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RENMINBI AS NUMBER TWO IN EAST ASIA

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ABSTRACT

This paper investigates the emerging influence of the Chinese renminbi on the exchange rate movements of East Asian currencies. China stopped pegging her currency to the US dollar and moved into a managed floating exchange rate system on July 21, 2005. The change in China's exchange rate regime opens a window of opportunity to investigate the influence of renminbi on the exchange rate movements of East Asian currencies. This paper uses daily exchange rate data from July 24, 2005 to October 31, 2011 for empirical analysis. Empirical results from this paper reaffirm the dominant position of the US dollar in East Asia. Our results indicate that the influence of the renminbi on the daily exchange rate movements of East Asian currencies is second only to that of the dollar. With the growing importance of the Chinese economy, the renminbi has begun to exert its influence on the exchange rate determinations in East Asia at least in the very short run. We have done extensive robustness checks to ensure the validity of our estimation results. In the 1990s and early 2000s, many studies document an increasing influence of the Japanese yen and suggest the emergence of a yen bloc in East Asia. While this issue is not the focus of the present paper, results of this paper do cast doubts on the making and prospect of a yen bloc in East Asia.

Keywords: Renminbi, East Asian Currencies, Exchange Rate Movements, Cointegrating Relations.

JEL Classification: F31, F36, F15

INTRODUCTION

The size of the Chinese economy has increased enormously in the last three decades or so. China has become the second largest economy and the largest exporter in the world. The Chinese government has taken various measures to internationalize the renminbi in recent years, for example, relaxing restrictions on renminbi deposits in Hong Kong, issue of renminbi-denominated bonds in Hong Kong, trade settlement for Chinese companies in renminbi and currency swap agreements with foreign central banks. Spurred by the increasing economic importance of China and the policy initiatives of the Chinese government to internationalize the renminbi, there is a growing research interest on the potential and prospect of the Chinese renminbi as an international currency (Chen *et al.*, 2009; Dobson and Masson, 2009; Ito, 2010; Frankel, 2011; Park and Song, 2011; Saidi *et al.*, 2011; Vallée, 2011; Cohen, 2012) among others.Many studies have suggested that the renminbi is on its way to becoming a major international currency in Asia(Shu *et al.*, 2007; Chen *et al.*, 2009; Ito, 2010). Empirical investigations into the influence of the renminbi on the regional currencies in East Asia are hampered by China's fixed exchange rate system, which makes the renminbi variations indistinguishable from US dollar movements for quite some time. Renminbi had been pegged to the US dollar at the rate of 8.28 RMB/USD from 1997 until July 21, 2005. On that date, China moved into a managed floating exchange rate regime with reference to a basket of currencies. In October 2008, the renminbi was re-pegged to the US dollar at 6.83 RMB/USD in response to the outbreak of the global financial crisis. Starting from June 21, 2010, renminbi was allowed to float against the US dollar once again (cf. Fig. 1 for the exchange rate movements of RMB/USD).

The literature has advanced two mechanisms through which the movements of renminbi can affect the exchange rate policy of other economies (Shu *et al.*, 2007; Chen *et al.*, 2009). First, Asian economiescompeting with China in export markets may be averse to appreciation against the renminbi. Asian economies have often pursued an export-driven strategy for economic growth. As the structure of China's exports, both in terms of market and commodity distributions, is similar to that of a number of Asian economies (Branson and Healy, 2005), Asian economies have the incentive to manage their currencies to stay competitive against China's exports. Second, China is the center of a large production chainin Asia (Branson and Healy, 2005; Zhang, 2008). Economies that are part of the Asian production network have the incentive to lower bilateral exchange rate volatility against the renminbi, especially when their firms are engaged in international transactionsdenominated inrenminbi. This paper investigates the emerging influence of the Chinese renminbi on seven East Asian currencies, namely the Indonesian rupiah, the Korean won, the Malaysian ringgit, the Philippines peso, the Singapore dollar, the New Taiwan dollar, and the Thai baht. Empirical results from this paper reaffirm the dominant position of the US dollar in East Asia. Our results indicate that the influence of the renminbi on the exchange rate movements of East Asian currencies is second only to that of the dollar while the influence of the yen is limited. The rest of this paper is organized as follows. Section 2 describes data used in this study. Section 3 describes our methodology. Section 4 discusses empirical results and conducts robustness checks. Section 5 concludes this paper.

