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Estimated Value-at-Risk Using the ARIMA-GJR-GARCH Model on BBNI Stock

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Abstract

Stocks are investment instruments that are much in demand by investors as a basis in financial storage. Return and risk are the most important things in investing. Return is a complete summary of investment and the return series is easier to handle than the price series. The movement of risk of loss is obtained from stock investments with profits. One way to calculate risk is value-at-risk. The movement of stocks is used to form a time series so that the calculation of risk can use time series. The purpose of this study was to find out the Value-at-Risk value of BBNI Shares using the ARIMA-GJR-GARCH model. The data used in this study was the daily closing price for 3 years. The time series method used is the model that will be used, namely the Autoregressive Integrated Moving Average (ARIMA)-Glosten Jagannathan Runkle - generalized autoregressive conditional heteroscedastic (GJR-GARCH) model. The stage of analysis is to determine the prediction of stock price movements using the ARIMA Model used for the mean model and the GJR-GARCH model is used for volatility models. The average value and variants obtained from the model are used to calculate value-at-risk in BBNI shares. The results obtained are the ARIMA(1,0,1)-GJR-GARCH(1.1) model and a significance level of 5% obtained value-at-risk of 0.0705.

Keywords: Stock, Return, Risk, Value-at-risk, ARIMA-GJR-GARCH.

1. Introduction

Investment is a delay in consumption now to be put into productive assets during a certain period to get profits in the future and increase the asset value owned (Tandelilin, 2010). An investment that can be an option is a stock investment. Shares are securities as evidence of the inclusion or ownership of a person or legal entity over a company, especially the company that trades its shares.

Investing in stocks is faced with high risk because stock returns are volatile. Stock returns change in a very fast period so the value of stock indices also changes, this movement is known as stock return volatility. High volatility will result in high risk as well if low volatility results in low risk. How to estimate risk in investments can use Value at Risk. This research will use the Value at Risk method in conducting stock risk analysis with a time series model.

Some researchers have used various time series models in financial problems, one of which is the ARCH model introduced by (Engle R.F, 1982). (Sukono, 2019) researched the Model Autoregressive Integrated Moving Average-Generalized Autoregressive Conditional Heteroscedasticity (ARIMA-GARCH) conducted to estimate the shortfall of several stocks in the Indonesian capital market. Based on the analysis of the study, the closing data of each selected stock has an average value and standard deviation that varies from each other. In addition, (Xu, 2015) used the ARIMA-GJR-GARCH model to forecast the renminbi exchange rate against the Hong Kong dollar. The GJR-GARCH model can be used for asymmetric data invariance equations. Based on the analysis of the paper, the ARIMA (1,1,1)-GJR-GARCH (1.1) model is the best model for exchange rates and forecasting.

In this study, the model that will be used is the ARIMA-GJR-GARCH model to estimate the value-at-risk value of Bank Negara Indonesia Tbk (BBNI) shares. The purpose of this study was to apply the ARIMA-GJR-GARCH model to BBNI stock data. The purpose of this study was to estimate the ARIMA-GJR-GARCH model in determining the amount of Value-at-Risk obtained in BBNI shares. The study used the Eviews 10 and Microsoft Excel applications.

2. Materials and Methods

The data used in this study is historical data on the daily closing price of Bank Negara Indonesia Tbk (BBNI) shares starting from October 24, 2019 to October 22, 2021. Data is obtained from www.financeyahoo.id.

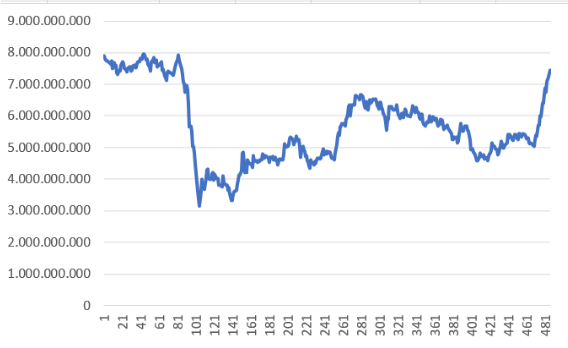

Figure 1: BBNI Share Closing Price

2.1 Stock Return

(Ruppert, 2011) Explained that return is the rate of return on the results obtained due to making investments. The return formulation is as follows:

$$R_t = \ln\left(\frac{S(t_i)}{S(t_{i-1})}\right) \tag{1}$$

by R_t declaring a stock return, $S(t_i)$ declares the stock price in the t_i period and $S(t_{i-1})$ declares the stock price in the t_{i-1} period, assuming $S(0) = 1$

2.2 Stationarity

Stationarity tests use Augmented Dickey-Fuller (ADF), with ADF test statistics being as follows:

$$ADF = \frac{\hat{\delta}}{SE(\hat{\delta})} \tag{2}$$

where $SE(\hat{\delta})$ is a standard error for $\hat{\delta}$. The decision-making criteria used are H_0: the data is not stationary and H_1: stationary data. If the value $ADF < \alpha$ then less H_0 In other words, stationary data. If the value $ADF > \alpha$ Then accept H_0 In other words, the data is not stationary (Tsay, 2005).

