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Research Article

Comparing Black-Scholes and GARCH Models in Long Strangle Option Strategies for LQ45 Index

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Abstract
This study compared the Black-Scholes and GARCH models in a long strangle strategy applied to the LQ45 index using closing price data from 1998 to 2021. It aimed to assess the benefits, calculate returns during crises and non-crisis periods, and evaluate performance through Average Mean Square Error (AMSE). The Black-Scholes model consistently outperformed GARCH in one- and three-month options. One-month options had an average return of 28.64%, and three-month options, 43.31%. In crises, Black-Scholes delivered average profits of 43.36% for one-month and 45.14% for three-month options. In non-crisis conditions, profits averaged 26% for one-month and 42.84% for three-month options. Model performance varied by option type and market context. Black-Scholes excelled in one-month call options (1.268% error), while GARCH performed better in one-month put options (1.0981% error). For three-month options, GARCH outperformed in call options (1.270% error), and Black-Scholes dominated put options (3.117% error). In summary, the choice between models should consider market conditions, favoring GARCH during crises and Black-Scholes in non-crisis scenarios.

Keywords: Black Scholes, GARCH, Option Contract, Long Strangle, LQ45 Index

JEL Classification: C58, G12, G14

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1. Introduction

The capital market is an important sector in a country's economy which plays a crucial role in allocating resources to productive sectors. In the capital market, investors have various choices of investment instruments, one of which is options trading. An option is a financial contract that gives the holder the right, but not the obligation, to buy or sell a certain asset at a certain price within a certain time period (Pratiwi, 2020).

One interesting options trading strategy to analyze is the Long Strangle Option strategy. This strategy involves purchasing two types of options, namely a call option and a put option with different strike prices, but with the same maturity date. The aim of this strategy is to profit from significant price movements, both up and down (Surur & Isynuwardhana, 2018).

In implementing the Long Strangle Option strategy, it is very important to have an accurate estimate of the option price. Two models that are often used in assessing option prices are the Black-Scholes Model and the GARCH Model. The Black-Scholes model has been a theoretical basis in options valuation for many years, but it assumes constant market volatility. On the other hand, the GARCH Model considers volatility fluctuations that may occur in real financial markets (Febrianti, 2018).

The LQ45 stock index comprises 45 firms with the market's largest and most liquid capitalization. The LQ45 index has been listed on the IDX since 1997 and has attracted the attention of many investors today. In the capital market, various types of investment bring together the capital owners and companies that need funds. Investors must be able to decide the type of investment to grow their capital with low to high risks. One type of investment in the capital market is stocks.

The following is an overview of the returns on the LQ45 Stock Index for the period 1998-2020

