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Original Article

Financial Engineering Using Option Strategy on Pharmaceutical Indonesia State-Owned Enterprises Holding

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Abstract: *The purpose of this study is to evaluate the use of long-straddle strategy option contracts on pharmaceutical state-owned enterprises (BUMN, Badan Usaha Milik Negara) by applying the Black Scholes and GARCH option models. The information consisted of the closing stock prices of INAF and KAEF, two holding corporations, from 2002 to 2021. The Black Scholes and GARCH models' average mean squared error percentages were compared with the Long Straddle Strategy's implementation to determine the study's results. The lower the percentage, the better the model. The outcome showed that the Black Scholes model outperformed the GARCH model for a one-month due date option contract, with error values on call options of 6.28% and put options of 4.279% for INAF and error values on call options of 5.24% and 3.29% for GARCH. The Black Scholes model continued to produce superior results for call options with a three-month option contract, with error values of 20.38% for INAF and 14.59% for KAEF. Conversely, the GARCH model was better on the put option, with a 14.69% error value for INAF and 9.50% for KAEF. Following the implementation of the Long Straddle Strategy on the pharmaceutical BUMN holding from 2002 to 2021, INAF reached 93% profitability with an average of 43%, while KAEF reached 78% profitability with an average of 41%.*

Keywords: *Black Scholes, Financial Engineering, GARCH, Option Contract.*

I. INTRODUCTION

In 2020, both PT Indofarma Tbk. (INAF) and PT Kimia Farma (Persero), Tbk. (KAEF) had received penalties affecting their stock trading activity that was temporary trading suspension based on the announcement from PT Bursa Efek Indonesia on 6 August 2020 (No. Peng-SPT-0028/BEI.WAS/08-2020). The suspension was caused by the COVID-19 vaccine testing by the pharmaceutical BUMN holding company PT Bio Farma (Persero). Figure 1 shows the fluctuating pattern and significant changes in INAF and KAEF daily returns from 2017 to 2021.

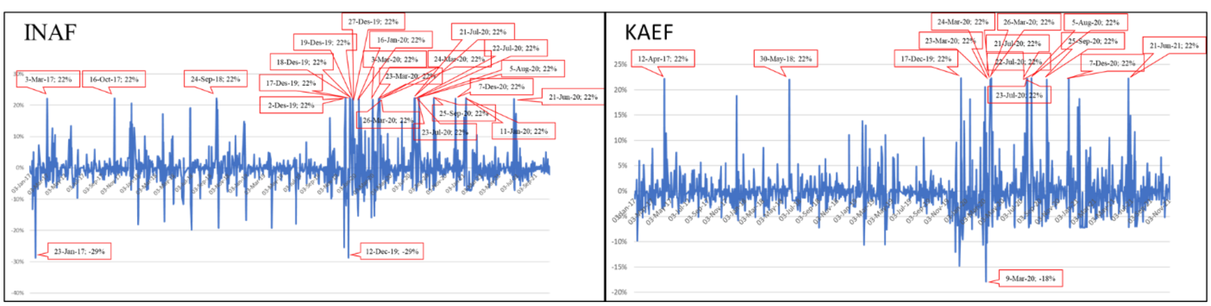

Figure 1: Stock daily return of INAF and KAEF from 2017 to 2021

Figure 1 shows that the maximum amount of INAF daily return was 22%, which occurred five times in the last five years, while the lowest daily return was -29%, which happened twice on 23 January 2017 and 12 December 2019. In addition, KAEF showed a maximum daily return of 22% that occurred 13 times in the last five years, while the lowest return was -18% on 9 March 2020.

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Table 1: Maximum and minimum daily return of INAF and KAEF in the last 20 years.