2.3 Mean Model

The ARIMA model is a combination of two univariate time series models: Autoregressive (AR) and Moving Average (MA). Orders are used in the ARIMA(p, d, q) model where p is the parameter of AR, d is the degree of data integration for data to be stationary, and q is the parameter of the MA.

A process $\{y_t\}$ ARIMA(p, d, q) if $\Delta^d y_t = (1 - L)^d y_t$ It is ARMA (p, q).

The ARMA model equation (p, q) is as follows:

$$W_t = \beta_0 + \varepsilon_t + \sum_{i=1}^{p} \beta_i W_{t-i} + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} \tag{3}$$

with W_t Data at the t, β_0 Constant, β_i coefficients of AR model parameters that depend on limits lag, θ_i coefficient of MA model parameters that depend on the limit lag, and ε_t This is a data error at time t.

In general, the ARIMA model is as follows (Uwilingiyimana, 2015).

$$\alpha(L)(1 - L)^d y_t = \theta \varepsilon_t; \{\varepsilon_t\} \sim WN(0, \sigma^2) \tag{4}$$

with ε_t following white noise (WN), Δ It's a difference operator.

ARIMA modeling process

In general, the ARIMA modeling process is:

1) Perform stationary data tests using Augmented Dickey-Fuller (ADF) by differencing
2) Identify the model by determining the values p and q with the autocorrelation function (ACF) and partial autocorrelation function (PACF) of the correlogram plot.
3) Parameter estimation can use the smallest square method or maximum likelihood
4) Diagnostic test with white noise and non-correlation test against residual using Box-Pierce or Ljung-Box
5) Forecasting, if the model is suitable it can be used for predictions made recursively.

2.4 Volatility Model

The GJR model (Glosten, Jagannathan, and Runkle, 1993) has a close relationship with the TGARCH model, so it is another asymmetric GARCH model another common form of the GJR-GARCH model (p,q) defined as follows (Glosten, 1993):

$$a_t = \sigma_t \epsilon_t, \;\; \sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_i a_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 + \gamma_i I_{t-i} a_{t-i}^2 + \varepsilon_t \tag{5}$$

for,

$$I_{t-i} = \begin{cases} 1, a_{t-i} < 0 \\ 0, a_{t-i} \geq 0 \end{cases} \quad (6)$$

with α_i is the i parameter of ARCH, β_j is the j parameter of GARCH and γ_i This is the parameter of the i leverage effect. I_{t-i} is a dummy variable which means a functional index that is worth zero when a_{t-i} positive and worth one when a_{t-i} negative. If parameters $\gamma_i > 0$ then negative error does not work which means that the influence of bad news will be greater than the influence of good news (Drisaki, 2007).

GJR-GARCH model process

1) Estimated GARCH model with time series model
2) Use residuals from the GARCH model to test the effects of ARCH
3) Perform diagnostic tests to observe the suitability of the model
4) Asymmetric effect test
5) If there is an asymmetric effect, it can be used to predict based on recursive predictions

2.5 Value-at-Risk and Risk Measures

One of the instruments on risk measurement is Value-at-Risk (VaR). VaR can be defined as the maximum loss on a particular period with a certain level of trust. VaR estimates usually use the standard method assuming that the return has one variable and is a normal distribution with μ is the average and σ is the standard deviation (Dwipa, 2016).

The equation in determining the var value is as follows:

$$VaR(r_t) = -\inf(r_t | F(r_t) \geq \alpha) \quad (7)$$

$$VaR(r_t) = -\hat{\mu}_t - \hat{\sigma}_t F^{-1}(\alpha) \quad (8)$$

VaR performance can be measured using backtesting. In 1998 Lopez introduced the size-adjusted frequency approach model as follows:

$$C_t = \begin{cases} 1 + (r_t - VaR_t)^2, r_t > VaR_t \\ 0, \qquad r_t \leq VaR_t \end{cases} \quad (9)$$

To test risk performance VaR can use a quadratic probability score (QPS). The equation is as follows:

$$QPS = \left(\frac{2}{n}\right) \sum_{i=1}^{n} (C_t - p)^2 \quad (10)$$

where n That's a lot of data, p It's a probability value, C_t It's an indicator of loss. If the QPS value is in the range of values [0,2] Then var performance is said to be good. The value of 0 is the minimum value that occurs when $r_t \leq VaR_t$ and 2 is the maximum value that occurs when the value $r_t > VaR_t$ (Sukono, 2019).

3. Results and Discussion

3.1. Data Stativity

Descriptive statistical data used is as follows:

Table 1: Descriptive Statistics Return of BBNI Stock

Stock	Number of Samples (N)	Mean	Maximum	Minimum
BBNI	485	0.00027	0.13647	-0.11719

Based on Table 1 the average value of BBNI shares with a total data of 485 is 0.00027. The maximum value obtained is 0.13647 and the minimum value is -0.11719. Stationary testing will be conducted using ADF and *Eviews 10 Software*.