Data Description

Daily exchange rates from 07/24/2005 to 10/31/2011 are used for empirical analysis. All data are obtained from DataStream. Daily exchange rates are the closing rates of each trading days in New York market. The bilateral exchange rates between the respective currencies and the numeraire currency are calculated as cross exchange rates between the US dollar exchange rates of the respective currencies and the US dollar exchange rates of the numeraire currency.

METHODOLOGY

In the 1990s and early 2000s, a body of literature investigates the emergence of a yen bloc in East Asia, in which the regional currencies are closely tied to the Japanese yen and the movement of their exchange rates are highly dependent on the exchange rates of yen, (Frankel and Wei, 1994; Aggarwal and Mougoue, 1996; Kwan, 1996; Tse and Ng, 1997; Zhou, 1998; Aggarwal *et al.*, 2000; Gan, 2000) and (Bowman, 2005). The vast majority of these studies are based on the weight-inference approach and Johansen cointegration technique. In this paper, we build on these two approaches to analyze the influence of the renminbi on the exchange rate movements of East Asian currencies.

The Weight-Inference Approach

The weight-inference approach was popularized by Frankel and Wei (1994, 2007, 2008) and has been extensively used in the literature, including work on currency regimes in East Asia, such as Kwan (1996); Bénassy Quéré (1999); Ohno (1999); Frankel et al. (2000); Gan (2000); Bénassy Quéré *et al.* (2004); McKinnon and Schnabl (2004); Bowman (2005); Eichengreen (2006); Shu *et* *al.* (2007); Chen *et al.* (2009); Ito (2010); and (Hwang, 2012). The weight-inference approach attempts to infer the implicit weights of the component currencies in a currency basket, to which the regional currency is pegged, by regressing the percentage changes in the value of the regional currency against the percentage changes in the values of the component currencies in the currency basket. The list of potential currencies in the currency basket is dictated by their use as an international means of payment and/or as legal tender in the country's main economic partners. An important issue is to choose a numeraire currency to measure the value of the regional currency and the component currencies in the basket. Typical choice in the literature is Swiss franc. In this paper, we use the Swiss francas numeraire. For the purpose of this paper, the regression model based on the weight-inference approach is framed to include the US dollar, Chinese renminbi, Japanese yen and Euro as component currencies in the currency basket, to which a regional currency is pegged:

$$\Delta(ac/sf)_t = \alpha + \beta_1\Delta(us/sf)_t + \beta_2\Delta(ch/sf)_t + \beta_3\Delta(ja/sf)_t + \beta_4\Delta(eu/sf)_t + \varepsilon_t \quad (1)$$

where Δ stands for the difference, and *ac, us, ch, ja and eu* are the log of the exchange rates of East Asian currency, US dollar, renminbi, yen and Euro respectively. All exchange rates are in terms of Swiss franc (CHF) and are expressed in price term (units of currency concerned per unit of CHF). This regression allows the weightings of US dollar, renminbi, yen and Euro to be determined for the East Asian currencies.

Several points on exchange rate arrangementscan be made from Equation 1:

1. Perfect peg to a single currency: If regional currency AC follows a perfect peg to the US dollar, then every movement in the USD/CHF rate will be seen in the AC/CHF rate. This implies $\beta_1 = 1,\ \beta_2 = \beta_3 = \beta_4 = 0$ and $R^2 = 1$.
2. Perfect basket peg: If regional currency AC follows a perfect basket peg, then all β's will be positive and significantand $R^2 = 1$.
3. Basket peg with flexibility: If regional currency AC follows a basket peg with some flexibility, all β's will be positive and significant and $R^2 < 1$. Smaller R^2 corresponds to greater exchange rate flexibility. If none of the β's is significantly different from zero, then AC is a freely floating currency.
4. Crawling peg: If regional currency AC follows a crawling peg, either to a single currency or a currency basket, then α will be significantly different from zero.

