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ARCH MODEL FOR FORECASTING BCA BANK STOCK PRICE VOLATILITY

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Abstract: *This research analyzes the Autoregressive Conditional Heteroskedasticity (ARCH(p) model to predict the BCA Bank share price in the range of January 2013 to November 2023. BCA Bank's share price, as one of the shares traded on the Indonesian Stock Exchange, requires accurate volatility modeling. Researchers initially use the ARIMA(0,1,2) model; however, due to heteroscedasticity, they apply the ARCH(8) model to overcome this issue. The results indicate that the ARCH(8) model yields the best performance, with the lowest AIC values for volatility. BCA Bank's daily stock price as of December 1, 2023, exhibited high volatility, indicating a significant risk to investors.*

Keywords**:** *ARCH, forecasting, heteroscedasticity, stock price, and volatility*

1. INTRODUCTION

Shares are one way investors earn income or returns [1]. Shares on the capital market can fluctuate up or down, and various factors influence them [2]. Some key influencing factors include market sentiment, macroeconomic conditions, and company fundamentals, among others. BCA Bank shares are one type of share on the Indonesian Stock Exchange.

BCA Bank is one of the private banks in Indonesia whose financial performance is a concern to investors. Therefore, it is necessary to analyze BCA Bank shares in the future to determine the returns from BCA Bank shares. However, in the case of BCA Bank share prices, there is volatility, so a model is needed that can handle this volatility. Modeling the volatility of BCA Bank share prices is of concern to investors in predicting future share prices of BCA Bank. Future BCA Bank share price movements can be predicted using one of the models, namely Autoregressive Conditional Heteroskedasticity (ARCH) [3].

Previous studies, such as that conducted by Agus Widarjono et al., have also examined financial volatility using the ARCH model. Their research focused on forecasting inflation in Indonesia and found that inflation volatility was generally high, with several periods exhibiting relatively low volatility. Furthermore, the study compared the ARCH model with the Ordinary Least Squares (OLS) model and concluded that the ARCH model provided a better fit for modeling inflation volatility in Indonesia [4]. Similarly, Budiandru et al. investigated the volatility of the Indeks Saham Syariah Indonesia (ISSI) and its potential future dynamics using both the Autoregressive Conditional Heteroskedasticity (ARCH) and the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models. Their findings indicated that the ISSI exhibited considerable fluctuations in returns, with an average return of approximately 3% [5]. Building upon these previous studies, the present research aims to analyze the volatility of Bank BCA's stock prices, thereby extending the application of volatility modeling to the Indonesian banking sector.

Based on previous research that discusses volatility, this study will employ an ARCH model, which allows for share price volatility to be influenced by earlier fluctuations at any time. The ARCH model used in BCA share prices can help investors or users make informed investment decisions, enabling them to achieve optimal returns from BCA shares. Research on the use of the ARCH (Autoregressive Conditional Heteroskedasticity) model in predicting BCA stock price volatility involves statistical methods designed to handle heteroscedasticity, which is

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a condition where the error variance is not constant over time. The analysis process begins with checking the stationarity of the data using statistical tests, such as the Augmented Dickey-Fuller (ADF) test, and data transformation if necessary. Furthermore, the appropriate ARCH or GARCH model is selected based on information criteria, such as the Akaike Information Criterion (AIC), and model parameters are estimated using the maximum likelihood method. The novelty of this study lies in its focus on BCA stock volatility specifically, which provides in-depth insight into stock price behavior in the Indonesian capital market, as well as the potential for multivariate analysis to compare BCA stock volatility with other stocks. Additionally, this study offers practical insights for investors and risk managers, enabling them to understand market dynamics better and develop more effective risk management strategies. With a strong methodological approach and a focus on analytical novelty aspects, this study contributes to the academic literature while providing practical benefits for investment decision-making.

2. METHODOLOGY

2.1. Model Autoregressive Conditional Heteroskedasticity (ARCH)

The ARCH model is a time series analysis model [6]. In the ARCH model, assumptions are violated in diagnostic analysis, namely, the residuals are white noise [7]. One violation of the assumptions in the ARCH model is heteroscedasticity. Heteroskedasticity is a residual that is not constant, so the estimates obtained do not meet the requirements of being unbiased [8]. The general form of the ARCH model in Equation 1 is as follows [9].

$$a_t = \sigma_t \varepsilon_t \;\; ; \; \sigma_t^2 = \alpha_0 + \alpha_1 a_{t-1}^2 + \cdots + \alpha_m a_{t-m}^2 \tag{1}$$

with $\alpha_0 > 0$ and $0 \leq a_i < 1$ with i=1,2,…,q, where the previous residual variance influences the ARCH model on the current residual variance [10]. In the ARCH model, order determination can be seen in the PACF graph of the squared residuals a_t^2 [11]. Apart from determining the order in the ARCH model, determining the best model is also carried out in the ARCH model. One way to choose the best model in an ARCH model is to use Akaike's Information Criterion (AIC) [12]. The AIC value used in determining the best model is the smallest.

