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How Did the Global Financial Crisis Misalign East Asian Currencies?

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Abstract

This paper investigates how the East Asian currencies were affected by the global financial crisis. We employ methodologies involving β-convergence and σ-convergence to examine the misalignments or divergence of East Asian currencies in different sample periods. Our empirical results show that exchange rate misalignments among East Asian countries were widening even before the global financial crisis. Active international capital flows such as yen carry trade also affected the movement of East Asian currencies. We conclude that it is necessary to establish a surveillance system within the East Asian area for purposes of early detection and prevention of intra-regional exchange rate misalignments.

Keywords: Asian Monetary Unit, AMU Deviation Indicator, PPP-Based AMU Deviation Indicator Adjusted by the Balassa–Samuelson Effect, β-Convergence and σ-Convergence, Regional Monetary Cooperation

JEL classification codes: F31, F33, F36

1. Introduction

The global financial crisis of 2007–2008 inflicted harm on the economies of not only the United States but also Europe and the emerging countries. The crisis was triggered by the BNP Paribas shock during the summer of 2007. American financial institutions were seriously affected by excessive defaults on sub-prime mortgages. Since the European financial institutions as well as American financial institutions held several significant sub-prime mortgage-backed securities, defaults on sub-prime mortgages inflicted heavy damage on the European financial institutions too. Also, although most of the financial institutions in East Asia were not directly affected by the defaults on sub-prime mortgages, the related economic slump in the United States and Europe indirectly caused adverse effects on the East Asian economy.

Sub-prime mortgages, which are housing loans for low-income households, are considered a prime cause of the global financial crisis. Under expectations of rising housing prices, the low-income classes availed sub-prime mortgages and became exposed to considerably high credit risks. Sub-prime mortgage-backed securities, which include Residential Mortgage-Backed Securities (RMBS) and Credit Default Swap (CDS), were created to transfer the credit risk to others. Simultaneously, the sub-prime mortgage-backed securities played an important role in financing the shortage of

savings in the United States. The sources of finance were not only Europe but also the oil-exporting Middle East countries and Russia. It is said that the European financial institutions played an important role in international financial intermediation between the United States and the oil-exporting countries.

Furthermore, oil money flowed into the European countries and created a housing bubble in Europe. The collapse of the housing bubble caused housing prices to fall and exposed the high credit risks of sub-prime mortgages and sub-prime mortgage-backed securities. The collapse turned the sub-prime mortgages into non-performing loans and increased the likelihood of the sub-prime mortgage-backed securities becoming irrecoverable. With the collapse of the housing bubble, the European financial institutions that held sub-prime mortgage-backed securities were affected as much as the financial institutions in the United States.

The American and European financial institutions and other institutional investors abruptly withdrew their funds from the emerging countries in East Asia, whose currencies drastically depreciated against the US dollar and the euro. Specifically, the exchange rate volatility of these currencies increased, and exchange rate misalignments occurred among some of them. It was also found that the Chinese monetary authority re-pegged the Chinese yuan to the US dollar in order to stabilize its exchange rate. Thus,

the exchange rates of the East Asian currencies were indirectly affected by the global financial crisis, although each of these East Asian countries maintained a sound financial sector. Given the circumstances mentioned above, the purpose of this paper is to analyze how the East Asian currencies were misaligned before and after the global financial crisis.

We obtained the empirical result that the exchange rates of East Asian currencies were asymmetrically affected by the global financial crisis. On one hand, we found a part of combinations of East Asian currencies that converged during the sub-sample periods, especially from the beginning of 2000 to the middle of 2005 and from the end of 2007 to the beginning of 2010. The global financial crisis reminded us of the importance of addressing the exchange rate misalignments that occurred among the East Asian currencies in order to stabilize the macro-economy in East Asia. On the other hand, from the viewpoint of regional monetary cooperation, it has become necessary to establish a surveillance system within the East Asian area for the early detection and prevention of exchange rate misalignments, which is believed to be one of the reasons for the Asian Currency Crisis of 1997.

This paper is structured along the following sections. In section 2, we review previous studies on the measurements of exchange rate surveillance, which include the

Asian Monetary Unit (AMU), and the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect. In section 3, we first explain the methodologies of β-convergence and σ-convergence and then employ the data from the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect to examine the exchange rate misalignments of East Asian currencies. We point out that one of the reasons for exchange rate misalignment arises from currency carry trade. In section 4, we conclude that the exchange rate misalignments in East Asian countries were a structural problem on the exchange rate regime. We suggest that it is necessary to promote regional monetary cooperation for the early detection and prevention of exchange rate misalignments among East Asian currencies.

2. AMU and PPP-Based AMU Deviation Indicator Adjusted by the Balassa–Samuelson Effect

After the Asian currency crisis of 1997, the monetary authorities of East Asian countries realized the importance of intra-regional monetary cooperation. Unfortunately, the exchange rate fluctuations in East Asian currencies are still asymmetric and some East Asian countries maintain strong interconnecting relationships with the US dollar. Ogawa (2004) pointed out that the exchange rate fluctuations of East Asian currencies

could be divided into two groups from the viewpoint of the asymmetric exchange rate response, and that intra-regional exchange rate misalignment was attributed to asymmetric exchange rate fluctuations. In order to detect and prevent exchange rate misalignment in its early stages, it is necessary for the monetary authorities of East Asian countries to monitor intra-regional exchange rates. To establish an intra-regional exchange rate surveillance system, the AMU and the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect have been proposed by Ogawa and Shimizu (2005) and Ogawa and Wang (2013a).