As a standard practice, we check if the variables in Equation 1 are stationary using ADF unit root test. The ADF statistics for all the variables exceed the critical value (in absolute value) at the 1 % level of significance, indicating that each of the difference of the log of exchange rates is stationary. The unit root test results justify using these series for regression analysis (see Table 1).
One obstacle the weight-inference approach often encounters is the high degree of multicollinearity among the independent variables in the regression equation. In the context of this paper, the correlation coefficient between the movements of RMB/CHF and USD/CHF is as high as 0.987 in the sample period (cf. panel A of Table 2). This might cause serious multicollinearity when estimating Equation 1. To circumvent this problem, we run a regression of the movement of the exchange rates of RMB/CHF on the movement of the exchange rates of USD/CHF, i.e.:

$$\Delta(ch/sf)_t = \delta + \beta\Delta(us/sf)_t + r_t \quad (2)$$

The residuals r_t from this regression are the changes in the exchange rates of RMB/CHF independent of the changes in the exchange rate of USD/CHF. The residuals are used to substitute for $\Delta(ch/sf)_t$ in Equation 1. As is evidenced in panel B of Table 2, the correlation coefficients between the independent variables have decreased considerably. In this modified model, the estimated β_1, β_2 and β_4 remain to be the weights of yen, renminbi and Euro respectively, but the estimated β_3 is not the weight of the US dollar any more. The weight of the US dollar $W(US)$

can be recovered from Equations 1 and 2. Plugging Equation 2 into Equation 1 gives the following equation:

$$\Delta(ac/sf)_t = (\alpha + \beta_2\delta) + (\beta\beta_2 + \beta_1)\Delta(us/sf)_t + \beta_2 r_t + \beta_3\Delta(ja/sf)_t + \beta_4\Delta(eu/sf)_t + \varepsilon_t \quad (3)$$

Therefore, the weight of the US dollar $W(US)$ is:

$$W(US) = \beta\beta_2 + \beta_1 \quad (4)$$

(Kwan, 1996) used an alternative method to deal with the multicollinearity problem when estimating the weightings of yen, the German markand the US dollar for the East Asian currencies. We extend the Kwan regression to include the Chinese renminbi:

$$\Delta(ac/us)_t = \alpha + \beta_1\Delta(ch/us)_t + \beta_2\Delta(ja/us)_t + \beta_3\Delta(eu/us)_t + \varepsilon_t \quad (5)$$

where Δ stands for the difference, and ac/us, ch/us, ja/us and eu/us are the log of the exchange rate of East Asian currency, the Chinese renminbi, the Japanese yen and the Euro respectively. All exchange rates are in terms of US dollar. As the US dollar is not included in the regression, its weightings for the regional currencies can't be estimated directly. Rather, the weightings of the US dollar are determined using the assumption that the weighting of the US dollar and the other international currencies sum up to 1. Therefore the weighting of the US dollar $\beta(US)$ is calculated as the difference between 1 and the weightings of the other international currencies estimated, i.e.

$$\beta(US) = 1 - \beta_1 - \beta_2 - \beta_3 \quad (6)$$

Cointegration Approach

This part of the paper investigates the relationships between the Chinese renminbi and East Asian currencies as well as the relationships between the Japanese yen and East Asian currencies, using cointegration technique. The existence of a regional renminbi (yen) block implies that there are cointegrating relations between renminbi (yen) and East Asian currencies. The finding of the absence of such cointegrating relations constitutes evidence against the existence of the renminbi (yen) bloc. We perform Johansen test to check if there are cointegrating relations between the yen and East Asian currencies, and between the renminbi and East Asian currencies. If there are cointegrating relations, we then use vector error correction model (VECM) to estimate the cointegrating equations and the adjustment coefficients of each currency in the cointegrating system.

