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Are the "ASEAN Plus Three" Countries Coming Closer to an OCA?[♣]

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Abstract

After the global financial crisis, it has become more recognized that the policy dialogues among both emerging and advanced economies on the exchange rate is necessary to prevent competitive devaluation. In this context, East Asian countries should also choose an adequate exchange rate system. However, there still exists a variety of exchange rate regimes in this area, which might suggest a possibility of coordination failure. To avoid this, the establishment of stable exchange rate linkages and the enhancement of monetary policy credibility in East Asia are needed. These discussions on common regional exchange rate policy are often related to the "Optimum Currency Area (OCA) theory" because stabilized exchange rates in the global economies are only assured by a "one size fits all" monetary policy in the end. Hence, the main purpose of this paper is to investigate whether East Asian countries—ASEAN5, China, Korea, and Japan—have developed into matching an OCA in recent years or not. While developing the earlier generalized purchasing power parity (G-PPP) model into an up-to-date non-linear econometric model and considering the adoption of the Asian monetary unit (AMU) into this area, this paper could have positive empirical results which suggest for forming a common currency in East Asia.

Keywords: OCA, Exchange rate, M-TAR, Co-integration with thresholds adjustment
JEL classification: F31, F33, F36

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1. Introduction

After the global financial crisis, it has become more recognized that the policy dialogues among both emerging and advanced economies about the exchange rate is necessary to prevent competitive devaluation. Regarding to the East Asian countries, as their lessons from the 1997-98 crisis, the *de facto* dollar peg was inadequate for the East Asian countries. The monetary authorities of the East Asian countries should choose an adequate exchange rate system not only to avoid the competitive devaluation, but also to prevent a possible currency crisis. Nonetheless, there seems still exist a fear of floating; hence, there still exists a variety of exchange rate regimes in East Asia.[i] The situation of the coordination failure in choosing adequate exchange rate regimes leads a monetary authority to commit a competitive devaluation as a beggar-my-neighbor policy. Therefore, the governments of East Asian countries should take further steps in the right direction of the regional financial cooperation from now onward.

After the 1997-98 crisis, 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) and elevated it up to the multiple agreement as the CMIM. To put teeth into the CMIM for the further role of crisis preventions, the exchange rate monitoring should be included for macroeconomic surveillance. Recently, the Asian monetary unit (AMU) has been developed and the AMU data and its deviation indicators are released from RIETI (Research Institute of Economy, Trade, and Industry, Japan). Such indicators expect to become a useful tool for an exchange rate monitoring and contribute to stabilize the exchange rates among the East Asian currencies. As proceeding economic dialogues among the East Asian countries for the economic/monetary cooperation, the establishment of stable exchange rate linkage and the enhancement of a credibility of monetary policy in East Asia are expected.

On the other hand, the concept of stable exchange rate networks in the region is often related to "Optimum Currency Area (OCA) theory." Strong linkage of stabilized exchange rates among the advanced global economies with the liberalized financial market are only assured by "one-size fits all" monetary policy in the end. A simple question will arise whether the East Asian counties have become to match to an OCA though the recent developments of the economic integration in this area. Since it has passed more than ten years after the 1997-98 Asian crisis, the accumulation of useful data will give us suggestive messages for future progress of economic/monetary integration in this area. Hence, the primary purpose of this paper is to clarify this issue using recent data.

On the other hand, many economic researchers have applied two major time series econometric approaches: the structural vector auto regression model (SVAR) by Blanchard-Quah (1989) and the maximum likelihood analysis of cointegration (MLCI) by Johansen and Juselius (1990) to address this issue. Bayoumi and Einchengreen (1993) firstly applied the usual SVAR approach into the case for the European monetary integration, which they focus the correlations of long-term economic shocks among member-states identified by the Blanchard-Quah decomposition. Bayoumi, Einchngreen, and Mauro (1999) applied it into East Asia. Another approach is known as the G-PPP model, which is firstly developed by Enders and Hurn (1994). They used MLCI, which is so called "the Johansen type" of cointegration approach, to identify the linear composition of real exchange rates which contains common stochastic trends among member states. [ii]

Although both approaches are useful for empirical analysis, researchers need to assume that linear convergence process toward long-run equilibrium as well as most econometric time series analysis assumed. Because of this assumption, it is not easy to identify whether the East Asian countries match to the conditions of OCA subject to assuring the robustness of estimations. Therefore, this paper is motivated to improve the robustness of estimation and to exclude the unrealistic assumption from an econometric model.

One of solutions for above challenges is to suppose non-linear model or asymmetric adjustment of mean reversion such as Enders and Siklos (2001)'s. Hence, to adopt asymmetric adjustments into the existent G-PPP model is the secondary purpose of this paper.

Rest of this paper is composed as follows; Section 2 gives a basic explanation of G-PPP model. In Section 3, the G-PPP model is modified as a usual economic model following the original concept of the PPP. The non-linear unit root test as a pre-test for cointegration is adopted in Section 4 and the up-to-dated econometric analysis tries to be adopted into the G-PPP model with recent data in Section5. Section 6 is saved for the concluding remarks.

2. Earlier works

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

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 countries of the trade partner.

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. Enders and Hurn (1994)'s 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 the 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 this 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,

$$y_{j,t} = \sum_{i=1}^{m+1} \theta_{j,i} \cdot y_{i,t} + \sum_{i=1, i \neq j}^{m+1} \eta_{j,i} \cdot re_{j,i,t} - \tau_j \cdot i_t, \; j = 1, \cdots, m+1 \tag{2.1}$$

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 Country j's currency vis-à-vis Country i's currency 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.