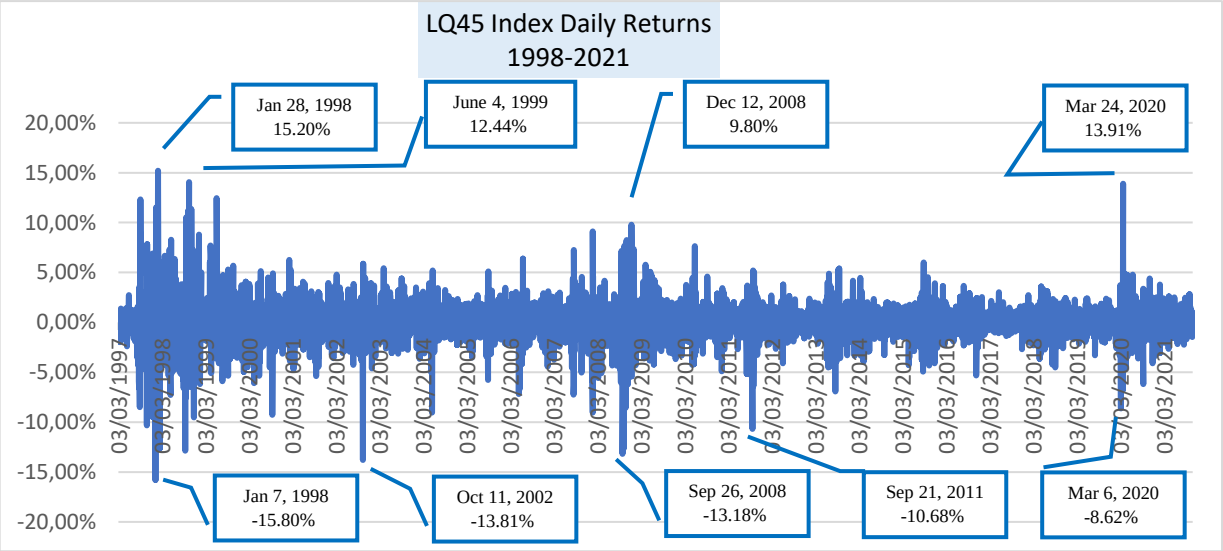


Figure 1. LQ45 Daily Returns 1998-2021 Period

From the figure above, it can be inferred that the daily returns on the LQ45 Index varied significantly, with the highest movement of 15.20%, which occurred on January 28, 1998, and the highest decline on January 7, 1998. The highest range of movement occurred during the economic crisis in 1998, as much as 30.99%, then in 2008 with a range of 22.98%, and when the Covid-19 pandemic attacked Indonesia in March 2020, the movement range was 22.53%.

Based on the volatility data above in both crisis and non-crisis years, this volatility movement potentially gave investors a profit or even a loss. To avoid losses, investors must minimize risk by using derivative instruments as a hedging tool, one of which is options. Hendrawan et al. (2020) defined an option as an investment instrument that functions as a tool to generate both returns and as a hedge.

Hendrawan & Sasmito (2021) found that using the long straddle strategy on the LQ45 index in 2009-2018 only reached a maximum of 60% profit potential, with an average potential profit of around 30%. Furthermore, Hendrawan et al. (2020) revealed the maximum profit potential by implementing the long straddle strategy on the option contract of the gold price index in 2008-2018 of 54.98% with an average profit potential of around 25-30%.

Previous studies have proven a significant difference between the profit potential (54.98% - 60%) and the average profit value of 25-30%. This finding means that there is still a certain amount that can be earned with this strategy, in contrast to the statement of Hull (2012) that the profits earned can be unlimited. After analyzing the phenomena above complemented by previous studies, this study aims to test the Black Scholes and GARCH models and calculate the potential profits obtained using the long strangle strategy.

2. Literature Review and Hypothesis

A derivative instrument is a contract agreement between two or more parties to trade a number of current assets at an agreed price but to be used in the future with a date predetermined in the contract (Dewi & Purnawati, 2016). Hull (2012), an option is a contract granting the owner the right to sell or purchase an asset at an agreed price, time, and amount. There are two basic types of options: call option and put option. A call option grants the owner the right to purchase an asset at a certain price, time, and amount, while a put option grants the buyer the right to sell an asset at a certain price, time, and amount (Mooy et al., 2017). The price agreed upon in the option contract is called the strike price or exercise price (Irawan et al., 2019). There is also an expiration date as the agreed due date during the option transaction.

Black Scholes Model

In 1973, Fischer Black, Myron Scholes, and Robert Merton achieved a major breakthrough in European stock option pricing. This breakthrough became known as the Black-Scholes-Merton (or Black-Scholes) model. Black-Scholes is a pricing model implemented to determine the fair price or value for call option and put option based on six variables: volatility, type of option, stock price, time, strike price, and risk-free interest rate (Hull, 2012).

According to Hendrawan (2010), in the Black & Scholes model, to calculate the expected rate of return, the basis of the risk-free asset variable is used to replace the expected return variable. The Black-Scholes equation for the call option is as follows:

$$C = SN(d1) - e^{-R_f T} XN(d2) \quad (1)$$

Meanwhile, the equation for the put option is as follows:

$$P = Xe^{-R_f T}N(-d2) - SN(-d1) \quad (2)$$

In which:

$$\mathbf{d1} = \left(\ln \frac{[S/X] + \left[R_f - \frac{\sigma^2}{2}\right]}{\sigma\sqrt{T}} T \right) \quad (3)$$

$$\mathrm{d2} = d1 - \sigma\sqrt{T} \quad (4)$$

Where:
S = spot stock price
X = Execution price (strike price)
T = Due time
Rf = Risk-free interest rate
σ = stock price variance/volatility
C = Call option value
P = Put option value
e = natural logarithm
Ln = natural algorithm