EMPIRICAL RESULTS

Section 4.1 reports estimation results based on the weight-inference approach using data from 07/24/2005 to 09/30/2008 and from 06/21/2010 to 10/31/2011 as renminbi was re-pegged to the US dollar from 10/01/2008 to 06/20/2010 and data from this period are excluded from our estimation. In section 4.2, data from 10/01/2008 to 06/20/2010 are included to check for the robustness of our estimation results. Section 4.3 reports estimation results using cointegration technique.

Empirical Results Based on the Weight-Inference Approach

Estimation results based on the weight-inference approach are reported in Table 3. The US dollar has the largest weightings in the currency basket for 4 out of the 7 East Asian currencies, namely the Indonesian rupiah (70.8%), the Philippines peso (73.1%), the Singapore dollar (43.6%) and the Thai baht (105.9%). The US dollar also has the second largest weightings for the other 3 East Asian currencies, i.e. the Korea won (29.9%), the Malaysian ringgit (41.5%), and the New Taiwan dollar (44.2%). This reaffirms the dominant position of the US dollar in this region. The Chinese renminbi has the largest weightings for 3 East Asian currencies, namely the Korea won, the Malaysian ringgit, and the New Taiwan dollar. Its weightings for these three currencies range from 53.2% to 46.4%. Moreover, renminbi has the second largest weighting for the Indonesian rupiah (19.2%). The weightings of the Japanese for all the seven East Asian currencies are small in magnitude and not different from zero statistically. The Euro has weightings ranging from 9.8% to

36.8% for the regional currencies. For the Singapore dollar and the Thai baht, Euro's weightings are 36.8% and 11.9% respectively, both of which are the second largest. The results suggest the Euro plays a far more important role in the region than the Japanese yen. Taken together, our results indicate that the influence of the renminbi on the exchange rate movements of East Asian currencies is second only to that of the dollar while the influence of the yen is negligible.

Table 4 presents estimation results using Kwan method to deal with the potential multicollinearity problem. The results are similar to and reaffirm the findings of the weight-inference approach.

Robustness Checks

This section conducts robustness checks on our estimation results based on the weight-inference approach. The following robustness checks are implemented:

1. CUSUM (cumulative sums) test of the least-square residuals is employed to check if the estimated coefficients are stable. The CUSUM of the least-square residuals is generally within the +5% and -5% significant lines for each of the regional currencies, suggesting that the estimated coefficients of our models are stable.
2. Outliers are identified using the studentized residuals (RStudent) and models are re-estimated excluding the outliers. To account for the potential impact of the outliers, we use the studentized residuals to identify the outliers at the first stage. Then we re-estimate the model with the outliers excluded from the sample and check if the estimation results are different from those with the outliers included in the sample. For all the regional currencies, the re-estimated results are similar to the estimated results with the outliers included in the sample, suggesting that our empirical results are not contingent on the outliers.
3. Models are re-estimated using a bootstrapping technique with 5,000 repetitions. As the underlying distribution of our sample is unknown, it is prudent and appropriate to use the bootstrapping procedure to check the stability of our estimation results. The bootstrapped results using 5000 repetitions are qualitatively the same as the estimation results reported in sections 4.1.
4. Models are re-estimated using contiguous data from 07/24/2005 to 10/31/2011, i.e. data from the period when renminbi was re-pegged to the US dollar (from 10/01/2008 to 06/20/2010) are included. The re-estimation results using the contiguous data are similar to those using the non-contiguous data.

Empirical Results Based on the Cointegration Approach

Table 5 presents the ADF unit root test results for the exchange rates of yen, renminbi and East Asian currencies. All exchange rates are in log and in terms of the US dollar. For levels of the exchange rate series, the ADF statistics are below their critical value (in absolute value) at the 5% level of significance, while all the statistics for the first difference of the exchange rate series exceed the critical value (in absolute value) at the 1% level, leading to the conclusion that there is one and only one unit root in the log of each exchange rate. The unit root test results justify using the log of these exchange rates for cointegration analysis.

