THE FEASIBILITY OF ASEAN+6 SINGLE CURRENCY: A VECTOR ERROR CORRECTION MODEL

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Abstract. *This paper explore the possibility of the establishment of a single currency among ASEAN countries and six other counties, namely China, South Korea, Japan, Australia, New Zealand and India. We simulated the single currency by using weighted average and principal component analysis methods. Those methods are applied to compare the stability of the single currency. Furthermore, this paper will also identify the possible impact of the exchange rate shocks to the member countries by analyzing the impulse response function.*

The results showed the single currency established by applying weighted average method is more stable than those of principal component analysis. The weights used in this method are the exchange rate volatilities of each ASEAN+6 countries. Moreover, impulse response function showed that the single currency will give much benefit to member countries, especially to Indonesia, Malaysia, Singapore, Philippines, Thailand, Vietnam, and China.

Keywords: *ASEAN+6, single currency, weighted average, principal component analysis, error correction model*

JEL Codes: *E32, F02, F15, F31*

Introduction

Economic crisis, hitting Asia in 1997, has triggered the ASEAN countries to integrate their economy. According to Kurniati (2007), the economic integration in one region is established by considering not only the geographical and historical similarity, but also economic relationship among countries in that region. The phenomenal process was the establishment of European Union (EU), which integrated Europe economy in the single market, with the single currency, named EURO. The single market involves the free circulation of goods, capital, people and services within the EU, and the customs union involves the application of a common external tariff on all goods entering the market. This efficiency has boosted the economy of EU countries, moreover EU can compete with the dominance of US economy.

The success story of the EU in establishing a single market in 1999 have motivated ASEAN region to create the single market. During ASEAN Summit in Bali October 2003, all ASEAN members agreed to establish a so-called "ASEAN Economic Community

(AEC)" as the realization and end-goal of economic integration as outlined in the ASEAN Vision 2020. It rearticulates its aims to create a stable, prosperous and highly competitive ASEAN economic region in which there is a free flow of goods, services, investment and a freer flow of capital, equitable economic development and reduced poverty and socio-economic disparities. The AEC plans to establish ASEAN as single market and production base, turning the diversity that characterizes the region into opportunities for business complementation making the ASEAN a more dynamic and stronger segment of the global supply chain.

Furthermore, the AEC involves not only the ASEAN countries, but also six other nations (China, India, Japan, South Korea, Australia and New Zealand), which is known as the ASEAN+6 group. They agreed to accelerate economic growth in East Asian countries, promote cooperation in energy, foods, and other fields vital to economic activities. The AEC establishment will end in the creation of a regional currency unit that had often been referred to as the Asian Currency Unit (ACU).

Some studies concerning the single currency establishment have been carried out. Study of Bayoumi and Mauro (2008) resulted that ASEAN condition has not yet fulfilled the single currency criteria. Moreover, Partisiwi (2010) analyzed the possibility of currency integration among ASEAN+3 countries by using Optimum Currency Areas (OCA) criteria. The result showed that Singapore Dollar was the most stable currency in the region during the period of analysis. However, this paper will involve a wider region, which are ASEAN+6 countries.

Drawing on the experience with the European Currency Unit (ECU) in the European Monetary System (EMS), proponents of an Asian currency basket have argued that the basket could play two key roles in the context of ASEAN+6. First, the basket could provide a framework for specifying exchange rate objectives as part of any formal effort to coordinate exchange rate policies. Such an approach would build, in particular, on the role the ECU notionally played in specifying exchange rate targets and divergence indicators in the exchange rate mechanism of the European Monetary System (EMS). Second, irrespective of whether there is formal agreement on exchange rate polices, the creation of an official currency basket could usefully catalyze the private sector into denominating financial assets in the basket along the lines the official ECU played in European Monetary System (EMS). Within the region, this has become known (somewhat misleadingly) as the parallel currency proposal (Eichengreen (2006)) and as leading (potentially) to the emergence of the ACU as a parallel currency alongside national currencies.

The objective of this paper is to get a single currency for ASEAN+6 countries (ACU) by using weighted average and principal component analysis methods. Those methods are applied to compare the stability of single currency. To this end, this paper will also try to identify the impact of ACU and exchange rate shocks of the countries by analyzing the impulse response function.

The rest of the paper will be organized as follows: Section 2 will explain the data and research methodology, followed by a discussion on section 3. Summary of the results and the policy implications will be provided in section 4.

Research Method

We used the macroeconomic data covering the period December 1999–December 2009, from ASEAN countries (i.e. Indonesia, Malaysia, Singapore, Thailand, Philippines, Vietnam, Cambodia, and Laos) plus six other countries of China, India, Japan, South Korea, Australia and New Zealand. The macroeconomic variables applied are exchange rate, GDP, and inflation rate. The data are collected from *World Economic Outlook Database* April 2009 and the CEIC Database.

The stages of data analysis in this paper are as follows:

1. Analyze descriptively the exchange rate among the ASEAN+6 countries.
2. Find the ACU by using weighted average method, where the weight applied is volatility of the exchange rate, GDP, and inflation rate.
3. Find the ACU by using principal component analysis method.
4. Compare the ACU stability obtained in step 2 and 3.
5. Apply VAR or VECM methods to analyze the feasibility of each country joining in ACU. The full steps are given in Appendix 1, or briefly, as follows:
   - Transform each variable to its logarithm.
   - Check the data stationary by using ADF test. If it is not, then take differencing.
   - Determine the optimal lag.
   - Examine the cointegration by using Johansen test.
   - Establish the VAR or VECM model
   - Analyze the IRF and FEVD

Those steps above are carried out using software Microsoft Excel 2007, Eviews 5.1 and Minitab 14.

Weighted Average

The weighted average is a method, where instead of each of the data points contributing to the final average, in such a way that the total weight is $\sum_{i=1}^{n} w_i$. Therefore, the weighted average is defined as:

$$\underline{y} = w_1\, \underline{x_1} + w_2\, \underline{x_2} + \ldots + w_n\, \underline{x_n}$$

where $w_i = \frac{a_i}{\sum_{i=1}^{n} a_i} x\ 100\%$

$\underline{y}$ = linear combination of variables and their weights

w_i = the i-th weight

$\underline{x_i}$ = the i-th variable

The weights used in this paper are as follows:

1. Volatility is the data fluctuation in the certain period, or statistically, known as standard deviation. In this paper, we use invers of the exchange rate volatility of each country. So, the exchange rate with a great volatility will be weighted lower than that which has a small volatility.
2. Gross Domestic Product (GDP) is a measure of a country's overall economic output. It is the market value of all final goods and services made within the borders of a country in a certain period. GDP is a sum of consumption (C), investment (I), government spending (G) and net exports (X), or mathematically, defined as:
   $$GDP = C + I + G + X$$
   In this paper, we use nominal GDP.
3. Inflation is a rise in the general level of prices of goods and services in an economy over a period of time. A chief measure of price inflation is the inflation rate, the annualized percentage change in a general price index (normally the Consumer Price Index) over time. We formulate the inflation rate as follow:

$$I_t = \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}} \, x \, 100\%$$

where

I_t = inflation rate at the t-th period

CPI_t = consumer price index at the t-th period

In this paper, we use invers of the inflation rate.

Principal Component Analysis

The principal component analysis (PCA) is a method that reduces data dimensionality by performing a covariance analysis between factors. The PCA involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. PCA was invented in early 1900 by Karl Pearson. Hotelling (1933) developed the procedure applying in the random vectors. Then, Rao (1964) used the PCA procedure in various applied research.

