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BLACK-SCHOLES MODEL AND BINOMIAL MODEL TESTS ON NVIDIA STOCK OPTION CONTRACTS

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Abstract: In order to invest, investors can purchase a number of shares. The characteristics of stocks are high risk/high return and low risk/low return. Stock price volatility is a measurement of how quickly and in a short period of time stock prices can rise or fall (fluctuate). With the advent of derivative instruments, specifically options, risk can be reduced in several ways. A contract known as an option grants its owner the right, but not the duty, to sell or acquire a specific quantity of the underlying asset at a specified price at a specific point in the future. Methods for calculating option prices in derivative instruments is the Binomial option model and the Black Scholes option model. The aim of this research to determine the accuracy of the Black Scholes compared with the Binomial in predicting call option shares of Nvidia Coorporation (NVDA) on the due date of 1 month, 2 months, and 3 months, using data price daily and call option which at 17 sample from January 2022 to May 2023. To determine the accuracy use price absolute error comparisson between the Black Scholes and the Binomial was conducted. In result the Black Scholes model is more accurate than the Binomial.
Keywords: Binomial Model, Black-Scholes Model, Option Pricing

INTRODUCTION

Investment is the commitment of a number of funds or other resources made at this time, with the aim of obtaining a number of benefits in the future (Tandelilin, 2017). An investor can make an investment by buying a number of shares today in the hope of benefiting from an increase in share price or a number of dividends in the future, in exchange for the time and risk associated with the investment.Share prices in the secondary market fluctuate according to market expectations. These fluctuations cause uncertainty in the share price, when the share price rises, the investor will get a profit, while if the share price falls, the investor will experience a loss. In the secondary market or in daily stock trading activities, stock prices fluctuate in the form of both increases and decreases. The formation of stock prices occurs due to the demand and supply for these shares. In other words, stock prices are formed by the supply and demand for these shares. This supply and demand occurs due to many factors, both specific to the stock (company performance and the industry in which the company is engaged) and macro factors such as interest rates, inflation, exchange rates and non-economic factors such as social and

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political conditions, and other factors.

Stock market returns are a critical sustainability factor for investment decision-making. Investors and stock market participants pay particular attention to the properties of stock market return volatility, such as time-varying volatility, volatility clustering/pooling, long memory or long-term dependence, and leverage effect. The phenomenon of volatility refers to the tendency of large changes in prices of financial assets to cluster together, resulting in the persistence of the magnitudes of price changes (Herbet, Ugwuanyi & Nwaocha, 2019)

Investors can evaluate the price and retrieval volatility of stock information on the capital market. According to Sari, Achsani, and Sartono (2017), capital market volatility depicts swings in a financial instrument's value over a predetermined time period. This explains why many market risk-assessment models use estimate of volatility parameters. The concept of volatility has been used in several financial models about pricing of options and corporate liabilities (Black-Scholes model), and portfolio diversification and hedging (Derman, 2022). Above all, understanding idiosyncratic volatility is important because of its direct implications on investors' portfolio and hedging strategies (Aziz, Ansari & McMillan, 2017). It is equally important because undiversified investors demand a premium for holding a firm's shares that are positively related to its idiosyncratic risk (Glover&Levine,2017).

Volatility is a measure of the extent to which stock prices can rise or fall (fluctuate) rapidly within a short time span. The higher the volatility, the greater the change in the stock price from day to day. Figure 1. shows the volatility of Nvidia Coorporation (NVDA) shares in the period January 2022 to May 2023.

