Empirical Analysis of Optimum Currency Area in East Asia

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1. Introduction

In recent years, it has become more recognized in East Asia that monetary and financial cooperation is necessary for preventing and managing future currency crises. The governments of East Asian countries have come to take a positive stance for regional financial cooperation since they experienced the Asian currency crisis in 1997. The monetary authorities of ASEAN plus three (Japan, China, and Korea) established a network of swap agreements among them under the Chiang Mai Initiative (CMI). They decided to develop the CMI at the ASEAN plus three Financial Ministers' Meeting in Istanbul in May of 2005.

Once a currency crisis happens, the CMI is expected to work as a "crisis management" method. However, it is not designed for any "crisis prevention" and does not have a deterrent effect. For possible financial and/or currency crises, countries should develop future regional monetary policy cooperation in the right direction for "crisis prevention."

Another remarkable development has occurred in the local bond markets in recent years after the "Asian Bond Market Initiative (ABMI)" was established by the ASEAN plus three Financial Ministers' Meeting in 2002. The experience from the Asian crisis has suggested that we should reduce "double mismatching" in terms of currency and maturity on the balance sheets of local financial institutions. Promoting securitization in the local financial transactions, and especially, developing the local bond markets should contribute to mitigating the maturity mismatching in borrowing from foreign countries and to preventing a possible future financial crisis that is deteriorated by a currency crisis. Cross-boarder transactions across local bond markets will also contribute to improved efficiency and further developments in regional bond markets. While some countries have begun to deregulate their capital accounts transactions in terms of the long-term capital inflows, there still exist strict regulations against cross-boarder short-term financial transactions.

How should we prevent a possible crisis that is caused by a "currency mismatch" on the balance sheets? Obviously, the question is related to choosing a suitable exchange rate regime for each of economies. Our experience of the Asian currency crisis reminds us of the fact that the *de facto* dollar peg was inadequate for East Asian countries that have close economic relationships with not only the United States but also Japan, European countries, and intra-regional countries. It is clear that heavy reliance on the single currency peg exchange rate system caused the Asian currency and financial crises. East Asian countries should choose an adequate exchange rate system to prevent a possible currency crisis. However, there still exists a variety of exchange rate regimes in East Asia. For example, Japan and Korea are adopting a free-floating exchange rate system, while China and Malaysia had adopted a dollar-peg system before July in 2005. Although the two latter countries announced that they changed their exchange rate regime into a managed floating exchange rate system, they have kept a *de facto* dollar peg system (Ogawa and Sakane (2006), Ito (2005)).

The variety of exchange rate systems in East Asia means that there still exists a possibility of a coordination failure in choosing exchange rate regimes. The monetary authorities have been discussing monetary and financial cooperation in recent years. One measure to solve a coordination failure for this area is to adopt a "common" exchange rate policy. The coordination of their exchange rate policies and the related monetary policies will contribute to stabilizing intra-regional exchange rates among their currencies. The establishment of stable exchange rate linkage and the enhancement of a credibility of monetary policy in East Asia also will further promote regional economic integrations.

On the other hand, countries trying to adopt a common currency exchange rate policy should form an "Optimum Currency Area (OCA)". If countries try to adopt a common exchange rate policy, they should satisfy the conditions for "one-size fits all" monetary policy in the end. It means that they need to give up the independence of their monetary policy. In other words, the precondition for regional common exchange rate policy is that there should exist another channel among countries other than managing their exchange rates to adjust to the asymmetric response to the economic shocks. Therefore, the main purpose of this paper is to investigate whether East Asian countries meet the OCA criteria or not.

2. Theory of Optimum Currency Area

2.1. Conditions for a common currency area

Since the success of European monetary integration, great benefits from a single currency area have come into the limelight again. Policy makers of not only East Asian countries but also other regions have started to discuss about possibilities of creating a common currency area. Especially after the Asian currency crisis, the debates about the monetary integration have also become relevant to the regional monetary policy arrangements to prevent a future possible currency crisis.

One of the benefits of regional monetary integration is that it saves transaction costs associated with exchanges of different currencies.[1] Economic agencies need to spend transaction costs to exchange different currencies in a situation where they use their home currencies as a medium of exchange in a region. An international monetary unification would save this kind of transaction costs. Moreover, network externalities may exist in a sense that a currency as a medium of exchange function better when there are fewer currencies which economic agents uses as a medium of exchange. In other words, having fewer currencies in a region would make the currency more efficient as a value measure.

In the European experience before the introduction of the euro, the monetary authorities managed to link their own home currencies to the European Currency Unit (ECU) that is a regional currency unit for the EU countries. This implies that there is a possibility for the monetary authorities to realign exchange rates of the home currencies vis-à-vis a common currency unit, or to quit linking their home currencies to the common currency unit. These possibilities might induce speculators to make speculative attacks against weaker currencies. One option for the monetary authorities is to make strong commitments to link their own home currencies to the common currency unit. The strongest commitment would be to participate in a currency union where the monetary authorities of the participating countries have no option to leave such a union. This type of strongest commitment would contribute to stabilizing exchange rate regimes because the monetary authorities build up confidence from private economic agents. The monetary authorities can make the strong commitment to solve the so-called "peso problem," where the possibility of exchange rate collapse increases domestic interest rates in terms of their home currencies due to expected depreciation and risk premium. Accordingly, a currency union contributes to decreasing in domestic interest rates in terms of the home currencies.

On the other hand, economies would face losses to some extent in such a monetary union in joining a currency union. First, economies would face in costs related with asymmetric shocks. Once the regional monetary integration is achieved, each of member countries can no longer adjust to any asymmetric shocks by making realignments of exchange rates, because they have already abandoned their national currencies. Asymmetric shocks change their terms of trade among countries in a currency union. In this situation, the economies would be forced to adjust through changes of prices. Some countries would face deflationary pressures while other countries would face inflationary pressures. Especially, the deflationary countries would face reduction in Gross Domestic Products (GDP). This would, in turn, increase unemployment in the countries in a situation of international labor immobility and downward stickiness of wage rates.

The second cost of international monetary integration is that national central banks would be forced to give up their own seignorage, because their authorities are consolidated into a single central bank. This implies also that national central banks would forego their autonomy of monetary policy. It is true that countries and economies would not face any problems as long as a single unified central bank in a currency union conducts a monetary policy that is optimal for all of the participating countries. However, the unified central bank could not always conduct an optimal monetary policy for all of the participating countries in the cases where asymmetric shocks occur to the countries, or where domestic central banks have different objective functions in monetary policy. Moreover, there is no guarantee that a unified central bank agrees with all of the national central banks as for situations where it is needed to act as a lender of last resort. The unified central bank might take a negative stance about being the lender of last resort, if it regards disinflation as the most important objective of the monetary policy.

The third cost of monetary integration is that the monetary authorities of the participating countries are forced to give up monetary sovereignty as well. If a country participates in a currency union, its government will be forced to give up one of fiscal revenue sources because seignorage is one of its fiscal revenue sources. Governments in the member countries will face a redistribution problem of seignorage that a unified central bank obtains from each of domestic central banks. It may be possible to solve the problem of redistribution of seignorage among the governments of the participating countries through international coordination.

As mentioned above, trade-offs exist. In monetary integration, policymakers should balance the savings in transaction costs from the creation of single money against the consequences of diminished policy autonomy from losing the exchange rate and monetary policy as instruments to respond to economic shocks. How much cost each of the economies must pay for a possible monetary integration depends on the applicability of conditions for integration. However, if another adjustment process exists and it works well after the abolishment of national currencies, economies would not need to pay such costs as listed above.

An important aspect in this issue relates to the theory of "Optimum Currency Area" (OCA). The original concepts came from Mundell (1961). An OCA is a minimum economic unit composed of the countries whose currencies are tied with each other by fixed exchange rates. According to the optimum currency area theories, feasibility of a common currency area in a region depends on whether the region is an optimum currency area or not.

It is pointed out that there exist some factors that determine an optimum currency area. Mundell (1961) itself pointed out that mobility of labor and other factors including capital, as a necessary condition for a common currency area. Labor and other factors of production flowing freely allow being countries affected symmetrically by disturbances. McKinnon (1963) regarded openness of economy as another necessary condition. Frankel (1999) suggests that a high degree of capital mobility, instead of nominal exchange rates, allows asymmetric shocks among countries to adjust their economies. Moreover, the fiscal transfer among countries to adjust out of the disequilibrium is essential to support the currency union. These conditions are regarded as necessary for the feasibility of a common currency area.

2.2. Empirical analysis on a feasibility of a common currency area

2.2.1. Structural VAR with Blanchard - Quah decomposition

2.2.1.1. Background

As discussed in the previous section, the two important criteria for the theory of "Optimum Currency Area" are the synchronization of the business cycles and high bilateral trade intensity in the region. Bayoumi and Eichengreen (1993) pointed out that the feasibility of a common currency area depends on whether countries share a symmetric response to economic shocks. Since the countries in the region do not need to make intra-regional adjustments for the economic shocks, they can form a common currency union that satisfies the condition for OCA. Especially, Bayoumi and Eichengreen focused on supply shocks by using the methodology of Blanchard and Quah (1989). In the following, the theoretical background to employ the Structural Vector Autoregressive (S-VAR) model is shown.[2]

Here, assuming that two countries (a home country and a foreign country) try to integrate their economies into one common currency union. The currency union is implemented by a single currency and a single monetary policy in the region. Although the assumption of perfect international capital mobility ties domestic rate of return of capital to the world interest rate, the interest parity includes the risk premium because yields on both governments' bonds are based on each country's credit risks. The two-country model is defined as follows:[3]

$$m_t - p_t = \varphi y_t - \alpha i_t + \varepsilon_{m,t} \tag{2.1}$$

$$y_t = \gamma(p_t^* - p_t) - \lambda(i_t - p_{t+1,t}^e + p_t) + \varepsilon_{d,t} \tag{2.2}$$

$$y_t = \bar{y} + \theta(p_t - p_{t,t-1}^e) + \varepsilon_{s,t} \tag{2.3}$$

$$m_t^* - p_t^* = \varphi^* y_t^* - \alpha^* i_t^* + \varepsilon_{m,t}^* \tag{2.4}$$

$$y_t^* = \gamma^*(p_t - p_t^*) - \lambda^*(i_t^* - p_{t+1,t}^{*\,e} + p_t^*) + \varepsilon_{d,t}^* \tag{2.5}$$

$$y_t^* = \bar{y}^* + \theta^*(p_t^* - p_{t,t-1}^{*\,e}) + \varepsilon_{s,t}^* \tag{2.6}$$

where m denotes the logarithm of nominal money supply, p denotes the logarithm of the price indices, i denotes the interest rate and y denotes the logarithm of the GDP in the home country. ε indicates the economic shock. Subscripts m, d, and s indicate the monetary shock, the demand shock, and the supply shock, respectively. Alphabets with asterisk indicate the variables of the foreign country and ones with superscript e indicate the expected values, respectively.

An equation of the interest rate parity with risk premium is defined as follows:

$$i_t - i_t^* = \frac{b_t - b_t^*}{\beta} - \frac{\sigma_t}{\beta} \tag{2.7}$$

$$\omega_t m_t + (1-\omega_t) m_t^* = \bar{m}_t \tag{2.8}$$

$$p_{t+1,t}^e \equiv E\left[p_{t+1} \middle| I_t \right] \tag{2.9}$$

where b denotes the logarithm of the home government's bond denominated in terms of its home currency, and b^* denotes that of the foreign government's bond denominated in terms of its foreign currency. σ indicates the risk premium, ω indicates the share of money circulating in the home country, and I_t shows the information set which is available at Time t.

