Asian Currency Unit (ACU), Deviation Indicators and Exchange Rate Coordination in East Asia: A Panel-Based Convergence Approach

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Abstract

Employing the panel convergence method of Phillips-Sul (2007) to the nominal deviation indicators of two recent unofficial constructions of an Asian Currency Unit (ACU) index, this paper examines the existence and extent of convergence in the movements of East Asian currencies against the ACU. Empirical results reveal that intra-East Asian exchange rate movements have not converged to form one, cohesive and unified bloc where currencies share homogenous movements, regardless of whether one examines the data on intra-East Asian exchange rate movements before or after the collapse of Lehman Brothers in September 2008. Instead, a separate number of convergent clubs or blocs in the region have formed in recent years. Finally, and most importantly, we observe at the end of the period of our examination that economies in the region are, generally, converging at different speeds to two opposing poles of convergence, that is, groups of relatively depreciating currencies and, on the other, groups of relatively appreciating currencies.

JEL: F31, F36, C33

Keywords: ASEAN+3 and Hong Kong, China; Asian Currency Unit; nominal deviation indicators; panel convergence test

Highlights:

- Intra-East Asian exchange rate movements have not converged to form one bloc.
- A separate number of convergent clubs in the region have formed in recent years.
- The number and composition of clubs depend on which deviation indicator and period used.
- There are two opposing convergent poles of relatively depreciating and appreciating currencies.
- Our results have important policy implications on exchange rate coordination in East Asia.

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Abstract

Employing the panel convergence method of Phillips-Sul (2007) to the nominal deviation indicators of two recent unofficial constructions of an Asian Currency Unit (ACU) index, this paper examines the existence and extent of convergence in the movements of East Asian currencies against the ACU. Empirical results reveal that intra-East Asian exchange rate movements have not converged to form one, cohesive and unified bloc where currencies share homogenous movements, regardless of whether one examines the data on intra-East Asian exchange rate movements before or after the collapse of Lehman Brothers in September 2008. Instead, a separate number of convergent clubs or blocs in the region have formed in recent years. Finally, and most importantly, we observe at the end of the period of our examination that economies in the region are, generally, converging at different speeds to two opposing poles of convergence, that is, groups of relatively depreciating currencies and, on the other, groups of relatively appreciating currencies.

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I. Introduction

Over the last 25 years and driven mainly by market forces, regional trade and investment integration has deepened in East Asia. The closer trade and financial ties between East Asian countries have made these economies highly and increasingly interdependent among each other. As a consequence, economies in the region are increasingly affected by shocks that originate from neighboring economies as well as being highly sensitive to policies adopted by their neighboring economies. The latter argument, on the other hand, triggers an important observation that East Asian economies also compete among each other in markets within and outside of the region and as such the potential of losing competitiveness against each other is treated with utmost sensitivity among countries in the region. In the extreme, the prospect of a beggar-thy-neighbor competitive depreciation strategy, which can be costly to the region in terms of large and unnecessary reallocation of resources across the region, always looms large (Kawai and Takagi 2012). Regardless, however, on whether one views the deepening economic relationships in the East Asian region as a story of economic integration or economic competition, the achievement of exchange rate stability among countries in the region is of paramount importance.[1]

Given that a case can be made out of the need to promote greater intra-regional exchange rate stability in East Asia, the key challenge to the achievement of this objective is that this would require a certain degree of exchange rate policy coordination. Since there is currently no consensus about the form that exchange rate policy coordination in the region will take, a number of studies have proposed the creation of a basket of appropriately weighted regional currencies. For instance, Ogawa and Shimizu (2005) proposed the construction of an ASEAN+3 (Association of Southeast Asian Nations, which includes Brunei Darussalam,

[1] This argument is supported by a number of empirical studies that indeed show intra-regional exchange rate volatility harms East Asian bilateral trade, e.g., Thorbecke (2008) and Hayakawa and Kimura (2009).

Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam, plus China, Japan and South Korea) regional currency basket *a la* the European Currency Unit (ECU) and calculated the weights of the ASEAN+3 currencies as an arithmetic average of the country's respective shares of PPP-based GDP and foreign trade. One important rationale for the calculation of this so-called Asian Currency Unit (henceforth ACU) is that it can serve to monitor the movements of regional currencies relative to this ACU as well as the collective movements of regional currencies against key external currencies such as the US dollar and the euro (Kawai 2009). In other words, the requirement of exchange rate policy coordination can be met in part by the creation of the ACU as a regional currency basket.

In order, however, for the ACU to be made useful in practice as an exchange rate policy coordinating device, policymakers should be guided on how it can conduct the monitoring of the movements of individual currencies in the region relative to this ACU. The main objective of this paper then is to demonstrate that the monitoring of the movements of individual currencies in the region relative to the ACU can be undertaken based on the idea of convergence in Deviation Indicators. Deviation Indicators measure the direction (i.e. appreciation or depreciation) and the magnitude of movements of individual East Asian currencies relative to the ACU. Given that the ACU is a weighted average of the regional currencies, a careful examination of the convergence in Deviation Indicators allows one to determine, for instance, the number and configuration of currencies that appreciate relative to the ACU regional average and those that depreciate with respect to the ACU regional average. In other words, convergence in Deviation Indicators would provide information on specific group of convergent countries whose currencies have either collectively appreciate or depreciate relative to the ACU regional average. It follows, therefore, that those currencies that belong to the same convergent group would have relatively stable bilateral exchange rates between them, regardless of whether a condition of region-wide exchange rate stability takes hold or not.

Furthermore, the illustration of possible paths that describe the movements of each individual currencies and each convergent group relative to the panel average is also a major feature of any analysis conducted on the basis of convergence in Deviation Indicators.

Thus, overall, convergence in Deviation Indicators can then provide policymakers a much more vivid and dynamic picture of exchange rate movements in the region that would be extremely valuable for them to carry out useful and effective exchange rate coordination in the region. In the very long-run for the region, information obtained from an analysis of the convergence in Deviation Indicator can, should the region so desire, facilitate in the formation of sub-regional currency blocs in which currencies in the region that have shown relative bilateral exchange rate stabilities due to the achievement of sufficient convergence in deviation indicator can take a multi-track or multi-speed approach to monetary integration. This can then help set the stage later on, again should the region aspire, with the eventual creation of a wider and unified regional monetary zone in East Asia.

After discussing the underlying motivation of our paper, one can argue that it would be much more convenient and straightforward to examine the Deviation Indicators based on the US dollar (USD) rather than based on the ACU. The main advantage of using the latter, however, is that it allows one to observe the movements of individual currencies relative to the regional average. This would, in turn, assist in understanding important issues with a regional dimension, such as the relative competitiveness of exports within the region. In addition, the limitation of the former is that in situations when, for instance, two regional currencies are both depreciating against the USD, but, at the same time, are both appreciating against the ACU, it would not be able to capture the two currencies' loss of competitiveness in exports relative to other East Asian countries.

In order for us to fully examine the convergence in Deviation Indicators and provide the above mentioned analysis, we apply the recently developed panel convergence method of

Phillips and Sul (2007) (henceforth P-S (2007)) to two alternative Deviation Indicators that are calculated using two recent unofficial constructions of an ACU in East Asia. To the best of our knowledge, there has been no previous work that applied this method to the exchange rates of Asian currencies relative to the ACU. The advantages that this convergence test offers in terms of the tasks set out in this paper, and especially on how this test compares with the traditional beta and sigma convergence tests are as follows: First, based on a time varying factor model, the test does not demand assumptions regarding the stationarity of the variables and allows for individual series to be transitionally divergent. Hence this methodology can accommodate long-run equilibria within a heterogeneous panel, outside of the co-integration setup. Second, this methodology can cluster panel currencies into convergent sub-groups when the whole panel convergence is absent. In other words, the test is able to detect whether any specific sub-groups of currencies are converging or diverging. It additionally provides information on the speed of convergence for each group detected. Third, this method provides information on relative transition parameters for each currency, which can be used to portray each currency's and each group's behavior relative to the panel cross-section average over time.

There have been two recent contrasting unofficial constructions of an ACU in East Asia. One, is the initial work of Ogawa and Shimizu (2005) that constructed an ASEAN+3 regional currency basket *a la* the European Currency Unit (ECU), which later on under the joint auspices of the Japan's Research Institute of Economy, Trade and Industry (RIETI) and Hitotsubashi University calculated a regional currency basket for the Chiang Mai Initiative Multilateralization (CMIM) member economies (i.e., ASEAN+3 plus Hong Kong, China). The other is by Pontines (2013) (henceforth VP (2013)) which is based on the seminal idea of a *reduced normalized in exchange* (RNVAL) of a currency by Hovanov et al (2004). The above panel convergence methodology of P-S (2007) is then applied to the so-called Deviation Indicators that were calculated from these two ACU constructions in the region in order to detect for convergence (absolute and conditional). In a nutshell, as also earlier defined, the Deviation Indicators measure the relative value for each of the currencies included in the currency basket against all the other currencies comprising the ACU.

Finally, also to the best of our knowledge, attempts to examine the convergence in Deviation Indicators of currencies in East Asia relative to a regional currency basket are almost virtually non-existent. The only previous and related studies that we can find are by Ogawa and Yoshimi (2009) and Ogawa and Wang (2013), both using traditional beta and sigma convergence tests and finding that the deviations of East Asian currencies relative to the ACU benchmark have been widening during 2005-early 2009 and 2005-early 2010, respectively. In view of this dearth of evidence as to the issue of relative exchange rate movements in East Asia, we believe that our paper makes a worthwhile and fresh contribution to the literature on monetary and financial integration in East Asia, in general, and to the issue of relative exchange rate movements in the region, in particular. Our paper is structured as follows. The next section provides more detail regarding the recent constructions of an ACU and the corresponding Deviation Indicators in the East Asian region. The third section discusses the method used to assess convergence in Deviation The fourth section presents our empirical results. The fifth section concludes.