Here *RE* is defined as a $m \times 1$ vector which consists of bilateral real exchange rates re, which each factor in *RE* is supposed to be a non-stationary time series. In the case that this vector is cointegrated by each factor of vector, non-stationary real exchange rates are combined to form a stationary relationship in the long run. Equation (2.1) can be transformed into the following equation in terms of vectors:

$$RE_t = AY_t \tag{2.2}$$

where Vector Y is $(m \times 1) \times 1$ 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 (2.2), factors of Vector *RE* are co-integrated. According to Stock and Watson (1988), Equation (2.1) can be converted to an equation that includes factors that have $m+1$ common trends as shown in the following equation:

$$Y_t = \delta \cdot \phi_t \tag{2.3}$$

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 (2.3) into Equation (2.2), the real exchange rate can be defined as follows;

$$RE_t = A\delta\phi_t \tag{2.4}$$

From Equation (2.4), 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 as follows;

$$\beta \cdot RE = 0 \tag{2.5}$$

where the error correction model (ECM) can detect the long-term relationship defined above, if it contains cointegrating vectors.

3. G-PPP approach and the OCA

3.1. PPP Puzzle

The Purchasing Power Parity (PPP) is one of the most basic factors of exchange rate determination. Cross-border arbitrage of commodity makes a law of one price, under which prices of one commodity are the same across the border. 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)[iii], 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:

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

and

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

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;

$$P_T\cdot A_T\cdot f'\left(k_T\right)=r \tag{3.3}$$

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

$$P_N \cdot A_N \cdot g'(k_N) = r \tag{3.5}$$

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

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

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

$$W(r, A_T) = A_T f\left[k_T(r, A_T)\right] - r k_T(r, A_T) \tag{3.7}$$

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;

$$P_T \cdot A_T f(k_T) = r k_T + W, \tag{3.8}$$

$$P_N \cdot A_N g(k_N) = r k_N + W. \tag{3.9}$$

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

$$p_T + a_T = \pi_{LT} \cdot w \tag{3.10}$$

$$p_N + a_N = \pi_{LN} \cdot w \tag{3.11}$$

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

Substitute $w = (p_T + a_T)/\pi_{LT}$ 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;

$$p = \frac{\pi_{LN}}{\pi_{LT}} \cdot a_T - a_N \cdot \quad (3.12)$$

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;

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

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

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;[iv]

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

where both countries' sector outputs are proportional to the same production functions $F(\cdot)$ and $G(\cdot)$, and weight γ and π_{LN}/π_{LT} 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;

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

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

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

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;

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

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

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

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;

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

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

$$ree_3 = \beta_{3,1} \cdot re_{3,1} + \beta_{3,2} \cdot re_{3,2} \tag{3.24}$$

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;

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

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 model with Real Effective Exchange Rates

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;

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

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.[v]

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;

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

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 $re_{j,i} = re_{j,n} - re_{i,n} = re_{n,i} - re_{n,j}$. 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 $\mathbf{re}$ which includes m elements of the real exchange rate; $re_{m+1,i}$, as below;

$$
\mathbf{ree}_t = \Omega \cdot \mathbf{re}_t \tag{3.28}
$$

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 $\mathbf{ree}$ 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.[vi] 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 $\mathbf{ree}$ which is characterized by m cointegrating relations can be described as the sum of a stationary component and a nonstationary component:

$$
\mathbf{ree}_t = \mathbf{r\bar{e}e}_t + \mathbf{r\tilde{e}e}_t \tag{3.29}
$$

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:

$$\mathbf{ree}_t = \Phi \cdot \mathbf{w}_t \tag{3.30}$$

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,

$$\Phi \cdot \mathbf{w}_t = \Omega \cdot \mathbf{re}_t \,. \tag{3.31}$$

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);

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

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:

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

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

$$\Psi \cdot \Phi = 0 \tag{3.33}$$

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

$$\mathrm{Z} \cdot \mathbf{re} = 0 \tag{3.34}$$

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 $\mathrm{rank(Z)} = 1$. Equation (3.34) can be shown as the following linear combination;

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

where this linear combination define that m 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. [vii]

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. 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.” It is assumed that this linear combination shown in Equation (3.35) defines the optimum currency area in the sense of Mundell (1961).

4. Exchange rates stability among the Asian currencies

4.1. Constructing the Asian monetary unit for a common currency policy

As lessons from the European monetary integrations and adoption of single currency, it is true that the European monetary system (EMS) with the European currency unit (ECU) could contribute to stabilizing the regional exchange rates among member states. Toward monetary integration, it is very important to assure exchange rates stability, convergence of inflation rates gap, and convergence of interest rates gaps among member states. Hence, the stability of real exchange rates among these countries should be checked before our investigation whether the East Asian countries can form the common currency area or not. Recently, the Asian monetary unit (AMU) has been developed and it expects to become a useful tool for an exchange rate monitoring and contribute to stabilize the exchange rates among the East Asian currencies. Following the ECU experiences in the Euroland, the regional monetary unit such as the Asian monetary unit (AMU) can be also adopted into this area for the Asian monetary integration. Therefore, this paper employs the AMU as for the regional monetary unit for Asia. Here, the AMU for eight Asian countries can be defined as a basket of the eight Asian currencies to check the real exchange rates stability as below;

$$S_{AMU/USD} = \sum_{i=1}^{8} \beta_i S_{i/USD} \tag{4.1}$$

where S is nominal exchange rates and i denotes the name of Asian currency included in the basket. The eight Asian currencies: the CNY, the IDR, the JPY, the KRW, the MLR, the PHP, the SGD, and the THB, are included. The coefficient β_i denotes the weight of the basket for Country i. Country i's nominal exchange rate vis-à-vis the AMU is defined as follows;

$$S_{AMU/i} = {S_{AMU/USD}}\Big/{S_{i/USD}} \tag{4.2}$$

Therefore, real exchange rates of Currency i vis-à-vis the AMU: $RE_{AMU/i}$ can also be defined as follows;

$$RE_{AMU/i,t} = \frac{\left(S_{AMU/i,t} / S_{AMU/i,0}\right) \cdot \left(P_{i,t} / P_{i,0}\right)}{P_{AMU,t} / P_{AMU,0}} \quad ,(4.3)$$

where $P_{AMU,t}$ denotes the weighted average of the price indices of the eight Asian countries at time t and $P_{i,t}$ denotes that of the United States at time t. The variables with the subscript 0 denotes the value measured at the base year. The changes of real exchange rates can be defined from the logarithm of Equation (4.3) as follows;

$$\begin{aligned} re_{AMU/i,t} &= \log\left(S_{AMU/i,t} / S_{AMU/i,0}\right) + \log\left(P_{i,t} / P_{i,0}\right) - \log\left(P_{AMU,t} / P_{AMU,0}\right) \\ &= s_{AMU/i.t} + p_{i,t} - p_{AMU,t} \end{aligned} \tag{4.4}$$

where s and p denote the logarithm of nominal exchange rates and the price indices, respectively.