Results of the Johansen test are reported inTable 6. Both trace test and the Max - Eigen testindicates that there are two cointegrating relations between renminbi and East Asian currencies (panel A of Table 6) , and there is no cointegrating relations between yen and East Asian currencies (panel B of Table 6). Table 7 presents statistics of the two cointegrating equations between renminbi and East Asian currencies and the adjustment coefficients of each currency in the cointegrating system. The existence of a regional yen block implies that there are cointegrating relations between yen and East Asian currencies. The finding of the absence of such cointegrating relations constitutes evidence against the existence of the yen bloc. Taken together, results from the cointegration analysis confirm that renminbi has close links with the East Asian currencies, but the yen does not.

CONCLUDING REMARKS

After three decades of spectacular growth in GDP and international trade, China has become the second largest economy and the largest exporter in the world. The increasing economic importance of China, together with the policy initiatives of the Chinese government to internationalize the renminbi, has raised the prospect of the Chinese renminbi as an international currency. This paper investigates the emerging influence of the Chinese renminbi on East Asian currencies, using daily exchange rate data from 07/24/2005 to 10/31/2011. Empirical results from this paper reaffirm the dominant position of the US dollar in East Asia. Our results indicate that the influence of the renminbi on the exchange rate movements of East Asian currencies is second only to that of the dollar while the influence of the yen is weak. With the growing importance of the Chinese economy, the renminbi has begun to exert its influence on the exchange rate determinations in East Asia at least in the very short run. We have done extensive robustness checks to ensure the validity of our estimation results: CUSUM test of the least-square residuals is employed to check if the estimated coefficients are stable; outliers are identified using the studentized residuals (RStudent) and models are re-estimated excluding the outliers; models are re-estimated using bootstrapping technique with 5,000 repetitions; models are re-estimated using contiguous data. In the 1990s and early 2000s, many studies, e.g. Aggarwal and Mougoue (1996); Kwan (1996); Tse and Ng (1997); Zhou (1998); Aggarwal *et al.* (2000); Gan (2000); and (Bowman, 2005), document an increasing influence of the Japanese yen on the East Asian currencies and suggest the emergence of a yen bloc in the region. While the issue of the yen bloc is not the focus of the present paper, results from this paper do cast doubts on the making and prospect of a yen bloc in East Asia.

Fig.-1. Exchange rate movements of RMB/USD from 2001.01.01 to 2011.10.31

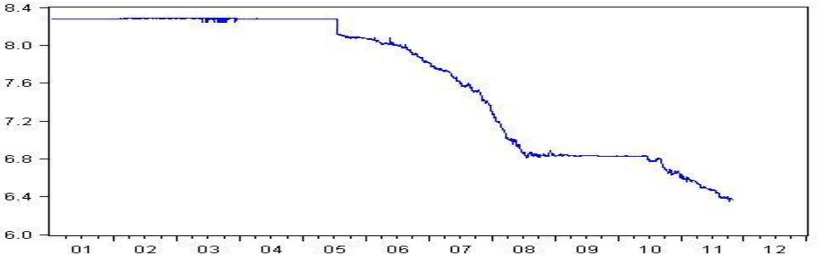

Table-1. Unit root tests for the log difference of exchange rates

	Swiss franc based		US dollar based	
	ADF	lag	ADF	lag
ΔCH	-34.892[a]	0	-27.833[a]	1
ΔIN	-37.142[a]	0	-20.962[a]	3
ΔJA	-35.556[a]	0	-24.662[a]	1
ΔKO	-36.240[a]	0	-23.609[a]	1
ΔMY	-38.442[a]	0	-14.093[a]	5
ΔPH	-37.227[a]	0	-40.876[a]	0
ΔSI	-35.287[a]	0	-35.953[a]	0
ΔTH	-25.977[a]	1	-40.383[a]	0
ΔTW	-36.714[a]	0	-33.385[a]	0
ΔEU	-32.879[a]	0		
ΔUS	-33.988[a]	0		

ADF critical values with constant in the test equation		
1%	5%	10%
-3.436	-2.863	-2.568

Notes: CH = Chinese renminbi; IN = Indonesian rupiah; JA = Japanese yen; KO = Korean won; MY = Malaysian ringgit; PH = Philippines peso; SI = Singapore dollar; TH = Thai baht; TW = Taiwan dollar; EU

= euro; US = US dollar. Δdenotes first difference. All exchange rates are in log. The test equation is estimated with constant only as the trend term is not significant. The optimal lag length is decided using minimum Schwartz criterion (Min SC). The maximum lag length is set according to Schwert (1989). It is 22 as our sample size is 1188.Superscript *a* denotes significance at the 1% level. The test results indicate that the difference of the log of all exchange rates is stationary.