II. Construction of an ACU Index and Deviation Indicators

Since an ACU is a weighted average of the values of currencies comprise by a certain group of Asian countries, it can then be calculated as follows:

$$ACU_t = \sum_{i=1}^{n} w_i \cdot FX_{i,t} \qquad (1)$$

where w_i and $FX_{i,t}$ represent the weight of currency i and the exchange rate against the numeraire currency, typically, the US dollar, of currency i. Clearly, decisions on: (i) how to calculate the weights; (ii) the coverage of currencies included in the basket; and, (iii) the choice of the base year, have to be decided, at the outset, in order to calculate the ACU. With regards to (i), typically, a measure of economic size is used and as such weights based on indicators such as GDP and trade volume share are the standard convention.[2] As far as (iii), ideally, the base year is chosen when a fundamental equilibrium of both the internal and external sectors is achieved. However, since it is difficult in practice to determine the internal equilibrium of a country, the alternative is to choose the base year when a measure of the total external transactions of countries is as close to balance as possible.

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2.1 Ogawa and Shimizu (2005) and RIETI/Hitotsubashi University constructions of an ACU index

As mentioned above, the initial work of Ogawa and Shimizu (2005) constructed an ASEAN+3 regional currency basket following the approach employed to calculate the European Currency Unit (ECU) under the European Monetary System (EMS).[3] The share of GDP measured at PPP and overall trade volumes (the sum of exports and imports) of each country comprising the regional currency basket were used to calculate the weights. Furthermore, the choice of the

[2] In the sub-section that follows, we present an alternative approach that avoids entirely the calculation of the basket weights based on standard economic indicators.

[3] A similar method of construction was undertaken by Gupta (2012) except that the set of regional currencies in the currency basket included not just the ASEAN+3 but also India and Hong Kong, China.

base year (this was referred to in the Ogawa and Shimizu (2005) study as the benchmark period) was made in the following manner: the total trade balance of the countries comprising the currency basket (Ogawa and Shimizu (2005) referred to this as the intra-regional trade balance), total trade balance of the countries comprising the currency basket (with the exception of Japan) with Japan, and the total trade balance with the rest of the world must be approximately zero. Based on this criterion, 2000 and 2001 were chosen as the base years.

More recently, under the joint auspices of the Japan's RIETI and Hitotsubashi University under the so-called Global COE project, the initial work of Ogawa and Shimizu (2005) were re-calculated this time for the economies comprising the CMIM (i.e., ASEAN+3 plus Hong Kong, China).[4] In the construction of the ACU for the CMIM member economies, the CMIM contribution shares of each of the individual member economies were used.

2.2 VP (2013) ACU index[5]

An alternative construction of the ACU index is based on a methodology that estimates optimal currency basket weights in the context of a minimized basket or portfolio of assets expressed in terms of national currencies. In a seminal paper, Hovanov et al (2004) showed that the values of any given currency (e.g., British pounds) depend on the chosen base currency (e.g., U.S. dollars, euros, Japanese yen), which creates ambiguity in the valuation of a currency, making it difficult to examine the dynamics of the time series of currency values. It should be noted that the choice of base currency is critical for obtaining a stable exchange rate. For example, using the US dollar as a base currency as opposed to the Japanese yen changes the relationship between the euro and the British pound. To overcome this base currency problem, they proposed a *reduced* (to the moment t_0) *normalized value in exchange* of ith currency:

[4] More information on the construction of the ACU index comprising of the CMIM member economies can be found in this website: http://www.rieti.go.jp/users/amu/en/cmi.html

[5] See, also, Pontines and Rajan (2008) and Pontines (2009).

$$\text{RNVAL}_i(t/t_0) = \frac{c_{ij}(t)}{\sqrt[n]{\prod_{k=1}^{n} c_{kj}(t)}} \Bigg/ \frac{c_{ij}(t_0)}{\sqrt[n]{\prod_{k=1}^{n} c_{kj}(t_0)}} = \sqrt[n]{\prod_{k=1}^{n} \frac{c_{ik}(t)}{c_{ik}(t_0)}} \qquad (2)$$

where $c_{ij}(t)$, $i,j = 1, \ldots, n$, are cross-currencies of exchange rates of n currencies at the moment t. Through division by the geometric mean of a basket of currencies, the value of any currency is the same regardless of the base currency chosen.

This *reduced normalized value in exchange (*$\text{RNVAL}_i(t/t_0)$) of a currency is useful for comparing the movements of individual currencies and basket currencies. Why? Typically, one makes statements like "the US dollar appreciates against the yen but depreciates against the euro". In contrast, if the *reduced normalized value in exchange* of the US dollar rises, it means that the value of the US dollar rises on average against the national currencies used in the computation of the geometric mean of the basket of national currencies (Hovanov et al., 2004).

Furthermore, it also allows the computation of a unique optimal, minimum-variance currency basket regardless of the base currency choice. The derivation of this minimum variance currency basket is calculated by the optimal weight vector w^* that solves the following optimal control problem:

$$Min\left(S^2(w) = \sum_{i,j=1}^{n} w_i w_j \text{cov}(i,j) = \sum_{i=1}^{n} w_i^2 s_i^2 + 2\sum_{\substack{i,j=1 \\ i<j}}^{n} w_i w_j \text{cov}(i,j) \right) \qquad (3)$$

under the constraints, $w_i \geq 0$, for all $i = 1, \ldots, n$, $w_1 + \ldots + w_n = 1$, where cov(i,j) is the covariance between $\text{RNVAL}_i(t/t_0)$ and $\text{RNVAL}_j(t/t_0)$, and s_i^2 is the variance of $\text{RNVAL}_i(t/t_0)$ for all $i,j = 1, \ldots, n$ and all $t = 1, \ldots, T$.[6] The optimal weights can also be transformed into optimal currencies' amounts $q_1^*, q_2^*, \ldots, q_n^*$ as follows:

[6] The optimal weights that minimize the variance of a currency basket can be easily computed using familiar optimization methods for diversifying a portfolio of assets. See Hovanov et al (2004) for details.

$$q_i^* = \frac{w_i^* \sum_{r=1}^{n} q_r c_{rj}(t)}{c_{ij}(t)}, \qquad \text{Let} \quad \mu = \sum_{r=1}^{n} q_r c_{rj}(t), \quad \text{thus} \quad q_i^* = \frac{w_i^* \mu}{c_{ij}(t)} \tag{4}$$

Here the positive factor μ can be easily solved with the identification of the optimal weights $w_1^*, w_2^*, \ldots, w_n^*$ derived from the minimization of the variance in Eq. (2), and $c_{1j}(t)$, $c_{2j}(t)$, . . ., $c_{nj}(t)$. Substituting μ into Eq. (4) we obtain the optimal currencies' amounts $q_1^*, q_2^*, \ldots, q_n^*$, which constitute the minimum variance currency basket.

Since we are minimizing a basket or portfolio of assets expressed in terms of national currencies, the currency weights are primarily determined by two main factors—the variance of the *reduced normalized value in exchange (*$\text{RNVAL}_i(t/t_0)$) of the national currencies included in the currency basket; and the covariance of the *reduced normalized value in exchange (*$\text{RNVAL}_i(t/t_0)$) of the national currencies included in the currency basket, and, hence, their correlations. Thus, based on the foregoing discussion, the major difference of the VP (2013) approach to the Ogawa and Shimizu (2005) and RIETI/Hitotsubashi University (henceforth RIETI/Hitotsubashi) constructions of an ACU index is that the former avoids the arbitrary choice as to which economic variables or indicators are to be used to calculate the currency weights.

2.3 Deviation Indicators

Ogawa and Shimizu (2005) proposed the calculation of the so-called Deviation Indicators, which measure the deviation in each of the currencies included in the currency basket from the benchmark period exchange rate, and with respect to the ACU (Equation (5)).

$$The\ Deviation\ Indicator\ (\%) = -\frac{(National\ Currency\ per\ ACU)^{Actual} - (National\ Currency\ per\ ACU)^{Benchmark}}{(National\ Currency\ per\ ACU)^{Benchmark}} \times 100 \tag{5}$$

In other words, it essentially measures the relative value for each of the currencies included in the currency basket against all the other currencies comprising the ACU, the latter of which serves as the regional benchmark. According to Equation (5), a positive (negative) value of the indicator suggests appreciation (depreciation) of the national currency against the ACU relative to its benchmark value. Based on the above mentioned two alternative constructions of the ACU, two sets of Deviation Indicators are calculated using Equation (5).

III. Methodology: The Phillips and Sul Convergence Test

Standard unit root and cointegration tests can reject long-run equilibrium because of short time span of the data in which two series can be in fact be converging in the long-run but the speed of convergence is not fast enough in the given sample period or the speed of convergence is different. The P-S (2007) method, however, is able to detect convergence in these two cases as it is based on a time-varying factor representation. Specifically, using common stochastic trends, the time varying factor model can accommodate long-run co-movement in aggregate behavior outside the cointegration framework and it further allows for the modeling of transitional effects. In other words, idiosyncratic factor loadings allow for individual heterogeneous and a period of transition in a path that is ultimately governed by some common long-run stochastic trend. By using the time-varying factor model, the P-S (2007) method is also more powerful than the traditional beta and sigma convergence tests. In particular, in addition to revealing the speed of convergence (if present) for the full panel, as do beta and sigma convergence tests, P-S (2007) method also highlights the different extent and speed of the convergence in the sub-groups of members through its club formation procedure.

3.1. Convergence of Factor Loadings

Consider a simple single factor model:

$$X_{it} = \delta_i \mu_t + \epsilon_{it}, \tag{5}$$

where δ_i measures the idiosyncratic distance between some common factor μ_t and the systematic part of the panel data X_{it} and ϵ_{it} stands for unit specific idiosyncratic components.

P-S (2007) propose a new time-varying loading factor representation:

$$X_{it} = \delta_{it}\mu_t, \tag{6}$$

where δ_{it} is a time-varying factor loading coefficient. P-S (2007) further allow δ_{it} to absorb ϵ_{it} and to have convergence behaviour over time in relation to the common factor μ_t. Specifically, δ_{it} is modeled in a semi-parametric form implying non-stationary transitional behaviour in the following way:

$$\delta_{it} = \delta_i + \sigma_i \xi_{it} L(t)^{-1} t^{-\alpha}, \tag{7}$$

where δ_i is fixed, ξ_{it} is *iid*(0, 1) across i but weakly dependent over t, and $L(t)$ is a slowly varying function (e.g., log t) for which $L(t) \to \infty$ as $t \to \infty$.

