SOURCES OF EXCHANGE RATE FLUCTUATIONS AND VOLATILITY TRANSMISSION IN FIVE SOUTHEAST ASIAN COUNTRIES

Apinya Wanaset

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Apinya Wanaset

School of Development Economics

Associate Professor.....Major Advisor

(Komain Jiranyakul, Ph.D.)

Assistant Professor.....Co-Advisor

(Santi Chaisrisawatsuk, Ph.D.)

Assistant Professor..... Co-Advisor

(Yuthana Sethapramote, Ph.D.)

The Examining Committee Approved This Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy (Economics).

Assistant Professor.....Committee Chairperson

(Bundit Chaivichayachat, Ph.D.)

Associate Professor.....Committee

(Komain Jiranyakul, Ph.D.)

Assistant Professor.....Committee

(Santi Chaisrisawatsuk, Ph.D.)

Assistant Professor.....Committee

(Yuthana Sethapramote, Ph.D.)

Associate Professor.....Dean

(Adis Israngkura, Ph.D.)

August 2010

ABSTRACT

Title of Dissertation	Sources of Exchange Rate Fluctuations and Volatility Transmission in Five Southeast Asian Countries
Author	Apinya Wanaset
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This research aims to investigate exchange rate behaviors in various aspects, especially 1) sources of exchange rate fluctuations: the pass-through effects of key macroeconomic variables on the exchange rate and 2) volatility transmission of exchange rate among five Southeast Asian countries namely Indonesia, Malaysia, the Philippines, Singapore and Thailand.

For research methodologies, this study employs a number of tools since it consists of two main features of exchange rate behaviors like sources of exchange rate fluctuations and volatility transmission of exchange rate among the selected countries. The former uses Vector Autoregressive (VAR) model with application of cointegration test, error correction model, impulse response analysis and variance decomposition is motivated to choose the list of variables to capture importance sources of fluctuations. The latter uses multivariate GARCH model to analyze the exchange rate volatility transmission among these countries. The results are also compared to the other measures like bi-variate analysis of impulse response and causality tests as well.

The results from the VAR analysis with its application including cointegration test, vector error correction model (VECM) suggest that first, all selected key macroeconomic variables are cointegrated for all of the selected countries. In other words, they have long run equilibrium. For short run, the results from VECM reveal that these countries can be achieved error correction mechanism in some of key macroeconomic variables. This means that there exists the convergence process. Second, these macroeconomic variables have affected exchange rate fluctuations from

impulse response analysis and variance decomposition analysis. The results show the instability in exchange rate movements in the case of Indonesia comparing to other countries in this region. However, Singapore has the most exchange rate stability. In summary, these results imply that changes in key macroeconomic variables are probably accompanied by exchange rate fluctuations.

For exchange rate volatility transmission, the results from multivariate GARCH model revealed that there are some evidences for direct and indirect volatility transmission across the currencies in this study. The volatility also generates from both its own markets and cross-markets. This supports to the hypothesis that co-movements of exchange rates in this region can explain the rapid transmission especially in post-crisis period. As a result, most of the cross-currency interactions seem to stem from the co-movements of exchange rates over time. The results of estimating from impulse response analysis suggest that most of them respond to contemporaneous change from another currency in both periods of time. An exception is Thai baht, which move quite independently from any other currencies during the pre-crisis period. The response of one currency to another currency in the post crisis period seems to be smaller than the previous one. As a result of most of these countries adopting the floating exchange rate regime that automatically adjusts, they enable a country to resist the impact of shocks. Granger causality analysis shows the significant of the cause and effect between currencies in this region.

The major finding implies that changes in key macroeconomic variables are likely to be accompanied by exchange rate fluctuations and higher volatility transmissions of these currencies in the post-crisis period. To achieve a financial stability, policy makers should provide an overall basket of incorporated policies and instruments not only the exchange rate interventions but also other factors-developing and strengthening financial system, and strengthen macroeconomic policies. In addition, central banks in the member state should conduct exchange rate policy on a regional basis in order to cope with any shocks and exchange rate volatility.

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TABLE OF CONTENTS

LIST OF TABLES

Tables **Page**

LIST OF FIGURES

Figures **Page**

CHAPTER 1

INTRODUCTION

1.1 Statement and Significance of the Study

The exchange rate is one of the essential economic indicators of economy's international competitiveness because it has a strong influence on economic developments, foreign trade and capital account that includes portfolio investment and foreign direct investment (FDI). The exchange rate volatility affects not only the values of domestic currency in term of foreign receipts and payments in the future but also affects their foreign currency values by affecting the volume and value of future trade flows. Therefore, exchange rate stability seems to provide benefit to the country in the sense that it does not create exchange rates uncertainty (Yagei, 2001: 2). Exchange rate volatility and contagion should be a matter for concern if it disrupts economic activity. In general, the movements of exchange rate stem from several factors such as economic fundamentals, policy intervention and expectations. In many cases, the exchange rate movements are also driven by psychological factors. After the collapse of Bretton Wood system about four decades ago, many empirical studies indicated that exchange rate behavior has significantly changed since many countries switched to the floating rate regime. In addition, the increasing globalization of economies also leads to be higher volatility in exchange rate (Karras et al., 2005: 214-215).

Recently, exchange rate volatility has attracted much attention. Since, it widely impacted on many agents in economy including traders, investors, portfolio managers, multinational firms and policy makers. Many studies try to explain exchange rate behavior in different perspectives, for example, forecasting pattern of exchange rate movement, measure of risk premium, analyzing how exchange rate volatility affected the key macroeconomic variables and transmission volatility of exchange rates. Various empirical tests have explored exchange behavior by using

data from both developed and developing countries so as to understand the behavior of exchange rates. Most existing studies on exchange rate behavior focus on individual issues, for instance exchange rate volatility transmission (Bollerslev, 1990: 498-505; Karolyi, 1995: 11-25; Kearney and Patton, 2000: 29-48), and sources of exchange rate volatility (Flood and Rose, 1995: 3-37; Karras et al., 2005: 213-226). However, only few studies have incorporated multiple perspectives especially studies concerned with Southeast Asian countries following the crisis of 1997. Thus, the main motivation for this research is to investigate exchange rate behaviors incorporated many perspectives in one paper by using many econometric tools both in short run and long run aspects. First issue of this study tries to explain the sources of exchange rate volatility in the long run that come from fundamental factors for example, GDP, money supply, inflation and oil price. Nevertheless, after Asian financial crisis in 1997, exchange rate behaviors seem to be changed from the pre-crisis period Ghosh et al., (2002: 55) and MacDonald (2007: 21). It is more dynamic and volatile. Hence the additional issue is to investigate exchange rate volatility transmission among the selected countries in short run by using daily data. This issue is planed to compare their behaviors in pre and post crisis periods as well.

Currently, Southeast Asian region is become a crucial part of the world trading system. Its international commercial trade has increased tremendously in the past decade. Thus, these countries are widely concentrated. Why this study is designed to choose five Southeast Asian countries namely Indonesia, Malaysia, Philippines, Singapore and Thailand. Since, they are the core countries to drive ASEAN economy and the pioneer of AFTA (ASEAN Free Trade Area) members together with high economic fundamental correlations. It is known that particular reasons of exchange rate volatility and transmission come from their economic fundamentals. Therefore, this study would like to investigate their exchange rate behaviors as sources of exchange rate volatility and exchange rate volatility transmission among them.

Recently, the five selected Southeast Asian countries have various exchange rate regimes both floating exchange rates and fixed exchange rate. A brief explanation of exchange rate system background in these countries is as following:

1.1.1 Exchange Rate Policy in Southeast Asian Countries

Following the Asian crisis experiences in 1997, many countries in Asia adopted managed or floating exchange rate system as the means of exchange rate determination to maintain international transactions. One clear reason is that the fixed exchange rate regime did not perform well in the crisis. Moreover, occasional large fluctuations which are typical of a fixed exchange rate system are more costly, destabilizing and disruptive to the economy than the more frequent but more gradual changes that may occur in a free float system. Thus, the floating exchange rates seem to be a better responsive to massive capital flows and the threat of self-fulfilling speculative attacks and are probably less vulnerable to such attacks.

Under a flexible exchange rate system the exchange rates are determined by the demand for and supply of currencies in exchange rate markets, and consequently, exchange rates are subjected to high volatility. As a result, pattern of exchange rate behaviors are quite different from the previous era especially prior to the Asian financial crisis in 1997(Ghosh et al., 2002: 55 and MacDonald, 2007: 21). The histories of exchange rate system are showed as following:

1) Indonesia

In the early 1970's, Indonesia adopted the simplified multiple exchange rate structure, including a Flexible General Exchange Rate, a Flexible Credit Foreign Exchange Rate and Export Rate. In 1983, the central bank of Indonesia decided to adopt the managed float policy and considered a wider range of currency.

Until 1989, the central bank of Indonesia revised the exchange rate system again. It sets the value of the rupiah against a basket of currencies, and intervened in the market around that central rate. The central rate was depreciated gradually according to the differential between domestic and foreign inflation, so as to stabilize the real exchange rate. In January 1994, a first step was undertaken to enhance exchange rate flexibility through the introduction of a band. Subsequently, exchange rate fluctuation band was widened up to a fluctuation range of 3 percent. Finally, in August 1997, after the Asian financial crisis, the managed floating exchange regime was replaced by a free-floating exchange rate arrangement.

2) Malaysia

In June 1967, the 3 separate dollars including M$ replaced the old sterling-linked Malaysian/Straits dollar and the unit of M$ was created. The central bank of Malaysia administered their exchange rate controls on behalf of the Malaysian government throughout Malaysia, with authority delegated to the authorized banks. Initially, the M$ was linked to pound sterling. With the floating of sterling and dismantling of the sterling area, Malaysia adopted the U.S. dollar as the intervention currency in place of the sterling in June 1972. The effective rate was established with a fluctuation range.

Since June 1973, Malaysia placed the effective rate for dollar on a controlled, floating basis. The central bank of Malaysia intervened only to maintain orderly market conditions and to avoid excessive fluctuations in the value of the ringgit. In June 1975, the controlled, floating effective rate was replaced. In order to maintain orderly exchange rate, the Malaysian government adopted a new exchange rate regime. The external value of the ringgit was to be determined in terms of a basket of major currencies, weighted on the basis of the major currencies of settlement as well as the major trading partners of Malaysia.

In 1998, following the Asian Financial Crisis, the exchange rate of the ringgit was no longer determined by demand and supply in foreign exchange markets. Malaysia returned to a fixed exchange rate system, pegged a rate against the U.S. Dollar at RM 3.80 per $1. Until 2005, the central bank of Malaysia revised their exchange rate system again by adopting managed float exchange rate system.

3) Philippines

From 1970 to 1984, the Philippines had a periodic history of multiple exchange rates with different rates to foreign exchange transactions, for instance, export, import and foreign debts, on the basis of a daily "Guided Rate".

In mid 1980s, with the economic takeoff of the neighboring in this regional area, the Philippines tried to improve market mechanism by removing distortions in its economic regimes and opening up the highly protected economy. Following a financial crisis in 1983, the multiple exchange rate structure was ended in 1984. Since then, the Philippine has maintained a floating exchange rate regime.

At present, like most countries in this region, the Philippine follows a market-determined foreign exchange policy or managed float. In other words, the central bank does not fix the exchange rate at a given level but instead allows the interplay of supply and demand for the currency to determine the exchange rate. Meanwhile, the central bank of Philippines's participation in the foreign exchange market is limited by either buying or selling dollars only to ensure orderly conditions and avoid unnecessary swings in the exchange rate. At the same time, the bank's role in monetary policy includes an inflation targeting framework which demands disciplined commitment to participate in the foreign exchange market only in well-defined circumstances. The central bank thus concerns itself with both factors simultaneously.

4) Singapore

After the final breakdown of Bretton Wood system in 1973, Singapore designed to peg their exchange rate to pound sterling and follow by U.S. dollar respectively. During this period, the Board of Commissioners of Currency played the main role in supporting Singapore's exchange rate system. The government signaled to financial market its commitment to maintain a strong convertible currency by backing the issue of domestic currency with foreign reserves.

In early 1980's, the government chose the exchange rate as the instrument of monetary policy in order to maintain exchange rate stability and promote Singapore as trading center in this region. They switched from a pegged exchange rate regime to managed float. With an aim to a more market-oriented approach, Singapore allowed its currency to float under the monitor of the Monetary Authority of Singapore (MAS).

The Asian financial crisis, with starting from the devaluation of Thai baht in 1997, led to pressure for an adjustment in exchange rate policy. The Monetary Authority of Singapore (MAS) adopted a more flexible approach in exchange rate management under higher uncertainty of the regional financial markets and rapid downturn in economic activity. The MAS expanded its exchange rate policy band, to cope with the problem at that time and it allowed the Singapore dollar to depreciate by about 20 %.

5) Thailand

In Thailand, after the major crisis in 1977, the central bank switched from pegged exchange rate regime (against a basket of currencies) to flexible exchange rate regime or managed float. Initially, monetary policy framework turned to use monetary targeting regime at the early period. However, the targeting of money supply would be less effective due to the uneven relationship between money supply and output growth. As a consequence, an inflation targeting regime was adopted in 2000.

The study from Bank of Thailand suggested that the development of Thailand monetary policy framework can be divided into three main periods

(1) Pegged exchange rate regime (Second World War – June 1997): Pegged exchange rates were adopted after the Second World War. The value of the baht was initially either pegged to a major currency / gold or to a basket of currencies. The basket regime was adopted from November 1984 until June 1997. During this period, the Exchange Equalization Fund (EEF) would announce and defend the baht value against the U.S. dollar daily, with monetary and financial measure were mainly designed to be in line with the pegged exchange rate regime.

(2) Monetary targeting regime (July 1997 – May 2000): Starting after the major crisis as well as the adoption of the floating exchange rate system on 2 July 1997, Thailand received financial assistance from the International Monetary Fund (IMF). During this period, Thailand has adopted the managed-float exchange rate with the value of the baht is determined by market forces. The Bank of Thailand would intervene in the market only when necessary, to prevent excessive volatilities and achieve economic policy targets. As the same time, monetary targeting regime was adopted. Under this policy, the Bank of Thailand targeted domestic money supply using the financial programming approach in order to ensure macroeconomic consistency as well as to reach the ultimate objectives of sustainable growth and price stability. The Bank of Thailand set the daily and quarterly monetary base targets, based on its daily liquidity management. It essentially aimed to ensure against excessive volatility in interest rates and liquidity in the financial system.

(3) Inflation targeting regime (May 2000 - present): After the IMF program, the Bank of Thailand developed an extensive reappraisal of both domestic

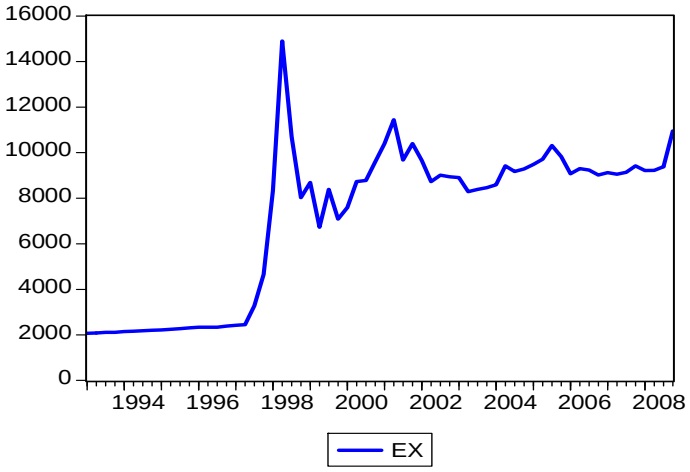
and external environments and concluded that the targeting of money supply would be less effective than the targeting of inflation. One of the main causes for change was that the relationship between money supply and output growth was becoming less stable, especially in the period after the crisis in 1997 and uncertainty in credit extensions as well as the rapidly changing Thailand financial sector.

At present, all of the five selected countries in this study switch to floating exchange rate system. Only Malaysia ringgit has maintained at a fixed exchange rate system, pegged a rate against the U.S. dollar in the early period after 1997. Another purpose of this study tries to compare performance and behavior in pre and post-crisis period as well.

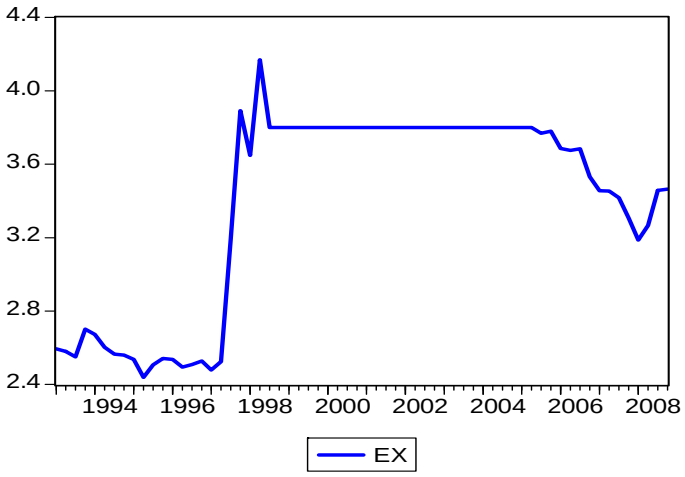
1.1.2 The Movement of Exchange Rate in Southeast Asian Countries

The movement of exchange rate in Southeast Asian countries expresses as following figures:

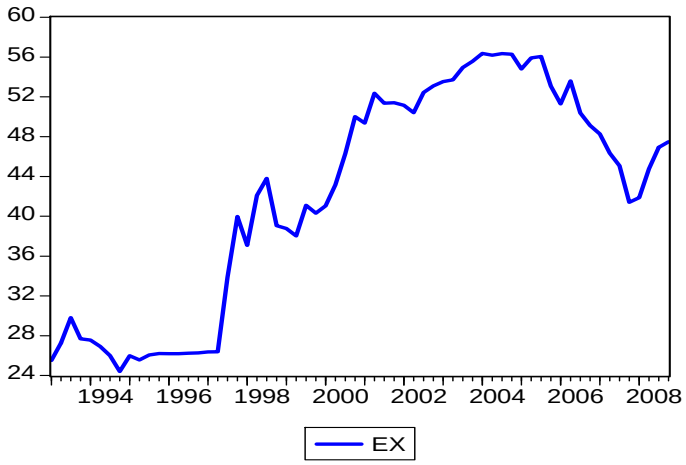
Indonesia (Rupiah : 1 U.S. Dollar)



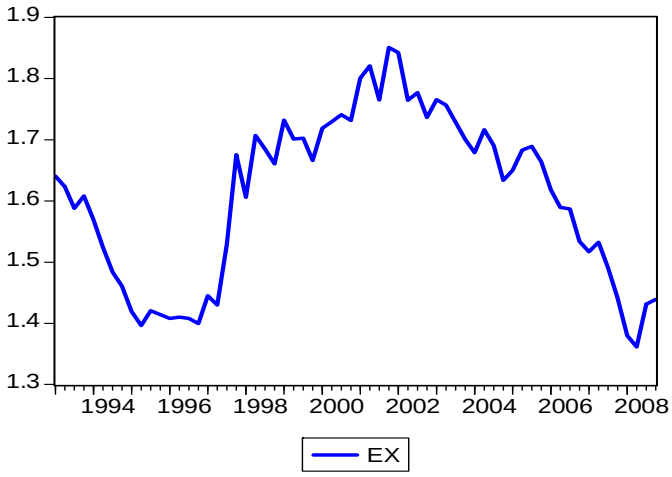
Malaysia (Ringgit : 1 U.S. Dollar)



Philippine (Peso : 1 U.S. Dollar)



Singapore (Singapore Dollar : 1 U.S. Dollar)



Thailand (Baht : 1 U.S. Dollar)

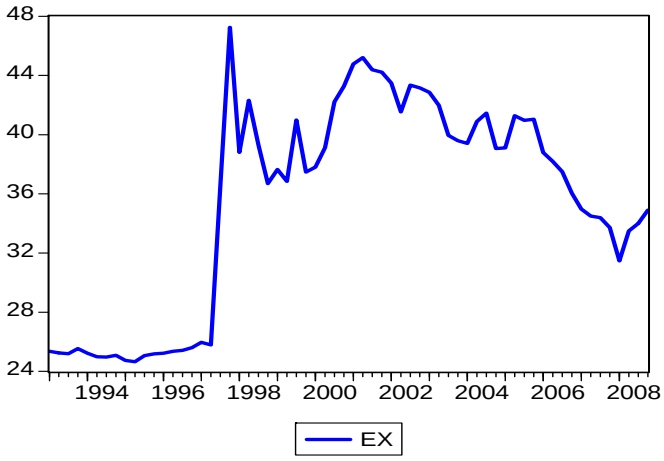


Figure 1.1 The Movement of Exchange Rate in Southeast Asian Countries

1.2 Objectives of the Study

This study aims to investigate exchange rate behaviors in various aspects, especially sources of exchange rates fluctuations and volatility transmission of exchange rates among five Southeast Asian countries namely Indonesia, Malaysia, Philippine, Singapore and Thailand. According to the changing of exchange rate regime and structural change in these economies after the crisis of 1997, exchange rate behaviors appear to have differed significantly compared to the pre-financial crisis period (Ghosh et al., (2002: 55) and MacDonald (2007: 21).

In addition, further aims of the study are:

1) To investigate the information transmission process among foreign exchange markets that are crucial to asset valuation, risk management, international financial management and economic policy from avoiding damage and loss, the co-movements in volatility also help understanding of financial markets, and shed light on issues such as contagion, and the transmission of shocks through the financial system. These contribute to risk education both in private and public sectors as well as supporting economic stability and sustainable growth.

2) To examine the sources of exchange rate fluctuations in five Southeast Asian countries including Indonesia, Malaysia, Philippine, Singapore and Thailand.

3) To compare the exchange rate behavior in important aspects, i.e., exchange rate volatility transmission in two period of time, pre and post the Asian financial crisis in 1997 as well as sources of exchange rate fluctuations in the selected Southeast Asian countries.

4) To provide the policy guidelines from the results of this study to private sector and the responsible authorities in order to cope with some serious situations and to design policy instruments or intervention strategy to intervene the exchange rate markets.

1.3 Methodology

According to this study consists of two main features of exchange rate behaviors like sources of exchange rate fluctuations and volatility transmission of exchange rate among five Southeast Asian Countries, therefore I employ the following methodology for each of them:

1.3.1 Vector Auto Regressive (VAR) Model

For the study of sources of exchange rate fluctuations**,** I examined macroeconomic variables that influent to exchange rate fluctuations. The existing literatures employ several methodologies to investigate relationship between macroeconomic variables such as least squares analysis, panel data studies, macro model simulations, and VAR models. The VAR approach has many advantages such as allowing investigation of the multivariate models and identifying structural shocks through variance decomposition, VAR model with its applications such as cointegration test, vector error correction model (VECM), Impulse response analysis, variance decomposition and causality analysis is motivated to choose the list of variables to capture importance sources of fluctuations in this study. It is one of the most popular methodology and widely used for multivariate time series analysis.

1.3.2 Multivariate GARCH

In this study, I employ multivariate GARCH model to analyze the exchange rate volatility transmission among these countries. It is known that there are many tools used to explain this issue e.g. regime switch models, stochastic volatility models and GARCH models.

GARCH models, the most popular for time varying estimation, initially introduced by Engle (1982: 987-1008) and consequently extended by many economist like Bollerslev (1986: 308-326), Bollerslev (1990: 498-505), Bollerslev and Engle (1993: 167-186), Engle (2001: 157-168), Bera and Kim (2002: 171-195). Both univariate and multivariate GARCH models have also been used to investigate volatility and correlation transmission and spillover effects in studies of contagion. Especially, multivariate GARCH model is more powerful to explain volatility

transmission and spillover effects. It includes both its own conditional variance and covariance.

1.4 Scope of the Study

This paper consists of two main features of behaviors:

1.4.1 Sources of Exchange Rate Fluctuations

This part tries to investigate various factors affecting behaviors of a currency's rate of exchange with other currencies, and to trace the sources of the recent fluctuations of exchange rate in the currency markets in order to gain a better understanding of the present complications by recapitulating the factors that influence or determine the exchange rate movements especially in the long run by using quarterly data.

At the basic concept, country's imports and exports predict the exchange rate. A huge trade or current account deficit results in the depreciation of exchange rate (Backus and Crucini, 2000: 185 and Aliyu, 2009: 6). It is widely known that one notion worth mentioning is the oil bill when the country is dependent on imported crude oil. On the other hand, current account surplus results in exchange rate appreciation. Moreover, relative price level or inflation rate as well as industrial production are crucial determinants of exchange rate.

1.4.2 Volatility Transmission of Exchange Rate among Southeast Asian Countries

This part aims to analyze volatility transmission of exchange rates among Southeast Asian countries in pre and post the financial crisis to compare their behaviors between two periods of time. Currently, exchange rate market rapidly responses to shocks and links to other markets. It is known that there are many reasons why the volatility of individual exchange rate is linked each other. One particular reason is that fundamentals of exchange rates, especially international trade and investment are related, and thus any new information about fundamentals may affect the volatility of corresponding currencies at the same time. Foreign exchange

markets are almost perfectly integrated on 24-hour trading basis, a change in one currency from the new information about fundamentals should be simultaneously transmitted to other currency changes.

Another reason for the linkage between volatility of exchange rates is market psychology. Although, there are no apparent common fundamentals between currencies, speculations based on fads, noises or herd instinct might be transmitted as well. However, many studies emphasize on the role of macroeconomic fundamentals view especially a contagion nature of currency crisis (Huang and Yang, 2002: 40). In this part, a multivariate GARCH model will be adopted to examine the volatility transmission of these currencies in short run and dynamic operating between the involved variables by using daily data. Since, it is able to well explain volatility from both their conditional variance and covariance.

1.5 Contribution of the Study

There are several expected contributions from this study as following:

1) This study provides useful information for policy maker and private sector in the sense of how volatility transmission among five Southeast Asian countries, sources of exchange rate fluctuations and comparison between these selected countries.

2) Both private and public sectors are able to cope with uncertainty situations from exchange rate volatility and to design the potential economic strategies by using this information.

3) Risk reduction as well as damaging avoidance from exchange rate fluctuations is additional benefits from this study.

1.6 Structure of Presentation

This study consists of 6 chapters as following:

1) Chapter 1 is the introduction that describes an overview of this study on exchange rate behaviors incorporating the significance of the study, its objective, scope, methodology, contributions and structure of presentation.

2) Chapter 2 contains literatures review. The review of related literatures is divided into three main parts. The first part of literatures review is the development of volatility study of time series in financial field. The second gives an overview of ARCH/GARCH models as well as VAR process with its applications. The last one focuses on empirical reviews of all related studies both sources of exchange rate fluctuations and exchange rate volatility transmission.

3) Chapter 3 presents the theoretical framework about exchange rate regime, exchange rate volatility and its impact, and the relationship between exchange rate and other key macroeconomic variables including GDP, money supply, inflation and oil price based on the purchasing power parity (PPP) and the flexible price monetary models.

4) Chapter 4 investigates sources of exchange rate fluctuations by mean of VAR model with the application of cointegration test, vector error correction model(VECM), impulse response analysis, variance decomposition and Granger causality test including introduction, methodology, empirical results and conclusion of this issue.

5) Chapter 5 analyzes exchange rate volatility transmission among the selected Southeast Asian countries by employing the multivariate GARCH model, impulse response analysis and causality test. This chapter also consists of its introduction, methodology, empirical results and conclusion.

6) Chapter 6 presents conclusions and policy implications which can be drawn from the study. I conclude with all of the empirical results of comparative exchange rate behaviors among the selected Southeast Asian countries as well as explaining the significant policy implications.

CHAPTER 2

REVIEW LITERATURES

2.1 Overview of Previous Studies

Exchange rate fluctuations plays a crucial role in financial decision making e.g. portfolio investment, international business management, risk management and policy intervention, therefore understanding of its behaviors and volatility forecasts are likely important to many parts in economy. There are several recent studies that examined exchange rate behavior in many perspectives. In early time, exchange rate volatility has been usually considered as an exogenous factor, rather than the thing that itself needs to be studied. Many papers investigated about the greater post-Bretton Woods (in the early 1970's) exchange rate volatility affecting the key macroeconomic variables to understand the international financial impact of shifts in exchange rates e.g. international trade, consumption, inflation and economic development by using various data set and econometric methods. For example, Baxter and Stockman (1989: 377) find that exchange rate system does not affect to behavior of industrial production, consumption, export and import. Similar to Gagnon (1993: 284) reports that the exchange rate volatility has the small influence on the volume of trade. Rose (2000: 7) concluded that a common currency enhances trade among economies. Whereas, Ito and Sato (2006: 1) find that exchange rate affects to the domestic prices in the East Asian countries.

While the influences of different exchange rate regime on the economy are still interesting. However, instead of examining the consequences of exchange rate volatility, many studies switch to explain the behavior of exchange rate itself by using the new econometric methods to estimate the conditional variances and co-variances. Engle (1982: 987-1008) was the first to introduce a formal modeling procedure, known as Auto-regressive Conditional Heteroskedasticity (ARCH) model, to capture such type of behavior in time series, the first study related to the estimation of the

variance of U.K. inflation. It allowed the conditional variance of time series to change over time as a function of past error term. This model was further extended to the Generalized ARCH (GARCH) model by Bollerslev (1986: 307-327). These behavior models have already proven useful in modeling various economic phenomena especially financial data sets. This is because the data sets including uncertainty that trend to change over time. In other word, ARCH and GARCH models are efficient tools for estimating conditional second moment statistical distribution like variances and covariances, see Engle (2001: 157-168). Many financial theories deal with the relationship between second moments of asset return and first moments e.g. expected asset return and other macroeconomic variables like exchange rate, GDP, inflation and money supply.

Consequently, exchange rate behaviors have been investigated in various purposes such as risk premium and volatility transmission between currencies. The extension of GARCH models, were developed from many economists. Starting by Engle et al. (1987: 391-407), they consider of two financial asset i.e. risky and riskless assets by using ARCH in mean or ARCH-M to capture risk premium. They assume that risk is measured as a function of the conditional variance of the risky asset. Thus, the price offered by risk adverse agent fluctuates over time. This suggests a positive value monotonically increasing function of conditional variance in the conditional mean equation.

As volatility model of the returns has been the main center of attention, understanding the co-movements of financial returns is the great practical importance. It is therefore important to extend the considerations to multivariate GARCH model. For instance, asset pricing depends on the covariance of the assets in a portfolio, and risk management and asset allocation e.g. to finding and updating optimal hedging positions, see Bollerslev et al. (1988: 116-131), Engle et al. (1990: 213-237), and Hansson and Hordahl (1998: 377-388). However, multivariate GARCH models have also been used to investigate volatility and correlation transmission and spillover effects in studies of contagion, see Tse and Tsui (2002: 351-362) and Bera and Kim (2002: 171-195). it should be flexible enough to be able to represent the dynamics of the conditional variances and co-variances.

Another part of this study is related to sources of exchange rate fluctuations, I study by mean of Vector Autoregressive (VAR) framework. VAR Model is widely used to investigate the relationship between macroeconomic variables based on a system of equations approach and endogenously determines of all the variables. In addition, it can explain relationships of these variables in many aspects such as variance decomposition, co-integration, impulse response, error correction mechanism and causality test. Earlier VAR studies have in many cases been concerned with measuring monetary policy and its macroeconomic effects. See e.g. Gordon and Leeper (1994: 1228-1247); Christiano, Eichenbaum and Evans (1996: 22-23).

2.2 Development of Volatility Study in Financial Field

The early empirical studies were widely employed the classical Ordinary Least Square (OLS) method to explain relationship between economic variables. This methodology seems to work well when variable is stationary. It can achieve Best Linear Unbiased Estimator (BLUE) principle. In statistics, given a sample of data, the estimator is a linear combination of this data which measures the right quantity with no systematic errors (unbiased) and is the most efficient (best) because its variance is minimal. However, it is widely known that financial data have a number stylized features for example, high frequency, non-stationary, non-normality, linear independent, volatility pooling and asymmetries in volatility.

Therefore, traditional econometric models are unable to explain some typical features for financial data sets. At least three of them are investigated by some economists. First, Stenius (1991: 41-45) indicated the empirical studies from stock markets that stock returns have leptokurtic distributions rather than normal distribution. According to Watsham and Parramore (1997: 78), one reason for this kind of distribution is discontinuous trading that produces periodic jumps in asset prices. Due to the markets are not continuously open and information may arrive during this period of time, so it results a jump in asset prices. The result is a leptokurtic distribution with fat tails and excess peakedness. Second, the patterns of them are volatility cluster. It means that large returns of either sign are expected to follow by large returns and vice versa. Third, features of financial data are leverage

effects. As Watsham and Parramore (1997: 125) mentions, there is evidence that volatility raises more following a large price fall than after a price rise of same magnitude. It means that financial data always response to bad news more than good news.

Consequently, it is generally known that the volatility of many financial return series is not constant over time and that these series exhibit prolonged periods of high and low volatility, often referred to as volatility clustering. Over the past two decades, the prominent model has been developed in order to capture this time-varying autocorrelated volatility process: the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. This model defines the time-varying variance as a deterministic function of past squared innovations and lagged conditional variances.

