.

Subsequently, the forthcoming cash flows were discounted to their present value by employing the Weighted Average Cost of Capital (WACC) of the organization. The calculation of the stock's intrinsic value involved the division of the aggregate present value of the cash flows by the total quantity of outstanding shares. The computations were facilitated using the pandas and numpy in Python.

2.4. The Application od DDM

The implementation of the Dividend Discount Model (DDM) entails the utilization of the most up-to-date dividend (D0) and an expected rate of dividend increase (g). The formula utilized in this study was:

$$P0 = D1/(r - g) \tag{2}$$

$$CDividend\ Yield = D1/P0 \tag{3}$$

Where “P0” is intrinsic value of the stock today, “D1” is expected dividend in the next period (one year from now), "r" is the desired rate of return, and “g” is growth rate of the dividend (assumed to be constant). The estimation of the required rate of return was conducted utilizing the Capital Asset Pricing Model (CAPM). The calculations of the model were facilitated by the utilization of Python's numpy and pandas.

3. Result and Discussion

3.1. Stock Price Prediction by ARIMA

Below graphs are the price trend prediction result for the five chose stocks by ARIMA model. Three years data from Jan 2020 to July 2022 was used to predict for next 500 days price trend. From July 2022 to September 2023, there is a year price data that can use to see the comparison between the real pricing trend compare with the predicted trend, and the part of yellow line ahead of the real price, from September 2023 to future, is the price trend prediction for future three month (Figure 1, 2, 3, 4 and 5).

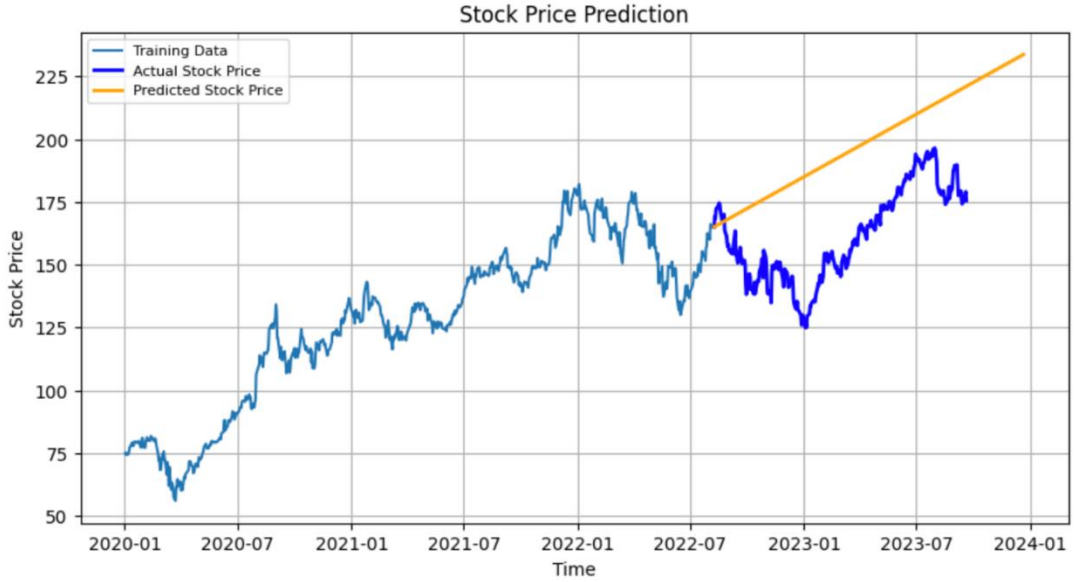


Fig. 1 AAPL (ARIMA)