Equation (7) ensures that δ_{it} converges to δ_i for all $\alpha \geq 0$, which therefore becomes a null hypothesis of interest for a cross section unit. For a panel, the corresponding null hypothesis would become $\delta_{it} \to \delta$ for some δ as $t \to \infty$ and $\alpha \geq 0$.

3.2. Relative Transition

In order to obtain information about the time-varying factor loading δ_{it}, P-S (2007) employ the relative version of δ_{it}, namely the relative loading factor or the *relative transition parameter*, as follows:

$$h_{it} = \frac{X_{it}}{\frac{1}{N}\sum_{i=1}^{N} X_{it}} = \frac{\delta_{it}}{\frac{1}{N}\sum_{i=1}^{N} \delta_{it}}, \tag{8}$$

where h_{it} is the relative transition parameter that measures δ_{it} in relation to the panel average at time t and therefore describes the transition path for country i relative to the panel average. Given Equation (8), it is apparent that the cross sectional mean of h_{it} is unity. In addition, if the factor loading coefficients δ_{it} converge to δ then the relative transition parameters h_{it} converge to unity. In this case, the cross sectional variance of h_{it}, H_t, converges to zero in the long run:

$$H_t = \frac{1}{N}\sum_{i=1}^{N}(h_{it} - 1)^2 \to 0 \text{ as } t \to \infty. \tag{9}$$

This property (Equation (9)) will be used to test the null hypothesis of convergence and to group economies into convergence clusters.

3.3. The $log\ t$ Convergence Test

A simple regression-based testing procedure is proposed by P-S (2007) to test the null of convergence, H_0: $\delta_i = \delta$ and $\alpha \geq 0$, against the alternative of H_A: $\delta_i \neq \delta$ or $\alpha < 0$.

The procedure involves three steps. First, calculate the cross sectional variance ratio H_1/H_t given that $H_t = \frac{1}{N}\sum_{i=1}^{N}(h_{it} - 1)^2$. Second, run the following OLS regression and compute a conventional robust t statistics, $t_{\hat{b}}$, for the coefficient $\hat{b}$ using the estimate of the long-run variance of the regression residuals:

$$log\left(\frac{H_1}{H_t}\right) - 2logL(t) = \hat{a} + \hat{b}log\ t + \hat{u}_t, \quad (10)$$

for $t = [rT], [rT] + 1, \dots, T$ with some $r > 0$. P-S (2007) recommend $r = 0.3$ based on their simulations. Other settings of the regression include $L(t) = log\ (t + 1)$ and that the fitted coefficient of log t is $\hat{b} = 2\hat{\alpha}$, where $\hat{\alpha}$ is the estimate of α under the null. Third, perform a one-sided t test of null $\alpha \geq 0$ using $\hat{b}$ and a standard error estimated using a heteroskedasticity and autocorrelation consistent (HAC) estimator. Given that the test statistic $t_{\hat{b}}$ is asymptotically normally distributed, the null of convergence is rejected at 5% significance level if $t_{\hat{b}} < -1.65$.

Note that $\hat{\alpha} \geq 1$ and accordingly $\hat{b} \geq 2$ implies level (absolute) convergence and that $1 > \hat{\alpha} \geq 0$ and accordingly $2 > \hat{b} \geq 0$ implies rates (conditional) convergence.

3.4. Club Convergence and Clustering

Rejection of the null of full panel convergence does not imply there is no evidence of convergence. There may be one or more convergence clusters as well as divergent units in the panel. Based on repeated log *t* regressions, P-S (2007) provide a four-step algorithm to detect such units of clusters:

1. Panel units X_{it} are ordered according to the last observation, X_{iT}.
2. The first k highest panel units are selected to form the subgroup G_k for some $N > k \geq 2$. Calculate the convergence test statistic $t_{\hat{b}}(k)$ for each k. The core group size k^* is chosen according to $k^* = argmax_k\{t_{\hat{b}}(k)\}$ subject to $min\{t_{\hat{b}}(k)\} > -1.65$. If $k^* = N$, there is full panel convergence. If $min\{t_{\hat{b}}(k)\} > -1.65$ does not hold for $k = 2$, drop the first unit and perform same procedure for the remaining units. If $min\{t_{\hat{b}}(k)\} > -1.65$ does not hold for every subsequent pair of units, there are no convergence clusters in the panel. In all other cases, a core group can be detected.
3. Add one remaining unit at a time to the core group and perform the $log\ t$ test. If the corresponding t statistic from this regression, $\hat{t}$, exceeds a chosen critical value, c,[7] then the unit is included in the current sub-group. The $log\ t$ test is run for this sub-group and if $t_{\hat{b}} > -1.65$, the formation of this sub-group is completed. Otherwise, raise the critical value c and repeat the procedure.
4. Form a sub-group of the units for which $\hat{t} < c$ in Step 3. Run the $log\ t$ test for this sub-group and if $t_{\hat{b}} > -1.65$, this cluster converges and there are two convergent sub-groups in the panel. Otherwise, repeat Steps 1–3 on this sub-group to determine whether a smaller convergent sub-group exists. If there is no k in Step 2 for which $t_{\hat{b}}(k) > -1.65$, the remaining units diverge.

IV. Data and Empirical Results

The VP (2013) method of calculating an ACU index was used to construct an optimal ACU index composed of the ASEAN+3[8] economies as well as Hong Kong, China using monthly

[7] Note that, following Phillips and Sul (2009), we set $c = 0$ in view that our number of observation is not particularly large.
[8] Note that Myanmar is not included in our sample for consistency due to the fact that the calculated Deviation Indicators provided by RIETI does not include Myanmar.

nominal exchange rate data for the period 2000m1 to 2013m6. As previously mentioned, these economies comprise what is known as the CMIM. After this, we then followed Ogawa and Shimizu (2005) on how to calculate the nominal deviation indicators and applied it to the VP (2013) ACU index. Nominal exchange rate data are collected from the International Financial Statistics (IFS). The calculated nominal deviation indicators from the RIETI/Hitotsubashi construction of an ACU index, on the other hand, were conveniently retrieved from the following website: http://www.rieti.go.jp/users/amu/en/index.html#data.

The two sets of deviation indicators calculated from the two alternative constructions of the ACU are illustrated in Figure 1 and Figure 2 respectively. In both cases, fluctuations of the deviation indicators started to widen around 2004-2005 period and further widened since the end of 2008. Overall, the VP and the RIETI/Hitotsubashi nominal deviation indicators share similar shapes, although the former seems to indicate relatively higher deviations than the latter for most currencies since 2003 though, to a lesser extent, during the period 2007-2008, for some currencies the VP indicator turn out to have relatively lower deviations than the RIETI/Hitotsubashi nominal deviation indicator.

Once the above were completed, we then moved on to apply the $log\ t$ convergence and club convergence tests to both the VP (2013) and RIETI/Hitotsubashi nominal deviation indicators.[9] Following the recommendation by P-S (2007), the convergence analysis is conducted on filtered data series in which the cyclical component of each series is removed by applying the Hodrick-Prescott (Hodrick and Prescott, 1997) filter. Note that the first four years (2000m1-2003m12) were excluded to eliminate the base year effect. Furthermore, it is widely known that the global financial crisis which peaked at the end of 2008 due to the collapse of the Lehman Brothers had profound effect on both developed and developing countries. To

[9] GAUSS programme used to carry out these tests are available from Professor Donggyu Sul's homepage: http://www.utdallas.edu/~dxs093000/papers/Recent%20Working%20Papers1.htm

examine whether and how the full panel and club convergence process, if present, are affected by the crisis, we divide our sample period around the time the Lehman Brothers collapsed in September 2008. Specifically, the following two sub-sample periods were chosen: a pre-crisis period corresponding to 2004m1-2008m9 and a post-crisis period corresponding to 2008m10-2013m6.[10]

As mentioned in Section 3.2, h_{it}, the relative transition parameter, describes the transition path for country i *vis-à-vis* the panel average. Correspondingly, the relative transition parameters with the cross sectional means in each of the convergent club would demonstrate one club's behavior in relation to the clubs' average. Following P-S (2007), for convergent clubs, if present, we present their relative transition parameters. This procedure is very insightful as important inference can be drawn based on such visual illustration of each club's relative transition path.

We first present the results according to the nominal deviation indicator of the VP (2013) ACU index (Table 1, Figure 3 and Figure 4), and then followed by the results of the convergence tests on the nominal deviation indicator of the RIETI/Hitotsubashi ACU index (Table 2, Figure 5 and Figure 6). The $log\ t$ convergence regression results presented in the upper panel of Table 1 suggest that, since $t_{\hat{b}} < -1.65$, the null of convergence is rejected in both the pre- and post-crisis periods. It implies that there is no full panel convergence in both sub-periods. We were not surprised by this finding as a full panel convergence would only be possible if the deviation indicators of all currencies have moved towards similar values via similar paths. This is clearly not the case, as shown in Figure 1.

As earlier mentioned, an important advantage of the P-S (2007) method is that it is able to highlight the different extent and speed of the convergence in the sub-groups of countries

[10] In the Appendix to the paper, we alternatively conducted the convergence analysis in which we did not do the estimation for two separate periods but instead work with the entire sample period, yet excluding the period around the time of the collapse of Lehman Brothers. When we do this, we obtain results that further reinforces our results and analysis reported in the main text of our paper.

through its process of club formation. The lower panel of Table 1 presents the results of such club convergence tests.

For the pre-crisis period (2004m1-2008m9), three convergent clubs are detected. Club 1 includes Brunei dollar, Chinese yuan, Korean won, and Singapore dollar. Club 2 includes the Hong Kong dollar, Japanese yen, Laos kip, Malaysian ringgit and the Philippine peso, and Club 3 includes the Cambodian riel and Indonesian rupiah. The speed of convergence, measured by the value of $\hat{b}$, indicates that Clubs 1 and 3 is slightly faster than Club 2, although in all three clubs $\hat{b} < 2$ and thus there is convergence in rates (conditional convergence) rather than convergence in levels (absolute convergence).