Given a set of points in Euclidean space, the first principal component (the eigen vector with the largest eigen value) corresponds to a line that passes through the mean and minimizes sum squared error with those points. The second principal component corresponds to the same concept after all correlation with the first principal component has been subtracted out from the points. Each eigen value indicates the portion of the variance that is correlated with each eigen vector. Thus, the sum of all the eigen values is equal to the sum squared distance of the points with their mean divided by the number of dimensions. PCA essentially rotates the set of points around their mean in order to align with the first few principal components. This moves as much of the variance as possible (using a linear transformation) into the first few dimensions. The values in the remaining dimensions, therefore, tend to be highly correlated and may be dropped with minimal loss of information. PCA is often used in this manner for dimensionality reduction. PCA has the distinction of being the optimal linear transformation for keeping the subspace that has largest variance.

In practice, a random sample of n individuals are obtained on p variables. The data for a PCA consists of an (n × p) data matrix Y and an (n × q) data matrix **X** of q covariates. To perform a PCA, one employs the unbiased estimator **S** for Σ or the sample correlation matrix **R**. Selecting between **S** and **R** depends on whether the measurements are commensurate. If the scales of measurements are commensurate, one should analyze **S**, otherwise **R** is used. Never use **R** if the scales are commensurate since by forcing all variables to have equal sample variance one may not be able to locate those components that maximize the sample dispersion.

Replacing Σ with S, one solves $|\mathbf{S} - \lambda\mathbf{I}| = 0$ to obtain eigen values and eigen vectors usually represented as $\hat{\lambda}_j$ and $\hat{p}_j$. Thus, the sample eigen vectors become $\hat{\mathbf{P}}$ and the sample eigen values become $\hat{\Lambda} = \text{diag}[\hat{\lambda}_j]$. The formula for the standardized principal components for all n individuals is

$$\mathbf{Z}^*_{n \times p} = \mathbf{Y}_d \hat{\mathbf{P}} \hat{\Lambda}^{-1/2} = \mathbf{Y}_d \hat{\mathbf{Q}}$$

Where $\mathbf{Y}_d$ is the matrix of deviation scores after subtracting the sample means and $\hat{\mathbf{Q}}$ are the sample covariance.

Vector Auto Regression (VAR)

The vector auto regression (VAR) model is one of the most successful, flexible, and easy to use models for the analysis of multivariate time series. It is a natural extension of the univariate autoregressive model to dynamic multivariate time series. The VAR model has proven to be especially useful for describing the dynamic behavior of economic and financial time series and for forecasting. It often provides superior forecasts to those from univariate time series models and elaborate theory-based simultaneous equations models. Forecasts from VAR models are quite flexible because they can be made conditional on the potential future paths of specified variables in the model.

In addition to data description and forecasting, the VAR model is also used for structural inference and policy analysis. In structural analysis, certain assumptions about the causal structure of the data under investigation are imposed, and the resulting causal impacts of unexpected shocks or innovations to specified variables on the variables in the model are summarized. These causal impacts are usually summarized with impulse response functions and forecast error variance decompositions.

VAR models in economics were made popular by Sims (1980). The definitive technical reference for VAR models is Lutkepohl (1991), and updated surveys of VAR techniques are given in Watson (1994) and Lutkepohl (1999) and Waggoner and Zha (1999). Applications of VAR models to financial data are given in Hamilton (1994), Campbell, Lo and MacKinlay (1997), Cuthbertson (1996), Mills (1999) and Tsay (2001).

For a set of n time series variables $y_t = (y_{1t}, y_{2t,} \ldots, y_{nt})'$, a VAR model of order p (VAR(p)) can be written as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + u_t$$

where the A_i 's are (nxn) coefficient matrices and $u_t = (u_{1t}, u_{2t}, \ldots, u_{nt})'$ is an unobservable i.i.d. zero mean error term.

Impulse Response Functions (IRF)

Impulse response function is used when we want to trace out the time path of the effect of structural shocks on the dependent variables of the model. More generally, an impulse response refers to the reaction of any dynamic system in response to some external change. In both cases, the impulse response describes the reaction of the system as a function of time (or possibly as a function of some other independent variable that parameterizes the dynamic behavior of the system).

Forecast Error Variance Decomposition (FEVD)

Forecast error variance decomposition indicates the amount of information each variable contributes to the other variables in a VAR model. Variance decomposition determines how much of the forecast error variance of each of the variable can be explained by exogenous shocks to the other variables. In other word, It tells how much of a change in a variable is due to its own shock and how much due to shocks to other variables. In the short run, most of the variation is due to own shock. But as the lagged variables' effect starts kicking in, the percentage of the effect of other shocks increases over time.

Empirical Results

Descriptive Analysis of Exchange Rate of ASEAN+6 Countries Currencies

The exchange rate movement is different among ASEAN+6 countries, clearly presented in Appendix 2. In general, the exchange rate of Malaysia, Singapore, Thailand, Japan, China, Australia and New Zealand appreciated to the US dollar in the period 2000-2008. Furthermore, the volatility of Indonesian exchange rate was the highest among other countries, i.e. 0.042. Whereas, exchange rate of China was eleven times more stable than Indonesia, i.e. 0.0038.

As seen in Appendix 3, the exchange rate tended to be unstable among countries in period 2000-2001. The economic crisis in 1997 still affected the ASEAN+6 countries, so that the currencies were very volatile. Nevertheless, in 2002, the countries had overcome that global financial crisis, therefore the exchange rate started to be stable in this period. The graphs in Appendix 3 also indicate that Malaysia, Vietnam, Cambodia, and China had succeeded in holding the exchange rate relative stable over the years.

Before establishing a single currency, we need to know the correlation of the exchange rate every ASEAN+6 member. It is completely provided in Appendix 4. The Pearson test result the significant correlation among the countries' exchange rates, which is summarized in Table 1.

Table 1 Correlation of the Exchange Rates of ASEAN+6 Countries (α = 5%)

Indo	Cam, Chi, Kor, Ind, Aus, Nz
Mal	Sing, Phi, Tha, Vie, Cam, Lao, Jap, Chi, Kor, Ind, Aus, Nz
Sing	Mal, Phi, Tha, Vie, Cam, Lao, Jap, Chi, Kor, Ind, Aus, Nz
Phi	Mal, Sing, Tha, Cam, Lao, Chi, Kor, Ind
Tha	Mal, Sing, Phi, Vie, Cam, Lao, Jap, Chi, Kor, Ind, Aus, Nz
Vie	Mal, Sing, Tha, Cam, Lao, Jap, Chi, Kor, Ind, Aus, Nz
Cam	Indo, Mal, Sing, Phi, Tha, Vie, Lao, Chi, Kor, Ind, Aus, Nz
Lao	Mal, Sing, Phi, Tha, Vie, Cam, Jap, Chi, Nz
Jap	Mal, Sing, Tha, Vie, Lao, Chi, Kor, Ind, Aus, Nz
Chi	Indo, Mal, Sing, Phi, Tha, Vie, Cam, Lao, Jap, Kor, Ind, Aus, Nz
Kor	Indo, Mal, Sing, Phi, Tha, Vie, Cam, Jap, Chi, Ind, Aus, Nz
Ind	Indo, Mal, Sing, Phi, Tha, Vie, Cam, Jap, Chi, Kor, Aus, Nz
Aus	Indo, Mal, Sing, Tha, Vie, Cam, Jap, Chi, Kor, Ind, Nz
Nz	Indo, Mal, Sing, Tha, Vie, Cam, Lao, Jap, Chi, Kor, Ind, Aus,

Based on the Table 1, the Indonesian exchange rate has the fewest correlations with other countries. However, China has correlation with all the countries. The correlations between Malaysia, Singapore, and Thailand are positively strong enough. It means that the exchange rates among those three countries tend to be similar. Furthermore, the strong and positive correlations were occurred not only between China and Malaysia, Singapore, Thailand, but also between Australia and Singapore, Thailand, Korea, New Zealand.