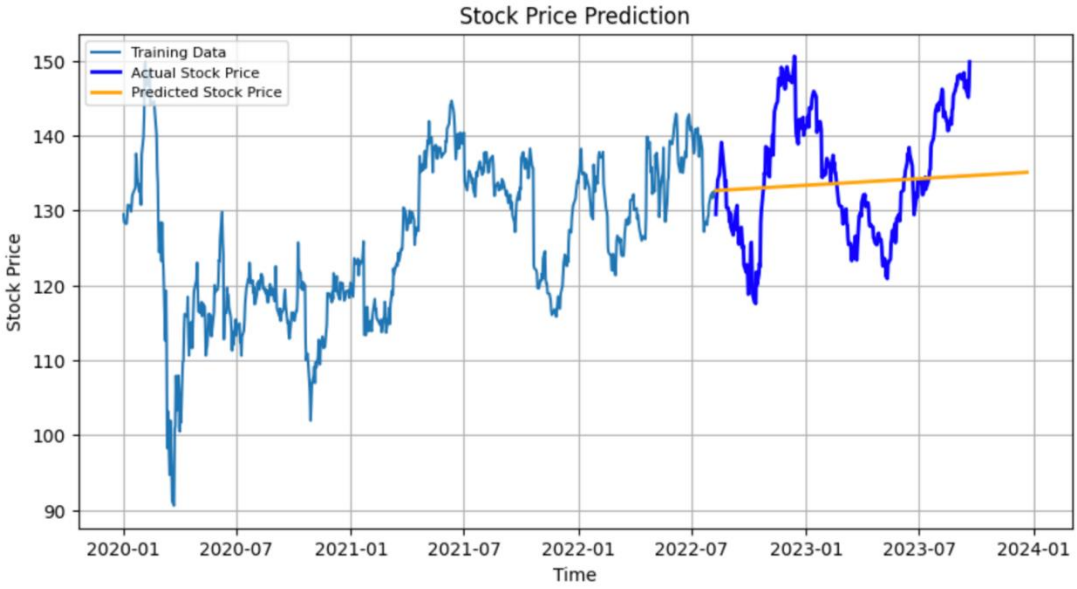


Fig. 2 IBM (ARIMA)

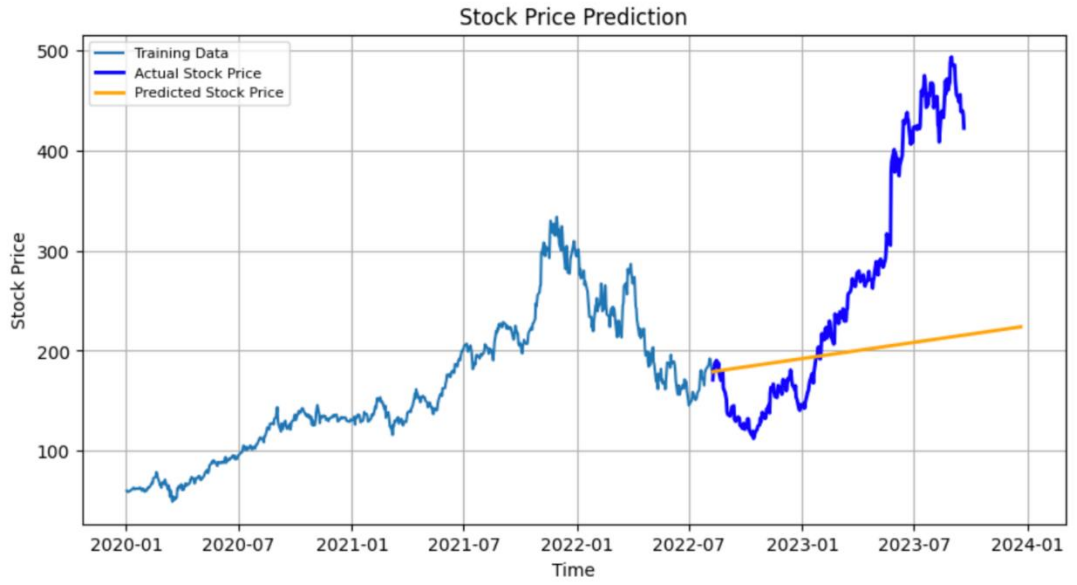


Fig. 3 NVDA (ARIMA)