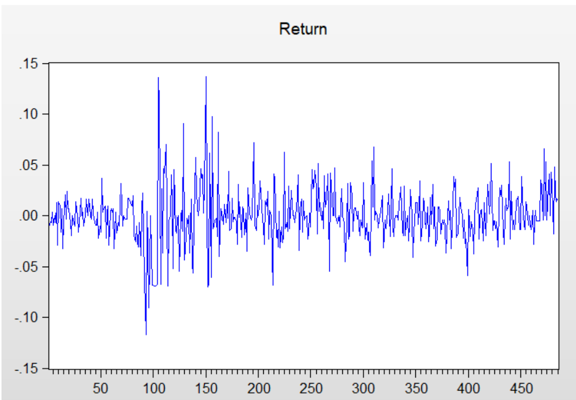

Figure 2: BBNI Stock Return Data

In Figure 2 it appears that the return of the stock moves fluctuating or up and down. The results obtained using the ADF test are worth 0.0000 which means H_0 rejected so that based on equation (2) BBNI stock return data has been stationary. Next will be the average model estimate or mean model.

3.2. Mean Model Estimate

The mean model estimates the ARIMA model. The ARIMA model obtained is ARIMA(1,0,1). The model has white noise and is a normal distribution to residuals. So that the ARIMA(1,0,1) model can be written using the equation in subheading 2.2.3 as follows:

$$\widehat{W}_t = 0.067256W_{t-1} - 0.983338\varepsilon_{t-1}$$

3.3. Estimated Volatility Model

In the mean model there is an ARCH effect so that it can be continued to estimate the volatility model. Previously there will be an estimate of the GARCH model after which asymmetric tests of the GARCH model are obtained. Based on simulations using Eviews software 10 GARCH models were obtained, namely GARCH(1,1). The model has been significant and the residual is white noise. The ARCH-LM Test will be conducted on the model. So it is obtained that the model does not have arch elements because the value obtained using the help of Eviews software 10 is greater than $\alpha = 5\%$. ARCH result is 0.6518.

The next process will be conducted asymmetric test that is cross correlogram between residual and residual square. So that the results are obtained as follows:

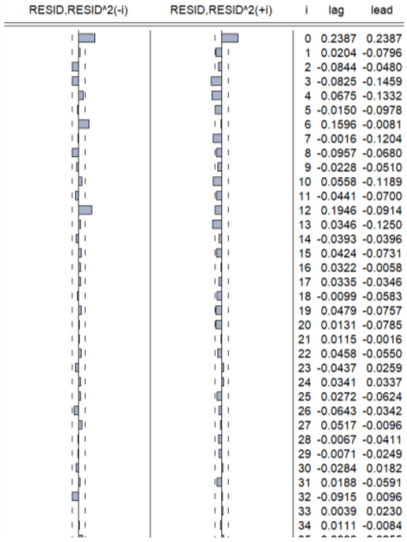

Figure 3. Output *Cross Correlogram*

Based on Figure 3, it is seen that the results of the cross correlogram on the lead section do not produce a value of 0. Therefore the GARCH (1,1) model has asymmetric properties and can be continued with the GJR-GARCH model estimation.

Estimates of volatility models using the GJR-GARCH model obtained the best model, namely the GJR-GARCH model (1,1). So that the model that can be created using the equation (5) is as follows:

$$\hat{\sigma}_t^2 = 2.16 \times 10^{-5} + 0.077008a_{t-1}^2 + 0.858262\sigma_{t-1}^2 + 0.093267I_{t-1}a_{t-1}^2$$

3.4. Estimate Value-at-Risk

Once obtained the mean model and volatility model, the VaR value will be calculated based on the results of these models. So that the estimated results of VaR bbni shares are shown in the following table:

Table 2: VaR Value of BBNI Stock

Stock	Mean	Varian	Standard Deviation	$F^{-1}(\alpha)$	VaR
BBNI	0.00611	0.00218	0.04671	-1.645	0.0705

Based on Table 2 above, the average value is obtained from the results of forecast 1 period of the ARIMA model (1,0,1) and the variant value is obtained from the results of forecast 1 period of the GJR-GARCH model (1,1). So that the Value-at-Risk value is obtained in Bank Negara Indonesia shares using the equation (8) which is 0.0705. In other words, if the investor makes an initial investment in BBNI shares of IDR 100,000,000 with a confidence level of 95%, the maximum loss obtained by the investor is IDR 7,050,049.

VaR performance can be calculated using equations (9) and equations (10), so the QPS value is 0.03107. based on the results of QPS estimates of var models obtained are said to be good because the value of QPS is in the range $[0, 2]$.

4. Conclussion

The mean model and volatility model used in BBNI shares to determine Value-at-Risk are the ARIMA(1,0,1)-GJR-GARCH(1,1) model. The level of risk on BBNI shares has a VaR value of 0.0705. In other words, if the investor makes an initial investment in BBNI shares amounting to IDR 100,000,000 with a confidence level of 95%, the maximum loss earned by the investor is IDR 7,050,049.

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