Table-2. Correlation coefficients between independent variables in weight-inference approach

Panel A correlation coefficients between independent variables in Equation 1				
	$\Delta(ja/sf)$	$\Delta(ch/sf)$	$\Delta(us/sf)$	$\Delta(eu/sf)$
$\Delta(ja/sf)$	1	0.613	0.622	0.372
$\Delta(ch/sf)$		1	0.987	0.605
$\Delta(us/sf)$			1	0.606
$\Delta(eu/sf)$				1
Panel B correlation coefficients between independent variables in Equation 2				
	$\Delta(ja/sf)$	r	$\Delta(us/sf)$	$\Delta(eu/sf)$
$\Delta(ja/sf)$	1	-0.002	0.622	0.372
r		1	1.41E-15	0.041
$\Delta(us/sf)$			1	0.606
$\Delta(eu/sf)$				1

Notes: Δ stands for the difference. *us/sf, ch/sf, ja/sf* and *eu/sf* are the log of the exchange rates of yen, renminbi, US dollar and Euro against the Swiss franc. r refers to the estimated residuals from $\Delta(ch/sf)_t = \delta + \beta\Delta(us/sf)_t + r_t$.

Table-3. Estimation results based on weight-inference approach

	α	β_1 (US)	β_2 (CH) (residuals)	β_3 (JA)	β_4 (EU)	Adj. R^2	DW	W(US)
IN	1.23E-05 (0.102)	**0.897[a]** **(25.014)**	**0.192[c]** **(1.810)**	-0.004 (-0.130)	**0.098[a]** **(3.424)**	0.643	2.188	0.708
KO	2.13E-04 (1.384)	**0.825[a]** **(13.695)**	**0.532[a]** **(3.088)**	-0.035 (-0.787)	**0.272[a]** **(5.418)**	0.604	2.247	0.299
MY	-1.43E-05 (-0.152)	**0.894[a]** **(41.435)**	**0.484[b]** **(2.151)**	0.014 (0.365)	**0.119[a]** **(5.222)**	0.774	2.526	0.415
PH	-1.48E-04 (-1.169)	**0.936[a]** **(30.916)**	0.207 (0.690)	-0.016 (-0.319)	**0.108[a]** **(3.937)**	0.702	2.387	0.731
SI	-8.43E-05 (-1.238)	**0.636[a]** **(26.098)**	**0.203[b]** **(2.521)**	0.010 (0.413)	**0.368[a]** **(15.478)**	0.850	2.197	0.436
TH	-2.28E-04 (-1.488)	**0.865[a]** **(28.215)**	-0.197 (-0.681)	0.047 (0.925)	**0.119[a]** **(3.886)**	0.580	2.333	1.059
TW	6.89E-05 (0.857)	**0.901[a]** **(47.034)**	**0.464[a]** **(4.908)**	-0.002 (-0.089)	**0.099[a]** **(5.512)**	0.872	2.099	0.442

Notes: All exchange rates are in terms of Swiss franc. CH = Chinese renminbi; IN = Indonesian rupiah; JA = Japanese yen; KO = Korean won; MY = Malaysian ringgit; PH = Philippines peso; SI = Singapore dollar; TH = Thai baht; TW = Taiwan dollar. Figures in parentheses are *t-statistics* adjusted for heteroskedasticity and autocorrelation using the Newey and West procedure (Newey and West, 1987). Superscripts *a, b, and c* denote the 1%, 5%, and 10% significant levels. Significant statistics are in bold. W(US) stands for the US dollar's weight.