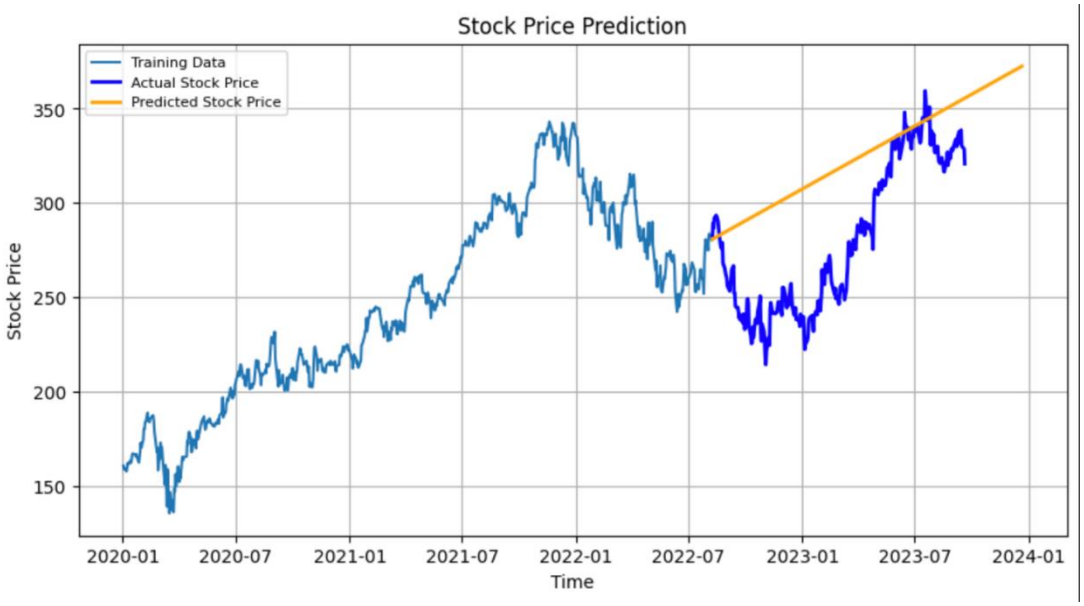


Fig. 4 MSFT (ARIMA)



Fig. 5 INTC (ARIMA)

By the prediction result graphs, the yellow line is the line of trend. By looking at the trend, AAPL, IBM, NVDA, and MSFT are in growing trend. INTC is in decreasing trend.

3.2. Stock Price Prediction by DCF

Below are Discounted Cash Flow five stocks price predicting result for next five years in year. The number means the increasing price or decreasing price for each year compare with now. The positive number means price increase, and the negative number means price decrease. The price prediction is in three digital places.

By the results in Table 1, the stock prices of AAPL, IBM, NVDA, and MSFT would increase in the future years, and INTC price would increase and then decrease.

Table 1. DCF Result Five Years

Stock Name	AAPL	IBM	NVDA	MSFT	INTC
First Year Price	136.161	42.802	16.632	149.259	27.663
Second Year Price	144.326	40.489	16.623	153.719	4.121
Third Year Price	153.249	43.287	16.65	160.946	2.369
Fourth Year Price	162.868	46.24	16.677	168.67	0.97
Fifth Year Price	173.236	49.356	16.705	176.926	-0.145

3.3. Stock Price Prediction by DDM

The DDM result of dividend yield for AAPL is -83%, for IBM -315%, NVDA -142%, MSFT -146%, and INTC -266%. Since the yield of the stock will increase as the price decreases, and the value of the stock will decrease as the price increases. The negative percentage in above demonstrate the prices for all the five stocks have potential power to growth in future (Table 2).