Here, the changes in GDP in both countries in response to the monetary shock, ε_m, can be defined as follows:

$$\hat{y} = -\theta A \varepsilon_m = -\theta A \varepsilon_m^* \tag{2.10}$$

$$\hat{y}^* = -\theta^* A^* \varepsilon_m = -\theta^* A^* \varepsilon_m^* \tag{2.11}$$

where,

$$A \equiv \frac{\lambda(\theta^* + \gamma^* + \lambda^*) + \lambda^*(\gamma + \lambda)}{\alpha\Delta}, A^* \equiv \frac{\lambda(\gamma^* + \lambda^*) + \lambda^*(\theta + \gamma + \lambda)}{\alpha\Delta},$$

and

$$\Delta \equiv \begin{vmatrix} \theta + \gamma + \lambda\left(1 + \frac{1+\varphi\theta}{\alpha}\right) & -(\gamma+\lambda) & -\frac{\lambda}{\alpha} \\ \frac{\alpha^*(1+\varphi\theta)}{\alpha} & -(1+\varphi^*\theta^*) & -\left(1+\frac{\alpha^*}{\alpha}\right) \\ \frac{\lambda^*(1+\varphi\theta)}{\alpha} - \gamma^* - \lambda^* & \theta^* + \gamma^* + \lambda^* & -\frac{\lambda^*}{\alpha} \end{vmatrix} > 0.$$

Equations (2.10) and (2.11) indicate that responses to the monetary shock are symmetric between the two countries.

Second, the changes in GDP of both countries in response to the demand shock, ε_d, can be defined as follows:

$$\hat{y} = \theta\left\{\frac{(\alpha+\alpha^*)(\theta^*+\gamma^*+\lambda^*) + \lambda^*(1+\varphi^*\theta^*)}{\alpha\Delta}\right\}\varepsilon_d \tag{2.12}$$

$$\hat{y}^* = \theta^*\left\{\frac{(\alpha+\alpha^*)(\gamma^*+\lambda^*) - \lambda^*(1+\varphi\theta)}{\alpha\Delta}\right\}\varepsilon_d \tag{2.13}$$

As in the case of the monetary shock, the response to the demand shocks are symmetry from Equations (2.12) and (2.13).

Third, the changes in gross domestic products of both countries in response to the supply shock, ε_s, can be written as well. The supply shocks, here, imply the effects on the production function of shocks such as productivity shocks and oil price shocks. The responses can be defined as follows:

$$\hat{y} = \frac{(1+\varphi^*\theta^*)\left\{\lambda^*(\gamma+\lambda)+\lambda(\gamma^*+\lambda^*)\right\}+(\gamma+\lambda)\left\{\lambda^*+\theta^*(\alpha+\alpha^*)\right\}+(\theta^*+\gamma^*+\lambda^*)\lambda}{\alpha\Delta}\varepsilon_s \quad (2.14)$$

$$\hat{y}^* = -\theta^* \frac{(\alpha+\alpha^*+\lambda\varphi)\gamma^*+\lambda^*\left\{(\alpha+\alpha^*)+\varphi(\theta+\gamma+\lambda)-1\right\}}{\alpha\Delta}\varepsilon_s \quad (2.15)$$

The response to supply shocks in Equations (2.14) and (2.15) are asymmetric between the home country and the foreign country. It means that the two countries need policy adjustments.

2.2.1.2. Empirical model

Given that the natural unemployment hypothesis holds, supply shocks have a long-term effect on GDP while demand shocks do not. Here, the time series properties of both the supply and demand shocks are defined as follows:

$$\begin{bmatrix} \dot{y}_t \\ \dot{p}_t \end{bmatrix} = \sum_{i=0}^{\infty} L_i \begin{bmatrix} a_{11} & a_{12i} \\ a_{21} & a_{22i} \end{bmatrix} \begin{bmatrix} \varepsilon_{d,t} \\ \varepsilon_{s,t} \end{bmatrix} \quad (2.16)$$

where $\dot{y}$ denotes a rate-of-change in GDP, $\dot{p}$ denotes a rate-of-change in price index, and L denotes the lag operator. Then, short-term effects of the demand shock are included as the restrictions in the VAR model as below:

$$\sum_{i=0}^{\infty} a_{11i} = 0 \quad (2.17)$$

Therefore, the VAR model is defined as follows:

$$\begin{aligned} \begin{bmatrix} \dot{y}_t \\ \dot{p}_t \end{bmatrix} &= B_1 \begin{bmatrix} \dot{y}_{t-1} \\ \dot{p}_{t-1} \end{bmatrix} + B_2 \begin{bmatrix} \dot{y}_{t-2} \\ \dot{p}_{t-2} \end{bmatrix} + \cdots + B_n \begin{bmatrix} \dot{y}_{t-n} \\ \dot{p}_{t-n} \end{bmatrix} + \begin{bmatrix} e_{yt} \\ e_{pt} \end{bmatrix} \\ &= \begin{bmatrix} e_{yt} \\ e_{pt} \end{bmatrix} + D_1 \begin{bmatrix} e_{yt-1} \\ e_{pt-1} \end{bmatrix} + D_2 \begin{bmatrix} e_{yt-2} \\ e_{pt-2} \end{bmatrix} + D_3 \begin{bmatrix} e_{yt-3} \\ e_{pt-3} \end{bmatrix} + \cdots \end{aligned} \quad (2.18)$$

where Vector $\left(e_{y,t}, e_{p,t}\right)'$ indicates residuals in the VAR model.

Here, it is assumed that the product of the orthogonal matrix defines the vector of the residuals in the VAR model, $\mathbf{C}$ and Vector$\left(\varepsilon_{d,t}, \varepsilon_{s,t}\right)'$, as follows:

$$\begin{bmatrix} e_{yt} \\ e_{pt} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_{dt} \\ \varepsilon_{st} \end{bmatrix}.$$

Then, the restrictions are summarize as follows

$$\sum_{i=1}^{\infty} \begin{bmatrix} d_{11i} & d_{12i} \\ d_{21i} & d_{22i} \end{bmatrix} \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} = \begin{bmatrix} 0 & \cdot \\ \cdot & \cdot \end{bmatrix}. \quad (2.19)$$

By identifying the supply shock to each of countries in a region, we can investigate whether countries share the symmetric responses or not.

2.2.1.3. Applying the S-VAR approach to European countries

Applying the S-VAR approach to Asian countries Bayoumi, Eichengreen, and Mauro (2000) apply the structural VAR model to analyze whether the East Asian region is a OCA or not. Table 2-1 shows the results of their empirical analysis. While identifying the economic shocks in each of economies, the correlation coefficients for the magnitude of response to the shocks are relatively higher among Malaysia, Indonesia, and Singapore. Also, correlation is higher between Singapore and Thailand. They conclude that these ASEAN countries might be able to form a common currency area. Supply shocks in Japan have positive correlation with Taiwan, Korea, and Australia. However, it has lower correlation with ASEAN countries except for Thailand.

Sato, Zhang, and Mcaleer (2001) also used a similar VAR approach investigate correlation relationships in some economic shocks among the East Asian countries. Their recent works focus more on the short-term synchronization of business cycles among countries

2.2.2. Enders and Hurn's (1994) G-PPP approach

2.2.2.1. Background

Enders and Hurn (1994) first developed the Generalized Purchasing Power Parity (G-PPP) model. It extends from a simple Purchasing Power Parity (PPP) model by taking into account difficulties in maintaining PPP because frequent occurred nominal and real shocks continuously affect macro-economic fundamentals. Price levels in foreign countries may have effects on domestic price levels because intermediate goods are imported from abroad. Therefore, Enders and Hurn argue that, even in the long run, changes in a bilateral exchange rate depend not only on changes in the relative prices between the related two countries but also on those in relative prices among other foreign countries.

As Mundell (1961) pointed out, such countries as have close economic relationships with each other can share factor mobility in their national income processes. With real exchange rates defined as a function of countries' income process, the real exchange rates among countries will be highly correlated. Therefore, Enders and Hurn (1994) considered that countries which satisfy the criterion for the optimum currency area should share a common stochastic trend because output shocks have a symmetrical effect on the real exchange rates. The existence of a common stochastic trend will bring into a constant relationship among currencies in the economic area. Such a stable relationship will help the monetary authorities keep their exchange rates fixed. Ultimately, these countries can abandon their national currencies and adopt a single currency into the region. Therefore, the area composed of these countries can be regarded as an optimum currency area.

2.2.2.2. Empirical Model

Here, assuming that an economic area which consists of m small countries, where these countries are geographically located near each other and are expected to form economic area. A large country, Country $m+1$, is located outside this economic area. The large country has a strong influence on trade and capital transactions among countries in the economic area. In addition, each of the monetary authorities in the economic area links its own home currency to an anchor currency. Under the perfect capital mobility, each of the countries faces the given world real interest rate.

In a situation of market clearing, aggregate supplies and aggregate demands are equal to each other. Because international trade and capital transactions have effects on aggregate demands, aggregate demands in one country depend on incomes in the other countries, real exchange rates of the home currency vis-à-vis the other countries, and the real interest rate. Accordingly, aggregate demands in each country can be written as a function of incomes in the other countries, real exchange rates of the home currency vis-à-vis the other currencies, and the world real interest rate. Here,

$$y_{j,t} = \sum_{i=1}^{m+1} \theta_{j,i} y_{i,t} + \sum_{i=1, i \neq j}^{m+1} \eta_{j,i} re_{j,i,t} - \tau_j i_t \, , \; j = 1, \cdots, m+1 \tag{2.20}$$

where y_j is logarithm of GDP in Country j, $re_{j,i}$ is logarithm of real exchange rate of Country j's currency vis-à-vis Country i's currency, θ is a propensity to import from Country j, η is a price elasticity of demand, and τ is responsiveness of aggregate demands to interest rate. In addition, it is assumed that each of the real exchange rate series is non-stationary.

It is known that a real exchange rate of Currency j vis-à-vis Currency i should be constant if the PPP holds between both currencies. However, the real exchange rate will fluctuate when asymmetric real shocks affect relative price of their products and, in turn, their output. If occurrence of shocks follows a stochastic process, the time series property of their real exchange rates should be non-stationary.

Now assume that there exists a real shock in Country 1. The real exchange rates of Currency 1 vis-à-vis the numéraire currency, Currency $m+1$, fluctuate because of the shocks. The real shocks in Country 1 are likely to spill over to other countries ($j = 2, \ldots, m$) that have close economic relationships with Country 1. It follows that real shocks in Country 1 affect real exchange rates of other currencies vis-à-vis the anchor currency. Thus, the spillover effects can be shown as follows;

$$re_{m+1,1} = b_{m+1,2}re_{m+1,2} + b_{m+1,3}re_{m+1,3} + \cdots + b_{m+1,m}re_{m+1,m} + \varepsilon_t \qquad (2.21)$$

where b is a coefficient of real exchange rate comovements and ε is a disturbance term, or a white noise.

There is a constant relationship of a common trend among the real exchange rate movements that were caused by the shocks. We can rewrite Equation (2.21) to obtain the following equation:

$$\beta_{m+1,1}re_{m+1,1} + \beta_{m+1,2}re_{m+1,2} + \beta_{m+1,3}re_{m+1,3} + \cdots + \beta_{m+1,m}re_{m+1,m} = 0\,, \beta \cdot RE_t = 0 \qquad (2.22)$$

where RE is a $m \times 1$ vector which consists of bilateral real exchange rates re.