2.3 Related Models in This Study

For this study, I would like to investigate time varying risk premium, sources of exchange rate volatility and volatility transmission among the five Southeast Asian countries. The suitable and chosen models for this study are Generalized Autoregressive Conditional Heteroscedasticity (GARCH) and Vector Auto Regressive (VAR) model.

2.3.1 ARCH / GARCH Models

The Autoregressive Conditional Heteroscedasticity (ARCH) models is a newly more efficient technique to explain the volatility of financial data that introduced by Engle (1982: 987-1008). The ARCH model allows the conditional variance of error term to change over time as a function of past errors leaving the unconditional variance constant. According to the traditional methodology of the least squares model assumes that the expected value of all error terms are constant. This assumption is called homoskedasticity. In general, financial data in which the variances of the error terms are not equal. The error terms may reasonably be expected to be larger for some ranges of the data than for others. As a result, these are suffered from heteroskedasticity (Engle, 2001: 157-168). The presence of

heteroskedasticity, the regression coefficients for an ordinary least squares regression are still unbiased, but the standard errors and confidence intervals estimated by conventional procedures will be too narrow, giving a false sense of precision. Instead of considering this as a problem to be corrected, ARCH and GARCH models treat heteroskedasticity as a variance to be modeled. As a result, not only the deficiencies of least squares are corrected, but also a prediction is computed for the variance of each error term. This prediction turns out often to be of interest, particularly the applications in financial field.

The GARCH model was introduced by Bollerslev (1986: 307-327) that is a more general case than the ARCH model. In their original form, a normal distribution is assumed, with a conditional variance that changes over time. For the ARCH model, the conditional variance changes over time as a function of past squared deviations from the mean. While the GARCH processes variance changes over time as a function of past squared deviations from the mean and past variances. The GARCH model is introduced to overcome the problems of the non-negativity constraints and optimal lag range setting. The most widely used GARCH model is GARCH (1,1) model. The (1,1) in parentheses is a standard notation in which the first number refers to how many autoregressive lags, or ARCH terms, appear in the equation, while the second number refers to how many moving average lags are specified, which here is often called the number of GARCH terms. Sometimes models with more than one lag are needed to find good variance forecasts. However, GARCH (1,1) is the most widely used GARCH model because it is accuracy and simplicity. It has the standard pattern as following:

Mean Equation,

$$\mathbf{Y_t} = \gamma_0 + \gamma_1 \mathbf{Y_{t-1}} + \varepsilon_t \qquad \textbf{----(2.1)}$$

$$\varepsilon_t = z_t \sqrt{h_t} \quad , \quad (z_t \sim \text{i.i.d. } N(0,1))$$

Variance Equation,

$$\mathbf{h_t} = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \beta_1 \mathbf{h_{t-1}} \qquad \textbf{----(2.2)}$$

$$\alpha_0 > 0, \quad \alpha_1 > 0, \quad \beta_1 \geq 0 \quad \text{and} \quad \alpha_1 + \beta_1 > 0$$

Y_t = mean of time series

h_t = variance of time series

ε_t = error term

Mean equation (2.1) and variance equation (2.2) are estimated simultaneously. This ARCH process generates series that exhibit excess kurtosis and volatility clustering (Engle, 1982: 987-1008). The model can be explained the effects of shocks to volatility that are usually last for quite long period.

The applications of GARCH / ARCH models are widely uses in financial field, for instant portfolio investment, risk premium and volatility transmission in financial market. The extensions of GARCH / ARCH models are also several typical applications such GARCH in mean or GARCH–M, Integrated GARCH or IGARCH, Threshold GARCH or TGARCH, Exponential GARCH or EGARCH and multivariate GARCH. However, for this study, the related models are only multivariate GARCH model.

For multivariate GARCH model has been used to investigate volatility and correlation transmission among variables and spillover effects in financial market such as stock market and foreign exchange market.

2.3.2 Vector Auto Regressive (VAR) Model

Vector Auto Regressive (VAR) models have been much used in empirical studies of macroeconomic issues since they were launched for such purposes by Sims (1980: 1-48). This first study related to the estimation of a six-variable dynamic system namely GNP, money supply, unemployment rate, wages, price level and import price based on an alternative style of macro-econometrics without using theoretical perspectives. He suggests that it should be feasible to estimate large scale macro-models as unrestricted reduced forms, treating all variable as endogenous (Sims, 1980: 1-48). This study employs the quarterly data of U.S from 1949 to 1975 and for West Germany 1958 to 1976. Sims also criticized the way that the classical simultaneous equations models are identified as well as questioned about the

exogenous assumptions for some variables not necessary backing by theoretical framework. In contrast, VAR model overcomes this problem from treating all variables as endogenous variables.

Basically, the form of a VAR model treats all variables symmetrically without making reference to the issue of dependence versus independence or of them as endogenous variables and estimating dynamic systems without using theoretical perspectives. This methodology is one of the most successful, flexible and easy to analyze the multivariate time series (Sims, 1980: 1-48). It is the extension of the univariate autoregressive model to dynamic multivariate time series and proven to be useful for explain the dynamic behavior of economic and financial time series.

They are now widely used in all kinds of empirical macroeconomic studies, from relatively theoretical exercises such as data description and forecasting, to tests of fully specified economic models. The tools employed by VAR analysis like Granger causality test, co-integration test, impulse response analysis, error collection mechanism (ECM) and variance decomposition. These applications can explain the relationship among variables and their behaviors.

2.4 Empirical Studies

Exchange rate behaviors in this study are consisted of two main interesting features: sources of exchange rate volatility and volatility transmission of exchange rate among five Southeast Asian countries in order to investigate and comparing their behaviors. Thus, I would like to review each topic as following

2.4.1 Sources of Exchange Rate Fluctuations

For this topic, I aim to examine pass-through effects of macroeconomic variables to the exchange rate among the selected Asian countries by using a Vector Autoregressive (VAR) analysis. However, most literatures are likely concerned about whether the exchange rates changes have significant impact on macroeconomic variables e.g. output, inflation, capital flow and money supply. For instance, Ito and Sato (2006: 7) focus on the pass-through effects of exchange rate changes on the domestic prices in the East Asian countries namely Indonesia, Korea, Thailand,

Malaysia and Singapore by using VAR framework. The data are monthly from 1993M1 to 2005M8 except for Indonesia (1993M3-2005M8) and Thailand (1993M1-2004M10). They find that the response of CPI to exchange rate shocks is positive and significant in Korea and Thailand, but the degree of exchange rate pass-through is much smaller in these countries than in Indonesia. Indonesia has the largest response of domestic variables to exchange rate shocks. Berument and Pasaogullari (2003: 401-435) focus on the effects of real depreciation on the economic performance of Turkey including three core variables e.g. real exchange rate, inflation and real output by considering quarterly data from 1987:1 to 2001:3. This study employs VAR analysis and Granger causality test to examine the relationship between them. They first analyzed the bivariate relationship between the set of the variables of interest. Consequently, VAR models are estimated, and the forecast error variance decompositions and impulse responses obtained from the VAR models are examined. The empirical evidence suggests that both inflation and output in core model are not influential in explaining the forecast error variance of the real exchange rate. However, in alternative models with including the current account and the capital account reveal the capital account and the current account have explanatory power in explaining the level of inflation and output that is consistent with economic theory. Moreover, the results show negative effect between output and real exchange rate from the bivariate analysis. For Granger causality test, they do not find a significant causality between the variables. However, they also find that a long-run relationship exists among the real exchange rate, inflation and output. Similar to Odusola and Akinlo (2001: 199-222) examine the impact of exchange rate depreciation on inflation, and output in Nigeria by employing VAR framework as well. Quarterly values of real GDP, money supply (broad money), official exchange rate, parallel exchange rate, prices (consumer price index: CPI), and lending rates are used in the study and the samples start from the period 1970-1 to 1995-4. Evidence from the study revealed the existence of mixed results of the impacts of the exchange rate depreciation on the output in both medium and long terms. These results tend to suggest that the adoption of a flexible exchange rate system does not necessary lead to output expansion, particularly in the short term. Furthermore, they find that official

exchange rate shocks are followed by increases in prices, money supply, and parallel exchange rate.

At the same time, macroeconomic factors are also believed to be the forces behind exchange rate fluctuations. Thus, several studies including this study provide another point of views that investigate the sources of exchange rate volatility like Karras et al. (2005: 213-226) examine whether there are remarkable increased in exchange rate volatility as impulse or propagation after the end of the Bretton Woods era. This study employs VAR model to investigate relationship among macroeconomic variables including exchange rate, the Federal Funds rate, money stock (M_2) and industrial production. They use monthly and quarterly data of two periods, the first period is 1957:1 to 1971:12, under the Bretton Woods system with low volatility. The second period is over the 1973:1 to 2000:12 under floating exchange rates with high volatility from developed countries namely the US, Canada, Germany, and the UK. The results suggest that after the collapse of the Bretton Woods system exchange rate volatility leads to increase so much. The possible reasons are the changing in economic structures e.g. regime switching and the increasing in variability such as violent economic shocks. Furthermore, they find that the increased exchange rate volatility is entirely the results of more violent shock. They also conclude that after the Bretton Woods period exchange rate volatility are likely more supportive of the idea that impulse, rather than propagation. Kopecky (2004: 21-24), by using high frequency exchange rate data examined the reaction of the Czech Crown/USD spot exchange rate to public macroeconomic announcements originating from the US and the Czech Republic. He directly tests the efficient market hypothesis. The exchange rate data cover the period 1997-2002, and the announcements of the actual/official data used in this paper consist of US. and Czech macroeconomic announcements for the same periods of time. The analysis of the volatility yields a spike in the ten minutes following the Czech's announcements. However, tests of efficient market hypothesis do not give support to any announcements specific effects due to Czech macroeconomic announcements.

In recent years, there are also widely examined about the relationship between stock returns and macroeconomic variables in different tools such as Kandir (2008: 35-45) examines the role of macroeconomic factors in explaining Turkish stock

returns. A multiple regression model is designed to test the relationship between stock portfolio return and seven macroeconomic variables e.g. industrial production, money supply, exchange rate, oil price, inflation rate, interest rate and world market return. Stock returns represent as dependent variable while seven macroeconomic variables as independent variables. The study uses monthly data from July 1997- June 2005. Empirical results reveal that interest rate, exchange rate and world market return seem to influence all of portfolio returns while industrial product, oil price and money supply do not have any significant impact on the stock return. However, inflation rate quite different from others, it is inconclusive from the significant for only three of twelve portfolios. They conclude that macroeconomic factors have a widespread effect on stock returns.

2.4.2 Volatility Transmission of Exchange Rate among Five Southeast Asian Countries

After the recent Asian crisis in 1997, many countries in this regional area have faced with higher exchange rate volatility (Hernandez and Montiel (2001: 7-9) and Similar to Karras et al., 2005: 213). Especially Indonesia has much more exchange rate volatility in the post-crisis period, while Malaysia has no exchange rate volatility from adopting fixed exchange rate regime. According to the very little empirical evidence is found concerning exchange rate behaviors of these countries. Indeed, most existing literatures have an overwhelming on North American and Europe focus. In this section, I would like to investigate exchange rate volatility transmission of five selected countries in South East Asia that most upset from this crisis.

During the last two decades, we have seen how different financial crisis originated in particular regions or countries and then extended geographically to others. Especially, the recent Asian crisis in 1997 that firstly started in Thailand with the financial collapse of the Thai baht came from the decision of the Thai government to float the baht. Consequently, the crisis spread out to other Southeast Asian Countries, South Korea and Japan. As a result, the crisis had significant macro-level effects, including sharp reductions in values of currencies, stock markets, and other assets, prices of several Asian countries. Many economists believe that the Asian

crisis was created not only by market psychology or technology, but also by their fundamental factors and policies that distorted incentives within the lender-borrower relationship. However, as long as the international markets are becoming more and more integrated, information that generated in one market can affect other markets. This study tries to explain how volatility of each country's currency is affected by other countries' currencies.

Volatility transmissions of financial variables are in the interest of several studies both in stock price and exchange rate with different tools. There are several main methodologies have been employed in the literature to analyze interrelations between financial markets, for example cross-correlations, VAR models, Cointegration models, GARCH models, Regime Switch models and Stochastic Volatility models. However, only the last three approaches particularly focused on volatility transmission.

Many pioneer empirical literatures have mainly focused on international transmission of shocks in returns, portfolio and stock market indices such as Eun and Shim (1989: 241-256) investigated the international transmission mechanism of nine stock market movements via Vector Auto Regressive (VAR) analysis, using daily nine stock market indices including U.S. at closing time and covering the period of 1979 -1985. The empirical test shows that the substantial amount of interdependence exists among these major developed stock markets e.g. innovation in foreign market collectively account for 26 percent of the error variance of national stock market. In addition, U.S. stock market is the most influential market in the world. However, I find that most of the initial empirical studies have focused on the analysis of relations in mean among different markets.

Recently, other interesting studies about volatility transmissions among different stock as well as exchange rate concentrate on the new methodology, GARCH technique. This technique was initial introduce by Engle (1982: 987-1008) and extended by many economists such as Bollerslev (1986:307-327), Bollerslev et al. (1988: 116-131), Kearney and Patton (2000: 29-48). Especially, multivariate GARCH model is very popular and useful to explain volatility transmission spill over across markets. Some studies focus on stock markets e.g. Karolyi (1995: 11-25) examines the short run dynamics of returns and volatility for the stock traded on New

York and Toronto stock exchanges by using bilateral GARCH. The data consists of daily stock market index at the close of market from 1981-1989, for S&P 500 and TSE 300. The results show stock returns in one market have an impact on not only the conditional market return but also the conditional market volatility of other market. Chulia/ et al. (2007: 3-25) analyze volatility transmission pattern be affected by stock market crisis between the US and Euro zone stock markets considering the effects of the September 11, March 11 and July 7 financial crises with daily stock market prices recorded at 15:00 GMT time for the US (S&P 500 index) and Euro zone (EuroStoxx50 index) for the period of January 2000- January 2006. This study employs multivariate GARCH model and take into account both the asymmetric volatility phenomenon and the non-synchronous trading problem. They find that there is bidirectional and asymmetric volatility transmission between the US and the Euro zone stock markets and show the different impacts that terrorist attacks had on both markets. The terrorist attack in September 11, New York affected volatility in Euro zone stock market but the terrorist attack in Madrid and London in March 11 and July 7, respectively, did not affect in the U.S. market. Finally, Engle and Susmel (1994: 3-25) examine price and volatility spillovers in stock market between New York and London using hourly returns. They conclude that these spillovers are quite small and of short duration.

Whereas, some studies employ the same tool for focusing on exchange rate behaviors such as Kearney and Patton (2000: 29-48) investigate exchange rate volatility transmission across the important European Monetary System (EMS) currencies prior to complete monetary unification in Europe. They use both daily and weekly data from April 1979 - March 1997 of the main European exchange rates, including the European Currency Unit (ECU), the German mark, the French franc, the Italian lira, and the British pound by mean of multivariate GARCH models. The results indicate that the models estimate on daily data be more significant than weekly data as well as the increasing temporal aggregation reduces observed volatility transmission in daily data. Furthermore, these currencies tend to transmit volatility through their covariance terms rather than directly through their own variances. At the same time, the German mark plays a dominant role as it is relatively insulated from outside shocks while transmitting more volatility than the other currencies. However,

for weekly data, they deriver in different solutions. They find that the models are estimated on weekly data reveal almost no transmission of volatility. These results support the conjecture that markets are seemed to transmit volatility when they are in active, rather than in calm.

Other interesting issues investigate about volatility transmissions between two different kinds of markets: equity market and global crude oil market. For instance, Malik and Hammoudeh (2007: 357–368) employ multivariate GARCH technique to examine the volatility and shock transmission mechanism among US equity, global crude oil market, and equity markets of major oil rich Gulf countries namely Saudi Arabia, Kuwait, and Bahrain by using daily data from 14 February 1994 to 25 December 2001. The data for oil market is the spot price for West Texas Intermediate and stock index of Saudi Arabia, Kuwait, and Bahrain represent for equity market. They find that there are significant transmissions among second moments. In all cases, Gulf equity markets receive volatility from the oil market. In general, the oil market is directly affected by economic and institutional factors, for example the world business cycle and OPEC oil production policy, as well as short-term incidental factors such as occurrence of political events and changes in oil inventories and weather conditions. Finally, the affects pass through equity market in these countries. Ebrahim (2000: 1-42) uses tri-variate GARCH models to investigate information transmission between the foreign exchange and associated money markets. This study quit be different from the exist papers that investigate the movement of news between markets in each asset class. It examines the nature of information transmission across different asset classes involving the foreign exchange and money markets. Three models are estimated for USD/CAD, USD/DEM, and USD/JPY exchange rate returns together with associated 90-day Eurocurrency market returns Euro-dollar, Euro-Canada, Euro-mark, and Euro-yen deposits in order to determine whether price and volatility spillovers exist between the markets. This study uses daily data on the USD/CAD, USD/DEM, and USD/JPY exchange rates from 4 January 1988 to 31 December 1998. The paper presents strong evidence of price and volatility spillovers in all three models, and some volatility spillovers are found to be asymmetric. Furthermore, the shocks from Eurocurrency markets have small quantitative effects on foreign exchange markets. Although volatility spillovers from Eurocurrency to

foreign exchange markets are small in all cases, the volatility in the Euro-Canada market is more sensitive to exchange rate shocks than Euro-mark and Euro-yen volatilities respectively.

CHAPTER 3

THEORETICAL FRAMEWORKS

In this section, I would like to discuss theoretical frameworks related to this study that consist of three main parts. First, an overview of exchange rate regime is provided in this part. In the second, sources of exchange rate fluctuations and its impacts to other economic variables and ultimate target are presented. Finally, the last part of this chapter offers theoretical frameworks about the relationship between exchange rate and key macroeconomic factors including inflation, GDP, money supply and oil price based the purchasing power parity (PPP) and the flexible price monetary model.

3.1 Exchange Rate Regime

Exchange rate regime is the way that a country manages its currency in respect to foreign currencies and foreign exchange market. As the same time, it is also closely related to monetary policies and macroeconomic impacts. Most countries in the world, both developed and emerging countries, try to fine-tune the optimal way to manage their currencies, so each of them has long history with regard to exchange rate regime. In general, exchange rate systems are classified on the basis of two traditional categories namely fixed exchange rate regime and floating exchange rate regime (MacDonald, 2007: 28).

An overview of exchange rate regimes can be expressed as the following:

Table 3.1 An Overview of Exchange Rate Regimes

Fixed exchange rate regime	Floating exchange rate regime
▪ Dollarization ▪ Currency board ▪ Pegged float - Single currency peg - Basket of currencies peg - Cooperative regime - Crawling peg - Target zones	▪ Free floating ▪ Managed floating

As can be seen from table 3.1, an overview of exchange rate regimes consist of two main types i.e. fixed exchange rate regime and floating exchange rate regime. Under the former, exchange rate is pegged to the anchor in various ranges of flexibility for example dollarization, currency board, single currency peg**,** basket of currencies peg, cooperative regime**,** crawling peg and target zones. Under the later, exchange rate is allowed to fluctuate according to demand and supply in the market such as free floating and managed floating.

3.1.1 Fixed Exchange Rate Regime

Fixed exchange rate regime is one type of exchange rate regimes that its currency value is matched to the value of another single currency or to a basket of other currencies, or to another measure of value, such as gold and silver. This system allows the monetary authority to control the exchange rate within a target rate. In early periods, fixed exchange rate regime was adopted by many countries known as gold standard system and the Bretton Woods system. They fix their currency value to gold or foreign currency value like the U.S. dollar and the British pound. The country fixing value of its domestic currency relative to that of a low-inflation country is one approach central banks have used to pursue price stability. Another advantage of this regime provides exchange rate stability that can lower inflation expectations to the

level prevailing in the anchor country. Furthermore, it seems to be easy to understand by public.

However, the experiences with fixed exchange rates point to the trade-off between reducing exchange rate volatility and foregoing an independent monetary policy (Ghosh et al., 2002: 23). In addition, their currencies may attacked by speculators if the currencies did not represent their true market value. In certain situations, fixed exchange rates may be preferable for their greater stability. For instance, in the case of Malaysia, his adoption of a peg to the U.S. dollar in the post Asian financial crisis period was highly successful. Basically, there are many characteristics of fixed exchange rate system such dollarization, a currency board, and pegged float.

3.1.1.1 Dollarization

Dollarization is one type of fixed exchange rate regime that adopts the foreign currency e.g. U.S. dollar as the currency of choice in a foreign country and legal tender. It means that the country uses foreign currency especially the U.S. dollar in parallel to or instead of the domestic currency. However, there are many other currencies used by other countries for official dollarization for instant the euro, the New Zealand dollar, the Swiss franc, the Indian rupee, and the Australian dollar.

In general, the major benefit of dollarization is promoting fiscal discipline and thus lower inflation and greater financial stability. Moreover, dollarized economies could enjoy a higher level of confidence among international investors, lower interest rate spreads on their international borrowing, reduced fiscal costs, and more investment and growth (Berg and Borensztein, 2000: 1). Nevertheless, in this case, monetary policy is delegated to the anchor country and seigniorage accrues to the issuing country (Ghosh et al., 2002: 40).

3.1.1.2 A Currency Board

A currency board is a monetary authority which is required to maintain a fixed exchange rate with a foreign currency and the monetary base a liability of the currency backed by its foreign exchange reserves (Handa, 2009: 359). The anchor currency is a currency chosen for its expected stability and international acceptability. Not only the U.S. dollar but also other currencies such as the British pound and the euro have been the anchor currency. This anchor currency need not be issued by a

central bank; a few currency boards have used gold as the anchor currency.This implies that domestic currency will be issued only against foreign exchange and that it remains fully backed by foreign assets, leaving little scope for discretionary monetary policy and eliminating traditional central bank functions (IMF, 2007: 8). The foreign exchange reserves increase through a balance of payments surplus and vise versa. An example of a successful currency board arrangement is Hong Kong.

3.1.1.3 Pegged Float

In this regime, the currency is pegged to some bands or values for example a basket of currencies, either fixed or periodically adjusted. The central bank intervene exchange rate by keeping it from deviating too far from a target band or value. The traditional pegs are single currency peg and basket of currencies peg. In the former, exchange rate is pegged to a fixed par value of only single foreign currency. In the later the rate is pegged to a basket consisting of weighted amounts of the currencies.

Furthermore, exchange rate sometime is not pegged at a specific rate but it is intervened in a predetermined manner to limit its movement by monetary authority. This characteristic of exchange rate regime sometime was called intermediate exchange rate regimes that consist of an array of differing systems allowing a varying degree of flexibility for instant cooperative regime, crawling peg and target zones and bands (Ghosh et al., 2002: 40-41).

3.1.2 Floating Exchange Rate Regime

Recently, floating exchange rate regime has appealed by many countries. Ghosh et al. (2002: 150) shows that it has the regime transitions from single currency pegs and basket of currencies pegs to pure floats and floats with discretionary intervention. Floating exchange rate or flexible exchange rate is another type of exchange rate regimes where currency value is allowed to fluctuate according to demand and supply in foreign exchange market and changed over time in order to adjust to the inflation difference. Under a floating exchange rate regime, one of the benefits is that countries become independent in term of their ability to implement domestic monetary policies (Rusydi and Islam, 2007: 25). In addition, the floating exchange rate automatically adjust as a result they enable a country to resist the

impact of shocks and foreign business cycles. On the other hand, there exists higher nominal exchange rate volatility in the countries that adopt floating exchange rate regime than fixed exchange rate regime. (Ghosh et al., (2002: 55) and MacDonald (2007: 21)).

Another point of view, Friedman (1953: 158) in his classic essay 'The Case for Flexible Exchange Rate' strongly supports the flexible exchange rate. He indicated that- advocacy of flexible exchange rates is not equivalent advocacy of unstable exchange rates. The ultimate objective is a world in which exchange rates, while free to vary, are in fact highly stable. Instability of exchange rates is a symptom of instability in the underlying economic structure. He believed that, in most circumstances, floating exchange rates are likely preferable to fixed exchange rates.

Basically, floating exchange rate regimes consist of two main characteristics i.e. free floating and managed floating systems.

3.1.2.1 Free Floating

Under a free floating or independent floating system, the exchange rate is determined by the market based on demand and supply and monetary policy usually functions without exchange rate considerations. Foreign exchange interventions are rare and meant to prevent undue fluctuations. But no attempt is undertaken to maintain a particular rate (IMF, 2002: 117). This system requires little or no official reserves and no restriction on monetary policies (Ghosh et al., (2002: 41). Under free floating exchange rate regime, exchange rates are allowed to autonomously adjust and fine tune the optimal exchange rates.

3.1.2.2 Managed Floating

In this system, exchange rates are free to move according to demand and supply as well. However, policy makers sometimes intervene in the exchange rate market in order to manage their exchange rate. For example, a central bank might allow exchange rate to float freely between an upper and lower bound. They may manage by the form of buying or selling large lots in order to provide price support or resistance. Basically, if prices and wages are fully flexible then exchange rate would be relevant and affect to the real economy. Nevertheless, exchange rate plays a crucial role in economic adjustment and international economic independence in case of prices and wages stickiness (Rusydi and Islam, 2007: 26-27). Under this system, the

monetary authority attempts to influence the exchange rate without a specific exchange rate path or target (IMF, 2007: 8).

3.2 Exchange Rate Volatility

In the post Bretton Woods era, many developed countries abandoned the fixed exchange rate system to more floating rate regime Ghosh et al., (2002: 55) and MacDonald (2007: 21). Exchange rates have been more volatile than the past and hardly to anticipate. Since, they widely become the subject of interesting studies. Exchange rate volatility should be a matter for concern if it disrupts economic activity. However, exchange rate volatility seems to stem from economic fundamental especially balance of payment, international trade and investment. Any new information about economic fundamental may affect to the exchange rate volatility. According to foreign exchange markets are almost perfectly integrated on a 24-hour trading basis, a change in one exchange rate volatility due to the new information about economic fundamentals should be simultaneously transmitted to the other exchange rate volatility. Within the macroeconomic fundamentals view, most explanations concentrate on a contagious nature of exchange rates in similar ways (Huang and Yang, 2002: 40).

Another reason for linkage between volatility of exchange rates is market psychology. Even though there are no apparent common fundamentals between currencies, but speculations based on fads, noises or herd instinct might be transmitted as well. Moreover, exchange rate is also regarded as relative volatility to information comprised in exchange rate expectation for instance, without of a risk premium, the forward exchange rate would be a measure of the expected exchange rate. As the same time, forward premium is a measure of the expected change in the exchange rate as well (MacDonald, 2007: 21-22).

Basically, foreign exchange intervention is another factor influence to the movement of exchange rate or exchange rate volatility. From the study of Kim (2002: 355) reveals that foreign exchange intervention has crucial effects on the exchange rate as well as reacts to the exchange rate significantly in order to stabilize the exchange rate in the market. In general, central bank manages the exchange rate by

intervening in the foreign exchange market to prevent excessive volatilities in the markets. In addition, exchange rates itself sometimes can be overshoot, interventions help in limiting the extent of overshooting in order to prevent excessive volatilities in the markets as well as to avoid the disruptive impacts and the need for costly real economic adjustment (Bank of Thailand, 2004: 5). Thus, the movements of exchange rate sometimes are dominated by the policy interventions especially during disordered movement period. In other words, policy interventions support to smooth out the exchange rate volatility.

Several empirical studies such as Berument and Pasaogullari, 2003: 405-406; Karras et al., 2005: 219 find that the consequences of exchange rate volatility affect several key economic factors including international competitiveness, foreign trade, capital account, foreign direct investment (FDI), portfolio investment and passing through the ultimate target, economic growth and stability (see figure 3.1).

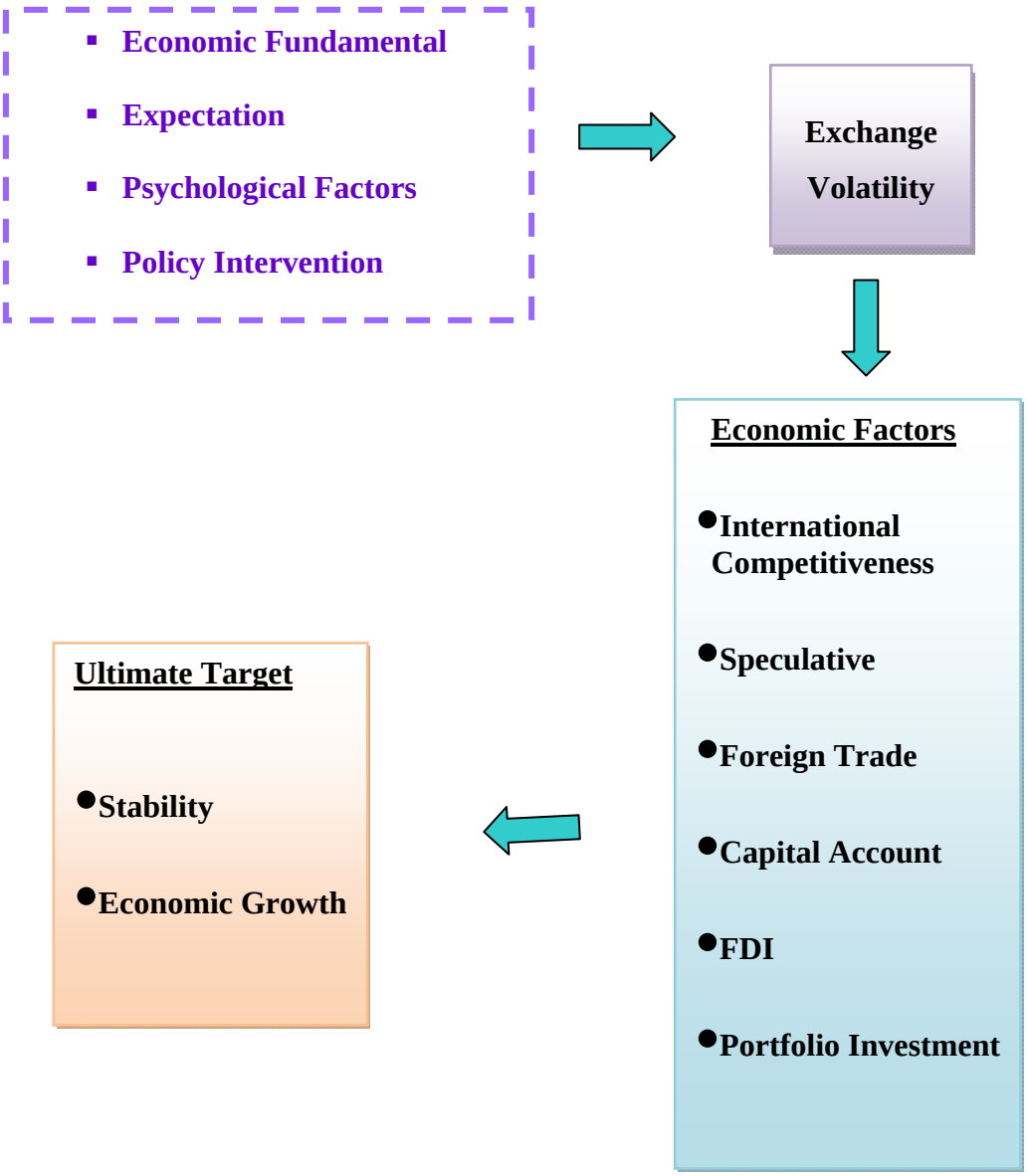


Figure 3.1 Sources of Exchange Rate Volatility and Its Impacts

Figure 3.1 shows the linkage between exchange rate volatility and other variables in the views of sources of its volatility and impacts. It expresses several sources of exchange rate volatility such as economic fundamentals, expectation, Psychological factors and policy intervention. At the same time, its volatility seems to follow by the fluctuation of economic factors such foreign trade, capital account and

FDI as well as passing though the economic ultimate targets i.e. economic growth and stability.

3.3 The Relationship between Exchange Rate and Key Macroeconomic Factors

In this section, I would like to examine the relationship between exchange rate fluctuations and key macroeconomic variables including real output, inflation, money supply and oil price. Many empirical studies such as Gagnon (1993: 269), Rose (2000: 7) and Ito and Sato (2006: 7) find that the consequences of exchange rate volatility affect several key economic factors. At the same time, the deviations of macroeconomic fundamental appear to characterize exchange rate movement over relatively long horizons (Sarno and Taylor, 2002: 264). In other word, the relationship between exchange rate and key macroeconomic variables e.g. real output are bi-directional causality (Berument and Pasaogullari, 2003: 406).

