GARCH MODEL FOR VOLATILITY OF STOCKS: A CASE STUDY OF STOCK PRICE IN TELECOMMUNICATIONS GROUP THAILAND

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Abstract— The aim of this research is to estimate stock volatility in stock of telecommunications. This study is based on GARCH processes. The performance will be measured based on Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE). The implied volatility from the model can be used to project future changes in stock price.

Index Terms— GARCH Model, MSE, MAPE.

I. INTRODUCTION

Nowadays there are many different types of investments, the most popular one is stock investing, and the ones with high risks usually give high returns. Risk often depends on the volatility of stock price, a measure for variation of stock price over time. There are many factors that can cause this variation such as economic uncertainty, political instability, operating performance, etc. Investors need models that can forecast volatility with some accuracy.

The Communication is important in the modern human and the telecommunication make we convenient and saving. We needed a device to help facilitate and enable us to communicate faster such as, Telephone, internet, radio and television. We have the necessary must be use telephone to ease for Communications or use internet to easy and fast for data transmission or send various work in addition, we also recognize the news or important events from radio and television as well. The telecommunications above in Thailand there are several network such as, Dtac, True Move, AIS(Advanced Info Service), TOT, True Internet, CAT internet, 3BB(three Broad Band), ThaiTV3(Thai Television 3 channel) or FM 106.5 MHz(Family Radio News).

Generalized AutoRegressive Conditional Heteroskedastics (GARCH) Model is the one time series models. GARCH model has been generalized by Bollerslev and Taylor(1986) from ARCH model [ARCH(q) Model defined by $\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \cdots + \alpha_q\varepsilon_{t-q}^2 = \alpha_0 + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-i}^2$ where $\varepsilon_t = \sigma_t z_t$, $\alpha_0 > 0$ and $\alpha_i \geq 0$] proposed by Engle(1986) which was applied to capture the stock market volatility. GARCH(p,q) model can be defined by $\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \cdots + \alpha_q\varepsilon_{t-q}^2 + \beta_1\sigma_{t-1}^2 + \cdots + \beta_p\sigma_{t-p}^2$ $= \alpha_0 + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-i}^2 + \sum_{i=1}^{p}\beta_i\sigma_{t-i}^2$ where $\varepsilon_t = \sigma_t z_t$, $\alpha_0 > 0$, $\alpha_i \geq 0$, $\beta_i \geq 0$ and the innovation sequence $\{\varepsilon_i\}_{i=-\infty}^{\infty}$ is independent and identically distributed with $E(\varepsilon_0) = 0$ and $E(\varepsilon_0^2) = 1$. Referring to the research by Ching Mun Lim and Siok Kun Sek(2013), "Comparing the performances of GARCH- type models in capturing the stock market volatility in Malaysia", pointed that GARCH models give good volatility forecasting in Malaysia market. David Ardia and Lennart F.Hoogerheide(2014) used GARCH model for impact of estimation frequency on Value-at-Risk and Expected Shortfall forecasts. David Ardia and Lennart F.Hoogerheide (2014) analyze the impact of the impact to updating parameter estimations on a daily, weekly, monthly or quarterly basis for commonly by GARCH model and used the information twelve years. Yung-Lieh Yang and Chia-Lin Chang (2008) used double-threshold GARCH (DTGARCH) model to investigate the effects of currency movements.The research by G.Prat-Ortega and S.E. Savel'ev (2014) use GARCH process to analyze the long range correlations(10876 daily data) between stock. It can explain the relationship of stock prices include, the mean, variance, probability density distribution and the noise spectrum. Angle Leon and Antoni Vaello-Sebastia (2009) GARCH employee stock option valuation of American and they presented GARCH effects on the underlying asset and analyze the price bias with respect to the constant volatility case. Basel M. A. Awartani and Valentina Corradi(2005) predicting the volatility of the S&P-500 stock index by GARCH models about asymmetries and They empirical the ability to predict for different GARCH models such as, GARCH, EGARCH, GJR- GARCH, QGARCH, TGARCH, AGARCH, IGARCH, RiskMetrics and ABGARCH. Wen-I Chuang, Hsiang-Hsi Liu and Rauli Susmel(2012) used the bivariate GARCH to investigate the relations between stock returns, trading volume and return volatility. Jean-Guy Simonato(2012) considered skewed and leptokurtic innovations of data by GARCH processes and used likelihood function is derived and the model is estimated with the daily returns of six international stock indexes. The results show that model provides good results they must be used data past ten years of index returns. Jui-Chung Hung(2009) used fuzzy logic system adjust asymmetric GARCH model. The