Examining this time the corresponding club transition paths as indicated by the relative transition parameters in Figure 3,[11] currencies in Club 1 appreciated relative to the cross-club mean from the beginning of the sample period until end-2007, which thereafter until the end of the sub-sample period, experienced very moderate depreciation. In contrast, currencies in Club 2 slightly depreciated from the beginning of the sub-period until end-2005, which then visibly appreciated thereafter at a stronger pace. We then observe these two clubs slowly move towards each other by the time the Lehman Brothers collapsed. In terms of Club 3, we observe a consistent depreciation relative to the cross-club average, making it to show no sign of convergence with Clubs 1 and 2. There are also two divergent currencies, the Thai baht and Viet Nam dong, which do not belong to any clubs or form a convergent club among the others. A likely explanation for the divergence of these two currencies from the rest of the panel currencies is that the Viet Nam dong showed persistent and much faster depreciation than any other panel currencies during the pre-crisis period, whilst the opposite was true for the Thai baht.

[11] To save space, here we do not present the individual transition parameter for each country. They are available upon request.

Moving on to the post-crisis period (2008m10-2013m6), we observe a drastic re-configuration of convergent clubs. There are now four clubs with rather different club members compared to the pre-crisis period. Similar though to the pre-crisis period, we observe rate (conditional) convergence rather than level (absolute) convergence (since in all cases $\hat{b} < 2$). Moreover, the values of $\hat{b}$ are in general lower than that from the pre-crisis period, implying a slower speed of convergence. Among these four clubs, specifically, currencies in Clubs 1 and 4 converge moderately faster than the currencies in Clubs 2 and 3 given their slightly higher values of $\hat{b}$. Looking at the members of each clubs in the post-crisis period, the Brunei dollar and the Singapore dollar, just as in the pre-crisis, are found to be in the same club that had the highest value of $\hat{b}$. The Thai baht, which was found to be a divergent economy during the pre-crisis period due to the Thai baht's faster appreciation relative to other currencies in the group has slowed down its speed of appreciation in the post-crisis period, and has then formed a club with the Chinese yuan. Meanwhile, the Japanese yen, Malaysian ringgit and the Philippine peso remained together in the same club, whilst the Hong Kong dollar has joined Cambodian riel and Indonesian rupiah in the same club. Finally, the Korean won and the Laos kip have joined the Vietnam dong as the three divergent economies in the post-crisis period.

The transition paths of these four clubs are depicted in Figure 4. Interestingly, there are two pairs of clubs that exhibited opposite transition paths in the post-crisis period. For instance, currencies in Club 1 (Brunei dollar and Singapore dollar) and Club 4 (Cambodian riel, Hong Kong dollar and Indonesian rupiah) converged within the clubs at almost the same speed (as indicated by their similar values of $\hat{b}$ in Table 1), but showed the opposite directions of persistent appreciation and depreciation, respectively, relative to the cross-club average. Meanwhile, Club 2 (Chinese yuan and Thai baht) and Club 3 (Japanese yen, Malaysian ringgit and Philippine peso) started with relative depreciation and appreciation, respectively, until mid-

2011 and then both reversed directions. Hence, Clubs 2 and 3 were moving toward each other until mid-2011 and started to diverge again.

Furthermore, when we compare Club 2 with Club 1, it is interesting to notice that their transition paths have starting points that are at similar levels, indicating that the currencies in these two clubs have appreciated relative to other currencies by similar percentages prior to the crisis. However, it seems that currencies in Club 2 (Chinese yuan and Thai baht) initially lost their momentum of relative appreciation immediately after the peak of the crisis before they started to appreciate again toward the end of our sample period. Looking at all four transition paths in Figure 4, it seems that Clubs 1 and 2 (Clubs 3 and 4) are both appreciating (depreciating) relative to the club average, although at different paces. Finally, with regard to the three divergent currencies of Korean won, Laos kip and Viet Nam dong, the first two currencies seemed to have their own distinctive transition path that did not move towards each other nor moved together with any other clubs, whilst Viet Nam dong continued its much faster depreciation compared with any other panel members.

The club formation process and the corresponding transition paths using the calculated nominal deviation indicator of the VP (2013) ACU index indicate that there are more clubs detected in the post-crisis period than prior to the crisis and there are significant changes in terms of club membership between these periods. The crisis had definitely sent an adverse shock to Asian currencies, and the reaction it seems among these countries are to form new and more clubs that behave in a less collective manner among each clubs. Specifically, whilst Club 1 and Club 2 in Figure 3 showed signs of convergence towards each other right before the crisis, during the post crisis period, a more divergent picture emerged, particularly, about three years after the peak of the crisis. In terms of the behaviour of individual currencies, two pairs tend to stand-out. The respective pairs, Brunei dollar and Singapore dollar, and Cambodia riel and

Indonesia rupiah, have always belonged to the relative appreciation and depreciation clubs, respectively. While, finally, Viet Nam dong is a divergent country throughout both sub-periods.

The $log\ t$ convergence and club convergence tests results for the nominal deviation indicators calculated from the RIETI/Hitotsubashi constructed ACU index are presented in Table 2 and the corresponding club transition paths in Figures 5-6. Looking at the $log\ t$ convergence test results in the upper panel of Table 2, we again see that the null of full panel convergence is rejected for both sample periods. This is the same finding that we obtained from our tests using the nominal deviation indicators calculated from the VP (2013) ACU index in Table 1. Moreover, given that $\hat{b} < 2$, the club convergence tests results for both sample periods suggest rate (conditional convergence) rather than level (absolute) convergence in all clubs detected, which is also in line with the findings obtained in Table 1.

The club convergence tests results for the pre-crisis period suggest that there are also three convergent clubs, although there are clear differences in terms of club membership between Tables 1 and 2 during this period. For instance, Laos kip and the Philippine peso, two currencies that originally belonged to the second club in Table 1, have now joined the first club which is comprised of the Brunei dollar, Chinese yuan, Korean won and the Singapore dollar. The Hong Kong dollar which used to belong in the second club in Table 1, is now found to be a divergent economy. It is interesting to note that the Thai baht, along with the Vietnam dong, are divergent countries in the pre-crisis period, irrespective of the nominal deviation indicators used to construct the ACU index. Moreover, each of these currency pairs have belonged in the same club in both Tables 1 and 2 – the Japanese yen and the Malaysian ringgit (club 2), and the Cambodia riel and Indonesia rupiah (club 3).

In the corresponding club transition paths for the pre-crisis period presented in Figure 5, although Club 3 maintained very similar level and shape when compared to the same club in Figure 3, Clubs 1 and 2 in Figure 5 behave differently as compared to the same clubs in

Figure 3. To be more specific, noticeably, the starting and ending points of the transition path of Club 1 in Figure 5 is relatively lower compared to the one in Figure 3, whereas, the transition path of Club 2 has varied from appreciation to depreciation and back throughout the pre-crisis period. This is definitely a reflection of the cross-club shifts that we earlier observed in Tables 1 and 2 in the case of the Laos kip and the Philippine peso as well as the exclusion of the Hong Kong dollar from any of the convergent clubs that we saw in Table 2.

During the post-crisis period according to the nominal deviation indicators calculated from the RIETI/Hitotsubashi ACU index, the club convergence tests suggest one additional convergent club in Table 2 compared to Table 1, making it a total of five clubs instead of four. Comparing club membership between Tables 1 and 2, the Japanese yen moved from club 3 to club 2 to join the Chinese yuan and the Thai baht, whereas the Korean won and Laos kip, two currencies that used to be divergent currencies in Table 1, have now formed the additional club from Table 1. Apart from these differences, we also notice that members of Club 1 and Club 4 in Table 1 are identical to those of the members in Club 1 and Club 5 in Table 2 . Also the Chinese yuan and Thai baht remain in the same club, irrespective of alternative indicator used. The same applies to the Malaysian ringgit and the Philippine peso. Similar to Table 1, Viet Nam dong is again a divergent country.

Looking at the club transition paths in Figure 6, Clubs 1 and 5 share similar shape as Clubs 1 and 4 in Figure 4. However, for Clubs 2 and 3 in Figure 6, the shapes of their transition paths seem to have been interchanged with the shapes of the transition paths of the same two Clubs in Figure 4. This may reflect the cross-club movement of the Japanese yen as reported in Tables 1 and 2.

Overall, we observe some of these systematic patterns at the end of our first and second sub-period of observation as depicted in Figures 3 and 5 and Figures 4 and 6, respectively. First, prior to the crisis, there have been signs of convergence across clubs in Figures 3 and 5 (e.g.

Club 1 and Club 2 in both figures). However, it appears that the convergence process for these two clubs using both indicators have been interrupted by the crisis. From thereon, there has been a greater number of formation of clubs and re-configuration in club membership between the two periods. Second, an examination of Figure 4 suggests two relatively opposing convergent poles at the very end of our period of observation. Specifically, Clubs 1 and 2 move towards the same direction of relative appreciation but at different pace, on one hand, whereas, Clubs 3 and 4 move towards relative depreciation also at different pace, on the other. An examination this time of Figure 6, suggests that at the end of the period of observation, Clubs 2 and 5 taken together formed a pole of relative depreciation, on one hand, while, also taken together, Clubs 1, 3 and 4 on the other hand, formed the other pole of relative appreciation.

V. Summary and Implications of the Results

There is a growing recognition in the East Asian region that excessive intra-regional exchange rate volatility can have harmful effects on the ever closer trade and financial ties between countries in the region. Specifically, there is an increasing perception that excessive intra-regional exchange rate volatility can hurt a number of the related dynamic developments in the region: the extent of intra-Asian trade as measured by an average of export and import shares; the related development of intra-Asian supply chains by multinational corporations since the early 1990s which has given rise to a growing intensity of vertical intra-industry trade in the region (Chow et al. 2010); and the rising intensity of FDI flows between countries in the region. Thus, in view that exchange rates form a vital link in the above growing interdependence among East Asian countries, working towards some form of regional exchange rate coordination can help in achieving intra-regional exchange rate stability.

