The Use Of The Black Scholes Model In Determining The Price Of The European Type Option

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**Abstract.**  Opsi adalah kontrak antara penjual dan pembeli opsi, sedangkan faktor yang mempengaruhi nilai opsi adalah harga saham (S), harga kesepakatan (K), tanggal jatuh tempo (T), suku bunga (r), volatilitas (σ). Pengaplikasian model-model dalam penelitian ini menggunakan data harga penutupan saham harian dari PT PP London Sumatra Indonesia Tbk pada tanggal 18 Juli 2019 sampai dengan 19 September 2019 sehingga diperoleh harga saham awal , tingkat suku bunga sebesar 5.5%, nilai volatilitas harga saham adalah sebesar 0.253. Perhitungan harga opsi dengan menggunakan model Black Scholes bertujuan untuk mengetahui semua nilai yang dihasilkan dari opsi put tipe Eropa. Dengan menerapkan model Black Scholes nilai yang dihasilkan dari opsi jual tipe Eropa adalah Rp14,768.

**Keyword:** *Saham, Black-Scholes, Opsi Tipe Eropa*

**Abstrak.**  An option is a contract between the seller’s option and the buyer’s option, while the factors that affect the value of the option are the stock price (S), the strike price (K), the maturity date (T), interest rate (r), volatility (σ). The application of the models in this study uses daily stock closing data from PT PP London Sumatra Indonesia Tbk from July 18, 2019, until September 19, 2019, so that the initial stock price is = Rp1,090, the interest rate is 5.5%, the value stock price volatility is 0.253. The computation of the option prices using the Black Scholes model aims to found out all the values ​​generated from European type put options. By applying the Black Scholes model, the value generated from the European type option is Rp14,768.

**Kata Kunci:** Stocks, Black-Scholes, European Type Option

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1. Introduction

According to [1] investment is a commitment to a number of funds or other resources carried out at this time, with the aim of obtaining a number of benefits in the future. In general, the activities carried out are investing a number of funds in real assets and financial assets. Investments in finance are related to financial assets, such as investments in stocks, bonds and other financial assets. Investment in the stock market is an investment full of risk, so investors must be very careful in investing their funds [2]-[3]. This is the reason for the emergence of alternative means of investing. One alternative investment that investors can choose is derivative products [4]-[5]-[6]. A derivative product is a financial instrument whose value depends on an underlying asset [7]-[8]-[9].

Derivative products can be used as instruments to manage risk and speculation, as well as to reduce transactions. One type of derivative product is options. According to [10] option is the right to do something and is not obliged to do it. Meanwhile, according to [6] option is a type of contract that gives the investor the right to buy or sell an asset at a mutually agreed price and time. An investor in trading options contracts must comply with mutually agreed rules and conditions. According to [11] in conducting options transactions, many things must be considered such as when to buy and when to sell, how it develops, the price level, considering the risks, as well as the strategy used to gain profits from the option transaction.

One of the models in the analytical method that is often used to calculate option prices is the Black-Scholes model. This model was developed by Fisher Black and Myron Scholes in 1973 to determine the price of European-type options assuming no dividend payments, no transaction costs, constant risk-free interest rates, and changes in stock prices following a random pattern [12].

Based on the description above, the authors raised the research with the title "Use of the Black Scholes Model in Determining European Type Option Pricing". Based on the background that has been described, the formulation of the problem is how much the price of European options is using the Black Scholes model. The purpose of this study is to obtain the results of option pricing using the Black Scholes Model.

1. Method

The type of research used in this research is applied research. The data used is secondary data. The data in this study is information on the closing stock price of PT PP London Sumatra Indonesia Tbk from 18 July to 19 September 2019 which was obtained from http://www.finance.yahoo.com. The variable to be studied is the movement of stock price data of PT PP London Sumatra Indonesia Tbk at time t(St ).

The definition of the variables used in this study is the movement of the stock price data of PT PP London Sumatra Indonesia Tbk at time t(St ) from 18 July to 19 September 2019 which was obtained from <http://www.finance.yahoo.com>.