Each factor in RE is supposed to be a non-stationary time series. However, this vector is cointegrated by each factor of β vector, so that non-stationary real exchange rates are combined to form a stationary relationship in the long run. Equation (2.20) can be transformed into the following equation in terms of vectors:

$$RE_t = AY_t \qquad (2.23)$$

where Vector Y is $(m+1)\times 1$ which consists of aggregate demands of each country, and Matrix A is $m \times (m+1)$ which depends on parameters, θ, η, and τ.

In Equation (2.23), factors of Vector RE are co-integrated. According to Stock and Watson (1988), Equation (2.20) can be converted to an equation that includes factors that have $m+1$ common trends as shown in the following equation:

$$Y_t = \delta\phi_t \qquad (2.24)$$

where δ is an $(m+1)\times(m+1)$ matrix and each of its factors is non-stationary, and ϕ is $m+1$ vector that contains non-stationary stochastic trends. Substituting Equation (2.24) into Equation (2.23), the real exchange rate can be defined as follows;

$$RE_t = A\delta\phi_t \qquad (2.25)$$

From Equation (2.25), it is clear that the real exchange rates depend on common trends of income process.

To detect cointegrating relationships, the Johansen methodology [Johansen and Juselius, 1990] is employed to test a long run relationship that is shown in Equation (2.22). Here, the error correction model (ECM) to detect the long-term relationship among the real exchange rates is defined as follows:

$$\Delta RE_t = \sum_{i=1}^{T} \Gamma_1 \Delta RE_{t-1} + \Pi RE_{t-1} + \varepsilon_t\,, \quad \Pi = \alpha\beta \qquad (2.26)$$

where a product of non-stationary Vector RE_t and Matrix Π must be stationary as well as other terms in the right-hand side equations, if it contains cointegrating vectors.

2.3. S-VAR vs. G-PPP

Mundell (1961)'s original development in the OCA theory explained that the region could be called the 'Optimum Currency Area' if there is factor mobility, and that one region should be separated from another region which share no factor mobility. In his original work, however, there is no detailed discussion about adjustment speeds toward an equilibrium. Therefore, it is still ambiguous whether the condition for OCA should be satisfied in the short run or in the long run.

The G-PPP approach is based on the cointegration analysis which takes a similar approach to the S-VAR model in the terms of the econometrics. However, in employing each of the time series approaches, an underlying assumption for the feasibility of the common currency area is different between the two models.

Bayoumi and Eichengreen (1993) and Bayoumi, Eichengreen, and Mauro (2000) focused only on symmetry of economic shocks among the countries in the region. Their S-VAR approach is implemented by comparing the fluctuation patterns of economic shocks. However, the symmetry of supply shocks is only a sufficient condition for an optimum currency area. It is true that asymmetric shocks will cause a disturbance in forming a currency union or in supporting the fixed exchange rate system. Nevertheless, other factors, such as factor mobility, economic openness to the other country, capital mobility, and so on, can remedy disequilibrium caused by these asymmetric shocks. Therefore, broader conditions for the OCA should exist, other than the condition of the symmetry of economic shocks. As long as these factors work well in the region, this criterion may not be a necessary and sufficient condition for implementing a common currency area.

As shown in the previous section, the original G-PPP theory developed by Enders and Hurn (1994) is based on the income process which is expected to share common shocks, where each of the elements in the cointegrating vector is defined as a log of the real output of each country. Since the G-PPP model described in the previous section or their original model does not allow for the nominal rigidities in the long run and all shocks are deemed to be permanent, the cointegrating relationship detected by the G-PPP approach is considered as a long-term equilibrium. This long-term relationship can also be regarded as the outcome of adjustment by the openness of the economy to foreign countries [McKinnon, 1963], the capital mobility [Frankel, 1999], or the factor mobility [Mundell, 1963]. Therefore, the equilibrium detected by the G-PPP approach can be regarded as a broader condition for the optimum currency area, which is an advantage over the feasibilities assumed in Bayoumi and Eichengreen (1993) and Bayoumi, Eichengreen, and Mauro

(2000).

In transitions toward equilibrium, the monetary authorities need to make policy coordination if adjustment process by the factor mobility is expected to be very slow and the nominal rigidities exist in the short run. Note that these total costs should not exceed the total benefit achieved from monetary integration in the long run. Since Mundell first developed the OCA theory, a lot of literature has discussed its criteria and has developed methodologies for empirical analysis. Bayoumi and Eichengreen (1993) and Bayoumi, Eichengreen, and Mauro (2000) have applied the Structural VAR approach assuming that the feasibility of a common currency area depends on whether countries share the symmetry of economic shocks or not. On the other hand, Enders and Hurn (1994) has employed the G-PPP approach assuming the feasibility of a common currency area depends on whether countries share common stochastic trends among their exchange rate.

An important aspect to address the issue regarding whether countries would meet OCA criteria or not depends on the assumption that researcher made. As for coverage of a single currency area, strict criteria may define that the countries should be included in the single currency area without any payment any additional costs to adjust asymmetric economic shocks in the region. However, if countries are allowed to pay related expenditures or losses as initial costs and opportunity costs to join a single currency, while adjustment process can take some time, broader condition should be adopted as the OCA criteria.

3. G-PPP Approach to the OCA

3.1. PPP Puzzle

The Purchasing Power Parity (PPP) is one of the most basic factors of exchange rate determination. Cross-boarder arbitrage of commodity makes a law of one price, under which prices of one commodity are the same across the boarder. The law of one price enables to determine the equilibrium level of the exchange rate between two countries in the long run. However, since a great number of empirical results from tests of the PPP for the post-Bretton-Woods period have shown that real exchange rates might follow a random walk, the PPP seems to be considered not to hold in the post-Bretton-Woods period. As Rogoff (1996) pointed out, international goods markets are not as highly integrated as domestic goods market, making the PPP theory a “puzzling theory.” Therefore, one can ask, what are the conditions for the international goods markets to be as highly integrated as domestic markets? This issue should be related to the theory of “Optimum Currency Area.”

Rogoff (1996) also pointed out, “Although we had arrived at the consensus that real exchange rates tend to converge toward a PPP in the long run, the observed enormous short-term volatility of the real exchange rate does not reconcile with the extremely slow rate of convergence supported by the empirical analysis." Indeed, the puzzle is that the half-life of the deviation from the PPP seems to be much longer than can be explained by the nominal rigidity of goods prices in the real economy. Hence, it seems that the slow rate of adjustment toward the long-term mean of the difference of prices or inflation between two countries may be caused by other factors.

The original theory of PPP was developed by Cassel (1921, 1922) and is one of the most well known theories that explain how exchange rates between two countries are determined. The key concept of this theory is the law of one price, as pointed out above. According to the PPP theory, a ratio of purchasing powers between two countries determines an exchange rate of these currencies. It is called as the absolute version of PPP. Cassel also developed the relative-version of PPP in terms of rates-of-change of variables, which suggests that the change in a bilateral exchange rate corresponds to differentials of inflation rates in the two countries. The relative version of PPP enables us to calculate the PPP by taking into account fixed transaction costs which include transportation costs and tariffs.

The clear concept of Cassel's works has been open to discussion and adopted into many cases. As Balassa (1964) and Samuelson (1964) pointed out, a currency of a country with higher growth rate of productivity should be undervalued due to higher inflation rates of non-traded goods especially when we calculate the purchasing power parity between a developed country currency and a developing country currency. The under-valuation of the PPP of the currency with higher growth rate of productivity is called the "Balassa-Samuelson effects."

The effects can be easily confirmed by introducing non-tradable goods or services in the traditional two-country and two-commodity model. According to Obstfeld and Rogoff (1996)[4], we assume that a small economy produces two composite goods: tradable goods and non-tradable goods. Labor can move instantaneously between the two sectors of tradable and non-tradable goods with in the economy. This assumption of labor mobility ensures an identical wage level in both of the sectors. Also, it is assumed that there exists perfect international capital mobility and perfect price flexibility.

The representative firms in Country i produce both goods and they maximize their profits. The present-value profits of each sector are defined as follows:

$$\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}\left[P_{T,s}\cdot A_{T,S},F\left(K_{T,s},L_{T,s}\right)-W_s L_{T,s}-\Delta K_{T,s+1}\right] \qquad (3.1)$$

and

$$\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}\left[P_{N,s}\cdot A_{N,s}, G\left(K_{N,s}, L_{N,s}\right)-W_s L_{N,s}-\Delta K_{N,s+1}\right] \qquad (3.2)$$

where P_T and P_N are the price of tradable goods and nontradable goods, respectively. A_T and A_N are the productivity level in the tradable sector and the nontradable sector, respectively. K_T and K_N represent capital stocks in the tradable sector and the nontradable sector, respectively. L_T and L_N are labor forces in the tradable sector and nontradable sector, respectively. Labor mobility enables the wages set at the same level, W, between both the sectors. The first order conditions for the profit maximization in both sectors are given as follows;

$$P_T\cdot A_T\cdot f'\left(k_T\right)=r \qquad (3.3)$$

$$P_T\cdot A_T\cdot\left[f\left(k_T\right)-f'\left(k_T\right)k_T\right]=W \qquad (3.4)$$

$$P_N\cdot A_N\cdot g'\left(k_N\right)=r \qquad (3.5)$$

$$P_N\cdot A_N\cdot\left[g\left(k_N\right)-g'\left(k_N\right)k_N\right]=W \qquad (3.6)$$

where r presented the interest rate given by the world capital market, and $k=K/L$.

Rewriting $k_T\left(r,A_T\right)=f'^{-1}\left(r/A_T\right)$ in Equation (3.3) and substituting $k_T\left(r,A_T\right)$ into k_T, Equation (3.4) tell us that a wage rate W should be a function of r and A_T, that is, $W\left(r,A_T\right)$;

$$W\left(r,A_T\right)=A_T f\left[k_T\left(r,A_T\right)\right]-rk_T\left(r,A_T\right) \qquad (3.7)$$

From the above equation, it is confirmed that the wage level in the home country depends on the interest rate and productivity level in the tradable sector. Here, the interest rate r is assumed as an exogenous variable for the small open economy. Substituting (3.4) and (3.6) into (3.3) and (3.5), respectively, the following two equations are derived;

$$P_T\cdot A_T f\left(k_T\right)=rk_T+W, \qquad (3.8)$$

$$P_N\cdot A_N g\left(k_N\right)=rk_N+W. \qquad (3.9)$$

Taking natural logs and differentiate these equations, the following two equations are derived, respectively;

$$p_T+a_T=\pi_{LT}\cdot w \qquad (3.10)$$

$$p_N+a_N=\pi_{LN}\cdot w \qquad (3.11)$$

where let $x\equiv d\log X=dX/X$ for any variables X. Also let $\pi_{LT}\equiv(W\cdot L_T)/\left(P_T\cdot Y_Y\right)$ and $\pi_{LN}\equiv(W\cdot L_N)/\left(P_N\cdot Y_N\right)$ be labor's share of the income generated in the tradables and nontradables sectors, respectively.

Substitute $w=\left(p_T+a_T\right)/\pi_{LT}$ from Equation (3.10), define the relative price as $P=P_N/P_T$, and set the price of tradable goods as a unity ($P_T=1$), then the relative price changes of nontradables in terms of tradables in the domestic market is give as follows;

$$p = \frac{\pi_{LN}}{\pi_{LT}} \cdot a_T - a_N . \tag{3.12}$$

Equation (3.12) suggests that the relative price changes in the domestic country depend on the ratio of the share of the income generated in the tradable sectors to nontradables and the productivity level in both of the sectors. As long as the inequality $\pi_{LN}/\pi_{LT} \geq 1$ holds, faster productivity growth in tradables sector than in nontradables sector gradually push the price of nontradables upward over time.