2.2. Research Methods

This research utilizes R Studio software and the daily Close BCA Bank share prices dataset from January 2, 2013, to November 30, 2023. The research utilizes R software for analysis. The research stages in the ARCH model are as follows.

1) Data Stationary Test

   Time series data is stationary if the time series is constant in mean and variance from time to time [13]. They are statistically checking stationarity using the ADF test. If the p-value is > 0.05, then the data is not stationary. Model identification

2) Model Identification

   Model identification can use Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) plots. ACF and PACF plots are also used to determine the model and model order. The ACF plot is used to determine Autoregressive (AR), while the PACF is used as a determinant of Moving Average (MA) [14].

3) Determining the Best Model

   One way to determine the best model is to use the AIC value. The AIC value is a time series model evaluation metric used to determine how well a model fits the data. A small AIC value indicates that the model is performing better or fits the data more closely.

4) Identify the ARCH model

   The ARCH test in the model utilizes the arch.test() function, which checks for heteroscedasticity. If the p-value is smaller than α = 5%, there is an element of heteroscedasticity in the residual model. The ARCH

model that can be predicted is an ARCH model with a p-value of the Lagrange Multiplier ARCH Test > 0.05. The ARCH model to be estimated is shown in Equation 1.

3. RESULT AND DISCUSSION

In time series data, there are four data patterns: horizontal or constant data patterns, seasonal data patterns, cyclical data patterns, and trend data patterns [15]. Based on the time series plot of BCA Bank daily shares for the period January 2013 – November 2023, which is shown in Figure 1.

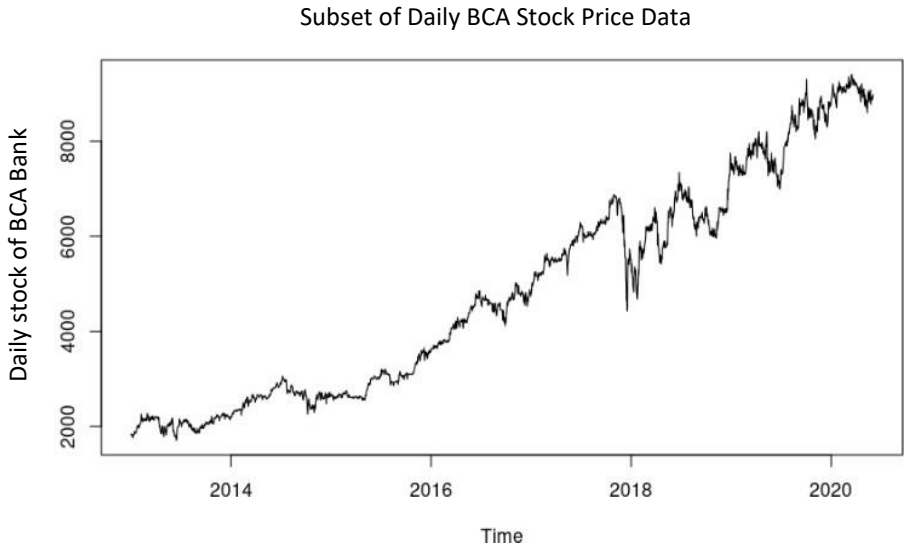

Figure 1. BCA Bank Daily Share Prices for the Period from January 2013 to November 2023

Figure 1 illustrates an upward trend that began in 2018. Based on Figure 1, the time series data is not stationary in mean or variance. Next, the Augmented Dickey-Fuller (ADF) test was carried out, which yielded a p-value greater than 0.05, indicating that the data is not stationary. Data non-stationarity can be handled by differencing the data. After differencing, the ADF test was carried out again, resulting in a p-value of 0.01, so it could be concluded that the data were stationary. Figure 2 shows the data pattern of BCA shares after stationarity. Next, model identification was carried out using the ACF and PACF plots in Figure 2.