experimental forecast of volatility is improved significantly if the leverage effect of clustering is considered in conjunction with the use of expert knowledge about the GARCH. In the same year, they show the results used from the method of functional fuzzy systems to analyze the clustering in the case of a GARCH model. They extracted the optimal parameters for the fuzzy membership functions and GARCH model from genetic algorithm(GA) because, the estimation problem for fuzzy GARCH model will fast convergence rate. And they simulations by stock market data from the Taiwan weighted index and the NADAQ composite index, and they used fuzzy system and GARCH model in 2011 to adaptively forecast stock market volatility by recursive least-squares(RLS). They estimation by in-sample and forecast by out-sample. Moreover, they adaptive Fuzzy-GARCH model with particle swarm optimization(PSO) in 2011 to estimate the parameters of the membership functions. Particle swarm optimization has been optimal solution with a rapid convergence rate.

II. DETAILS EXPERIMENTAL

2.1 Data and Methodology

In this research, we conduct on stock market volatility of the telecommunications group in a period of 10 years between 1994 and 2014. The time series data usually are the form non-stationary. Therefore, it cannot be analyzed without stationary test, that is, mean and variance of data has to stable when time change. However, if the time series data is used without stationary test, the variables of Equation (2) are not related, we can observe from the statistics with non-standard distribution. It demonstrate the error has autocorrelation problem at a high level, which is not acceptable in the statistics.

The stationary testing of time series data has to test by Unit Root Test. In this research we shall present two methods for stationary test including Augmented Dickey-Fuller test(ADF) and Phillips-Perron test(PP). Before GARCH model is used to forecast the stock volatility we necessary to know all the parameters based on stock price data of GARCH model, the parameters in this research are α_0, α_i, and β_i for $i = 1,2,3,\ldots$.

2.1.1 The Maximum Likelihood Estimation

Let $X_1, X_2, \ldots, X_n$ be an independent and identically distribution, where n and θ represent sample and unknown parameters, respectively. The probability function in general form is defined as:

$$f(x_1, x_2, \ldots, x_n; \theta) = f(x_1; \theta) f(x_2; \theta) \cdots f(x_n; \theta) \cdot = \prod_{i=1}^{n} f(x_i; \theta). \quad (1)$$

The likelihood function is the density function regarded as a functions of the parameter θ. The ***likelihood function*** is defined as:

$$L(\theta \mid x_1, x_2, \ldots, x_n) = f(x_1, x_2, \ldots, x_n; \theta) = \prod_{i=1}^{n} f(x_i; \theta). \quad (2)$$

Suppose that $f(x_i; \theta)$ is probability density function(pdf) with unknown parameter θ. We can find ***Maximum Likelihood Estimator*** as follows:

$$\max_{\theta} L(\theta \mid x_1, x_2, \ldots, x_n) \cdot \quad (3)$$

In practice, the Maximum Likelihood is difficult to estimate directly. Instead of log-likelihood, we shall estimate using the following maximize of log-likelihood:

$$\max_{\theta} \ln L(\theta \mid x_1, x_2, \ldots, x_n) \cdot \quad (4)$$

The parameters are estimated using ***Maximum log-likelihood estimation*** according to Equation (4).

2.1.2 GARCH model

Generalized AutoRegressive Conditional Heteroskedastics (GARCH) Model is a type of time series model. The GARCH model has been generalized by Bollerslev and Taylor(1986) from ARCH proposed by Engle(1986) which was applied to capture the stock market volatility. GARCH (*p*, *q*) model defined by

$$\varepsilon_t = \sigma_t z_t,$$
$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2, \quad (5)$$

where $\varepsilon_t = \sigma_t z_t$, $\alpha_0 > 0$, $\alpha_i \geq 0$, $\beta_i \geq 0$ and the innovation sequence $\{\varepsilon_i\}_{i=-\infty}^{\infty}$ is independent and identically distributed with $E(\varepsilon_0) = 0$ and $E(\varepsilon_0^2) = 1$.