Here, two small countries (Country 1 and 2) are introduced to define the real exchange rate. The price indices in Country 1 and 2 can be shown using Equation (3.12), respectively;

$$\overline{p}_1 = (1-\gamma)p_1 = (1-\gamma)\left(\frac{\pi_{LN}}{\pi_{LT}} \cdot a_{T,1} - a_{N,1}\right) \tag{3.13}$$

$$\overline{p}_2 = (1-\gamma)p_2 = (1-\gamma)\left(\frac{\pi_{LN}}{\pi_{LT}} \cdot a_{T,2} - a_{N,2}\right) \tag{3.14}$$

where $\overline{p} = \gamma p_T + (1-\gamma)p_N$ and γ denotes the weight of the prices of tradables in the price index, $\overline{p}$. If the exchange rate between Country 1 and Country 2 is determined according to the relative PPP, the real exchange rate change, $re_{1,2}$, can be defined as follows;[5]

$$re_{1,2} = \overline{p}_2 - \overline{p}_1 = (1-\gamma)(p_2 - p_1) = (1-\gamma)\left[\frac{\pi_{LN}}{\pi_{LT}} \cdot (a_{T,2} - a_{T,1}) - (a_{N,2} - a_{N,1})\right] \tag{3.15}$$

where both countries' sector outputs are proportional to the same production functions $F(\cdot)$ and $G(\cdot)$, and weight γ and μ are also the same in both countries. Again, as long as the inequality $\pi_{LN}/\pi_{LT} \geq 1$ holds, faster productivity growth in tradables sector than in nontradables sector still will push the price of nontradables upward over time in each domestic market. While the two countries have same productivity growth in tradable sector, differentials in productivity growth rate in nontradable sector between the two countries causes inflation differentials between the two countries. It will push the relative PPP.

As long as both of the countries have the same growth rate of productivity in the tradable sectors as well as in the nontradable sectors with similar economic structures, the nominal exchange rate would be equal to the relative PPP. It means that, if the relative PPP holds and the real exchange rates are constants over time, the two countries can fix their exchange rate. Therefore, the condition for the PPP to hold between the two countries is regarded as a sufficient condition for the OCA.

3.2. Relationship between the PPP and the OCA

Next, three countries are assumed to exist in the world: two small countries (Country 1 and Country 2) and one large country (Country 3). Country 1 and Country 2 are also small enough that those of technology growth rates do not affect the Country 3's technology growth. The two small countries have similar economic structures, and both of the countries have the same production functions, $F(\cdot)$ and $G(\cdot)$, and the same productivity growth rate, $\tilde{a}_T$ and $\tilde{a}_N$, because Country 1 and 2 share labor mobility and capital mobility. Accordingly, under perfect flexible price setting, the exchange rate between the two countries satisfies the relative PPP.

Country 1 and 2 trade with Country 3 but do not share labor mobility with Country 3. Also, although the productivity growth rates in tradable sectors are identical among all the three countries through arbitrage, the growth rate in nontradables in Country 3 is different from that of Country 1 or Country 2. Here, defining the productivity growth rate at Time t in tradable sectors in all three countries as $\tilde{a}_{T,t} = \mu + \varepsilon_{T,t}$, that of nontradable in Country 1 and Country 2 as $\tilde{a}_{N,t} = \mu + \varepsilon_{N,t}$, and that of nontradable in Country 3 as $a_{N,3,t} = a_{N,3,t-1} + \varepsilon_{N,3,,t}$, where each series, ε_T, ε_N, and $\varepsilon_{N,3}$ denotes white noise, each of price indices at Time t is defined as follows;

$$\overline{p}_{1,t} = (1-\gamma_1)p_{1,t} = (1-\gamma_1)\left(\frac{\pi_{LN,1}}{\pi_{LT,1}}\cdot \tilde{a}_{T,t} - \tilde{a}_{N,t}\right) = \Gamma_1\left[\Pi_1\left(\mu+\varepsilon_{T,t}\right) - \left(\mu+\varepsilon_{N,t}\right)\right] \quad (3.16)$$

$$\overline{p}_{2,t} = (1-\gamma_2)p_{2,t} = (1-\gamma_2)\left(\frac{\pi_{LN,2}}{\pi_{LT,2}}\cdot \tilde{a}_{T,t} - \tilde{a}_{N,t}\right) = \Gamma_2\left[\Pi_2\left(\mu+\varepsilon_{T,t}\right) - \left(\mu+\varepsilon_{N,t}\right)\right] \quad (3.17)$$

$$\overline{p}_{3,t} = (1-\gamma_3)p_{3,t} = (1-\gamma_3)\left(\frac{\pi_{LN,3}}{\pi_{LT,3}}\cdot \tilde{a}_{T,t} - a_{N,3,t}\right) = \Gamma_3\left[\Pi_3\left(\mu+\varepsilon_{T,t}\right) - (a_{N,3,t-1}+\varepsilon_{N,3,t})\right] \quad (3.18)$$

where $\Gamma_i = 1-\gamma_i$ and $\Pi_i = \pi_{LN,i}/\pi_{LT,i}$.

Here, the real exchange rates among the three countries can be defined as follows;

$$re_{1,2} = \Gamma_2\left(\Pi_2\tilde{a}_T - \tilde{a}_N\right) - \Gamma_1\left(\Pi_1\tilde{a}_T - \tilde{a}_N\right) = \left(\Gamma_2\Pi_2 - \Gamma_1\Pi_1\right)\varepsilon_{T,t} - \left(\Gamma_2 - \Gamma_1\right)\varepsilon_{N,t} \quad (3.19)$$

$$re_{1,3} = \Gamma_3\left(\Pi_3\tilde{a}_T - a_{N,1}\right) - \Gamma_1\left(\Pi_1\tilde{a}_T - \tilde{a}_N\right) = \left(\Gamma_3\Pi_3 - \Gamma_1\Pi_1\right)\varepsilon_{T,t} - \Gamma_3\left(a_{N,3,t-1} + \varepsilon_{N,3,t}\right) + \Gamma_1\varepsilon_{N,t} \quad (3.20)$$

$$re_{2,3} = \Gamma_3\left(\Pi_3\tilde{a}_T - a_{N,3}\right) - \Gamma_2\left(\Pi_2\tilde{a}_T - \tilde{a}_N\right) = \left(\Gamma_3\Pi_3 - \Gamma_2\Pi_2\right)\varepsilon_{T,t} - \Gamma_3\left(a_{N,3,t-1} + \varepsilon_{N,3,t}\right) + \Gamma_2\varepsilon_{N,t} \quad (3.21)$$

As long as a similar economic structure between Country 1 and Country 2 assures that $\Gamma_1 = \Gamma_2$ and $\Pi_1 = \Pi_2$, the real exchange rate in Equation (3.19) can be constant over time and equal to zero at every time. Even if $\Gamma_1 \neq \Gamma_2$ and $\Pi_1 \neq \Pi_2$, the PPP holds in the case where the real exchange rates between Country 1 and Country 2 would be stationary over time. It means that the two countries can fix their nominal exchange rate under the perfect price flexibility. On the other hand, in Equations (3.20) and (3.21), the movements of exchange rates between Country 1 and Country 3 or between Country 2 and Country 3 also depend on the productivity growth rates in the nontradable sector in Country 3. In this case, the real exchange rates will change over time. Since the productivity growth rates in nontradable sector in Country 3 follows the random walk in this model, the real exchange rates in Equations (3.20) and (3.21) should be nonstationary. Thus, the PPP does not hold if the productivity growth rates in the nontradable sector in both of the countries are not equal to zero and a similar economic structure does not assures same weights parameters.

Therefore, under the perfect price flexibility, the exchange rates between Country 1 and Country 2 satisfy the PPP as a condition for "Optimum Currency Area." Countries can keep their nominal exchange rates fixed because there exists factor mobility between the countries. On the other hand, exchange rates between both the two countries and Country 3 do not satisfy the PPP. Neither of the two small countries can keep their nominal exchange rates against the currency of Country 3 because there exists no factor mobility between each of the two countries and Country 3. Therefore, Country 3 should be excluded from this regional fixed exchange rate system.

Here, each country's real effective exchange rates can be defined as follows;

$$ree_1 = \beta_{1,2} \cdot re_{1,2} + \beta_{1,3} \cdot re_{1,3} = \beta_{1,2}(re_{1,2} - re_{1,3}) + re_{1,3} = \beta_{1,2} \cdot re_{3,2} - re_{3,1} \qquad (3.22)$$

$$ree_2 = \beta_{2,1} \cdot re_{2,1} + \beta_{2,3} \cdot re_{2,3} = \beta_{2,1}(re_{2,1} - re_{2,3}) + re_{2,3} = \beta_{2,1} \cdot re_{3,1} - re_{3,2} \qquad (3.23)$$

$$ree_3 = \beta_{3,1} \cdot re_{3,1} + \beta_{3,2} \cdot re_{3,2} \qquad (3.24)$$

where $re_{j,k} = re_{j,n} - re_{k,n} = -re_{n,j} + re_{n,k}$. $\beta_{j,i}$ indicates Country j's trade weight on Country i in its total trade volume.

Equations (3.22), (3.23), and (3.24) can be summarized as matrix form as follows;

$$\begin{pmatrix} ree_1 \\ ree_2 \\ ree_3 \end{pmatrix} = \begin{pmatrix} -1 & \beta_{12} \\ \beta_{21} & -1 \\ \beta_{31} & \beta_{32} \end{pmatrix} \begin{pmatrix} re_{3,1} \\ re_{3,2} \end{pmatrix} \qquad (3.25)$$

All of the real effective exchange rates for the three countries can be defined by the linear combination of bilateral real exchange rates between Country 1 or 2 and Country 3. Since Country 1 and Country 2's real exchange rate is equal to zero or is stationary over time, the real effective exchange rates of the two countries should share a "common trend". However, the real effective exchange rates of Country 3 did not contain the "common trend" in Equation (3.25). Therefore, if there exists a "common trend of PPP" among the real effective exchange rates, then the relevant countries can satisfy the condition for "Optimum Currency Area."

