The Estimation Model for Measuring Performance of Stock Mutual Funds Based on ARCH / GARCH Model

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ABSTRACT

The purpose of this study is to obtain the estimation model for measuring performance of stock mutual funds based on ARCH/GARCH model adopted from Treynor–Mazuy's model. Treynor–Mazuy's model is a performance measure model that considers the abilities of fund managers in terms of market timing ability and stock selection ability. Market return included into the model indicated that the model contains the problem of heteroscedasticity that can happen on stock prices because of their fluctuations. Heteroscedasticity problem may lead to biased estimation of model, and thus ARCH/GARCH models are required to solve the problem. The research uses net asset value (NAV) data of the twenty nine mutual funds that effectively operated during the period January 2008–June 2015. The research finding states that the estimation value obtained Treynor–Mazuy's model indicated bias due to heteroscedasticity problem by using time series data in OLS model. The volatility model that can be used to solve the problems is GARCH (2,2), which establishes a model with an accurate estimation result.

Keywords: ARCH/GARCH, heteroscedasticity, volatility, Treynor-Mazuy's model

1. INTRODUCTION

Mutual fund is a form of investor's indirect investment in the portfolio of assets managed by fund managers of investment companies. There are several types of mutual funds that can be chosen by investors as their investment products; one of them is stock mutual fund. Stock mutual fund is a type of mutual fund that is most demanded by investors in Indonesia. Association of Indonesian Mutual Fund Managers states that stock mutual fund is still a favored mutual fund for investors in Indonesia. The statement is based on the evidence of the average Net Asset Value (NAV) of stock mutual funds in year 2015 that amounted to 36,30%, which was higher than the protected funds (22,10%), fixed income mutual funds

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(18,16%), money market mutual funds (10,53%), and mixed mutual funds (7,06%).

NAV per unit of the mutual fund has a principle similar to the stock price. NAV per unit may move up or down from day to day as well as stock prices. As a portfolio of at least 80% of investment funds allocated to stocks, the NAV per unit value is affected by market prices of the stocks on demand and supply in the mutual funds in each day. Higher fluctuations of the price or the return, more fluctuated the NAV return per unit of mutual funds, it indicates that the portfolio of mutual funds could not be separated from the problem of investment risk.

Here is the fluctuation of the average return of the NAV per unit for stock mutual funds in Indonesia during the years 2008-2014:

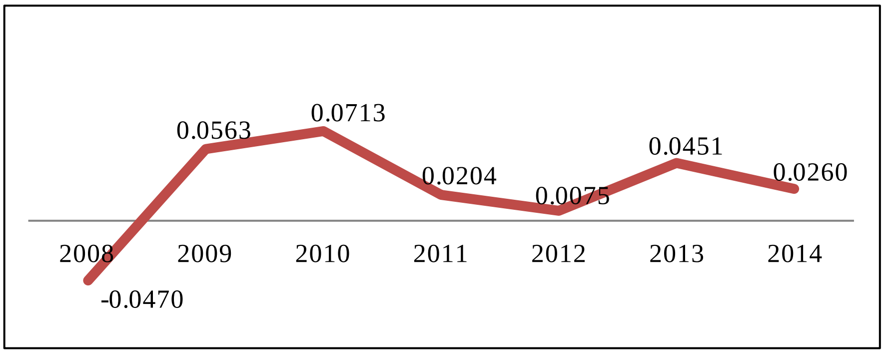

Figure 1.1 Average Return of NAV per Unit for Stock Mutual Funds During Period 2008-2014

The fluctuation on portfolio return as illustrated in Figure 1.1 resulted in the emergence of the volatility problem in estimating of returns. Volatility is a variant of the diverse patterns of time series data, in particular the financial data (Engle, 2004). Volatility often appears during the beta testing based on time series data, it because the financial time series data is extremely high volatility. Referring to Figure 1.1, the form of return volatility NAV per unit during the years 2008-2014 is described as follows:

