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Is the Renminbi East Asia's Dominant Reference Currency? A Reconsideration

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Abstract

Recent empirical studies show that the Chinese currency renminbi is either becoming or has become a dominant reference currency in East Asia. This paper reviews the evidence with daily exchange rate data from seven East Asian economies namely, Indonesia, Korea, Malaysia, the Philippines, Singapore, Thailand and Taiwan. We consider the likely problems and pitfalls associated with the application of Frankel-Wei regressions to determine the weights of the US dollar and the renminbi in the implicit currency baskets. We show empirically the estimation of currency weights using non-orthogonalised renminbi movements could suffer from imprecision and/or inconsistency. To circumvent the simultaneity bias problem present in most of these regressions, we use country-specific VAR models to take into explicit account the mutual interaction of the exchange rates variables. Impulse response analysis reveals that the US dollar still retains its dominant regional influence but the role of the renminbi in East Asian exchange rate determination has increased after the global financial crisis.

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Keywords: Currency baskets; Renminbi; US dollar; Vector Autoregressions; East Asia

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1. Introduction

Reflecting the open nature of their economies as well as their geographically diversified trade patterns, most East Asian countries have adopted a *de facto* basket peg system as their exchange rate regime. The monetary authorities in these countries manage their exchange rates by soft pegging towards a broad basket of currencies which typically comprises the currencies of major trading partners and competitors (Williamson, 2005). In this way, domestic firms can have a more stable trading environment as well as retain their cost-competitiveness. Under this regime, the weights assigned to the component currencies are usually not disclosed to the public. Frankel and Wei (1994) developed a method for uncovering the weights assigned to the major international currencies such as the US dollar, the German mark and the yen constituting the currency basket. These weights capture the combined effect of the respective major international currency's direct impact on the East Asian currency and its indirect impact through the regional currencies.

Many studies applied the Frankel-Wei type regression to the East Asian countries to determine the regional influences of world major currencies.[1] The region was found to be on a soft dollar peg before the 1997 Asian currency crisis, as the weight on the US dollar turned out to be close to one while those for the German mark and the yen were small and statistically insignificant in the pre-Asian crisis period. Although the East Asian exchange rates exhibited greater flexibility during the Asian crisis, the US dollar was found to be still heavily weighted in the currency baskets after the crisis (McKinnon, 2000). Consequently, the region was characterized as being an "East Asian dollar standard" whereby the US dollar served as an anchor for exchange rate polices in the region. Meanwhile, various studies including Kearney and Muckley (2007) found a notable yen influence despite the absence of a "yen bloc" in the region.

More recently, the economic rise of China has led to the question of whether exchange rate management in the East Asian economies has shifted course to pay more attention to the renminbi as a key reference currency. After all, China has become the second largest economy as well as the largest exporter of goods in the world. Indeed, China is already one of the top (if not the most important) trading partner for most East Asian economies. Intra-regional trade has tripled since 2000 and regional production networks have spread rapidly with China playing the role of an assembly hub for final goods. The East Asian economies not only need to retain external competitiveness relative to China but also to maintain exchange rate stability with respect to the renminbi in light of

[1] Some studies apply extensions to the Frankel-Wei method such as rolling regressions that allow for structural breaks in the data, adding lags to the explanatory variables to cater for dynamic effects and modeling heteroskedastic error terms with GARCH processes. There are also other studies that employ different empirical methods for instance cointegration analysis, Markov switching techniques and structural VAR models to study currency relationships in the region.

their strengthening trade, investment and financial linkages with China. When a foreign currency like the renminbi becomes a reference point, it exhibits greater co-movement with the domestic currency and assumes a larger weight in the implicit currency basket.

There is a growing literature that applies the Frankel-Wei type or other methodology to determine the extent which the renminbi influences exchange rate determination in the region. With few exceptions,[2] most studies found the renminbi gaining influence over time. For instance, *Chen et al.* (2009) and Ito (2010) found fluctuations in the renminbi that are orthogonal to US dollar movements exert a substantial impact on exchange rate movements in East Asia. Meanwhile, Fratzscher and Mehl (2011) constructed a regional factor that is highly important in explaining Asian currency movements and showed the renminbi Granger causes or has predictive content on this factor. In fact, several studies found the influence of the renminbi has surpassed that of the US dollar for some East Asian currencies. Specifically, Cavoli and Rajan (2010) found several East Asian currencies exhibited greater stability against the renminbi compared to the US dollar. Both Henning (2012) and Subramanian and Kessler (2012) utilized non-orthogonalised renminbi movements in Frankel-Wei regressions to show that the renminbi is already a dominant reference currency in East Asia, suggesting the possibility that a *de facto* "renminbi bloc" has emerged.