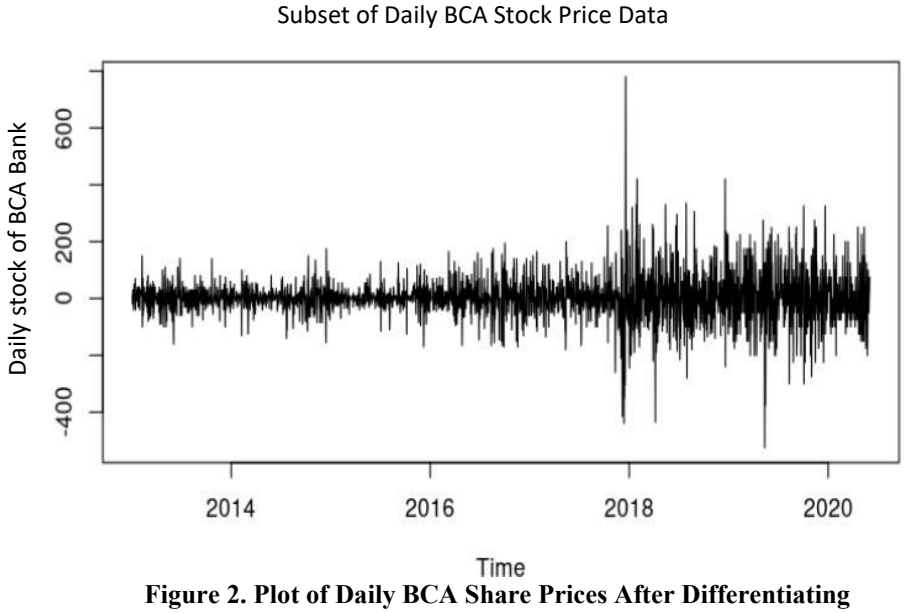

Figure 2. Plot of Daily BCA Share Prices After Differentiating

Figure 2 shows a time series plot of Bank BCA's daily stock prices from approximately 2013 to 2020. The horizontal axis (X-axis) represents time, while the vertical axis (Y-axis) shows the daily stock price changes of Bank BCA. The plot illustrates the fluctuations (volatility) of stock returns over time, with a dense concentration of data points around zero and several extreme spikes during specific periods.

From an academic perspective, the plot indicates the presence of non-constant volatility (heteroskedasticity) throughout the observation period. During the early years (2013–2016), the stock price movements appear relatively stable with low amplitude. However, from around 2017 to 2019, there was a noticeable increase in fluctuation amplitude, suggesting a rise in market volatility. The extreme spike around 2018 may correspond to a market shock or specific economic event that heightened uncertainty in stock prices. This pattern supports the core assumption of ARCH/GARCH models, where the residual variance is not constant but depends on past residual values—a phenomenon known as volatility.

Figure 3 shows the AR(p) and MA(q) orders in the ARIMA model. Based on Figure 3 of the ACF and PACF plots, the combination of AR(p) and MA(q) orders for the ARIMA model in predicting daily BCA stock data is ARIMA (0,1,1), ARIMA (0,1,2), ARIMA (1,1,2), ARIMA (2,1,2), and ARIMA (3,1,2).

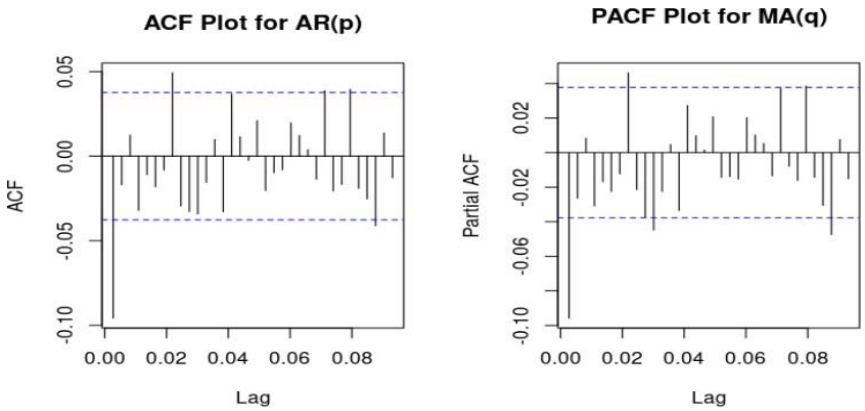

Figure 3 Plot ACF and PACF

Next, the best ARIMA model was selected based on the smallest AIC value, as shown in Table 1. The next stage is a diagnostic test to see whether the residuals from the ARIMA(0,1,2) model are white noise. The diagnostic test identifies heteroscedasticity from the ARIMA(0,1,2) model. One method used to identify heteroskedasticity is the ARCH test, as shown in Figure 4.

Table 1. The AIC value of each model

ARIMA MOdel	AIC value
ARIMA (0,1,1)	31095.16
ARIMA (0,1,2)	31071.32
ARIMA (1,1,2)	31072.71
ARIMA (2,1,2)	31073.74
ARIMA (3,1,2)	31075.86

Table 2 shows the p-value from the arch. test(), where the p-value is <5%, so there is heteroscedasticity in the residuals in the ARIMA(0,1,2) model. Since this model fails the heteroscedasticity diagnostic test, the ARIMA(0,1,2) model is unable to predict BCA share prices.