That said, one can argue that it would be of benefit for the policymakers in the region that in working towards an effective form of exchange rate coordination in the region, they are valuably informed and guided by the process that underpins the achievement of intra-regional exchange rate stability—the construction of the ACU and examination of convergence in ACU based deviation indicators in the region. Conducting convergence test on the ACU based-deviation indicators would be much more informative for policy makers, especially given that such foreign exchange market stability is often absent and even if it is present, it is oftentimes disrupted by external shocks. Specifically, convergence test of deviation indicators would detect specific currencies that form groups that either jointly appreciate or depreciate relative to the ACU regional average. In that regard, the evidence provided in this paper based on convergence tests of two recent contrasting constructions of nominal deviation indicators of ACU indices indicates that the state of play in terms of relative exchange rate movements within the region is quite complex and as such achieving the worthwhile objective of exchange rate stability in East Asia is not going to be easy.

First of all, we find that intra-East Asian exchange rate movements have not converged to form one, cohesive and unified bloc where currencies share homogenous movements, regardless of whether one examines the data on intra-East Asian exchange rate movements before or after the collapse of Lehman Brothers in September 2008. In other words, there is a sufficient amount of heterogeneity in bilateral East Asian exchange rate movements that hinder the economies in the region to form a single and unified exchange rate bloc. Instead, a certain separate number of convergent clubs or blocs in the region have formed in recent years, of which the number and composition of these convergence clubs vary, depending on which measure of the nominal deviation indicator of an ACU that one uses as well as on the period the data is examined. This variation in the number and composition of convergence clubs depending on which measure of the nominal deviation indicator of an ACU is a reasonable one since based on our earlier foregoing discussion, the major difference of the VP (2013) approach to the Ogawa and Shimizu (2005) and RIETI/Hitotsubashi University (henceforth

RIETI/Hitotsubashi) is that the construction of an ACU index by the former avoids the arbitrary choice as to which economic variables or indicators (e.g., trade, GDP) are to be used to calculate the currency weights.[12]

Finally, and most importantly, we observe at the end of the period of our examination that economies in the region are, generally, converging at different speeds to two opposing poles of convergence, i.e., groups of relatively depreciating currencies, and, on the other, groups of relatively appreciating currencies. While this is beyond the scope of our paper, we are inclined to surmised that these two opposing poles of convergence can be driven by the gamut of real and monetary factors such as the relative competitiveness positions of countries in the region, differing growth rates, diverging fiscal balances as well as the varying extent of monetary policy stances and regimes in these countries[13]. For future study, it will be worthwhile and interesting to examine on what determines the values and convergence of the nominal deviation indicators.

In view that observers have pointed out that a gradual and calibrated approach in which policy dialogue and surveillance takes centre-stage in the near term is the more realistic option at this stage in the region (Gupta, 2012), the implications of the above results to policy suggest that the calculation of ACU-based nominal deviation indicators can provide policymakers in the region a useful monitoring and surveillance device of the movements in intra-East Asian exchange rates. Once policymakers are in turn convinced of the usefulness of such monitoring device and decide to employ an ACU-based nominal deviation indicator in exchange rate surveillance work, they should then be made aware of its distinguishing features and limitations. The rationale being that, in line with what we obtained from the above, the number and

[12] As previously shown by Pontines (2009), avoiding the arbitrary choice of an economic variable or indicator to calculate the currency weights and resorting to a more scientific method of deriving the optimal currency basket weights via an optimal control method gives rise to an ACU that can deliver greater intra-regional exchange rate stability.

[13] See for example You and Sarantis (2011, 2012a, 2012b) for incorporating a range of economic fundamentals into alternative exchange rate models to determine the value of the Chinese Yuan.

composition of convergent clubs vary depending on which ACU-based nominal deviation indicator one uses. Thus, a strategy of employing alternative versions of ACU-based nominal deviation indicator is a prudent choice.

Furthermore, one repercussion of the above general finding of an intra-regional deviation indicator convergence occurring at different speeds and at two opposing poles of trajectories of convergence is that it has apparently altered competitive trading relationships in the region. For instance, without barring other possible reasons that may contribute to this alleged change, we learned of accounts where Japanese companies are relocating their manufacturing production bases from China to other locations in Asia.[14] In the very long-run, countries in the region can take a multi-track or multi-speed approach in which those that have shown relative bilateral exchange rate stabilities due to the achievement of sufficient convergence in deviation indicator let alone real convergence among each other, can begin the process of a formal exchange rate arrangement. That is, a sub-regional exchange rate currency system that could be modeled on the European Monetary System (EMS). Any sub-regional currency arrangements formed can then eventually be linked into a wider and unified regional monetary zone.

VI. Conclusion

This paper empirically examines the existence and extent of convergence in deviation indicator in the ASEAN+3 economies as well as Hong Kong, China. In undertaking this objective, we employ the recently developed panel convergence method of P-S (2007) to the nominal deviation indicators of two recent unofficial constructions of the ACU to detect convergence

[14] See, for instance, Ito and Shimizu (2009). As pointed out by these two authors, the relocation of Japanese manufacturing bases had been to weaker regional currencies, such as Viet Nam. For examples of this alleged de-concentration of production bases, see for instance the PriceWaterhouseCoopers study on Viet Nam's Automotive Component Industry as well as the Bloomberg article entitled, "Nissan Ships Cars Home as Yen Erodes Century of Made-in-Japan (August 30, 2012)."

in the exchange rate movements in these economies. The advantage of this time-varying factor model is that it uses common stochastic trends which can accommodate long-run co-movement in aggregate behavior outside of the cointegration framework and further allows for the modeling of transitional effects. Furthermore, the P-S (2007) method is also more powerful than the traditional beta and sigma convergence tests since not only it reveals the speed of convergence (if present) for the full panel, the method also highlights the different extent and speed of the convergence in the sub-groups of members through its club formation procedure.

Empirical results reveal that intra-East Asian exchange rate movements have not converged to form one, cohesive and unified currency bloc, regardless of whether one examines the data on intra-East Asian exchange rate movements before or after the collapse of Lehman Brothers in September 2008. Rather, a certain separate number of convergent clubs or blocs in the region have formed in recent years, of which the number and composition of these convergent clubs vary, depending on which measure of the nominal deviation indicator of an ACU that one uses as well as on the period the data is examined. Third, and most importantly, we observe at the end of the period of our examination that economies in the region are, generally, converging at different speeds to two opposing poles of convergence, i.e., groups of relatively depreciating currencies and, on the other, groups of relatively appreciating currencies.

It is interesting that despite important strides achieved by the region in the area of financial and monetary cooperation in recent years, given the critical role of the exchange rate in the ongoing process of economic integration in the region, there has been limited progress in exchange rate policy cooperation. That said, the above results suggest that one way to move forward is the adoption and calculation of ACU-based nominal deviation indicators which can provide policymakers in the region a useful monitoring and surveillance device of the movements in intra-East Asian exchange rates. Specifically, information provided in our study in terms of convergent groups in the region and their relative transition paths provide an illustration on how such nominal deviation indicators can greatly assist in the efficient monitoring of movements in relative exchange rates in East Asia over time. At the same time, however, policymakers should be made aware of the distinguishing features and limitations of such ACU-based nominal deviation indicators in exchange rate surveillance work. The reason is that as we have found from the above, the number and composition of convergence clubs vary depending on which ACU-based nominal deviation indicator one uses. Thus, a strategy of employing alternative versions of ACU-based nominal deviation indicator in assessments of exchange rate convergence is a prudent choice.

In the near term, adopting such approach can be facilitated by the inclusion of ACU-based nominal deviation indicators convergence analysis in surveillance reports submitted to senior finance and central bank officials in the ASEAN+3 region. The inclusion of such kind of analysis in exchange rate surveillance work in the region is expected to significantly contribute to an open and candid discussions in the high-level official meetings of the senior finance and central bank officials in the ASEAN+3 region. Once sufficient trust and confidence are built into this process, economies in the ASEAN+3 region can better realize and understand the benefits of any sub-regional exchange rate arrangement which would then facilitate the achievement of intra-regional exchange rate stability. This would help set the stage for a move toward more ambitious plans for more formal and stronger forms of exchange rate coordination in the wider East Asian region.

Appendix: Convergence tests for the entire sample period but excluding the period of the Lehman Brothers collapse

We excluded six months before and six months after the outbreak of the recent financial crisis in September 2008 (2008m3-2009m2) from our sample period and re-estimated the *log t* and club convergence tests for the whole sample period. The results are presented in Table A1 and the corresponding club averages are presented in Figures A1 and A2.

Again the log t convergence tests reject the null of full panel convergence. Interestingly, we observe that the club convergence test results between the VP (2013) and RIETI/Hitotsubashi indicators are very similar. In both cases, there are three clubs. All clubs show $\hat{b} < 2$ and thus there is convergence in rates rather than convergence in levels. Club members in club 1 are almost identical with the only exception of the Chinese yuan, while club members in clubs 2 and 3 are exactly identical. Moreover, Vietnam dong is divergent in both indicators. The only noticeable difference between the two sets of results as mention is that the Chinese yuan is a member of club 1 using the VP (2013) indicator but it is divergent using the RIETI/Hitotsubashi indicator. One possible reason for this results is that when we look back at the results presented in the main text using the VP (2013) indicator shown in Table 1, prior to the crisis, the Chinese yuan belongs to club 1 where currencies appreciated in most of the sub-sample period but depreciated toward the end (Figure 3); after the crisis, the Chinese yuan switched to club 2 where currencies depreciated in most of the sub-sample period but appreciated toward the end. Belonging to such two clubs where currencies have opposite trajectories in terms of their relevant values before and after crisis may have explained why the Chinese yuan becomes divergent when we examine the whole sample period.

On the other hand, comparing Table A1 with the sub-sample results (Tables 1 and 2), the similarity between results based on the two alternative indicators are much more profound when the whole sample period is employed. One would expect so since despite differences between these two sets of indicators in the two sub-sample periods (pre- and post-crisis), the overall patterns of the relative currency values in the whole sample period is more similar, especially when the crisis period is excluded. For instance, although the Japanese yen belonged to different clubs when one looks at pre- and post-crisis within each indicator (Tables 1 and 2), it joined the overall appreciating club 1 in the cases of both indicators when the whole sample period is investigated, which then recognises the general appreciation pattern of its relative values for this particular club (Figures A1 and A2).