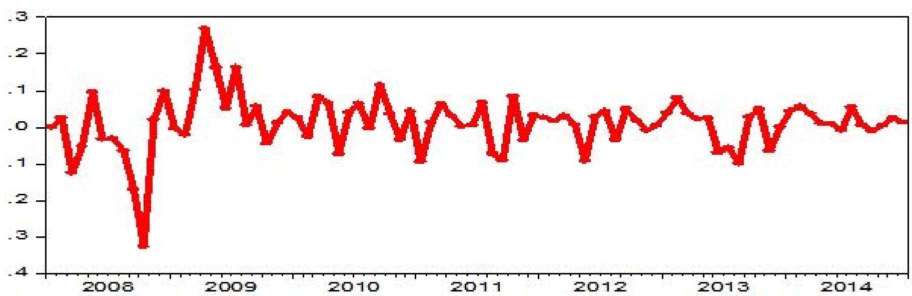

Figure 1.2 Volatility of Average Return of NAV for Stock Mutual Funds During Period 2008-2014

High volatility determined by the state in which the fluctuation data is relatively high, followed by fluctuations in the low and then high again. The volatility can be influenced by

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the macro and micro enterprises. Macro factors related to corporate external conditions, such as interest rates, inflation rates, the level of national productivity, and political factors. Micro factors related to the company's internal conditions, such as changes in management, availability of raw materials, and labor productivity (Schwert, 1989).

Fluctuations in time series data will make the mean and variance values that produced are not constant. By this condition, it is difficult to estimate the performance of stock mutual funds based on the calculation of NAV return and the market return. Based on this calculation, there are several models for estimating the performance of the mutual funds, one of them is Treynor–Mazuy's model. This model is considering fund manager's ability in terms of their market timing ability and stock selection ability (Paramita, 2015).

The measurement process of performance based on Treynor–Mazuy's model is applying an ordinary least square (OLS) method that indicated bias in the estimation results. The bias caused by the problems of data distribution and heteroscedasticity as the result of using time series data. A very high fluctuation is resulted a very high volatility, so that the estimation of the mutual funds performance indicated not accurate. For addressing the problem, the model of ARCH (autoregressive conditional heteroscedasticity) or GARCH (generalized autoregressive conditional heteroscedasticity) used in this study with the aim to obtain the more accurate estimation model for measuring and estimating the performance of mutual funds, especially for Treynor–Mazuy's model that used as the initial model in this research.

2. LITERATURES

One model to analyze the performance of mutual funds is Treynor–Mazuy's model (1966). This model was developed to test the ability of fund managers in terms of market timing ability and security selection ability which are the measures of their ability to anticipate changes in the market. They found no evidence that the mutual funds managed by fund managers outperform the market. Treynor–Mazuy's model (1966) is the development of Jensen model that adds the quadratic factor in the market risk premium as an independent variable.

Several studies using Treynor–Mazuy's model have been carried out by Rao (2000) and Sehgal (2008). In Indonesia, Anita (2013) and Paramita (2015) used the model in their research. Paramita (2015) has added dual beta component to the model for measuring and estimating the performance of stock mutual funds. The advantages of Treynor–Mazuy's model are capable of showing comparison of the performance between mutual funds and market, and also capable of measuring the ability of fund managers in making stock selection and market timing (Paramita, 2015).

Treynor–Mazuy's model is using market risk as the only risk factor that determine the portfolio return. The data obtained from financial markets have known often have a high

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level of volatility, so that the results of the analysis could be bias because of the problem of heteroscedasticity (conditional heteroscedasticity). With the high level of volatility in the data, it would require an econometric model based on specific approaches to address the problem of volatility or to accommodate heteroscedasticity problem. A model that can be used is ARCH/GARCH model.