3.3. Extended G-PPP for Real Effective Exchange Rate

Now, assuming that Country j has n countries as its trade partners and has strong trade relationships with m countries among them. The real effective exchange rates of Country j, ree_j, where countries $1, 2, \cdots, j, \cdots, m$ have the common trend while countries $m+1, \cdots, n$ do not share the common trend, can be defined with currency of country j as follows;

$$\begin{aligned} ree_j &= \xi_j \cdot (\rho_{j,1} re_{j,1} + \rho_{j,2} re_{j,2} + \cdots + \rho_{j,m} re_{j,m}) \\ &+ (1-\xi_j) \cdot (\rho_{j,m+1} re_{j,m+1} + \cdots + \rho_{j,n} re_{j,n}) \end{aligned} \quad (3.26)$$

where $re_{j,i}$ is the logarithm of the real exchange rate between Country i and Country j. The coefficients, $\rho_{j,i}$ ($\sum_{i=1,i\neq j}^{m} \rho_{j,i} = 1$, $\sum_{i=m+1}^{n} \rho_{j,i} = 1$), denote that Country j 's trade weights on Country i and ξ are the trade weights of a group of countries that share the common currency.[6]

Here, we focus on the part of real effective exchange rates, which are defined by $m-1$ trade partners who share the common trend with Country j and Country $m+1$ who does not share the common trend with country j. Equation (3.26) is rewritten as follows;

$$ree_j^{\xi} = \omega_{j,1} re_{j,1} + \omega_{j,2} re_{j,2} + \cdots + \omega_{j,m} re_{j,m} + \omega_{j,m+1} re_{j,m+1} \quad (3.27)$$

where the coefficients $\omega_{j,i} (\sum_{i=1,i\neq j}^{m+1} \omega_{j,i} = 1)$ denote the country j 's trade weights on Country i and Country $m+1$. Equation (3.27) is rewritten in terms of the currency of Country $m+1$ as follows:

$$\begin{aligned} ree_{j,t}^{\omega} &= \omega_{j,1}(re_{j,1,t} - re_{j,m+1,t}) + \cdots + \omega_{j,m}(re_{j,m,t} - re_{j,m+1,t}) + re_{j,m+1,t} \\ &= \omega_{j,1} re_{m+1,1,t} + \cdots + \omega_{j,m} re_{m+1,m,t} - re_{m+1,j,t} \end{aligned}$$

where $re_{j,k} = re_{j,n} - re_{k,n} = -re_{n,j} + re_{n,k}$. Each of real effective exchange rates of m countries in the region in terms of the currency of Country $m+1$ and a real effective exchange rate of Country $m+1$ in terms of the currency basket of m country currencies can be written as follows;

$$\begin{aligned} ree_{1,t}^{\omega} &= -re_{m+1,1,t} + \omega_{1,2} re_{m+1,2,t} + \cdots + \omega_{1,m} re_{m+1,m,t} \\ ree_{2,t}^{\omega} &= \omega_{2,1} re_{m+1,1,t} - re_{m+1,2,t} \cdots + \omega_{2,m} re_{m+1,m,t} \\ &\vdots \\ ree_{m,t}^{\omega} &= \omega_{m,1} re_{m+1,1,t} + \cdots + \omega_{m,m-1} re_{m+1,m-1,t} - re_{m+1,m,t} \\ ree_{m+1,t}^{\omega} &= \omega_{m+1,1} re_{m+1,1,t} + \cdots + \omega_{m+1,m-1} re_{m+1,m-1,t} + \omega_{m+1,m} re_{m+1,m,t} \end{aligned} .$$

These $m+1$ real effective exchange rates can be shown as Matrix Ω which defines the trade weights, and Vector **re** which includes m elements of the real exchange rate; $re_{m+1,i}$, as below;

$$\mathbf{ree}_t = \Omega \cdot \mathbf{re}_t \quad (3.28)$$

where

$$\underset{(m+1)\times m}{\Omega} = \begin{bmatrix} -1 & \omega_{1,2} & \cdots & \omega_{1,m-1} & \omega_{1,m} \\ \omega_{2,1} & -1 & \cdots & \omega_{2,m-1} & \omega_{2,m} \\ \vdots & \vdots & \cdots & \vdots & \vdots \\ \omega_{m,1} & \omega_{m,2} & \cdots & \omega_{m,m-1} & -1 \\ \omega_{m+1,1} & \omega_{m+1,2} & \cdots & \omega_{m+1,m-1} & \omega_{m+1,m} \end{bmatrix}$$

and Vector **ree** includes the $m+1$ real effective exchange rates.

Each of the real effective exchange rates is expected to include a common stochastic trend because the countries have strong trade relationships with each other and they tend to share common technologies.[7] It is assumed that the $m+1$ real effective exchange rates share a common stochastic trend. Using Stock and Watson's (1988) common trend representation for any cointegrated system, the vector **ree** which is characterized by m cointegrating relations can be described as the sum of a stationary component and a nonstationary component:

$$\mathbf{ree}_t = \mathbf{r\bar{e}e}_t + \mathbf{r\tilde{e}e}_t \qquad (3.29)$$

The stationary component $\mathbf{r\bar{e}e}_t$ is $E(\mathbf{r\bar{e}e}_t) = 0$ in this model since the logarithm of the real effective exchange rate can be expected to converge toward zero-mean in the long run. Therefore, the vector **ree** can only be described as the non-stationary component $\mathbf{r\tilde{e}e}$. By the definition of common trend in Stock and Watson (1988), the following equation is obtained:

$$\mathbf{ree}_t = \Phi \cdot \mathbf{w}_t \qquad (3.30)$$

where Φ is a $(m+1)\times(m+1)$ matrix. Vector $\mathbf{w}_t$ is the non-stationary stochastic trend which is characterized by a random walk. Substituting Equation (3.30) into Equation (3.28), then,

$$\Phi \cdot \mathbf{w}_t = \Omega \cdot \mathbf{re}_t\,. \qquad (3.31)$$

Here, the non-null matrix Ψ which is composed of $(m+1)\times(m+1)$ and is defined to obtain the following equation from Equation (3.31);

$$\Psi \cdot \Phi \cdot \mathbf{w}_t = \Psi \cdot \Omega \cdot \mathbf{re}_t\,. \qquad (3.32)$$

If there exists a nonzero $\mathbf{w}$ for which $\Psi \cdot \Phi \cdot \mathbf{w}_t = 0$, $\Psi \cdot \Phi$ does not have a full rank. The rank condition will be expected as follows:

$$\text{rank}(\Psi \cdot \Phi) = \text{rank}(\Phi) < m\,.$$

As long as the rank condition holds, there exists a non-null matrix Ψ which satisfies the following equation;

$$\Psi \cdot \Phi = 0 \qquad (3.33)$$

When defining $Z = \Psi \cdot \Omega$ and substituting it into Equation (3.32), the following equation is obtained;

$$\mathrm{Z} \cdot \mathbf{re} = 0 \qquad (3.34)$$

If we could find a matrix Z, which satisfies $\mathrm{rank}(\mathrm{Z}) < m$ and Equation (3.34), it means that there exists nonzero $\mathbf{re}$ for $\mathrm{Z} \cdot \mathbf{re} = 0$ and that the matrix Ψ is not a null matrix. Accordingly, the number of rank Ω must be smaller than m. Here, it is assumed that $\mathrm{rank}(\mathrm{Z}) = 1$. Equation (3.34) can be shown as the following linear combination;

$$\zeta_1 \cdot re_{m+1,1} + \zeta_2 \cdot re_{m+1,2} + \cdots + \zeta_m \cdot re_{m+1,m} = 0 \qquad (3.35)$$

where this linear combination define that $m+1$ countries form a common currency area in terms of the currency of Country $m+1$ which is the same G-PPP model that Enders and Hurn (1994) developed.

The G-PPP model explains that a PPP holds if a linear combination of some bilateral real exchange rate series has equilibrium in the long run, even though each of the bilateral rate series is non-stationary. It is assumed that this linear combination defines the optimum currency area in the sense of Mundell (1961).

3.4. Anchor currency and the G-PPP

As shown in Mundell (1961), the idea of the optimum currency area works best if each economy has "internal" factor mobility and "external" factor immobility. To adjust the external disturbance coming from factor immobility and to assure the balance-of-payments equilibrium, the exchange rates between the insider currency and the outsider currencies need to be flexible.

Since the common currency area is evaluated by the exchange rates in the G-PPP model, the currency of Country $m+1$ in Equation (3.35) as a numéraire should be able to define a boundary between the internal factor mobility and the external factor immobility properly. The relative prices to the standardized international market will help explain external trends and to distinguish them from "internal unique trends." To define the currency area in terms of normalized goods internationally, we may be able to use the key currency as a numéraire currency. Using the US dollar, Equation (3.35) can be written as:

$$\zeta_1 \cdot re_{US,1} + \zeta_2 \cdot re_{US,2} + \cdots + \zeta_m \cdot re_{US,m} = 0 \qquad (3.36)$$

This linear combination is defined as "the currency area evaluated by the US dollar." If the countries have a large trade share with US, the US dollar as an anchor currency will be applicable to define the common currency area. It means that if countries in the area try to stabilize dollar-home currency real exchange rate to adopt it a target of their exchange rate policy, real exchange rates among countries will become stable.

4. Is East Asia an OCA?

4.1. A common currency basket system

Some empirical researches found that a currency basket system would contribute to stabilizing trade balances and capital flows for East Asian countries. Ito, Ogawa, and Sasaki (1998) estimated optimal weights on the US dollar and the Japanese yen in a currency basket, which stabilize trade balances for East Asian countries before the Asian currency crisis. Most of East Asian countries pegged their currencies to the US dollar before 1997. However, if East Asian countries had formed a regional monetary coordination by introducing a common regional currency unit, a desirable exchange rate policy for East Asian countries would have been a more flexible exchange rate system with reference to a currency basket which would have worked as a nominal anchor better than the US dollar.

This section investigates whether East Asia, especially the group of the ASEAN plus three (Japan, China, and Korea) countries is an OCA. Because East Asian countries have strong economic relationships with more than one specific country such as the United States, a currency basket system which is composed of several major currencies should be desirable for these economies rather than the dollar peg system.

As discussed in Section 3, it is important for the extended G-PPP model that a numéraire currency can define a boundary between the internal factor mobility and the external factor immobility properly. To define a possible currency area in terms of normalized goods internationally, a linear combination should be evaluated by the currency of the major trade partner. If countries have a common objective to stabilize trade balances by creating a common policy area, the choice of a numéraire currency in the extended G-PPP model equals the choice of a nominal anchor for monetary and exchange rate policy.

To address this issue, G-PPP model is extended to evaluate a common currency area by using the basket currency in this section. One of the advantages of the G-PPP approach over the S-VAR approach is that we can compare some types of currency area with different major currency as an anchor currency.

Kawasaki (2005), Kawasaki and Ogawa (2006), and Ogawa and Kawasaki (2006, 2007) extended the Enders and Hurn (1994) G-PPP model by using the concept of a stochastic trend among the real effective exchange rates of countries in the common currency policy area. Here, the "extended G-PPP model" is used for the following analysis.

After the Asian Currency Crisis in 1997, it is said that some East Asian countries changed their exchange rate policy from the *de facto* dollar peg system to a currency basket system for a while. Each country makes reference to a currency basket that includes not only three major currencies, e.g. the US dollar, the euro, and the Japanese yen, but also other East Asian currencies. Here, we assume that a country adopts a basket currency as their target policy as did Ogawa and Kawasaki (2007).

In the case where an East Asian country adopts $m-1$; ($m>1$), neighboring countries' currencies and $h-m$; ($h>m$), major trading partners' currencies (such as the US dollar or other major currencies) into the basket currency as its target policy, Country i's reference rate can be expressed as

$$re_{CB,i} = \varphi_{1,i} \cdot re_{1,i} + \cdots + \varphi_{j,i} \cdot re_{j,i}, \sum_{i,j=1, i\neq j}^{h+1} \varphi_{j,i} = 1, \tag{4.1}$$

where h is the number of exchange rates which are included in the currency basket and m is the number of countries in the possible region of currency union.