The AMU is a currency basket unit that is calculated based on the weighted average of the currencies of ASEAN+3 and follows the same procedures used to calculate the European Currency Unit (ECU). Each currency's weight in the currency basket is based on the share of GDP and trade volume. Because both the United States and the euro area are important trading partners of East Asian countries, the AMU is denominated based on a weighted average of the US dollar and the euro. Figure 1 shows the exchange rate of the US dollar and the euro vis-à-vis the AMU from the beginning of 2000 to May of 2013. The AMU was clearly weaker than a weighted average of the US dollar and the euro from late 2000 until the end of 2008. Over that period, some East Asian currencies depreciated against the US dollar and the euro, due to active capital flows. However, the

trend of depreciation appeared to stagnate in the middle of 2005, when the Chinese monetary authority made an announcement regarding the reform of its foreign exchange regime. From the end of 2005, the AMU appreciated against the US dollar and the euro, and followed a significant uptrend of appreciation after the bankruptcy of Lehman Brothers. Some of the euro member countries plunged into a serious debt crisis at the time, and the excessive depreciation of the euro particularly accelerated the appreciation of the AMU.

In strengthening surveillance over intra-regional exchange rates, Ogawa and Wang (2013a) employed purchasing power parity (PPP) as a benchmark rate, and calculated the PPP-based AMU deviation indicator. Due to data constraints, the PPP was calculated based on consumer price index (CPI). It is well known that CPI includes the price of non-tradable goods, and therefore the PPP based on CPI tends to diverge from the exchange rate, following the law of one price. In general, the growth rate of productivity in the tradable goods sectors is higher than that in the non-tradable goods sectors. The rate of inflation in the price of tradable goods thus tends to be lower than that for non-tradable goods, and the PPP based on the CPI differs from the exchange rate based on the law of one price for tradable goods. With respect to the productivity differential, Ogawa and Wang (2013a) calculated the growth rate of productivity by referring to the

real GDP and employment in both the tradable and non-tradable goods sectors, and adjusted the PPP-based AMU deviation indicator by the Balassa–Samuelson effect.[1,2] Figure 2 shows the PPP-based AMU deviation indicators adjusted by the Balassa–Samuelson effect of ASEAN6+3. There is a tendency for the Japanese yen, the Chinese yuan, and the Malaysian ringgit to be undervalued, while there is a tendency for the Korean won, the Indonesian rupiah, the Thai baht, the Vietnamese dong, and the Philippine peso to be overvalued. The Singapore dollar tends to be balanced over the entire sample period. The divergence spread between the maximum and the minimum was near to 80% after the bankruptcy of Lehman Brothers.

In order to stabilize the real effective exchange rate and eliminate failures to cooperate on exchange rate policy, it is necessary for the monetary authorities of East Asian countries to engage in policy coordination. The best means of achieving policy coordination on exchange rates is to implement an exchange rate policy based on a common currency basket. As mentioned above, the AMU and the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect are useful for engaging in intra-regional monetary cooperation and exchange rate coordination. These indicators are particularly expected to make it easier to detect intra-regional exchange rate misalignments in their early stages.

3. β and σ Convergences of East Asian Currencies

After the collapse of the housing bubble in the summer of 2007, many European financial institutions confronted a serious liquidity crisis. For example, in the United Kingdom, Northern Rock received a liquidity support facility from the Bank of England, and Bradford & Bingley was nationalized. In Iceland, although Kaupthing Bank had not declared bankruptcy, the Icelandic Financial Supervisory Authority (IFSA) took control of the bank. In Germany, Dresdner Bank that was one of Germany's largest financial institutions, was merged with Commerzbank. In Europe, many financial institutions were seriously affected by defaults on sub-prime mortgages: the more sub-prime mortgage-backed securities a financial institution owned, the more serious the crisis it confronted. At the same time, financial institutions were also affected by the collapse of the land-price bubble in Europe. Both the defaults on sub-prime mortgages and the collapse of the land bubble worsened the balance sheet of financial institutions. Furthermore, the European financial institutions were also confronting a counterparty risk due to the unpredictable damage from defaults on sub-prime mortgages.

Under the impact of the global financial crisis and credit uncertainty in the United States and Europe, the risk tolerance of the American and European financial

institutions and institutional investors was much lower than in peacetime. As a result, the financial institutions and institutional investors who were in trouble withdrew their short-term money from all over the world, and the US dollar and the euro circulated back into the United States and Europe. Naturally, short-term money was also withdrawn from the emerging countries, and the currencies of some emerging countries were sold and significantly depreciated against the US dollar and the euro. East Asian currencies were also affected by the withdrawal of the US dollar and the euro.

In order to investigate how the East Asian currencies were affected by the global financial crisis, we employ the β-convergence and σ-convergence approaches to examine their fluctuations. The concept of β-convergence is borrowed from the growth literature in which one may regress the average growth rate of GDP on its initial level and interpret a negative correlation as a sign of convergence. This property is also described in econometrics as a reversion to the mean. While the concept of σ-convergence is borrowed from the empirical growth literature too and used to measure degrees of convergence at each point in time, it should be kept in mind that σ-convergence occurs with the condition that the variable's cross-sectional variance decreases over time.

3-1. β-Convergence

Based on advanced studies in the past, we know that β-convergence can measure convergence from the aspect of multiple series; if the series exhibits the property of convergence, the estimated coefficient β is said to represent the speed of convergence as well.