The ASEAN+6 Single Currency Establishment Using Weighted Average Method

Each ASEAN+6 exchange rate has different volatility. We use the inverse of that volatility to obtain the weight of each country, so the country that has a great volatility will be given by a small weight. Result of the weights can be seen in Table 2.

Based on Table 2, the exchange rate volatility of Indonesia, Vietnam, Cambodia, Laos, Japan, Australia, and New Zealand tends to decrease period-by-period, therefore their weights become larger. It is different for Singapore, Philippines, Thailand, Korea, and India, which tend to increase all over periods.

The ACU is also can be established from linear combination of the exchange rate, weighted by using GDP and inflation rate. The results of those weights are given in Table 3 and Table 4, respectively.

Table 2 The ACU Weights Based on Exchange Rate Volatility (%)

Country	Period		
	2000-2004	**2004-2008**	**2000-2008**
Indo	0.001	0.002	0.001
Mal*	-	5.296	5.296
Sing	20.980	9.313	7.911
Phi	0.229	0.199	0.216
Tha	0.467	0.327	0.272
Vie	0.002	0.004	0.002
Cam	0.016	0.019	0.011
Lao	0.001	0.001	0.001
Jap	0.126	0.149	0.128
Chi*	-	1.977	2.145
Kor	0.014	0.009	0.007
Ind	0.638	0.419	0.392
Aus	4.435	8.919	3.572
Nz	2.865	8.383	2.565
Stdev	**9.544**	**10.280**	**7.701**

Note:
(*) calculated in July 2005-Desember 2008, because of the exchange rate system change.

Table 3 The ACU Weights Based on GDP (%)

Country	Period		
	2000-2004	**2004-2008**	**2000-2008**
Indo	2.490	3.267	2.967
Mal	1.283	1.462	1.395
Sing	1.154	1.268	1.227
Phi	0.959	1.087	1.046
Tha	1.644	1.878	1.788
Vie	0.452	0.565	0.522
Cam	0.054	0.068	0.063
Lao	0.025	0.032	0.029
Jap	52.909	40.310	45.241
Chi	18.549	25.783	23.012
Kor	7.326	7.970	7.708
Ind	6.566	8.190	7.558
Aus	5.747	7.111	6.517
Nz	0.841	1.008	0.927
Stdev	**25.302**	**31.255**	**28.919**

Table 3 explains that GDP contribution of each ASEAN+6 member tend to increase, and relatively similar between period 2000-2004 and period 2004-2008. Japan has a greatest contribution among ASEAN+6 countries, but it tends to decrease from 52.9% (period 2000-2004) to 40.3% (period 2004-2008), otherwise Vietnam, Cambodia, Laos, and New Zealand have the smaller contribution among those countries. The ACU establishment using the GDP of each country gives the volatility 28.9 percent.

Table 4 The ACU Weights Based on Inflation Rate (%)

Country	Period		
	2000-2004	2004-2008	2000-2008
Indo	1.492	1.905	1.580
Mal	7.047	6.259	6.406
Sing	13.828	13.763	14.236
Phi	2.376	2.907	2.589
Tha	7.418	4.494	6.363
Vie	8.894	1.707	6.485
Cam	14.416	2.724	10.422
Lao	0.847	2.312	1.413
Jap	17.997	38.805	24.977
Chi	12.539	5.885	10.507
Kor	3.213	5.341	4.027
Ind	2.539	2.959	2.589
Aus	3.131	5.487	3.837
Nz	4.263	5.452	4.570
Stdev	**75.216**	**35.794**	**59.788**

Table 4 indicates the weights based on the inflation rate. In the same way as GDP contribution, we use inverse of the inflation rate. Therefore, country with high inflation, like Laos, will be given a small weight. Otherwise, we give the larger weight for Japan because of its low inflation. In the period 2000-2008, the ACU establishment using the inflation rate of each country gives the volatility 59.8 percent. Table 5 gives the ACU weights based on the GDP and the inflation rate, where each variable is weighted as 50 percent.

Table 5 The ACU Weights Based on GDP and Inflation Rate (%)

Country	Period		
	2000-2004	2004-2008	2000-2008
Indo	1.991	2.586	2.273
Mal	4.165	3.861	3.900
Sing	7.491	7.516	7.731
Phi	1.668	1.997	1.818
Tha	4.531	3.186	4.075
Vie	4.673	1.136	3.503
Cam	7.235	1.396	5.243
Lao	0.436	1.172	0.721
Jap	35.453	39.557	35.109
Chi	15.544	15.834	16.759
Kor	5.270	6.655	5.867
Ind	4.553	5.574	5.074
Aus	4.439	6.299	5.177
Nz	2.552	3.230	2.749
Stdev	**42.302**	**30.140**	**37.280**

In Table 5, we composite the variable GDP and variable inflation rate, in order to obtain new weights. Japan is given a larger weight than other countries, because it has large GDP and low inflation. But, we give a smaller weight for Laos, i.e. 0.72 percent in the period 2000-2008. The volatility of this single currency is 37.28 percent.

The ASEAN+6 Single Currency Establishment Using PCA

The single currency for ASEAN+6 countries was also established by using principal component analysis. Applying this method, we had principal components (PC) derived from linear combinations of each ASEAN+6 exchange rate, so that the information in the PC was composite of all exchange rates with certain weights. For every principal component, we obtain its eigen value and variance. It is clearly given in Table 6. In this paper, we choose a PC with the largest variance; therefore, information of each exchange rate will be explained maximum.

Table 6 The Characteristic Root and Variance of the Principal Components

	Eigen Value	Variance (%)	Variance Cumulative (%)
PC1	7.559	53.991	53.991
PC2	2.942	21.015	75.006
PC3	1.497	10.691	85.697
PC4	0.931	6.649	92.346
PC5	0.509	3.636	95.982
PC6	0.277	1.979	97.960
PC7	0.089	0.639	98.599
PC8	0.067	0.478	99.077
PC9	0.055	0.391	99.467
PC10	0.028	0.199	99.667
PC11	0.019	0.134	99.800
PC12	0.014	0.102	99.902
PC13	0.008	0.056	99.958
PC14	0.006	0.042	100.000

Table 7 The weights of ACU Using Principal Component Analysis Method

Negara	Eigen Vector of PC1
Indo	-0.02045
Mal	-0.31811
Sing	-0.35173
Phi	-0.15808
Tha	-0.34444
Vie	0.234603
Cam	0.267421
Lao	-0.02228
Jap	-0.16855
Chi	-0.28268
Kor	-0.29663
Ind	-0.29518
Aus	-0.34376
Nz	-0.32001
Standard Deviation	**192.446**