Because $re_{i,k} = re_{i,j} - re_{k,j} = -re_{j,i} + re_{j,k}$, Equation (4.1) can be expressed in terms of the currency of the other country in the basket. We rewrite it in terms of the US dollar as

$$re_{CB,i} = \varphi_{1,i} re_{1,US} + \cdots + \varphi_{h,i} re_{h,US} + re_{US,i}. \tag{4.2}$$

Here, we presume that the monetary authorities in the seven East Asian countries adopt the currency basket as their exchange rate policy and use the same composition of the basket currency. The real exchange rates of each East Asian currency in terms of the basket currency can be rewritten as a general vector form.

$$\underset{(m\times 1)}{\mathbf{re}_{CB}} = \underset{(m\times h)}{\mathbf{F}} \cdot \underset{(h\times 1)}{\mathbf{re}_{US}} \tag{4.3}$$

Therein, $\mathbf{re}_{CB} = \left[re_{CB,1}, \cdots, re_{CB,m}\right]'$; vector $\mathbf{re}_{US}$ includes h number of exchange rates of each of the related currencies against the US dollar, $\mathbf{re}_{US} = \left[re_{1,US}, \cdots, re_{h,US}\right]'$, and

$$\underset{(m\times h)}{\mathbf{F}} = \begin{pmatrix} -1 & \varphi_{1,2} & \cdots & \varphi_{1,m} & \cdots & \varphi_{1,h} \\ \varphi_{2,1} & -1 & \cdots & \varphi_{2,m} & \cdots & \varphi_{2,h} \\ \vdots & \vdots & \ddots & \vdots & \cdots & \vdots \\ \varphi_{m,1} & \varphi_{m,2} & \cdots & -1 & \cdots & \varphi_{m,h} \end{pmatrix}.$$

If the monetary authorities in the region agree to peg their own currencies to the regional currency basket and intervene in foreign exchange markets to maintain stability of their intra-regional exchange rate, a long-term property of those real exchange rates should be stationary: $\mathbf{re}_{CB} = 0$.[8] Here, we define the non-null matrix, $\mathbf{Z}$, which is composed of $m \times m$; Equation (4.3) can be written to obtain the following equation.

$$\underset{(m\times m)}{\mathbf{Z}} \cdot \underset{(m\times h)}{\mathbf{F}} \cdot \underset{(h\times 1)}{\mathbf{re}_{US}} = 0 \tag{4.4}$$

If there exists a nonzero matrix, $\mathbf{Z}$, for which $\mathbf{Z}\cdot\mathbf{F}\cdot\mathbf{re}_{US} = 0$, then $\mathbf{Z}$ does not have a full rank. If we could find a matrix $\mathbf{Z}$ which satisfies $\text{rank}(\mathbf{Z}) < m$, there exists a nonzero $\mathbf{re}_{US}$ for $\mathbf{Z}\cdot\mathbf{F}\cdot\mathbf{re}_{US} = 0$ and matrix $\mathbf{Z}$ is not a null matrix. Accordingly, the number of rank $\mathbf{Z}$ must be smaller than m, which is a same logic of the rank condition of G-PPP theory in Kawasaki and Ogawa (2006). In the case of $\text{rank}(\mathbf{Z}) = 1$, there must exist only one cointegration relationship among real exchange rates, $\mathbf{re}_{US}$; then, the long-term equilibrium among the regional real exchange rates against the US dollar is defined as

$$\zeta_1 \cdot re_{US,1} + \zeta_2 \cdot re_{US,2} + \cdots + \zeta_h \cdot re_{US,h} = 0, \tag{4.5}$$

where ζ_i indicates the cointegrating vectors.

Here, partitioning vector $\mathbf{re}_{US}$ into the two groups of insider currencies and outsider currencies, and of both trade weights, matrix $\mathbf{F}$ can also be partitioned: the trade weights into the two matrixes for insider and outsider currencies, respectively. Consequently, Eq. (4.3) can be rewritten in a general form as

$$\underset{(m\times 1)}{\mathbf{re}_{CB}} = \underset{(m\times m)}{\mathbf{F}_1} \cdot \underset{(m\times 1)}{\mathbf{re}_1} + \underset{[m\times(h-m)]}{\mathbf{F}_2} \cdot \underset{[(h-m)\times 1]}{\mathbf{re}_2}, \tag{4.6}$$

where $\mathbf{F} = \begin{pmatrix}\mathbf{F}_1 & \mathbf{F}_2\end{pmatrix}$ and $\mathbf{re}_{US} = \begin{pmatrix}\mathbf{re}_1 & \mathbf{re}_2\end{pmatrix}'$.

Because matrix $\mathbf{F}_1$ has an inverse matrix, vector $\mathbf{re}_1$ would be solved using matrix $\mathbf{F}$ as follows.

$$\mathbf{re}_1 = \mathbf{F}_1^{-1} \cdot \mathbf{re}_{CB} - \mathbf{F}_1^{-1}\mathbf{F}_2 \cdot \mathbf{re}_2 \tag{4.7}$$

In Equation (4.7), $\mathbf{re}_1$ would be defined by $\mathbf{re}_2$, which means that real exchange rates among East Asian countries in the region would be defined by the currencies outside the region. Therefore, Equation (4.4) can also be rewritten as

$$\underset{(m\times m)}{\mathbf{Z}} \cdot \underset{(m\times h)}{\mathbf{F}} \cdot \underset{(h\times 1)}{\mathbf{re}_{US}} = \underset{(m\times m)}{\mathbf{Z}} \cdot \underset{(m\times m)}{\mathbf{F}_1} \cdot \underset{(m\times 1)}{\mathbf{re}_1} + \underset{(m\times m)}{\mathbf{Z}} \cdot \underset{[m\times(h-m)]}{\mathbf{F}_2} \cdot \underset{[(h-m)\times 1]}{\mathbf{re}_2} = 0. \tag{4.8}$$

If there exist several major currencies which dominate the exchange rates of regional currencies against the US dollar, such as the Japanese yen and the euro, these exchange rates against the US dollar are not included in vector $\mathbf{re}_1$ but in vector $\mathbf{re}_2$ in Equation (4.7). Although three major currencies dominate all regional currencies exogenously, the major currencies are not mutually cointegrated. For that reason, the minimum number of rank($\mathbf{Z}$) for which $\mathbf{Z}\cdot\mathbf{F}\cdot\mathbf{re}_{US}=0$ would be $h-m=2$. There should exist at least two cointegration relationships that are not overlapped between the yen-dollar and the euro-dollar exchange rates.

If Japan is included as a neighboring country and its exchange rate against the US dollar is included in vector $\mathbf{re_1}$, the minimum number of the rank condition would be $h-m=1$. The Japanese yen would serve as an endogenous variable in the cointegrating system as well as other Asian currencies and only the euro-dollar exchange rates would dominate all of regional currencies exogenously.

4.2. Empirical analysis

4.2.1. Methodology

For this empirical analysis, a dynamic OLS (DOLS) is used to estimate the cointegrating vector. We rewrite Equation (4.5) as follows.

$$re_{US,EU} = \beta_1 \cdot re_{US,1} + \beta_2 \cdot re_{US,2} + \cdots + \beta_m \cdot re_{US,m} + \beta_{JP} \cdot re_{US,JP} \tag{4.9}$$

Equation (4.13) represents the long run relationship whose coefficient can be estimated using the OLS. To estimate it, we add the leads and lags, deterministic trend, and constant term into Equation (4.13) as shown below.

$$\begin{aligned} re_{US,EU} =& \beta_0 + \beta_1 \cdot re_{US,1,t} + \beta_2 \cdot re_{US,2,t} + \cdots + \beta_m \cdot re_{US,m,t} + \beta_{JP} \cdot re_{US,JP,t} \\ &+ \sum_{i=1}^{m} \sum_{j=-k}^{k} \gamma_{i,j} \Delta re_{US,i,t+j} + \beta \cdot t + u_t \end{aligned} \tag{4.10}$$

Then, the property of the residuals by the DOLS estimates is

$$\hat{u}_t = \phi_1 \cdot \hat{u}_{t-1} + \phi_2 \cdot \hat{u}_{t-2} + \phi_3 \cdot \hat{u}_{t-3} + \cdots + \phi_p \cdot \hat{u}_{t-p} + e_t, \tag{4.11}$$

where the sample distribution will be adjusted as

$$\hat{\sigma}'_u = \hat{\sigma}_u / (1 - \phi_1 - \phi_2 - \phi_3 - \cdots - \phi_p)\,. \tag{4.12}$$

In our earlier works, we could find several linear combinations which had cointegration relationships while we set the basket weight on three major currencies in advance. In this paper, basket weights on the anchor currencies, which include the US dollar and the euro, will be set by the estimation. The more countries adopt the common currency basket exchange rate policy, the less robust result we had with small sample by using the Johansen approach.

In this paper we use the dynamic OLS (DOLS) to estimates the cointegrating vector. We rewrite Equation (3.35) as follows:

$$re_{US,EU} = \beta_1 \cdot re_{US,1} + \beta_2 \cdot re_{US,2} + \cdots + \beta_m \cdot re_{US,m} + \beta_{JP} \cdot re_{US,JP} \tag{4.13}$$

Equation (4.13) is the long-term relationship to estimate by the OLS. To estimate it, we add the leads and lags, deterministic trend, and constant term into Equation (4.13) as follows:

$$\begin{aligned} re_{US,EU} = {} & \beta_0 + \beta_1 \cdot re_{US,1,t} + \beta_2 \cdot re_{US,2,t} + \cdots + \beta_m \cdot re_{US,m,t} + \beta_{JP} \cdot re_{US,JP,t} \\ & + \sum_{i=1}^{m} \sum_{j=-k}^{k} \gamma_{i,j} \Delta re_{US,i,t+j} + \beta \cdot t + u_t \end{aligned} \tag{4.14}$$

Then, the property of the residuals by the DOLS estimates is show as follows:

$$\hat{u}_t = \phi_1 \cdot \hat{u}_{t-1} + \phi_2 \cdot \hat{u}_{t-2} + \phi_3 \cdot \hat{u}_{t-3} + \cdots + \phi_p \cdot \hat{u}_{t-p} + e_t \tag{4.15}$$

Where the sample distribution will be adjusted as follows:

$$\hat{\sigma}'_u = \hat{\sigma}_u / (1 - \phi_1 - \phi_2 - \phi_3 - \cdots - \phi_p) \tag{4.16}$$

We attempt to estimate the cointegrating vector with endogenous weights in the common currency basket. In this paper, we test the following combinations, ASEAN 5, ASEAN 5 + Korea, ASEAN 5 + China, and ASEAN 5 + Korea + China for $r = 2$, and ASEAN 5 + Japan, ASEAN 5 + Korea + Japan, ASEAN 5 + China + Japan, and ASEAN 5 + Korea + China + Japan for $r = 1$.[9] We assumed serial correlation of residuals was captured by an $AR(4)$, and leads and lags was $k = 2$ in Equation (4.14).

4.2.2. Data

The sample period for our empirical tests covers the period between January 1987 and March 2007. Our sample includes data for the period of the Asian currency crisis. We divide the sample period into two sub-sample periods which can be characterized as a "pre-crisis" period from January 1987 to June 1997 and a "post-crisis" period from January 1998 to March 2007. Eight East Asian countries are included: Korea, Singapore, Malaysia, Thailand, the Philippines, Indonesia, China, and Japan. Their major trading partners include the EU and the US. The real exchange rates were based on monthly data of nominal exchange rates and consumer price indices of the related countries.[10] We calculated the prior euro for estimation before the 1997 crisis.[11] These data were referred from the IMF *International Financial Statistics* (CD-ROM).[12] Before estimating coefficients in Equation (4.14), the existence of at least one cointegrating relationship among the exchange rates of related currencies against the US dollar should be verified.[13] We conducted the Johansen test to detect the cointegrating relationship for the combination of regional countries: ASEAN 5 + Japan, ASEAN 5 + Japan + Korea, ASEAN 5 + Japan + China, and ASEAN 5 + Japan + Korea + China. The EU and the US were assumed to be their major trade partners.[14]

4.2.3. Analytical results

Table 4-1 shows the results of the trace test. Assuming a maximum of lags in VAR models as six lags in the effective sample period, we chose an adequate model for each of the VAR models.[15] We had a small finite sample in conducting the Johansen's ML approach; therefore, the critical value for the trace test was corrected following Johansen (2002). For the pre-crisis period of January 1987 to June 1997, we detected no cointegrating relationship for either of the combinations of ASEAN 5 + Japan or ASEAN 5 + Japan + Korea; the small sample corrected statistics in the trace test indicated the existence of two cointegrating relationships at most for the least of the combinations. For the post-crisis period of January 1998 to March 2007, the corrected test statistics indicated that there exists one cointegrating relationship at most among the related exchange rates for all combinations.