In order to explain the methodology of β-convergence, we assume that a data-generating process follows an $AR(p)$ process, which can be expressed as

$$A_{i,t} = a_i + x_{i1}A_{i,t-1} + x_{i2}A_{i,t-2} + x_{i3}A_{i,t-3} + \cdots + x_{ip}A_{i,t-p} + \varepsilon_{i,t} \qquad (1)$$

where i and t denote country and time indices, a_i is the country dummy (idiosyncratic factor), the error term $\varepsilon_{i,t}$ reflects exogenous shocks, and $\varepsilon_{i,t} \sim W.N.(0, \sigma^2)$.

Eq. (1) can be rewritten as follows:

$$\triangle A_{i,t} = a_i + \beta_i A_{i,t-p} + \sum_{j=1}^{p-1} \gamma_{i,j} \triangle A_{i,t-j} + \varepsilon_{i,t} \qquad (2)$$

where $\beta_i = \sum_{j=1}^{p} x_{i,j} - 1$ and $\gamma_{i,j} = \sum_{k=1}^{j} x_{i,k} - 1$.

From Eq. (2), the value of β_i represents the speed of convergence if $\beta_i < 0$ and $t \to \infty$. According to the property of stochastic processes and multiple-series data, β_i can be estimated by the panel unit root test method.

The panel unit root tests employed here are based on Levin, Lin, and Chu (LLC,

2002) and Im, Pesaran, and Shin (IPS, 2003). Both LLC and IPS allow for individual-specific effects as well as dynamic heterogeneity, while IPS alone allows for dynamic heterogeneity on individual unit root statistics. In the LLC test, the null and alternative hypotheses are $H_0 : \beta_i = \beta = 0$ and $H_1 : \beta < 0$, respectively, whereas in the IPS test, the null and alternative hypotheses are $H_0 : \beta_i = 0$ for all i and $H_1 : \beta_i < 0$ for some of i.

3-2. σ-Convergence

The other concept of convergence well employed in the growth literature is σ-convergence, which concerns cross-sectional dispersion. In the notion of σ-convergence, if the cross-sectional variance (or standard deviation) of variables is trending downward, it means that the degree of integration increase.[3]

Given an $AR(p)$ process that is constructed by the variance (or standard deviation) across a group of variables as follows:

$$B_t = b + y_1 B_{t-1} + y_2 B_{t-2} + y_3 B_{t-3} + \cdots + y_p B_{t-p} + u_t \qquad (3)$$

where b is a drift term, and $u_t \sim W.N.\left(0, \sigma^2\right)$.

Eq. (3) can be rewritten as follows:

$$\triangle B_t = b + \varphi B_{t-p} + \sum_{j=1}^{p-1} \rho_j \triangle B_{t-j} + u_t \qquad (4)$$

where $\varphi = \sum_{j=1}^{p} y_j - 1$ and $\rho_j = \sum_{k=1}^{j} y_k - 1$.

According to the property of stochastic process and time series data, the coefficient of φ can be estimated by the time series unit root test method.

The time series unit root tests employed here are based on the Augmented Dickey–Fuller (ADF, 1979) and Phillips–Perron (PP, 1988) approaches. Both ADF and PP correspond to higher-order unit root processes. However, the PP approach allows for error term autocorrelation and potential heteroskedasticity. In both the ADF and PP, the null and alternative hypotheses are $H_0 : \varphi = 0$ and $H_1 : \varphi < 0$, respectively.

3-3. Data and Analytical Periods

The data used in our empirical analysis is from the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect because it can reflect exchange rate fundamentals as well as macroeconomic conditions. For calculating the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect, the data of AMU is from the Research Institute of Economy, Trade and Industry (RIETI), CPI from the *International Financial Statistics* of the International Monetary Fund (IMF), and productivity calculated by real GDP and employment from the department of statistics and the statistical yearbook of each country.[4]

The sample period is based on a weighted average variance of the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect (hereafter weighted average variance) as shown in Figure 3.[5] In addition to the full sample period (from January 2000 to January 2010), we divide the full sample period into 7 sub-sample periods to check for convergence of exchange rate misalignment among East Asian currencies. From the fluctuations of weighted average variance, it is clear that weighted average variance was on an uptrend from the end of 2001 to the beginning of 2004 and then showed a downward trend until the middle of 2004. After this, the weighted average variance again shifted into an upward trend until the first quarter of 2005, and then turned into a downward trend by the middle of 2005. From the third quarter of 2005 to the summer of 2007, the weighted average variance rose dramatically, and then fell into a downtrend between the third quarter of 2007 and the beginning of 2008. Until the autumn of 2008, the weighted average variance was once more in an uptrend, and then dropped to the same level as of the middle of 2005. From the end of 2008, it kept at a stable level. Therefore, the first sub-sample period ranges from January 2000 to June 2004, the second sub-sample period from January 2000 to June 2005, the third sub-sample period from January 2000 to July 2007, and the fourth sub-sample period from January 2000 to August 2008.[6] Finally, the remaining periods of the first, second,

and third sub-sample periods are defined as three other sample periods.[7]

3-4. Empirical Analysis Results of β- and σ-Convergences

From the theoretical model and the PPP-based AMU deviation indicators adjusted by the Balassa–Samuelson effect of East Asian currencies, we investigate whether the East Asian currencies exhibit trends of convergence in different sample periods, particularly before and after the global financial crisis. We test the property of convergence in different combinations by the methodology of β-convergence. The test is conducted from the aspects of cross section and time series simultaneously. We then check whether cross-sectional variance of the PPP-based AMU deviation indicators adjusted by the Balassa–Samuelson effect is trending downward by σ-convergence. If the tests on β-convergence and σ-convergence are statistically significant, it means that exchange rate misalignments *did* occur in East Asian currencies temporarily and exchange rate fluctuations converged in the long run.