There are several theoretical frameworks that explain about the relationship between exchange rate and other economic variables as following:

3.3.1 The Relationship between Exchange Rate and Inflation

The relationship between exchange rate and inflation has been another issue in the various popular studies. One of the classical basic determinants of the exchange rate is purchasing power parity (PPP) that adopts to explain long run equilibrium of it based on the law of one price. This theory indicates that the homogeneous goods should sell for the same price in home and foreign country. Thus, the condition of absolute PPP can be expressed as following: (Sarno and Taylor, 2002: 52-53) Copeland (2005: 63), and MacDonald (2007: 41)

$$S_t = \frac{P_t}{P_t^*} \qquad \text{-----(3.1)}$$

where, S_t = nominal exchange rate

P_t = overall price in home country

P_t^* = overall price in foreign country

The PPP principle states that nominal exchange rate is determined as the ratio of the overall price level in home and foreign country. Due to the difference of price level in each country, it is make sense to reformulate PPP condition in equation (3.1) into log form as:

$$\ln S_t = \ln P_t - \ln P_t^*$$

$$s_t = p_t - p_t^* \quad \text{-----(3.2)}$$

From equation (3.2), s is represented log form of nominal exchange rate, S and p and p* also stand for log form of price in home country, P and price in foreign country, P* respectively. Consequently, I design to take the derivative of natural log in equation (3.2) to attain the proportional rate of change i.e. d (ln S) = ds = dS/S and so on.

$$ds_t = dp_t - dp_t^* \quad \text{-----(3.3)}$$

Equation (3.3) explains that the rate of currency appreciation/ depreciation, s is equal to the different between the home country inflation rate, dp and the foreign inflation rate, dp*.

If dp > dp* then ds is positive or depreciation and vise versa. In other word, inflation in one country can only be higher (lower) than another one to the extent that its exchange rate depreciation (appreciation) (Copeland (2005: 63).

3.3.2 The Relationship between Exchange Rate and Real Sector

The relationship between exchange rate and real sector has been widely considered both in developed and developing countries. For this study, I employ real output as the represent of real sector. Several empirical studies reveal the statistical significant of the relationship between exchange rate and real output (see Kanin and

Rogers, 1997: 25-26; Odusola and Akinlo, 2001: 209; Berument and Pasaogullari, 2003: 413).

From the viewpoint of the classical theoretical framework, the flexible price monetary approach is always adopted to explain exchange rate determination. Following Sarno and Taylor 2002: 108-109, monetary equilibrium is achieved when the supply of and demand for money in domestic and foreign country are equalized as given by:

$$m_t = p_t + k\, y_t - \theta\, i_t \qquad \text{-----(3.4)}$$

$$m_t^* = p_t^* + k^*\, y_t^* - \theta^*\, i_t^* \qquad \text{-----(3.5)}$$

m_t	=	money supply in domestic country
m_t^*	=	money supply in foreign country
p_t	=	price level in domestic country
p_t^*	=	price level in foreign country
y	=	real output in domestic country
y_t^*	=	real output in foreign country
i_t	=	interest rate in domestic country
i_t^*	=	interest rate in foreign country
k, k^*, θ, θ^*	=	parameter

Equation (3.4) represents monetary equilibrium in domestic country and Equation (3.5) also represents monetary equilibrium in foreign country.

As the same time, the purchasing power parity (PPP) is assumed to be hold as well. This obtains PPP condition from equation (3.2) as following:

$$s_t = p_t - p_t^*$$

From equation (3.4) and (3.5)

$$p_t = m_t - k\, y_t + \theta\, i_t \qquad \text{-----(3.6)}$$

$$p_t^* = m_t^* - k^* y_t^* + \theta^* i_t^* \quad \text{-----(3.7)}$$

Substitute equation (3.6) and (3.7) in equation (3.2), and in order to simplify, this model assumes income, interest and money elasticity be the same for domestic and foreign country i.e. $k = k^*$, $\theta = \theta^*$

The solution of nominal exchange rate can be express as

$$s_t = (m_t - m_t^*) - k (y_t - y_t^*) + \theta (i_t - i_t^*) \quad \text{-----(3.8)}$$

From equation (3.8), an increase in domestic real output relative to foreign generates the excess demand for money in home country. In order to increase their real money balance, domestic residents reduce their expenditure and prices fall until obtaining the new money market equilibrium. The fall in domestic prices via the purchasing power parity (PPP) principle creases an appreciation in domestic currency (Sarno and Taylor, 2002: 109) or negative output-exchange rate relationship. In sum, an increasing in domestic real output has its indirect effect on exchange rate through demand for money.

3.3.3 The Relationship between Exchange Rate and Financial Market

There exists the closed relationship between exchange rate and financial market. The linkage of exchange rate and financial market is usually explained through money demand and supply via many international economic frameworks such as the flexible price monetary model. This model attempts to exhibit how changes in the supply of and demand for money both directly and indirectly affect to exchange rates. This study explains this topic based on the flexible price monetary approach as well.

The fundamental equation of the flexible price monetary model expresses in equation (8) as following: Sarno and Taylor (2002: 109), Copeland (2005: 149), and MacDonald (2007: 96).

$$s_t = (m_t - m_t^*) - k (y_t - y_t^*) + \theta (i_t - i_t^*)$$

This equation shows the positive relationship between nominal exchange rate and domestic money supply relative to the foreign money stock. It implies that a rise in the domestic money supply relative to the foreign money stock results in a depreciation of the domestic currency relative to the foreign currency and vise versa.

3.3.4 The Relationship between Exchange Rate and Oil Price

In the past few years, the world seems to have entered into an era of higher oil price volatility as a result of imbalance between demand and supply in the market. In the past, the serious rise of oil price occurred mostly from the disruption of oil supply such as the Gulf War, the oil crisis in 1973 and 1979. Conversely, during this period, the oil price seems to fluctuate with the absence of any particular disruption of oil supply. It is likely generated from other factors for instant market demand and the impact of speculative transactions in the oil futures market.

In general, an oil prices increase with all things being equal should be considered positive for oil exporting countries and negative for oil importing countries such as having a stagflationary impact on the economy. An oil price shock affects macroeconomic performance through various channels. First, higher oil prices trigger a transfer of income from oil importing countries to oil exporting counties through a shift in the terms of trade. Second, a rise in oil prices reduces industrial outputs through higher cost of production. As the same time, it affects disposable income and the domestic price of tradable goods. All of these could be the important factors determining exchange rate in the long run. Therefore, the potential importance of oil price affecting to exchange rate movement leads to greater interest in several studies such as Krugman (1983: 179), McGuirk (1983: 843-844) and Amano and Norden (1998: 303-304). The impact of oil price shock appears through term of trade and domestic price level.

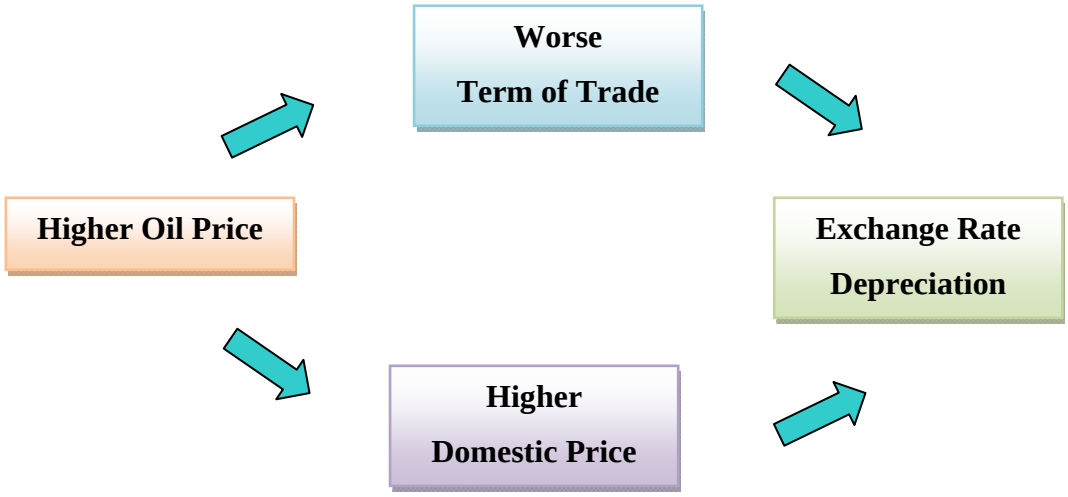


Figure 3.2 Impact of Oil Price to Exchange Rate for Oil Importing Countries

As can be seen from figure 3.2, the impact of higher oil price for oil importing countries leads to pass though exchange rate both in term of trade and domestic price level. Over the last few years, the relationship has broadened that the exchange rate has become very responsive to changes in the world price of crude oil via term of trade (see Backus and Crucini, 2000: 185 and Aliyu, 2009: 6). An increase in oil price causes worse term of trade for oil importing countries and leading to exchange rate depreciation. For another channel, a rise of oil price also affects to economic activity include both supply and demand sides. The supply side effects are related to the fact that higher oil price leads to higher cost of production whereas the demand side effect is derived from the fact that an increase in oil price causes lower disposable income and higher domestic price of tradable goods. All of these lead to an increase in the price level and potentially an increase in the inflation rate based on the purchasing power parity (PPP) principle. In sum, both of impacts via term of trade and domestic price level could be the important factor determining exchange rate in long term. For oil importing countries, the rise of oil prices may have an important influence on exchange rate depreciation.

The overall of relationship between exchange rate and other variables can be expressed as table 3.2

Table 3.2 The Relationship between Exchange Rate and Other Variables

Variable	Relationship (direction)	Theory
1. Exchange rate and inflation	positive	The purchasing power parity (PPP)
2. Exchange rate and real output	negative	The flexible price monetary model
3. Exchange rate and money supply	positive	The flexible price monetary model
4. Exchange rate and oil price	positive	The purchasing power parity (PPP)

Table 3.2 shows the summary of exchange rate and other variables relationship including inflation, real output, money supply and oil price. Most of them have positive relationship excluding exchange rate and real output being negative. This explanation based on the well known international economic theories i.e. the purchasing power parity (PPP) and the flexible price monetary model.

CHAPTER 4

SOURCES OF EXCHANGE RATE FLUCTUATIONS

4.1 Introduction

The exchange rate is one of the essential economic indicators of economy's international competitiveness because it has a strong influence on economic developments, foreign trade and capital account that includes portfolio investment and foreign direct investment (FDI). Thus, many literatures try to focus on a linkage between macroeconomic variables and exchange rate volatility, particularly output, money growth, inflation and interest rate. Some of these papers present the significant relationships between macroeconomic variables and exchange rate volatility such as Sarno and Taylor (2002: 264), Karras et al. (2005: 224-225) and Ito and Sato (2006: 1). On the other hand, Flood and Rose (1995: 3-4) have found that macroeconomic volatility is not an important source of exchange rate volatility in case of G-7 countries on the most recent floating period. It is almost entirely neglected in the existent literatures. Thus, this study aims to investigate sources of exchange rate volatility in Southeast Asian countries namely Indonesia, Malaysia, Philippine, Singapore and Thailand in order to understand the sources of fluctuations in exchange rate in these countries. In other word, this study tries to answer the question that macroeconomic variables are important predictors of emerging exchange rate market in Southeast Asian region.

What are the causes of exchange rate fluctuations? In general, the movements of exchange rate stem from several factors such as economic fundamentals, policy intervention and expectations. In many cases, the exchange rate movements are also driven by psychological factors. However, this study is intended to cover only economic fundamental factors. After the collapse of Bretton Wood system about four decades ago, some countries in Southeast Asia began to move towards more flexible exchange rate regimes such as Philippine and Singapore whereas the others still kept a

regime virtually pegged in nominal terms. Nominal pegs against the US dollar, together with other policy measures such as financial liberation, brought on the crisis sooner and made it more widespread. Consequently, some countries abandoned the dollar-pegged regime, while others reverse to restrictive regulatory measures to cope with excessive capital movements maintaining the dollar-pegged regimes such as Malaysia.

In recently, many empirical studies indicated that exchange rate behavior has significantly changed since many countries switched to the floating rate regime. In addition, the increasing globalization of economies also leads to be higher volatility in exchange rate (Flood and Rose, 1995: 5; Karras et al., 2005: 224-225). Understanding the causes of exchange rate fluctuation helps both private and public sectors to reduce their risk from serious situations. Furthermore, policy makers are able to design policy instruments or intervention strategy to intervene the exchange rate.

4.2 Methodology

For the study of sources of exchange rate fluctuations**,** I would like to examine macroeconomic variables that influent to exchange rate fluctuations. The previous literatures employ several methodologies to investigate relationship between macroeconomic variables such as least squares analysis, panel data studies, macro model simulations, and VAR models. With many advantages of a VAR approach like allowing investigate the multivariate model and identifying structural shock through variance decomposition, VAR model is motivated to choose the list of variables to capture importance sources of fluctuations in this study. It is one of the most popular methodology and widely used for multivariate time series analysis.

Vector Auto Regressive (VAR) models have been much used in empirical studies of macroeconomic issues since they were launched for such purposes by Sims (1980: 1-48). He suggests that it should be feasible to estimate large scale macro-models as unrestricted reduced forms, treating all variable as endogenous. All the variables in a VAR are treated symmetrically by including for each variable an equation explaining its evolution based on its own lags and the lags of all the other variables in the model. It means that a VAR model seeks patterns in available data,

with no assumptions. As opposed to empirical specifications derived from theoretical models which predict the way the variables will affect each other. Sims also criticized the way that the classical simultaneous equations models are identified as well as questioned about the exogenous assumptions for some variables not necessary backing by theoretical framework. In contrast, VAR model overcomes this problem from treating all variables as endogenous variables. It puts no theoretical restrictions on the way the variables affect one another internally. In practice, there are many tools employed by VAR analysis like Granger causality, co-integration test, impulse response analysis, error collection mechanism and variance decomposition. These applications can explain the relationship among variables and their behaviors. However, in this study, I firstly would like to test for cointegration and error correction mechanism following by impulse response analysis, variance decomposition and causality test.

Based on these considerations, I select a VAR model with five endogenous variables including exchange rate, GDP, CPI, money supply and oil price (Odusola and Akinlo, 2001: 218-219; Berument and Pasaogullari, 2003: 405; Ito and Sato, 2006: 7-11) These selected variables in this model have the relationship under economic theoretical frameworks. First, GDP is represented relationship between exchange rate and real sector. Second, based on purchasing power parity (PPP), home country inflation rate or CPI is another factor that influences on the movement of exchange rate. Similarly, oil price derivers the same impact on exchange rate. Finally, the linkage of exchange rate and financial market is usually explained through money supply (see chapter 3).

These variables express as following:

EX	=	Exchange rate
Y	=	Gross Domestic Product (GDP)
CPI	=	Consumer Price Index
M	=	Money supply
OP	=	Oil price

The basically VAR process can express in this form:

$$\mathbf{Y_t} = \boldsymbol{\mu} + \sum_{i=1}^{p} \boldsymbol{\phi_i}\, \mathbf{Y_{t-i}} + \mathbf{u_t}\,, \qquad t = 1,2,\ldots,T \qquad \text{---(4.1)}$$

$$p \geq 1 \text{ and } 1 \leq i \leq p$$

$$u_t = R\,\varepsilon_t$$

where,

Y_t = vectors are observable

μ = vector of intercept term

ϕ_i = vector of coefficient

ε_t = vector of error term

R = unknown fixed non-singular matrix

$$\boldsymbol{\varepsilon_t} \sim \text{iid } N(0,I)\,, \qquad t = 1,2,\ldots,T$$

From VAR model, the vectors $Y_t = (Y_{1t}, Y_{2t},\ldots, Y_{kt})'$, t = -p + 1,2,…,T, are observable, p is a specified non-negative integer ($p \geq 1$) and $\mu = (\mu_1, \mu_2,\ldots, \mu_k)'$ is an unknown k ×1 vector of intercept term. Vector $\phi_i = [\phi_{ijl}]_{j\times l=1,2,\ldots,k}$ is unknown k×k matrix of coefficient matrices ($1 \leq i \leq p$), R is unknown fixed non-singular matrix.

However, all time series that used in this study including both periods of time-pre and post Asian financial crisis in 1997. Dummy variable is employed as exogenous variable in this model. It takes the values 0 for the pre crisis period and 1 for the post crisis period in order to indicate the absence and presence of some categorical effect that may be expected to shift the outcomes.

In this section, I would like to do cointegration test that represent the long run relationship between these macroeconomic variables and follow by error correction mechanism, Impulse response analysis, and variance decomposition.

4.2.1 Cointegration Test and Vector Error Correction Model (VECM)

The concept of cointegration test (Engle and Granger, 1987: 251-276; Johansen, 1995: 111-132) has become popular in many empirical studies. For Johansen's method, it was developed from the initial approach by Engle and Granger 1987: 251-276 that builds directly on maximum likelihood estimation instead of

partly relying on least squares. This application tests for the relationship between non-stationary time series variables. If two or more series each have a unit root or I(d) process, whereas a linear combination of them is stationary or I(0), then these time series are cointegrated. It means that there exist long run relationships. According to the results of this study present that all variables are I(1) or non stationary and multivariated model. Hence, Johansen cointegration test (Johansen and Juselius, 1990: 169-210) is appropriated for this study by using Vector Autoregressive (VAR) at level of each series test for cointegration.

Under this considerations, Johansen (1995: 111-132) deals with the more general case where y_t follows a VAR(p) process that is focused on the effect of the lag specification on the test results. It can be expressed as following form:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + \varepsilon_t \quad \text{--- (4.2)}$$

y_t = k ×1 random vector

A_i = k ×k fixed coefficient matrices

ε_t = vector of error term

$\varepsilon_t \sim$ iid $N(0,I)$, $t = 1,2,\ldots,T$

Enders (2004: 372) indicated that "cointegrated variables share the same stochastic trends and so cannot drift too far apart". In order to perform Johansen's cointegration analysis (Johansen, 1995: 111-132) the VAR in equation (4.2) is converted into a vector error correction model (VECM) by incorporating an error correction mechanism term (Dy_{t-1}) into the system. The transformed VECM is presented in equation (4.3) as following:

$$\Delta y_t = D_1 \Delta y_{t-1} + D_2 \Delta y_{t-2} + \ldots + D_{p-1} \Delta y_{t-p+1} + D y_{t-1} + e_t \quad \text{---(4.3)}$$

where, $D_i = -(A_{i+1} + \ldots + A_p)$, $i = 1,2,..,p-1$

and $D = (A_1 + A_2 + A_p - I_n) = -A(1)$

y_t = k ×1 random vector , $y_t \sim CI(1)$

D = k ×k fixed cointegration matrix

D_i = k ×k fixed coefficient matrices

e_t = k ×1 white noise process

Δ is the first-difference operator. If cointegration or long run equilibrium is existed, error correction mechanism (ECM) consequently performs to test. It is possible that these macroeconomic variables are not equal to this long run equilibrium value all the times. Whenever, it diverges from this equilibrium the "error" will tend to be corrected over time by error correction mechanism. It is a dynamical system with the properties that the deviation of the current state from its long run relationship representing by its short run dynamics.

4.2.2 Impulse Response Analysis

For the VAR model, a shock to any single variable transmits dynamically to all the endogenous variables. An impulse response function traces the effect of a one time shock on current as well as future values of the endogenous variables. From equation (4.1), the set of ϕ_i is called the impulse response functions. Plotting the impulse response functions is a practical way to visually represent the behavior of time series in response to the various shocks at the time of the shock and over subsequent points in time (Enders, 2004: 274). For this study, impulse response analysis presents the response of exchange rate to key macroeconomic shocks

4.2.3 Variance Decomposition

Variance decomposition is another way to characterize the dynamic behavior of a VAR system through forecast future fluctuation. It separates the variation in an endogenous variable in to the component shocks and simply apportions the variance of forecast error in the selected variable to those of the other variables and its own shock as well. The forecast error variance decomposition shows the proportion of the movements in a sequence from its own shocks and shocks to other variables (Enders,

2004: 280). Thus, it also helps to explain impact of macroeconomic shocks to exchange rate fluctuations in this study.

Data

The data set in this study consists of quarterly time series data of macroeconomic variables including exchange rate, GDP, CPI, money supply, and oil price of five Southeast Asian countries namely Indonesia, Malaysia, Philippines, Singapore and Thailand. The macroeconomic data are obtained from International Financial Statistic: IFS of the International Monetary Fund (IMF), and oil price data using Europe Brent Sport Price FOB from the U.S. Government Official Energy Statistic covering the period of 1993-Q1 through 2008-Q4 for all countries. For GDP and money supply data sets, they are designed to apply with seasonal adjustment by moving average method in order to eliminate the seasonal fluctuation.

The data descriptions / sources can be express as table 4.1

Table 4.1 Data Description / Sources

	Indonesia	Malaysia	Philippine	Singapore	Thailand
EX	Market rate, end of period	Official rate, end of period	Market rate, end of period	Market rate, end of period	Official rate, end of period
CPI	Consumer Price Index	Consumer Price Index	Consumer Price Index	Consumer Price Index	Consumer Price Index
GDP*	GDP at 2000 price	GDP at 2000 price	GDP at 2000 price	GDP at 2000 price	GDP at 2000 price
MS*	M2	M3	M4	M3	M3
OP	Europe Brent Sport Price FOB	Europe Brent Sport Price FOB	Europe Brent Sport Price FOB	Europe Brent Sport Price FOB	Europe Brent Sport Price FOB

Note: * seasonal adjustment

4.3 Empirical Results

This study employs a 5-variable VAR including exchange rate, GDP, consumer price index (CPI), money supply and oil price for cointegration test and continues to perform VECM if the long run equilibrium is existed. Consequently, it is investigated how exchange rate responds to macroeconomic variables shocks through the impulse response function analysis, variance decomposition and causality test.

The estimation of a VAR model firstly requires the explicit choice of lag length in the model. The appropriate lag length selection of the VAR is another important step. Too few lags mean that the regression residuals do not behave as white noise processes. The model will not well capture the actual error process so that γ (see equation (4.4)) and its standard error will not be well estimated. On the other

hand, too many lags reduce the power of the test to reject the null hypothesis and lost degree of freedom as well (Ender, 2004: 264). For this study, the appropriate lag length of the VAR of the selected Southeast Asian countries are presented in table 4.2

Table 4.2 The Appropriate Lag Length of the VAR

	Indonesia	Malaysia	Philippe	Singapore	Thailand
Lag length	5	1	5	1	2

The appropriate lag length of the VAR is determined by using standard model selection criteria of Akaike Information Criterion (AIC), Akaike (1973: 267-281). Adoption of a general-to-specific modeling approach points to a VAR of order 1 for Malaysia and Singapore, order 2 for Thailand and order 5 for Indonesia and Philippines, as an adequate representation of these data set.

4.3.1 Unit Root Test

Before processing each time series, this study needs to test each variable's unit root to investigate weather a time series variable is non-stationary. Non-stationary data could cause spurious regression and therefore bias the study. Thus, this study employing the popular methods are Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979: 427-431, 1981: 1057–1072) and Phillips-Perron (PP) test (Phillips and Perron, 1988: 335-346). Both of them test for the existence of a unit root, if the process has a unit root then it is a non-stationary time series. It means that the movements of stochastic process depend on time trend as well as the variance of the series is diverging to infinity with time trend.

so, $\text{Var}(Y_t) = \sum_{i=1}^{t} \sigma^2 = t\,\sigma^2$

$\text{Var}(Y_t)$ = variance of the series

t = time trend

For unit root test, the null hypothesis of the ADF and PP tests is that the variable is non-stationary. It is the method to determine whether the time series data is consistent with I(1) process with a stochastic trend (non-stationary) or I(0) process, that is stationary.

From the infinite-order autoregressive model,

$$\Delta y_t = \mu + \gamma y_{t-1} + \sum_{i=2}^{\infty} \beta_i \Delta y_{t-i+1} + \varepsilon_t \quad \text{-----(4.4)}$$

Equation (4.4), if $\gamma = 0$, this is entirely in first difference or I(1) process and has a unit root. It means that this time series data is non-stationary at its level. Therefore, I would like to do unit root test these data in order to check for stationary. The results from these time series data are reported in Table 4.3

Table 4.3 ADF and PP Test Statistics

Unit Root Test	**ADF-test**		**PP-test**	
	No trend	**Trend**	**No trend**	**Trend**
Indonesia				
EX	-1.711600	-2.491348	-1.709728	-2.604512
GDP	0.401956	-1.125838	0.053150	-1.662683
MS	3.332205	0.658069	3.536499	0.869448
CPI	0.810075	-2.813483	1.336802	-2.290178
OP	-0.788689	-4.235850*	-1.503218	-2.728950
Δ EX	-7.460665*	-7.401176*	-7.472842*	-7.404317*
Δ GDP	-3.364354**	-3.507084**	-8.804212*	-8.838729*
Δ MS	-1.349820	-3.259029**	-7.784415*	-9.130442*

Table 4.3 (Continued)

Unit Root Test	ADF-test		PP-test	
	No trend	Trend	No trend	Trend
Δ CPI	-4.620606*	-4.808156*	-4.603815*	-4.865473*
Δ OP	-4.608140*	-2.912925	-1.648515	-1.459921
Malaysia				
EX	-1.593682	-1.233843	-1.667047	-1.415279
GDP	3.868665	-0.799391	1.667561	-2.801240
MS	1.872125	-0.193645	2.943884	0.971159
CPI	0.883634	-1.023633	1.070078	-0.579345
OP	-0.788689	-4.235850*	-1.503218	-2.728950
Δ EX	-7.644543*	-7.716436*	-7.686521*	-7.729874*
Δ GDP	-2.285661	-6.215278*	-8.081069*	-11.13100*
Δ MS	-1.235848	-2.120080	-5.363871*	-5.973352*
Δ CPI	-5.733492*	-5.827581*	-5.733492*	-5.827581*
Δ OP	-4.608140*	-2.912925	-1.648515	-1.459921
Philippine				
EX	-1.415535	-0.815085	-1.440096	-1.075936
GDP	2.311689	1.871005	0.087817	-6.078649*
MS	0.912209	-3.018690	1.534416	-2.591732
CPI	1.412281	-2.072345	1.412281	-0.984306
OP	-0.788689	-4.235850*	-1.503218	-2.728950
Δ EX	-7.032019*	-7.078249*	-7.084632*	-7.099272*

Table 4.3 (Continued)

Unit Root Test	ADF-test		PP-test	
	No trend	Trend	No trend	Trend
Δ GDP	0.012780	-1.280283	-21.28416*	-25.40091*
Δ MS	-0.713321	-0.899419	-10.58803*	-11.26689*
Δ CPI	-5.335103*	-5.330099*	-5.194174*	-4.995788*
Δ OP	-4.608140*	-2.912925	-1.648515	-1.459921
Singapore				
EX	-0.999974	-0.892579	-1.250676	-1.043844
GDP	-0.112058	-1.819104	-0.000662	-1.840096
MS	2.145203	0.632312	2.575104	1.016224
CPI	0.486070	-1.352858	0.957317	-0.257905
OP	-0.788689	-4.235850*	-1.503218	-2.728950
Δ EX	-8.203218*	-8.215436*	-8.212868*	-8.214946*
Δ GDP	-7.882270*	-7.860876*	-8.093385*	-8.910857*
Δ MS	-4.770324*	-5.304162*	-4.683679*	-5.298062*
Δ CPI	-3.572341*	-3.703045**	-3.621321*	-3.74867**
Δ OP	-4.608140*	-2.912925	-1.648515	-1.459921
Thailand				
EX	-1.811651	-1.553589	-1.801274	-1.538791
GDP	-0.956890	-2.109320	-0.565041	-2.483996
MS	0.239442	-1.027163	0.239999	-1.054673
CPI	-0.915971	-2.438523	-0.969999	-1.968645

Table 4.3 (Continued)

Unit Root Test	ADF-test		PP-test	
	No trend	Trend	No trend	Trend
OP	-0.788689	-4.235850*	-1.503218	-2.728950
Δ EX	-8.140796*	-8.201061*	-8.140796*	-8.220335*
Δ GDP	-2.377583	-2.228324	-8.271363*	-8.209476*
Δ MS	-6.400230*	-6.316296*	-6.406205*	-6.322151*
Δ CPI	-5.150200*	-5.052769*	-3.706536*	-3.59736**
Δ OP	-4.608140*	-2.912925	-1.648515	-1.459921

Note: * significance at the 1% level
** significance at the 5% level

As can be seen from the table 4.3, ADF and PP test statistics suggest that most of time series data including exchange rate, GDP, money supply and CPI have a unit root. The null hypothesis of a unit root cannot be rejected. In other word, non-stationary elements exist in all of them. After raw data using first difference the results show all of variables be achieved stationary or I (1) process. Exception for oil price data set, the results from unit root test may not clear to indicate whether it is stationary at level or I (1) process. In general, it seems to be I (1) process in several studies (Berument and Pasaogullari, 2003: 417; Olomola and Adejumo, 2006: 31; and Kandir, 2008: 41). Thus, this study is also followed I(1) process in case of oil price.

4.3.2 Cointegration Test and Vector Error Correction Model (VECM)

For the study of sources of exchange rate volatility**,** I firstly would like to investigate the long run relationship between these key macroeconomic variables including CPI, exchange rate, GDP, money supply and oil price in five Southeast Asian countries namely Indonesia, Malaysia, Philippine, Singapore and Thailand. A

five-variable VAR model is used to estimate by means of cointegration test and error correction model.

1) Cointegration Test

The estimation of a VAR model firstly requires the explicit choice of lag length in the model. The appropriate lag length selection of the VAR is another important step. For this study, the appropriate lag lengths of the VAR in the model are presented as following:

Table 4.4 The Appropriate Lag Length of the VAR at Level

	Indonesia	Malaysia	Philippe	Singapore	Thailand
Lag length	4	5	5	5	5

The appropriate lag length of the VAR is determined by using standard model selection criteria of the well known Akaike Information Criterion (AIC), Akaike (1973: 267-281). Adoption of a general-to-specific modeling approach points to a VAR of order 5 for most of them excluding order 4 for Indonesia ,as an adequate representation of these data set.

This application is used to determine the presence of cointegrating vectors in a set of non stationary time series. According to the results from unit root tests of these variables suggest that all variables are I(1) process. In other word, these time series data have a unit root or non stationary since we proceed with cointegration tests. The procedure utilizes two statistic tests in order to determine the number of cointegrating equations. The first test is based on the trace statistics which test the null hypothesis of r (rank) cointegrating vectors against the alternative of r or more cointegrating vectors. Another is maximal eigen-value test using to test the null hypothesis that there are at most r cointegrating vectors against the alternative of r + 1 cointegrating vectors. The results present as following:

Table 4.5 The Results from Cointegration Test

Country	Trace Statistic	No. of cointegration equation(s)	Max Eigen Value	No. of cointegration equation(s)
Indonesia	93.5324	1	51.2474	1
Malaysia	62.9986	2	38.6372	2
Philippe	51.3438	2	49.6274	1
Singapore	55.3478	2	59.4763	1
Thailand	7.4148	5	7.4148	5

Note: significance at the 5% level

As can be seen from table 4.5, the results suggest that levels of these variables are non-stationary but cointegrated. The cointegration is existed. It means that they have long run relationship or equilibrium relation. Trace test indicates that most of them including Malaysia, Philippine and Singapore have 2 cointegrating equations at the 0.05 level. Indonesia and Thailand have 1 and 5 cointegrating equation(s) respectively. For the results from maximal eigen-value test, they are small difference from the previous one. There is only one cointegrating equation in cases of Indonesia, Philippine and Singapore. Malaysia and Thailand have 2 and 5 cointegrating equations respectively. In overview, most of them have long run equilibrium from 1 or 2 cointegrating equation(s) excluding 5 cointegrating equations of Thailand. If the cointegration is existed then we continue to proceed error correction model.

2) Vector Error Correction Mechanism: VECM

Under the principle of cointegration and error correction model is that there often exists a long run equilibrium relationship between economic variables. However, they may be disequilibrium especially in the short run. A proportion of disequilibrium is corrected in the next period with the error correction mechanism (ECM) therefore the error correction process is a means to harmonize short run and long run behaviors.

From equation (4.3), D is coefficient vector of an error correction mechanism term. It is the one period lagged value of the estimated error of the cointegrating regression obtained from OLS estimation. The absolute value of D explains how quickly the equilibrium is restored. The results from vector error correction model (VECM) are expressed as following

Table 4.6 The Results from the Vector Error Correction Model (VECM)

Error Correction	Indonesia	Malaysia	Philippine	Singapore	Thailand
EX	-0.1463	-3.1644*	1.6905*	0.4302	-0.5941
CPI	-0.0175	-0.0337	-0.0792	-0.3505*	-0.2575*
GDP	-0.0254	0.1889	-0.0442	1.3544*	0.0015
MS	-0.0524*	-0.6521*	0.8780*	-0.9276	0.5094*
OP	0.4537*	-5.8915*	2.7889*	-1.9701	-0.0022

Note: * significance at the 5% level

As can be seen from table 4.6, the estimations of short run dynamic base on vector error correction model (VECM) show that the error correction term (ECT) coefficients of money supply and oil price are significant at the 5% level in case of Indonesia. These imply that the time series data can not drift too far apart and the convergence is also achieved in the long run. As the same time, statistics indicate that exchange rate, money supply and oil price are also significant in case of Malaysia and Philippine. For Singapore, CPI and GDP achieve the error correction mechanism whereas CPI and money supply play this role for Thailand. In overview, the short run adjustments of key macroeconomic variable in these countries can be expressed in figure 4.1.