ARCH model first introduced by Engle (1982) which states that the changes in residual (error term) is caused by the function of the independent variables and the residual value in the past. ARCH model is further enhanced by Bollerslev (1986) which states that the residual depends not only on the residual in a past but also the residual variance in a past, it known as GARCH model. ARCH model shows that the variance estimation can be done by smoothing the square of the standard deviation of the mean value. While GARCH model provides the greater flexibility to estimate the variance of the conditional time varying on stock returns and market returns. Thus, estimating return by taking the time varying conditional volatility into an account, expected to improve the accuracy of estimating beta (Berglund and Knif, 1999; Bollerslev et al., 1988), which is a predictor of return.

Some relevant research has been conducted by several researchers. As the inventor of the ARCH model, Engle (1982) conducted a study of the variability of the inflation rate in the UK during the years 1958-1977 by using ARCH model. Through this model, Engle comparing the estimation results between the OLS method with ARCH model by maximum likelihood estimation. The findings show that ARCH model capable of improving the results of OLS method and obtain a more realistic prediction of variance. These findings are further developed by Bollerslev (1986) with GARCH model that incorporate the residual variance. The findings showed that by including the residual variance into the equation, the regression result is better than ARCH model.

Devaney (2001) is using the methodology of mean in GARCH (GARCH-M) to investigate the process of generating returns on Real Estate Investment Trust (REIT). His findings were that the GARCH-M is able to estimate the mortgages portfolio, better than the equity portfolios. While Angelidis et al. (2004), which evaluates the performance of the ARCH for modeling value at risk (VaR) over several diversified portfolio in five equity indexes, found that the structure of ARCH model produces the most accurate estimation, which is different for each portfolio.

In Indonesia, Waharika et al. (2013) are using GARCH model to estimate the value at risk (VaR) of Composite Stock Price Index and LQ-45 Index. GARCH model was found good enough in estimating the value of VaR in stock index containing heteroskedastic volatility. While Ratnasari et al. (2014) estimate volatility by using GARCH-M model in analyzing the daily data of WIKA stock return, from October 18, 2012 until March 14, 2014. Their findings state that one of the best models for estimating the volatility of WIKA stock price is GARCH-M (1,1).

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3. RESEARCH METHODS

3.1 Operational of Variables

This research was conducted in two stages. The first stage is to run Treynor–Mazuy's model to get the value of a predictor (beta) of each stock mutual fund. The variables used by Treynor–Mazuy's model are: (1) The independent variables consisting of excess return of market ($Rm - Rf$) and quadratic excess return of market $(Rm - Rf)^2$. The proxies for market portfolio and risk-free assets are used respectively Composite Stock Price Index (CSPI) and Bank Indonesia Certificates, (2) The dependent variable is the excess return of stock mutual fund portfolio $(Rp_t - Rf)$.

The second stage is operating ARCH/GARCH model based on the results that have been obtained from Treynor–Mazuy's model. The variables used are control variables consisting of residual or standard deviation (ARCH) and variance of the residual or conditional variance (GARCH).

3.2 Sample Research

Based on the purposive sampling method, the sample criteria used in this study were, (1) Stock mutual funds are effectively operating in Indonesia during the period January 2008-June 2015, (2) Stock mutual funds are including an information regarding Net Asset Value (NAV) during the period of January 2008–June 2015. Based on these criteria, the sample size amounted to 29 stock mutual funds.

3.3 Data Analysis Method

Data used in the form of time series data which will be used to form the OLS regression equation based on Treynor–Mazuy's model (1966) as in the equation as follows:

$$R_{it} - R_{ft} = \alpha i + \beta i\,(R_{mt} - R_{ft}) + \gamma_i\,(R_{mt} - R_{ft})^2 + e_{it} \qquad (1)$$

where αi reflects the selection ability that demonstrate the ability of fund managers to select the right stocks in mutual funds portfolio, γ_i reflects the market timing ability that demonstrate the ability of fund managers to make adjustments for the assets in portfolio to anticipate market prices changes. As for $R_{it} - R_{ft}$ or we can change it with $R_{pt} - R_{ft}$ for portfolio as excess return of stock mutual fund portfolio.