From the preceding methods, we have the stationary of time series data, *p* and *q* which appropriate with GARCH (*p*, *q*) model. Moreover, we have parameters for GARCH (*p*, *q*) model with time series data, to be able to forecast the volatility of stock availables. The following GARCH(1,1) model is used in this research.

$$\varepsilon_t = \sigma_t z_t,$$
$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2, \quad (6)$$

where $\varepsilon_t = \sigma_t z_t$, $\alpha_0 > 0$, $\alpha_1 \geq 0$, $\beta_1 \geq 0$.

2.2 Model Evaluation

The performance of the model is important to measure the accuracy. Since all model for forecasting have an error, we have to use tools for error measurement to show that the models have a good enough performance for applications. Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE) are used in this research. The obtained results from MSE and MAPE is less enough. This means the model is accurate.

2.2.1 Mean Squared Error (MSE)

$$MSE = \sum_{t=1}^{n} \frac{e_t^2}{n}, \quad (7)$$

where e_t is an error and $e_t = x_t - \hat{x}_t$, x_t is the actual observed value at time t, $\hat{x}_t$ is the obtained forecast value at time t and n is the amount of data for the forecast.

2.2.2 Mean Absolute Percentage Error (MAPE)

$$MAPE = \sum_{t=1}^{n} \frac{\left|\frac{e_t}{x_t}\right| \times 100}{n}, \quad (8)$$

where e_t is an error and $e_t = x_t - \hat{x}_t$, x_t is the actual observed value at time t, $\hat{x}_t$ is the obtained forecast value at time t and n is the amount of data for the forecast.

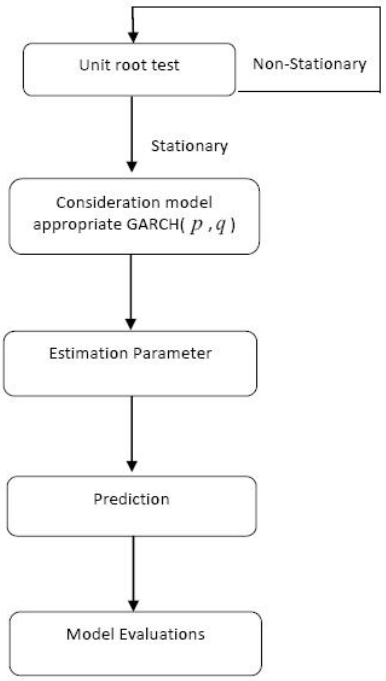


Diagram showing the process of stock price information analyzing process.

III. ESTIMATION RESULTS

The results on stock market volatility of the telecommunications group in a period of 10 years between 1994 and 2014 are presented in this section. ADF test statistic.

3.1 Unit Root results

The unit root test is stationary or non-stationary verification of data. To avoid mean and variance values which are non-stationary in the difference period, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) methods are used in considering statistically significant at confidence level 99%, 95% and 90%. After that, we considered the stationary by comparing between statistical significance and ADF test statistic. If ADF is greater than statistical significance, the data is non stationary. For Phillips-Perron (PP) methods it is conducted in the same as ADF test statistic.

For testing unit root of Advanced Info Service(AIS) at the level, we have to test three steps as follows.

- without trend and intercept
- with intercept but without trend
- with trend and intercept

at confident levels 99%, 95% and 90%(critical values 1%, 5% and 10%).

The results of ADF test statistics and PP test statistics less than the critical values. Therefore, it can be concluded that the data is stationary as show in table 1 and table 2.

Table 1: The Augmented Dickey-Fuller (ADF) test statistic

Levels	Critical Values			ADF test statistic	status
	1%	5%	10%		
without trend and intercept (None)	-2.565401	-1.940884	-1.616659	-5.957456	Stationary
with intercept but without trend	-3.431411	-2.861894	-2.567001	-6.193123	Stationary
with trend and intercept	-3.959780	-3.410657	-3.127110	-5.599218	Stationary

Table 2: The Phillips-Perron (PP) test statistic

Levels	Critical Values			ADF test statistic	status
	1%	5%	10%		
without trend and intercept (None)	-2.565401	-1.940884	-1.616659	-5.955325	Stationary
with intercept but without trend	-3.431410	-2.861893	-2.567001	-6.194207	Stationary
with trend and intercept	-3.959779	-3.410657	-3.127110	-5.592773	Stationary

3.2 Stock price analysis for Advance Corporation.

3.2.1 Data description

The stock price data in Advanced Info Service(AIS) Corporation is a time series, it is trend to down direction as figure 1 below.