No	Year	INAF					KAEF				
		Minimum Daily Return		Maximum Daily Return		Range	Minimum Daily Return		Maximum Daily Return		Range
		Date	%	Date	%		Date	%	Date	%	
1	2002	14-Oct-02	-14%	28-Oct-02	9%	23%	14-Oct-02	-13%	28-Oct-02	19%	33%
2	2003	17-Jun-03	-14%	16-Sep-03	30%	44%	17-Sep-03	-17%	16-Sep-03	29%	46%
3	2004	17-May-04	-42%	29-Nov-04	23%	65%	23-Jun-04	-7%	27-Oct-04	8%	15%
4	2005	29-Aug-05	-15%	23-Sep-05	24%	40%	29-Aug-05	-11%	28-Nov-05	11%	21%
5	2006	10-May-06	-8%	8-Sep-06	10%	18%	5-Oct-06	-7%	12-Dec-06	10%	18%
6	2007	15-Aug-07	-11%	26-Jun-07	30%	40%	16-Aug-07	-24%	25-Jun-07	17%	42%
7	2008	8-Oct-08	-27%	8-Sep-08	22%	50%	8-Oct-08	-24%	14-Oct-08	10%	33%
8	2009	23-Mar-09	-23%	19-Mar-09	30%	53%	23-Mar-09	-27%	19-Mar-09	30%	56%
9	2010	25-May-10	-10%	6-Jan-10	14%	23%	26-Oct-10	-8%	21-Oct-10	9%	18%
10	2011	22-Sep-11	-11%	25-Oct-11	26%	36%	5-Aug-11	-7%	23-Jun-11	22%	28%
11	2012	30-Apr-12	-9%	5-Dec-12	17%	25%	4-Jun-12	-9%	13-Nov-12	22%	31%
12	2013	27-Aug-13	-11%	17-May-13	11%	22%	20-Aug-13	-17%	10-Sep-13	12%	29%
13	2014	16-Dec-14	-8%	9-Dec-14	22%	31%	19-May-14	-5%	9-Jan-14	12%	17%
14	2015	24-Aug-15	-15%	11-Nov-15	12%	27%	11-Aug-15	-10%	7-Oct-15	11%	21%
15	2016	30-Dec-16	-11%	15-Jan-16	28%	39%	13-Sep-16	-10%	22-Nov-16	22%	32%
16	2017	23-Jan-17	-29%	16-Oct-17	22%	51%	13-Jan-17	-10%	12-Apr-17	22%	32%
17	2018	2-Jul-18	-20%	24-Sep-18	22%	42%	5-Sep-18	-7%	30-May-18	22%	29%
18	2019	12-Dec-19	-29%	27-Dec-19	22%	51%	12-Dec-19	-15%	17-Dec-19	22%	37%
19	2020	28-Feb-20	-16%	7-Dec-20	22%	38%	9-Mar-20	-18%	7-Dec-20	22%	40%
20	2021	24-Jun-21	-7%	21-Jun-21	22%	30%	19-Jul-21	-7%	21-Jun-21	22%	29%
Average			**-16%**		**21%**	**37%**		**-13%**		**18%**	**30%**

As shown in Table 1, there was a higher fluctuation of daily return in the period of 20 years. INAF reached its maximum daily return of 30% on 16 September 2003, 26 June 2007, and 19 March 2009, while the minimum return was -42% on 17 May 2004. Additionally, KAEF received the maximum return of 30% on 19 March 2009 and the minimum return of -27% on 23 March 2009. From the table, it can be observed that the widest range was 56% in the year 2009.

Both Figure 1 and Table 1 show that investor was presented with risk due to the return volatility of both INAF and KAEF. As a result, this volatility could create either profitable return value to the investors or cause some degree of risk that can lead to return loss.

Previous similar studies have compared pricing option models with different volatility approaches to decide on which model was the best to use (see Bhat et al., 2016; Bi et al., 2014; Hendrawan, 2013; Hendrawan, 2018; Hendrawan, Akbar, et al., 2020; Hendrawan & Sasmito, 2021; Kartika, 2010; Sheraz & Preda, 2014; Zakaria & Abdalla, 2012). However, there was a limited number of research conducted on the Indonesian stock market.

This study focuses on testing and comparing two models with different volatility approaches on the pharmaceutical BUMN holding company stocks to select the most accurate model. The investing strategy application on contract options would define the amount of investment. The strategy of choice will be influenced by the volatility of the investment object. The strategy used in this study was the long straddle strategy, which is believed to be able to counteract against high fluctuation of the stock market situation. This strategy was also used when the investors were unsure whether the price movement would go up or down on the expiration time. In the long straddle strategy, investors pay calls and put options at the same time with the same execution price and expiration time. With the aforementioned data and phenomena, this study aims to test different option models on the pharmaceutical state-owned enterprises holding companies from 2002 to 2021 using the long straddle strategy.