4.2. The M-TAR Unit root test

One of the recently developed unit root tests is the momentum threshold auto-regressive (M-TAR) model. The M-TAR unit root test is employed to investigate the property of the real exchange rate, where the unit root test with the momentum threshold separates the convergent speed toward the long-term mean when the exchange rate appreciates from the convergent speed as it depreciates; hence, the mean-reversion process is regarded as an asymmetric error correcting process. Enders and Granger (1998) developed the methods of detecting the non-linearity of adjustment process considering the threshold autoregressive (TAR) model as below;

$$\Delta re_t = I_t \rho_1 \left(re_{t-1} - \tau\right) + \left(1 - I_t\right) \rho_2 \left(re_{t-1} - \tau\right) + \sum_{i=1}^{p} \alpha_i \Delta re_{t-1} + \varepsilon_t \tag{4.5}$$

$$\rho_1 < 0, \rho_2 < 0 \text{ , } I_t = \begin{cases} 1 & if \quad re_{t-1} \geq \tau \\ 0 & if \quad re_{t-1} < \tau \end{cases} \text{ ,}$$

where re_t indicates the changes of real exchange rates at time t , ρ_1 and ρ_2 indicate adjustment process respectively, The coefficient $Z^+ = I_t \rho_1$ is regarded as the appreciation-correcting coefficient, and the coefficient $Z^- = \left(1 - I_t\right) \rho_2$ is regarded as the depreciation-correcting coefficient, the non-zero value: τ is a threshold. Equation (4.5) is assumed that the mean reversion process of real exchange rates would converge to the value around the long-term mean but would not achieve to the exact value of the long-term mean beyond the threshold value: τ. This assumption can be explained by the enormous discussion about the failure of PPP.[viii]

As far as we could know exact value of the threshold: τ, asymmetric adjustment process toward the long term equilibrium could be detected in Equation (4.5). If a threshold of mean reversion is unknown, we should employ the momentum TAR model as follows;

$$\Delta re_t = I_t \rho_1 re_{t-1} + (1 - I_t)\rho_2 re_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta re_{t-1} + \varepsilon_t \tag{4.6}$$

$$\rho_1 < 0, \rho_2 < 0 \;\; I_t = \begin{cases} 1 & if \quad \Delta re_{t-1} \geq 0 \\ 0 & if \quad \Delta re_{t-1} < 0 \end{cases}.$$

If estimated values of ρ could not be rejected the null hypothesis of unit root: $Z^+ = Z^- = 0$, the data generating process of series re_t might follow the white noise process. On the other hand, if the null of $Z^+ = Z^-$ could be rejected, the adjustment process might be asymmetric.

4.3. Data and empirical strategies for the non-linear unit test

The real exchange rates are constructed from the monthly nominal exchange rate and the monthly consumer price indices from the *IMF-IFS*. The sample for the empirical tests covers the period between January 2000 and December 2010. While eight East Asian countries include Korea, Singapore, Malaysia, Thailand, the Philippines, Indonesia, China, and Japan as a possible candidate of member states for the common currency union, the USD and the consumer price indices of the US are also included into the calculation of the AMU. The weight of basket for each of selected eight countries in Equation (4.1) is converted from the weights for all thirteen countries of the AMU definition from *RIETI* (Research Institute of Economy, Trade, and Industry, Japan). The choice of lag length for Equation (4.6) follows AIC.

4.4. Analytical results for asymmetric unit root test

Table 1 shows the results of the M-TAR asymmetric unit root test. The M-TAR unit root test revealed that the PPP does not hold in the long-run for the real exchange rates of Asian currencies vis-à-vis the USD since series contain the unit root. For the THB, the depreciation correcting coefficient: zeta-minus indicates significant at 5% significance level. As the null of $Z^{+} = Z^{-}$ is rejected, the THB real exchange rates vis-à-vis the USD would reveal the asymmetric adjustment process toward the long-term equilibrium if the THB deviated from it. Therefore, the properties of exchange rates of most Asian currencies vis-à-vis the USD indicate $I(1)$ process.

Although the CNY, the IDR, the JPY, and the PHP real exchange rates vis-à-vis the AMU contain the unit root, the KRW, the MLR, the SGD real exchange rates vis-à-vis the AMU revealed that the appreciation correcting coefficient: zeta-plus shows significant. The KRW would reveal the asymmetric adjustment process toward the long-term equilibrium if the KRW deviated from it. Although the depreciation correcting coefficient: zeta-minus indicates insignificant for the MLR and SGD, the null of symmetric adjustment could not be rejected.

From the result of M-TAR unit root test, the most of the Asian currencies indicate that the failure of PPP for the USD. For the AMU, some countries revealed the PPP holds asymmetrically. It means that once the currency appreciates beyond the long-term equilibrium level, it would be corrected at last. However, once it depreciates, the misalignment would not be corrected.

Why cannot the most cases satisfy the PPP holds between each Asian currency and the AMU? The composition of basket should reflect the economic integration to some extent. There will be two reasons. One is that the weights or/and components for the basket has not been adequate yet. Although there existed tariff and non-tariff barrier among these selected countries, the PPP would hold if there could exists a highly integrated good market in the region. To assure this, the more proceeding and deepening of the regional integration would be needed.