The estimation results of β-convergence and σ-convergence were summarized in Table 2.[8] For example, out of 502 combinations, 154 were statistically significant in the test of β-convergence, 69 in σ-convergence and 32 in both β- and σ-convergences during the sub-sample periods from January 2000 to June 2004. With respect to the

detail of convergent combinations, most of them included the Japanese yen, the Chinese yuan, the Singapore dollar, the Malaysian ringgit and the Thai baht.

From the empirical analysis results, it is clear that East Asian currencies do not converge in most sample periods. Especially since late 2005, the combinations that were accepted in the early sample periods have also been rejected. One of the main reasons for this can be attributed to exchange rate fluctuations. Since 2005, active international capital flows such as yen carry trade occurred in some East Asian countries, especially between Japan and Korea. The capital flows of the two countries on the category of other investments are shown in figures 4 and 5.[9] The category of other investments is given as the difference between assets and liabilities. Therefore, the category of other investments being positive implies capital outflows, while a negative value implies capital inflows. In the case of Japan, the category of other investments tended to be positive before the third quarter of 2008, and then turned negative. This indicates that capital outflows occurred in Japan before the global financial crisis, after which capital inflows commenced. Due to capital flows, the Japanese yen experienced depreciation before the bankruptcy of Lehman Brothers, following which it appreciated. In the case of Korea, the category of other investments was negative until the third quarter of 2008 and became positive since around the end of 2008. This implies that capital inflows

occurred in Korea before the global financial crisis, after which capital outflows arose. Active capital flows made the Korean won tend toward overvaluation since 2006 and fall into undervaluation after the bankruptcy of Lehman Brothers. By comparing the other investments of Japan with that of Korea, we find that they were moving in opposite directions, especially from the beginning of 2006 to the third quarter of 2008. One of the main reasons for this can be yen carry trade.

Active capital flows affected the exchange rate stationarity of East Asian countries, especially undervalued the Japanese yen and overvalued of the Korean won, the Thai baht, and the Indonesian rupiah from July 2005 to July 2007. A dramatic withdrawal of short-term money from East Asia by Western financial institutions and institutional investors accelerated the depreciation of East Asian currencies against the US dollar and the euro. At the same time, since the defaults on sub-prime mortgages had only a limited effect on the financial institutions of Japan, the Japanese yen was considered a relatively riskless currency, and consequently was bought in markets across the world. Since the summer of 2007, the Japanese yen appreciated against the US dollar and the euro substantially. The depreciation of emerging currencies and appreciation of the Japanese yen led to exchange rate misalignments among the East Asian currencies. Therefore, the asymmetric response, blamed as one reason for the Asian Currency Crisis, is still an

urgent issue that needs to be resolved.

4. Conclusion

In this paper, we employed β-convergence, σ-convergence, and the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect to investigate how East Asian currencies have been affected by the global financial crisis. We obtained empirical evidence that some East Asian currencies were seriously affected by the global financial crisis, and that yen carry trade also had a strong impact on exchange rate misalignments of East Asian currencies. Within 502 combinations in 8 different sample periods, we found that only a small number of combinations were statistically significant in the sub-sample periods from January 2000 to June 2004, January 2000 to June 2005, and July 2007 to January 2010. The number of stationary combinations came near to zero when we took into account sample periods prior to the global financial crisis. According to our empirical results, it is obvious that exchange rate misalignments in the East Asian currencies had occurred before the global financial crisis and continued after that. As far as the whole analytical results are concerned, it is clear that the East Asian currencies misaligned not only in the short term but also in the long term. This means that exchange rate misalignments occurring in East Asian

currencies are a structural problem on exchange rate regimes.

The foreign exchange policies adopted by East Asian countries subjected the East Asian currencies to the global financial crisis indirectly and widened the exchange rate misalignments. In order to resolve and prevent exchange rate misalignments in East Asia, it is necessary for the monetary authorities of East Asian countries to ensure surveillance over intra-regional exchange rates. As a measurement of surveillance, some policymakers and scholars have suggested that the monetary authority of each country employ a common currency basket to monitor fluctuations of intra-regional exchange rates (e.g. Williamson 2000, Kuroda and Kawai 2003, Ogawa 2004). For establishing an intra-regional exchange rate surveillance system among the East Asian countries, both the AMU and the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect emerge useful.

After experiencing the global financial crisis of 2007–2008 as well as the Asian Currency Crisis of 1997, we have found it necessary to establish a surveillance system over intra-regional exchange rates and also important to carry out policy coordination for facilitating the adjustment of intra-regional exchange rate misalignments. If we can develop an intra-regional exchange rate surveillance system and ensure policy coordination, each country as well as the whole of East Asia will stand to gain. To

strengthen the soundness of the financial system, deter speculative attacks on currencies, and adjust the misalignments of exchange rates, the East Asian countries are expected to monitor their exchange rate systems by assertively following a common currency basket, and correcting their exchange rates when necessary.

[1] Ogawa and Wang (2013a) define the productivity of the tradable goods sector (α_T) as a quotient of real GDP (Y_T) in terms of employment (L_T) and the productivity of the non-tradable goods sector (α_N) as a quotient of real GDP (Y_N) in terms of employment (L_N) in order to calculate the Balassa–Samuelson effect.