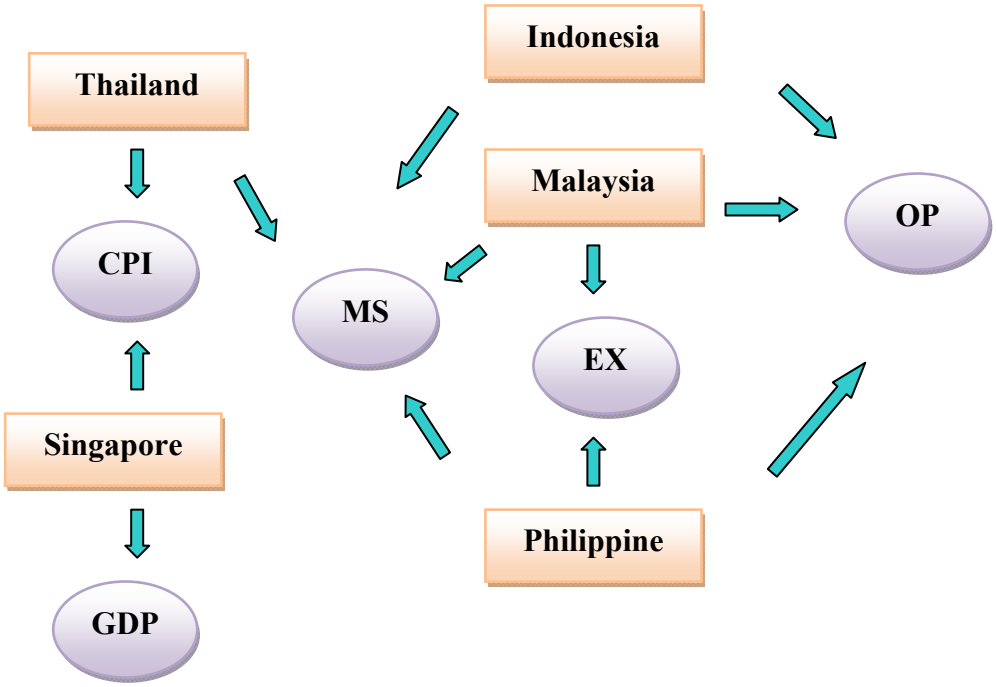


Figure 4.1 Short Run Adjustment of Key Macroeconomic Variables

Whenever the adjustments can be taken place within the same period or the absolute error correction term coefficients less than 1 such as CPI during 0.2575 to 0.3505 and money supply during 0.0524 to 0.8780 (see table 4.6). This implies that the system settles down quickly. However, the adjustments sometimes take longer time than one period (3 months) or the absolute error correction term coefficients more than 1 e.g. in case of exchange rate, GDP and oil price (see table 4.6). They are able to catch up an equilibrium value that exceeded the actual value for many periods. This consists with theoretical framework that real sector representing by GDP always slowly adjust comparing to money supply in financial sector. For oil price and exchange rate, they seem to be more complicated from depending on various uncontrollable exogenous factors such as demand and supply in the world or international markets. Thus, their convergences are likely taken longer time.

4.3.3 Impulse Response Analysis

The impulse response analysis is one of the popular applications in the empirical studies covering the dynamic relationship among macroeconomic variables within VAR models. It measures the time profile to the effect of shock or impulse on the expected future values of a variable. This study also employs this application to investigate the response of exchange rate to other macroeconomic variables. Since only the results of exchange rate response to other macroeconomic variables are expressed and omitted others. The results are shown as following:

1) Indonesia

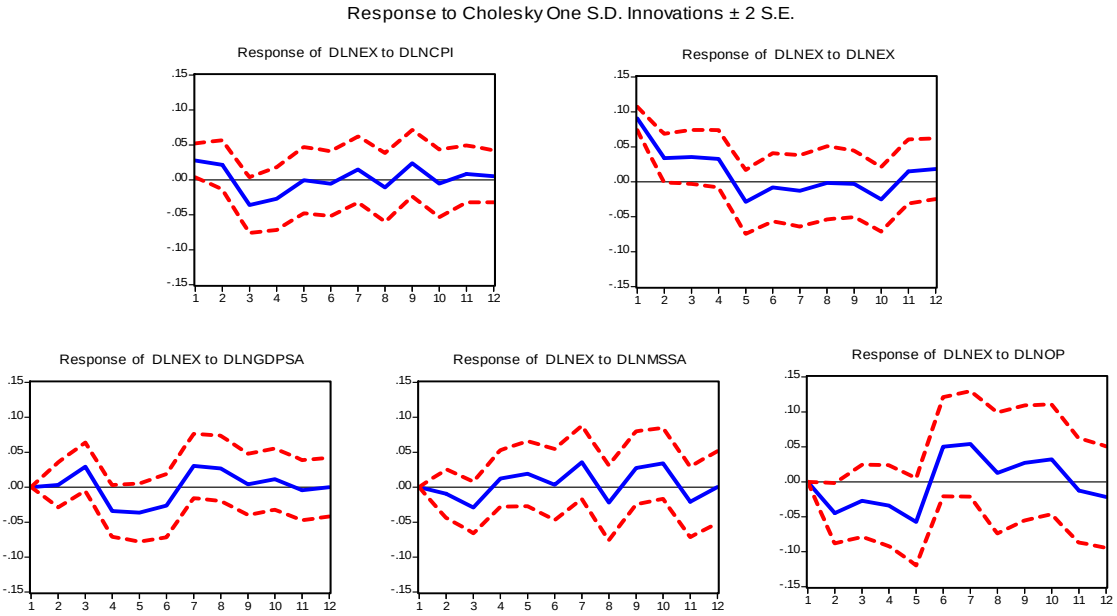


Figure 4.2 Indonesia's Impulse Response of Exchange Rate to Other Economic Variables

2) Malaysia

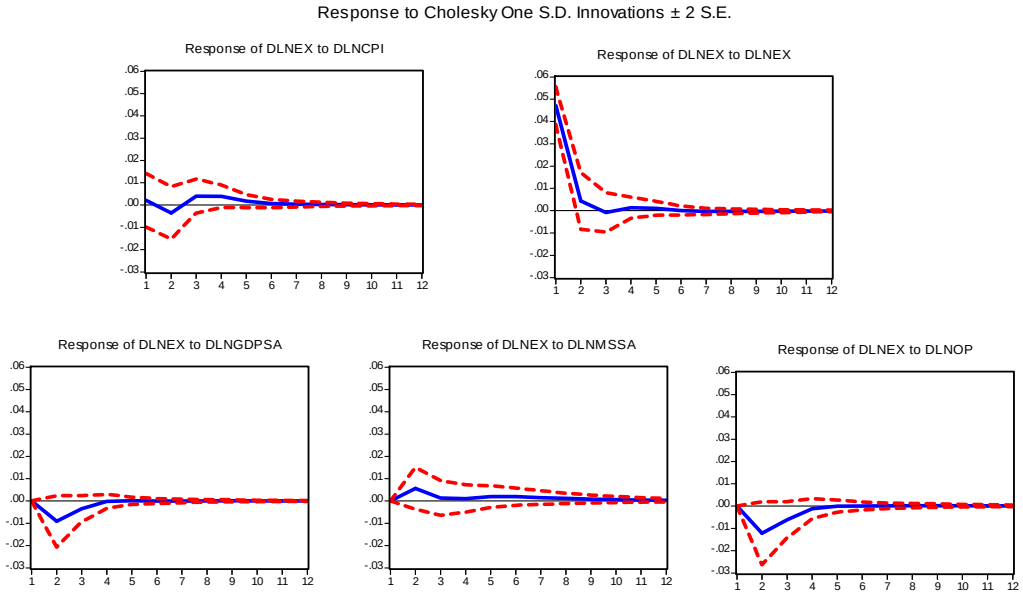


Figure 4.3 Malaysia's Impulse Response of Exchange Rate to Other Economic Variables

3) Philippines

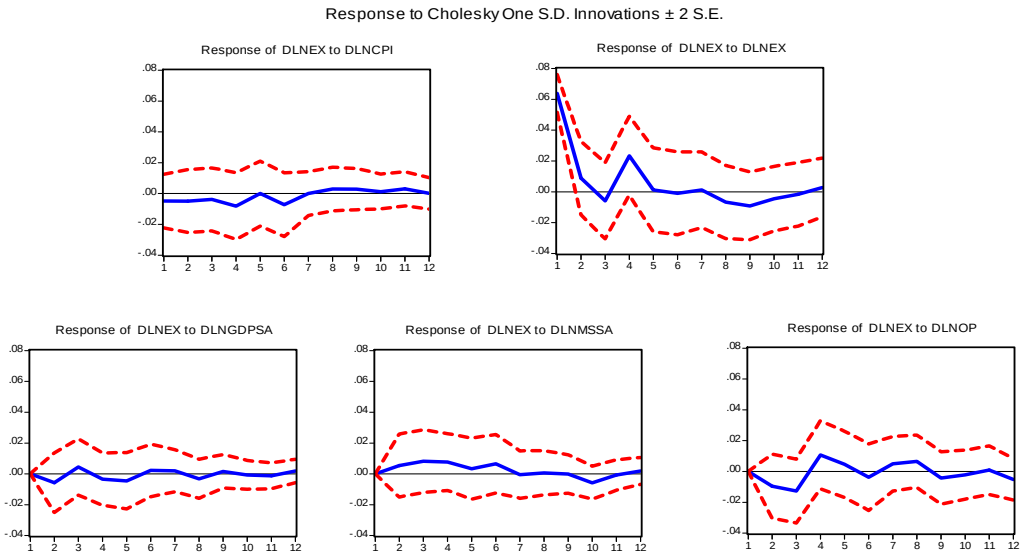


Figure 4.4 Philippines's Impulse Response of Exchange Rate to Other Economic Variables

4) Singapore

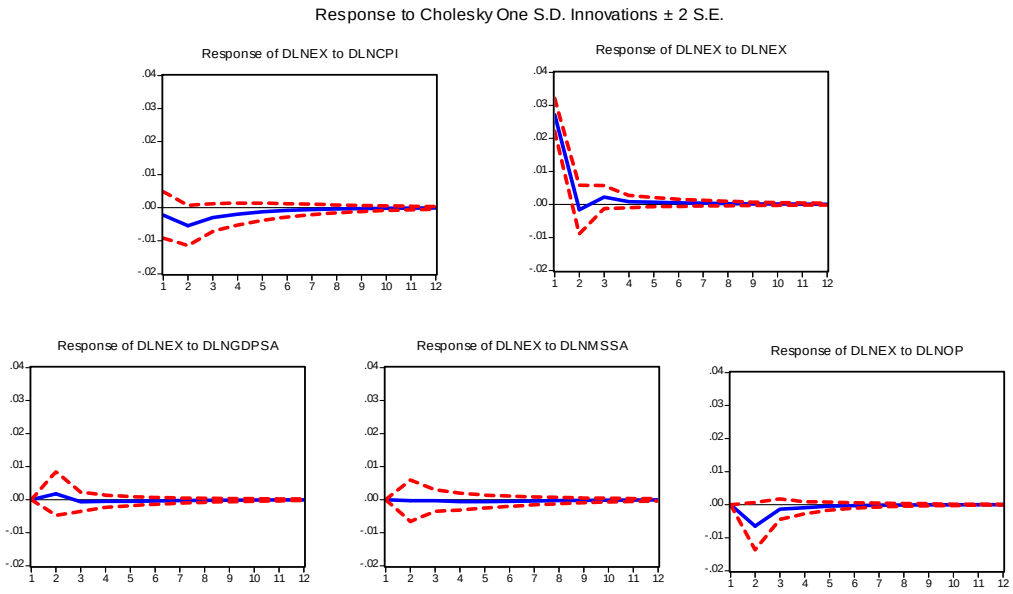


Figure 4.5 Singapore's Impulse Response of Exchange Rate to Other Economic Variables

5) Thailand

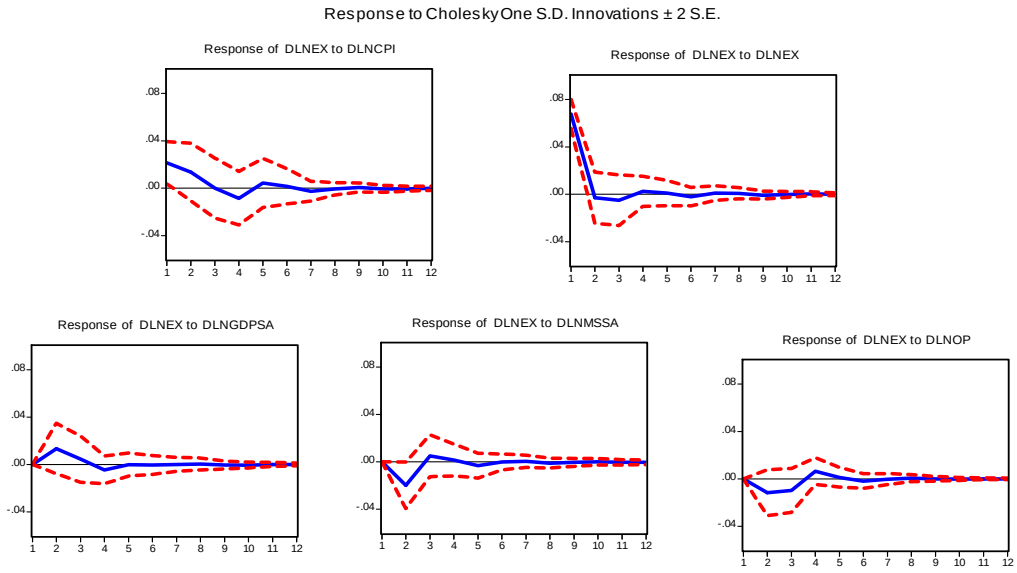


Figure 4.6 Thailand's Impulse Response of Exchange Rate to Other Economic Variables

Note: The two outer curves represent the lower and upper standard error bands for the 10 percent level of significance and the middle curve represents the median response.

As can be seen from Figure 4.2 - 4.6, the impulse response results display the impact of one unit volatility shock from key macroeconomic variables on exchange rate. They suggest that exchange rate responds to contemporaneous change from all macroeconomic variable shocks in the system, including CPI, GDP, money supply and oil price for all the selected Southeast Asian countries. In other word, exchange rate is contemporaneously affected by change in key macroeconomic variables. This ordering reflects the fact that exchange rate behavior is least determined by key macroeconomic variables and its own shocks as well. Moreover, it has been found that the highest level of exchange rate volatility response is attributable to its own shocks for all countries.

In overview, Singapore's exchange rate has the lowest impact from other macroeconomic variables and returning to equilibrium in short period of time

following by Malaysia and Thailand respectively. It implies that the Singapore dollar has the most stable. This is supported by the empirical fact, showing only Singapore dollar proved relatively insulated from the financial crisis shock in 1997. Whereas, Indonesia rupiah, Philippine peso and Thai baht are likely more volatile from the impact of key macroeconomic variable shocks and they take longer time to return equilibrium than any others. It implies that their economic fundamentals and exchange rate are sensitive to shock and less stable. Consider to Indonesia, the results reveal that exchange rate has the highest volatility from macroeconomic shocks. The results are supported by empirical fact in the financial crisis in 1997 that Indonesia rupiah is high volatile. It is one of the countries most affected by the crisis and switching to a free-floating exchange rate arrangement. During this period, the Indonesia rupiah value dropped significantly, from about 2,500 rupiah per dollar at the start of the crisis, to about 8,000 rupiah as of mid-1999.

Consider to each macroeconomic variable, the impulse response analysis presents that Consumer Price Index (CPI) shock seems to be the most influent on exchange rate fluctuations following by oil price and money supply shock respectively. However, in case of Singapore, GDP shock and money supply shock have little impact to exchange rate fluctuations. The particular reasons have come from strong economic fundamental with a sound and efficient financial system (Khor et al., Monetary Authority of Singapore 2004: 20-21).

4.3.4 Variance Decomposition

The properties of estimated VAR models are also often described with the help of variance decomposition. The graph shows what percentage of total variance is explained by each macroeconomic variable. This is an average over one period. The results of the variance decomposition tests are presented as follows:

1) Indonesia

Table 4.7 Indonesia's Variance Decomposition of Exchange Rate

Period	DLNCPI	DLNEX	DLNGDPSA	DLNMSSA	DLNOP
1	8.545202	91.45480	0.000000	0.000000	0.000000
2	9.611277	73.60078	0.077547	0.705345	16.00506
3	14.30420	59.75632	4.883380	5.358157	15.69795
4	14.82315	52.97077	9.213582	5.005668	17.98683
5	11.72059	44.86045	12.06466	5.274860	26.07944
6	10.57349	40.28805	13.03634	4.753511	31.34861
7	9.579929	34.71134	13.58314	7.521787	34.60381
8	9.521963	33.36479	14.93125	8.525671	33.65633
9	10.43968	31.67148	14.19951	9.957496	33.73184
10	9.783961	30.96521	13.52202	11.94982	33.77898

As can be seen from table 4.7, Indonesia's variance decomposition of exchange rate analysis reveals that the largest share of shock to exchange rate come from its own shocks about 91.5% in the first quarter period while having 31% in the 10^{th} quarter period. Its own shocks represent to the rest of all impact excluding the selected variables in this model. Next is the oil price which accounts for about 33.8 % in the 10^{th} quarter period. In addition, GDP and money supply shocks also account for about 13.5% and 11.9% respectively in the 10^{th} period. For CPI, it has the least impact to exchange rate fluctuations (about 9.8%).

2) Malaysia

Table 4.8 Malaysia's Variance Decomposition of Exchange Rate

Period	DLNCPI	DLNEX	DLNGDPSA	DLNMSSA	DLNOP
1	0.211264	99.78874	0.000000	0.000000	0.000000
2	0.693616	88.86774	3.293741	1.252951	5.891950
3	1.298421	86.53618	3.676224	1.284830	7.204342
4	1.880070	85.94108	3.649351	1.321921	7.207575
5	1.983097	85.73020	3.639001	1.461304	7.186398
6	1.995663	85.59304	3.633425	1.602960	7.174916
7	1.999835	85.51297	3.629900	1.689093	7.168201
8	2.001887	85.46873	3.627885	1.736088	7.165410
9	2.002424	85.44411	3.626851	1.762039	7.164578
10	2.002426	85.43081	3.626302	1.776120	7.164345

As can be seen from table 4.8, Malaysia's variance decomposition of exchange rate analysis presents the difference from the previous one. It shows that 1% of oil price shock has the most influence on exchange rate volatility which accounts for about 7 % excluding its own shock taking about 85% in the 10^{th} quarter period. Follow by GDP, CPI and money supply respectively. Because of adopting fixed exchange rate regime after the Asian crisis in 1997, Malaysia ringgit is likely stable. Macroeconomic variables have been little impact on exchange rate fluctuations.

3) Philippine

Table 4.9 Philippines's Variance Decomposition of Exchange Rate

Period	DLNCPI	DLNEX	DLNGDPSA	DLNMSSA	DLNOP
1	0.597530	99.40247	0.000000	0.000000	0.000000
2	1.131518	95.32365	0.742688	0.664508	2.137640
3	1.387355	89.94656	1.114341	2.063559	5.488184
4	2.434989	86.77496	1.175635	2.825758	6.788655
5	2.411302	85.95241	1.541263	2.994821	7.100199
6	3.308397	84.19403	1.592529	3.694106	7.210942
7	3.290852	83.76800	1.652587	3.678505	7.610061
8	3.368866	83.00655	1.805561	3.616536	8.202489
9	3.437640	82.83309	1.812958	3.546948	8.369368
10	3.426848	82.31810	1.802184	4.091028	8.361843

Philippine is one of many countries that exchange rate is highly responsive to key macroeconomic variable shocks. The results show that 1% of oil price shock has the most influence on exchange rate fluctuations, of about 8%, followed by 4% and 3% from money supply and CPI shocks, respectively. Similar to impulse response analysis, variance decomposition presents a small volume (about 1.8 %) of exchange responding to GDP shock.

4) Singapore

Table 4.10 Singapore's Variance Decomposition of Exchange Rate

Period	DLNCPI	DLNEX	DLNGDPSA	DLNMSSA	DLNOP
1	0.661969	99.33803	0.000000	0.000000	0.000000
2	4.205841	90.23973	0.398795	0.015580	5.140056
3	5.197647	89.06972	0.446199	0.027437	5.258994
4	5.623159	88.50550	0.471969	0.072607	5.326760
5	5.788656	88.26662	0.498834	0.114801	5.331084
6	5.859271	88.14972	0.515541	0.145485	5.329981
7	5.890228	88.09171	0.525469	0.164441	5.328147
8	5.904304	88.06258	0.530947	0.175260	5.326912
9	5.910856	88.04794	0.533870	0.181137	5.326193
10	5.913963	88.04061	0.535392	0.184233	5.325803

In case of Singapore, excluding its own shock, the results show that 1% of CPI and oil price shocks have the most influence on exchange rate volatility, of about 5-6 %, followed by GDP and money supply shocks respectively. Similar to impulse response analysis results, both of the later are likely insignificant to affect to the movement of exchange rate.

5) Thailand

Table 4.11 Thailand's Variance Decomposition of Exchange Rate

Period	DLNCPI	DLNEX	DLNGDPSA	DLNMSSA	DLNOP
1	9.150080	90.84992	0.000000	0.000000	0.000000
2	10.84500	77.24046	3.032511	6.593411	2.288618
3	10.55121	75.56805	3.282556	6.827303	3.770883
4	11.45537	73.93079	3.535486	6.705728	4.372623
5	11.70371	73.56301	3.517153	6.838517	4.377604
6	11.72351	73.50985	3.513708	6.828026	4.424912
7	11.81473	73.43313	3.509428	6.822590	4.420127
8	11.81302	73.41265	3.510679	6.839002	4.424657
9	11.81584	73.40666	3.512840	6.840759	4.423901
10	11.81863	73.40144	3.516130	6.840237	4.423569

For Thailand, both CPI and money supply shocks have the most impacted on exchange rate fluctuations of about 12% and 7% respectively. It means that shocks from inflation and money market have impacts on the fluctuations of Thai baht. For oil price shock, it accounts for about 4.4% in the 10^{th} period, one reason that energy import of Thailand takes more than 10% of GDP. Basically, the country's imports and exports predict the exchange rate. A huge trade or current account deficit that is, import payments exceed export earnings results in the depreciation of the baht as such oil price shock enforce to exchange rate fluctuations.

Table 4.12 Comparison the Impact of Key Macroeconomic Variables to Exchange Rate Fluctuations (at the 10th quarter period)

(%)

Country	DLNCPI	DLNEX	DLNGDP	DLNMS	DLNOP
Indonesia	9.8	31.0	13.5	11.9	**33.8**
Malaysia	2.0	85.4	3.6	1.8	**7.2**
Philippine	3.4	82.3	1.8	4.1	**8.4**
Singapore	**5.9**	88.0	0.5	0.2	**5.3**
Thailand	**11.8**	73.4	3.5	**6.8**	4.4

As can be seen from table 4.12, I would like to compare the impact of macroeconomic shock to exchange rate fluctuations among Southeast Asian countries. Consider to the results from variance decomposition analysis at the 10th quarter period in table 4.12, similar to impulse response analysis results, the results present that the largest share of shock to exchange rate come from their own shocks for all countries. Singapore takes the highest account for about 88% follow by Malaysia and Philippine. In addition, CPI and oil price shocks seem to be the main cause to enforce exchange rate volatility. Exception for Malaysia, instead of CPI, GDP and oil price plays the important role for this reason. However, the shock from money market that represents by money supply shock has high influent on exchange rate fluctuations in case of Indonesia and Thailand.

In overview, the results quite show the instability in exchange rate movement in case of Indonesia when it is compared to other countries in this region. All of macroeconomic shocks are influence to exchange rate fluctuations in higher level than any other countries following by Philippine. However, Singapore has the most exchange rate stability, it can tolerate from key macroeconomic variable shocks. These results also support impulse response analysis. For Malaysia, exchange rate is likely to stabilize from adopting of the dollar-pegged regime after the financial crisis in 1997. For Thailand, Thai baht seems to have more stable than Indonesia rupiah and Philippine peso, however it quite be sensitive from inflation and money market shocks.

4.4 Conclusion and Implications

This study aims to examine sources of exchange rate fluctuations of Southeast Asian countries namely Indonesia, Malaysia, Philippine, Singapore and Thailand for the period from 1993Q1 to 2008Q4 by using a five variable VAR model with the application of cointegration test, vector error correction model (VECM), impulse response analysis and variance decomposition. The results from cointegration test suggest that key macroeconomic variables of all selected countries in this region have long run equilibrium. The statistic testing from trace and maximal eigen-value indicate that there are 1-2 cointegrating equation(s) in case of Indonesia, Malaysia, Philippine and Singapore. Only Thailand, it has 5 cointegrating equations. As the cointegration or long run equilibrium is existed. Consequently, this study is continued to perform error correction model. The results from VECM reveal that all of these selected countries can be achieved error correction mechanism in some of key macroeconomic variables such as exchange rate, money supply and oil price in case of Malaysia and Philippine (see figure 4.1). This means that there exists the convergence process.

The results provide economically reasonable and statistically significant coefficients as well as reveal that the selected key macroeconomic variables including CPI, GDP, money supply and oil price are the main sources of exchange rate fluctuations for the application of impulse response analysis and variance decomposition. In addition, the largest share of shock to exchange rate come from its own shock as well as CPI and oil price shocks seem to be the main cause to enforce exchange rate fluctuations. Consider to each country, the results indicate that Singapore is the most stable economy. This is because its exchange rate has the lowest impact from other macroeconomic variables and returning to equilibrium in short period of time following by Malaysia and Thailand respectively. Other two countries, Indonesia and Philippine are likely less exchange rate stability, it quite be sensitive to macroeconomic variable shocks and taking time to return equilibrium. This is supported by the empirical fact that Singapore dollar was relatively stable during and post the Asian financial crisis because of its strong economic fundamental and exchange rate management.

Finally, I would like to discuss implications of the results. Both impulse response analysis and variance decomposition suggest that exchange rate fluctuations in Southeast Asian countries governed by the same set of key macroeconomic variables including CPI, GDP, money supply and oil price, which are similar and interrelated in several studies (see Kopecky (2004: 1); Karras et al. (2005: 224); and Ito and Sato (2006: 25-26)). As stated above, exchange rate responses to the selected key macroeconomic shocks. It implies that particular sources of exchange rate fluctuations come from macroeconomic variables. This is supported by economic reasons and theoretical frame work that there exist linkages between exchange rate and key macroeconomic variables (see chapter 3). In other word, exchange rate is particularly determined by economic fundamental. Thus, policy makers are able to take care of exchange rate fluctuations by means of controlling these factors especially CPI, being the most influent on exchange rate fluctuations following by oil price and money supply respectively. This encourages policy maker decisions in many countries to adopt inflation targeting as a policy instrument. Because inflation targeting has helped achieve the primary objective of price stability as well as a decline in exchange rate volatility (Weera Prasertnukul et al., 2008: 4-6).

CHAPTER 5

VOLATILITY TRANSMISSION OF EXCHANGE RATE AMONG SOUTHEAST ASIAN COUNTRIES

5.1 Introduction

Recently, exchange rate volatility transmissions have become the major topic. After the Asian financial crisis in 1997, many economic literatures have been sparked by interest in the volatility transmission between foreign exchange markets. The exchange rate volatility trended to occur in waves and throughout the region, reflecting the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model (Kearney and Patton, 2000: 30). In general, exchange rate volatility stems from many reasons such as economic fundamental, speculation, psychological factors and policy intervention. Why exchange rate volatility links each other, one reason that their economic fundamental of these countries such trade and investment are related to each other. Thus, any new fundamental information might transform impact from one currency to another currency. Worldwide foreign exchange markets are almost perfectly integrated on a 24-hour trading basis, so that the volatility transmits to corresponding countries at the same time. The changing in volatility of one currency due to the new information should be transmitted to the other currency's volatility simultaneously. However, the previous empirical facts showed that the volatility during crisis is too large to explain only by fundamentals (Sachs et al., 1996: 15-18). Another main reason to explain this situation is market psychology. Although there are no common fundamental change, but it occurs from speculations based on fads, noises or herd instinct instead.

These exchange rate volatilities widely impacted on many agents in economy including traders, investors, portfolio managers and multinational firms. They would play greater attention to manage their financial risk exposures with higher costs. Policy makers also concerned about maintaining the stability of their financial systems. Therefore, exchange rate behaviors have become popular topic. It is found that many empirical tests have explored exchange behaviors by using data from both developed and developing countries (Kearney and Patton, 2000: 29-48; Supaat et al., 2003: 1-20 and Karras et al., 2005: 213-226) so as to understand the behaviors of exchange rate as well as to cope with the serious damage from exchange rate volatility. In addition, the awareness of the volatility transmission nature of exchanges rate across markets is also importance to economic policy makers. Hence it is significant for a financial stability perspective. According to the volatility transmission across markets may be possible for a large shock in one currency to impact on other currencies. At the same time, linkages across markets can affect the success that policies are implemented. If policy-makers can estimate the depth and duration of any policy impact in one financial market to other markets, they are able to develop more effective policies as well.

However, only few studies incorporated many perspectives and methodologies about exchange rate volatility transmissions in one paper especially the group of Southeast Asian countries. The aim of this study is to investigate the extent of volatility spillovers among exchange rates for five Southeast Asian financial markets namely, Indonesia rupiah, Malaysia ringgit, Philippine peso, Singapore dollar and Thai baht. Specifically, first this study will describe the data and the general form of m-GARCH model that is used in this study. Second, I would like to examine how volatility of each currency is affected by other currencies. Third, I will compare the temporal behavior of volatility transmission for pre-crisis and post-crisis periods with various methodologies including m-GARCH model, correlation between currency return, impulse response analysis, and Granger causality test. In the last section, conclusions the main results and their policy implication will be presented and discussed.

Exchange Rate System Background

After the Asian financial crisis in 1997, many Southeast Asian countries have been abandoned their pegged exchange rate regime and shifting to flexible exchange rate regime including Indonesia, Philippine and Thailand. An exception was Malaysia which they returned to a fixed exchange rate system, pegged to a rate against the U.S. Dollar in early period after crisis then switched to a managed float. For Singapore dollar, the Monetary Authority of Singapore (MAS) adopted a more flexible approach in exchange rate management by expanding its exchange rate policy band after this crisis.

Table 5.1 Exchange Rate Regimes in Southeast Asia

Country	Pre-crisis	Post-crisis
Indonesia	Basket of currencies	Managed Float
Malaysia	Basket of currencies	Peg to US Dollar*
		Managed Float**
Philippine	Basket of currencies	Managed Float
Singapore	Managed Float	Free Float
Thailand	Basket of currencies	Managed Float

Note: pre and post Asian crisis in 1997

* 1998-2005

** 2005-2010

As can be seen from table 5.1, excluding Malaysia, most of these selected Southeast Asian countries employed floating exchange rate regime to cope with exchange rate management problems after the financial Asian crisis in 1997. In the pre-crisis era, the Southeast Asian countries experienced relatively stable and little volatility because of their peg exchange rate regime. However, in the post-crisis period the exchange rate in this region seems to be more volatile than the previous one. Most of them have shifted toward the greater floating in exchange rate regime that exchange rate is determined by the private market through supply and demand. It

is consistent with the study of Ghosh et al. (2002: 55) and MacDonald (2007: 21) that the nominal exchange rate volatility is greater under floating regime than under pegged regime. Nevertheless, the floating exchange rates automatically adjust since they enable a country to resist the impact of shocks and foreign business cycles.

During the last two decades, we have seen how different financial crisis originated in particular regions or countries and then extended geographically to others. Especially, the recent Asian crisis in 1997 that firstly started in Thailand with the financial collapse of the Thai baht came from the decision of the Thai government to float the baht. Consequently, the crisis spread out to other Southeast Asian countries, South Korea and Japan. As a result, the crisis had significant macro-level effects, including sharp reductions in values of currencies, stock markets, and other assets, prices of several Asian countries. Many economists believe that the Asian crisis was created not only by market psychology or technology, but also by their fundamental factors and policies that distorted incentives within the lender-borrower relationship. However, as long as the international markets are becoming more and more integrated, information that generated in one market can affect other markets. This study tries to explain how volatility of each country's currency is affected by other countries' currencies.

As can be seen from Figure 5.1, during the pre-crisis era, the movements of exchange rates in Southeast Asian countries are likely stable. However, Indonesia rupiah is the most depreciated about 20 % during this period.