In this research, $R_{pt} = \frac{NAB_t - NAB_{t-1}}{NAB_{t-1}}$ (2)

Furthermore, based on the regression result obtained from Treynor–Mazuy's model, performed an analysis of the residual value by using the estimation model of ARCH/GARCH. ARCH model stated that the variance of residual depends on the residual from past. In general, the formations of ARCH model are expressed with the equations below:

$$Yt = \beta_0 + \beta_1 X_1 t + et \qquad (3)$$

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$$\sigma_t^2 = \alpha_0 + \alpha_1 e^2_{t-1} + \alpha_2 e^2_{t-2} + \ldots. + \alpha_p e^2_{t-p} \quad (4)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_1 e^2_{t-1} \quad (5)$$

where et is describing the residual indicated containing the heteroscedasticity, and p is describing the number of residual from past (lag). The residual assumed is the square of the residual in lag period.

ARCH model, furthermore, developed by Bollerslev (1986) which states that the variance of residual not only depends on the residual from past, but also the variance of residual from past, thus becoming GARCH (p, q), where q is the number of the variance of residual in lag period. The variance of residual by GARCH model can be written as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 e^2_{t-1} + \gamma_1 \sigma^2_{t-1} \quad (6)$$

In GARCH model, variance of residual σ_t^2 is affected by the residual from past and also the variance of residual from past or in lag period.

For some residual period (p) and residual variance (q), GARCH (p, q) becomes:

$$\sigma^2_{i,t} = \alpha_0 + \alpha_1 e^2_{t-1} + \ldots + \alpha_p e^2_{t-p} \ldots + \gamma_1 \sigma^2_{t-1} + \ldots + \gamma_q \sigma^2_{t-q} \quad (7)$$

$$\sigma^2_{i,t} = \alpha_0 + \sum_{i=1}^{p} \alpha_1 e^2_{t-1} + \sum_{j=1}^{q} \gamma_j \sigma^2_{t-j} \quad (8)$$

where α_1 indicates the element of ARCH (p), γj indicates the element of GARCH (q).

Therefore, the residual often affect the dependent variable being observed so heteroscedasticity factor can be one of the independent variables, then in this study will be established also a regression model based ARCH in Mean (ARCH-M).

Furthermore, to find the best model to estimate the performance of stock mutual funds, the regression results obtained from Treynor–Mazuy's model by applying OLS method will compared with the regression results obtained from ARCH/GARCH model. To reach the aim, we used several tests to get the Best Linear Unbiased Estimator (BLUE) result, consists of the data normality test (Jarque–Bera model), the autocorrelation test (Breusch-Godfrey model), the multicollinearity tests (variance inflation factors model), and the heteroscedasticity test (Breusch-Pagan-Godfrey model).

4 RESULT AND DISCUSSION

The first discussion is about result by using Treynor–Mazuy's model. Based on equation (1), the results are described by outputs from E-Views program, as follows:

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Table 4.1 :

The Regression Model By Using Treynor Mazuy's Model

Dependent Variable: RP_RF__

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001679	0.001392	-1.206306	0.2310
RM_RF__	1.117174	0.021021	53.14631	0.0000
RM_RF2__	0.309980	0.115284	2.688846	0.0086

Based on the output above, the Treynor–Mazuy model is:

RP_RF__ = -0.001679 + 1.117174 RM_RF__+ 0.309980 RM_RF2__

The probability values indicate that each independent variables affect significanty, at α = 5%. The constant α_i is negative shows that fund managers are not able to establish an optimal portfolio, but have the ability on market timing, according to the value of γi positive. Furthermore, to determine whether the model is BLUE or not, carried out some tests with the following results:

Table 4.2 :