[2] With reference to the PPP-based AMU deviation indicator and the Balassa–Samuelson effect, the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect is given by the following equation:

$$\Delta DI^{PPP\ Adjusted\ by\ BS} \approx \Delta DI^{PPP} + \omega_N \cdot \left(\dot{\alpha}_T - \dot{\alpha}_N\right) - \omega_N^* \cdot \left(\dot{\alpha}_T^* - \dot{\alpha}_N^*\right)$$

$\Delta DI^{PPP\ Adjusted\ by\ BS}$ is the rate of change in PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect, ΔDI^{PPP} is the rate of change in PPP-based AMU deviation indicator, ω_N is the weight of non-tradable goods with regard to the general price level of the domestic economy, $\dot{\alpha}_T$ is the rate of change in productivity in the tradable goods sectors of the domestic economy, $\dot{\alpha}_N$ is the rate of change in productivity in the non-tradable goods sectors of the domestic economy, ω_N^* is the weight of non-tradable goods with regard to the general price level of the foreign economy, $\dot{\alpha}_T^*$ is the rate of change in productivity in the tradable goods sectors of the foreign economy, and $\dot{\alpha}_N^*$ is the rate of change in productivity in the non-tradable goods sectors of the foreign economy. For more detail, see Ogawa and Wang (2013a).

[3] β-convergence tends to generate σ-convergence, but this process is offset by new disturbances that tend to increase dispersion. In other words, β-convergence is necessary but not a sufficient condition for σ-convergence. For more detail, see Barro and Sala-i-Martin (2004), Ogawa and Kumamoto (2008), and Ogawa and Wang (2013b).

[4] Table 1 summarizes the data sources.

[5] The weighted average variance of the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect is calculated based on the weight of each currency in the AMU, as well as the PPP-based AMU deviation indicator adjusted by the Balassa–Samuelson effect.

[6] To ensure a large amount of data in empirical analysis, the starting points of the first four sub-sample periods are set at January 2000.

[7] Since the sample size from August 2008 to January 2010 is too small to be a proper sample period, we skipped analyzing it. However, with the accumulation of data, it is also necessary to take into account the sample periods after the bankruptcy of Lehman Brothers.

[8] The estimation results of β-convergence and σ-convergence are not reported completely because of space limitations but are available upon request. The lag lengths of both tests on β-convergence and σ-convergence are based on the Schwartz Bayes Information Criteria (SBIC).

[9] As mentioned in Hattori and Shin (2007), interbank positions are able to outline the aggregate yen liabilities. Therefore, we focus on the category of other investments in financial account to identify the channel of yen carry trade within the East Asian area.

References

Barro, R. J. and X. Sala-i-Martin, 2004, *Economic Growth*. MIT Press, Cambridge, MA.

Dickey, D. A. and W. A. Fuller, 1979, Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, **74**, pp. 427-31.

Engle, R. F. and C. W. J. Granger, 1987, Co-integration and error correction: Representation, estimation and testing. *Econometrica*, **55**, pp. 251-76.

Granger, C. W. J. and P. Newbold, 1974, Spurious regression in econometrics. *Journal of Econometrics*, **2**, pp. 111-20.

Hamilton, J. D., 1994, *Time Series Analysis*. Princeton University Press, Princeton, NJ.

Hannan, E. J. and B. G. Quinn, 1979, The determination of the order of an autoregression. *Journal of Royal Statistical Society*, **41**, pp. 190-95.

Hattori, M. and H. Shin, 2007, The broad yen carry trade. *IMES Discussion Paper Series*, 2007-E-19.

Hosking, J. R. M., 1981, Lagrange-multiplier tests of multivariate time-series models. *Journal of Royal Statistical Society*, **43**, pp. 219-30.

Im, K. S., M. H. Pesaran and Y. Shin, 2003, Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, **115**, pp. 53-74.

Johansen, S., 1988, Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, **12**, pp. 231-54.

Juselius, K., 2006, *The Cointegrated VAR Model: Methodology and Applications*. Oxford University Press, Oxford, NY.

Kuroda, H. and M. Kawai, 2003, Strengthening regional financial cooperation in East Asia. *PRI Discussion Paper Series*, 03A-10.

Levin, A., C. F. Lin and C. S. J. Chu, 2002, Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, **108**, pp. 1-24.

Ljung, G. M. and G. E. P. Box, 1978, On a measure of lack of fit in time series models. *Biometrika*, **65**, pp. 297-303.

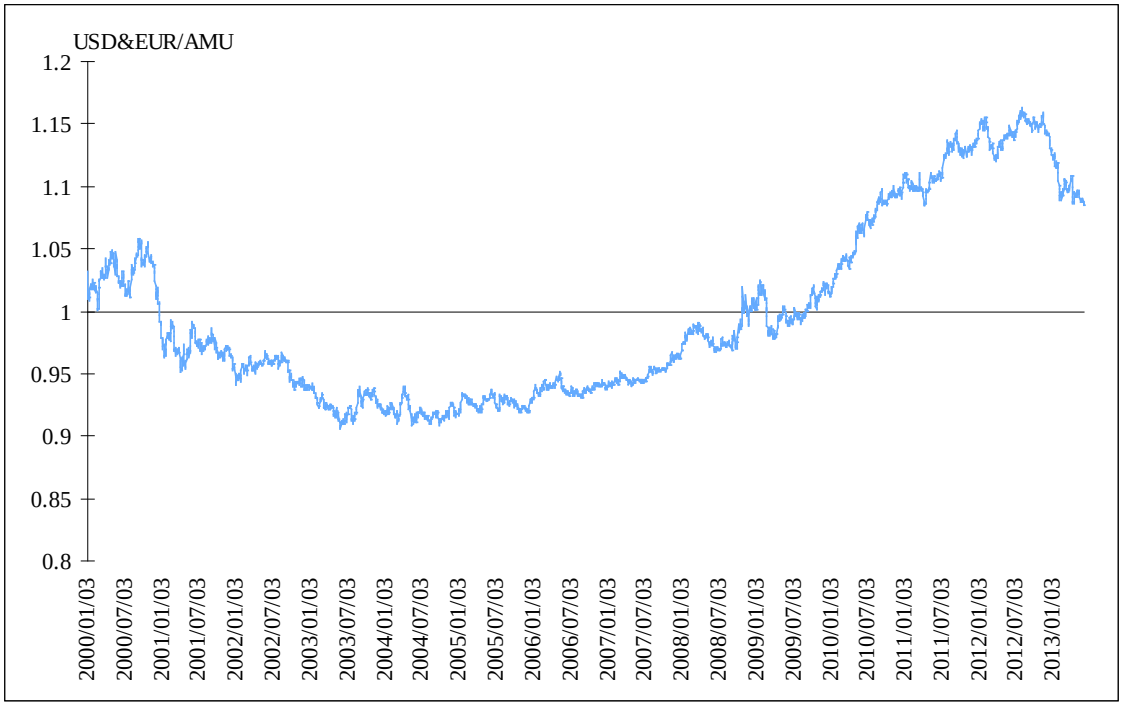
Ogawa, E., 2004, Regional monetary cooperation in East Asia against asymmetric responses to the US dollar depreciation. *The Journal of the Korean Economy*, **5**, pp. 43-72.