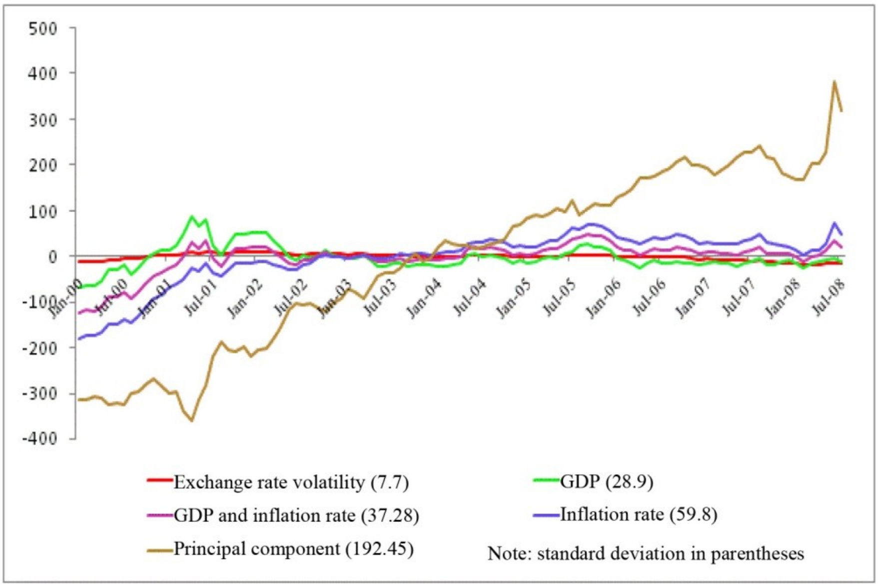
From the Table 6, we should use the first PC (PC1), which has eigen value 7.56 and the largest variance among others, i.e. 53.99 percent. In the other words, the PC1 can explain 53.99 percent of the exchange rate variety every ASEAN+6 countries. Using that eigen value, we also can obtain the eigen vector consist of the weights of ACU, which is given in Table 7. The single currency established has volatility 192.45.

Comparison between Weighted Average Method and PCA Method

The single currency establishment using weighted average and principal component analysis methods indicates different characteristics. We can check the stability of the ACU through the volatility the currency all over years. Clearly, it is described in Figure 1.

Based on the Figure 1, the ACU established using weighted average method is relatively stable. However, the principal component analysis results the high unstable ACU with standard deviation 192.45. The minimum volatility of ACU is established using weighted average method, where the weights are the exchange rate of each ASEAN+6 country. Therefore, we can apply this method to establish the stable ASEAN+6 currency. Furthermore, we will use this result in analyzing the response of each country to the ACU establishment.

Figure 1 The Trend of ACU Using Weighted average Method and Principal Component Analysis Method



Response of ASEAN+6 Countries to the ACU Establishment

In this part, we will identify the feasibility of each ASEAN+6 country in changing its currency to the ACU. To solve this problem, we can apply a VAR or VECM model. The variables used in this model are the exchange rate of each ASEAN+6 country and the stable single currency established by using weighted average method. Besides that, we will also identify the response of each country to the shock of the greatest currencies in the world, i.e. US Dollar and Euro.

Before applying VAR or VECM estimation, we should carry out some tests in order to obtain an appropriate model. The tests include stationary test, optimal lag determination, cointegration test. We will briefly explain those tests below.

Data Stationarity Test

The first step is checking the stationarity all the variables using Augmented Dickey-Fuller (ADF) test. The test indicates that all the variables are stationary in their first difference, except to Indonesia exchange rate, which is stationary in level. Result of the stationary test can be seen in Table 8.

Table 8 Unit Root Test Using Augmented Dickey-Fuller (ADF)

Variable	Level	First difference
Indo	**-3.861***	
Mal	0.376	**-3.236***
Sing	-0.495	**-7.918***
Phi	-2.207	**-8.949***
Tha	-0.928	**-6.893***
Vie	-1.865	**-11.329***
Kam	-2.294	**-10.180***
Lao	-2.222	**-7.908***
Jep	-0.479	**-8.758***
Chi	2.413	**-3.578***
Kor	-1.197	**-8.382***
Ind	-1.972	**-6.383***
Aus	-1.373	**-7.029***
Nz	-1.301	**-7.024***
ACU	-1.703	**-6.875***
USD	-1.209	**-7.023***
Euro	-0.806	**-7.121***

Note: *) the variable is stationary at $\alpha = 5\%$

Optimal Lag Determination

The second step is determining the optimal lag used in the estimation. However, we need to examine the model stability, so that the maximum lag will be obtained. In our paper, the model is stable in the first lag, therefore we do need check the AIC, SC, and adjusted R^2. The test result is given in Appendix 5.

Cointegration Test

The cointegration test is applied because there are variables in the model that are not stationary in level, but stationary in first difference. It is possibly that there are cointegration among variables, or in other words, there are long run relationship among variables. We use Johansen cointegration test, the result can be seen in Appendix 6.

Result of the cointegration test indicates that there are cointegration between variable Vietnam, Laos, China and ACU, USD, and Euro. Therefore, we use VECM model for those three countries, whereas we use first-order VAR model for other countries. Table 9 summarizes models used in this paper.

Impulse Response Functions (IRF) of the ASEAN+6 Countries

Impulse responses trace out the response of current and future values of each of the variables to a one-unit increase in the current value of one of the standard deviation. It is a one-period shock, which reverts to zero immediately. The figure of impulse responses is presented in Figure 2.

Based on the Figure 2, shocks of ACU, USD, and Euro have different impacts to the ASEAN+6 countries. The ACU shock tends to be stable in the next three years applied in Indonesia, Malaysia, Singapore, Thailand, Vietnam, Cambodia, Laos, and China. However, the ACU shock in the other countries, i.e. Japan, India, Australia, and New Zealand, tend to be unstable. In the Philippines and Korea, shock of the ACU has a small effect, and not in their equilibrium in next three years. The impact of the USD and Euro currencies is clearly seen in Philippines, Japan, Korea, India, Australia, and New Zealand. Consequently, the ACU has not given more benefits to these countries.

Table 9 Models Established in This Paper

Variable	Model
Indo, ACU, USD, Euro	VAR (1)-*1st difference*
Mal, ACU, USD, Euro	VAR (1)-*1st difference*
Sing, ACU, USD, Euro	VAR (1)-*1st difference*
Phi, ACU, USD, Euro	VAR (1)-*1st difference*
Tha, ACU, USD, Euro	VAR (1)-*1st difference*
Vie, ACU, USD, Euro	VECM (1), rank 1
Cam, ACU, USD, Euro	VAR (1)-*1st difference*
Lao, ACU, USD, Euro	VECM (1), rank 2
Jap, ACU, USD, Euro	VAR (1)-*1st difference*
Kor, ACU, USD, Euro	VAR (1)-*1st difference*
Chi, ACU, USD, Euro	VECM (1), rank 1
Ind, ACU, USD, Euro	VAR (1)-*1st difference*
Aus, ACU, USD, Euro	VAR (1)-*1st difference*
Nz, ACU, USD, Euro	VAR (1)-*1st difference*

Forecast Error Variance Decomposition (FEVD) of the ASEAN+6 Countries

Forecast error variance decomposition determines how much of the forecast error variance of each of the ASEAN+6 exchange rate can be explained by exogenous shocks, i.e. ACU, US Dollar, and Euro, to the other variables in the certain period.
Result of FEVD of each country is presented in Appendix 7.

In the long run, the variance of the exchange rate most of the ASEAN+6 countries, i.e. Indonesia, Malaysia, Singapore, Thailand, Vietnam, Laos, Japan, India, and New Zealand, are mainly explained by US Dollar variance. It implies that those countries are greatly influenced by US Dollar. However, Euro explains the variance of exchange rates in Philippines, Cambodia, and Australia. The variance of exchange rate in China is dominated by itself in the long run. It indicates that China currency is greatly influenced by its internal factor in the next three years.

