MODELLING AND FORECASTING EXCHANGE RATE OF US DOLLAR AGAINST MALAYSIAN RINGGIT USING HYBRID ARIMA-GARCH AND ARIMA-EGARCH MODELS

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To my beloved family, teachers and friends.

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ABSTRACT

Modelling and forecasting financial time series data has become the area of interest in financial world. However, the data exhibits certain stylized facts that must be handled by an appropriate models. Thus, this study was conducted to develop hybridization models between Autoregressive Integrated Moving Average (ARIMA) model and Generalized Autoregressive Conditional Heterocedasticity (GARCH) family model for daily exchange rate data. Later, the performance of modelling and forecasting for the best models among them will be compared. GARCH family models are divided into two categories which are symmetric (GARCH) and asymmetric (EGARCH) models. In this study, daily data of U.S. Dollar exchange rate against Malaysia exchange rate (USD/MYR) is used from the period of 1st November 2010 until 30th August 2016 collected from the Central Bank of Malaysia. The data are divided into two parts where 90% of the data is used as in-sample period taken from 1st November 2010 until 3rd February 2016. Meanwhile, for another 10% is used for the out-sample period taken from 4th February 2016 until 30th August 2016. EViews software and Microsoft Excel are used in this study to analyze the data. The performance of the hybrid models are evaluated using AIC, MAE, RMSE and MAPE. Results showed that, hybrid ARIMA-EGARCH model is the best model in modelling and forecasting daily exchange rate data compared to hybrid ARIMA-GARCH model.

ABSTRAK

Pemodelan dan peramalan bagi data siri masa kewangan telah menjadi suatu bidang yang diminati dalam dunia kewangan. Walau bagaimanapun, data tersebut telah mempamerkan suatu pengubahsuaian fakta yang perlu dikendalikan oleh model yang sesuai. Oleh itu, kajian ini dijalankan untuk membangunkan model penghibridan antara model Autoregresi Purata Bergerak Terkamir (ARIMA) dan model Autoregresi Teritlak Heteroskedastisiti Bersyarat (GARCH) untuk data kadar pertukaran wang harian. Kemudian, prestasi pemodelan dan peramalan bagi model yang terbaik di kalangan mereka akan dibandingkan. Model GARCH dibahagikan kepada dua kategori iaitu simetri (GARCH) dan tidak simetri (EGARCH) model. Dalam kajian ini, data harian bagi kadar pertukaran wang bagi dolar AS terhadap kadar pertukaran wang Malaysia (USD/MYR) digunakan dari tempoh 1 November 2010 sehingga 30 Ogos 2016 yang diperolehi daripada Bank Negara Malaysia. Data tersebut telah dibahagikan kepada dua bahagian di mana 90% daripada data telah digunakan sebagai data *in-sample* diambil dari 1 November 2010 hingga 3 Feb 2016. Sementara itu, bagi 10% lagi digunakan sebagai data *out-sample* yang diambil dari 4 Jan 2016 sehingga Ogos 30 2016. Perisian EViews dan Microsoft Excel telah digunakan dalam kajian ini untuk menganalisis data. Prestasi model hibrid telah dinilai dengan menggunakan AIC, MAE, RMSE dan MAPE. Keputusan telah menunjukkan bahawa, model hibrid ARIMA-EGARCH adalah model terbaik dalam permodelan dan peramalan data bagi kadar pertukaran harian berbanding model hibrid ARIMA-GARCH.

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LIST OF ABBREVIATION

ACF	-	Autocorrelation Functions
ADF	-	Augmented Dicker-Fuller
AIC	-	Akaike Information Criterion
AIC_c	-	Corrected Akaike Information Criterion
AME	-	Absolute Mean Error
AR	-	Autoregressive Process
ARCH	-	Autoregressive Conditional Heteroscedasticity
ARMA	-	Autoregressive Moving Average
ARIMA	-	Autoregressive Integrated Moving Average
BIC	-	Bayesian Information Criterion
EGARCH	-	Exponential Generalized Autoregressive Conditional Heteroscedasticity
EViews	-	Econometrics Views
GARCH	-	Generalized Autoregressive Conditional Heteroscedasticity
JB	-	Jarque-Bera
LM	-	Lagrange Multiplier
MA	-	Moving Average
MAE	-	Mean Absolute Error
MAPE	-	Mean Absolute Percentage Error
MaxAPE	-	Maximum Absolute Percentage Error
PACF	-	Partial Autocorrelation Functions
RMSE	-	Root Mean Square Error
SSE	-	Sum of Square
SBIC	-	Schwarz Bayesian Information Criteria
TIC	-	Theil Inequality Coefficient