Ogawa, E. and K. Kawasaki, 2003, Possibility of creating a common currency basket for East Asia. *JBICI Discussion Paper Series*, 5.

Ogawa, E. and M. Kumamoto, 2008, Inflation differentials and the differences of monetary policy effects among euro area. *TCER Working Paper Series*, E-9.

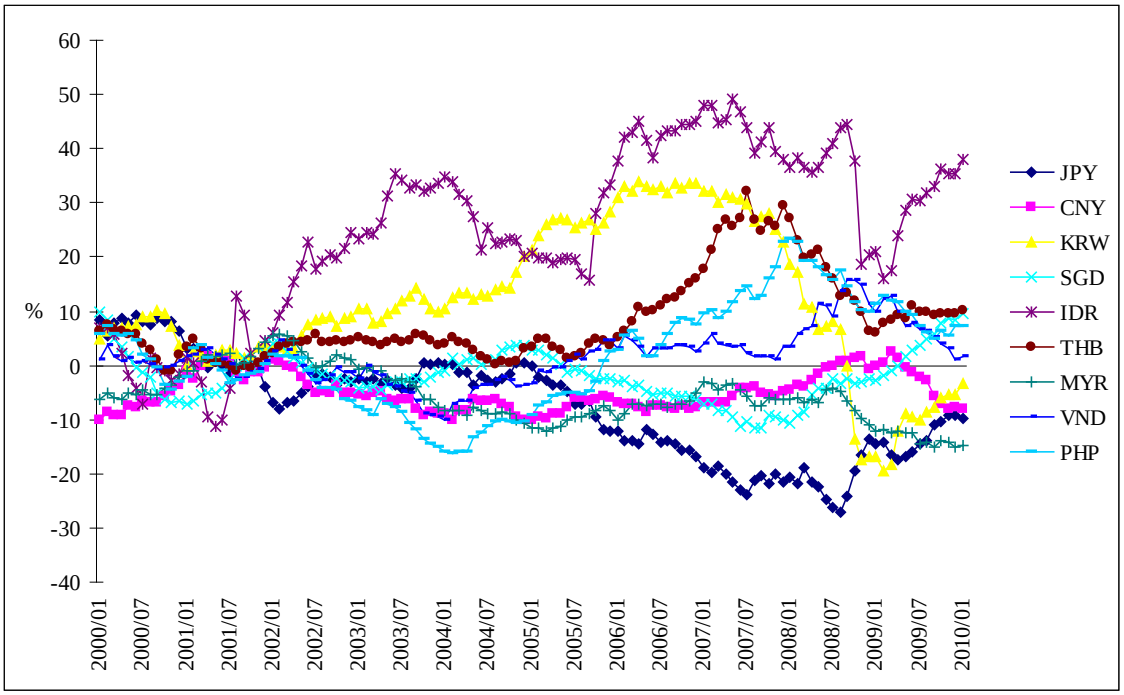
Ogawa, E. and M. Sakane, 2006, Chinese yuan after Chinese exchange rate system reform. *China & World Economy*, **14**, pp. 39-57.
Ogawa, E. and J. Shimizu, 2005, A deviation measurement for coordinated exchange rate policies in East Asia. *RIETI Discussion Paper Series*, 05-E-017.
Ogawa, E. and J. Shimizu, 2011, Asian monetary unit and monetary cooperation in Asia. *ADBI Working Paper Series*, 275.
Ogawa, E. and Z. Wang, 2013a, AMU deviation indicators based on purchasing power parity and adjusted by Balassa–Samuelson effect. *Global Journal of Economics*, forthcoming.
Ogawa, E. and Z. Wang, 2013b, How did the global financial crisis misalign East Asian currencies? *RIETI Discussion Paper Series*, forthcoming.
Ogawa, E. and T. Yoshimi, 2009, Analysis on β and σ convergences of East Asian currencies. *RIETI Discussion Paper Series*, 09-E-018.
Phillips, P. C. B. and P. Perron, 1988, Testing for a unit root in time series regression. *Biometrika*, **75**, pp. 335-46.
Shittu, O. I. and M. J. Asemota, 2009, Comparison of criteria for estimating the order of autoregressive process: A Monte Carlo approach. *European Journal of Scientific Research*, **30**, pp. 409-16.
Vahid, F. and J. V. Issler, 2002, The importance of common cyclical features in VAR analysis: A Monte Carlo study. *Journal of Econometrics*, **109**, pp. 341-63.
Williamson, J., 2000, *Exchange Rate Regimes for Emerging Markets: Reviving the Intermediate Option*. Institute for International Economics, Washington, D.C.