Table-4. Estimation results based on Kwan method

	α	β_1(CH)	β_2(JA)	β_3 (EU)	Adj. R^2	DW	β(US)
IN	1.18E-05	**0.192**[c]	-0.001	**0.102**[a]	0.014	2.187	0.707
	(0.098)	**(1.813)**	(-0.044)	**(3.408)**			
KO	2.19E-04	**0.525**[a]	-0.062	**0.227**[a]	0.061	2.246	0.310
	(1.424)	**(2.978)**	(-1.433)	**(4.988)**			
MY	-1.16E-05	**0.481**[b]	0.001	**0.098**[a]	0.045	2.528	0.420
	(-0.125)	**(2.097)**	(0.038)	**(3.785)**			
PH	-1.45E-04	0.204	-0.028	**0.088**[a]	0.012	2.389	0.736
	(-1.157)	(0.668)	(-0.705)	**(2.662)**			
SI	-8.30E-05	**0.202**[b]	0.003	**0.357**[a]	0.409	2.201	0.438
	(-1.125)	**(2.482)**	(0.163)	**(15.010)**			
TH	-2.26E-04	-1.200	0.036	**0.100**[a]	0.012	2.335	1.064
	(-1.481)	(-0.682)	(0.857)	**(2.617)**			
TW	6.93E-05	**0.464**[a]	-0.003	**0.096**[a]	0.084	2.099	0.443
	(0.863)	**(4.906)**	(-0.198)	**(6.230)**			

Notes: All currencies are expressed in terms of US dollar. CH = Chinese renminbi; IN = Indonesian rupiah; JA = Japanese yen; KO = Korean won; MY = Malaysian ringgit; PH = Philippines peso; SI = Singapore dollar; TH = Thai baht; TW = Taiwan dollar. β(US) stands for the US dollar's weight.Figures in parentheses are *t-statistics* adjusted for heteroskedasticity and autocorrelation using the Newey and West procedure. Superscripts *a, b, and c* denote the 1%, 5%, and 10% significant levels. Significant statistics are in bold.

Table-5. Unit root tests for the US dollar based exchange rates

	ADF	lag		ADF	lag
CH	1.034	1	ΔCH	**-27.833**[a]	1
IN	-2.035	2	ΔIN	**-20.962**[a]	3
JA	-2.408	1(τ)	ΔJA	**-24.662**[a]	1
KO	-0.766	0	ΔKO	**-23.609**[a]	1
MY	-2.116	5(τ)	ΔMY	**-14.093**[a]	5
PH	-1.750	1	ΔPH	**-40.876**[a]	0
SI	-2.522	0(τ)	ΔSI	**-35.953**[a]	0
TH	-1.818	1	ΔTH	**-40.383**[a]	0
TW	-2.677	1(τ)	ΔTW	**-33.385**[a]	0

ADF critical values with constant (constant and trend) in the test equation

1%	5%	10%
-3.436 (-3.966)	-2.863(-3.414)	-2.568(-3.129)

Notes: CH = Chinese renminbi; IN = Indonesian rupiah; JA = Japanese yen; KO = Korean won; MY = Malaysian ringgit; PH = Philippines peso; SI = Singapore dollar; TH = Thai baht; TW = Taiwan dollar. Δdenotes first difference. All exchange rates are in log. (τ) indicates the test equation is estimated with constant and trend as the trend term is significant at the 5% level. The optimal lag length is decided using minimum Schwartz criterion (Min SC). The maximum lag length is set according to Schwert (1989). It is 22 as the sample size is 1188 in this paper. Superscript *a* denotesthe 1% significant level. Significant statistics are in bold. The test results indicate that all US dollar based exchange rates have one and only one unit root.