II. LITERATURE REVIEW

A) Option Theory

In the early 1970s, Fischer Black, Myron Scholes, and Robert Merton achieved a remarkable breakthrough in the determination of stock option pricing. It involved an advancement of the model coined as the Black-Scholes (or sometimes Black-Scholes-Morten) model. This model defined how volatility could be predicted from historical or implied option pricing. From different studies on volatility modelling, there is a model entitled generalized autoregressive conditional heteroskedasticity or GARCH (1,1) that was coined by Bollerslev (1986). The formulas for GARCH (1,1) are stated below.

$$\sigma_n^2 = \gamma V_L + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2 \dots\dots\dots\dots\dots\dots.(1)$$

If the weight of γ is assigned for V_L, the weight of α is assigned for u_{n-1}^2, and the weight of β is assigned for α_{n-1}^2, then the total of all constants must be equal to 1.

$$\gamma + \alpha + \beta = 1 \quad (2)$$

If it is determined that $\omega = \gamma VL$, then the GARCH (1,1) model can be defined as:

$$\alpha^2 = \omega + \alpha u_{n-1}^2 + \beta\sigma_{n-1}^2 \quad (3)$$

Hull (2019) stated that for the stable GARCH modelling process, it is assumed that $\alpha + \beta < 1$

B) Long Straddle Strategy

Long Straddle Strategy is a strategy that would give profit to the buyer or investor if the stock price prediction on its expiration time from the contract option moves significantly upward towards the call option or downward towards the put option from the current stock price subtracted with the premium value of the put option. Because the investor can earn from this method regardless of how much the stock price changes before the option contract expires, they would only buy after the current price of the stock (at the money position). The premium value of both call and put options represents this strategy's maximum loss potential. Figure 2 below shows the graph of potential profit and loss of the Long Straddle Strategy.

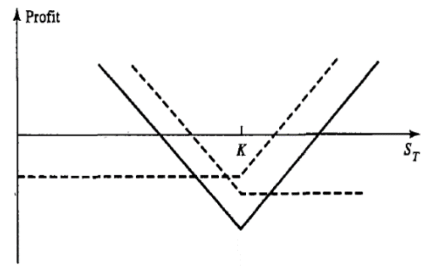

Figure 1: Potential profit and loss from Long Straddle Strategy (Hull, 2019)

C) Previous Research

Hendrawan & Sasmito (2021) tested the application of option contracts using Black Scholes and GARCH models on index LQ45 with Long Straddle Strategy from 2009 to 2019. According to the outcome, for an option contract with a one-month due date, the Black Scholes model showed better results than the GARCH model, with a 2.77% error value on the call option and 1.56% on the put option. When changed to a two-month due date, the GARCH model appeared to be better than the Black Scholes model, with an 8.12% error value on the call option and 4.00% on the put option. Lastly, using a three-month due date, the Black Scholes model returned to be better than the GARCH model, showing a 12.38% error value on the call option and 5.50% on the put option. The use of the Long Straddle Strategy on LQ45 in this period of time only achieved a maximum of 60% profitability with an average of approximately 30%.

Prior to that, Hendrawan et al. (2020) compared the accuracy of the index option between Black Scholes and the GARCH option model using IHSG data from 2009 to 2018 using the Long Straddle Strategy. Black Scholes model was more accurate for the put option for the one-month option with 0.18%, while the GARCH model was more accurate for the call option with 0.26%. For the two-month option, both presented a similar pattern in which the GARCH model was more accurate for the call option with 0.92% and the Black Scholes model for the put option with 0.26%. Finally, the Black Scholes model had better accuracy for the three-month option, with 2.00% and 0.31% for call and put options, respectively.