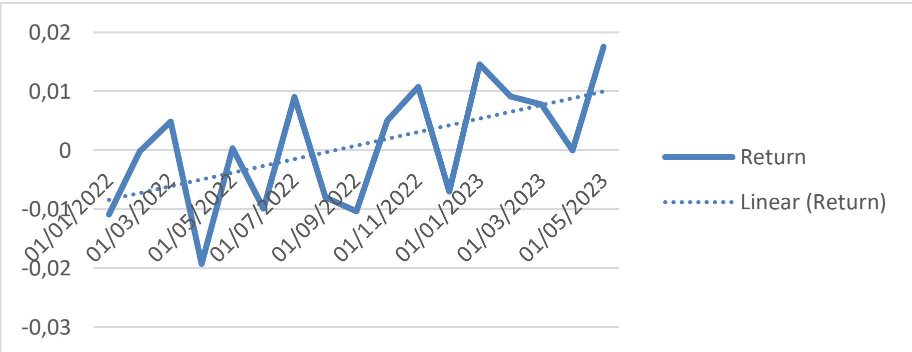

Figure 1 Volatility Stock Return NVDA in the period January 2022- May 2023
Source : www.yahoofinance.com, data that has been processed by the author, (2023)

After the covid pandemic, AI companies became a trending and attractive industry for investors. As businesses from Nvidia (NVDA) and Marvell (MRVL) to Microsoft (MSFT) and Google (GOOG, GOOGL) ride the hype the wave that began with the debut of ChatGPT in 2022, AI is the trendiest buzzword on Wall Street. Nvidia made business news on May 30 when it became the first company to join the ultra-exclusive $1 trillion club. The manufacturer and developer of AI hardware and software reached the landmark by increasing its valuation by an amazing $280 billion or roughly 40% since May 15, accomplishing a moonshot that is essentially unmatched in the history of the capital

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markets (it closed slightly below that threshold).

The Nvidia phenomenon, however, has a negative side. It perfectly captures the epic, enormous increase in market cap that all Trillion-Dollar Club members experienced this year. In fact, the five current members with valuations over 14 figures are practically devouring the S&P 500 index. That is undesirable. The big cap index has only been raised this year by their coordinated ascent. In addition, it has increased the price of businesses that were already pricey before their recent growth, making it highly improbable that they would be able to raise the markets on their few (less than a dozen) shoulders in the future. Most likely, their valuations have already been overextended to the point that they will eventually snap back. The most extreme instance of the froth that has engulfed the Trillion-Dollar Club is the rise of Nvidia (Tully, 2023).

Certainly, rational investors anticipate profits that are in line with the risks they must accept. As a result, in addition to the rewards predicted, investors who want to participate in the stock market, notably, also take into account the dangers associated with their decision. Derivative instruments are one type of financial investment tool. Financial market derivative products have seen significant expansion. This is connected to the growth of the financial markets and the need to address financial pressures. In general, derivative products are goods whose price or value is established by or derived from other goods known as underlying assets (Hull,2021)

The benefits of derivative products are generally as a means of hedging funds to minimize risk as well as as a means of investment by utilizing the potential for speculation (Firmansyah et all, 2020). One of the most widely traded derivative instruments is an option, which is a contract that gives the contract holder the right, not the obligation, to sell or buy a certain amount of an underlying asset at an agreed price at a certain time in the future (Hull,2021). Options are frequently used in the American markets, including the Dow Jones Index and Nasdaq (USA), Indice de Precios y Cotizacione (Mexico), and Toronto Stock Exchange (Canada) (Singh et all, 2020). Of the various option pricing models, the Black Scholes option model is one that is often used in option determination, as is the binomial option model. Both models have differences in the distribution used and the execution time. The Black Scholes option model has a continuous distribution; the execution time is European-style, which can only be executed at maturity, while the Binomial option model has a discrete distribution; the execution time is American-style, which can be executed before maturity. From these differences, a comparison is made of the most accurate model for determining options.The black-scholes option model and the binomial option model are methods of determining option prices in derivative instruments. In Indonesia, the use of derivatives is still not very widespread. Only market players in the financial sector use derivatives for return or hedging purposes. So, this research was conducted to calculate the premium price of call options on Nvidia Coorporation shares. In this study, the maturity period or execution time in predicting option premiums is done over a period of 1 month, 2 months, and 3 months. With these time periods, we can see the changes in the value of the option premium and know its accuracy.