Another reason is related to our methodologies. Although the movement of each currency's real exchange rate vis-à-vis the AMU are considered as an endogenous variables, the movements of the other composed currency in the AMU are assumed as exogenous variables. If the region is expected to form an integrated market, to possess the supply chains, and to share technological growth, which become the determinants of real exchange rate, the movement of real exchange rates among the regional currencies are all endogenous. Hence, the G-PPP model, which can consider the endonegeousity of the exchange rates movement to some extent, will be employed to address this issue in the next section.

5. The G-PPP model with the AMU

5.1. Composing a reference exchange rate for a common exchange rate policy

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 each of these economies rather than the dollar peg system. As Williamson (2005), Kawai and Takagi (2000), and Ogawa and Ito (2002) suggested G-3 currency basket: the US dollar, the euro, and the yen would contribute, the basket peg system composed three major currencies is expected to promote international trade, foreign direct investments, and economic developments. If the countries expect to stabilize their exchange rates among East Asian currencies to promote intra-regional trade and investment, a monetary authority of each country can adopt the reference exchange rates vis-à-vis the G3 currency basket as their managed float exchange rate policy. Gradually, intra-regional exchange rate will be stabilized. This will become the first step for a monetary integration to form a possible common currency/policy area.

Next step for integrations is to adopt the regional currency unit as a tool of the monetary system as well as the European Monetary system. The monetary system forces the member countries to intervene the foreign exchange rate market to constrain the movement of exchange rates in the band. For installing the common currency unit as a system into the region initially, the region should be a OCA. Therefore, this section investigates whether East Asia, especially the group of the ASEAN plus three (Japan, China, and Korea) countries is an OCA.

To address this issue, Kawasaki and Ogawa (2006) and Ogawa and Kawasaki (2007 and 2008) extended the Enders and Hurn (1994)'s 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. The G-PPP model is defined the possible currency area denominated with the numéraire currency. The advantage of this approach is that we can consider the several options in composing the AMU; weights, components, and policy rules into analysis.

Here, the "extended G-PPP model" is used for the following analysis. In the case where an East Asian country adopts $m-1$; (the integer $m>2$), neighboring countries' currencies and $h+1$; ($h \geq 0$), major trading partners' currencies which include the US dollar and/or other major currencies into the basket currency as its target policy, Country j's reference rate can be expressed as

$$
\begin{aligned}
re_{AMU,j} &= \vartheta_j \left(\varphi_{j,1} re_{j,1} + \varphi_{j,2} re_{j,2} + \cdots + \varphi_{j,m} re_{j,m} \right) \\
&\quad + \left(1-\vartheta_j\right)\left(\varphi_{j,m+1} re_{j,m+1} + \cdots + \varphi_{j,m+h} re_{j,m+h} + \varphi_{j,US} re_{j,US} \right),
\end{aligned}
$$

$$
\vartheta_j \sum_{i=1, i\neq j}^{m} \varphi_{j,i} + \left(1-\vartheta_j\right) \sum_{i=m+1, i\neq j}^{m+h,US} \varphi_{j,i} = 1 . \tag{5.1}
$$

Defining the weight: $\phi_{i,j}$ for $i \neq j$ as follows;

$$
\phi_{i,j} = \begin{cases} \vartheta_i \varphi_{j,i} \mid \quad i = 1, \ldots, m \\ \left(1-\vartheta_i\right) \varphi_{j,i} \mid i = m+1, \ldots, m+h \end{cases}
$$

and substituting real exchange rates as $re_{j,i} = re_{US,i} - re_{US,j}$, Equation (5.1) 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

$$\begin{aligned} re_{AMU,j} = {} & \phi_{j,1} re_{US,1} + \cdots + \phi_{j,m} re_{US,m} - \left(\phi_{j,US} + 1\right) re_{US,j} \\ & + \phi_{j,m+1} re_{US,m+1} + \cdots + \phi_{j,m+h} re_{US,m+h} \end{aligned} . \tag{5.2}$$

Here, we define the vector: $\mathbf{re}_{AMU} = \left[re_{AMU,1}, \cdots, re_{AMU,m} \right]'$ which includes m number of the real exchange rates vis-à-vis the AMU,[ix] and the $(m+h)\times 1$ vector: $\mathbf{re}_{US}$, which is composed of the two groups of insider currencies and outsider currencies; $\mathbf{re}_{US} = \left(\mathbf{re}_1 \quad \mathbf{re}_2\right)'$, where the $m\times 1$ vector: $\mathbf{re}_1 = \left[re_{US,1}, \ldots, re_{US,m} \right]'$ and the $h\times 1$ vector: $\mathbf{re}_2 = \left[re_{US,m+1}, \ldots, re_{US,m+h} \right]'$. Two matrixes $\mathbf{F}_1$ and $\mathbf{F}_2$ are composed of the trade weights for insider and outsider currencies, respectively. Consequently, the vector $\mathbf{re}_{RMU}$ composed of m number of real exchange rates vis-à-vis the AMU can be defined in a general form as

$$\underset{(m\times 1)}{\mathbf{re}_{AMU}} = \underset{(m\times m)}{\mathbf{F}_1} \cdot \underset{(m\times 1)}{\mathbf{re}_1} + \underset{[m\times h]}{\mathbf{F}_2} \cdot \underset{[h\times 1]}{\mathbf{re}_2}, \tag{5.3}$$

where

$$\underset{m\times m}{\mathbf{F}_1} = \begin{bmatrix} 1-\phi_{1,US} & \phi_{1,2} & \cdots & \phi_{1,m-1} & \phi_{1,m} \\ \phi_{2,1} & 1-\phi_{2,US} & \cdots & \phi_{2,m-1} & \phi_{2,m} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \phi_{m-1,1} & \phi_{m-1,2} & \cdots & 1-\phi_{m-1,US} & \phi_{m-1,m} \\ \phi_{m,1} & \phi_{m,2} & \cdots & \phi_{m,m-1} & 1-\phi_{m,US} \end{bmatrix},$$