Table 2. Heteroscedasticity Identification

Portmanteau-Q test		
Order	**PQ**	**p.value**
4	259	0
8	478	0
12	648	0
16	735	0
20	790	0
24	839	0

Lagrange Multiplier test		
order	**LM**	**p.value**
4	4062	0
8	1456	0
12	946	0
16	665	0
20	523	0
24	433	0

Next, ARCH modelling is employed because the ARCH model can effectively handle heteroscedasticity problems. ARCH modelling in R Studio, using the gearshift function provided by the search library. The estimated parameters are p and q, which will be ARMA(0,2). The modelling function is GARCH(p,q), so the q value will be set to 0. So, GARCH(p,0) will be the same as ARCH(p). The ARCH model that can be predicted is an ARCH model with a p-value of the LM ARCH test > 0.05. The modeling carried out on BCA Bank's daily stock predictions shows that the models suitable for forecasts are the ARCH(7) and ARCH(8) models. Determining the best ARCH model uses the AIC values from the ARCH(7) and ARCH(8) models. The AIC value in the ARCH(7) model is 11.10, while the AIC value in the ARCH(8) model is 11.09. The smallest AIC values are found in the ARCH(8) model.

The ARCH(8) model will predict BCA share prices. The BCA share price predicted using the ARCH(8) model is shown for the next five days in Figure 4. Figure 4 shows that the BCA share price prediction generates volatility within the data interval. The green line shows the lower limit, the blue line shows the upper limit, and the prediction results are displayed on the red line.

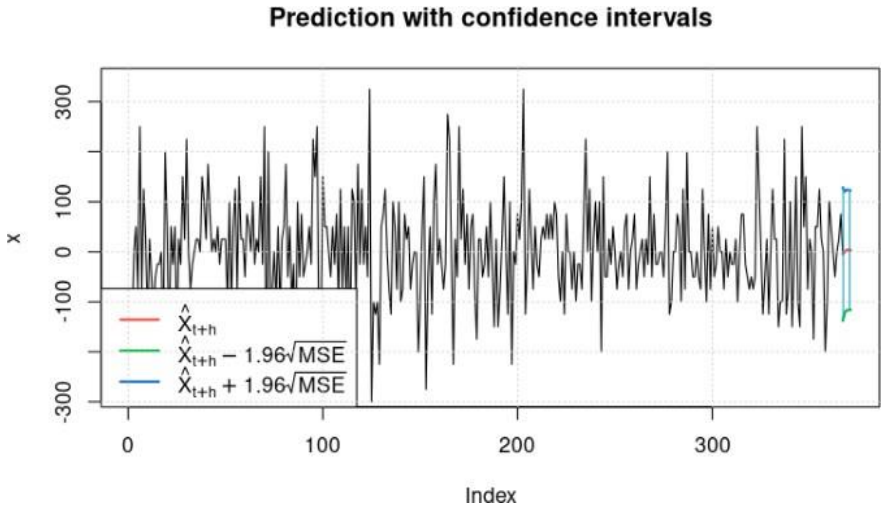

Figure 4 BCA Share Price Prediction Results

The ARCH(8) model estimates indicate that BCA Bank's daily stock price volatility fluctuates considerably throughout the observation period in Figure 4. This volatility reflects the degree of variation or instability in stock returns over time, measured from the squared residuals (error variance) of the regression model. In the ARCH framework, the conditional variance at time t (σ_t^2) is determined by a series of past squared residuals, representing the dependence of current volatility on previous market shocks. Consequently, when extreme price movements occur in prior periods, the model predicts higher volatility in subsequent periods. The resulting conditional standard deviation serves as an empirical measure of predicted daily fluctuations and can be used directly to assess market stability and investment risk levels.

Scientifically, these findings support the existence of the volatility clustering phenomenon in the Indonesian stock market, where periods of high volatility are often followed by subsequent periods of high volatility. This behavior suggests that market fluctuations are not purely random but exhibit dynamic patterns that can be modeled statistically. Both internal factors, such as corporate policies and financial performance, and external factors, including macroeconomic conditions and market sentiment, may influence the elevated volatility observed in BCA Bank's stock. Therefore, this study not only provides an empirical illustration of the degree of

uncertainty in BCA Bank's stock price but also makes an academic contribution by enhancing the understanding of dynamic volatility behavior and investment risk management within Indonesia's financial sector.

4. CONCLUSION

Based on the results and discussion presented in the BCA Bank Daily Share Price data from January 2013 to November 2023, the data can be modeled using the best ARIMA(0,1,2) model. However, due to the heteroscedasticity of the ARIMA(0,1,2) model, a model is needed to handle heteroscedasticity. One model that addresses heteroscedasticity is the ARCH (Autoregressive Conditional Heteroscedasticity) model. The best ARCH model is obtained with the smallest AIC values. The smallest AIC values are obtained from the ARCH(8) model. The prediction results of the ARCH(8) model indicate that the volatility of the predictions falls within the actual data interval.

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