Garch Model

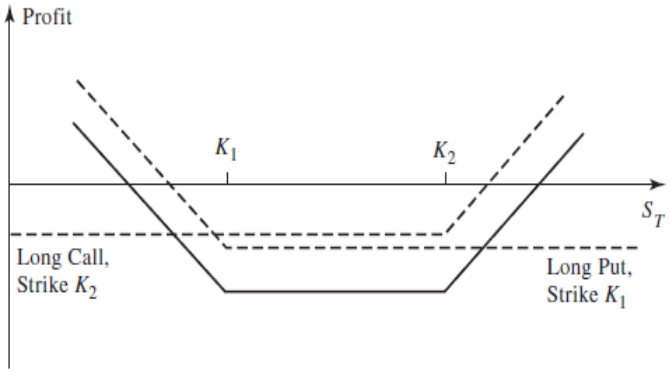
Bollerslev (1986) developed the GARCH parsimony model, selecting a simpler model so that the variance is always positive. Hendrawan (2010), the GARCH model provides a more flexible framework for capturing conditional variances' dynamic structure. The GARCH model can be delivered as follows:

$$\sigma^2=\gamma VL+\alpha u\_(n-1)^2+\beta\sigma(n-1)^2 \quad (5)$$
$$\omega=\gamma VL \quad (6)$$
$$\sigma^2=\omega+\alpha u(n-1)^2+\beta\sigma(n-1)^2 \quad (7)$$

Description:
σ^2 = error variation at time n
ω = constant component
α = ARCH parameter
β = GARCH parameter
VL = long-term variation

If ω,α dan β can be estimated, then we can calculate:
γ as 1-α-β. In a stable GARCH process, it will conform to the equation $\alpha+\beta<1$.

Long Strangle Strategy
Strangle is an options strategy comprising call options and put options with the same due date and different redemption values. The redemption value in a put option is lower it in a call option. In the strangle strategy, investors wager that there will be a significant price movement (Dewi & Ramli, 2018). The benefits of this strategy will always be obtained on broad stock price movement, with limited risk and unlimited profit potential if the price moves considerably and is cheaper than the straddle. The disadvantage of this strategy is that it requires a significant movement to make a profit (Hull, 2012).



Source: Hull (2012)

Figure 2. Strangle Strategy Model

Previous Studies
Hendrawan & Sasmito (2021) conducted a study using the Long Straddle strategy to evaluate the application of option contracts to the Black-Scholes option model and the GARCH option model on the LQ45 Index. The findings of this study were obtained by comparing the average percentage value of the square root of the error from the Black-Scholes and GARCH models with the implementation of the Long Straddle strategy.

Next, Hendrawan et al. (2020) used AMSE to examine the accuracy of two historical volatility models using the Black-Scholes and GARCH volatility models based on the ARIMA model lag. JCI data for 2009-2018 used the long strangle strategy. The results show that the GARCH model was more accurate than the Black-Scholes for one- and two-month call options with a yield of 0.26% and 0.92%, while for one- and two-month put options, the Black-Scholes model was more accurate with a value of 0.18% and 0.26%. For the three months, Black Scholes was more accurate in both put and call options with values of 2% and 0.31%.

Furthermore, Hendrawan (2010) compared the Black-Scholes and the GARCH option models for Astra, BCA, Indofood, and Telkom stock options on the Indonesia Stock Exchange. This study

aimed to find the best lag of the GARCH model, which was formed from the best ARIMA. The selection of the best GARCH model was visible from the lowest AIC and SIC. Subsequently, the best GARCH model was estimated for the value of the variance to be used as a basis. Finally, Harikumar et al. (2004) empirically examined the performance of option prices using both the Black Scholes and GARCH models, using data for British Pounds, Swiss Francs, and Japanese Yen. The dominant test was performed, and the average error (AMSE) was calculated. This study revealed that the Black Scholes model outperforms the GARCH model.