and

$$\underset{m\times h}{\mathbf{F}_2} = \begin{bmatrix} \phi_{1,m+1} & \phi_{1,m+2} & \cdots & \phi_{1,m+h-1} & \phi_{1,m+h} \\ \phi_{2,m+1} & \phi_{2,m+2} & \cdots & \phi_{2,m+h-1} & \phi_{2,m+h} \\ \vdots & \vdots & \cdots & \vdots & \vdots \\ \phi_{m-1,m+1} & \phi_{m-1,m+2} & \cdots & \phi_{m-1,m+h-1} & \phi_{m-1,m+h} \\ \phi_{m,m+1} & \phi_{m,m+2} & \cdots & \phi_{m,m+h-1} & \phi_{m,m+h} \end{bmatrix}.$$

Here, combining two matrixes $\mathbf{F}_1$ and $\mathbf{F}_2$ into one matrix as $\mathbf{F} = \begin{pmatrix} \mathbf{F}_1 & \mathbf{F}_2 \end{pmatrix}$, the real exchange rates of each East Asian currency in terms of the basket currency can be rewritten as a general vector form.

$$\underset{(m\times 1)}{\mathbf{re}_{AMU}} = \underset{(m\times(m+h))}{\mathbf{F}} \cdot \underset{((m+h)\times 1)}{\mathbf{re}_{US}} \tag{5.4}$$

where

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

If the monetary authorities in the region agree to peg their own currencies to the AMU 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: $\mathbf{re}_{RMU} = 0$.[x] Here, we define the non-null $m \times m$ matrix, $\mathbf{Z}$, if there exists a nonzero matrix, $\mathbf{Z}$,which does not have a full rank, Equation (5.4) can be as,

$$\underset{(m\times m)}{\mathbf{Z}} \cdot \underset{(m\times 1)}{\mathbf{re}_{AMU}} = \underset{(m\times m)}{\mathbf{Z}} \cdot \underset{(m\times(m+h))}{\mathbf{F}} \cdot \underset{((m+h)\times 1)}{\mathbf{re}_{US}} = 0 \tag{5.5}$$

As shown in the condition of Equation (3.34), if matrix $\mathbf{Z}$ satisfies 0<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).

5.2. Detecting the cointegrating relationship with the asymmetric adjustment

As following the usual methodology to estimate the long-run relationship of cointegration for the case of $\text{rank}(\mathbf{Z}) = 1$, Equation (5.5) can be rewritten as follows;

$$re_{US,m+h,t} = \beta_1 \cdot re_{US,1,t} + \beta_2 \cdot re_{US,2,t} + \cdots + \beta_m \cdot re_{US,m,t} + \beta_{m+1} \cdot re_{US,m+1,t} + \nu_t \tag{5.6}$$

where $re_{US,i,t}$ are the individual $I(1)$ components of real exchange rates, β_i are the estimated parameters and ν_t is the disturbance term which is considered serially correlated. As shown in Enders and Siklos (2001), the asymmetric cointegration model focuses on the disturbance in the equation above. To detect the asymmetric adjustment process on the disturbance, the non-linear econometric model is specified as follows;[xi]

$$\begin{gathered}\Delta \nu_t = I_t \rho_1 \nu_{t-1} + (1 - I_t) \rho_2 \nu_{t-1} + \sum_{i=1}^{p-1} \gamma_i \Delta \nu_{t-1} + \varepsilon_t \\ \rho_1 < 0, \rho_1 < 0\end{gathered} \tag{5.7}$$

where ε_t is supposed as the white-noise process and I_t is the indicator function such that;

$$I_t = \begin{cases} 1 \text{ if } \Delta \nu_{t-1} \geq 0 \\ 0 \text{ if } \Delta \nu_{t-1} < 0 \end{cases}. \tag{5.8}$$

The equations above is called as the asymmetric cointegration approach with the momentum threshold autoregressive model (M-TAR). In the M-TAR model above, the adjustment process toward the long-term equilibrium which is defined as Equation (3.35). While usual cointegrated model is assumed symmetric convergent process if there exists a cointegrating vector, asymmetric adjustments of the long-term mean-reversion process ($\mathrm{Z}^+ = I_t \rho_1, \mathrm{Z}^- = (1 - I_t) \rho_2$) are considered in the M-TAR model.[xii]

If estimated values of ρ could not be rejected the null hypothesis of unit root: $\mathrm{Z}^+ = \mathrm{Z}^- = 0$, the data generating process of series ν_t contains a unit root which might follow the random walk process. On the other hand, if the null of $\mathrm{Z}^+ = \mathrm{Z}^-$ could be rejected, the adjustment process might be asymmetric.

5.3. Data and empirical strategies for the non-linear cointegrating test

The real exchange rates are constructed from the daily nominal exchange rate from *Datastream* and the monthly consumer price indices from the *IMF-IFS*. The sample for the empirical tests covers the period between January, 2000 and December, 2010 While eight East Asian countries include Korea, Singapore, Malaysia, Thailand, the Philippines, Indonesia, China, and Japan as a possible member states, the EURO, the USD, and the consumer price indices of the US and the EU are included into the estimations of Equation.

The empirical strategies of this paper are that 1) estimating Equation (5.6) with standard OLS and serve the residuals as a series, 2) adopting the M-TAR unit root test into the series of residuals, where the lags of Equation (5.7) are obtained from the AIC, and 3) applying two null hypothesis tests: $Z^{+} = Z^{-} = 0$, where the series has unit root, and $Z^{+} = Z^{-}$, where the adjustment reveals as a symmetric process.