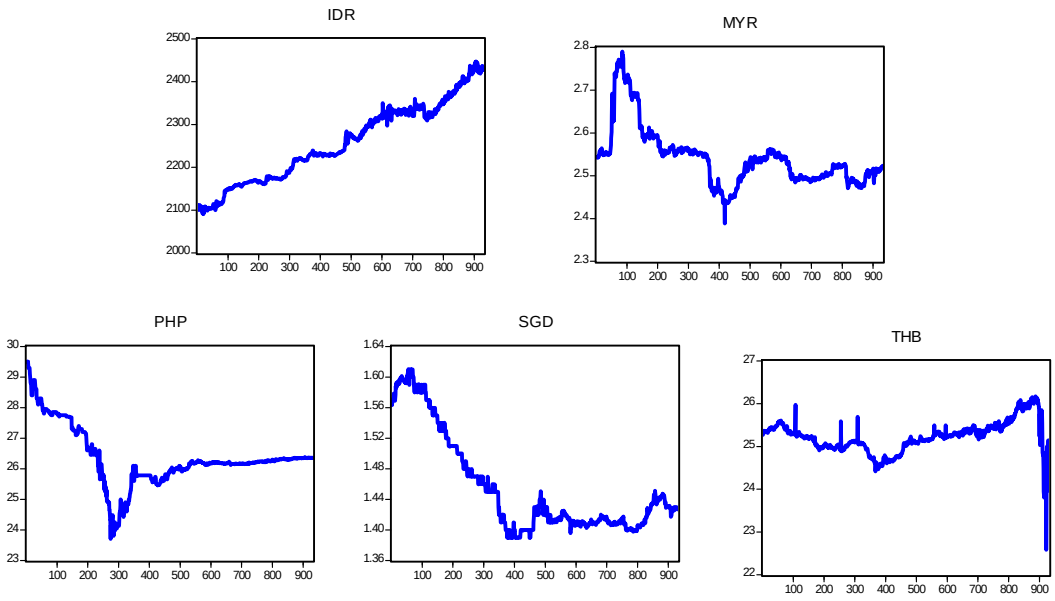


Figure 5.1 The Pre-Crisis Movement of Exchange Rate in Southeast Asian Countries

For the post-crisis era, exchange rates in these countries seem to have fluctuated particular from the floating exchange rate regime. (see figure 5.2) In addition, most of them move quite the similar pattern especially Malaysia ringgit, Philippine peso, Singapore dollar and Thai baht. Only Indonesia rupiah has a different pattern of movement from others.

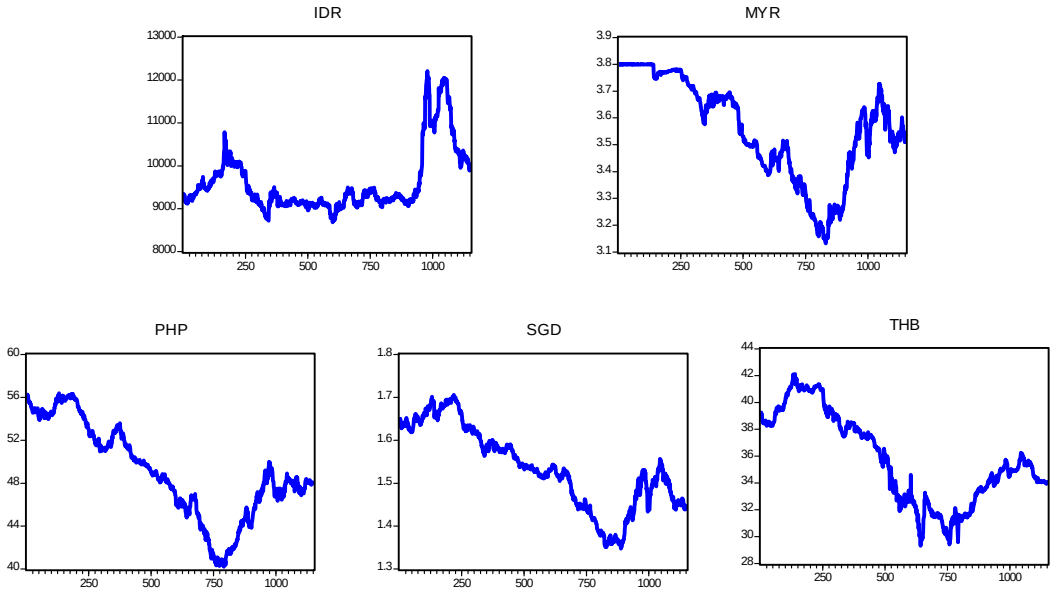


Figure 5.2 The Post-Crisis Movement of Exchange Rate in Southeast Asian Countries

5.2 Methodology

In this section, I would like to review methodologies that have been applied in the analysis of volatility transmission in this study. It is known that there are many tools used to explain about this issue e.g. regime switch models, stochastic volatility models and GARCH models.

Regime switch models focus on exchange rate behavior of volatility due to the existence of structural changes. This approach models non-linearity in time series assuming different behavior or structural break in one subsample to another. Several empirical studies were introduced by many economist e.g. Lastrapes and Koray (1990: 402-423), Engle and Susmel (1994: 3-25) and Edwards and Susmel (2003: 328-348). However, in some situations, it is found that regime switch model would not perform well especially switching from one to low variance and not much drift. In addition, it is likely to miss the direction of change for a short period of time which regime shift, but it trends to obtain the correct direction during long period of time (Engel, 1994: 152-154).

Stochastic volatility models were introduced by Taylor (1982: 203-226). They considered volatility as an unobservable variable and model the logarithm of volatility as a stochastic linear model. They are another alternative to analyze volatility transmission between financial markets. These models, however, have not been as popular as the GARCH models. So it is suggested by the few empirical literature existing. Because of the main disadvantage of Stochastic Volatility models is that, assuming the error term is a Gaussian process, and the variable is not conditional. Furthermore, estimation is not as easy as in the case of GARCH as well as less efficiency (Engle, 2001: 157-158).

GARCH models, the most popular for time varying estimation, initially introduced by Engle (1982: 987-1008) and consequently extended by many economist like Bollerslev (1986: 307- 327), Engle et al. (1987: 391-407), Bollerslev (1990: 498-505), Bollerslev and Engle (1993: 167-186), Bera and Kim (2002: 171-195). Both univariate and multivariate GARCH models have also been used to investigate volatility and correlation transmission and spillover effects in studies of contagion. In particular, multivariate GARCH model was pioneered by Kraft and Engle (1982: 293-

302) and Bollerslev, Engle and Wooldridge (1988: 116-131). Its process was assumed that a vector transform of the covariance matrix included both its own conditional variance and covariance can be written as a linear combination of its lagged values. Thus, it is more powerful to explain volatility transmission and spillover effects. Andersen, et al., (1999: 457) argue that these models work well relative to competing alternatives. Given the advantage of GARCH model, this study is designed to adopt the multivariate GARCH frame work.

5.2.1 Multivariate GARCH Model

To estimate this model for the volatility transmission, I would like to specify an equation for the determination of the conditional mean. It is important to capture any co-movement relationships that may exist between the exchange rates. The data in this study are represented by the return on each currency between time t and t-1 (Kearney and Patton, 2000: 35) as following.

$$R_{i,t} = \ln\left(\frac{S_{i,t}}{S_{i,t-1}}\right) = \mu_i + \varepsilon_i \qquad \text{-----(5.1)}$$

where:

$R_{i,t}$ = the return on currency i between time t and t-1

$S_{i,t}$ = the spot rate of currency i at time t (measured with US$1 as the commodity currency)

μ_i = a long-term drift coefficient

ε_i = the error term for currency i at time t

i = 1,2,3,4,5 and 1= IDR, 2= MYR, 3= PHP, 4= SGD and 5= THB (Indonesia rupiah, Malaysia ringgit, Philippine peso, Singapore dollar and Thai baht)

The VECM representation which introduced by Bollerslev et al. (1988: 121-131) to estimate the model for the first moment simultaneously with those for the second moment as the following specification (in matrix form):

$$\text{vech}\,(\mathbf{H_t}) = \text{vech}\,(\mathbf{A_0}) + \sum_{i=1}^{q} \mathbf{A_i}\ \text{vech}\,(\boldsymbol{\varepsilon}_{t-i}\,\boldsymbol{\varepsilon}'_{t-i}) + \sum_{j=1}^{p} \mathbf{B_j}\ \text{vech}\,(\mathbf{H_{t-i}}) \quad \text{--- (5.2)}$$

$\mathbf{H_t}$	=	conditional variance-covariance
$\mathbf{A_0}$	=	positive definite matrix of parameters
$\mathbf{A_i}$	=	parameters matrixes
$\mathbf{B_j}$	=	parameters matrixes
$\boldsymbol{\varepsilon_t}$	=	error terms

where , $\boldsymbol{\varepsilon_t} \sim$ iid N (0,I)

Equation (5.2) presented a simplified version of the model by assuming that $\mathbf{A_i}$ and $\mathbf{B_j}$ are diagonal matrixes. In this case, it is possible to obtain conditions for $\mathbf{H_t}$ to be positive definite for all t

However, some drawbacks of the multivariate extension by Bollerslev et al. (1988: 116-131) are the large number of parameters to estimate, the difficulties to obtain a stationary covariance process, and the problems to get a positive-definite (co)variance matrix. Many of these problems are circumvented by the BEKK model (Baba, Engle, Kraft and Kroner) proposed by Engle and Kroner (1995: 122-150). For this study, I also employ the BEKK model to estimate transmission volatility among variables. The BEKK model for the multivariate GARCH (1,1) can be given as following:

$$\mathbf{H_{t+1}} = \mathbf{C}'\mathbf{C} + \mathbf{A}'\boldsymbol{\varepsilon_t}\boldsymbol{\varepsilon}'_{\mathbf{t}}\mathbf{A} + \mathbf{B}'\mathbf{H_t}\mathbf{B} \quad \text{---(5.3)}$$

H_t	=	Positive definite of conditional covariance matrix
C	=	Parameter n × n matrix,
A	=	Parameter n × n matrix
B	=	Parameter n × n matrix
ε_t	=	error terms matrix

For this study, n equals to five including Indonesia rupiah, Malaysia ringgit, Philippine peso, Singapore dollar and Thai baht.

$$\mathbf{H_t} = \begin{pmatrix} h_{11,t} & h_{12,t} & h_{13,t} & h_{14,t} & h_{15,t} \\ h_{21,t} & h_{22,t} & h_{23,t} & h_{24,t} & h_{25,t} \\ h_{31,t} & h_{32,t} & h_{33,t} & h_{34,t} & h_{35,t} \\ h_{41,t} & h_{42,t} & h_{43,t} & h_{44,t} & h_{45,t} \\ h_{51,t} & h_{52,t} & h_{53,t} & h_{54,t} & h_{55,t} \end{pmatrix}$$

$$\mathbf{C} = \begin{pmatrix} c_{11} & 0 & 0 & 0 & 0 \\ c_{21} & c_{22} & 0 & 0 & 0 \\ c_{31} & c_{32} & c_{33} & 0 & 0 \\ c_{41} & c_{42} & c_{43} & c_{44} & 0 \\ c_{51} & c_{52} & c_{53} & c_{54} & c_{55} \end{pmatrix}$$

$$\mathbf{A} = \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{pmatrix}$$

$$\mathbf{B} = \begin{pmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{pmatrix}$$

$$\boldsymbol{\varepsilon_t} = \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \\ \varepsilon_{5,t} \end{pmatrix}$$

For equation (5.3), the elements of matrix **A** capture the effects of shocks or unanticipated events on conditional variances (volatility). Whereas matrix **B** shows how current levels of conditional variances are affected by past conditional variances. The total number of estimated elements for the variance equations in five-variable case is 65, 1/2 ($5n^2 + n$).

The conditional variance for each equation (excluding constants) can be expanded for the five-variable GARCH (1,1) as following:

$$\begin{aligned} h_{11,t+1} = {} & a^2_{11}\varepsilon^2_{1,t} + 2\, a_{11}a_{21}\varepsilon_{1,t}\varepsilon_{2,t} + 2a_{11}a_{31}\varepsilon_{1,t}\varepsilon_{3,t} + 2a_{11}a_{41}\varepsilon_{1,t}\varepsilon_{4,t} + 2a_{11}a_{51}\varepsilon_{1,t}\varepsilon_{5,t} \\ & + a^2_{21}\varepsilon^2_{2,t} + 2a_{21}a_{31}\varepsilon_{2,t}\varepsilon_{3,t} + 2a_{21}a_{41}\varepsilon_{2,t}\varepsilon_{4,t} + 2a_{21}a_{51}\varepsilon_{2,t}\varepsilon_{5,t} + a^2_{31}\varepsilon^2_{3,t} \\ & + 2a_{31}a_{41}\varepsilon_{3,t}\varepsilon_{4,t} + 2a_{31}a_{51}\varepsilon_{3,t}\varepsilon_{5,t} + a^2_{41}\varepsilon^2_{4,t} + 2a_{41}a_{51}\varepsilon_{4,t}\varepsilon_{5,t} + a^2_{51}\varepsilon^2_{5,t} \\ & + b^2_{11}h_{11,t} + 2b_{11}b_{21}h_{12,t} + 2b_{11}b_{31}h_{13,t} + 2b_{11}b_{41}h_{14,t} + 2b_{11}b_{51}h_{15,t} \\ & + b^2_{21}h_{22,t} + 2b_{21}b_{31}h_{23,t} + 2b_{21}b_{41}h_{24,t} + 2b_{21}b_{51}h_{25,t} + b^2_{31}h_{33,t} \\ & + 2b_{31}b_{41}h_{34,t} + 2b_{31}b_{51}h_{35,t} + b^2_{41}h_{44,t} + 2b_{41}b_{51}h_{45,t} + b^2_{51}h_{55,t} \end{aligned} \quad \text{---(5.4)}$$

$$\begin{aligned} h_{22,t+1} = {} & a^2_{12}\varepsilon^2_{1,t} + 2\, a_{12}a_{22}\varepsilon_{1,t}\varepsilon_{2,t} + 2a_{12}a_{32}\varepsilon_{1,t}\varepsilon_{3,t} + 2a_{12}a_{42}\varepsilon_{1,t}\varepsilon_{4,t} + 2a_{12}a_{52}\varepsilon_{1,t}\varepsilon_{5,t} \\ & + a^2_{22}\varepsilon^2_{2,t} + 2a_{22}a_{32}\varepsilon_{2,t}\varepsilon_{3,t} + 2a_{22}a_{42}\varepsilon_{2,t}\varepsilon_{4,t} + 2a_{22}a_{52}\varepsilon_{2,t}\varepsilon_{5,t} + a^2_{32}\varepsilon^2_{3,t} \\ & + 2a_{32}a_{42}\varepsilon_{3,t}\varepsilon_{4,t} + 2a_{32}a_{52}\varepsilon_{3,t}\varepsilon_{5,t} + a^2_{42}\varepsilon^2_{4,t} + 2a_{42}a_{52}\varepsilon_{4,t}\varepsilon_{5,t} + a^2_{52}\varepsilon^2_{5,t} \\ & + b^2_{12}h_{11,t} + 2b_{12}b_{22}h_{12,t} + 2b_{12}b_{32}h_{13,t} + 2b_{12}b_{42}h_{14,t} + 2b_{12}b_{52}h_{15,t} \\ & + b^2_{22}h_{22,t} + 2b_{22}b_{32}h_{23,t} + 2b_{22}b_{42}h_{24,t} + 2b_{22}b_{52}h_{25,t} + b^2_{32}h_{33,t} \\ & + 2b_{32}b_{42}h_{34,t} + 2b_{32}b_{52}h_{35,t} + b^2_{42}h_{44,t} + 2b_{42}b_{52}h_{45,t} + b^2_{52}h_{55,t} \end{aligned} \quad \text{---(5.5)}$$

$$\begin{aligned} h_{33,t+1} = {} & a^2_{13}\varepsilon^2_{1,t} + 2\, a_{13}a_{23}\varepsilon_{1,t}\varepsilon_{2,t} + 2a_{13}a_{33}\varepsilon_{1,t}\varepsilon_{3,t} + 2a_{13}a_{43}\varepsilon_{1,t}\varepsilon_{4,t} + 2a_{13}a_{53}\varepsilon_{1,t}\varepsilon_{5,t} \\ & + a^2_{23}\varepsilon^2_{2,t} + 2a_{23}a_{33}\varepsilon_{2,t}\varepsilon_{3,t} + 2a_{23}a_{43}\varepsilon_{2,t}\varepsilon_{4,t} + 2a_{23}a_{53}\varepsilon_{2,t}\varepsilon_{5,t} + a^2_{33}\varepsilon^2_{3,t} \\ & + 2a_{33}a_{43}\varepsilon_{3,t}\varepsilon_{4,t} + 2a_{33}a_{53}\varepsilon_{3,t}\varepsilon_{5,t} + a^2_{43}\varepsilon^2_{4,t} + 2a_{43}a_{53}\varepsilon_{4,t}\varepsilon_{5,t} + a^2_{53}\varepsilon^2_{5,t} \\ & + b^2_{13}h_{11,t} + 2b_{13}b_{23}h_{12,t,t} + 2b_{13}b_{33}h_{13,t} + 2b_{13}b_{43}h_{14} + 2b_{13}b_{53}h_{15,t} \end{aligned}$$

$$+ b^2_{23}h_{22,t} + 2b_{23}b_{33}h_{23,t} + 2b_{23}b_{43}h_{24,t} + 2b_{23}b_{53}h_{25,t} + b^2_{33}h_{33,t}$$
$$+ 2b_{33}b_{43}h_{34,t} + 2b_{33}b_{53}h_{35,t} + b^2_{43}h_{44,t} + 2b_{43}b_{53}h_{45,t} + b^2_{53}h_{55,t} \quad \text{---(5.6)}$$

$$h_{44,t+1} = a^2_{14}\varepsilon^2_{1,t} + 2\,a_{14}a_{24}\varepsilon_{1,t}\varepsilon_{2,t} + 2a_{14}a_{34}\,\varepsilon_{1,t}\varepsilon_{3,t} + 2a_{14}a_{44}\,\varepsilon_{1,t}\varepsilon_{4,t} + 2a_{14}a_{54}\,\varepsilon_{1,t}\varepsilon_{5,t}$$
$$+ a^2_{24}\,\varepsilon^2_{2,t} + 2a_{24}a_{34}\,\varepsilon_{2,t}\varepsilon_{3,t} + 2a_{24}a_{44}\,\varepsilon_{2,t}\varepsilon_{4,t} + 2a_{24}a_{54}\,\varepsilon_{2,t}\varepsilon_{5,t} + a^2_{34}\,\varepsilon^2_{3,t}$$
$$+ 2a_{34}a_{44}\,\varepsilon_{3,t}\varepsilon_{4,t} + 2a_{34}a_{54}\,\varepsilon_{3,t}\varepsilon_{5,t} + a^2_{44}\,\varepsilon^2_{4,t} + 2a_{44}a_{54}\,\varepsilon_{4,t}\varepsilon_{5,t} + a^2_{54}\,\varepsilon^2_{5,t}$$
$$+ b^2_{14}h_{11,t} + 2b_{14}b_{24}h_{12,t} + 2b_{14}b_{34}h_{13,t} + 2b_{14}b_{44}h_{14,t} + 2b_{14}b_{54}h_{15,t}$$
$$+ b^2_{24}h_{22,t} + 2b_{24}b_{34}h_{23,t} + 2b_{24}b_{44}h_{24,t} + 2b_{24}b_{54}h_{25,t} + b^2_{34}h_{33,t}$$
$$+ 2b_{34}b_{44}h_{34,t} + 2b_{34}b_{54}h_{35,t} + b^2_{44}h_{44,t} + 2b_{44}b_{54}h_{45,t} + b^2_{54}h_{55,t} \quad \text{---(5.7)}$$

$$h_{55,t+1} = a^2_{15}\varepsilon^2_{1,t} + 2a_{15}a_{25}\varepsilon_{1,t}\varepsilon_{2,t} + 2a_{15}a_{35}\,\varepsilon_{1,t}\varepsilon_{3,t} + 2a_{15}a_{45}\,\varepsilon_{1,t}\varepsilon_{4,t} + 2a_{15}a_{55}\,\varepsilon_{1,t}\varepsilon_{5,t}$$
$$+ a^2_{25}\,\varepsilon^2_{2,t} + 2a_{25}a_{35}\,\varepsilon_{2,t}\varepsilon_{3,t} + 2a_{25}a_{45}\,\varepsilon_{2,t}\varepsilon_{4,t} + 2a_{25}a_{55}\,\varepsilon_{2,t}\varepsilon_{5,t} + a^2_{35}\,\varepsilon^2_{3,t}$$
$$+ 2a_{35}a_{45}\,\varepsilon_{3,t}\varepsilon_{4,t} + 2a_{35}a_{55}\,\varepsilon_{3,t}\varepsilon_{5,t} + a^2_{45}\,\varepsilon^2_{4,t} + 2a_{45}a_{55}\,\varepsilon_{4,t}\varepsilon_{5,t} + a^2_{55}\,\varepsilon^2_{5,t}$$
$$+ b^2_{15}h_{11,t} + 2b_{15}b_{25}h_{12,t} + 2b_{15}b_{35}h_{13,t} + 2b_{15}b_{45}h_{14,t} + 2b_{15}b_{55}h_{15,t}$$
$$+ b^2_{25}h_{22,t} + 2b_{25}b_{35}h_{23,t} + 2b_{25}b_{45}h_{24,t} + 2b_{25}b_{55}h_{25,t} + b^2_{35}h_{33,t}$$
$$+ 2b_{35}b_{45}h_{34,t} + 2b_{35}b_{55}h_{35,t} + b^2_{45}h_{44,t} + 2b_{45}b_{55}h_{45,t} + b^2_{55}h_{55,t} \quad \text{---(5.8)}$$

Equation (5.4), (5.5), (5.6), (5.7) and (5.8) show how shocks and volatility are transmitted across exchange rate markets and overtime by using the estimated variance-covariance matrix of the parameters along with the mean and standard error vectors. Volatility transmits from time t to time t+1 (see table 5.2) via 1) variance transmission terms such as $h_{11,t}$, $h_{22,t}$, $h_{33,t}$ 2) covariance transmission terms such as $h_{12,t}$, $h_{13,t}$,$h_{14,t}$ and 3) error term such as $\varepsilon^2_{1,t}$, $\varepsilon^2_{3,t}$, $\varepsilon_{1,t}\varepsilon_{4,t}$.

This study estimates in five variables; Indonesia rupiah, Malaysia ringgit, Philippine peso, Singapore dollar and Thai baht. From these conditional variance equations, the parameters are expressed as table 5.2

Table 5.2 Parameters in Conditional Variance Equations

Independent Variable	$h_{11,t+1}$	$h_{22,t+1}$	$h_{33,t+1}$	$h_{44,t+1}$	$h_{55,t+1}$
$\varepsilon_{1,t}\varepsilon_{2,t}$	$2a_{11}a_{21}$	$2a_{12}a_{22}$	$2a_{13}a_{23}$	$2a_{14}a_{24}$	$2a_{15}a_{25}$
$\varepsilon_{1,t}\varepsilon_{3,t}$	$2a_{11}a_{31}$	$2a_{12}a_{32}$	$2a_{13}a_{33}$	$2a_{14}a_{34}$	$2a_{15}a_{35}$
$\varepsilon_{1,t}\varepsilon_{4,t}$	$2a_{11}a_{41}$	$2a_{12}a_{42}$	$2a_{13}a_{43}$	$2a_{14}a_{44}$	$2a_{15}a_{45}$
$\varepsilon_{1,t}\varepsilon_{5,t}$	$2a_{11}a_{51}$	$2a_{12}a_{52}$	$2a_{13}a_{53}$	$2a_{14}a_{54}$	$2a_{15}a_{55}$
$\varepsilon_{2,t}\varepsilon_{3,t}$	$2a_{21}a_{31}$	$2a_{22}a_{32}$	$2a_{23}a_{33}$	$2a_{24}a_{34}$	$2a_{25}a_{35}$
$\varepsilon_{2,t}\varepsilon_{4,t}$	$2a_{21}a_{41}$	$2a_{22}a_{42}$	$2a_{23}a_{43}$	$2a_{24}a_{44}$	$2a_{25}a_{45}$
$\varepsilon_{2,t}\varepsilon_{5,t}$	$2a_{21}a_{51}$	$2a_{22}a_{52}$	$2a_{23}a_{53}$	$2a_{24}a_{54}$	$2a_{25}a_{55}$
$\varepsilon_{3,t}\varepsilon_{4,t}$	$2a_{31}a_{41}$	$2a_{32}a_{42}$	$2a_{33}a_{43}$	$2a_{34}a_{44}$	$2a_{35}a_{45}$
$\varepsilon_{3,t}\varepsilon_{5,t}$	$2a_{31}a_{51}$	$2a_{32}a_{52}$	$2a_{33}a_{53}$	$2a_{34}a_{54}$	$2a_{35}a_{55}$
$\varepsilon_{4,t}\varepsilon_{5,t}$	$2a_{41}a_{51}$	$2a_{42}a_{52}$	$2a_{43}a_{53}$	$2a_{44}a_{54}$	$2a_{45}a_{55}$
$\varepsilon^2_{1,t}$	a^2_{11}	a^2_{12}	a^2_{13}	a^2_{14}	a^2_{15}
$\varepsilon^2_{2,t}$	a^2_{21}	a^2_{22}	a^2_{23}	a^2_{24}	a^2_{25}
$\varepsilon^2_{3,t}$	a^2_{31}	a^2_{32}	a^2_{33}	a^2_{34}	a^2_{35}
$\varepsilon^2_{4,t}$	a^2_{41}	a^2_{42}	a^2_{43}	a^2_{44}	a^2_{45}
$\varepsilon^2_{5,t}$	a^2_{51}	a^2_{52}	a^2_{53}	a^2_{54}	a^2_{55}
$h_{11,t}$	b^2_{11}	b^2_{12}	b^2_{13}	b^2_{14}	b^2_{15}
$h_{22,t}$	b^2_{21}	b^2_{22}	b^2_{23}	b^2_{24}	b^2_{25}
$h_{33,t}$	b^2_{31}	b^2_{32}	b^2_{33}	b^2_{34}	b^2_{35}
$h_{44,t}$	b^2_{41}	b^2_{42}	b^2_{43}	b^2_{44}	b^2_{45}
$h_{55,t}$	b^2_{51}	b^2_{52}	b^2_{53}	b^2_{54}	b^2_{55}
$h_{12,t}$	$2b_{11}b_{21}$	$2b_{12}b_{22}$	$2b_{13}b_{23}$	$2b_{14}b_{24}$	$2b_{15}b_{25}$
$h_{13,t}$	$2b_{11}b_{31}$	$2b_{12}b_{32}$	$2b_{13}b_{33}$	$2b_{14}b_{34}$	$2b_{15}b_{35}$
$h_{14,t}$	$2b_{11}b_{41}$	$2b_{12}b_{42}$	$2b_{13}b_{43}$	$2b_{14}b_{44}$	$2b_{15}b_{45}$
$h_{15,t}$	$2b_{11}b_{51}$	$2b_{12}b_{52}$	$2b_{13}b_{53}$	$2b_{14}b_{54}$	$2b_{15}b_{55}$
$h_{23,t}$	$2b_{21}b_{31}$	$2b_{22}b_{32}$	$2b_{23}b_{33}$	$2b_{24}b_{34}$	$2b_{25}b_{35}$
$h_{24,t}$	$2b_{21}b_{41}$	$2b_{22}b_{42}$	$2b_{23}b_{43}$	$2b_{24}b_{44}$	$2b_{25}b_{45}$
$h_{25,t}$	$2b_{21}b_{51}$	$2b_{22}b_{52}$	$2b_{23}b_{53}$	$2b_{24}b_{54}$	$2b_{25}b_{55}$

Table 5.2 (Continued)

Independent Variable	$h_{11,t+1}$	$h_{22,t+1}$	$h_{33,t+1}$	$h_{44,t+1}$	$h_{55,t+1}$
$h_{34,t}$	$2b_{31}b_{41}$	$2b_{32}b_{42}$	$2b_{33}b_{43}$	$2b_{34}b_{44}$	$2b_{35}b_{45}$
$h_{35,t}$	$2b_{31}b_{51}$	$2b_{32}b_{52}$	$2b_{33}b_{53}$	$2b_{34}b_{54}$	$2b_{35}b_{55}$
$h_{45,t}$	$2b_{41}b_{51}$	$2b_{42}b_{52}$	$2b_{43}b_{53}$	$2b_{44}b_{54}$	$2b_{45}b_{55}$

The meaning of symbols in Table 5.2, for example, the symbol $h_{11,t}$ describes the conditional variance (volatility) for the Indonesia rupiah at time "t" and $h_{12,t}$ shows the conditional covariance between the Indonesia rupiah and Malaysia ringgit in our model. The error term "ε" in each model represents the effect of 'news' (i.e., unexpected news or shocks) in each model on different currencies. For $\varepsilon^2_{1,t}$, $\varepsilon^2_{2,t}$, and $\varepsilon^2_{3,t}$ represent the deviations from the mean due to some shocks in a particular currency. In addition, the cross values of error terms like $\varepsilon_{1,t}\varepsilon_{2,t}$ represents the "news" in the Indonesia rupiah and Malaysia ringgit in time period "t".

5.2.2 Causality Test

The concept of a causality test was first introduced by Granger (1969: 424-438). It explains cause and effect between two variables or pairwise analysis. A Granger causality test has been carried out to create the direction of causality of the linkage between currencies in the selected countries in this study. It is based on the regression of each volatility proxy on its lagged values and on the lagged values of all the other variables. In this part of the present study, I would like to examine the cause and effect between these currencies.

Granger causality is a part of the VAR model. Granger (1969: 424-438) defines causality as the degree to which the variable x can explain behavior of variable y, and reduce variable y's conditional variance: x causes y. The opposite circumstance will be expressed as y causes x. If both are true, both x and y maintain a feedback relationship or bi-directional causality. If neither is true then x and y have independent relations or no causality. This study employs Granger causality test in

order to examine cause and effect among these currencies in five Southeast Asian Countries.

Data:

The data used in this study consisted of time series of daily exchange rate in terms of local currency against US dollar of five Southeast Asian countries namely Indonesia rupiah, Malaysia ringgit, Philippines peso, Singapore dollar and Thai baht from January 1993 through June 1997 for the pre-crisis (Period 1) comparing to January 2005 to July 2009 for the post-crisis (Period 2). Daily observations are at the close of business day. These data extracted from PACIFIC Exchange Rate Service.

5.3 Empirical Results

This study employs the multivariate GARCH model to investigate the volatility transmission of these currencies namely Indonesia rupiah, Malaysia ringgit, Philippines peso, Singapore dollar and Thai baht during two period of time pre and post Asian financial crisis in 1997. I would like to compare their behaviors in the views of volatility transmission, causality and the dynamic response to other currency shock (impulse response analysis). In the first part of this section, descriptive statistics for all return series are presented.

5.3.1 Description of the data

The data in this study are represented by the return on each currency between time t and t-1 and table 5.3 and table 5.4 give some of the key features of the variables including mean, standard deviation, skewness, kurtosis, Jacque-Bera p-value and ARCH (1) p-value. For kurtosis, it measures whether the data are peaked or flat, relative to a normal distribution. If the kurtosis of data is more than 3, it implies that the variance has more extremely deviated than modestly-sized deviations. Skewness is a measure of symmetry.

Table 5.3 Summary Statistics for All Return Series in Period 1

Currency	IDR	MYR	PHP	SGD	THB
Mean	0.000151	-8.19E-06	-0.000121	-9.93E-05	-2.35E-05
Standard deviation	0.00228	0.00272	0.00323	0.00286	0.00548
Skewness	-0.0842	1.3340	-2.3209	-0.1087	-0.60723
Kurtosis	10.5430	29.1439	33.1036	6.5633	48.9252
Jacque-Bera (p-value)	2,205.83	2,6761.55	3,5951.20	493.84	81,785.73
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ARCH(1) p-value	0.0000	0.0000	0.0000	0.0000	0.0000

Table 5.4 Summary Statistics for All Return Series in Period 2

Currency	IDR	MYR	PHP	SGD	THB
Mean	5.60E-05	-6.60E-05	-0.000136	-0.000117	-0.000123
Standard deviation	0.00708	0.00329	0.00418	0.00345	0.00576
Skewness	1.0950	-0.1803	-0.0468	-0.2968	0.6829
Kurtosis	22.6310	7.2456	4.3432	8.1440	25.2951
Jacque-Bera (p-value)	18,695.80	869.96	86.87	1,284.80	23,907.55
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ARCH(1) p-value	0.0000	0.0000	0.0000	0.0000	0.0000

As can be seen in table 5.3 and table 5.4, summary statistics for all return series in Period 1 and Period 2 show that most of mean returns are negative exception for Indonesia rupiah. The Thai baht has the highest standard deviation in period 1, whereas Indonesia rupiah plays this role in period 2. All currencies display only small variations from zero skewness in both periods of time. In addition, most of them are

negative skewness and thus skew to the left. As is common for financial time series, all currencies exhibit excess kurtosis in both periods of time. The next statistic, Jarque–Bera statistic is used to test whether or not the series resembles normal distribution. With all p-values of each currency equal to zero at four decimal places, it rejects the null hypothesis that these series are well approximated by the normal distribution. Thus, not all of the data sets fit a normal distribution. As can be seen from the summary statistics, all series are found to be leptokurtic (i.e., fat tails) therefore the mean equations in all cases are tested for the existence of autoregressive conditional heteroscedasticity (ARCH), as suggested by Engle (1982: 987-1008).

The last statistic presented is the p-value using to the test for ARCH effects in the error term of the models for the first moment. The statistics indicate that all currencies exhibit ARCH (1) effects in their error terms. For the p-value, it represents the probability that the null hypothesis of no ARCH is falsely rejected with each currency equal to zero at four decimal places as well.

5.3.2 Correlation between currencies

The correlation is one of the most common and useful statistic that describes the degree of relationship between two variables. In this part, I would like to check for the correlation between currencies in five Southeast Asian countries.