Table A1 provides useful information as it delivers an overview of convergence in the whole sample period. However, we should note that it may overlook the dynamics within each sub-period, especially when external shocks occur such as the 2008 financial crisis. In particular, the same country may belong to different clubs or divergent when we investigate the sub-period whilst such dynamic information cannot be revealed when the impact of the collapse of Lehman Brothers is excluded from the analysis. Hence, we are inclined to place more weight on the results reported in the main text.

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Table 1: The log t convergence and club convergence tests results using the VP (2013) nominal deviation indicators:

log t convergence tests	
2004m1-2008m9	2008m10-2013m6
$\hat{b}: -1.659$ $t-stat: -23.321^{*}$	$\hat{b}: -1.078$ $t-stat: -94.937^{*}$

club convergence tests			
2003m1-2008m9		2008m10-2013m6	
Club 1 $\hat{b}: 1.427$ $t-stat: 8.493$	Brunei dollar Chinese yuan Korean won Singapore dollar	Brunei dollar Singapore dollar	Club 1 $\hat{b}: 0.552$ $t-stat: 1.082$
Club 2 $\hat{b}: 0.332$ $t-stat: 12.842$	Hong Kong dollar Japanese yen Laos kip Malaysian ringgit Philippine peso	Chinese yuan Thai baht	Club 2 $\hat{b}: -0.125$ $t-stat: -1.434$
		Japanese yen Malaysia ringgit Philippine peso	Club 3 $\hat{b}: 0.089$ $t-stat: 1.118$
Club 3 $\hat{b}: 1.375$ $t-stat: 10.344$	Cambodian riel Indonesian rupiah	Cambodian riel Hong Kong dollar Indonesian rupiah	Club 4 $\hat{b}: 0.521$ $t-stat: 2.998$
Divergent $\hat{b}: -2.213$ $t-stat: -57.798^{*}$	Thai baht Viet Nam dong	Korean won Laos kip Viet Nam dong	Divergent $\hat{b}: -1.868$ $t-stat: -256.937^{*}$

Note: * indicates rejection of the null hypothesis of convergence at the 5% significance level.
Source: Authors' calculations.

Table 2: The $\log t$ convergence and club convergence tests results using the RIETI/Hitotsubashi nominal deviation indicators:

log t convergence tests			
2004m1-2008m9 $\hat{b}: -2.026$ $t - stat: -22.666^{*}$		2008m10-2013m6 $\hat{b}: -1.015$ $t - stat: -73.411^{*}$	
club convergence tests			
2003m1-2008m9		2008m10-2013m6	
Club 1 $\hat{b}: 0.565$ $t - stat 4.929$	Brunei dollar Chinese yuan Korean won Laos kip Philippine peso Singapore dollar	Brunei dollar Singapore dollar	Club 1 $\hat{b}: 1.871$ $t - stat: 5.986$
		Chinese yuan Japanese yen Thai baht	Club 2 $\hat{b}: 0.027$ $t - stat: 0.162$
Club 2 $\hat{b}: -0.108$ $t - stat: -0.049$	Japanese yen Malaysian ringgit	Malaysian ringgit Philippine peso	Club 3 $\hat{b}: -0.030$ $t - stat: -0.559$
Club 2 $\hat{b}: 1.523$ $t - stat: 12.620$	Cambodian riel Indonesian rupiah	Korean won Laos kip	Club 4 $\hat{b}: -0.037$ $t - stat: -0.168$
Divergent $\hat{b}: -2.374$ $t - stat: -189.188^{*}$	Hong Kong dollar Thai baht Viet Nam dong	Cambodian riel Hong Kong dollar Indonesian rupiah	Club 5 $\hat{b}: 0.166$ $t - stat: 1.271$
		Viet Nam dong	Divergent

Note: * indicates rejection of the null hypothesis of convergence at the 5% significance level. There are no statistics for Viet Nam dong during the post-crisis period as it is a single divergent country.

Source: Authors' calculations.