5.4. Analytical results for non-linear cointegration test

Table 2 shows the empirical result of the OLS estimation for the cointegrating relationship: Equation (4.12) assuming their residuals reveal asymmetric convergence toward the long-term relationship. For the cases for the ASEAN5 + Japan and the ASEAN5+three countries, the coefficients for all explanatories in Equation (4.12) indicate significant. For other combinations, coefficients suggest insignificant. [xiii]

Table 3 shows the empirical result for the M-TAR unit root test for the residuals from Equation (5.6). For all cases, there exist attractors to correct deviations from the long-term equilibrium (symmetrically or asymmetrically) at least. While the MLCI test could not detect the cointegrating vector suggested OCA for the East Asian countries in some cases, these prominent results has been brought by the asymmetric cointegating model.

For the combinations of ASEAN 5 countries, the coefficient of zeta-plus indicates significantly negative at 1% significance level. On the other hand, the coefficient of zeta-minus indicates insignificant, namely, the process of the residuals from Equation (5.6) revealed the asymmetric unit root. Also, while the coefficient of zeta-minus indicates insignificant for the combination of ASEAN5 and China, the coefficient of zeta-plus indicates significantly negative at 1% significance level. Although these two combinations suggest that the process of the residuals follows the asymmetric unit root process, the null of symmetric unit root for these combinations cannot be rejected. These conflicts might suggest that there exist a lack of endogenous variables in the cointegrating spaces.

For the combination of ASEAN5 + Japan, ASEAN5 + China + Korea, ASEAN5 + China + Japan, the coefficient of zeta-minus and zeta-plus indicates significantly negative at least 5% significance level. As null hypothesis of symmetry cannot be rejected, it suggests that there exists usual symmetric adjustment process toward the long-term equilibrium, namely, the G-PPP hold for these combinations

On the other hand, for the combination for the largest region (ASEAN5 + China + Korea + Japan), both coefficients indicate significantly negative at 10% significance level. Although the null of symmetry can be rejected, the null of $Z^{+} = Z^{-} = 0$ cannot be rejected at usual significance level. It suggested that the magnitude of coefficient is not large enough to reject the null of unit root so far.

The empirical results in this section suggest that region includes ‘plus three’ countries can form a common currency area in the sense of Mundell (1961). The result here is contrastive to the result from our previous empirical studies which the samples covered the period before the Asian crisis. Also, some other empirical works employed the S-VAR or G-PPP suggested that one or two of ASEAN5 countries could form a common currency area with China and/or Korea through the 80’s/90’s.[xiv] The results obtained here might be coherent with recent developments of economic integration in this area. As the many studies pointed that multinational enterprises has been optimizing their supply chains, information technological resources, and capital flows through the decade from 2000 to 2010, the real, labor and financial markets in the East Asia has been promoted to be integrated during this decade. Therefore, we can conclude that the 'ASEAN plus three countries' have been closer to OCA than before.

Other reasons for the OCA holds with the latest data might be considered as follows: 1) the 'Lehman shocks' and the global financial crisis in 2007-2008 affected the East Asian economies as the demand shocks symmetrically[xv], 2) as the recent financial shocks and crisis had corrected heavy reliance on credibility of the US dollar in the global financial market, East Asian currencies are also decreasing the strong linkage with the dollar, and 3) therefore, as the Japanese yen has been appreciating against both the US dollar and the Euro after 2008, its' movement has become a strong determinant of exchange rates movement among other East Asian currencies.

The second and the last possibilities might lead us to identify whether the 'ASEAN plus three' countries come closer to OCA or not. Because current rapid appreciation of Japanese yen might be temporal, nominal/monetary shocks from US or the Euroland would not affect the Asian economies permanently. It is true that the medium term perspectives on economic growth in this area might be affected by huge decline of the outside economies and the home currency's appreciation towards the currencies of the trade partners such as the dollar or the Euro. Although the multinational enterprises in this area may take further shift of their business focusing from outside to this region, economic integration in this area has been deepening through this decade. Therefore, the suggestive results for strong linkages among the 'ASEAN plus three' countries' currencies with the latest data would be supported with other macro-economic data.

6. Conclusion

This paper investigated whether East Asian countries: ASEAN5, China, Korea, and Japan, have become to match to an OCA in recent years or not. While developing the earlier G-PPP model into the up-to-dated non-linear econometric model, considering the adoption of the AMU into this area, and using the real exchange rates, this paper could have the empirical results as follows: 1) the combinations of ASEAN 5 countries with 'plus one' country: Korea or Japan, can form the common currency area, 2) the combinations ASEAN 5 with 'plus two' countries: China and Japan, Korea and Japan, or China and Korea can form a common currency area, and 3) ASEAN 5 plus three countries have come closer to OCA for the period including recent years. These results are addressed from the dramatic proceeding of economic integration in recent years. This empirical result will prompt the monetary authorities in this area to have further discussions not only about monetary cooperation but also about monetary integrations in this area.

Although all findings from empirical results in this paper support that it is possible for the East Asian countries to form a common currency union, note that, in transitions toward an equilibrium, namely single currency union, countries must need to make a policy coordination if adjustment process by those motilities is expected to be very slow and the nominal rigidities exist in the short run. Therefore, we should bear in mind that these total costs should not exceed the total benefit achieved from monetary integration in the long run. "An anchor currency" should be included in the region, but "a sinker currency" should not be included under the mask of darkness.

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[i] 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))

[ii] Zhang, Sato and McAleer (2004) employed the S-VAR approach to investigate the correlations of the business cycle among the East Asian countries. Their estimation showed that the coefficients for each of six East Asian countries: China, Indonesia, Korea, Malaysia, Singapore, and Thailand, showed a lower correlation with Japan for the period of 1980Q1-1997Q1. However, once they extended the samples to the post crisis period, they could have larger positive coefficient of correlations than the results for the pri-crisis period. Our rough calculation employed the S-VAR approach which covers the period of 1998Q1-2007Q3 suggests the coefficients of correlation with Japan are from 0.30 to 0.52 for the ASEAN5 countries and Korea, and the coefficients of correlation with Korea are from 0.37 to 0.68 for the ASEAN5.