Table 5.5 Correlation between Currencies in Period 1

	IDR	MYR	PHP	SGD	THB
IDR	1.0000	-0.5984	-0.3591	-0.7511	0.3173
MYR		1.0000	0.5079	0.8037	0.0778
PHP			1.0000	0.7185	0.2745
SGD				1.0000	0.1239
THB					1.0000

Note: period 1 is pre-crisis in 1997 (1993-1997)

As can be seen from table 5.5, in period 1, correlation statistics present that Singapore dollar, Malaysia ringgit and Philippine peso are high relationship among them. The correlation statistics are higher than 0.5. It means that all of them are likely to move together in the same way. Whereas Thai baht and Indonesia rupiah have small degree of relation to other currencies, the correlation statistic between them is about 0.3. Moreover, Indonesia rupiah has negative correlation to Singapore dollar, Malaysia ringgit and Philippine peso as well.

The movements of exchange rate returns in post-crisis are displayed as following

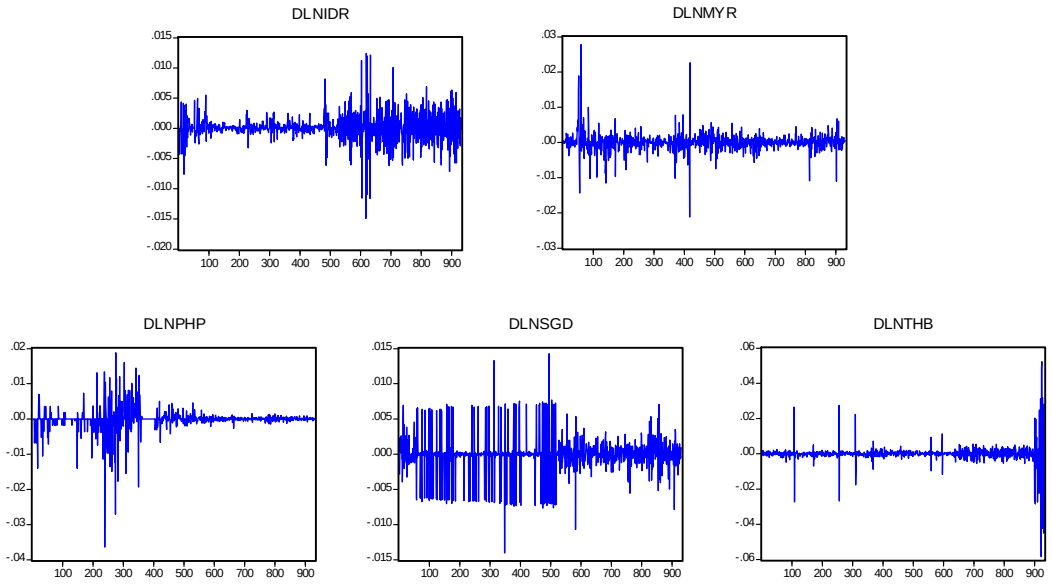


Figure 5.3 The Pre-Crisis Movement of Exchange Rate Returns

For period 2, the post-crisis, the all correlation statistics present positive relationship among them. Especially four of them including Singapore dollar, Malaysia ringgit, Philippine peso and Thai baht are highly related, the correlation statistics are higher than 0.87 (see table 5.6). The movements of them seem to go together. Only Indonesia rupiah has small relationship with others, the correlation statistics less than 0.26. Its movement pattern quite differs from other four currencies. (see figure 5.2)

Table 5.6 Correlation between Currencies in Period 2

	IDR	MYR	PHP	SGD	THB
IDR	1.0000	0.2593	0.1073	0.0446	0.1509
MYR		1.0000	0.9394	0.9255	0.8958
PHP			1.0000	0.9192	0.9397
SGD				1.0000	0.8730
THB					1.0000

Note: period 2 is post-crisis in 1997 (2005-2009)

The movements of exchange rate returns in post-crisis are displayed as following

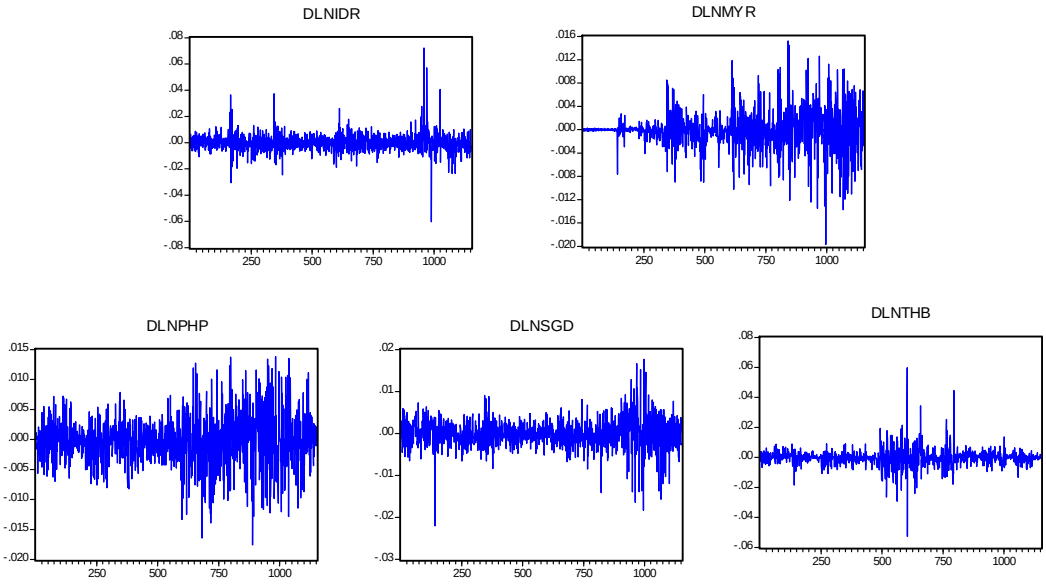


Figure 5.4 The Post-Crisis Movement of Exchange Rate Returns

5.3.3 Unit Root Test

In general, most of time series data are non-stationary. Similar to other time series data, exchange rate also needs to test for stationary to investigate weather a time series variable is non-stationary. This study employs the popular methods,

Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979: 427-431, 1981: 1057–1072) and Phillips-Perron (PP) test (Phillips and Perron 1988: 335-346). Both of them test for the existence of a unit root, if the process has a unit root then it is a non-stationary time series. It means that the movements of stochastic process depend on time trend as well as the variance of the series is diverging to infinity with time trend.

For unit root test, the null hypothesis of the ADF and PP tests is that the variable is non-stationary. The rejection of the null hypothesis implies stationary. Both ADF test and PP test are the methods to determine whether the time series data are consistent with I(1) process with a stochastic trend (non-stationary) or I(0) process, that is stationary.

From the infinite-order autoregressive model,

$$\Delta y_t = \mu + \gamma y_{t-1} + \sum_{i=2}^{\infty} \beta_i \Delta y_{t-i+1} + \varepsilon_t \qquad \text{---(5.9)}$$

Equation (5.9), if $\gamma = 0$, this is entirely in first difference or I(1) process and has a unit root. It means that this time series data is non-stationary at its level. Therefore, I would like to do unit root test these data in order to check for stationary. The results from these time series data are reported in table 5.7 and table 5.8

Table 5.7 ADF and PP Test Statistics in Period 1

Unit Root Test	ADF-test		PP-test	
	No trend	Trend	No trend	Trend
IDR	-0.074453	-3.259380	0.184476	-4.257698*
MYR	-1.682448	-2.302947	-1.674171	-2.315405
PHP	-3.762242*	-2.895560	-3.501818*	-2.702856
SGD	-1.669998	-0.673054	-1.701977	-0.655346
THB	-2.556234	-2.655142	-5.881821*	-6.069913*
Δ IDR	-30.02128*	-30.01106*	-51.62844*	-51.79952*
Δ MYR	-27.81129*	-27.79679*	-27.89612*	-27.88157*
Δ PHP	-15.60488*	-15.93056*	-34.29196*	-34.62673*
Δ SGD	-26.40730*	-26.47748*	-40.68733*	-40.98349*
Δ THB	-6.245235*	-6.252527*	-65.01490*	-61.62998*

Note: * significance at the 5% level

Table 5.8 ADF and PP Test Statistics in Period 2

Unit Root Test	ADF-test		PP-test	
	No trend	Trend	No trend	Trend
IDR	-1.461793	-1.605528	-1.770294	-1.928735
MYR	-1.426161	-1.095021	-1.427398	-1.098546
PHP	-1.612478	-0.633339	-1.613529	-0.621381
SGD	-1.012301	-1.649262	-1.012301	-1.620793
THB	-1.179489	-1.223787	-1.161174	-1.223787
Δ IDR	-37.40543*	-37.38912*	-37.36220*	-37.34864*
Δ MYR	-34.14450*	-34.15456*	-34.14366*	-34.15370*
Δ PHP	-34.51449*	-34.57764*	-34.51447*	-34.57732*
Δ SGD	-33.96620*	-33.95179*	-33.96620*	-33.95179*
Δ THB	-35.53963*	-35.53038*	-35.54165*	-35.53241*

Note: * significance at the 5% level

As can be seen from table 5.7 and table 5.8, ADF and PP test statistics in both period of time present that most of exchange rates are likely non-stationary at their level. The null hypothesis of a unit root cannot be rejected. However, after the data are applied to do first difference, the results show all of variables be achieved stationary or I(1) process.

5.3.4 The Results from Multivariate GARCH Model

In this study, I would like to investigate how a shock to one currency transmits to other currencies in terms of its impact on the model implied volatility of the return on exchange rate (log differenced of exchange rates) for five currencies in Southeast

Asia including Indonesia rupiah, Malaysia ringgit, Philippine peso, Singapore dollar and Thai baht in the system. The results of estimating from the multivariate GARCH model with BEKK parameterization for each variance equation are reported in table 5.9.

Table 5.9 The Results of Estimating from the Multivariate GARCH in Period 1

Independent Variable	$h_{11,t+1}$	$h_{22,t+1}$	$h_{33,t+1}$	$h_{44,t+1}$	$h_{55,t+1}$
$\varepsilon_{1,t}\varepsilon_{2,t}$	0.008830	0.011482	-0.001419	-0.000686	0.000483
$\varepsilon_{1,t}\varepsilon_{3,t}$	0.006626	-0.001891	0.001243	-0.000147	0.003758
$\varepsilon_{1,t}\varepsilon_{4,t}$	-0.011184	0.000542	0.000087	-0.003632	0.002774
$\varepsilon_{1,t}\varepsilon_{5,t}$	0.013898	0.000307	0.001792	-0.002232	0.021913
$\varepsilon_{2,t}\varepsilon_{3,t}$	0.001194	-0.013651	-0.001970	0.000040	0.000461
$\varepsilon_{2,t}\varepsilon_{4,t}$	-0.002015	0.003909	-0.000138	0.000976	0.000340
$\varepsilon_{2,t}\varepsilon_{5,t}$	0.002504	0.002215	-0.002839	0.000600	0.002686
$\varepsilon_{3,t}\varepsilon_{4,t}$	-0.001512	-0.000644	0.000121	0.000209	0.002645
$\varepsilon_{3,t}\varepsilon_{5,t}$	0.001879	-0.000365	0.002488	0.000129	0.020900
$\varepsilon_{4,t}\varepsilon_{5,t}$	-0.003171	0.000104	0.000174	0.003177	0.015424
$\varepsilon^2_{1,t}$	0.024510*	0.000795	0.000448	0.001276	0.001970
$\varepsilon^2_{2,t}$	0.000795	0.041443*	0.001124	0.000092	0.000030
$\varepsilon^2_{3,t}$	0.000448	0.001124	0.000863*	0.000004	0.001792
$\varepsilon^2_{4,t}$	0.001276	0.000092	0.000004	0.002585*	0.000976
$\varepsilon^2_{5,t}$	0.001970	0.000030	0.001792	0.000976	0.060929*
$h_{11,t}$	0.733368*	0.444577	0.753271	0.644104	0.378587
$h_{22,t}$	0.444577	0.552155*	0.736044*	0.781725*	0.379615
$h_{33,t}$	0.753271*	0.736044*	0.945237*	0.959011*	0.429073
$h_{44,t}$	0.644104*	0.781725*	0.959011*	0.894451*	0.570375
$h_{55,t}$	0.378587	0.379615	0.429073	0.570375	0.325942*
$h_{12,t}$	1.141995	0.990909	1.489215*	1.419172*	0.758201
$h_{13,t}$	1.486506*	1.144077	1.687625*	1.571882*	0.806081

Table 5.9 (Continued)

Independent Variable	$h_{11,t+1}$	$h_{22,t+1}$	$h_{33,t+1}$	$h_{44,t+1}$	$h_{55,t+1}$
$h_{14,t}$	1.374577*	1.179045	1.699877*	1.518051*	0.929379
$h_{15,t}$	1.053837	0.821628	1.137029	1.212239	0.702559
$h_{23,t}$	1.157388	1.275006*	1.668216*	1.731684*	0.807175
$h_{24,t}$	1.070241	1.313975*	1.680326*	1.672381*	0.930641
$h_{25,t}$	0.820514	0.915655	1.123952	1.335480	0.703512
$h_{34,t}$	1.393105*	1.517081*	1.904198*	1.852337*	0.989410
$h_{35,t}$	1.068042	1.057191	1.273697	1.479184	0.747938
$h_{45,t}$	0.987622	1.089503	1.282944	1.428527	0.862344

Note: * significance at the 5% level

As can be seen from table 5.9, in the pre-crisis period, the results from BEKK model indicate that there are some statistically significant transmission coefficients at the 5% level. It reveals that Indonesia rupiah receives volatility from its own shock and own variance as well as the variance and covariance from Philippine peso and Singapore dollar. As the same time, it transmits volatility to both Philippine peso and Singapore dollar as well. Similarly, the Malaysia ringgit seems to have the same interaction pattern as Indonesia rupiah. However, the results show no relationship between Indonesia rupiah and Malaysia ringgit during this period. Moreover, it also expresses the closed relationship between Philippine peso and Singapore dollar. The volatilities directly transmit between Philippine peso and Singapore dollar and indirectly transmit through Indonesia rupiah and Malaysia ringgit as well. Only the Thai baht does not transmit volatility directly to any other currency and receive volatility from any others as well. It means that the movement of Thai baht is quite independent from any other currencies during this period.

For period 2, the post-crisis period, the results of estimating from the multivariate GARCH model with BEKK parameterization for each variance equation are reported in Table 5.10.

Table 5.10 The Results of Estimating from the Multivariate GARCH in Period 2

Independent Variable	$h_{11,t+1}$	$h_{22,t+1}$	$h_{33,t+1}$	$h_{44,t+1}$	$h_{55,t+1}$
$\varepsilon_{1,t}\varepsilon_{2,t}$	0.009722*	0.020565*	0.001197*	0.002699	0.001108
$\varepsilon_{1,t}\varepsilon_{3,t}$	0.003025*	0.003848*	0.002865*	0.000438	0.000492
$\varepsilon_{1,t}\varepsilon_{4,t}$	0.003157	0.008312*	0.000420	0.002237	0.001582
$\varepsilon_{1,t}\varepsilon_{5,t}$	0.001930	0.005583*	0.000772	0.002588	0.003533
$\varepsilon_{2,t}\varepsilon_{3,t}$	0.003037*	0.008106*	0.003629*	0.001149	0.001419
$\varepsilon_{2,t}\varepsilon_{4,t}$	0.003170	0.017509*	0.000532	0.005864*	0.004556*
$\varepsilon_{2,t}\varepsilon_{5,t}$	0.001938	0.011759*	0.000978	0.006784*	0.010178*
$\varepsilon_{3,t}\varepsilon_{4,t}$	0.000986	0.003276*	0.001273	0.000952	0.002025
$\varepsilon_{3,t}\varepsilon_{5,t}$	0.000603	0.002200*	0.002340	0.001102	0.004523
$\varepsilon_{4,t}\varepsilon_{5,t}$	0.000629	0.004753*	0.000343	0.005622*	0.014528*
$\varepsilon^2_{1,t}$	0.004840*	0.004882*	0.000472*	0.000515	0.000192
$\varepsilon^2_{2,t}$	0.004882*	0.021660*	0.000758*	0.003538*	0.001596*
$\varepsilon^2_{3,t}$	0.000472*	0.000758*	0.004341*	0.000093	0.000315
$\varepsilon^2_{4,t}$	0.000515	0.003538*	0.000093	0.002429*	0.003252*
$\varepsilon^2_{5,t}$	0.000192	0.001596*	0.000315	0.003252*	0.016225*
$h_{11,t}$	0.846987*	0.830145*	0.925875*	0.857580*	0.678843*
$h_{22,t}$	0.830145*	0.757699*	0.925758*	0.861735*	0.888664*
$h_{33,t}$	0.925875*	0.925758*	0.853730*	0.951089*	0.549529*
$h_{44,t}$	0.857580*	0.861735*	0.951089*	0.883827*	0.854667*
$h_{55,t}$	0.678843*	0.888664*	0.549529*	0.854667*	0.769955*
$h_{12,t}$	1.677048*	1.586190*	1.851633*	1.719310*	1.553400*
$h_{13,t}$	1.771106*	1.753298*	1.778142*	1.806250*	1.221546*
$h_{14,t}$	1.704534*	1.691585*	1.876795*	1.741209*	1.523397*
$h_{15,t}$	1.516537*	1.717813*	1.426597*	1.712244*	1.445930*
$h_{23,t}$	1.753409*	1.675047*	1.778029*	1.810621*	1.397636*
$h_{24,t}$	1.687502*	1.616089*	1.876676*	1.745423*	1.743000*
$h_{25,t}$	1.501383*	1.641146*	1.426507*	1.716388*	1.654366*

Table 5.10 (Continued)

Independent Variable	$h_{11,t+1}$	$h_{22,t+1}$	$h_{33,t+1}$	$h_{44,t+1}$	$h_{55,t+1}$
$h_{34,t}$	1.782147*	1.786346*	1.802191*	1.833683*	1.370641*
$h_{35,t}$	1.585589*	1.814043*	1.369889*	1.803180*	1.300942*
$h_{45,t}$	1.525990*	1.750193*	1.445892*	1.738250*	1.622412*

Note: * significance at the 5% level

As can be seen from table 5.10, during the post-crisis period, there are interactions between the variables' second moments. The results reveal some evidence of direct and indirect volatility transmission across the currencies in Southeast Asian countries. The volatility generates from both its own markets and cross-markets as well. Indonesia rupiah receives volatility from its own shock together with Malaysia ringgit and Philippine peso and transmits volatility to these currencies. As the same time, Malaysia ringgit seems to have the same interaction pattern as Indonesia rupiah. In addition, it seems to be sensitive in the sense that it receives volatility from all of these currencies. Singapore dollar and Thai baht are closed relationship and transmitted shock and volatility to each other. Furthermore, shocks from Malaysia ringgit are also transmitted to both of them. However, most of the cross-currency interactions represented by covariance between pair of currencies seem to stem from the co-movements of exchange rates over time.

In summary, the results show significant volatility transmissions between second moments of these five currencies in both periods of time. Especially during the post-crisis period, there was higher degree of volatility transmissions than the previous one. After the financial Asian crisis in 1997, most of exchange rates in Southeast Asian countries are more volatile from the switching to floating exchange regimes. Thus, shock as well as conditional variance and covariance from one currency can be rapidly transmitted to others during this period.

5.3.5 Impulse Response Analysis

The impulse response analysis is one of the popular methodologies to examine the dynamic response of one variable to shocks. The impulse response function is able to trace the effect of a one time shock on current and future values of the endogenous variables. In general, a shock to one currency is transmitted to other currencies (Kearney and Patton, 2000: 29-30; Nikkinen et al., 2006: 87). This study also employs the impulse response function to assess the variety and length of each currency's response by mean of the dynamic structure of the Vector Autoregressive (VAR) that is widely used in analysis of the effects of structural shocks.

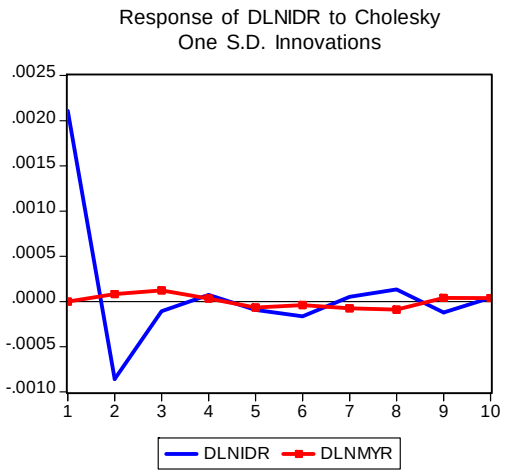
This study designs to investigate the impulse response of each pair of currencies or bi-variate analysis in order to illustrate the dynamic impact of shock from one currency to another one. However, the estimation of a VAR model firstly requires the explicit choice of lag length in the model. The appropriate lag lengths of the VAR for each pair of currencies of the selected Southeast Asian countries are determined by using standard model selection criteria of Akaike Information Criterion (AIC), Akaike (1973: 267-281) and they are presented in table 5.11

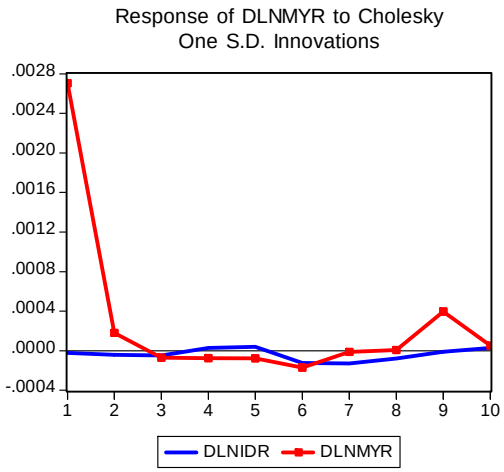
Table 5.11 Lag Length of Each Pair Currencies in Period 1

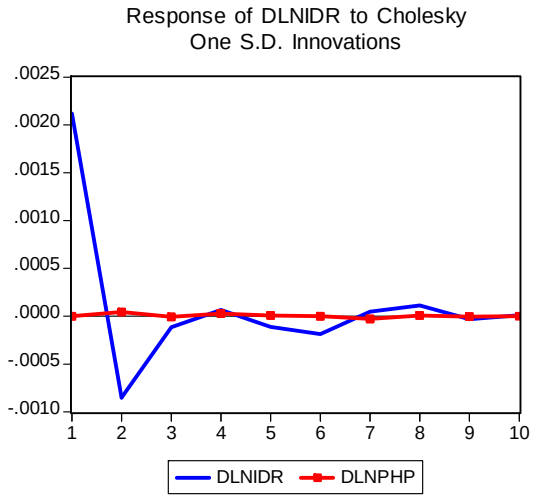
Lag length	MYR	PHP	SGD	THB
IDR	8	6	2	8
MYR		8	3	8
PHP			5	8
SGD				8

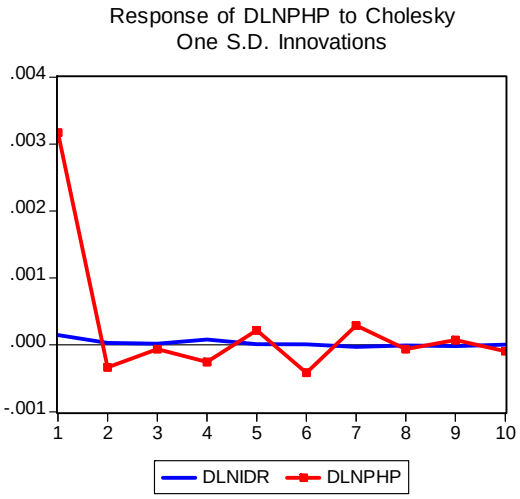
As can be seen from table 5.11, the appropriate lag lengths are between 2-8 lags in period 1. This pre-crisis period, most of these countries adopted fixed exchange rate regime, therefore exchange rate seemed to be stable representing with long lag lengths. Only Singapore employed floating exchange rate regime, its lag lengths were likely shorter than any other countries.

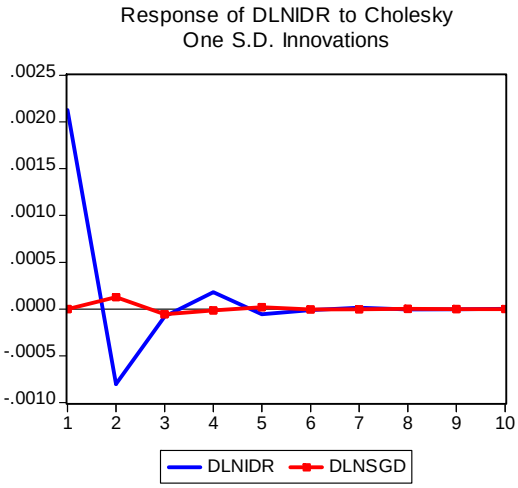
To illustrate the dynamic of VAR (Vector Autoregressive), this study computes the simulated response of the one currency to another currency by using impulse response analysis. The results are presented as following:










Response of DLNIDR to Cholesky
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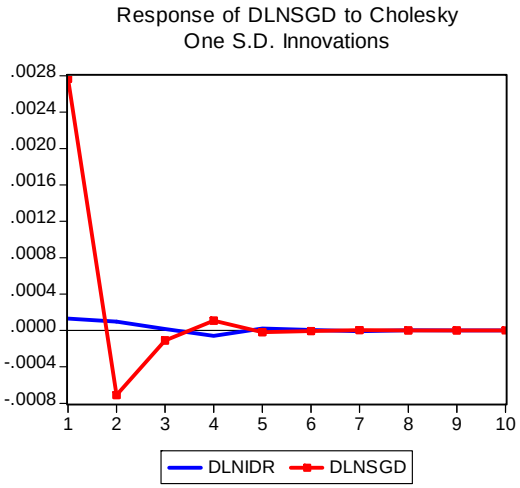
Response of DLNSGD to Cholesky
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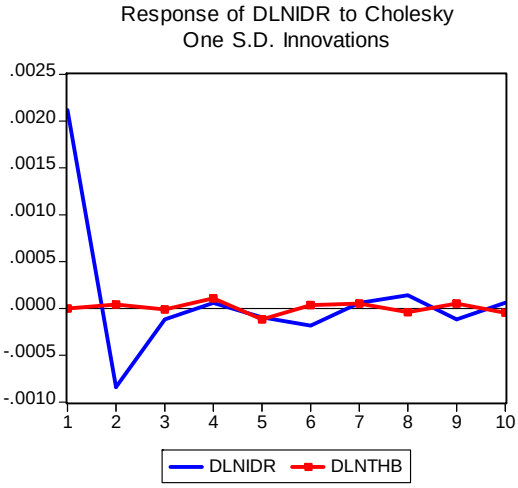
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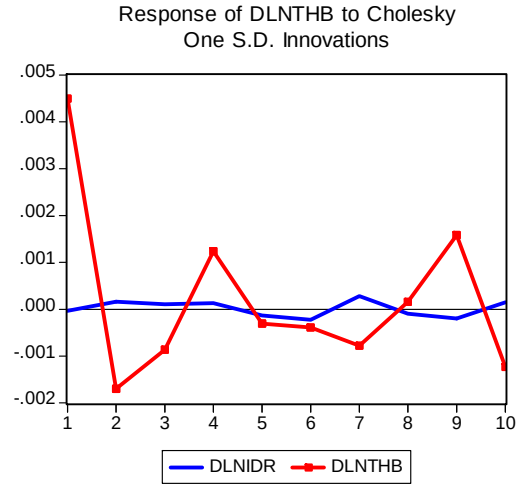
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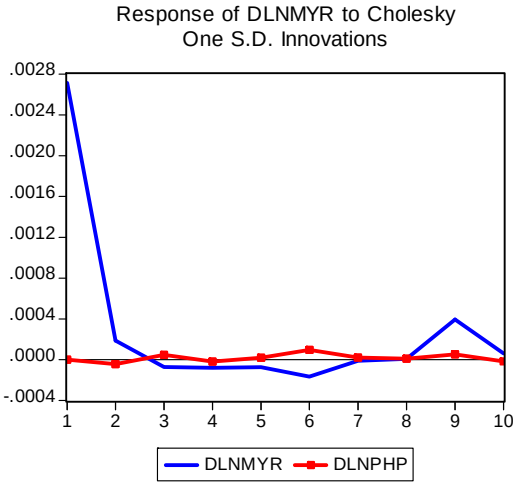
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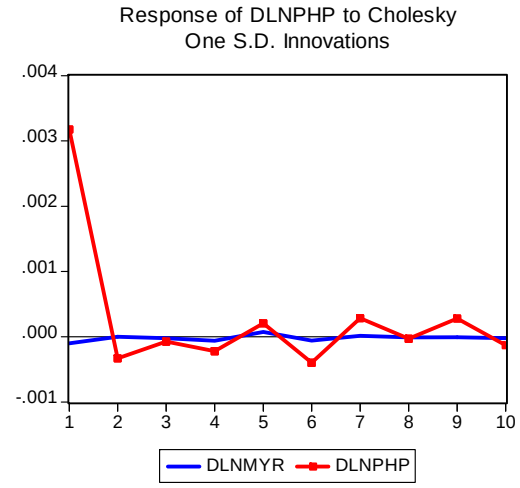
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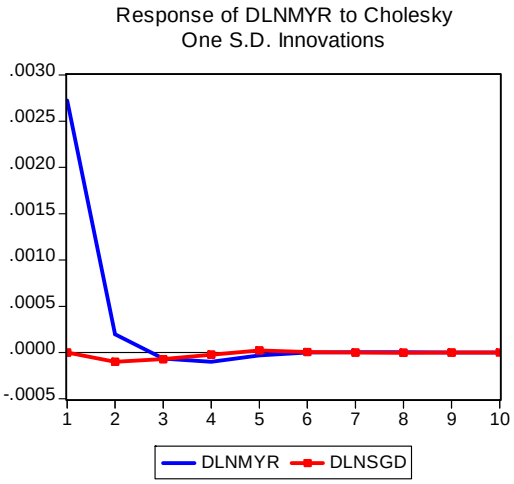
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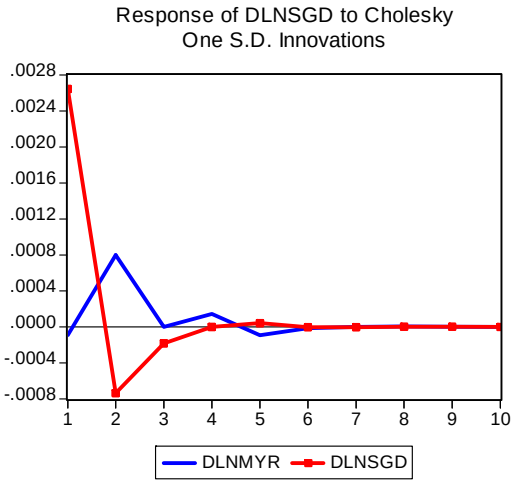
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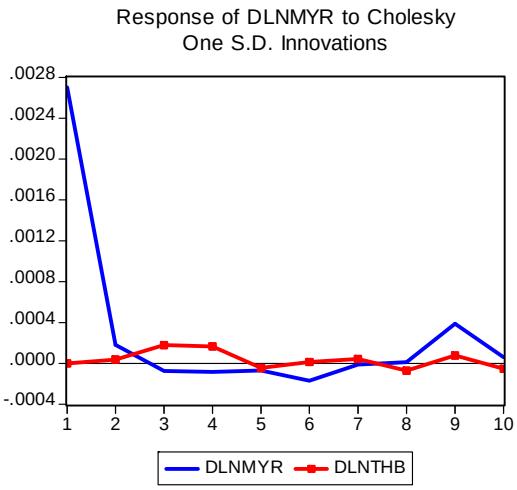
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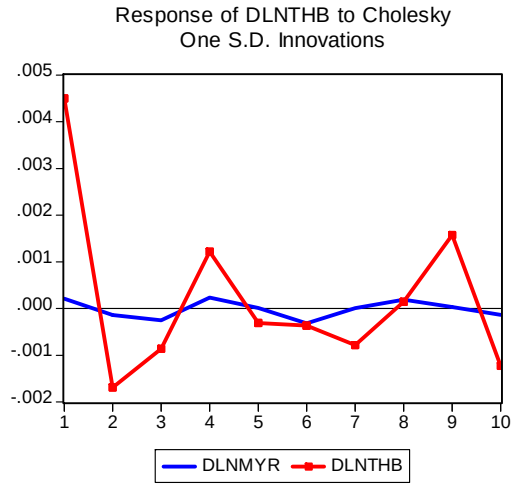
Response of DLNTHB to Cholesky
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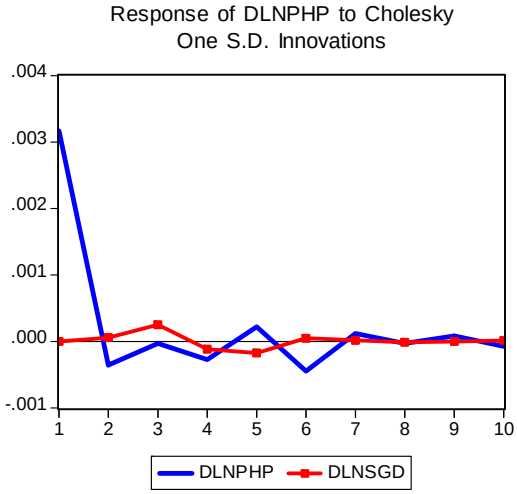
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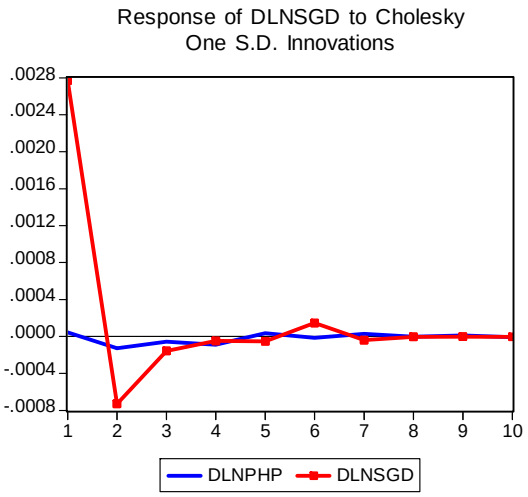
Response of DLNSGD to Cholesky
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DLNPHP DLNSGD

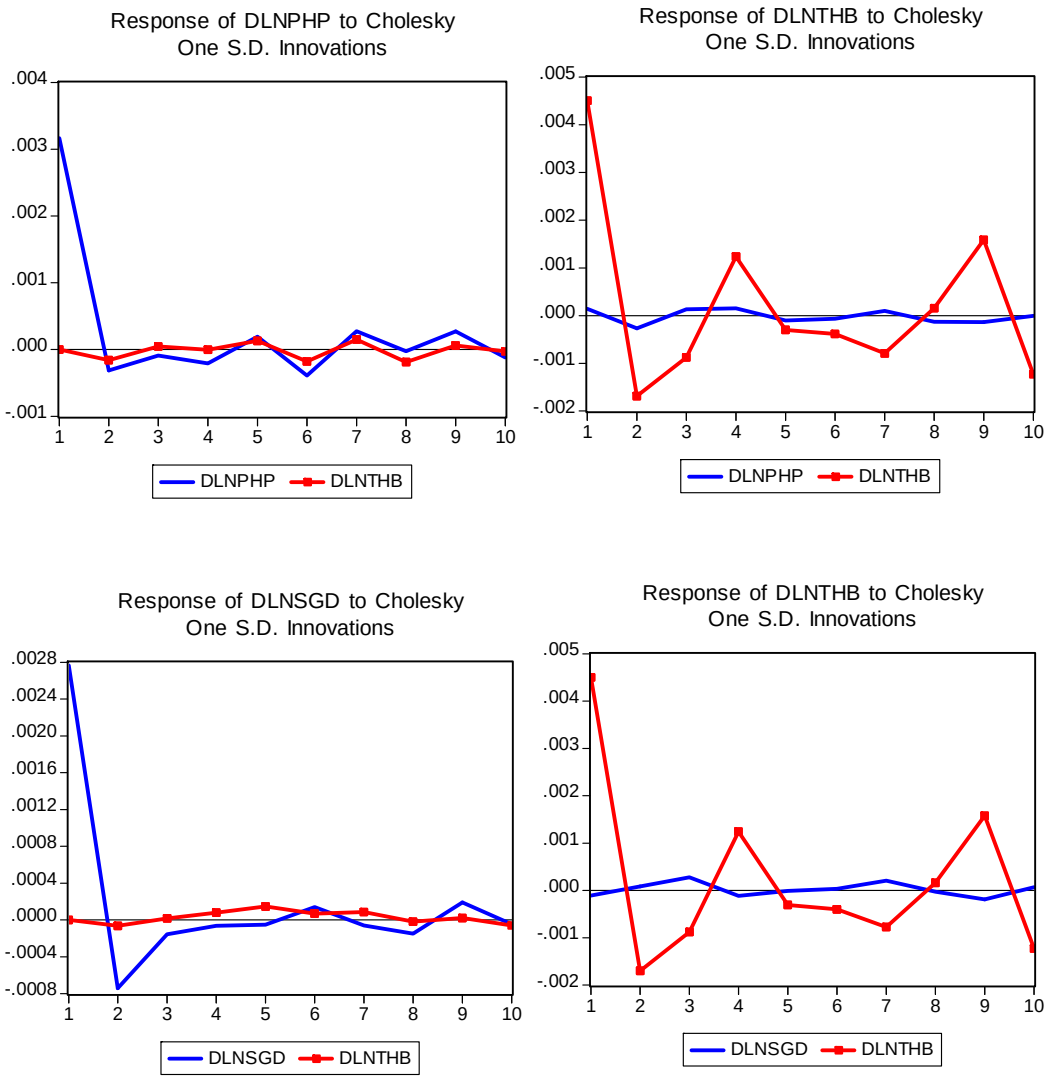


Figure 5.5 Impulse Response of Each Pair Currencies in Period 1

As can be seen from figure 5.5, the results show the response of return on one currency to the return on another currency. Most of them probably respond to contemporaneous change from another currency and return to equilibrium within 3-4 days. In other word, shocks arise in one currency affecting to another currency and appear to have diminished over time. Exception is Thai baht which seems to be more volatile from the impacts of another currency and persistent for a long time. It implies that its economic fundamentals and exchange rates are sensitive to shock and less stable during this period of time.