The Multicollinearity Test

Variance Inflation Factors

Variable	Coefficient Variance	Un-centered VIF	Centered VIF
C	1.94E-06	1.176467	NA
RM_RF__	0.000442	1.177481	1.174109
RM_RF2__	0.013290	1.329570	1.174109

Table 4.3 :

The Autocorrelation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.469792	Prob. F(2,84)	0.6268
Obs*R-squared	0.984499	Prob. Chi-Square(2)	0.6112

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Table 4.4 :

The Normality Test (1)

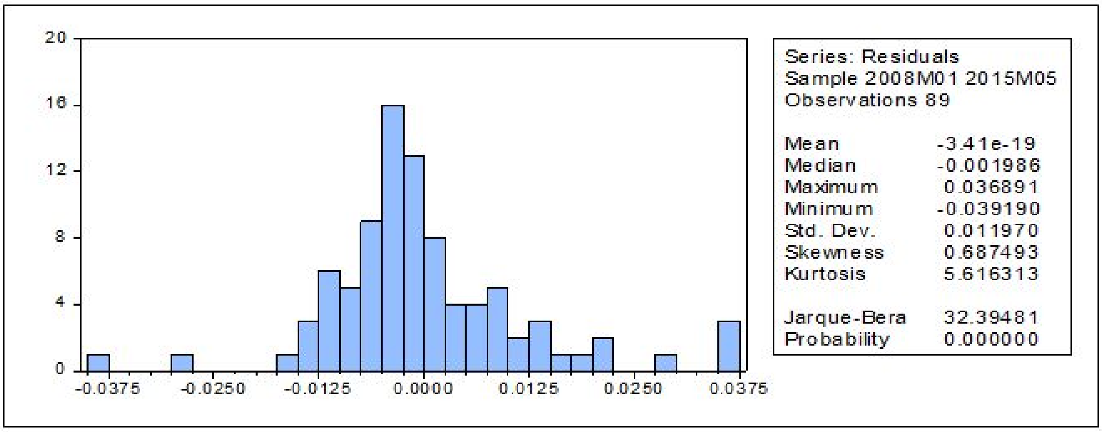

Table 4.5 :

The Heteroscedasticity Test (1)

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	13.46194	Prob. F(2,86)	0.0000
Obs*R-squared	21.21983	Prob. Chi-Square(2)	0.0000
Scaled explained SS	45.73241	Prob. Chi-Square(2)	0.0000

Based on the test results above, it is known that the estimation model is formed indeed free from autocorrelation (prob. 0.6268 > 0.05) and multicollinearity (centered VIF < 5), but not free from the problem of heteroscedasticity (prob. 0.0000 < 0,05) and normality (prob. 0.000000 < 0.05). It caused by the condition of the data which have high volatility and resulted in the estimation model are made is not accurate.

To solve the problem of heteroscedasticity, then ARCH/GARCH model is used in which the analysis is based on the residual value obtained from estimation model that have been formed. This is the next topic of discussion.

Based on data processing, the results are as follows:

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Table 4.6 :

The Regression Model By Using Treynor ARCH/GARCH Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
@SQRT(GARCH)	0.754486	0.275454	2.739059	0.0062
RM_RF2__	0.232502	0.063060	3.687008	0.0002
RM_RF__	1.044895	0.009964	104.8652	0.0000
C	-0.009238	0.002823	-3.272006	0.0011
Variance Equation				
C	9.78E-06	4.68E-06	2.091082	0.0365
RESID(-1)^2	0.423794	0.158147	2.679748	0.0074
RESID(-2)^2	-0.323650	0.155493	-2.081448	0.0374
GARCH(-1)	1.217323	0.162709	7.481610	0.0000
GARCH(-2)	-0.379372	0.112464	-3.373270	0.0007

R-squared	0.972904	Mean dependent var	0.003642
Adjusted R-squared	0.971948	S.D. dependent var	0.073940
S.E. of regression	0.012384	Akaike info criterion	-6.113928
Sum squared resid	0.013036	Schwarz criterion	-5.862269
Log likelihood	281.0698	Hannan-Quinn criter.	-6.012492
Durbin-Watson stat	2.007174		