Conclusion

The volatilities of exchange rate among ASEAN+6 countries are highly varied. The highest volatility is experienced by Indonesia, i.e. 0.042, whereas China has a minimum volatility, i.e. 0.0038. Based on those exchange rates, we establish a single currency, formally called as Asian Currency Unit (ACU). The ACU is resulted by using two methods, i.e. weighted average method and principal component analysis method. By comparing the standard deviation, the ACU established by applying weighted average method is more stable than another method. The weights used in this method are the exchange rate volatilities of each ASEAN+6 country.

Based on the impulse response function, we can know the response of each country if there are shocks of the ACU, US Dollar, and Euro. The result indicates that Japan, India, Australia, and New Zealand will need a longer time to establish the single currency. However, we predict that the ACU establishment in the short future will give much benefit in the other countries, i.e. Indonesia, Malaysia, Singapore, Philippines, Thailand, Vietnam, and China.

Figure 2 The IRF of Each Country to the to ACU, US Dollar and Euro

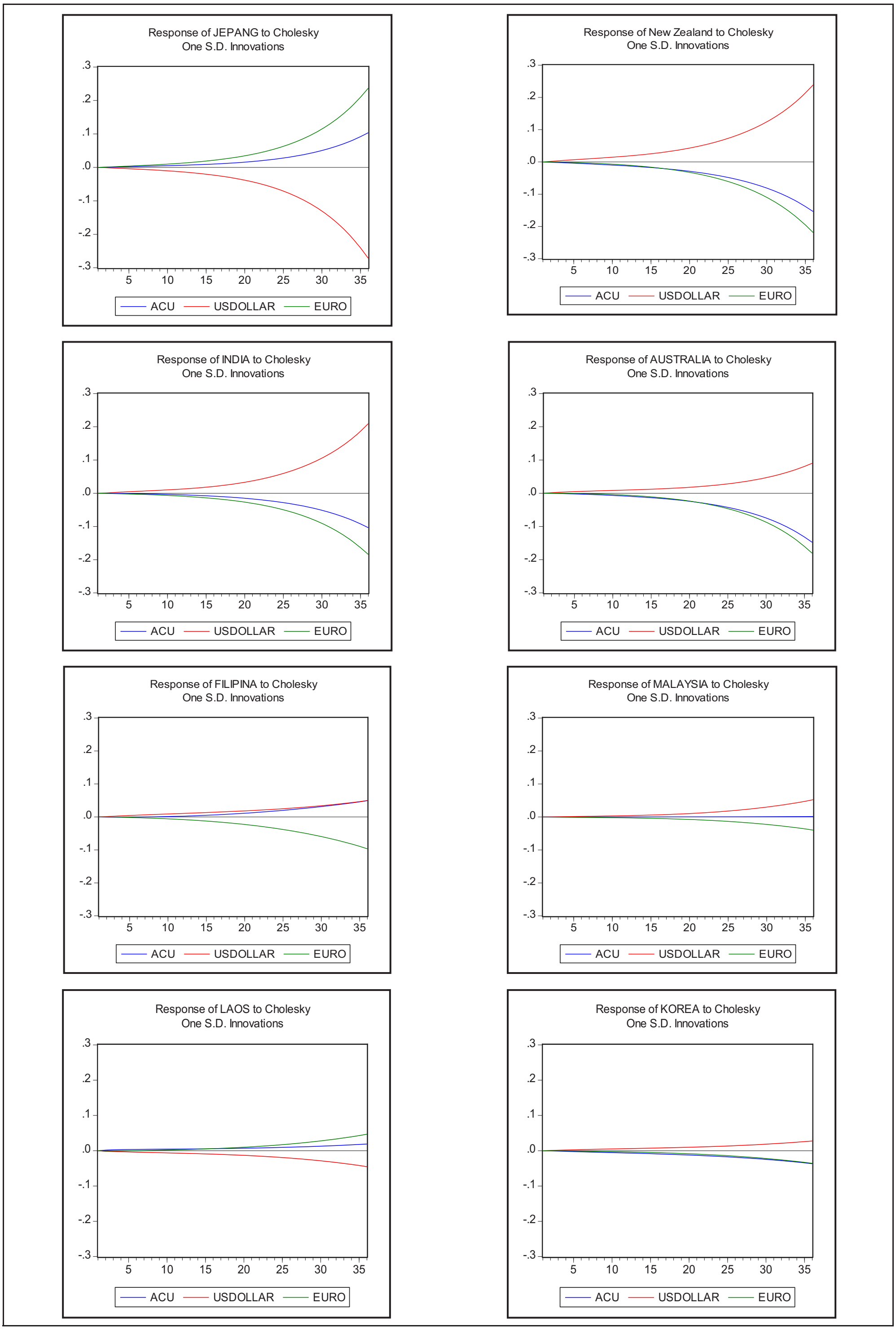
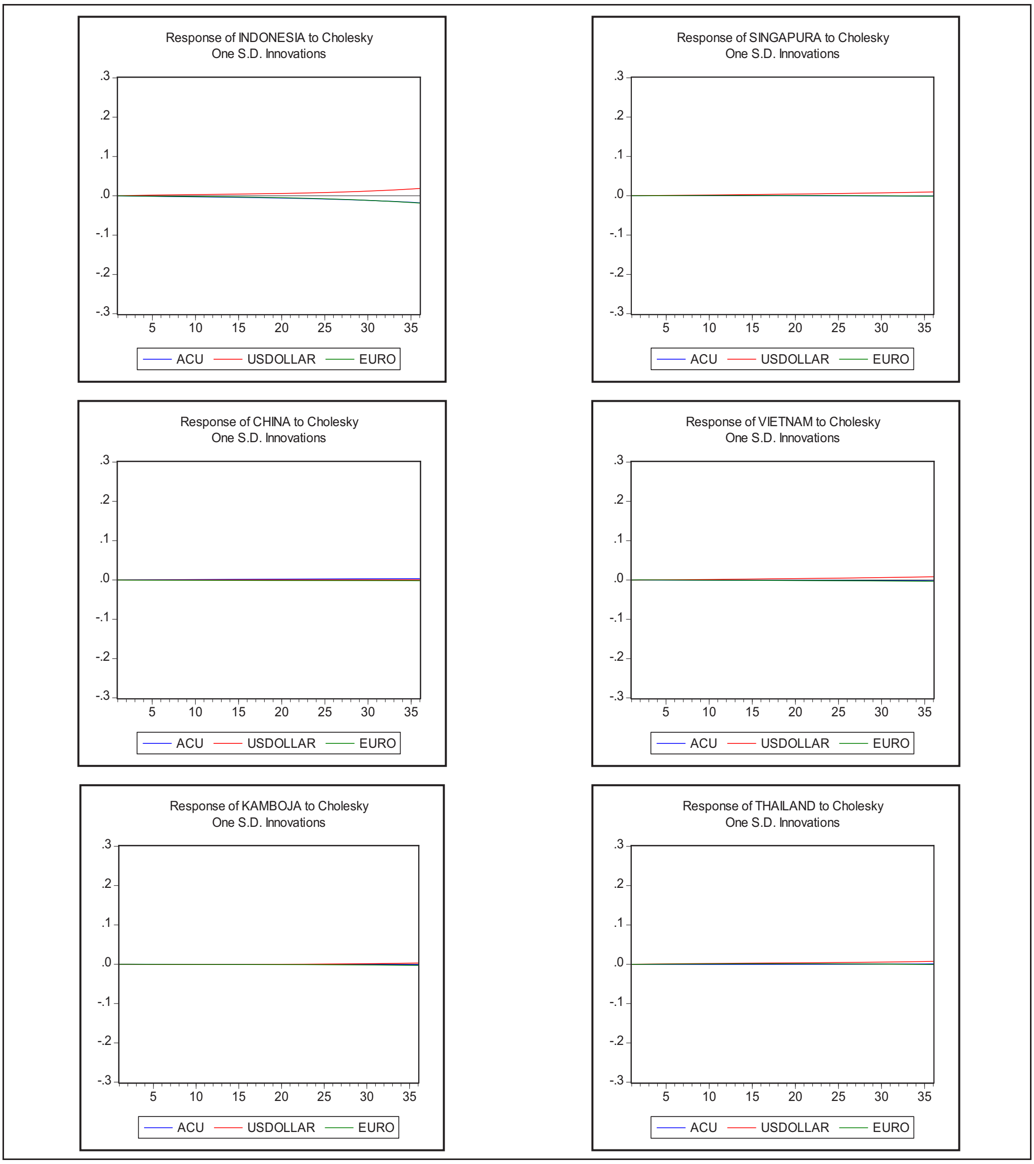