Another study by Bhat et al. (2016) aimed to empirically observe the pricing option of currency traded in the stock market using the Black-Scholes-Merton (BSM) Option Pricing Model and Duan's non-linear GARCH (NGARCH) option pricing model. In this study, the comparison of pricing performance and biases from the two models was made within the volatility period in the current market of exchange-trade currency in India. The results were the opposite of what the researchers intended: the more advanced NGARCH model calculated weaker pricing performance compared to the simpler BSM model. However, the orthogonality test presented that the NGARCH model is free of the strike price and expiration biases in relation to the BSM model. It was concluded that deterministic BSM performed a much better pricing option function compared to the time-varying volatility model based on GARCH.

Narayan et al. (2016) conducted a test based on the GARCH model for a unit root. Two endogenous structural breaks were allowed in the model. The test was performed on the unit root of 156 US stocks listed on the NYSE in the period of 1980 to 2007. From the results, the null hypothesis of the unit root was rejected in 40% of the stocks. Additionally, the null hypothesis was rejected in 50% of the stocks in four out of nine sectors. In conclusion, using the economic significance analysis, this study showed that most of the stocks with mean-reverting prices tend to do better than the stocks with non-stationary prices.

Lastly, a study by Bi et al. (2014) highlighted the 64% increase in the Indian capital market in only a decade period. The trading turnover of options in FY11 reached Rs. 193.95.710 crore, and the volume of trade that was generated by the market options reached almost twice as much as the volume generated in the combination of both the cash market and the future market. Therefore, it showed the importance of stock trading and pricing options in the derivatives market of India. Additionally, volatility was a crucial factor that affected the option pricing, but it was very difficult to predict. Consequently, the accurate volatility estimation must be taken into account. Volatility estimation can be used to determine the stock option or future options. Empirical research has shown that differences in historical volatility use in option pricing models would create biases in pricing. The GARCH model can be a solution for this matter, and this research utilized the GARCH model to estimate the volatility and later use it in the BSM model to calculate option pricing.

D) Research Methodology

As quantitative research, this study seeks to implement option theory using Black Scholes and GARCH models. The purpose of this study is to compare the implementation of both option theories for stocks related to the pharmaceutical BUMN holding company PT Indofarma, Tbk (INAF) and PT Kimia Farma, Tbk (KAEF). Data used were daily closing prices of PT Indofarma, Tbk (INAF) and PT Kimia Farma Tbk (KAEF) that were calculated into daily returns. This research used secondary data (i.e., daily closing prices) which were obtained from Bloomberg in the period of 2002 to 2021.

The analysis method used was the average percentage mean squared error (AMSE), in which the lower the AMSE, the better the model. The formula is as stated below.

$$\text{AMSE} = \frac{1}{N}\sum_{t=1}^{N}\left(\frac{APt-SPt}{APt}\right)^2 \quad \ldots\ldots(4)$$

Here,
Apt = Actual premium value
SPt = Premium value of the model calculation result
N = Number of experiments

In this research, it was assumed that the actual premium value is the exercise price subtracted from the index in its expiration time (one-month, two-month, and three-month periods).

III. RESULTS AND DISCUSSION

A) Comparison of volatility

Volatility calculation was conducted using historical volatility data (one and three months) and the GARCH model over a period of 20 years. The results are shown in Table 2 below.

Table 2: Comparison of volatility calculations

Volatility	INAF			KAEF		
	Avg	Max	Min	Avg	Max	Min
Historical Volatility BS	57.16%	253.30%	6.91%	47.85%	220.52%	8.93%
GARCH	60.24%	341.32%	25.59%	52.32%	265.85%	26.00%

Table 2 shows that INAF daily returns from 2002 to 2021 were 4,709. Based on the volatility calculations, the average volatility value was 57.16%, with a maximum of 253.30% and a minimum of 6.91%. Meanwhile, the GARCH model presented 60.24% average volatility with a maximum of 341.32% and a minimum of 25.59%. In the same period of time, KAEF's daily return was 4,838. Black Scholes's model showed a volatility average of 47.85% with a maximum of 220.52% and a minimum of 8.93%.