LIST OF SYMBOL

$\emptyset_p$	-	AR polynomial
θ_q	-	MA polynomial
ε_t	-	error term at time *t*
δ	-	constant term
λ	-	minimum residual mean square error value
Δ	-	lag order of the autoregressive process
H_0	-	null hypothesis
H_1	-	alternative hypothesis
$\hat{\theta}$	-	tested time series
σ_t^2	-	estimated conditional variance
ε_{t-i}^2	-	past squared return
σ_{t-j}^2	-	past of conditional variance
α_0	-	mean of the volatility
α_i	-	size effect
β_j	-	degree of volatility persistence
γ_i	-	sign effect
n	-	sample size
$\hat{\rho}_k^2$	-	squared sample autocorrelation at lag *k*
d	-	amount of differencing
p	-	autoregressive part order
q	-	moving average part order

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CHAPTER 1

INTRODUCTION

1.0 Introduction

In business and economic fields, modelling and forecasting of time series data is a common research activity in areas such as crude oil price, gold price, exchange rate and stock market. In general, time series data for financial markets always exhibit uncertainty and variability in market changes which are called volatility. In the aspect of exchange rate, volatility refers to the measure of fluctuations of currency. Exchange rate volatility become a major concern as it can give impact on international trade, economic growth, macroeconomic variables as well as export and import for a country. For example, exchange rate volatility induces uncertainty into international transaction that leads to the decreases in international trade and economic welfare (Wong and Lee, 2016). Therefore, modelling and forecasting of exchange rate plays a crucial role for government, financial agencies and institution and also academicians which can help them to gain useful information in making great decisions for a better future.

Our country, Malaysia, is not an exception to the exchange rate volatility. As exchange rate is one of the key indicators for Malaysia's economic growth, depreciation or appreciation of ringgit is of interest to many people including investors, policy makers, financial analysts as well as researchers. It is a known fact that for the past two years, ringgit Malaysia (MYR) had dropped to its lowest level in 17 years since the Asian financial crisis in 1998. One of the main factors contributing to the falling ringgit is declining of oil prices in June 2014 as Malaysia is one of the main oil exporters throughout the world.

1.1 Background of the Study

Modelling and forecasting volatility of financial time series data has been an increasing interest over the last few years. This is due to the fact that volatility plays a crucial role for many financial and economic applications such as in investment, risk management, monetary policy making and security valuation. Volatility can be defined as a condition where the conditional variance changes between extremely high and low value.

In the current study, exchange rate data from the period of 1st November 2010 until 30th August 2016 will be used as the set for real data. The reason these data are chosen as a case study is because it is not only volatile but also play a salient role in economic growth. Exchange rate can be defined as a price for which the currency of a country can be exchanged for another country's currency. Foreign exchange market is the responsible party that determined the rate of exchange between different currencies.

Fluctuations of exchange rate are the increase or decrease in the value of currency against other currency at international level. Generally, fluctuation in exchange rate occurred due to the demand and supply of the currency in foreign exchange market. In simple words, value of one currency will increase if the demand is increased and depreciate when its supply is increased. Other factors that influence the variations and fluctuations in exchange rates include interest rate, inflation, political stability and economic performance.

Financial analysts started to model and explain the behaviour of exchange rate returns and volatility using time series econometrics models because of unexpected events that occurred such as non-constant variance in the financial markets and uncertainties in prices and returns (Ramzan et. al, 2012). Conditional heteroscedastic models are the most cmmon and frequently applied models for exchange rate series (Zakaria and Abdalla, 2012).

Hence, the current study aims to investigate performances of hybrid Box-Jenkins ARIMA models with the GARCH family models. The performances of modelling and forecasting between these models will be compared.

1.2 Statement of Problem

Over the past few decades, fluctuations and movements of exchange rate have created an interest among financial economists, policy makers and academician. Consequently, various types of case studies and methods were applied to the data in order to handle certain characteristics that exist in the series.