Figure 2 (Cont'd). The IRF of Each Country to the to ACU, US Dollar and Euro



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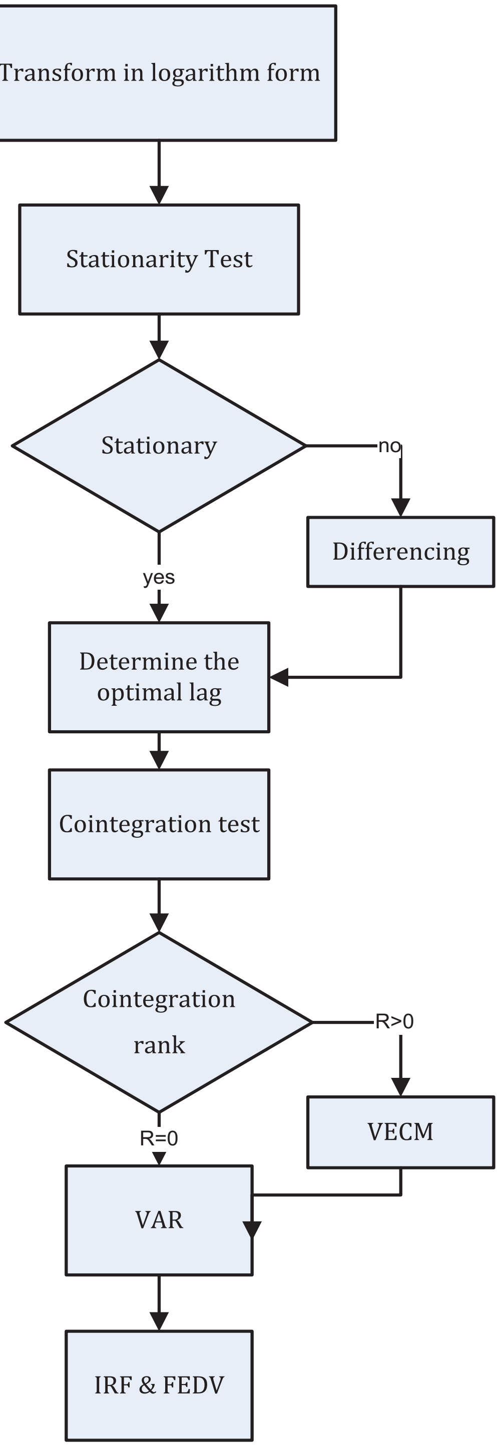
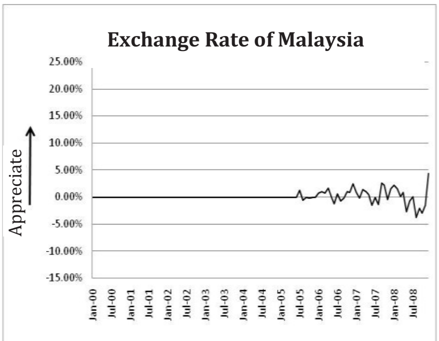
Appendix 1 Flow Chart of VAR or VECM Analysis.

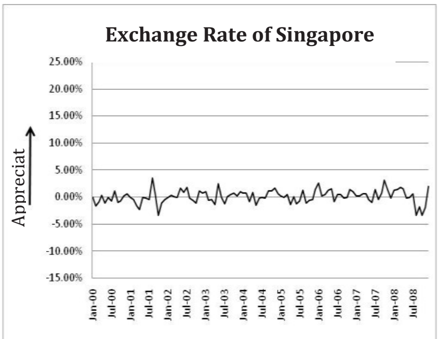


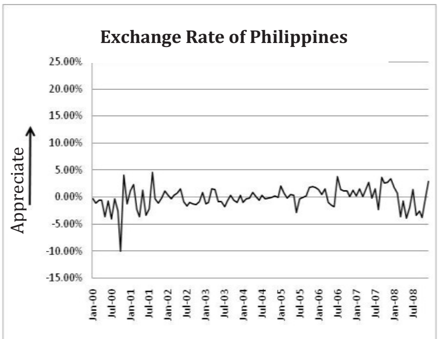
Appendix 2 Descriptive Statistics of ASEAN+6 Exchange Rates (%).

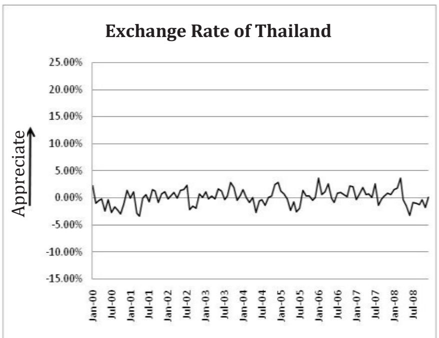
No	Country	Average	Minimum	Maximum	Standard Deviation
1	Indonesia	-0.314	-14.707	20.105	4.201
2	Malaysia	0.090	-3.732	4.431	0.977
3	Singapore	0.124	-3.345	3.513	1.210
4	Philippines	-0.131	-10.003	4.593	2.035
5	Thailand	0.092	-3.454	3.679	1.527
6	Vietnam	-0.155	-3.533	2.027	0.485
7	Cambodia	-0.069	-2.264	2.067	0.563
8	Laos	-0.082	-12.987	3.823	1.632
9	Japan	0.139	-4.331	5.600	2.390
10	China	0.178	-0.133	2.078	0.377
11	Korea	-0.034	-12.902	17.909	3.269
12	India	-0.090	-6.347	4.212	1.423
13	Australia	0.096	-15.891	6.323	3.196
14	New Zealand	0.139	-9.823	7.694	3.187

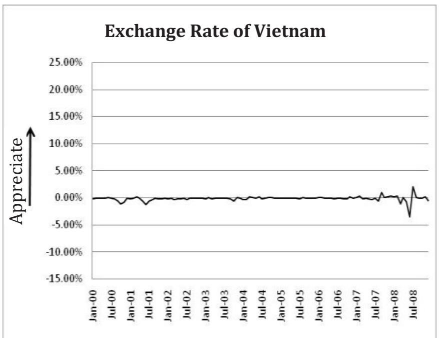
Appendix 3 Trend of the ASEAN+6 Exchange Rates