In contrast, the GARCH model calculated 52.32% average volatility with a maximum of 265.85% and a minimum of 26.00%. It appeared that the more the observations conducted, the lower the maximum volatility value was. In reverse, the more observations conducted, the higher the minimum volatility value was. The calculation of annual historical volatility and GARCH volatility for both INAF and KAEF in the period of 2002 to 2021 were some of the variables that can be utilized in determining option pricing with the Black Scholes model. The average volatility of the GARCH model for both INAF and KAEF presented higher values when compared to annual historical volatility.

B) Profit from Implementing Long Straddle Strategy

Table 3: Profit from Long Straddle Strategy Implementation

Holdings		1 month		3 months	
		Black Scholes	GARCH	Black Scholes	GARCH
INAF	Avg	43%	39%	47%	43%
	Max	73%	74%	92%	93%

	Min	18%	16%	22%	16%
KAEF	Avg	40%	35%	47%	42%
	Max	59%	56%	78%	72%
	Min	13%	9%	10%	5%

Table 3 presents the profit ratio for INAF and KAEF using Black Scholes and GARCH models in the period of 2002-2021. Following this calculation, the Black Scholes model appeared to have higher profitability in the three-month period for both INAF and KAEF compared to the GARCH model.

C) Testing Black Scholes and GARCH Models

Table 4: GARCH and Black Scholes model AMSE results

Holdings	Maturity	Option	AMSE		Remarks
			BS	GARCH	
INAF	1 month	Call	6.28%	6.30%	Model BS was better than GARCH(1,1)
		Put	4.28%	4.28%	Model BS was better than GARCH(1,1)
	3 months	Call	20.38%	20.55%	Model BS was better than GARCH(1,1)
		Put	14.83%	14.69%	Model GARCH(1,1) was better than BS
KAEF	1 month	Call	5.24%	5.38%	Model BS was better than GARCH(1,1)
		Put	3.29%	3.35%	Model BS was better than GARCH(1,1)
	3 months	Call	14.59%	15.00%	Model BS was better than GARCH(1,1)
		Put	9.67%	9.50%	Model GARCH(1,1) was better than BS

In Table 4, the AMSE calculation of Black Scholes and GARCH models for INAF and KAEF in the period of 2002-2021 showed that the Black Scholes model was more accurate than the GARCH model in the one month for both calls and put options. Meanwhile, the GARCH model appeared to be more accurate than the Black Scholes model in the three-month period for the put option. Furthermore, longer contract time caused a higher error rate in both models.

D) Discussion

This research has given theoretical evidence that the Long Straddle Strategy did not appear to be the best strategy to implement the contract option for pharmaceutical BUMN holdings from 2002 to 2021. On average, the Long Straddle Strategy only allow both INAF and KAEF to reach approximately 42% profitability, with the maximum profitability of 9% occurring in 2016 with a three-month expiration time.

The findings also showed that the Black Scholes model performed better than GARCH based on the error value given by the Long Straddle Strategy. This result supports previous studies by Hendrawan & Sasmito (2021) using used LQ45 index from 2009 to 2018; Hendrawan, Akbar, et al. (2020) stated that the Black Scholes model had better contract options on gold price than the GARCH model in the period of one-month, two-month, and three-month, and lastly Bhat et al., (2016) in which deterministic Black Scholes model did a better job in pricing option than the time-varying volatility model based on GARCH.

IV. CONCLUSION

To conclude, the use of contract options for pharmaceutical state-owned enterprises holdings from 2002 to 2021 resulted in better performance when the Black Scholes model was implemented compared to the GARCH model. This can be observed from the average percentage mean squared error (AMSE) values on the call and put options on the one-month and three-month expiration time in which the AMSE values of the Black Scholes model were lower than the GARCH model. In this research, the GARCH model only outperformed the Black Scholes model in the three-month expiration time in which the GARCH model had lower AMSE values in the put option.

Long Straddle Strategy did not give significant results in the implementation of the pharmaceutical state-owned enterprises holdings. Based on the tests on one-month and three-month expiration times, the contract option reached maximum profitability of up to 93% and minimum profitability of only 5%. Average profitability was roughly 42%. The due date of the option contract caused a linear effect on the error percentage of each model. The higher the due date, the higher the AMSE value and vice versa. This phenomenon applies to both the call option and the put option.

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