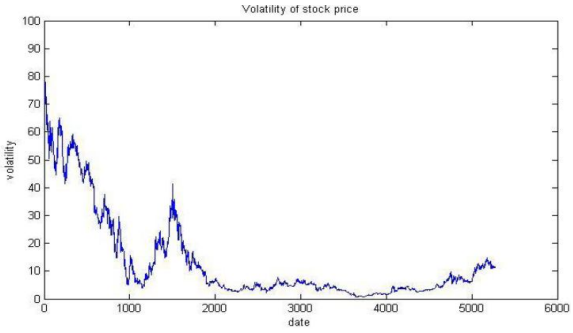


Figure 1 Plot of stock price for Advanced Info Service(AIS) Corporation

3.2.2 The performance of GARCH Model

The performance of GARCH Model also found the errors of model. It have MSE = 0.00011959028186194 and MAPE = 10.3897787116143 as figure 2 and figure 3 below.

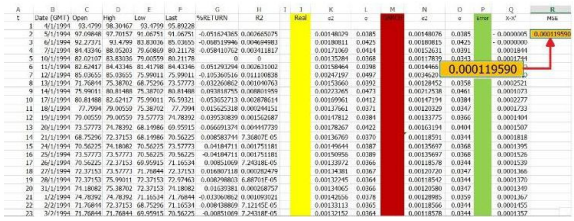


Figure 2 Forecasting the data and model evaluation for Advanced Info Service(AIS) corporation using MSE

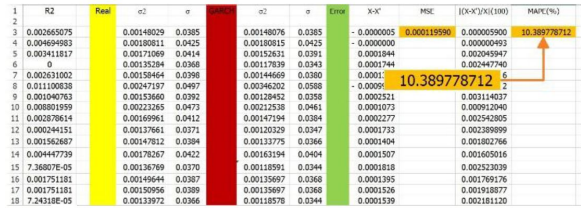


Figure 3 Forecasting the data and model evaluation for Advanced Info Service(AIS) corporation using MAPE

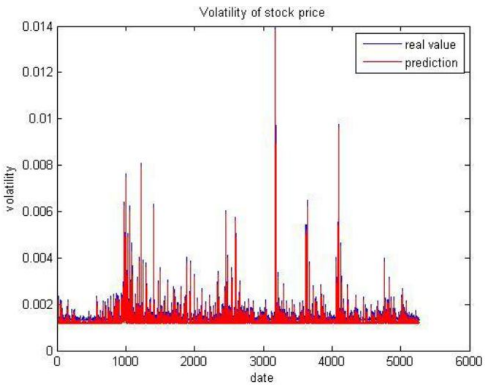


Figure 4 The graphs are compared the volatility of real value and prediction value

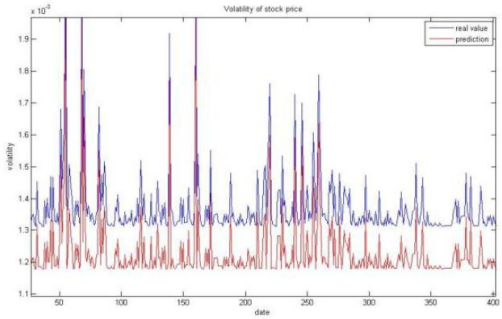


Figure 5 (Zoom in)The graphs are compared the volatility of real value and prediction value

From figure4 and figure5 shows that predicted volatility have similar to actual volatility. This may be useful in trading decisions for investors.

CONCLUSION

We analyzed the volatility of stock prices using GARCH Model. Since, the data of stock price in Advanced Info Service(AIS) has a lot of volatility, the prediction may be an error but GARCH Model is the model for analysis of the volatility of stock as well. The analysis results using MSE and MAPE. The results obtained indicate that GARCH Model based on the stock price has MSE = 0.00011959028186194 and MAPE = 10.3897787116143 for the stock price in telecommunications group Thailand (A case study of stock price in Advanced Info Service (AIS)).

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