At this stage, the steps of the Black Scholes model for European option prices will be carried out. The steps are as follows:

1. Retrieve data on the share price of PT PP London Sumatra Indonesia Tbk from the website <http://www.finance.yahoo.com>.
2. Write the closing stock prices sequentially, call it closing price .
3. Calculating relative price:

(1)

1. Calculate the daily return value which is ln of the relative price:

(2)

1. Calculating the estimated mean of daily stock returns:

(3)

1. Calculating the standard deviation of stock returns:

(4)

1. Calculating stock price volatility:

(5)

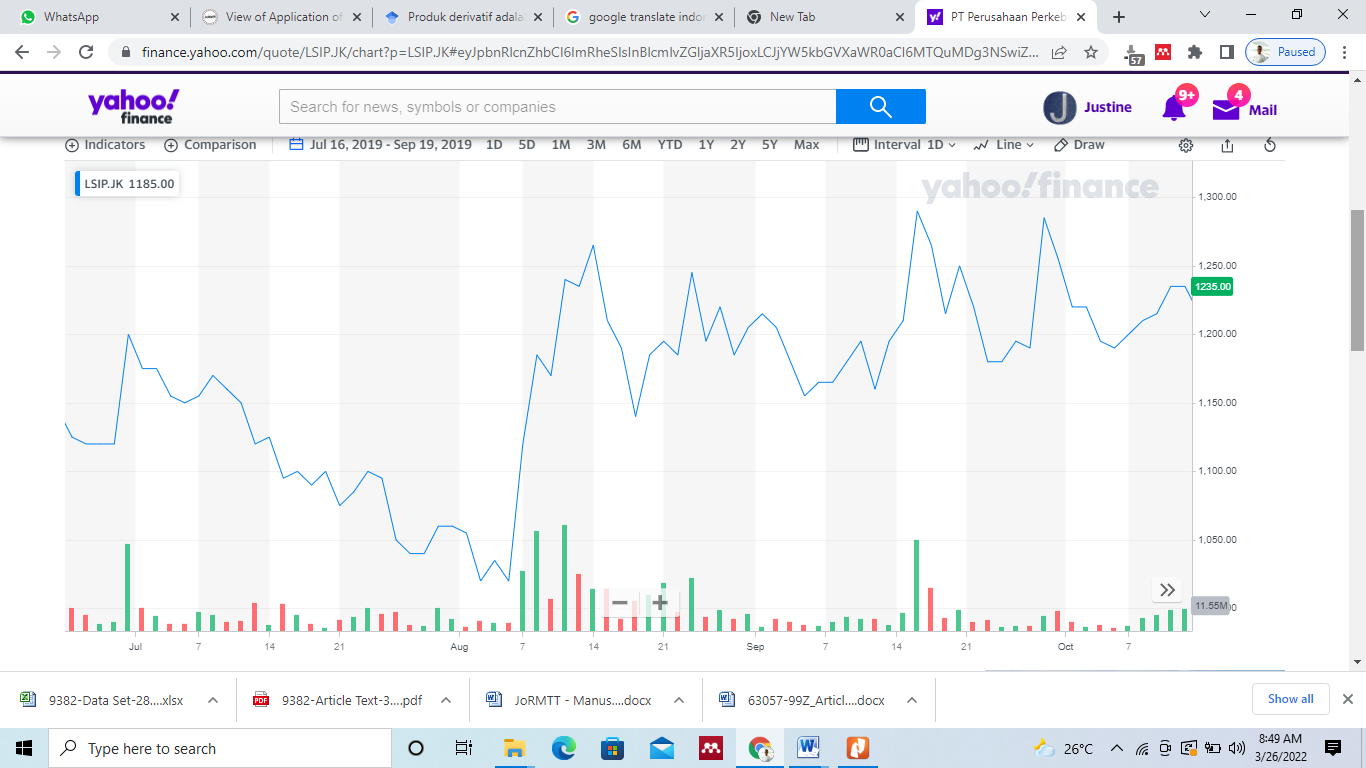
1. Determining the price of European options using the Black Scholes model:

(6)

1. The calculation of the price of the European type of put option using the Black Scholes model is obtained by .
2. Results and Discussion

The data used in this study is the daily closing share price of PT PP London Sumatra Indonesia Tbk. The reason for using closing data is because closing data is the most important price in conducting technical analysis, where closing prices reflect all market participants (especially institutional market participants who have more accurate information) at the time of trading. The closing price reflects the price position at which investors dare to hold, in the face of all information that may occur at night when there is no trade. More than 90% of the technical indicators used by technical analysts use closing prices as their main input. This causes the position of the closing price to trigger a buy signal or a sell signal.

This study uses data on the daily closing share price of PT PP London Sumatra Indonesia Tbk with a trading period of 46 days. The calculation of stock prices is based on the maturity period seen in the interest rate data. Stock daily closing price data PT PP London Sumatra Indonesia Tbk can be seen in Figure 1.