Figure 1. Exchange Rate of Asian Monetary Unit



Source: RIETI online database.

Figure 2. PPP-Based AMU Deviation Indicators Adjusted by Balassa–Samuelson Effect



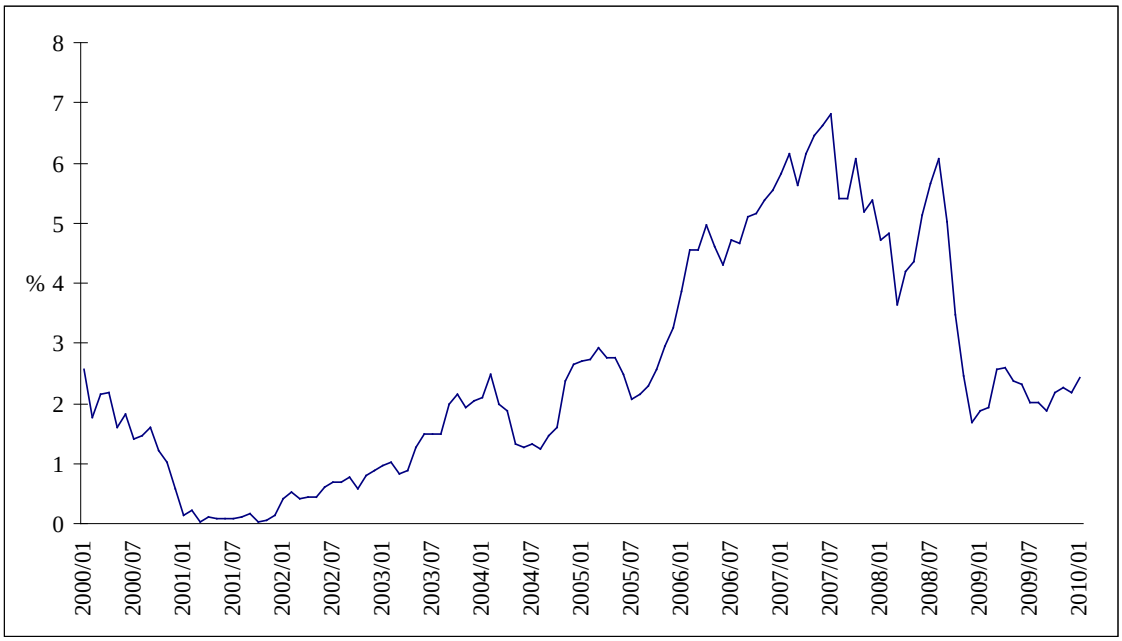
Source: Ogawa and Wang (2013a).

Table 1. Data Sources of Real GDP and Employment

	Real GDP	Employment
Japan	Japan Statistical Yearbook Cabinet Office, Government of Japan	OECD Structural Analysis Statistics Ministry of Internal Affairs and Communications
China	China Statistical Yearbook National Bureau of Statistics of China	China Statistical Yearbook National Bureau of Statistics of China
Korea	Korea Statistical Yearbook Statistics Korea	OECD Structural Analysis Statistics Ministry of Employment and Labor
Singapore	Yearbook of Statistics Singapore Department of Statistics Singapore	Ministry of Manpower
Indonesia	Statistical Yearbook of Indonesia Statistics Indonesia	Statistical Yearbook of Indonesia Statistics Indonesia
Thailand	Thailand Statistical Yearbook National Statistical Office	Office the National Economic and Social Development Board
Malaysia	Yearbook of Statistics Malaysia Department of Statistics Malaysia	Yearbook of Statistics Malaysia Department of Statistics Malaysia
Vietnam	Statistical Yearbook of Vietnam General Statistics Office of Vietnam	Statistical Yearbook of Vietnam General Statistics Office of Vietnam
The Philippines	Philippine Statistical Yearbook National Statistical Coordination Board	Bureau of Labor and Employment Statistics

Authors' summarization.

Figure 3. Weighted Average Variance of PPP-Based AMU Deviation Indicators Adjusted by Balassa–Samuelson Effect



Source: Ogawa and Wang (2013a).