METHODS

This study uses call option data with a maturity period of 1 month, 2 months, and 3 months will be conducted on daily stock price and 17 sample points call option on the stock price of Nvidia Coorporation (NVDA), from January 2020 to May 2023. Data obtained from

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www.yahoo-finance.com. The calculation is done using 2 (two) methods, namely the Black Scholes Option Pricing Model and the Binomial Option Pricing Model, and assuming that the call option of NVDA stock is a European Call Option.
The steps that will be used in the calculation of the estimated call option value of NVDA shares are as follows:

a. Calculation of Stock Price Volatility

The equation for calculating the estimated volatility of NVDA shares is

$$S = \left[\frac{1}{n-1}\sum_{i=1}^{n} u_i^2 - \frac{1}{n(n-1)}\left(\sum_{i=1}^{n} u_i\right)^2\right]^{0.5}$$

Standard deviation per year : $S^* = s / \sqrt{\tau}$

The standard error of the volatility estimate : $e = S^* / \sqrt{2n}$

b. Calculation of call option value

After calculating volatility, there are two models used to calculate the call option value, namely the black scholes option model and the binomial model. Black & Scholes, (1973), provides a fundamental foundation in the formation of option prices. Black & Scholes answers the problems in option calculation so that it is better from a theoretical or practical point of view. This model uses the risk free asset variable as the basis for calculating the expected rate of return, this variable replaces the expected return variable.
The equation to calculate the call option value with the Black Scholes Option Pricing Model is

$$C = SN(d1) - e^{-R_f T} XN(d2)$$

$$d1 = \left[\ln \frac{[S/X] + \left[R_f + \frac{\sigma^2}{2}\right]T}{\sigma\sqrt{T}}\right]$$

$$d2 = d1 - \sigma\sqrt{T}$$

Description:
S = Current share price (current price)
X = Strike price
T = Time to maturity (maturity)
r = Risk-free interest rate
σ = Stock price volatility
c = Value of the European call option
N(x) = Cumulative probability distribution for a normally distributed variable with mean = 0 and standard deviation = 1. Note that r is the nominal interest rate and r>0.

The binomial call option equation for period n can be written as :

$$C = e^{-nr\Delta t} \sum_{j=0}^{n} \left(\frac{n!}{j!(n-j)!}\right) p^j (1-p)^{n-j}$$

C = value of the call option
e = price of the underlying asset
u = increase after one period
d = decrease after one period
r = risk-free interest rate
Δt = time of one period
n = number of periods from t

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p = (er∆t - d) / (u - d)

The Binomial Option Pricing Model option equation for period n can be written as:
C = [p C up + (1 − p) C down] / r

Where:
P = (r-d) / (u-d), u > r > d
P = probability of rising stock prices, assuming that investors are risk neutral.
C = price / value of a call
Cup = Max [0,u * S - X] = the intrinsic value of the call if the stock price increases by u times from its initial price
Cdown = Max [0,d * S - X] = the intrinsic value of the call if the stock price drops by d times its initial price.
r = Interest rate + 1

c. Profit/Loss Calculation

The steps that must be taken to determine the investor's profit/loss from investing in a call option at maturity are as follows:

1. Calculating the addition/subtraction to the amount of money owned if the investor exercises the call option at maturity, i.e. profit/loss (π) is the share price at maturity call option (ST), minus the exercise price (X), minus the maturity call option value (c); (π=ST - X - c).
2. Calculate the reduction in the amount of money held if the investor does not exercise the call option at maturity, which is the call option value at maturity (c).

d. Calculation of Price Absolute Error

Calculation of Price Absolute Error is done after the calculation of the average value of the calculation of profit/loss due n months, so the Price Absolute Error is the average value of the calculation of profit/loss due n months divided by the number of months of stock movement used in the study. The Price Absolute Error value is used to determine how much the error rate is from determining the call option value, where the Price Absolute Error value is an absolute price. The model will be more accurate if the price absolute error is smaller.