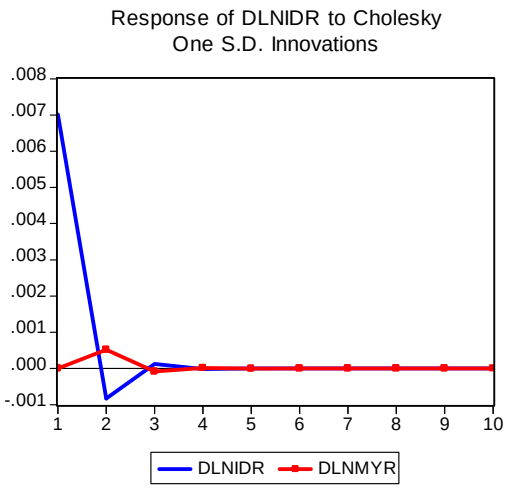
For period 2, similar to the previous one, the important step of empirical research based on the vector autoregressive (VAR) model is the choice of the lag order because all inference in the VAR model depends upon the correct model specification. In this study, the optimal lag lengths are determined by using standard model selection criteria of Akaike Information Criterion (AIC), Akaike (1973: 267-281). The appropriate lag lengths of VAR for each pair of currencies of the selected Southeast Asian countries are as following:

Table 5.12 Lag Length of Each Pair Currencies in Period 2

Lag length	MYR	PHP	SGD	THB
IDR	1	1	7	1
MYR		1	7	1
PHP			4	2
SGD				2

In the post-crisis period, the appropriated lag lengths are between 1-7 lags. Most of them display only 1-2 lag lengths. This particular reason may come from the switching toward the greater floating exchange rate regime of these countries. The movements of these currencies could be adjusted in short period. Except that the Singapore dollar has the longer lags than the pre-crisis period. It is probably more stable and persistent (see table 5.4, low standard deviation).

The results of estimating from impulse response analysis that shows the response of the one currency to another currency shock are presented as following:


Response of DLNIDR to Cholesky
One S.D. Innovations
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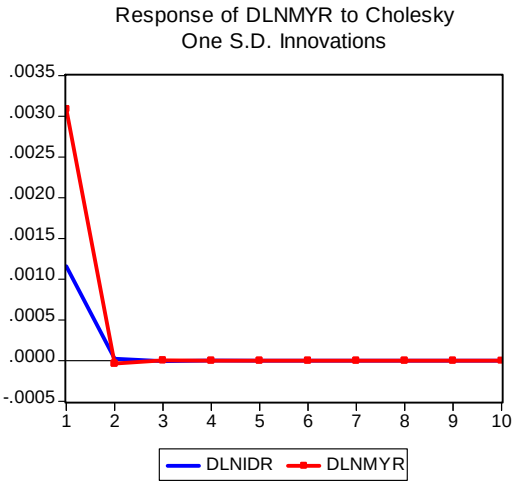
DLNIDR
DLNMYR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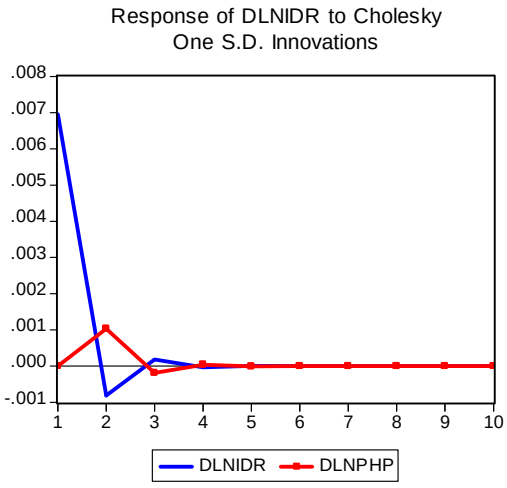
DLNIDR
DLNMYR


Response of DLNIDR to Cholesky
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DLNIDR
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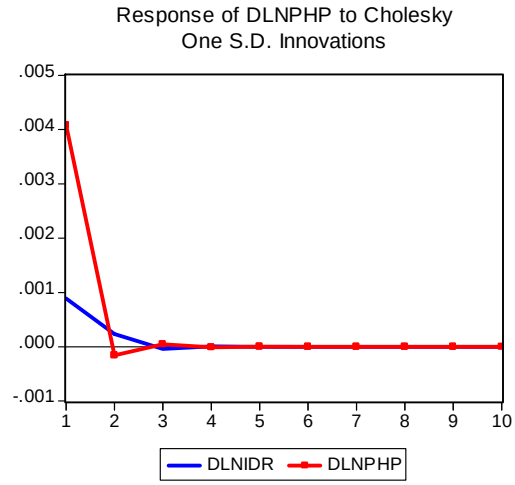
Response of DLNPHP to Cholesky
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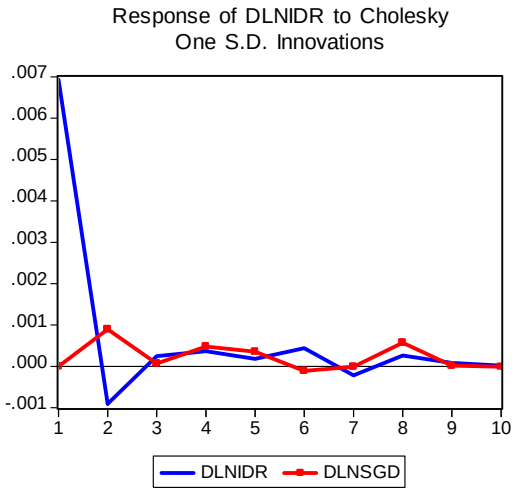
DLNIDR
DLNPHP


Response of DLNIDR to Cholesky
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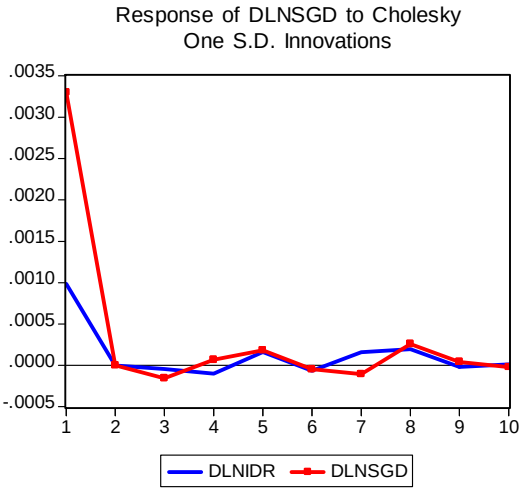
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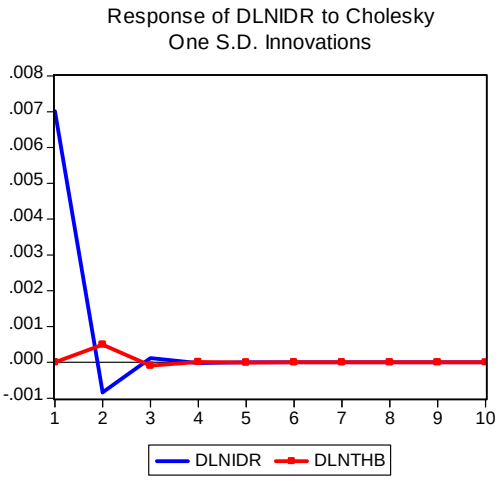
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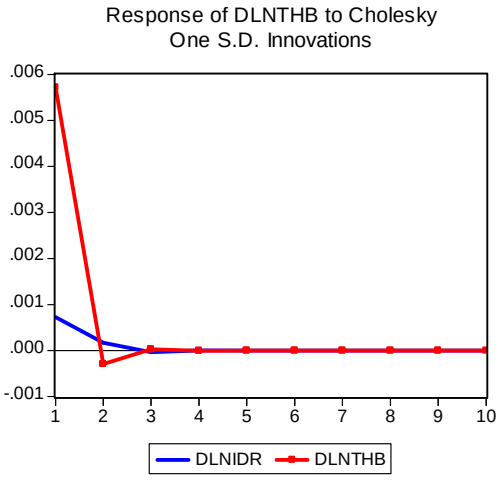
DLNIDR DLNTHB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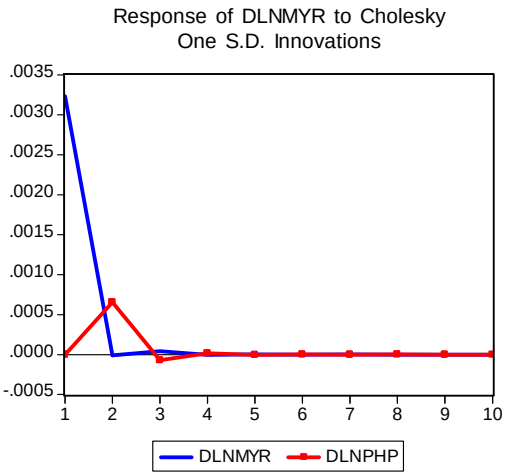
DLNIDR DLNTHB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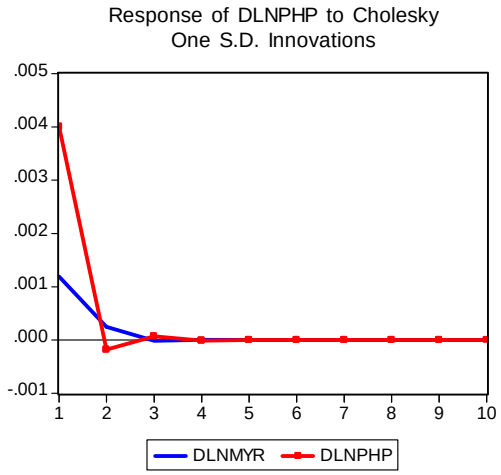
DLNMYR DLNPHP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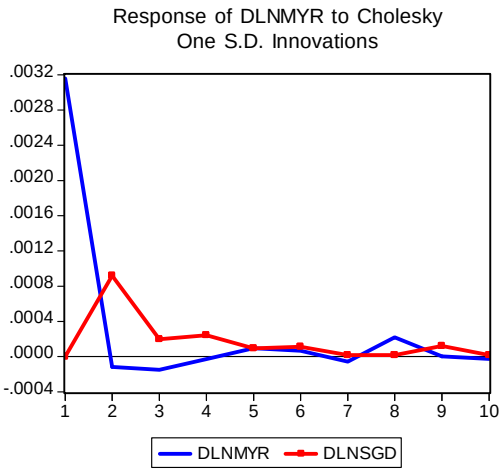
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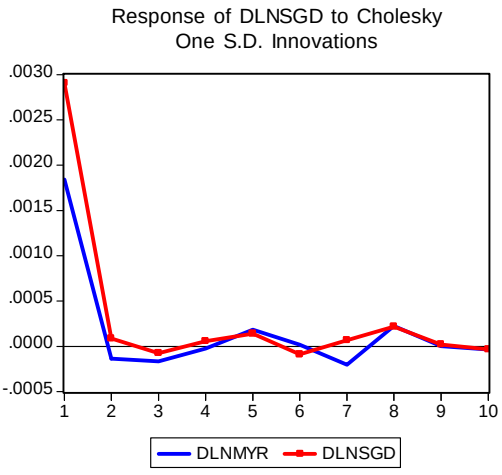
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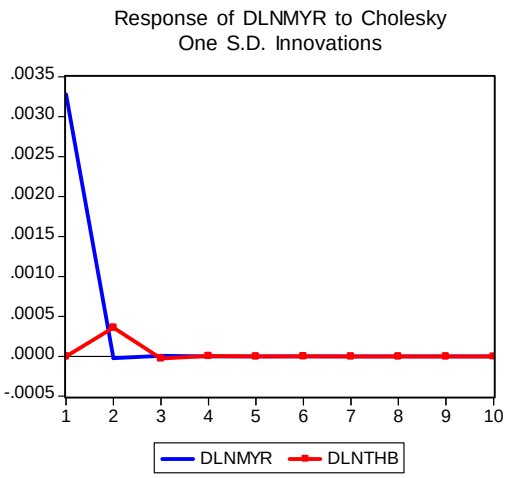
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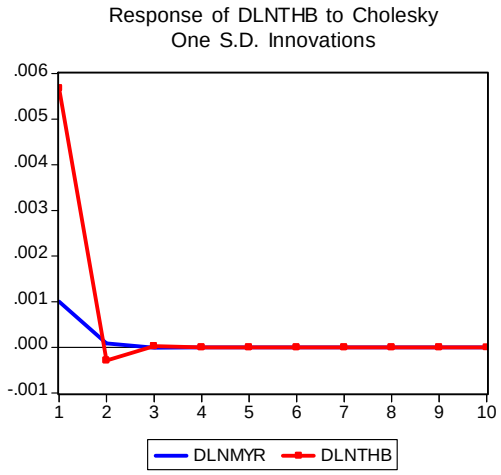
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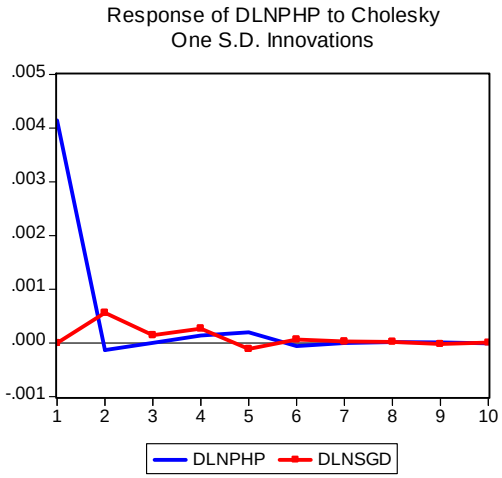
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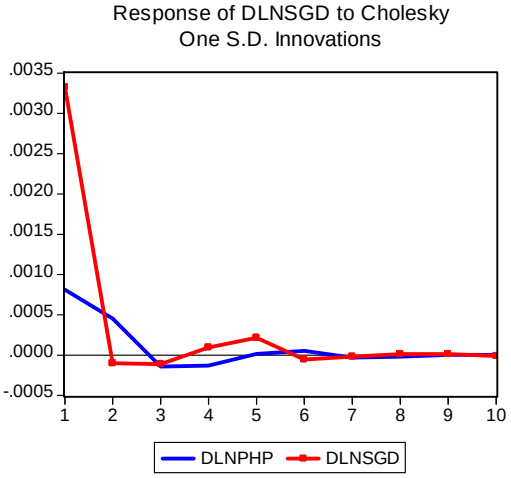
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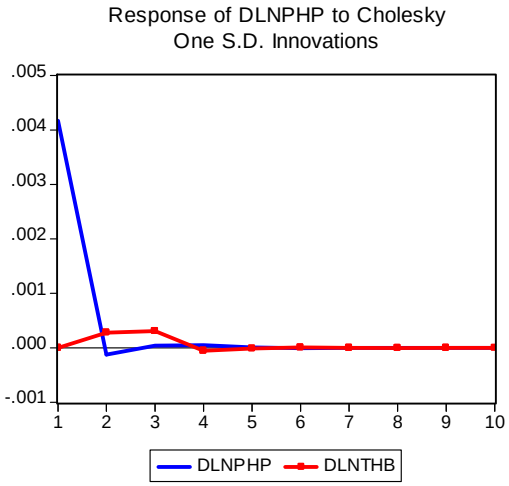
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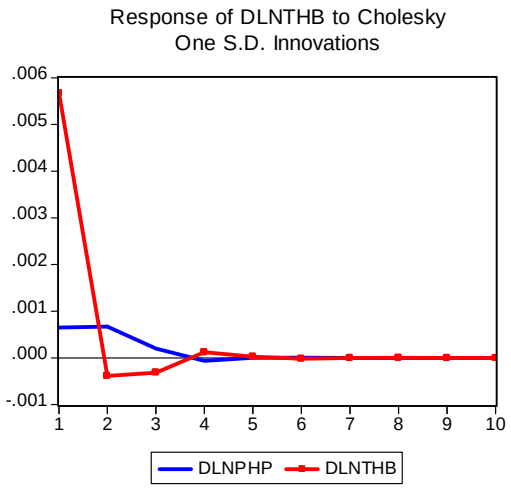
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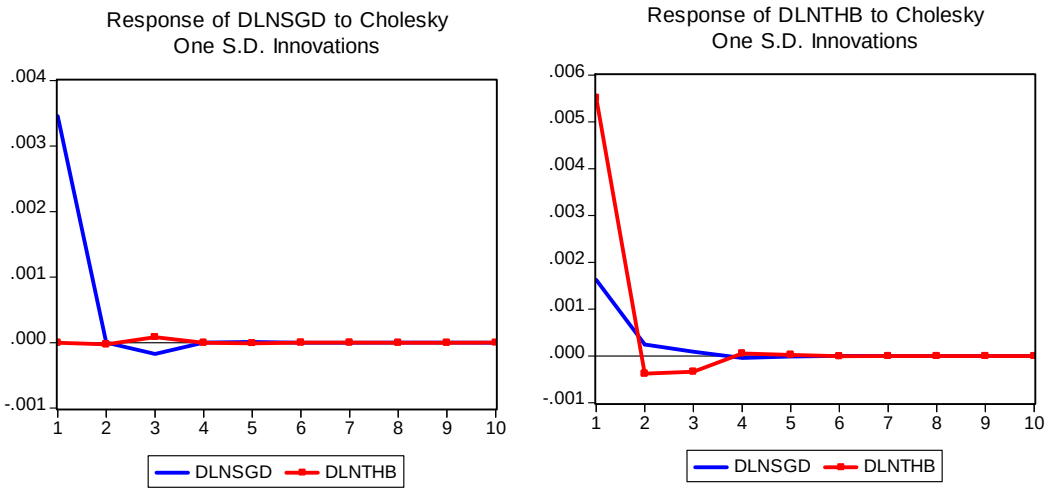

Figure 5.6 Impulse Response of Each Pair Currencies in Period 2

As can be seen from figure 5.6, the impacts of shocks between these currencies are not very high during the post-crisis period and most of them cancel out after 2-4 days. Since the movements of these currencies are more flexible to adjust base on the floating exchange rate system. The Singapore dollar seems to take longer time to return equilibrium than any other currencies.

In sum, the results suggest that the magnitude and persistence of the innovating originating in one currency's return and have an impact on subsequent return of another currency in both period of time. However, in the post-crisis period, the response of one currency to another currency is quite smaller than during the previous one since floating exchange rates automatically adjust and enable a country to resist the impact of shocks. In addition, the impacts can be canceled out in short period.

5.3.6 Causality Test

Causality test, first introduce by Clive Granger (1969: 424-438), is a technique for determining whether one variable is useful in forecasting another. It explains cause and effect between two variables or pairwise analysis. The outstanding of the Granger causality test has been carried out to create the direction of causality of the linkage between variables. It is based on the regression of each volatility proxy on its lagged values and on the lagged values of all the other variables. In this part of the

present study, I would like to investigate the cause and effect between currencies in five Southeast Asian countries during pre and post Asian financial crisis in 1997. This test provides four possible outcomes including X causes Y only, Y causes X only, bi-directional causality and no causality. Base on the Granger Causality Model procedure, five exchange rate time series are tested.

This study also applies the Granger causality with vector autoregressive (VAR). Hence it can represent a causal chain model that takes account of the prior information concerning the ordering of the variables and non-sensitive to normal distribution of error term (Hacker and Hatemi, 2006: 1490-1498). This is useful in financial economic since many financial variables are likely non-normality including exchange rate in this study.

The Granger causality test estimates the results of two regressions as expressing in equation (9) and (10) (see Granger, C.W.J., 1969: 424-426)

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{P} \alpha_i \Delta Y_{t-i} + \sum_{i=1}^{P} \beta_i \Delta X_{t-i} + e_t \quad \text{-----(5.10)}$$

(X_t causes Y_t if β_i is not equal to zero)

$$\Delta X_t = a_0 + \sum_{i=1}^{P} a_i \Delta Y_{t-i} + \sum_{i=1}^{P} \gamma_i \Delta X_{t-i} + u_t \quad \text{-----(5.11)}$$

(Y_t causes X_t if a_i is not equal to zero)

If the χ-squared statistic is above critical value for the χ-squared distribution, then we reject the null hypothesis that X does not Granger cause Y (equation 5.10), meaning that X Granger causes Y. Similar to equation (5.10), we reject the null hypothesis that Y does not Granger cause X in equation (5.11), if the χ-squared statistic is above critical value for the χ-squared distribution as well. The results of causality analysis in the pre-crisis (period 1) are reported as following:

Table 5.13 Exchange Rate Causality Test in Period 1

Variable	Relationship	χ-squared	P-value
Δ MYR and Δ SGD	Δ MYR ⟶ Δ SGD	90.15984	0.0000*
The rests	no causality		

Note: A ⟶ B denotes causality running from variable A to variable B
* significance at the 5% level

Figure 5.7 Causality of Currencies in Period 1

As can be seen from table 5.13 and figure 5.7, the empirical results from this study reveal that there is only one relationship between Malaysia ringgit and Singapore dollar with high significance. The Malaysia ringgit indeed leads the change in Singapore dollar. For the rests, there is no causality between these currencies during the pre-crisis period. This result supports the empirical fact that exception of Singapore employing managed float, most of these countries adopt fixed exchange rate regime during this period of time. Exchange rates are likely stable. Thus, the movement of exchange rates seems to be independent and depended upon government policy of each country. Similar to m-GARCH results reveal that there is little linkage among these currencies in this period. For Singapore, the economic fundamental had high related to Malaysia because Malaysia was Singapore's main import sources especially natural resources and raw goods as well as its largest export market.

The results of causality analysis in the post-crisis (period 2) are reported as following:

Table 5.14 Exchange Rate Causality Test in Period 2

Variable	Relationship			χ-squared	P-value
Δ IDR and Δ PHP	Δ PHP	→	Δ IDR	18.40582	0.0000*
Δ IDR and Δ SGD	Δ SGD	→	Δ IDR	7.74726	0.0054*
Δ MYR and Δ PHP	Δ PHP	→	Δ MYR	40.12989	0.0000*
Δ MYR and Δ SGD	Δ SGD	→	Δ MYR	64.46693	0.0000*
	Δ MYR	→	Δ SGD	5.89889	0.0152*
Δ PHP and Δ SGD	Δ SGD	→	Δ PHP	9.06482	0.0026*
	Δ PHP	→	Δ SGD	25.09588	0.0000*
Δ PHP and Δ THB	Δ PHP	→	Δ THB	13.84007	0.0002*
The rests	no causality				

Note: A → B denotes causality running from variable A to variable B

* significance at the 5% level

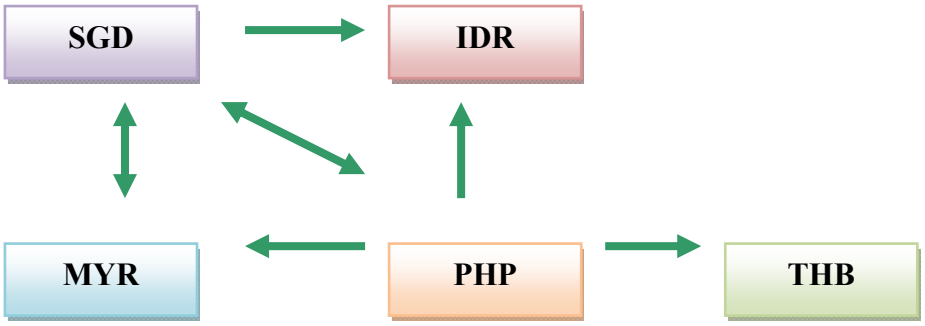

Figure 5.8 Causality of Currencies in Period 2

As can be seen from figure 5.8, the post-crisis (period 2), results from causality analysis show the various linkages between currencies in five Southeast Asian countries. Singapore dollar and Philippine peso play the important role to determine the movements of other currencies such as Indonesia rupiah and Malaysia ringgit. In addition, there are bi-directional causalities between Singapore dollar and

Philippine peso as well as Singapore dollar and Malaysia ringgit. It means that there are strong impacts as interaction ways between them. For Indonesia rupiah, it absorbs impacts from both Singapore dollar and Philippine peso. As the same time, the changing in Philippine peso also affects on Thai baht.

The relationships among currencies in five Southeast Asian countries during post-crisis period are likely more complicated than the pre-crisis period. The changing in one currency influence to others, especially Singapore dollar and Philippine peso play the central role to determine other currencies. Consistence with the studies of Ghosh et al., (2002) and MacDonald (2007) indicated that there exists higher nominal exchange rate volatility in the countries that adopt floating exchange rate regime than fixed exchange rate regime. However, Ghosh et al., (2002) explained that "Under floating exchange rate, there may be significant *noise* (short-term movements that are rapidly reversed). As the horizon lengthens, such temporary movements would cancel out, leading to a decrease in measured volatility. Conversely, nominal exchange rates under pegged regimes may indeed display zero variability (against the reference currency) in the short run. As the horizon lengthens, however, there is a greater likelihood of a change in parity- a devaluation or a revaluation-which may imply very significant movements of nominal exchange rate".

5.4 Conclusion

This study aims to examine the transmission of volatility and shocks among exchange rates of five Southeast Asian countries, namely Indonesia, Malaysia, Philippine, Singapore and Thailand by mean of multivariate GARCH model. The results of this model support to the hypothesis that co-movements of exchange rate in this region can explain the rapid transmission. There are some evidences for direct and indirect volatility transmission across the currencies under this study. The volatility generates from both its own markets and cross-markets as well. Especially, it has higher degree of volatility transmissions in the post-crisis period than the previous one. As a result, most of the cross-currency interactions seem to stem from the co-movements of exchange rates over time.

However, it would be useful to compare the multivariate GARCH results to other methodologies in order to examine other point of views in this study. The alternative tools that are employed to investigate the exchange rate volatility transmission are Impulse response analysis and Granger causality test. For Impulse response analysis, another methodology to evaluate the dynamic impact of shocks on volatility is to investigate the response of one currency to another currency shock in this study. The results of estimating from impulse response analysis show that most of them are probably respond to contemporaneous change from another currency in both period of time. An exception for Thai baht, its movement is not influenced by any other currencies during the pre-crisis period. However, in the post-crisis period, the response of one currency to another currency seems to be smaller than the previous one. Hence most of these countries adopt floating exchange rate regime that automatically adjust, they enables a country to resist the impact of shocks.

Consistent with the multivariate GARCH model and Impulse response analysis, Granger causality analysis show the statistic significant of the cause and effect between currencies in five Southeast Asian countries. In the pre-crisis period, the movements of them are probably independent. There is only one relationship between Malaysia ringgit and Singapore dollar. However, after the financial Asian crisis in 1977, the results from causality analysis show the various linkages between currencies in this region. Singapore dollar and Philippine peso play the important role to determine the movements of other currencies. Overall, there are strong impacts as interaction ways between them.

In conclusion, all of methodology in this study including multivariate GARCH model, Impulse response analysis and Granger causality analysis are probably show the transmission of volatility and shocks in the same way. There are transmissions of volatility and shocks among exchange rates of five Southeast Asian countries especially in the post-crisis period.

CHAPTER 6

CONCLUSIONS AND POLICY IMPLICATION

6.1 Conclusions

The exchange rate is one of the key macroeconomic variables that influent to decision making of agents and economic activities including consumption, investment, terms of trade and government policy. As such, attention has been focused on characterizing its behavior. This study has examined, exchange rate behavior specially sources of exchange rate fluctuations and exchange rate volatility transmission among five Southeast Asian countries Indonesia, Malaysia, Philippine, Singapore and Thailand.

This study consists of two main empirical parts.

6.1.1 Sources of Exchange Rate Fluctuations

For sources of exchange rate fluctuations, I examine the pass-through effects of key macroeconomic variables on the exchange rate in five selected countries by using a Vector Autoregressive (VAR) analysis. The macroeconomic variables used in this study are exchange rate, GDP, CPI, money supply, and oil price from the period of 1993-Q1 through 2008-Q4. Based on the VAR analysis with the application of cointegration test, vector error correction model (VECM), impulse response analysis, and variance decomposition, the results suggest that all of the selected key macroeconomic variables including CPI, GDP, money supply and oil price are the major sources of exchange rate fluctuations for the application of impulse response analysis and variance decomposition. The Singapore dollar has the lowest impact from other macroeconomic variables, returning to equilibrium in short period of time whereas Indonesia rupiah and Philippine peso are likely more volatile from the impact of key macroeconomic variable shocks and they take longer time to return equilibrium than others.