Figure 1: VP (2013) nominal deviation indicator

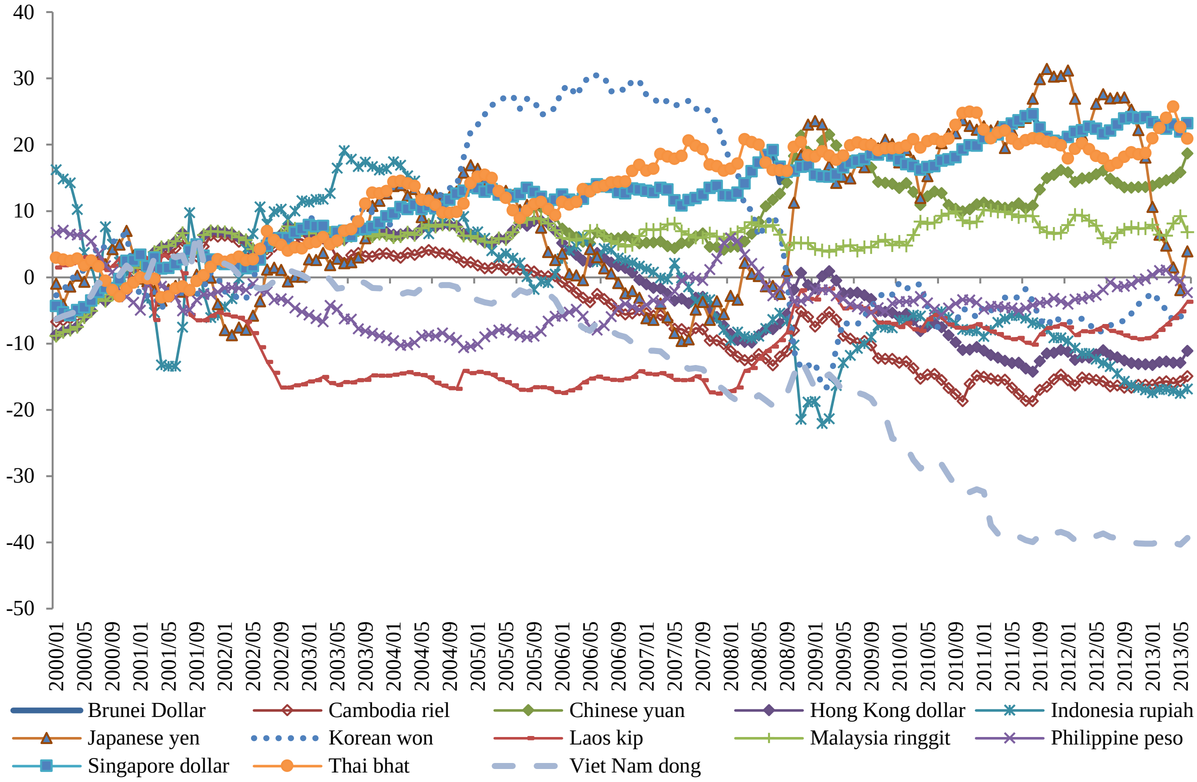


Figure 2: RIETI/Hitotsubashi nominal deviation indicator

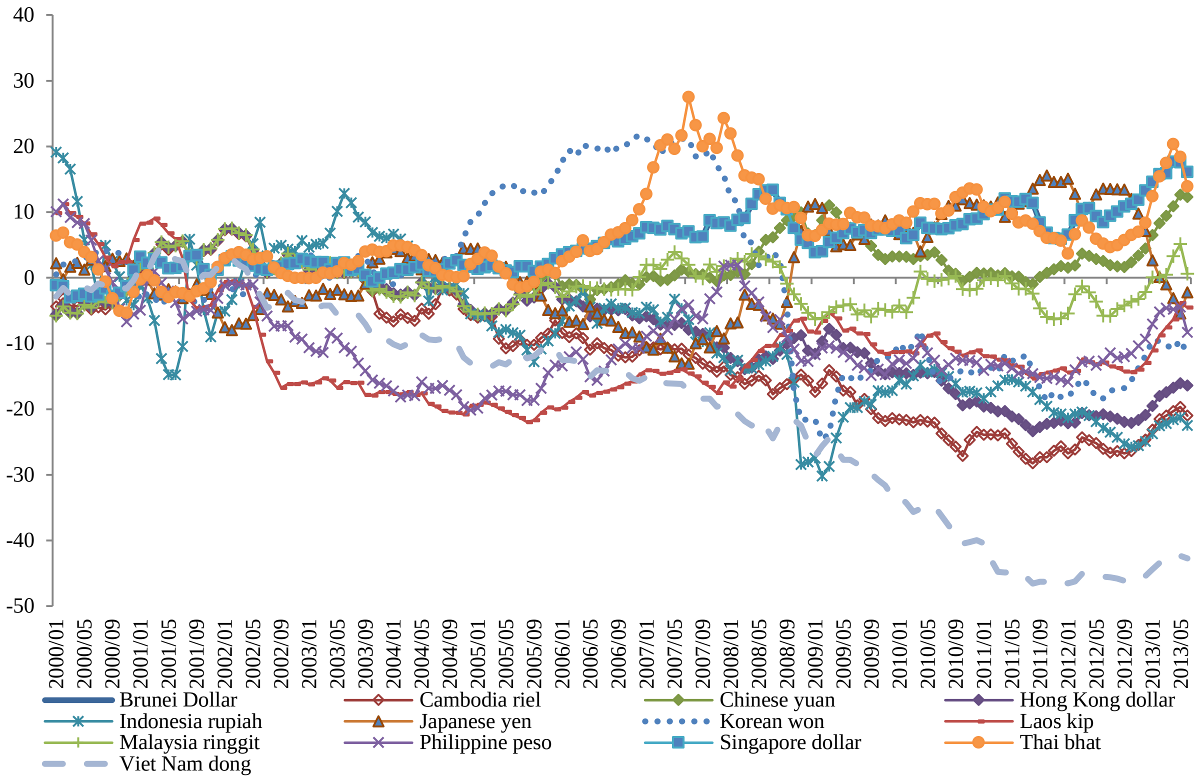
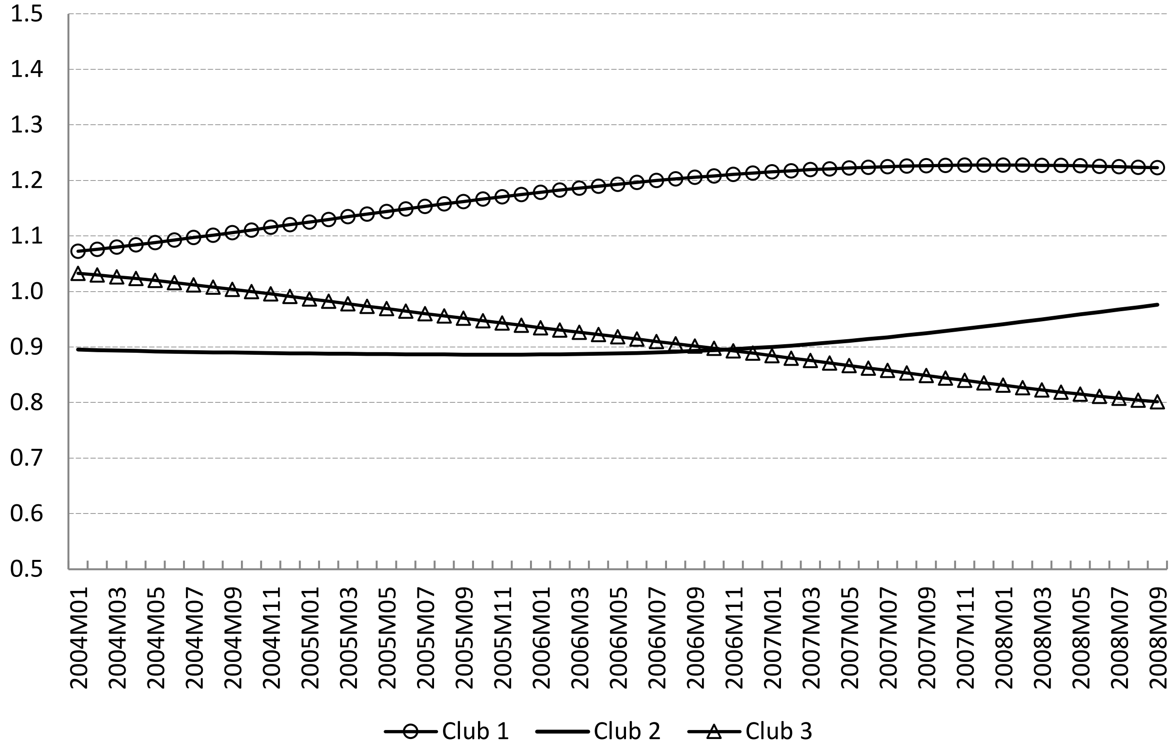
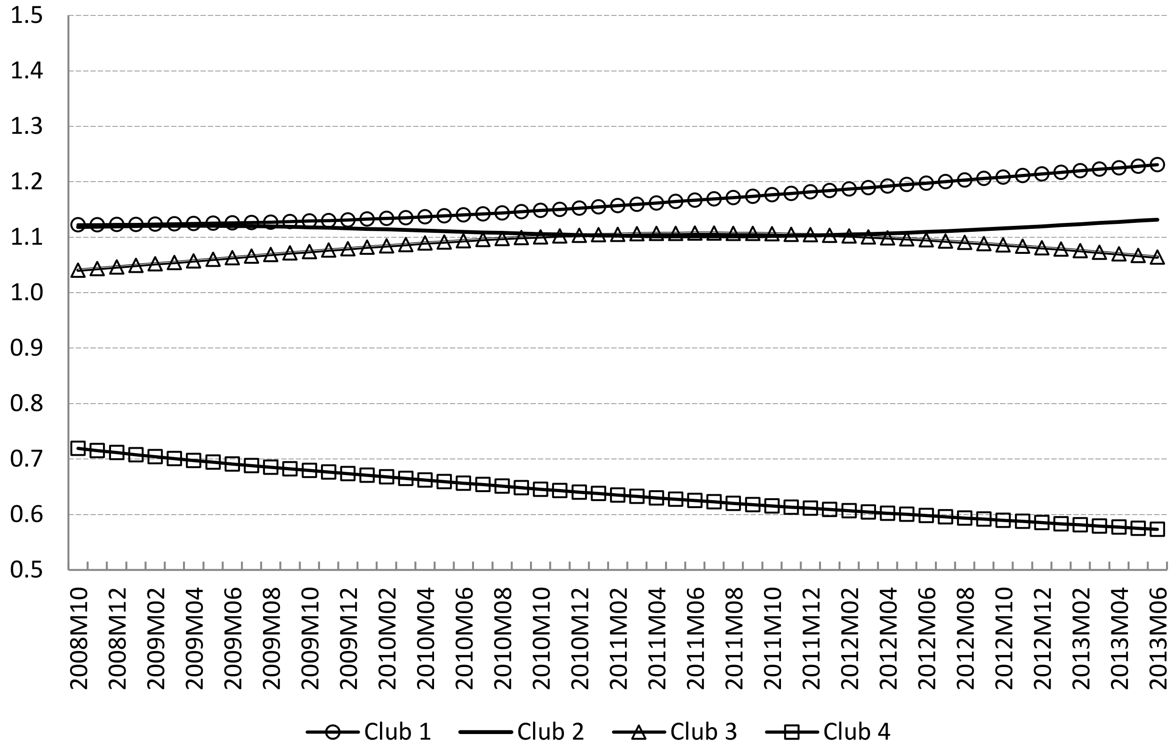


Figure 3: Relative transition paths across clubs based on the VP (2013) nominal deviation indicator (pre-crisis period 2004m1-2008m9)



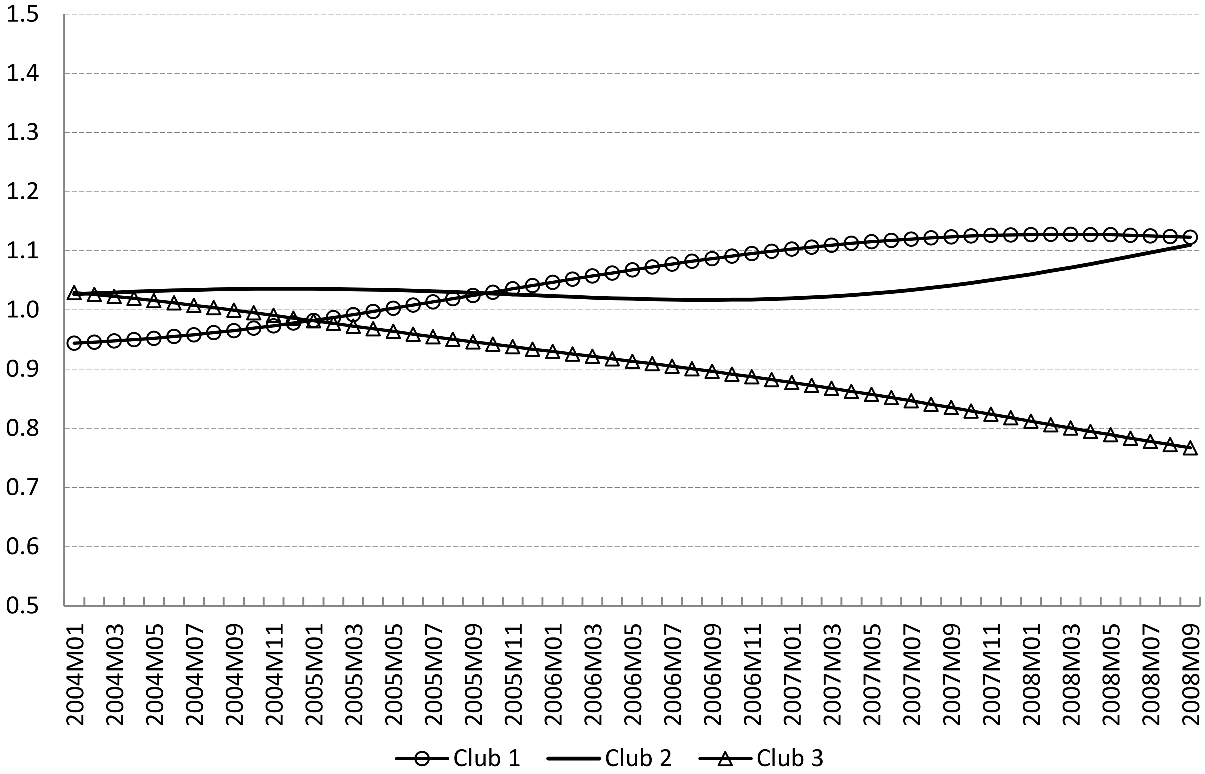
Source: Authors' calculations.