Based on the outputs above, the estimation equation consists of the regression model and the variance of residual model are :

RP_RF__ = -0.009238 + 1.044895 *RM_RF__ + 0.232502*RM_RF2__ + 0.754486*@SQRT(GARCH)

GARCH = 9.78E-06 + 0.423794*RESID(-1)^2 - 0.323650*RESID(-2)^2 + 1.217323*GARCH(-1) -0.379372*GARCH(-2)

An explanation of the results of ARCH/GARCH model as the output shown above is that the best model to address the problem of heteroscedasticity is GARCH (2,2). And by using the ARCH-M models as the regression model, where the residual become one of the independent variables, the model generated better, indicated by the probability value of each independent variable is less than 5% (p value of <0.05).

As for proving that the model produced a better estimation model, then the next tests

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for whether the model is BLUE.

Table 4.7 :

The Normality Test (2)

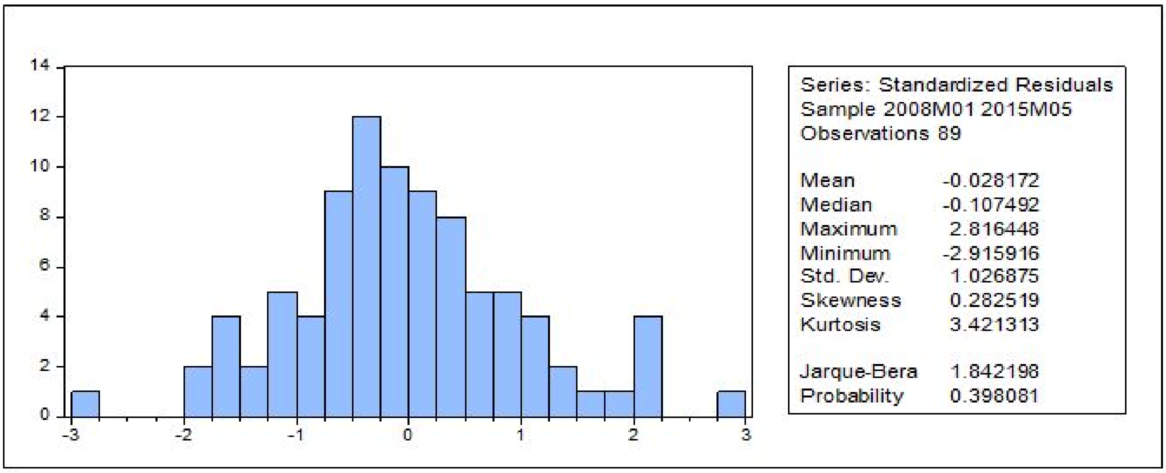

Table 4.8 :

The Heteroscedasticity Test (2)

Heteroskedasticity Test: ARCH

F-statistic	0.020545	Prob. F(1,86)	0.8864
Obs*R-squared	0.021018	Prob. Chi-Square(1)	0.8847

Based on the results of tests performed, the regression model has proven to free from heteroscedasticity and normality problem. These findings also demonstrate that by using the ARCH-M as the estimation model and GARCH (2,2) as the variance of residual model, the weakness of the operating results of Treynor-Mazuy's model earlier can be repaired.

5 CONCLUSIONS

Based on the results and discussions that have been described, it can be made a few conclusions. First, by using the Treynor-Mazuy's model, the estimation and measurement of stock mutual funds performance tend to be biased. This is due to (a) the problem of heteroscedasticity as a result of the high data volatility, and (b) the problem of data distribution were not normally although each of the independent variables known to influence the independent variables. Second, by operating the ARCH/GARCH model, the bias problem that could cause the results become not accurate can be solved by ARCH-M and GARCH (2,2). This model also improving the results of calculations based on Treynor-Mazuy's model as has been done previously.

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