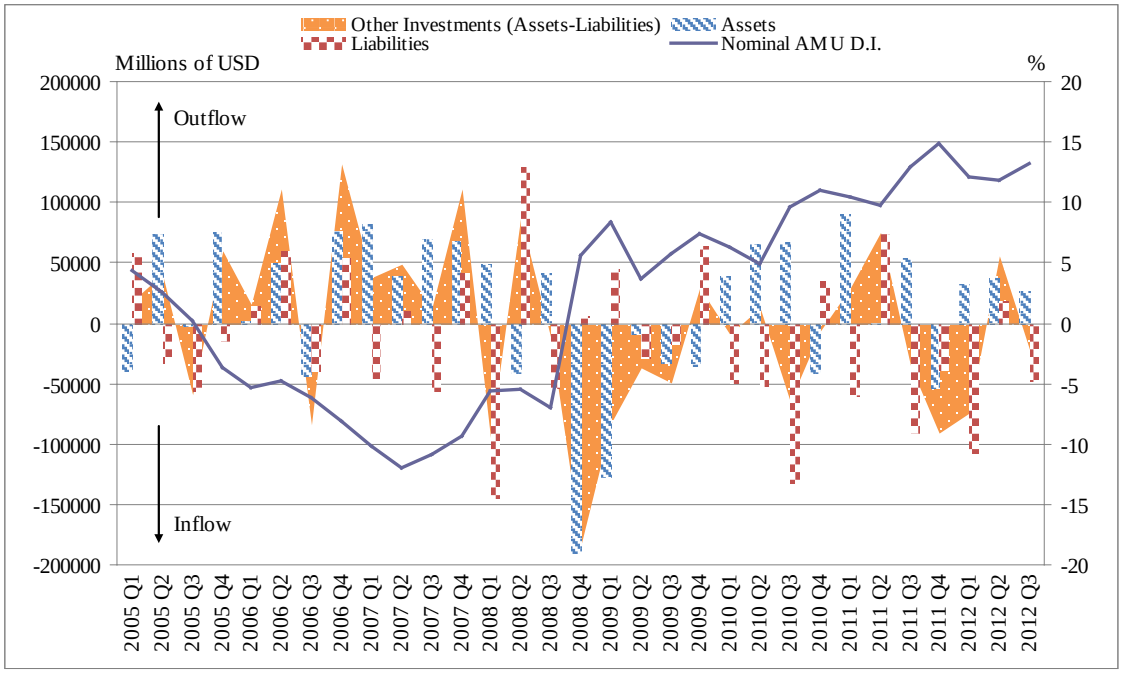
Table 2. Results of Convergence Test

		Sample Periods															
		2000.1~ 2004.6		2000.1~ 2005.6		2000.1~ 2007.7		2000.1~ 2008.8		2000.1~ 2010.1		2004.6~ 2010.1		2005.6~ 2010.1		2007.7~ 2010.1	
β-convergence		154		129		0		0		0		33		18		110	
σ-convergence		69		72		7		16		19		9		28		109	
β-convergence & σ-convergence		32		32		0		0		0		1		0		23	
LLC	IPS	111	121	72	124	0	0	0	0	0	0	33	0	18	0	110	15
ADF	PP	48	56	50	59	4	7	13	5	18	4	8	1	28	1	89	78

Note: In each sample period, the candidates for convergence test combine two currencies at least and nine currencies at most, and the total number of combinations is 502. Test results (how many convergent combinations there are) are summarized in the cell, respectively.

Source: Ogawa and Wang (2013a).

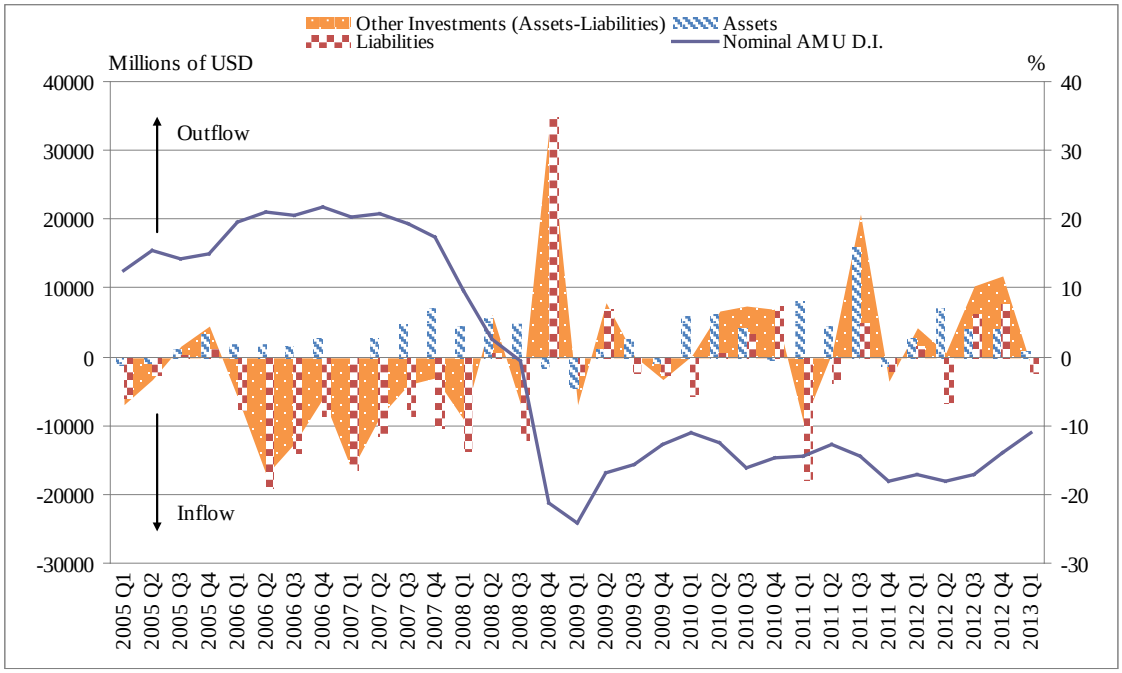
Figure 4. Capital Flow (Other Investments) and Nominal AMU Deviation Indicator, Japan (2005.Q1–2012.Q3)



Note: The left scale gives the volume of trade in other investments; the right scale gives the rate of change of the nominal AMU deviation indicator.

Source: International Financial Statistics (IMF) and RIETI online database.

Figure 5. Capital Flow (Other Investments) and Nominal AMU Deviation Indicator, Korea (2005.Q1–2013.Q1)



Note: The left scale gives the volume of trade in other investments; the right scale gives the rate of change of the nominal AMU deviation indicator.

Source: International Financial Statistics (IMF) and RIETI online database.