3. Data and Method

This study employs a quantitative method with comparative and verification approaches. Verification equals examining the truth of a theory or a previous study. According to Morse et al. (2016), verification confirms the existing theory by examining and validating it. This study compared the LQ45 index data during crisis and non-crisis conditions and compared the best model between Black Scholes and GARCH in one- and two-month periods.

To acquire the best analysis of the model, a mathematical function is required for the average percentage mean squared error (AMSE) method.

$$AMSE = \frac{1}{N}\sum_{t=1}^{N}\left(\frac{APt-SPt}{APt}\right)^2 \quad (8)$$

Description:
Apt = Actual option premium value
SPt = option premium value calculated by model
N = Number of conducted experiments

In practice, the lower the AMSE value, the better the results.

4. Results

Calculating the profit percentage of the long-strangle strategy during the crisis and non-crisis years

Before calculating the percentage of profits gained from using the long strangle strategy, firstly, the volatility of Black Scholes and GARCH was calculated with a total of 5798 LQ45 index price data for the 1998-2021 period with the following results:

Table 1. Volatility of Index LQ45

Volatility	Average	Lowest	Highest
Black Scholes	24.91%	6.02%	111.27%
GARCH	25.11%	6.85%	122.40%

Based on the table above, it can be inferred that the volatility of GARCH was higher than that of Black Scholes, for the average volatility of GARCH was 25.11%, the lowest volatility was 6.85%, and the highest was 122.40%.

The following are the results of the profit calculation of the Black Scholes and GARCH models in the years of crisis:

Table 2. Profits during Crisis Years

Year	One-month		Three-month	
	Black Scholes	GARCH	Black Scholes	GARCH
1998	48.58%	48.99%	42.51%	41.30%
2008	37.29%	36.86%	47.03%	46.19%
2020	44.21%	43.80%	45.87%	45.45%
Average	43.36%	43.22%	45.14%	44.31%
Lowest	37.29%	36.86%	42.51%	41.30%
Highest	48.58%	48.99%	47.03%	46.19%

During years of economic crisis, the profit of the Black Scholes model was greater than the GARCH model, with an average of 43.36% for the one-month option and 45.14% for the three-month option. Meanwhile, during non-crisis years, the profit earned was lower, on average 26.39% for the one-month option and 42.84% for the three-month option, in which the Black Scholes model was still better than the GARCH model, according to the following table:

Table 3. Comparison of Profits during Crisis and Non-Crisis Years

Conditions		One-month		Three-month	
		Black Scholes	GARCH	Black Scholes	GARCH
Crisis	Average	43.36%	43.22%	45.14%	44.31%
	Lowest	37.29%	36.86%	42.51%	41.30%
	Highest	48.58%	48.99%	47.03%	46.19%
Non-crisis	Average	26.39%	26.20%	42.84%	42.59%
	Lowest	6.50%	6.50%	18.29%	18.29%
	Highest	47.11%	47.11%	78.51%	77.27%

Determining the best model from Black Scholes and GARCH for one- and three-month options during crisis and non-crisis conditions.
The following table shows the AMSE calculation of the Black Scholes and the GARCH models with one-month and three-month option contracts to determine the best model.

Table 4. Calculation of the Best Model

Period	AMSE	Model		Results
		Black Scholes	GARCH	
One-month	Call	1.268667%	1.270755%	Black Scholes was better than GARCH.
	Put	1.098229%	1.098149%	GARCH was better than Black Scholes
Three-month	Call	4.196231%	1.270755%	GARCH was better than Black Scholes
	Put	3.117565%	3.120434%	Black Scholes was better than GARCH.

For the one-month option contract, the Black Scholes model was better than the GARCH model for call options with an error value of 1.268%, while for put options, the GARCH model was better with an error value of 1.0981%. For the three-month option contract, the GARCH model was better than Black Scholes for call options with an error value of 1.270%, while on the contrary, the put option of the Black Scholes model was better with an error value of 3.117%.

Furthermore, this study compared AMSE values during crisis and non-crisis years.