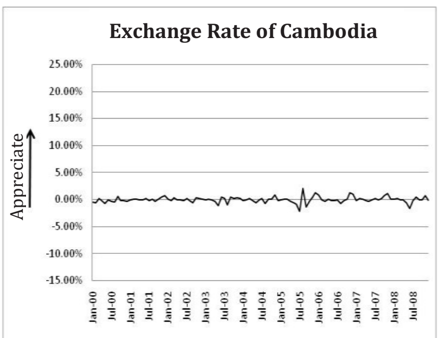


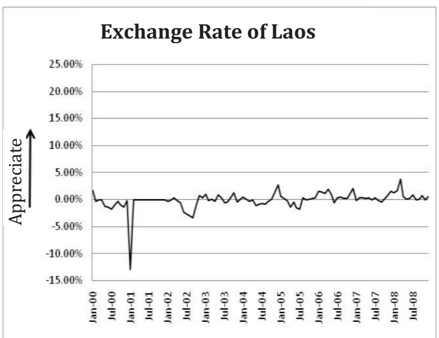


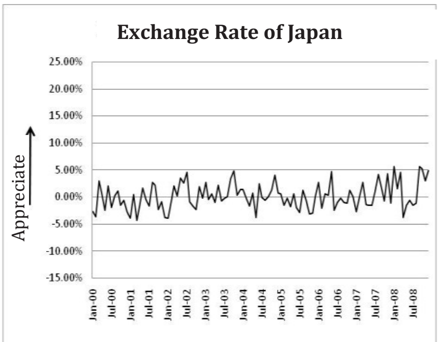











Exchange Rate of Japan
Appreciate
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
-5.00%
-10.00%
-15.00%
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
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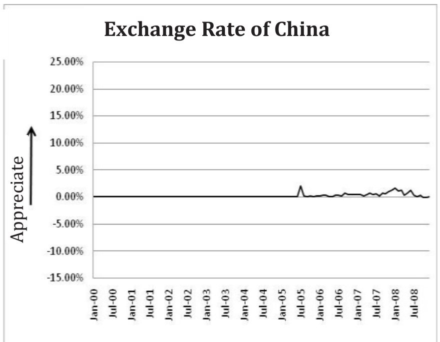
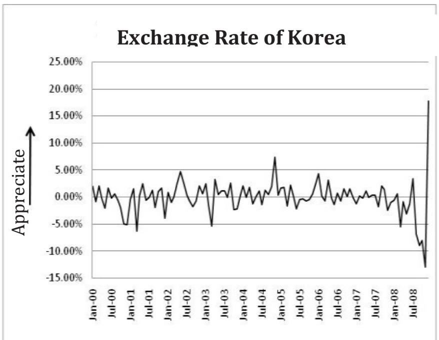
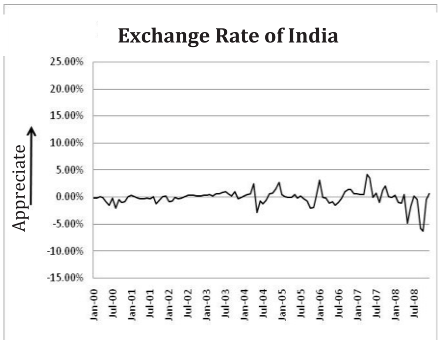
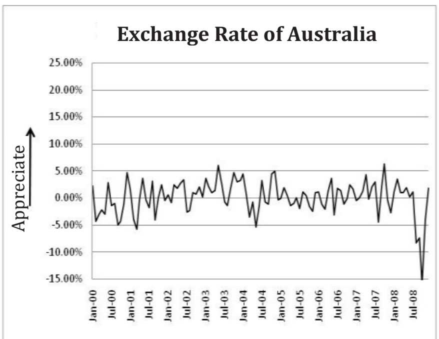
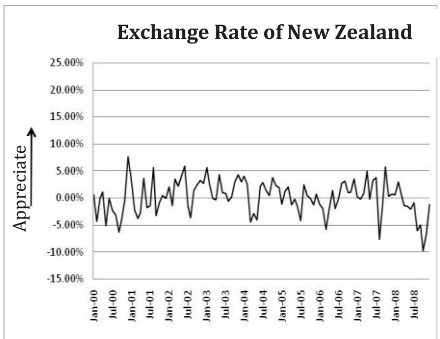

Exchange Rate of China
Appreciate


Exchange Rate of Korea
Appreciate


Exchange Rate of India
Appreciate


Exchange Rate of Australia
Appreciate


Exchange Rate of New Zealand
Appreciate

Appendix 4 Correlation among ASEAN+6 Exchange Rates

	Indo	Mal	Sing	Phi	Tha	Vie	Cam	Lao	Jap	Chi	Kor	Ind	Aus	Nz
Indo	1													
Mal	-0.043	1												
Sing	0.018	0.911*	1											
Phi	0.150	0.645*	0.516*	1										
Tha	0.178**	0.862*	0.947*	0.592*	1									
Vie	0.176**	-0.588*	-0.698*	0.152	-0.598*	1								
Cam	0.223*	-0.380*	-0.563*	0.268*	-0.444*	0.851*	1							
Lao	0.040	0.291*	0.212*	0.817*	0.291*	0.444*	0.493*	1						
Jap	0.097	0.245*	0.496*	0.175**	0.510*	-0.190*	-0.163**	0.272*	1					
Chi	-0.220*	0.907*	0.898*	0.571*	0.826*	-0.642*	-0.431*	0.341*	0.387*	1				
Kor	0.312*	0.555*	0.673*	0.263*	0.684*	-0.478*	-0.594*	-0.097	0.211*	0.348*	1			
Ind	0.227*	0.696*	0.723*	0.494*	0.763*	-0.349*	-0.344*	0.153	0.371*	0.495*	0.783*	1		
Aus	0.209*	0.665*	0.839*	0.151	0.838*	-0.768*	-0.725*	-0.176**	0.489*	0.602*	0.800*	0.776*	1	
Nz	0.192*	0.565*	0.750*	-0.003	0.745*	-0.811*	-0.762*	-0.358*	0.423*	0.508*	0.758*	0.694*	0.973*	1

Note : (*) significant at α = 5 %
(**) significant at α = 10 %

Appendix 5 The AIC, SC and Coefficient of Determination at the First Lag

Model	Akaike Information Criterion	Schwarz Criterion	R^2
Indo, ACU, US Dollar, Euro	-28.48100	-27.98141	0.954053
Mal, ACU, US Dollar, Euro	-31.11575	-30.61615	0.957050
Sing, ACU, US Dollar, Euro	-31.35672	-30.85712	0.953910
Fil, ACU, US Dollar, Euro	-29.87608	-29.37648	0.957036
Tha, ACU, US Dollar, Euro	-30.44204	-29.94245	0.955092
Vie, ACU, US Dollar, Euro	-32.05824	-31.55865	0.955416
Cam, ACU, US Dollar, Euro	-31.80095	-31.30135	0.953854
Lao, ACU, US Dollar, Euro	-29.90237	-29.40277	0.954705
Jap, ACU, US Dollar, Euro	-29.10522	-28.60563	0.956993
Kor, ACU, US Dollar, Euro	-28.81231	-28.31271	0.954715
Chi, ACU, US Dollar, Euro	-33.08432	-32.58473	0.954094
Ind, ACU, US Dollar, Euro	-30.30869	-29.80909	0.954560
Aus, ACU, US Dollar, Euro	-29.18494	-28.68535	0.953864
Nz, ACU, US Dollar, Euro	-29.06778	-28.56819	0.954552