1. Stock daily closing price data PT PP London Sumatra Indonesia Tbk
   1. Calculating the Relative Price of Shares

Before calculating the return value from the stock price, first calculate the relative price value of the stock using equation (1) in order to obtain:

For t = 1, then:

For t = 2, then:

For t = 3, then:

For t = 44, then:

For t = 45, then:

1. Calculation Result of Share Relative Price

|  |  |  |
| --- | --- | --- |
| No | Closing Price | Share Relative Price |
| 0 | 1090 | 0 |
| 1 | 1100 | 1.009 |
| 2 | 1075 | 0.977 |
| ⋮ | ⋮ | ⋮ |
| 44 | 1265 | 0.981 |
| 45 | 1215 | 0.960 |

* 1. Stock Price Daily Return

If t is the observation time interval, is the stock price at time *t*, and is the stock price return to *t*, then can be calculated using equation (2) to obtain:

For t = 1, then:

For t = 2, then:

For t = 3, then:

For t = 44, then:

0.01957

For t = 45, then:

1. Stock Price Return Calculation Results

|  |  |  |
| --- | --- | --- |
| No | Closing Price | Stock Price Return |
| 0 | 1090 | 0 |
| 1 | 1100 | 0.009132484 |
| 2 | 1075 | −0.022989518 |
| ⋮ | ⋮ | ⋮ |
| 44 | 1265 | −0.01957 |
| 45 | 1215 | −0.040328045 |

* 1. Calculating Mean Estimation of daily stock ln

To calculate the estimated mean of ln daily stock returns using equation (3) to obtain:

1. Stock Price Return Calculation Results

|  |  |  |
| --- | --- | --- |
| No | Closing Price | Stock Price Return |
| 0 | 1090 | 0 |
| 1 | 1100 | 0.009 |
| 2 | 1075 | −0.023 |
| ⋮ | ⋮ | ⋮ |
| 44 | 1265 | −0.019 |
| 45 | 1215 | −0.040 |
|  | Amount | 0.109 |

0.002

So the estimated mean value of ln daily stock returns obtained is 0.002.

* 1. Calculating the standard deviation based on Table 3

If n is the number of observed data, is the stock price return, is the estimated mean of daily stocks, is the standard deviation of , so the formula to calculate the standard deviation of ln stock returns uses equation (4) so we get:

0.016130857

So the standard deviation value is 0.016130857.

* 1. Stock Price Volatility

If is stock price volatility, is obtained by the formula , where is the number of trading days in one year, so equation (5) can be used to calculate stock price volatility. Where , 246 trading days for one year that is active in the capital market, so we get:

0.25300

So the value of stock price volatility is 0.25300.

* 1. Risk Free Interest Rate

The risk-free interest rate is obtained from the average interest rate for Bank Indonesia Certificates (SBI) for the duration of the study which is tested per month. The research time is three months, starting from July 2019 to September 2019.

1. Stock Bank Indonesia Interest Rate

|  |  |  |
| --- | --- | --- |
| No | Date | BI 7-Day Repo Rate |
| 1 | 18 Juli 2019 | 5.75 % |
| 2 | 22 Agustus 2019 | 5.50 % |
| 3 | 19 September 2019 | 5.25 % |
| Amount |  | 16.5% |
| Average |  | 5.5% |

In this study, the authors use a year of risk-free interest rate tested per month as shown in Table 4 with the sum of the interest rates being 16.5% and an average of 5.5% or 0.055.

* 1. Strike Price

Based on information on the stock price of PT PP London Sumatra Indonesia Tbk which was traded from July 18, 2019 to September 19, 2019 or equivalent to 46 trading days, the strike price was Rp.889.

* 1. Calculation of Sell Options Using the Black Scholes Model

The formula for determining the price of a European type of put option is using equation (6), where:

0.6838

The Normal Cumulative Distribution Density function for the values ​​of and in the Black Scholes Model is:



0.0084

0.0084

0.0084

0.0025



Calculation of put options using the Black Scholes model:

Based on research using a sample of PT PP London Sumatra Indonesia Tbk daily closing price data for three months traded from July 14, 2019, to September 19, 2019, to get the value of the put option on the Black Scholes Model, first look for the return value of the stock price, Stock price return serves to see how much the stock price returns at each trading period. Then look for the standard deviation and produce a value of 0.016130857. After looking for stock price returns and standard deviations, then to find the value of stock price volatility is by equation (6), where its stock price volatility, is obtained by the formula , where T is the number of trading days for one year, using the formula Thus, the volatility value is 0.253. Where the value of volatility is the price fluctuation of a stock, this is because the greater the volatility, the greater the probability that the stock price will change.

The interest rate used in this research is the interest rate for Bank Indonesia Certificates (SBI) for a period of 3 trading months which is calculated from July 2019 to September 2019 which is 0.055. As for the strike price, it is obtained based on information on the daily closing price of the stock itself, which is Rp889.