With regard to the variance decomposition, we can also analyze the response of variables from shocks that quantify what percentage of total variance is explained by each macroeconomic variable. The results reveal that for all countries the largest share of shock to exchange rate come from internal shocks. In addition, CPI and oil price shocks seem to be the main cause to enforce exchange rate volatility. However, the shock from money market (i.e. the money supply shock) has a strong influence on exchange rate volatility in the case of the Indonesia rupiah and the Thai baht. Similar to impulse response analysis, the results indicates that Singapore has the most exchange rate stability. It can tolerate key macroeconomic variable shocks whereas Indonesia shows most instability in exchange rate movement compared to other countries in this region. In the case of Indonesia, all macroeconomic shocks influence to exchange rate fluctuations to a higher level than the other countries. The overall results from variance decomposition can be expressed as table 6.1

Table 6.1 Comparison the Impact of Key Macroeconomic Variables to Exchange Rate Fluctuations (at the 10^{th} Quarter Period)

(%)

Country	DLNCPI	DLNEX	DLNGDP	DLNMS	DLNOP
Indonesia	9.8	31.0	13.5	11.9	**33.8**
Malaysia	2.0	85.4	3.6	1.8	**7.2**
Philippine	3.4	82.3	1.8	4.1	**8.4**
Singapore	**5.9**	88.0	0.5	0.2	**5.3**
Thailand	**11.8**	73.4	3.5	**6.8**	4.4

In summary, results of applications from VAR including cointegration test, vector error correction model (VECM), impulse response analysis, and variance decomposition, provide economically reasonable and statistically significant coefficients that macroeconomic variables are the particular sources of exchange rate fluctuations. This is consistent with the studies of Sarno and Taylor, 2002: 264, Berument and Pasaogullari, 2003: 406 and Kanin and Rogers 1997: 25-26. The major finding implies that changes in key macroeconomic variables are likely to be accompanied by exchange rate fluctuations.

6.1.2 Volatility Transmission of Exchange Rate among Southeast Asian Countries

This study examined the transmission of volatility and shocks among exchange rates of the five Southeast Asian countries. It investigated how volatility of each currency was affected by other currencies as well as comparing the temporal behavior of volatility transmission for pre and post crisis periods with various methodologies. These included multivariate GARCH model, correlation between currency return, impulse response analysis, and Granger causality test. The data used in this study consisted of time series of daily exchange rate in terms of local currency against the US dollar from January 1993 through June 1997 for the pre-crisis period (Period 1) compared to January 2005 to July 2009 for the post-crisis period (Period 2).

The results of correlation among these currencies show positive relationship excluding Indonesia rupiah, which shows some negative correlation to Malaysia ringgit, Philippine peso and Singapore dollar in the pre-crisis period. Moreover, Thai baht and Indonesia rupiah have only a small degree of relation to other currencies as well. For the post-crisis period, all correlation statistics present positive relationships. The movements of these currencies seem to go together, but again the Indonesia rupiah has small relationship with others.

The results of estimating from multivariate GARCH model with BEKK parameterization show the significant interaction between second moments of these currencies especially in the post-crisis period. For the pre-crisis period, not surprisingly, most of them receives volatility from its own shock and own variance as well as the variance and covariance from each other. Furthermore, the results indicate that Philippine peso and Singapore dollar have the closed relationship. Only the Thai baht does not transmit volatility directly to any other currency or receive volatility from any others as well. It means that the movement of the Thai baht was likely independent from any other currencies during this period. However, the post-crisis period, exchange rates were more volatile and had a higher degree of volatility transmissions than during the previous one. All of them seem to be sensitive in the sense that they open to receive volatility from each other. In addition, the Singapore dollar and Thai baht are closed relationship and transmitted shock and volatility to

each other as well. However, most of the cross-currency interactions represented by covariance between pair of currencies seem to stem from the co-movements of exchange rates over time.

The impulse response analysis from bi-variate VAR models, show that most currencies are likely to respond to contemporaneous change from another currency and return to equilibrium within 3-4 days in the pre-crisis period. In other word, shocks arising in one currency affected to another currency and then appear to have diminished over time. Only the Thai baht seems to be more volatile from the impacts of another currency and persistent for a long time. It implies that Thai economic fundamentals and exchange rate are sensitive to shock from other currencies in this region and less stable than any others during this period of time. However, the post-crisis period, the impacts of shocks between these currencies are not very high and most of them cancel out after 2-4 days. One particular reason is that these currencies were more flexible under the floating exchange rate system. In conclusion, in the post-crisis period, the response of one currency to another currency quite smaller than the previous one since floating exchange rate regime automatically adjust and enables to resist the impact of shocks. In addition, the impacts can be canceled out in short period.

Using the Granger causality test in the pre-crisis period, the empirical results reveal that the movements of five currencies examined quite be independent. There is only one relationship between the Malaysia ringgit and Singapore dollar with a high level significance. The Malaysia ringgit indeed leads the change in the Singapore dollar. For the rests, there is no causality between these currencies during this period. One particular reason is that most of them adopted fixed exchange rate regime generated the stability of exchange rates. The movement of exchange rate seems to be independent and depended upon government policy of each country. Conversely, in the post-crisis period, the relationships between these currencies are probably more complicated than in the previous one. The results from causality analysis show the various linkages between currencies in five Southeast Asian countries especially the Singapore dollar and Philippine peso play an important role determining the movements of other currencies.

In summary, the overall findings reveal that key macroeconomic variables seem to be the particular sources of exchange rate fluctuations, especially inflation and oil prices. In other words, changes in key macroeconomic variables are probably accompanied by exchange rate fluctuations, which are consistent with the study by Sarno and Taylor, 2002: 264 and Ito and Sato, 2006: 2.

Another topic of this study, exchange rate volatility transmission among five Southeast Asian countries, the results show that there are high positive correlations between currencies and the significant interaction between second moments of these currencies in this region especially in the post-crisis period after adopting of more flexible exchange rate regime. In addition, the impacts of shocks between these currencies are not very high in the post-crisis period as well, due to automatic adjustment of exchange rate from more flexible rates.

Lastly, about the results of the Granger causality test show that the relationships between these five currencies are probably more complicated in the post-crisis period. When there are the various linkages between currencies in this region. The Singapore dollar and Philippine peso play a central role in determining the movements of other currencies.

6.2 Policy Implication

The finding from this study reveals that key macroeconomic factors are particular sources of exchange rate fluctuations in these countries. In other word, changes in economic fundamentals affect fluctuations of exchange rate. In addition, exchange rate volatility probably results in a higher degree of transmission among these currencies after the financial Asian crisis in 1997. One particular reason comes from structural change. Most of these countries adopted more flexible exchange rates that allowed exchange rates in line with demand and supply in the market. Therefore, exchange rate seems to have high volatility and transmit vitality to each other. In addition, the increases in exchange rate volatility probably arose from the increase of capital flow between these countries and a more volatile economic environments, characterized by more violent economic shocks including crises, persistence, and contagion. (Karras et al., 2005: 224)

To achieve a financial stability, it is important for economists and policy makers to understand factors affecting the exchange rates from its fundamental values as well as how shocks affect exchange rates and are transmitted to other currencies in this region. It means that policy makers are able to take care of exchange rate fluctuations by mean of controlling these key macroeconomic factors and provide the right incentives for the markets to develop their ability to cope with changing circumstances. In my view, for small open economies like the five Southeast Asian countries in this study, government policies should be able to moderate exchange rate fluctuations. This is supported by the recent econometric research work of the Monetary Authority of Singapore, showing that exchange rate policy frameworks may have helped to soften the negative spillover effects from high volatility in international financial market (Supaat et al., 2003: 23). Furthermore, Khor et al. (2004: 20-21) argued that the success of the Singapore exchange rate regime reflected the strong institutional setup, which included credible price stability, fiscal discipline, considerable openness and transparency and well-developed capital markets. As they note, “increasingly, the key issues facing policymakers lie not in the particular choice of the exchange rate system, but in the institutions and policies underpinning it”.

Exchange rate stability is one of the major considerations for most of monetary policy makers. Experiences of many countries also reveal that the high levels of exchange rate volatility can be disruptive to exports and investment (Eichengreen, 2007: 23). The study of Besimi (2004: 17), suggests that the size of the volatility effect is reduced if there is greater stability of the exchange rate, thus requiring attention to be paid to the exchange rate stability. In terms of the implications of exchange rates for monetary policy, there are various comments and questions such as what is the appropriate intervention of monetary policy to exchange rate changes or what pattern should the monetary policies take in order to take care of exchange rate.

Currently, it is widely accepted that the government and the private sectors are able to help markets perform better by providing appropriate financial regulations and infrastructure (Bossone and Promisel, 1998: 2). Furthermore, from the successful experience of exchange rate stability in some countries like Singapore, it is confirmed that government policies seem able to encourage exchange rate stability (Khor et al.,

2004: 20-21). I concur that policy makers should provide an overall set of policies and instruments not only the exchange rate interventions but also for the following:

First, developing and strengthening financial system is the importance factor to enlarge the economy's resistance to shocks. A sound and efficient financial system with well developed liquid capital markets contribute to efficient intermediation of financial flows. This helps reduce the serious exchange rate fluctuations. Opening the domestic banking sector to greater competition also stimulates them to improve their performances in the long run.

Second, recently, high exchange rates and other key macroeconomic volatility together with worldwide external shocks have frequently occurred. It is important for policy maker to pursue closer monitoring as well as develop early warning systems about the emergence of risks and vulnerabilities in the financial system in order to lessen lost from crisis. Moreover, in some emerging economies may lack of a comprehensive perspective that leads to the contagious nature of the crisis being underestimated.

Finally, the financial crisis in 1997 has shown that the majority of the five countries of this study need to strengthen macroeconomic policies in order to set up healthy economic foundations. Sound macroeconomic policies seem to encourage macroeconomic balance with lower exposure to speculative currency attacks, and volatility in capital flows together with soften the negative spillover effects from high volatility in international financial market. In addition, healthy macroeconomic policies also maintain price stability in the system as a result of greater exchange rate stability.

However, policy makers should aware about cost-benefit implications of interventions as well. In my view, good strategic policies should provide the right incentives for the markets to develop their ability to cope with changing circumstances or various shocks in the private sector. Many private sector activities are affected by exchange rate fluctuations including consumption and investment decision making, portfolio management, risk management, international financial management, and decisions made by international business firms. Not only public sectors are able to handle strategies to cope with risks and losses from the exchange rate fluctuations, but private sectors also set their own strategies to avoid damages.

They can use derivatives to hedge or mitigate risk from exchange rate volatility in the underlying asset by entering into a derivative contract such as future contract, forward contract and option whose value moves in the opposite direction to their underlying position and cancels some or all of it out.

Future Exchange Rate Policy

The overall results from this research support that key macroeconomic variables are the major sources of exchange rate fluctuations. In other words, the changes in key macroeconomic variables or fundamental factors always accompany by the fluctuation in exchange rates. Furthermore, exchange rates of the selected countries have high positive correlations and significant interaction between second moments of these currencies in the region especially after the 1997 crisis. They seem to have high volatility and transmission is facilitated by many factors. First, these countries have strong economic relationship. Each of them is a major trading partner of others including export, import, foreign direct investment and portfolio investment. A change in one currency is thus simultaneously transmitted to other currencies. Second, the empirical evidence suggests that the increased exchange rate volatility is entirely the result of more violent shocks which originated in an increasingly volatile environment (Karras et al., 2005: 215). Finally, market psychology factors are also the particular sources of exchange rate volatility and transmission. Even though there are no apparent common fundamentals between currencies, speculations based on fads, noises or herd instinct might be rapidly transmitted as well. Thus, it is found that most of these currencies are likely moved together through contagion in this region.

In addition, following the ASEAN Roadmap plans to establish ASEAN as a single market and production base by 2015 (ASEAN Summit 2009). The ultimate goal is to allow the free flow of goods, services and investments across the ten nation region in order to enhance economic competitiveness as a whole. This means that will be closer economic integration and higher correlation between member nations in real and financial sectors. Furthermore, the financial and monetary integrations of ASEAN in four projected by the Roadmap (capital market development, capital account liberalization, liberalization of financial services and currency cooperation) will also lead to closer relationship between them. As a result, instead of using individual

country policies, central banks in the member state should conduct exchange rate policy on a regional basis in order to cope with any shocks and exchange rate fluctuations. The future direction of each country should seek to increase cooperation within the region and thus maintain as well as enhance strong financial system throughout the region.

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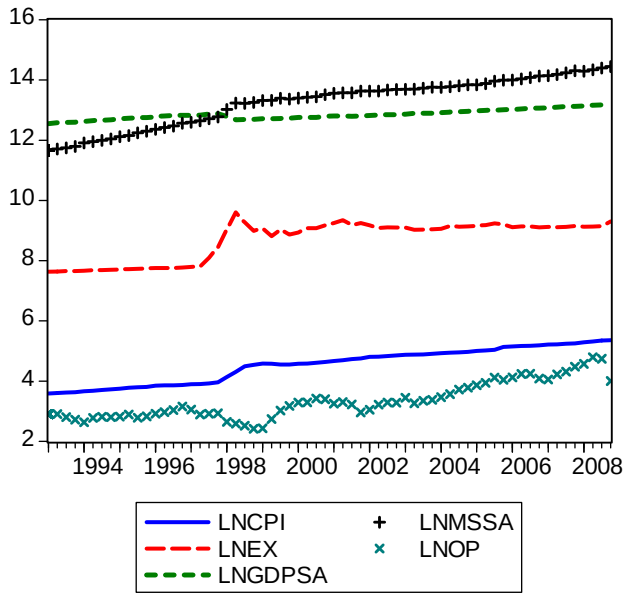
APPENDICES

APPENDIX A

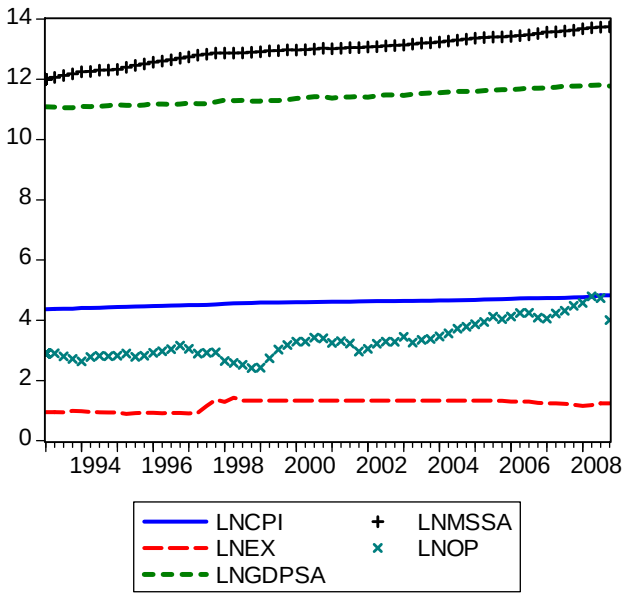
The Movement of Key Macroeconomic Variables

These graphs are presented as logarithm (rescaled) form of consumer price index (CPI), exchange rate (EX), and oil price (OP) as well as logarithm form of seasonally adjusted of gross domestic product (GDP) and money supply (MS).

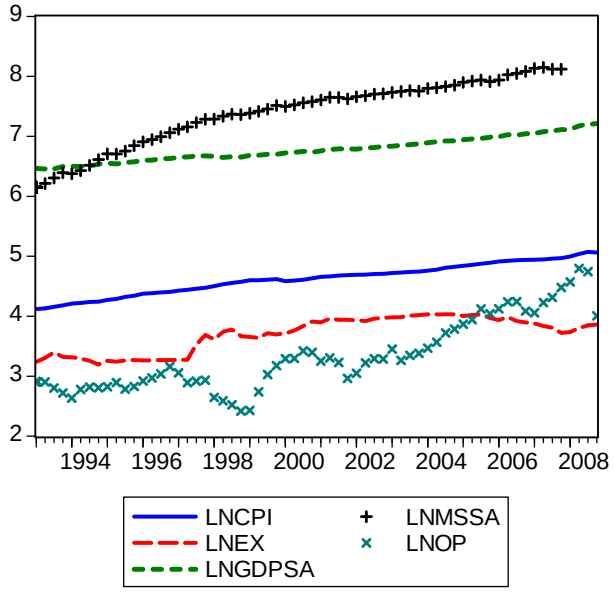
Indonesia:



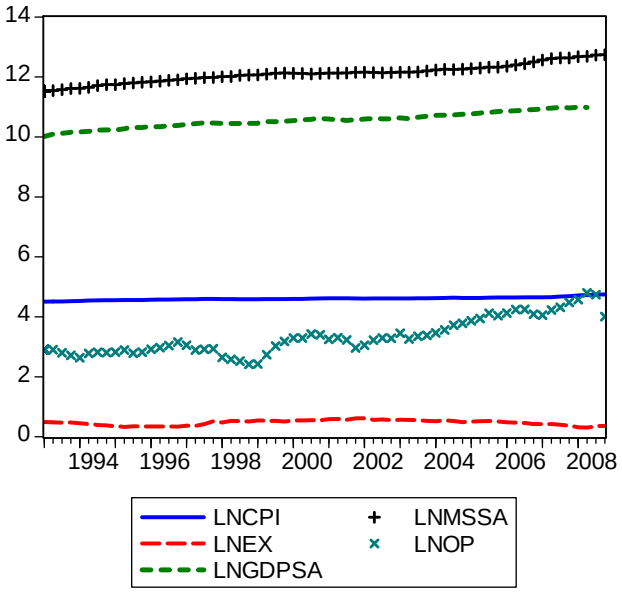
Malaysia:



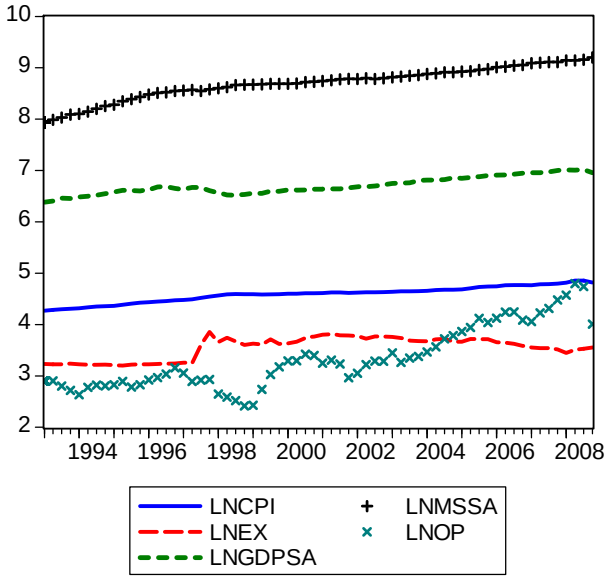
Philippine:



Singapore:



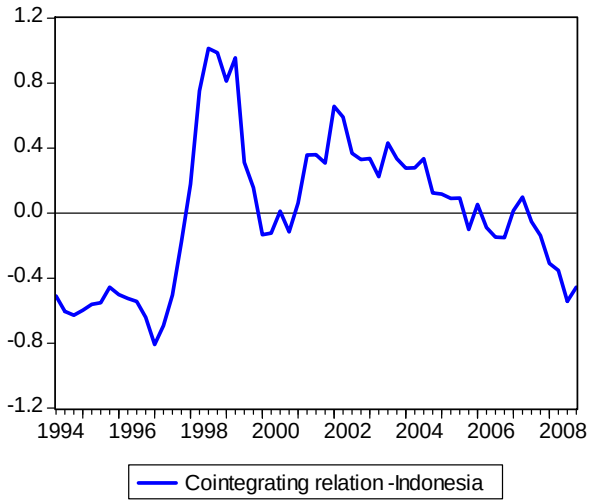
Thailand:



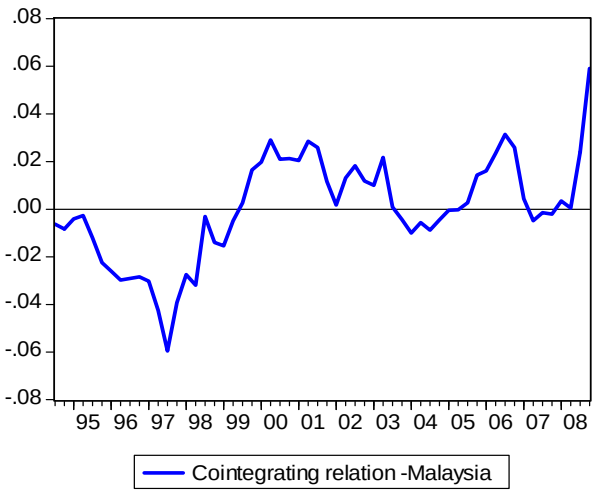
Cointegrating Relation of Key Macroeconomic Variables

These graphs are presented cointegrating relation of key macroeconomic variables of five Southeast Asian countries namely Indonesia, Malaysia, Philippine, Singapore and Thailand.

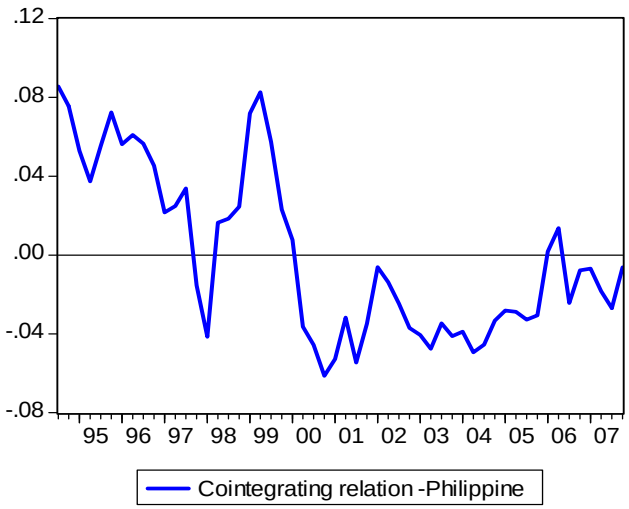
Indonesia:



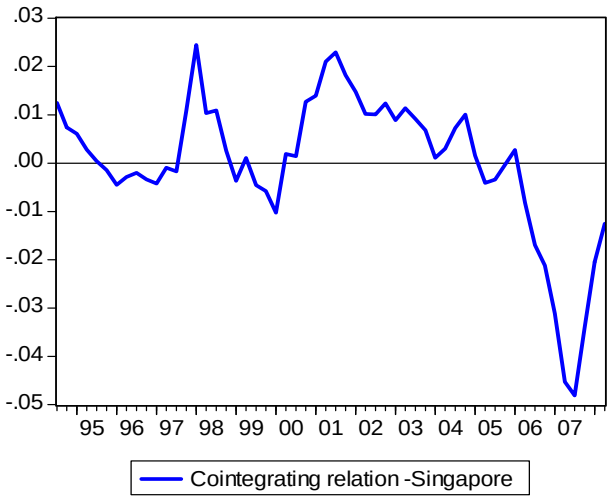
Malaysia:



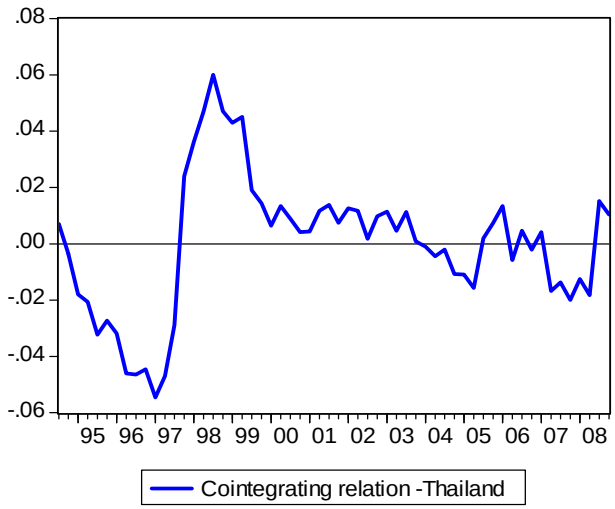
Philippine:



Singapore:



Thailand:

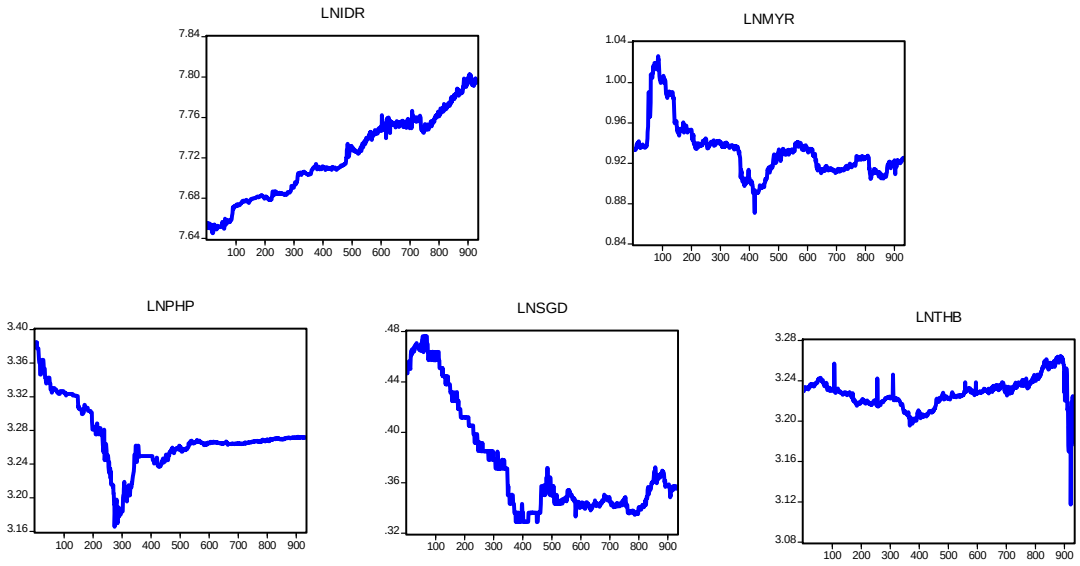

.08
.06
.04
.02
.00
-.02
-.04
-.06
95 96 97 98 99 00 01 02 03 04 05 06 07 08
Cointegrating relation -Thailand

APPENDIX B

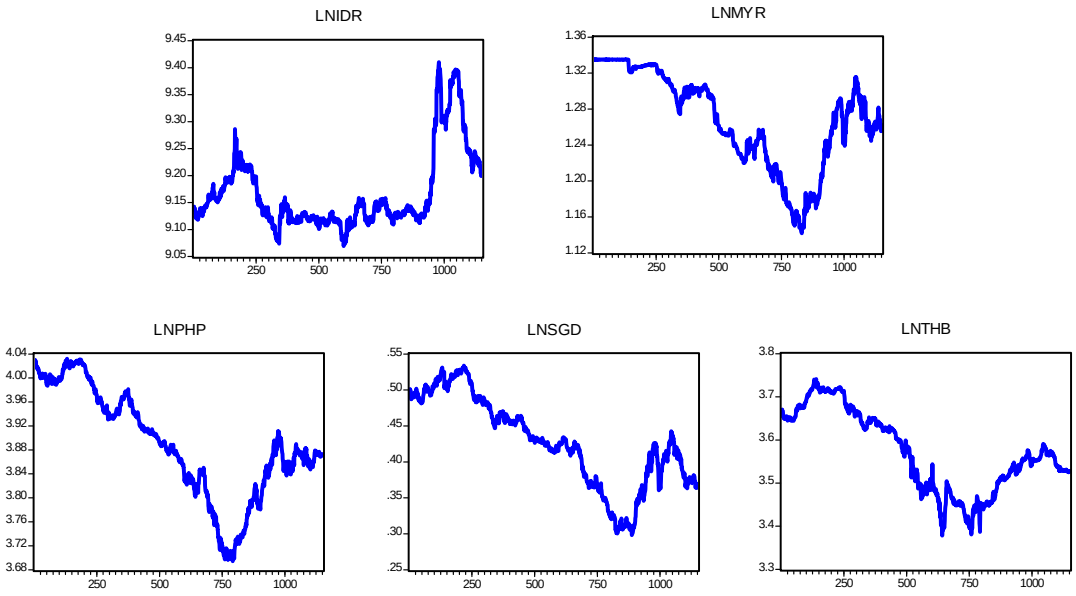
The Movement of Currencies in Five Southeast Asian Countries

These graphs are presented as logarithm (rescaled) form of currencies in five Southeast Asian countries namely Indonesia rupiah, Malaysia ringgit, Philippine peso, Singapore dollar and Thai baht.

Pre-Crisis Period:

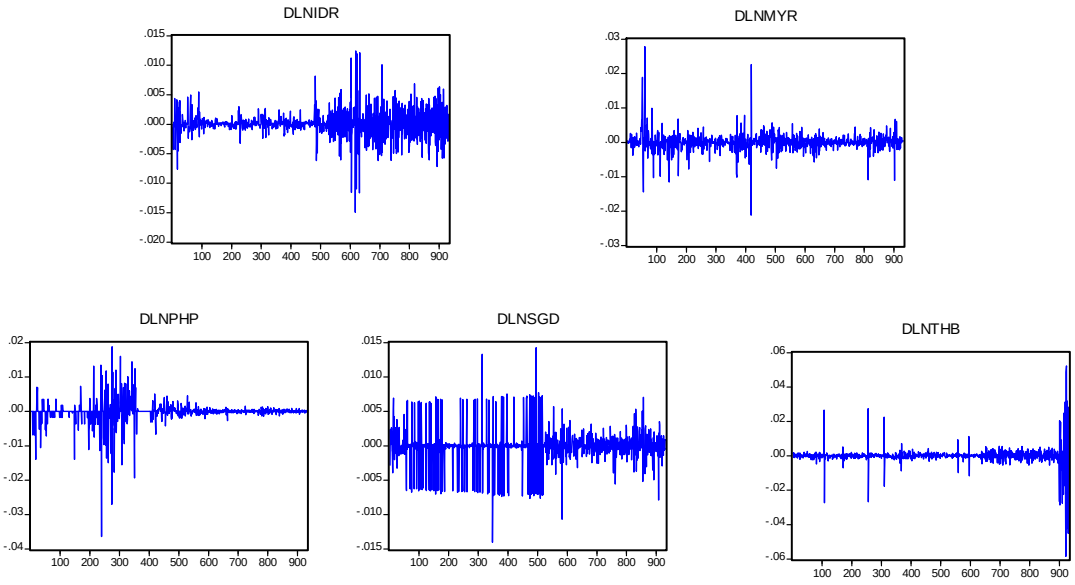


Post-Crisis Period:

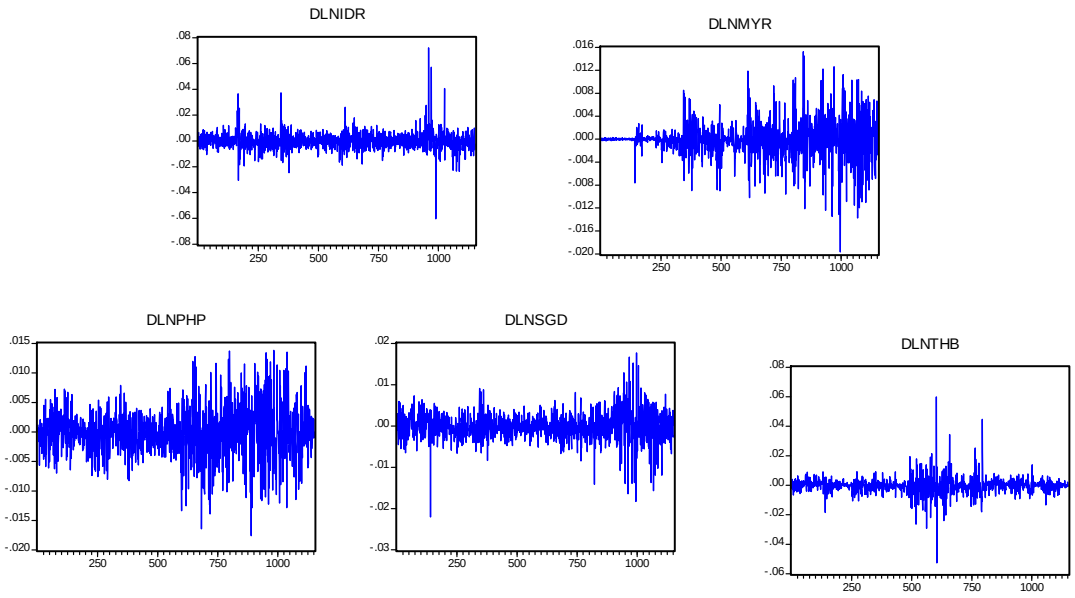


These graphs are presented as first different logarithm form of currencies in five Southeast Asian countries namely Indonesia rupiah, Malaysia ringgit, Philippine peso, Singapore dollar and Thai baht.

Pre-Crisis Period:



Post-Crisis Period:



BIOGRAPHY

NAME	Apinya Wanaset
ACADEMIC BACKGROUND	Bachelor of Science (Economics) Kasetsart University, 1985
	Master of Science (Development Economics) National Institute of Development Administration, 1988
	Master of Business Administration Thammasat University, 1994
PRESENT POSITION	Assistant Professor School of Economics Sukhothai Thammathirat Open University