Table 5. AMSE calculation during the crisis and non-crisis years

Conditions	Period	AMSE	Model		Results
			Black Scholes	GARCH	
Crisis	One-month	Call	4.65950%	4.67127%	Black Scholes was better than GARCH.
		Put	2.93634%	2.92504%	GARCH was better than Black Scholes
	Three-month	Call	18.66460%	4.67127%	GARCH was better than Black Scholes
		Put	9.41829%	9.41340%	GARCH was better than Black Scholes
Non-crisis	One-month	Call	0.77909%	0.77978%	Black Scholes was better than GARCH.
		Put	0.82688%	0.82843%	Black Scholes was better than GARCH.
	Three-month	Call	2.11416%	0.77978%	GARCH was better than Black Scholes
		Put	2.19592%	2.19992%	Black Scholes was better than GARCH.

During the 1998, 2008, and 2020 crises, the GARCH model tended to be better than Black Scholes

for both one-month and three-month options, except for the one-month call option contract, the Black Sholes model was better with an error value of 4.65%. Meanwhile, during non-crisis, the Black Scholes model tended to be better except for call option contracts for the three months; the GARCH model was better with an error value of 0.779%.

5. Discussion

The calculation results of this study prove that the long strangle strategy could generate profits greater than 60%, as can be seen in the Black Scholes model and the GARCH model with a three-month option contract that occurred in 2001 with a profit of 70.73%-71.54%, in 2002 with a profit of 62.86%-63.27%, in 2007 with a profit of 65.45%-66.26%, and in 2003 with a profit of 77.27%-78.51% which made the highest profit in this long strangle strategy.

Another interesting thing was that during years of crisis, the profit with this long strangle strategy was, on average, greater than that during non-crisis for both the Black Scholes and GARCH models for one-month and three-month options. For one month, the profit ranged from 43.22%-43.36%, and for three months, 44.31%-45.14%, but this profit was still lower than the profit that has occurred in a few non-crisis years with a maximum profit of 78.15%.

An analysis was done to determine the best model by comparing AMSE values for the Black Scholes and GARCH models for one-month and three-month option contracts during crisis and non-crisis conditions. From the research results, the average error value was higher during the economic crisis than during non-crisis. At the same time, the best model was obtained with the lowest error value.

6. Conclusion

This study has proven that the long strangle strategy can generate a profit greater than 60%; the Black Scholes model could generate the highest profit of 78.51%, while the GARCH model can generate the highest profit of 77.27%. However, the average profit obtained was 28.51% for the Black Scholes model, 28.33% for the GARCH model for the one-month option, 43.13% for the Black Scholes model, and 42.81% for the GARCH model for the three-month option.

The Black Scholes model gained higher profits than the GARCH model for both one-month and three-month option contracts during the crisis and non-crisis conditions. For a one-month contract during the crisis, the average ratio of Black Scholes to GARCH was 43.36% vs. 43.22%, non-crisis 26.39% vs. 26.20%, for three-month options contracts was 45.14% vs. 44.31% during the crisis and 42.84% vs. 42.59% during non-crisis.

A three-month option contract could generate an average of 33.86% greater profit than a one-month option contract in both the Black Scholes and the GARCH models. During a crisis, profits increased by an average of 34.35% for the one-month option and 3.92% for the three-month option.

The best model was obtained in this study for a one-month option contract; the Black Scholes model was better than the GARCH model for call options (1.268% vs 1.270%), while the GARCH model was better than the Black Scholes model for put options (1.0981% vs 1.0982%). For the three-month contract, the GARCH model was better than the Black Scholes model for call options (1.027% vs. 4.196%), and vice versa, the Black Scholes model was better than the GARCH model for put options (3.117% vs 3.120%).

During the crisis, the GARCH model performed better than the Black Scholes model except for the call option for the one-month option; the Black Scholes model was better than GARCH (4.659% vs. 4.671%). Meanwhile, during non-crisis, the black Scholes model was better than GARCH except for the call option in the three-month option (2.114% vs. 0.779%).

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Ethics declarations

Availability of data and materials

Data sharing does not apply to this article as no new data were created or analyzed in this study.

Competing interests

The authors reported no potential competing interest.