Table-6. Tests for cointegration between renminbi (yen) and East Asian currencies

Panel A Tests for cointegration between renminbi and East Asian currencies

Rank	Eigen value	trace	p-value	Max-Eigen	p-value
None	0.066	**228.040** [a]	0.000	**81.226** [a]	0.000
At most 1	0.041	**146.813** [a]	0.008	**49.242** [b]	0.029
At most 2	0.026	97.572	0.121	31.530	0.381
At most 3	0.020	66.042	0.254	23.704	0.544

At most 4	0.017	42.337	0.359	19.920	0.418
At most 5	0.008	22.417	0.567	9.659	0.861
At most 6	0.007	12.758	0.383	8.613	0.476
At most 7	0.003	4.145	0.391	4.145	0.391

Panel B Tests for cointegration between yen and East Asian currencies

Rank	Eigen value	trace	p-value	Max-Eigen	p-value
None	0.037	154.355	0.651	45.398	0.414
At most 1	0.029	108.965	0.910	35.411	0.687
At most 2	0.021	73.545	0.983	25.516	0.921
At most 3	0.017	48.032	0.994	19.829	0.945
At most 4	0.011	15.368	0.998	12.835	0.989
At most 5	0.005	10.595	0.998	6.318	0.999
At most 6	0.005	9.050	0.960	6.076	0.953
At most 7	0.003	2.974	0.880	2.974	0.880

Notes: Tests for cointegration between yen and 7 East Asian currencies are performed with 8 lags in the VAR and with constant and trend in the cointegration equation as the trend term is significant at the 5% level. Tests for cointegration between renminbi and 7 East Asian currencies are performed with 1 lag in the VAR and constant only in the cointegration equation as the trend term is not significant. The optimal lag length is decided using minimum Schwartz criterion. Rank denotes the number of cointegrating equations. Superscript *a* and*b*denote rejection of the hypothesis at the 1% and 5% levels. Both trace test and Max-Eigen test indicate that there is no cointegration between yen and East Asian currencies, while there are two cointegrating relations between renminbi and East Asian currencies. Significant statistics are in bold.

Table-7. Cointegrating relations between renminbi and East Asian currencies

CH	IN	KO	MY	PH	SI	TH	TW	const.
Cointegrating equation 1								
normalized cointegrating coefficients of equation 1 (*t-statistics* in parentheses)								
1.000	0.000	**0.443**[a]	0.241	**-1.188**[a]	-0.094	0.179	0.168	-0.760
		(3.585)	(0.479)	**(5.870)**	(0.406)	(0.232)	(0.449)	(0.514)
adjustment coefficients of equation 1 (t-statistics in parentheses)								
-0.004[a]	0.003	0.006	0.001	**0.009**[a]	**-0.005**[b]	0.005	**-0.005**[a]	
(6.286)	(1.000)	(0.015)	(0.005)	**(2.943)**	**(2.397)**	(1.289)	**(3.121)**	
Cointegrating equation 2								
normalized cointegrating coefficients of equation (*t-statistics* in parentheses)								
0.000	1.000	**-0.727**[a]	-0.405	**0.705**[a]	**-1.994**[a]	**0.400**[c]	**1.803**[a]	**-13.169**[a]
		(5.672)	(0.776)	**(3.372)**	**(4.742)**	**(1.753)**	**(4.659)**	**(-8.585)**
adjustment coefficients of equation 1 (t-statistics in parentheses)								
-0.002[a]	**-0.008**[b]	0.003	-0.002	**-0.016**[a]	0.002	**-0.010**[b]	0.003	
(2.831)	**(2.135)**	(0.701)	(0.003)	**(4.908)**	(0.764)	**(2.374)**	(1.366)	

Notes: CH = Chinese renminbi; IN = Indonesian rupiah; JA = Japanese yen; KO = Korean won; MY = Malaysian ringgit; PH = Philippines peso; SI = Singapore dollar; TH = Thai baht; TW = Taiwan dollar. Cointegrating relations between Chinese renminbi and East Asian currencies are based on Error Correction Model (ECM) estimated with 1 lag in the VAR and with constant only in the cointegration equation (CE) as the trend term is not significant. The optimal lag length is decided using minimum Schwartz criterion (Min SC). Superscripts *a, b, and c denote* the 1%, 5%, and 10% significant levels. Significant statistics are in bold.

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