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

[iv] 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 $re_{j,i} = p_i - p_j$

[v] 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.

[vi] 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.

[vii] The assumption: $\mathrm{rank}(Z) = 1$ is the necessary condition here for employing the usual OLS estimation of cointegration test developed by Engel and Granger (1987). On the other hand, Kawasaki and Ogawa (2006) which employs the MLCI approach suggested that there existed several cointegrating vector among five or six currencies in the G-PPP model. If $1<\mathrm{rank}(Z) < m$, there might suggest existence of factors in addition to the mobility to hold the PPP such like monetary/exchange rate policy, market turmoil, or future expectations . Hence, we might detect the different long-term equilibrium which the G-PPP model does not imply. Although empirical analysis might not be able to detect the G-PPP relationships which the theoretical model of this paper suggests, the detected cointegrating relationships here could assure the existence of the long-term equilibrium among Asian currencies at least. Such relationship could take a important role for the decision making of monetary/exchange rate policy.

[viii] If there exists relatively large transaction cost of trade between two countries, the PPP would not hold.

[ix] Although the AMU by RIETI is denominated by the composite currency of the dollar and the euro, Equation (5.2) can be regarded as a general form of the AMU. See details of the formal AMU definition by RIETI: (http://www.rieti.go.jp/users/amu/en/)

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

[xi]. If we specify the symmetric adjustment process as $\Delta v_t = \rho v_{t-1} + \varepsilon_t$, the usual two-step methodology entails.

[xii] The threshold autoregressive model (TAR) can be assumed in the analysis if the constant term are included in estimating Equation (5.6).

[xiii] The variables which indicate insignificant from OLS estimation may not affect the long-term equilibrium but may be able to be excluded from the cointegrating relationship unless it indicates a feature of weak exogeneous variable.

[xiv] See empirical results from Zahang, Sato, and McAller (2004) and Ogawa and Kawasaki (2008). Bayoumi, Einchengreen and Mauro (2000) also had some results for the period of 1968-1996.

[xv] ASEAN5 countries, Korea, and Japan had experienced 6-22% decrease of export to the previous year in 2008. China had also experienced small increase of export growth. The Korean won or the Thai baht had

experienced large depreciation after sub-prime crisis or ‘Lehman shocks.’ However, these depreciations against the US dollar might be corrections for the misalignment of real exchange rates.

Table 1: M-TAR Unit Root test for real exchange rates of Selected ASEAN+3 Countries

Country	Denominated Currency	DF	Lag(s)	(Upper: Z-Plus) (Lower: Z-Minus)	Coefficient (with S.E.)			F statistics (Probability) H: Rho(+)=Rho(-)=0		H: Rho(+)=Rho(-)	
China, Main land (CNY)	USD	103	13	Z_PLUS	0.001536306	0.014527452		0.16963		0.239743	
				Z_MINUS	-0.007312216	0.013335648		(0.84421288)		(0.62543265)	
	RMU	125	2	Z_PLUS	-0.0591524	0.042501267		1.64194		0.002188	
				Z_MINUS	-0.05610117	0.049009377		(0.19775207)		(0.96276808)	
Indonesia (IDR)	USD	125	2	Z_PLUS	0.000590272	0.015165059		0.28923		0.205971	
				Z_MINUS	0.010377994	0.013815165		(0.74934043)		(0.65073093)	
	RMU	129	0	Z_PLUS	-0.007511887	0.014935781		0.18686		0.371329	
				Z_MINUS	0.004236675	0.012191697		(0.82978647)		(0.54335231)	
Japan (JPY)	USD	129	0	Z_PLUS	-0.005101485	0.023967181		1.25924		1.074655	
				Z_MINUS	-0.042592899	0.027083832		(0.28733562)		(0.30183556)	
	RMU	129	0	Z_PLUS	-0.005182046	0.015666625		0.10776		0.001977	
				Z_MINUS	-0.006287443	0.019301674		(0.89792420)		(0.96460196)	
Korea	USD	119	5	Z_PLUS	-0.026666786	0.028375523		0.86039		0.000469	
				Z_MINUS	-0.025791782	0.028465399		(0.42561231)		(0.98275081)	
	RMU	129	0	Z_PLUS	-0.05099705	0.024425709	**	2.29209		3.456666	*
				Z_MINUS	0.010631741	0.022408982		(0.10515652)		(0.06527558)	
Malaysia	USD	115	7	Z_PLUS	0.028824519	0.027663811		0.6872		1.239819	
				Z_MINUS	-0.011954202	0.026204856		(0.50503525)		(0.26782778)	
	RMU	129	0	Z_PLUS	-0.092793059	0.037984103	***	3.04648	*	1.59292	
				Z_MINUS	-0.016591172	0.046931251		(0.05095972)		(0.20918647)	
Philippines	USD	129	0	Z_PLUS	0.001172417	0.017687861		0.23133		0.124351	
				Z_MINUS	0.008963992	0.013241699		(0.79380711)		(0.72493783)	
	RMU	129	0	Z_PLUS	-0.023092789	0.022753611		0.53132		0.408533	
				Z_MINUS	-0.003646769	0.020196421		(0.58910957)		(0.52384813)	
Singapore	USD	129	0	Z_PLUS	0.029401503	0.030243264		0.47259		0.571021	
				Z_MINUS	0.000203325	0.0240488		(0.62446053)		(0.45123126)	
	RMU	115	7	Z_PLUS	-0.196464126	0.072803859	****	4.26864	***	0.541949	
				Z_MINUS	-0.118614438	0.084774203		(0.01628310)		(0.46312501)	
Thailand	USD	127	1	Z_PLUS	-0.0283852	0.019039586		2.85579	*	5.065298	**
				Z_MINUS	0.024851505	0.012492841	**	(0.06121034)		(0.02612932)	
	RMU	129	0	Z_PLUS	0.006922679	0.021921962		0.39772		0.587308	
				Z_MINUS	-0.014543553	0.017436266		(0.67267077)		(0.44486226)	