After all the values ​​in the discussion above are obtained, then before determining the value of the put option using the Black Scholes Model, first determine the values ​​of and . Where the value of = 2.3997 and = 0.6838. To determine the value of the cumulative distribution of the method, look for the values ​​of and based on the normal distribution table. Where = 0.0025 and = 0.2470 for the Black Scholes model.

After all the required values ​​are obtained, then to get the price of European put options using the Black Scholes Model is equation (6) with P = 14,7683.

The value obtained from the calculation method is a fair value for European type put options. Based on the history price, it can be seen that the strike price was lower than the stock price on July 18, 2019, namely at the start of trading or contracts, where = Rp1,090. It can also be seen at the maturity date, which is September 19, 2019, with a share price of Rp1,215 which is also higher than the strike price. Based on this value, this situation is called out of the money where the put option is zero. When the put option is zero, the investor will automatically not exercise his rights, and the investor will lose the premium value of Rp14,7683. The value generated by the Black Scholes Model is the premium value of the option that must be paid by the investor at the beginning of the agreement as a sign that the investor is willing to buy the stock at maturity. This instrument is called an option because this agreement gives the option holder the right to determine whether or not to exercise the option he holds.

1. Conclusion

The conclusion from this research is that the price value of the European type of Black Scholes Model selling option is Rp14,7683, with the estimated mean value of ln daily stock returns obtained is 0.002. The volatility value of the stock price is 0.253. The strike price is Rp889 and the interest rate is 0.055 or 5.5%.

References

[1] B. Rahardjo, *Jeli Investasi Saham ala Warren Buffet: Strategi Meraup Untung di Masa Krisis*. Penerbit Andi, 2021.

[2] L. Guiso and P. Sapienza, “Trusting the stock market,” *J. Finance*, vol. 63, no. 3, hal. 2557–2600, 2008, doi: 10.1111/j.1540-6261.2008.01408.x.

[3] A. Rudiwantoro, “Langkah Bijak Berinvestasi Saham Dengan Menggunakan Pendekatan Analisis Rasio,” *J. Akunt. Dan Bisnis Indones.*, vol. 2, no. 2, hal. 72–84, 2021.

[4] M. V. Noël Amenc, “Benefits and risks of alternative investment strategies,” *J. Asset Manag.*, vol. 4, no. 2, hal. 96–118, 2003, doi: 10.1057/palgrave.jam.2240097.

[5] T. M. Josia Arthur Philip Sumampouw, Chriestie E. J. C. Montolalu, “Metode Quasi Monte Carlo Dengan Barisan Bilangan Acak Halton Dalam Menentukan Nilai Kontrak Opsi Tipe Binary Pada Saham PT. Gudang Garam, Tbk,” *d’Cartesian J. Mat. dan Apl.*, vol. 9, no. 2, hal. 140–144, 2021, doi: 10.35799/dc.9.2.2020.29147.

[6] A. Rusdianingrum dan B. Budiyanto, “Aplikasi Penentuan Harga Opsi Tipe Eropa Dengan Menggunakan Model Black Scholes,” *J. Ilmu dan Ris. Manaj.*, vol. 4, no. 10, hal. 1–19, 2015.

[7] H. P. Qisti Nissa, Neva Satyahadewi, “Penentuan Harga Opsi Beli Tipe Eropa Menggunakan Metode Trinomial,” *Bimaster Bul. Ilm. Mat. Stat. dan Ter.*, vol. 9, no. 3, hal. 379-386., 2020, doi: 10.26418/bbimst.v9i3.41045.

[8] A.Vashishtha and S. Kumar, “Development of financial derivatives market in India-a case study,” *Int. Res. J. Financ. Econ.*, vol. 37, no. 37, hal. 15–29, 2010.

[9] B. Ziqiang Lu dan Y. Zhu, “Critical value-based Asian option pricing model for uncertain financial markets,” *Phys. A Stat. Mech. its Appl.*, vol. 525, hal. 694–703, 2019, doi: 10.1016/j.physa.2019.04.022.

[10] A. B. Amalia, “Penentuan harga opsi Eropa Model Black-Scholes Dengan Metode Beda Hingga Upwind,” Doctoral dissertation, UIN Sunan Ampel Surabaya, 2021.

[11] M. Resta and P. Pagnottoni, “Technical Analysis on the Bitcoin Market: Trading Opportunities or Investors’ Pitfall?,” *Risks*, vol. 8, no. 2, hal. 44, 2020, doi: 10.3390/risks8020044.

[12] J. C. Hull, *Options, Futures, and Other Derivatives*. New Jersey : Pearson Education International, 2009.