Table 2. The Dividend Yield result from DDM

Stock Name	AAPL	IBM	NVDA	MSFT	INTC
Result	-83%	-315%	-142%	-146%	-266%

3.4. Empirical Analysis

In the data analysis for five stocks, the residual errors appear to vacillate around zero and have a uniform standard deviation. The density diagram suggests a zero-mean normal distribution. Also, in the QQ-plot, each dot was precisely aligned with the red line. Overall, they are good fit in each data analysis. Therefore, the ARIMA prediction result for these five stocks would be good. By looking at the trend, AAPL, IBM, NVDA, and MSFT are in growing trend. INTC is in decreasing trend. The prediction of price trend is good for all stocks by looking at the ARIMA result graphs. The five predicted price trend also are constant with the real price trend from July 2022 to September 2023. However, ARIMA model cannot give an exact value prediction, it can only provide a predicted trend for future days. There could be little inaccurate in the price trend prediction. Because it is design for making short term prediction, it would be affected by the outside factors such as governmental, or international economy.

For the DCF model, the result graphs demonstrate that AAPL, IBM, NVDA, and MSFT are in grow trend also. There is a different in INTC that ARIMA suggests INTC would be decrease line, but DCF suggests INTC price would growth for one year, and then decreasing for four years. In accuracy, DCF shows a better accuracy than ARIMA, because it can give the exact predicted number for future years prices, not only give a trend line. Also, the pricing trend of AAPL, IBM, NVDA, and MSFT in DCF are keeping very constant with ARIMA model. AAPL and MSFT in both ARIMA and DCF growth fast, and IBM, NVDA growth slow in future. For INTC, overall, it demonstrates a decreasing trend for future years.

For the model of DDM, all five stocks got a big negative number, which is good as dividend yield prediction. In finance, the yield of the stock will increase as the price decreases. In contrast, the value of the stock will decrease as the price increases. The fluctuation of dividend yields in relation to stock prices can result in seemingly elevated values for stocks experiencing rapid declines in value. Therefore, the DDM suggest all five stock prices have potential to growth.

Overall, about the three models' accuracy, the ARIMA model can provide a good future price trend line, but the price fluctuation around the predicted trend line is big. So, its accuracy isn't that well. In comparison, DCF model result would be better, because its result is not linear. So, it can better describe the price fluctuation in future. For DDM model, it can work as a reference and helping model, because it suggests all the chose stocks' price have good potential to growth which is different from ARIMA and DCF. So, it can work to help us see the future price prediction, but we cannot make conclusion by only look at its predicted result.

3.5. Limitations

For all ARIMA, DCF, and DDM, they have some limitations. The ARIMA model presupposes linearity and does not inherently have the ability to account for abrupt structural breaks or shifts in the time series. The model demonstrates optimal suitability for short-term forecasting, whereas its accuracy tends to diminish when used to longer time horizons. The process of determining the ideal parameters (p, d, q) can pose significant challenges and typically necessitates specialized knowledge and skill. For DCF, the process necessitates the evaluation of forthcoming cash flows, a task that is subject to subjectivity and variability due to the assumptions made regarding growth rates, revenue forecasts, and cost frameworks. The determination of a suitable discount rate, commonly referred to as the weighted average cost of capital (WACC), may also add a degree of variability. For DDM, the underlying assumption of the model posits that dividends are the exclusive avenue via which shareholders get returns. This phenomenon has the capacity to disregard or fail to consider any prospective gains in capital. The application of the Dividend Discount Model (DDM) may be deemed less appropriate for corporations that do not provide dividends or exhibit inconsistent dividend trends, for example like Tesla or Amazon.

4. Conclusion

This article used ARIMA, DCF, and DDM to predict and analysis for five stocks future prices, AAPL, IBM, NVDA, MSFT, and INTC. Also, a comparison of each model result between the three model also shown in the paper. By the predicted result from above three models, only DDM suggested all the five technology stocks have strong potential to growth in the future. Both ARIMA and DCF suggest AAPL, IBM, MSFT, and NVDA would growth in future, but INTC price would decrease in the future. ARIMA and DCF also demonstrate that AAPL and MSFT prices would growth fast in the future. NVDA and IBM prices would growth slower. Also, by the result from three prediction models, DCF performance a better result. Therefore, among those world most significant and prestigious technology companies and three prediction models, the stock of AAPL and MSFT and the model of DCF would be most recommended from the above research.

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