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

Table 2: OLS Estimation for Asymmetric Integration

Country/Combination	*D.F.* / *D.W.*	Explanatories †							
		Japan (Yen)	**Korea (Won)**	**China (Yuan)**	**Indonesia (Rupiah)**	**Malaysia (Ringgit)**	**The Philippines (Peso)**	**Singapore ($SG)**	**Thailand (Baht)**
ASEAN 5	127	-	-	-	0.528048476 ****	-1.666714952 ****	-0.265570695 *	0.3418469	1.154285774 ****
	0.30158	-	-	-	(0.049670534)	(0.312068185)	(0.136133751)	(0.284662307)	(0.242836794)
ASEAN 5 + China	126	-	-	0.378181501	0.549333276 ****	-1.671473843 ****	-0.361468635 ****	-0.011435077	1.219691547 ****
	0.34183	-	-	(0.239489075)	(0.051187546)	(0.310263774)	(0.148340703)	(0.360751750)	(0.244948549)
ASEAN 5 + Korea	126	-	0.16753058 **	-	0.523082636 ****	-1.687078908 ****	-0.208375042	0.647735398 **	0.860846903 ****
	0.28106	-	(0.0751939060)	-	(0.048963822)	(0.307445091)	(0.136493600)	(0.312137246)	(0.273004372)
ASEAN 5 + Japan	126	-0.882692968 ****	-	-	0.300792487 ****	-3.040137798 ****	-0.755978909 ****	2.760965597 ****	1.284522712 ****
	0.63802	(0.104809802)	-	-	(0.048158387)	(0.298998049)	(0.123864662)	(0.367106290)	(0.195624931)
ASEAN 5 + China + Korea	125	-	0.569982115 ****	1.711845324 ****	0.607499438 ****	-1.757539575 ****	-0.505060117 ****	-0.216578948	0.451991675 *
	0.52546	-	(0.101549433)	(0.320365351)	(0.047083568)	(0.278811851)	(0.135537670)	(0.325748037)	(0.258868221)
ASEAN 5 + China + Japan	125	-0.88077203 ****	-	0.362270926 *	0.321676369 ****	-3.0417076 ****	-0.846775063 ****	2.417282096 ****	1.346893356 ****
	0.68985	(0.103758609)	-	(0.191511729)	(0.048934733)	(0.295986226)	(0.131676407)	(0.406293370)	(0.196440488)
ASEAN5 + Korea + Japan	125	-0.8693104 ****	0.02867949	-	0.303387831 ****	-3.022801339 ****	-0.738752497 ****	2.7766541 ****	1.232314503 ****
	0.62751	(0.109295502)	(0.063944837)	-	(0.048657103)	(0.302430785)	(0.130059871)	(0.369933081)	(0.228174252)
ASEAN 5 + China + Korea + Japan	124	-0.736259376 ****	0.301647532 ****	1.070686758 ****	0.389812031 ****	-2.86243447 ****	-0.843140307 ****	1.910223557 ****	0.919738445 ****
	0.72797	(0.110380462)	(0.096274675)	(0.292200945)	(0.052055133)	(0.291735094)	(0.127269839)	(0.424721334)	(0.233736449)

†: *:10%, **:5%, ***:2.5%, ****:1% Significance level, Standard Error is shown in the parenthesis.

Table 3: M-TAR Unit Root test for Residuals from Cointegration Estimation

Country	DF	Lag(s)		Coefficient (with S.E.)			F statistics (Probability) H: Rho(+)=Rho(-)=0		F statistics (Probability) H: Rho(+)=Rho(-)	
ASEAN 5	117	6	Zeta PLUS	-0.221891808	(0.07509896)	****	4.74584	***	1.403252	
			Zeta MINUS	-0.103683431	(0.078430730)		(0.01042912)		(0.23858067)	
ASEAN 5 + China	117	6	Zeta PLUS	-0.236626313	(0.076641855)	****	5.21967	****	1.153801	
			Zeta MINUS	-0.125792709	(0.084255747)		(0.00673934)		(0.28496515)	
ASEAN 5 + Korea	117	6	Zeta PLUS	-0.175194501	(0.074559207)	***	3.6867	**	0.267063	
			Zeta MINUS	-0.124735396	(0.074370692)	*	(0.02800994)		(0.60628430)	
ASEAN 5 + Japan	111	9	Zeta PLUS	-0.238511713	(0.119582191)	**	3.04874	*	6.20E-05	
			Zeta MINUS	-0.239506029	(0.111896743)	**	(0.05140854)		(0.99373254)	
ASEAN 5 + China + Korea	117	6	Zeta PLUS	-0.238688839	(0.095579494)	***	4.34835	***	0.020238	
			Zeta MINUS	-0.221548463	(0.102348579)	**	(0.01508088)		(0.88711792)	
ASEAN 5 + China + Japan	111	9	Zeta PLUS	-0.264616854	(0.125767544)	***	3.23399	**	0.001556	
			Zeta MINUS	-0.259528874	(0.117530019)	***	(0.04314112)		(0.96860251)	
ASEAN5 + Korea + Japan	111	9	Zeta PLUS	-0.225488146	(0.117012752)	*	2.98816	*	0.01103	
			Zeta MINUS	-0.238618254	(0.111021880)	**	(0.05444897)		(0.91654476)	
ASEAN 5 + China + Korea + Japan	113	8	Zeta PLUS	-0.21390781	(0.127321593)	*	2.1139		0.000946	**
			Zeta MINUS	-0.209987068	(0.115552191)	*	(0.12551718)		(0.97551832)	

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