Table 4-2 presents the results of the DOLS for the pre-crisis period. We found no combinations for which all coefficients indicated a significant result among the variables for both rank conditions. Despite the significant test statistics for each of the second cointegrating vectors for the combination of ASEAN 5 + Japan + Korea, the existence of cointegrating vectors had already been rejected using the Johansen test. On the other hand, although there exist, at most, two cointegrating vectors among them for the combination of ASEAN 5 + Japan + Korea + China in Table 4-1, test statistics for some countries were not significant for any rank condition.

In most cases, for the pre-crisis period, the Japanese yen was excluded not only from a possible currency area but also from the reference of currency baskets as in the rank conditions $r = 1$ and $r = 2$. In addition, the euro was excluded as in $r = 2$. Consequently, the *de facto* dollar peg exchange rate system in East Asian countries might be synonymous with enormous fluctuations in their exchange rates against the Japanese yen and the euro.

Table 4-3 shows the DOLS result for the post-crisis period. For the combination of ASEAN 5 + Japan, all the test statistics for the rank condition of $r = 1$ were significant. On the other hand, once the Korean won and/or the Chinese yuan were included in the region, the test statistics for these two currencies were indicated as not significant. For the combinations of ASEAN 5 + Japan + Korea, ASEAN 5 + Japan + China, and ASEAN 5 + Japan + Korea + China, most of the test statistics for ASEAN 5 and Japan were indicated as significant. [16]

Table 4-3 shows mixed results for the possibilities of introducing a common currency policy into East Asia. However, East Asian countries including Japan seem to satisfy the conditions for optimum currency area in recent years. Although the test statistics reported in Table 4-3 were changed dramatically from those of the post crisis period shown in Table 4-2, these changes might be consistent with recent developments of economic integration in the region because East Asian countries have been deepening their mutual relationships in terms of international trade, foreign direct investment, and international finance during 1998–2007.[17]

4.3. Analytical results

In this section, we investigated possibilities of adopting a common currency basket peg arrangement into the ASEAN plus three. The DOLS is used to estimate the cointegrating vector for ASEAN plus three currencies with the currency basket of the US dollar and the euro as an anchor currency according to the extended G-PPP model. We obtained the analytical results that the Japanese yen should be included as an endogenous variable in the long-term relationship as well as other East Asian currencies while the Japanese yen worked exogenously as well as the US dollar and the euro in the system composed of the East Asian currencies. It implies that it is increasing the possibilities of success in adopting the common currency basket arrangement into the ASEAN plus three countries that include Japan. While our empirical result might not directly support the evidence of processing in an economic integration in East Asia, there exist a few empirical studies which have found positive evidences for the economic integration in East Asia recently.

5. Conclusion

It has become much more recognized in East Asia that regional monetary and financial cooperation is necessary for preventing and managing future currency crises after we experienced the 1997-98 Asian currency crisis. Furthermore, in recent years, the monetary authorities of the ASEAN plus three (Japan, China, and Korea) countries have started discussing the “Regional Monetary Unit” to stabilize their exchange rates and encouraging study of a possible common currency integration in East Asia. This issue is being studied and discussed by a Research Group under the ASEAN+3 Financial Ministers' Meeting.

A rationale for introducing the rigid regional exchange rate system into East Asia is to prevent a possible crisis. It is also true that a stable exchange rate system and a credible monetary policy will promote the regional transactions not only in financial market but also in product market, thus, enhancing the regional economy. However, there are three key issues that need to be addressed in efforts toward a possible economic integration in the region.

First, we should consider an optimal size of region that should adopt common regional monetary arrangements. Although the regional exchange rate policy coordination and its arrangements would contribute to reducing their exchange rate volatility and misalignments and to saving the intra-regional transaction cost to some extent, countries should satisfy the conditions for coordinated monetary policies. Thus, the question of the size of the area where coordinated monetary policies can be adopted is related to the theory of "Optimum Currency Area." There still exists room for careful applications into East Asian countries and extended areas (e.g. ASEAN 10 countries, ASEAN 10 plus three, or more or less?). Therefore, further investigation should be applied by using up-to-date econometric methodologies.

The second issue relates to what kind of exchange rate systems the countries should choose. After the Asian currency crisis, some of the East Asian countries seem to have given up adopting the *de facto* dollar peg and moved to the managed floating exchange rate system. However, it is true that there exists a "fear of floating" among the monetary authorities in the crisis-hit countries and their neighboring countries. As a result, there exist several kinds of exchange rate systems in East Asia. The "Regional Monetary Unit" in East Asia is expected to be a medium of exchange in the region, and the regional arrangements should be implemented by using this currency unit. However, such arrangements have not been designed yet. If an "Asian Monetary System" would be designed by following the European Monetary System, the regional monetary unit will follow the floating exchange rates system against the outside currencies. It is still doubtful that all the countries in the region agree to move to a floating exchange rate system against the currencies of their major trading partners outside the region. Therefore, both cost and benefit for each of countries to join the single monetary and exchange rate arrangement should be evaluated.

Third, we should consider how the countries should move to the possible monetary integrations in East Asia. As many have pointed out, the process of economic integration in East Asia would be quite different from the European experience as it is characterized by both real and monetary integration now developing in East Asia. In designing an international financial architecture for this area, an important aspect is that, in our economic theoretical and empirical analysis, we should consider factors that are specific to East Asia; its history, economic systems, and political environments. Findings from these studies would contribute to policy makers and their decisions in the early stage of integration.

In promoting a common currency union in East Asia, it is the most realistic to begin with efforts aimed at international currency cooperation to stabilize bilateral exchange rates among East Asian countries that share very strong economic relationship with each other. For this purpose, it is important that East Asian countries rapidly strengthen their economic relationships with the real economic aspects of other East Asian economies through intra-regional trade transactions and foreign direct investments. The strengthening relationships in real economy would give the governments of East Asian countries an incentive to stabilize bilateral exchange rates among East Asian currencies and to establish a foundation for a common currency in international trade and financial transactions among East Asian countries. Moreover, in recent years, world economy has a trend to make bilateral and regional free trade agreements along with the WTO system. Movements toward the free trade area contribute to elimination of some trade obstacles that includes tariffs and non-tariff barriers. However, economic agents would regard exchange rate risks as an important trade obstacle after they conclude free trade agreements with several countries. Even though we can use forward contracts to hedge exchange rate risk, we have to pay some costs for avoiding risk. In this situation we would face in increased necessity to eliminate exchange rate risks and the related transaction costs. Under the strong commitment of future keeping linking their home currencies against the trade partners' currencies, say, in the common currency union economic agents would not face in exchange rate risks.

The ASEAN countries had already concluded that the ASEAN Free Trade Area (AFTA) started from 2002. Also, some governments of East Asian countries, including Japan and Korea, are studying effects and feasibility of bilateral free trade agreements with other East Asian countries. The ASEAN countries, Japan, Korea, and China suggested establishing an East Asia Free Trade Area for the ASEAN + 3 (Japan, Korea, and China). Bilateral and regional free trade agreements are complementary to a multilateral trade arrangement represented by the WTO. It is expected that bilateral free trade agreements among East Asian countries would strengthen their trade relationships and capital relationships. Economic agents in East Asian countries should face in foreign exchange risk in their bilateral exchange rates that impede international trade transactions and direct investments, even after we remove tariff and non-tariff barriers under free trade agreements. The economic agents will have to cope with the foreign exchange risks.

The movements toward bilateral and regional free trade agreements might gain momentum to form a common currency area in East Asia if East Asian countries have an international coordination to stabilize bilateral exchange rates among the countries in the international monetary field. For example, if the free trade agreements include a clause that government and private sectors in East Asia should make efforts to use their own currencies in their trade and financial transactions, the clause might accelerate the departure from using exclusively the US dollar as a settlement currency in their transactions. Moreover, East Asian countries have another international monetary cooperation that they can try to create a foreign exchange market for East Asian currencies.

Thus, governments of East Asian countries should try to have bilateral and regional free trade agreements with many other countries in East Asia, including the international monetary cooperation that contributes to gaining momentum for forming a common currency area in East Asia. The free trade agreements are expected to contribute to movements toward an Asian currency union through strengthening trade and financial relationships among East Asian countries as well as through the direct international monetary cooperation.

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[1] De Grauwe(1992) summarized merits and demerits of international monetary integration.

[2] See detail of theoretical model in Ogawa (1999).

[3] The economic agents are assumed to behave the rational expectations.

[4] See Section 2 of Chapter 4 in Obstfeld and Rogoff (1996).

[5] In a general model, a real exchange rate is defined by $re_{j,i} = ne_{j,i} + p_i - p_j$, where ne denotes a nominal exchange rate. In Chapter 4 of Obstfeld and Rogoff (1996), the item used as a numéraire, therefore the real exchange rate can be defined by $re_{j,i} = p_i - p_j$

[6] Here, it is assumed that the shocks from the outside of common currency area affect the real effective rate of country j temporarily. In the case where only country j is permanently affected by the countries that do not adopt the common currency basket as an anchor currency, it is difficult to maintain a common currency in the region.

[7] Enders and Hurn (1994) developed the G-PPP model based on the real fundamental macroeconomic variables. They assumed that these variables shared common trends within a currency area.

[8]. Suppose that an $h \times 1$ vector: $\mathbf{re}_{US}$ is characterized by m cointegrating relations.

[9] When using the OLS approach to estimate the coefficients of variables, it should be assumed that related variables are cointegrated and have only one cointegration relationship. To assure this assumption, we should examine whether the related variables are cointegrated before we estimate the coefficients by the dynamic OLS. However, if we examine the combination of ASEAN5, Korea, China, and Japan, we need to include 9 variables in the error correction model. Small sample property and many endogenous variables in the error correction model in the Johansen approach will cause less robust results by the low degree of freedom. For the combinations tested here, the existence of the cointegration relationship among the variables have not been confirmed by the Johansen methods.

[10]. For the prior euro real exchange rates, we calculated a GDP-weighted average of the CPI.

[11]. The method of calculation of the prior euro is provided by the PACIFIC Exchange rate service of The University of British Colombia (http://fx.sauder.ubc.ca/).

[12]. Before the 1994 exchange rate unification, there existed a dual foreign exchange rate market in China. As described in Fernald, Edison, and Loungani (1999), 80% of transactions related to the Chinese exports were referred to the non-official, floating exchange rates; therefore, the effective nominal depreciation against to the US dollar was estimated as less than 7% while the official rate depreciated 35% at the 1994 reform. However, the swap date used in their paper was not

available to us. We use the official RMB exchange rate in IFS.

[13]. We conducted the unit root test as well and confirmed that all variables had a unit root.

[14]. See Johansen and Juselius (1990).