Appendix 6 Result of Johansen Cointegration Test

Rank	λ_{trace}	**Critical Value (5%)**
Indo, ACU, USD, Euro		
0	46.64166	47.85613
1	24.63013	29.79707
2	7.510649	15.49471
3	0.043494	3.841466
Mal, ACU, USD, Euro		
0	38.60792	47.85613
1	20.79516	29.79707
2	5.915911	15.49471
3	0.872011	3.841466
Sing, ACU, USD, Euro		
0	37.78240	47.85613
1	17.13571	29.79707
2	6.525310	15.49471
3	0.050508	3.841466
Phi, ACU, USD, Euro		
0	56.12025	47.85613
1	25.54700	29.79707
2	5.649375	15.49471
3	0.108565	3.841466
Tha, ACU, USD, Euro		
0	41.91968	47.85613
1	15.31504	29.79707
2	7.989733	15.49471
3	1.435593	3.841466
Vie, ACU, USD, Euro		
0	50.00117	47.85613
1*	21.44482	29.79707
2	8.185035	15.49471
3	1.561551	3.841466
Cam, ACU, USD, Euro		
0	36.76991	47.85613
1	18.10819	29.79707
2	6.191718	15.49471
3	0.352932	3.841466

Rank	λ_{trace}	**Critical Value (5%)**
Lao, ACU, USD, Euro		
0	58.89951	47.85613
1	30.39794	29.79707
2*	12.85954	15.49471
3	0.294620	3.841466
Jap, ACU, USD, Euro		
0	36.44368	47.85613
1	15.93044	29.79707
2	3.783029	15.49471
3	0.070545	3.841466
Kor, ACU, USD, Euro		
0	32.30180	47.85613
1	15.16439	29.79707
2	6.443466	15.49471
3	0.042205	3.841466
Chi, ACU, USD, Euro		
0	61.81246	47.85613
1*	26.17734	29.79707
2	12.34751	15.49471
3	1.011927	3.841466
Ind, ACU, USD, Euro		
0	37.29049	47.85613
1	18.23316	29.79707
2	8.179547	15.49471
3	0.593806	3.841466
Aus, ACU, USD, Euro		
0	45.79360	47.85613
1	23.11905	29.79707
2	6.340328	15.49471
3	0.437020	3.841466
Nz, ACU, USD, Euro		
0	43.80712	47.85613
1	20.09695	29.79707
2	7.581558	15.49471
3	0.280989	3.841466

Note:
(*) cointegrated at $\alpha = 5$ %

Appendix 7 Forecast Error Variance Decomposition Result of Each ASEAN+6 Countries

Period	Country	ACU	US Dollar	Euro
INDONESIA				
1	100	0	0	0
6	98.08656	0.588888	1.069074	0.25548
12	89.63605	3.466202	5.112977	1.78477
18	73.94729	9.070997	11.40418	5.57754
24	53.82972	16.1345	18.28957	11.74621
30	35.2954	22.12102	23.90521	18.67838
36	22.78015	25.4921	27.4615	24.26626
MALAYSIA				
1	100	0	0	0
6	94.59516	0.002568	3.760982	1.641289
12	63.58695	0.00335	24.64084	11.76886
18	23.38822	0.002732	50.70055	25.90849
24	11.26124	0.010608	57.72823	30.99992
30	13.26235	0.021278	55.71437	31.002
36	17.11337	0.030393	52.7582	30.09804
SINGAPORE				
1	100	0	0	0
6	98.39707	0.127243	1.276074	0.19961
12	92.43253	0.256881	6.624321	0.686268
18	81.50632	0.240818	17.16979	1.083072
24	65.69832	0.183275	33.01267	1.105735
30	47.38282	0.217166	51.58096	0.819054
36	31.62318	0.369776	67.19758	0.809464
PHILIPPINES				
1	100	0	0	0
6	80.63438	1.193125	16.61785	1.55465
12	33.04371	1.285086	48.23425	17.43696
18	20.03806	5.835692	40.91501	33.21123
24	25.12962	9.302244	26.994	38.57414
30	29.60152	10.75708	18.88397	40.75743
36	32.11873	11.16885	14.52516	42.18726
THAILAND				
1	100	0	0	0
6	98.00189	0.065689	1.539022	0.393398
12	91.74759	0.09479	6.498613	1.659007
18	82.80268	0.074355	13.89749	3.225478
24	72.40575	0.078224	23.16848	4.347545
30	60.86803	0.177695	34.54166	4.412608
36	47.42863	0.478944	48.57872	3.513707

Appendix 7. (Continued)

Period	Country	ACU	US Dollar	Euro
VIETNAM				
1	100	0	0	0
6	95.41427	1.184642	2.692157	0.708935
12	68.57351	3.846797	25.1996	2.380101
18	33.93238	5.849365	53.91961	6.298648
24	15.10984	6.353011	69.37758	9.159566
30	8.423682	6.190865	74.7803	10.60515
36	6.874395	5.883756	75.96191	11.27993
CAMBODIA				
1	100	0	0	0
6	95.85608	0.155812	2.299946	1.688162
12	85.10185	0.501619	7.107818	7.288717
18	74.27595	0.970387	8.792859	15.9608
24	61.67439	2.047864	7.689605	28.58814
30	40.0069	4.579902	13.29581	42.11738
36	16.54161	7.634542	30.20122	45.62263
LAOS				
1	100	0	0	0
6	77.60545	10.14403	11.18071	1.069811
12	65.37778	12.59768	20.02906	1.995488
18	51.84233	12.47016	27.6139	8.073607
24	37.97558	11.16911	33.26756	17.58776
30	26.68206	9.564093	36.53237	27.22147
36	18.92775	8.186033	37.99436	34.89186
JAPAN				
1	100	0	0	0
6	78.0489	2.99656	9.417939	9.536598
12	35.37682	7.311962	29.5253	27.78592
18	15.9638	8.088726	40.53393	35.41354
24	10.05079	7.71218	45.13541	37.10161
30	8.494497	7.331324	47.06337	37.11081
36	8.145712	7.117323	47.8895	36.84746
KOREA				
1	100	0	0	0
6	95.22456	1.994808	2.526967	0.253665
12	77.75511	10.0706	10.00258	2.171711
18	53.11298	21.72926	17.88344	7.274322
24	30.94426	31.50246	22.46756	15.08572
30	16.23745	36.79504	23.64954	23.31797
36	8.252281	38.55582	23.11808	30.07381

Appendix 7. (Continued)

Period	Country	ACU	US Dollar	Euro
CHINA				
1	100	0	0	0
6	90.30536	4.865403	0.13843	4.690811
12	84.08552	9.823926	0.184917	5.905632
18	79.56935	13.67925	0.22503	6.52637
24	76.0346	16.77621	0.257614	6.93158
30	73.21819	19.27914	0.283752	7.218916
36	70.94172	21.32102	0.304863	7.432403
INDIA				
1	100	0	0	0
6	65.8378	1.189424	24.85902	8.113753
12	16.39771	5.736176	54.55881	23.30731
18	3.331663	9.034838	57.10584	30.52765
24	0.964946	10.72608	54.16936	34.13961
30	0.64611	11.52502	51.60445	36.22442
36	0.660851	11.87878	50.02548	37.43488
AUSTRALIA				
1	100	0	0	0
6	89.66807	1.521316	8.742562	0.068053
12	64.06366	11.1847	21.00432	3.747312
18	34.29983	25.25867	23.7325	16.709
24	14.81244	33.16919	19.89798	32.12039
30	6.489703	34.89671	16.01195	42.60164
36	3.544572	34.47226	13.76928	48.21389
NEW ZEALAND				
1	100	0	0	0
6	80.75736	5.16439	12.98869	1.089561
12	39.74913	16.0844	36.2978	7.868673
18	14.48093	21.14806	46.3469	18.02411
24	4.620969	21.32418	47.44359	26.61126
30	1.407486	20.11949	46.1991	32.27392
36	0.433514	19.01593	44.99614	35.55442