Figure 4: Relative transition paths across clubs based on the VP (20103) nominal deviation indicator (post-crisis period 2008m10-2013m6)



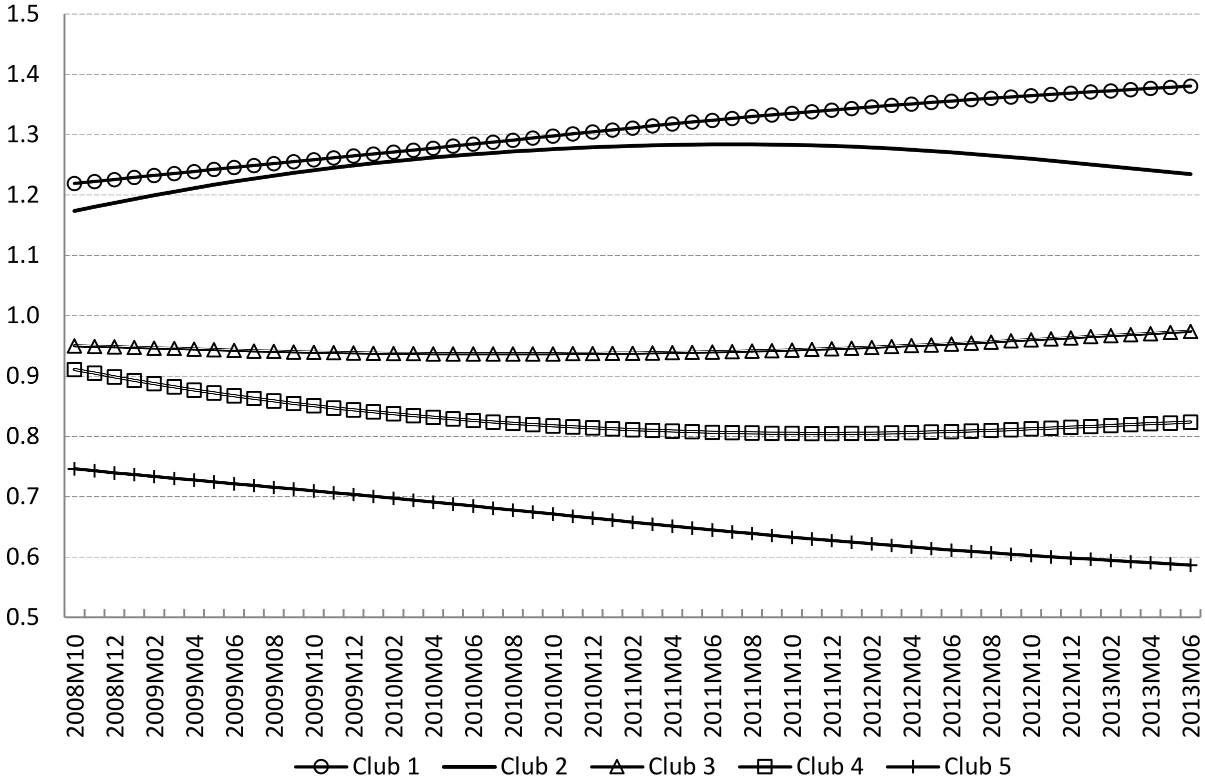
Source: Authors' calculations.

Figure 5: Relative transition paths across clubs based on the RIETI/Hitotsubashi nominal deviation indicator (pre-crisis period 2004m1-2008m9)



Source: Authors' calculations.

Figure 6: Relative transition paths across clubs based on the RIETI/Hitotsubashi nominal deviation indicator (post-crisis period 2008m10-2013m6)



Source: Authors' calculations.

Appendix Table and Figures

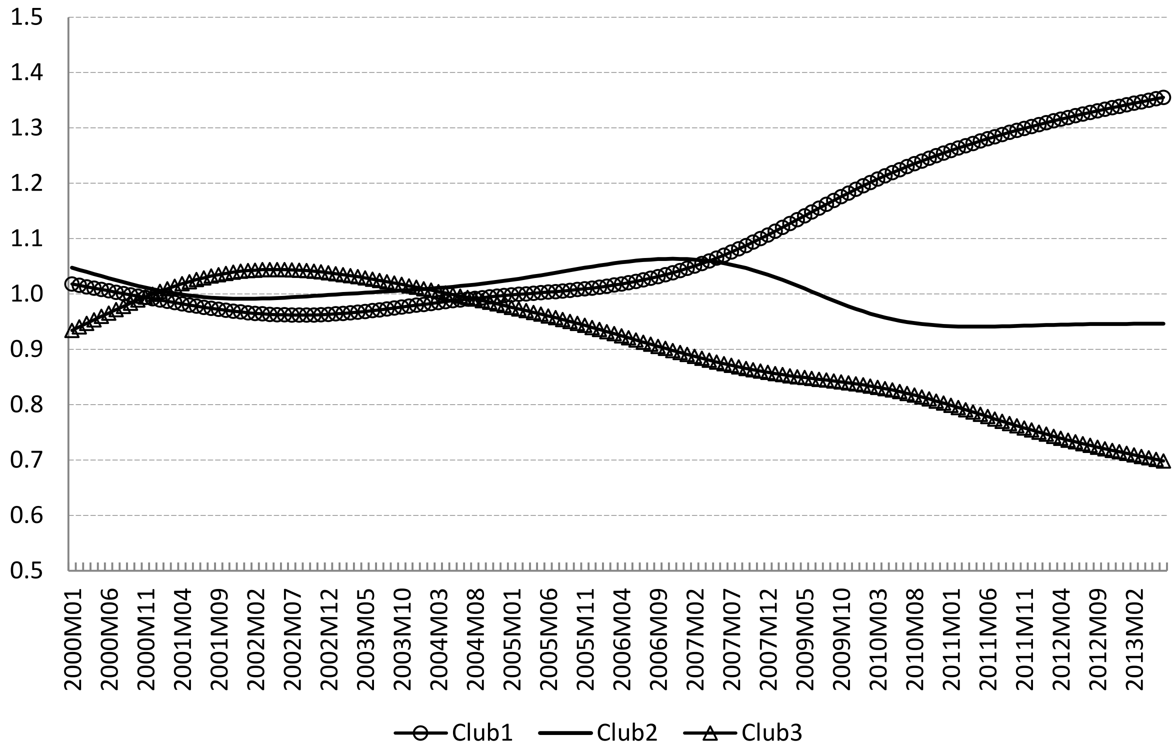
Table A1: The log t convergence and club convergence tests results using the VP (2013) and nominal deviation indicators 2004m1-2013m6 (excluding the crisis period 2008m3-2009m2):

log t convergence tests			
VP(2013)		RIETI/Hitotsubashi	
$\hat{b}: -2.183$ $t-stat: -83.913^{*}$		$\hat{b}: -2.414$ $t-stat: -31.140^{*}$	
club convergence tests			
VP(2013)		RIETI/Hitotsubashi	
Club 1 $\hat{b}: -0.012$ $t-stat: -0.326$	Brunei dollar Japanese yen Laos kip Singapore dollar Thai baht	Brunei dollar Chinese yuan Japanese yen Laos kip Singapore dollar Thai baht	Club 1 $\hat{b}: 0.254$ $t-stat: 4.883$
Club 2 $\hat{b}: 0.072$ $t-stat: 1.549$	Indonesian rupiah Korean won Malaysian ringgit Philippine peso	Indonesian rupiah Korean won Malaysian ringgit Philippine peso	Club 2 $\hat{b}: 0.030$ $t-stat: 1.353$
Club 3 $\hat{b}: 0.355$ $t-stat: 0.968$	Cambodian riel Hong Kong dollar	Cambodian riel Hong Kong dollar	Club 3 $\hat{b}: -0.330$ $t-stat: -0.998$
Divergent $\hat{b}: -3.200$ $t-stat: -18.245^{*}$	Chinese yuan Viet Nam dong	Viet Nam dong	Divergent

Note: * indicates rejection of the null hypothesis of convergence at the 5% significance level. There are no statistics for Viet Nam dong during the post-crisis period as it is a single divergent country.

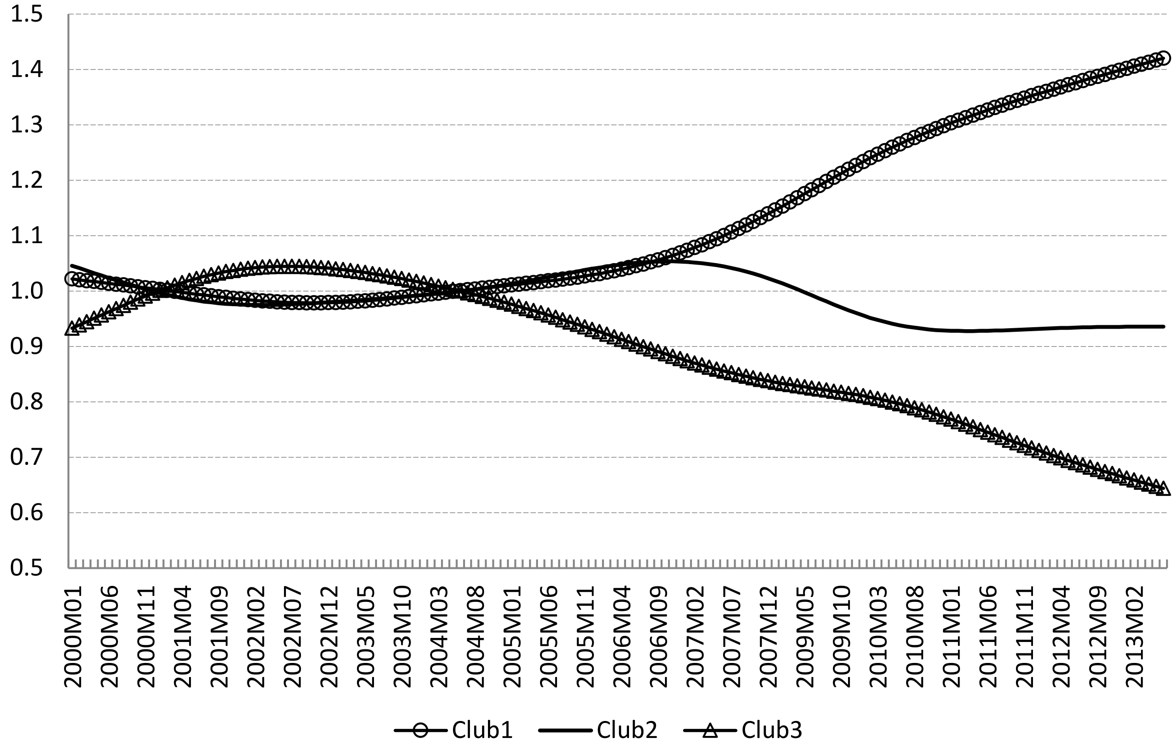
Source: Authors' calculations.

Figure A1: Relative transition paths across clubs based on the VP (2013) nominal deviation indicator 2004m1-2013m6 (excluding the crisis period 2008m3-2009m2)



Source: Authors' calculations.

Figure A2: Relative transition paths across clubs based on the RIETI/Hitotsubashi nominal deviation indicator 2004m1-2013m6 (excluding the crisis period 2008m3-2009m2)



Source: Authors' calculations.