Autoregressive Moving Average (ARMA) model had been widely applied to various types of time series data because of its ability in handling nonstationary data and it is easy to implement. Nevertheless, it is unable to handle nonlinearity and volatility features that exist in the data series. For this purposes, other appropriate model that have the ability to capture the volatility of daily exchange rate data are required. Generalized Autoregressive Conditional Heteroscedasticity (GARCH) family model is a well-known and frequently applied method especially in handling volatility for data series. Hence, GARCH family model are used in this study to capture the volatility effect in the series.

GARCH family models can be categorized into types which are symmetric and asymmetric. In this study, for symmetric models, GARCH model is chosen, while for asymmetric models, EGACH model is chosen. Hence, the current study is conducted to investigate the performance of hybrid ARIMA with symmetric GARCH, specifically ARIMA-GARCH and hybrid ARIMA with asymmetric GARCH, specifically ARIMA-EGARCH for daily exchange rate data.

The combination of linear ARIMA model with nonlinear GARCH model is necessary so that the conditional mean and conditional heteroscedasticity of the exchange rate series can be captured. Furthermore, by combining these models, it can

be an effective way to overcome the drawbacks of each component and able to improve the accuracy of forecasting.

1.3 Objectives of the study

The current study is conducted with the following objectives:

1) To develop the best hybrid ARIMA-GARCH model for exchange rate data.

2) To develop the best hybrid ARIMA-EGARCH model for exchange rate data.

3) To compare the modelling and forecasting performances of ARIMA-GARCH and ARIMA-EGARCH models for exchange rate data.

1.4 Scope of the Study

This study focuses mainly on the hybridization between ARIMA model and GARCH family models in modelling and forecasting volatile data by using E-Views software. GARCH family models can be divided into two groups which are symmetric and asymmetric. In the current study, for symmetric, GARCH model is chosen while for asymmetric, EGARCH model is chosen. Daily data of U.S. Dollar exchange rate against Malaysia exchange rate (USD/MYR) is used in this study. The duration of the data is from the period of 1st November 2010 until 30th August 2016 obtained from the Central Bank of Malaysia (Bank Negara Malaysia). For modelling, the performance will be compared through the value of AIC, while for forecasting performance, three evaluation criteria will be compared which are RMSE, MAE and MAPE.

1.5 Significance of the Study

Through this study, we will model and forecast the exchange rate data using hybrid ARIMA-GARCH and ARIMA-EGARCH models. Generally, ARIMA models can handle nonstationary data while the GARCH family models have the ability to capture nonlinear characteristics of the variance in the series. Therefore, it is hoped that this study can produce the best model for predicting volatile data.

Forecasting's accuracy of exchange rates play a crucial role because substantial amount of trading takes place through the currency exchange market. It can also affect economic growth for a country in cases of appreciation and depreciation of currency that occurred in foreign exchange market. Hence, forecasting of exchange rate can provide useful information which helps the financial institutions, policy makers and investors to make correct decisions in order to mitigate their losses in financial market.

1.6 Limitation of the Study

Daily data of U.S. Dollar exchange rate against Malaysia exchange rate (USD/MYR) from 1st November 2010 until 30th August 2016 were used in the current study. For time series models, hybridization between Box-Jenkins ARIMA with the GARCH family models is chosen. Since the data encountered symmetric and asymmetric properties, the performances between hybrid ARIMA-GARCH and ARIMA-EGARCH model will be compared.

1.7 Organization of the Report

This report comprise of five chapters. Chapter 1 starts with the introduction to the current study, followed by the background of the study, statement of problem, objectives of the study, scope of the study and significance of the study. Then, it describes the limitation of the study and end with the thesis organization.

Chapter 2 presents previous works that are related to the current study. In this chapter, reviews on exchange rate data and reviews on hybridization of ARIMA models with GARCH family models are presented.

Chapter 3 discusses the research methodology for the current study. It consists of Box-Jenkins ARIMA methodology, GARCH family models methodology and hybridization of ARIMA with GARCH family models methodology.

Chapter 4 presents the analysis of hybrid ARIMA-GARCH and ARIMA-EGARCH models. The best hybrid model in modelling the series will be chosen based on Akaike's Information Criterion (AIC) while for forecasting, the best hybrid model is selected based on the values of RMSE, MAE and MAPE.

The last chapter which is Chapter 5 presents the summary and conclusions made from this study. This final chapter ends with some suggestions for future research.

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