RESULTS AND DISCUSSION

Global factors are now more vulnerable to local systemic and non-systemic hazards as a result of the growth in risk in portfolios across all financial markets. The options contract, which is comparable to both futures and forwards in that each instrument derives its value from the future price of the underlying asset, is another related form of instrument. These agreements also include the potential acquisition or disposal of an asset at a preset price in the future. Options contracts, in contrast to the first two, give the holder the choice but not the duty to carry out a predetermined transaction with a third party.Because they reduce negative risks without sacrificing upside possibilities, options contracts are preferred to other types of derivative instruments (Grima & Thalassinos ,2020). Arbitrage considerations should be incorporated in the pricing of options when the movement in stock prices follows a discrete binomial process or a limited form of such a process. Despite being innovative, the Black-Scholes-Merton technique involved complex mathematical calculations. (Singh et all, 2020). Investors can choose which model is more accurate and take it into consideration before making a decision on an investment by lowering risk by

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selecting an option pricing model.

Comparison results of call option value between Black Scholes Option Pricing Model and Binomial Option Pricing Model with a period of 1 month.

Table 1. Value Price Absolute Error t = 1 Month

Price Absolute Error	
Black Scholes	Binomial
t = 1 Month	t = 1 Month
1,78%	1,98%

Source: data that has been processed by the author (2023)

The price absolute error value of the two option models, Black Scholes and Binomial with a maturity period of 1 month, The Black Scholes option model of 1,78%, while the price absolute error value for the Binomial option model is 1,98%. Based on the price absolute error value with a maturity period of 1 month, the Black Scholes option model has a smaller price absolute error value than the Binomial option model, it can be concluded that the Black Scholes option model is more accurate than the Binomial option model.

Comparison results of call option value between Black Scholes Option Pricing Model and Binomial Option Pricing Model with a period of 2 months.

Table 2. Value Price Absolute Error t = 2 Months

Price Absolute Error	
Black Scholes	Binomial
t = 2 Months	t = 2 Months
1,32%	2,17%

Source: data that has been processed by the author (2023)

The Black Scholes option model has a price absolute error value of 1,32%, while the Binomial option model has a price absolute error value of 2,17%. Both option models have a maturity time of two months. Given that the Black Scholes option model and the Binomial option model both have lesser price absolute error values with a maturity period of one month, it may be said that the Black Scholes option model is more accurate than the Binomial option model.
Comparison results of call option value between Black Scholes Option Pricing Model and Binomial Option Pricing Model with a period of 3 months.

Table 3. Value Price Absolute Error t = 3 Months

Price Absolute Error	
Black Scholes	Binomial
t = 3 Months	t = 3 Months
3,36%	2,68%

Source: data that has been processed by the author (2023)

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The Binomial option model has a price absolute error value of 2,68% compared to the Black Scholes option model's 3,36%. The maturity period for both option models is two months. It can be claimed that the Binomial option model is more accurate than the Black Scholes option model because the Binomial models have smaller price absolute error values than Black Scholes option model with a three-month maturity time.

CONCLUSION

Based on the results of research data processing and the discussion that has been described, it can be concluded that the calculation of the call option value using the Black Scholes Option Pricing Model is more accurate than using the Binomial Option Pricing Model at a maturity period of 1 month because the absolute error value of the price on Black The Scholes Option Pricing Model is smaller than the call option value. price absolute error value from the Binomial Option Pricing Model, calculating the call option value using the Black Scholes Option Pricing Model is more accurate than using the Binomial Option Pricing Model at a maturity period of 2 months because the price absolute error value in the Black Scholes Option Pricing Model is higher small compared to calculating the call option value using the Black Scholes Option Pricing Model. price absolute error value from the Binomial Option Pricing Model, calculating the call option value using the binomial option pricing model is more accurate than using the Black Scholes option pricing model at a maturity period of 3 months because the absolute error value of the price in the binomial option pricing model is smaller compared to price. the absolute error value of the black Scholes option pricing model, finally, from calculating the absolute error data of prices for maturity periods of 1 month, 2 months, and 3 months, only at the maturity period of 3 months the binomial option pricing model is more accurate compared to black Scholes option pricing model, so the black Scholes option pricing model is more accurate than the binomial option pricing model. So the Black Scholes Option Pricing Model can be used as a basis for investors to invest in Nvidia shares.

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