[15]. Following reduction of the number of lags, an adequate model of VAR is selected. The test of $H_{i,j} : VAR(i) < VAR(j)$ in lags is asymptotically distributed as χ^2 with $(j-i)p^2$ degrees of freedom.

[16]. When we extended the sample period from Ogawa and Kawasaki (2007), we obtained different results from those of our earlier work for the combinations including the Korean won and the Chinese yuan. Especially, in 2006.1–2006.12, the Japanese yen was depreciating dramatically against the other Asian currencies. It was still depreciating even in early 2007. Therefore, possible structural breaks or misalignments in the yen-dollar exchange rates might be suspected after 2005. If policymakers in the region seek to capture collective movements of exchange rates against the outside major currencies for monitoring purposes, a regional monetary unit, such as the AMU from RIETI or ACU from ADB, and its divergence indicator could be helpful for them to plan coordination of macro economic policies. It would be able to detect such misalignments easily.

[17]. Ogawa (2004) found that the linkages of the East Asian currencies with the US dollar have decreased since the Asian currency crisis.

Table 2-1: Correlation coefficients of responses to supply shock in 9 Asian Countries(1969-89)

	Malaysia	Indonesia	Singapore	The Philippines	Thailand	Hong Kong	Japan	Taiwan	Korea	Australia	New Zeland
Malaysia	1.00										
Indonesia	0.49	1.00									
Singapore	0.40	0.32	1.00								
The Philippines	0.05	0.16	0.01	1.00							
Thailand	0.02	0.16	0.33	0.14	1.00						
Hong Kong	0.12	0.40	0.42	0.00	0.33	1.00					
Japan	-0.02	0.03	0.02	0.03	0.32	-0.23	1.00				
Taiwan	0.00	0.32	0.42	0.15	0.54	0.40	0.23	1.00			
Korea	0.17	0.11	0.21	0.07	0.21	0.18	0.17	0.01	1.00		
Australia	0.00	0.14	0.08	-0.16	0.25	0.13	0.36	0.27	0.04	1.00	
New Zeland	0.04	0.22	0.19	-0.01	0.21	0.00	0.22	0.07	0.01	0.07	1.00

(Source) Bayoumi, Enchengreen, and Mauro (2000)

Table 4-1: Johansen tests

Combination	k	H_0	1987:1 - 1997:6 Eigen Vector	Trace	Small-sample corrected ††	k	1998:1 - 2007:3 Eigen Vector	Trace	Small-sample corrected ††
ASEAN5 + Japan	4	0	0.379	144.097 ***	119.177	6	0.476	183.733 ***	127.121 *
		1	0.209	85.976	71.853		0.339	116.466 ***	84.680
		2	0.181	57.306	47.162		0.229	73.389 **	53.768
		3	0.126	32.896	26.670		0.178	46.404	34.692
		4	0.073	16.507	14.185		0.135	26.060	14.602
		5	0.047	7.196	5.042		0.090	10.960	7.042
		6	0.011	1.380	1.154		0.011	1.183	1.144
ASEAN5+ Japan + Korea	6†	0	0.417	214.550 ***	153.251	4	0.568	236.877 ***	187.942 ***
		1	0.296	149.733 ***	105.875		0.406	147.836 ***	118.060
		2	0.265	107.638 ***	69.509		0.271	92.545 *	71.876
		3	0.197	70.724 *	41.811		0.160	59.104	45.294
		4	0.161	44.339	25.844		0.151	40.627	15.995
		5	0.113	23.252	19.449		0.108	23.247	12.894
		6	0.070	8.843	5.978		0.082	11.125	5.768
		7	0.001	0.081	0.056		0.019	2.072	1.191
ASEAN5+ Japan + China	6	0	0.376	234.181 ***	164.791 **	4	0.486	225.678 ***	172.497 ***
		1	0.318	177.685 ***	127.578 *		0.400	155.817 ***	114.290
		2	0.286	131.708 ***	86.229		0.278	102.244 **	74.068
		3	0.275	91.281 ***	61.320		0.199	68.034	48.396
		4	0.189	52.767 *	36.399		0.184	44.795	15.446
		5	0.123	27.629	19.796		0.132	23.386	10.809
		6	0.094	11.905	8.716		0.065	8.489	5.572
		7	0.001	0.076	0.065		0.013	1.426	1.349
ASEAN5+ Japan + Korea + China	4	0	0.423	287.505 ***	218.875 ***	4	0.621	312.906 ***	242.013 ***
		1	0.414	220.476 ***	170.768 ***		0.519	209.968 ***	158.892
		2	0.345	155.294 ***	121.739		0.294	132.424 **	102.052
		3	0.266	103.662 ***	82.286		0.275	95.578 *	71.592
		4	0.196	65.948 **	45.028		0.182	61.436	45.562
		5	0.164	39.267 *	24.752		0.144	40.168	18.110
		6	0.091	17.464	15.085		0.106	23.666	10.472
		7	0.042	5.805	3.555		0.083	11.739	4.634
		8	0.005	0.565	0.376		0.024	2.543	1.425

k: lag lengths Significance Level: *:5%, **:2.5%, ***:1%

†: Model includes following lags: (t-1), (t-2), (t-3), (t-4), (t-6)

††: The trace test statistics are correced. Small sample correction of trace test derived in Johanse (2002)

Table 4-2: DOLS estimation (pre crisis: 1987:1-1997:6)

Dependent variables	Explanetories							
	Japan (Yen)	Indonesia (Rupiah)	Malaysia (Ringgit)	The Philippines (Peso)	Singapore ($SG)	Thailand (Baht)	Korea (Won)	China (Yuan)
EU/US (rank=1)	0.0504 (0.29144)	-1.3721 (1.82888)	0.8183 (0.56962)	-0.4216 (0.41533)	-0.0654 (1.3852)	1.6692 (3.32783)		
EU/US (rank=2)		-1.1568 (1.08593)	0.7888 (0.50146)	-0.4154 (0.36426)	0.0645 (0.768)	1.3811 (2.13926)		
JP/US (rank=2)		4.9484 **** (1.02249)	0.2897 (0.47217)	-0.5560 (0.34297)	3.5966 **** (0.72313)	-7.7342 **** (2.01427)		
EU/US (rank=1)	-0.2682 (-0.21068)	-1.5716 (1.16027)	1.9836 **** (0.73461)	-0.7779 ** (0.37422)	0.2405 (0.86174)	1.4307 (2.07024)	0.7783 * (0.42252)	
EU/US (rank=2)		-2.4697 ** (1.1402)	1.5785 * (0.80725)	-0.5686 (0.40823)	-0.6075 (0.73546)	3.1595 (2.04327)	0.5770 (0.42189)	
JP/US (rank=2)		3.2139 **** (1.23539)	1.6754 * (0.87465)	-0.8696 ** (0.44231)	2.8813 **** (0.79686)	-5.8147 **** (2.21386)	0.9224 ** (0.45711)	
EU/US (rank=1)	-0.0010 (-0.3021)	-1.1859 (1.76589)	0.7663 (0.61289)	-0.3543 (0.49669)	0.0304 (1.53214)	1.2113 (3.34682)		-0.06734 (0.23699)
EU/US (rank=2)		-1.21459 (1.12852)	0.7264 (0.59198)	-0.3592 (0.46701)	-0.0206 (0.93581)	1.4384 (2.1195)		-0.0398 (0.22674)
JP/US (rank=2)		4.5865 **** (0.98017)	0.4826 (0.51417)	-0.7135 * (0.40562)	3.9728 **** (0.81279)	-7.8931 **** (1.84089)		0.1396 (0.19694)
EU/US (rank=1)	-0.3889 *** (-0.15503)	-0.6212 (0.87749)	2.8050 **** (0.56788)	-0.8306 **** (0.26485)	-0.3905 (0.68503)	0.7727 (1.55188)	1.6558 **** (0.39999)	-0.4308 **** (0.13656)
EU/US (rank=2)		-2.2022 *** (0.96165)	2.0096 **** (0.71425)	-0.4859 (0.34991)	-1.4654 * (0.80924)	3.4504 ** (1.73753)	1.1305 *** (0.47553)	-0.3418 * (0.20621)
JP/US (rank=2)		3.4246 **** (1.28042)	1.8693 *** (0.95101)	-0.8362 * (0.46589)	2.5550 *** (1.07749)	-5.9043 *** (2.31349)	1.1728 * (0.63315)	-0.1667 (0.27456)

†Significance level: *10%, **5%, ***2.5%, ****1%,

Table 4-3: DOLS estimation (post crisis: 1998:1-2007:3)

Dependent variables	Explanetories							
	Japan (Yen)	Indonesia (Rupiah)	Malaysia (Ringgit)	The Philippines (Peso)	Singapore ($SG)	Thailand (Baht)	Korea (Won)	China (Yuan)
EU/US (rank=1)	-0.4870 **** (-0.11463)	0.5547 **** (0.09789)	-3.9578 **** (0.57135)	-0.4810 *** (0.19682)	2.5703 **** (0.53181)	0.6959 *** (0.3102)		
EU/US (rank=2)		0.4760 **** (0.14048)	-4.0739 **** (0.82622)	-0.3420 (0.28478)	1.5982 *** (0.67329)	0.8585 * (0.45695)		
JP/US (rank=2)		0.2585 (0.22444)	0.3587 (1.32002)	-0.4088 (0.45499)	2.7218 *** (1.0757)	-0.4801 (0.73005)		
EU/US (rank=1)	-0.4761 **** (-0.12936)	0.5524 **** (0.11252)	-4.0564 **** (0.77148)	-0.4788 ** (0.21893)	2.5630 **** (0.5742)	0.7277 ** (0.36598)	0.0006 (0.16307)	
EU/US (rank=2)		0.4867 **** (0.14885)	-4.1562 **** (1.02341)	-0.3504 (0.31083)	1.6712 ** (0.76261)	0.8690 * (0.50949)	-0.0023 (0.1792)	
JP/US (rank=2)		0.3129 (0.2134)	-0.3899 (1.46722)	-0.2397 (0.44562)	1.9950 * (1.09331)	-0.1168 (0.73043)	-0.3262 (0.2569)	
EU/US (rank=1)	-0.4420 **** (-0.12243)	0.6132 **** (0.15405)	-3.9973 **** (0.55968)	-0.5036 *** (0.21976)	2.3582 **** (0.56572)	0.6190 * (0.32075)		0.51605 (0.93862)
EU/US (rank=2)		0.53401 **** (0.18884)	-4.0487 **** (0.73612)	-0.3490 *** (0.27394)	1.6418 (0.7075)	0.6943 (0.42625)		0.3555 (1.18235)
JP/US (rank=2)		0.4464 (0.28404)	0.0294 (1.10721)	-0.6215 (0.41204)	1.7910 * (1.06416)	-0.3737 (0.64114)		1.9056 (1.7784)
EU/US (rank=1)	-0.4156 **** (-0.1453)	0.6515 **** (0.18837)	-3.7729 **** (0.90923)	-0.6253 * (0.33186)	2.3243 **** (0.63645)	0.4893 (0.49874)	0.1242 (0.23921)	1.0989 (1.49397)
EU/US (rank=2)		0.5471 *** 0.22669	-4.1246 **** 1.01511	-0.3678 0.38812	1.6369 ** 0.7629	0.7293 0.57738	-0.0030 0.22904	0.4234 1.7553
JP/US (rank=2)		0.3136 0.32854	-0.5261 1.47117	-0.3158 0.56248	1.7326 1.10566	0.0201 0.83678	-0.2753 0.33195	0.3677 2.54391

†Significance level: *10%, **5%, ***2.5%, ****1%,