Granted that China's growing economic dominance could very well lend impetus to regional economies to benchmark their currencies towards the renminbi, it does appear somewhat surprising that the renminbi has overtaken the US dollar as the dominant reference currency of the region. After all, China's capital account remains largely closed and the renminbi is not yet fully convertible. Notwithstanding the pro-active steps taken by Chinese authorities to liberalize the capital account and internationalize the renminbi, foreign trade and financial transactions in the region continue to be denominated or invoiced mainly in the US dollar. Moreover, East Asian economies hold their foreign reserves largely in US dollars and it is thus advantageous for them to benchmark their exchange rate towards the US dollar in order to have more stability in terms of domestic purchasing power. In sum, we expect the US dollar still enjoys incumbency advantages and network effects as the pre-eminent international currency to be able to exert a dominant influence on East Asia exchange rates.

The purpose of this paper is to review the empirical evidence on the role played by the renminbi in regional exchange rate determination. First, we consider the likely problems and pitfalls

[2] For instance, Balasubramanian *et al.* (2011) found, after allowing for structural changes in the data, that the renminbi fluctuations that are orthogonal to US dollar movements play only a limited role in the exchange rate polices of East Asian economies. Meanwhile, Girardin (2011) found the central banks in the region are benchmarking their currencies against a broader range of Asian currencies instead of a single regional reference currency.

associated with the application of the Frankel-Wei methodology in determining the weights of US dollar and the renminbi in the implicit currency baskets. The high collinearity between the renminbi and the US dollar led many preceding research to use only the part of renminbi fluctuations that are orthogonal to US dollar movements. However, this results in biased currency weight estimates and consequently, several other studies use non-orthogonalised renminbi fluctuations. We show empirically that the renminbi variable is endogenous in the majority of Frankel-Wei regressions reflecting the reverse causality of East Asian currency fluctuations on renminbi movements. In these cases, the Frankel-Wei regressions suffer from simultaneity bias problems resulting in invalid statistical inference on the currency weights.

The second contribution of this paper is to propose an alternative method to assess the relative regional influence of the renminbi vis-a-vis the US dollar on East Asian currencies. To overcome the simultaneity bias, we estimate country-specific Vector Autoregression (VAR) models that allow for endogenous interactions among all the exchange rate variables. The impact which reference currencies have on East Asian currencies can then be assessed through impulse response analysis. This model is applied to daily exchange rate data of the following seven countries: Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand. There are two sample periods one before and another after the global financial crisis which allows us to investigate how exchange rate dynamics have changed after the crisis. To pre-empt the results, we found the US dollar retains its dominant influence over regional exchange rates but the role of the renminbi in East Asia exchange rate determination has increased post-crisis.

This paper proceeds as follows. The next section provides a review of the potential problems that arise in the application of Frankel-Wei methodology to determine the weight of renminbi in the implicit currency baskets. In Section 3, we utilized East Asian exchange rate data to test for the presence of various econometric problems associated with the Frankel-Wei regressions. The findings from the alternative VAR analysis, along with pre- versus post-crisis comparisons are found in section 4. Section 5 concludes.

2 Problems with the Application of Frankel-Wei Regressions

Frankel and Wei (1994) developed and popularized a method for estimating the implicit weights assigned to major international currencies in a currency basket. In particular, they employ the following regression:

(1) $$\Delta e_t^i = \gamma + \delta_{USD}\Delta e_t^{USD} + \delta_{EUR}\Delta e_t^{EUR} + \delta_{YEN}\Delta e_t^{JPY} + \varepsilon_t$$

where the e terms denote the value of each currency in terms of the Swiss franc which is the numeraire of choice, and the first difference of the log exchange rate is given by $\Delta e_t = e_t - e_{t-1}$. The superscripts *i, USD, EUR* and *YEN* denote an Asian currency, the US dollar, Germany mark and Japanese yen respectively. In this regression, the δ coefficients are considered to represent the weights of the respective reference currencies in the basket. More recently, in order to examine the influence of renminbi movements on exchanges rates in the region, a number of studies have applied the Frankel-Wei methodology with a renminbi term included explicitly in the specification of the model as follows:[3]

(2) $$\Delta e_t^i = \gamma + \delta_{USD}\Delta e_t^{USD} + \delta_{EUR}\Delta e_t^{EUR} + \delta_{YEN}\Delta e_t^{YEN} + \delta_{RMB}\Delta e_t^{RMB} + \varepsilon_t$$

In other words, the home currency now has the renminbi added as a reference currency in its implicit currency basket.

However, we note that empirical investigations into the influence of renminbi are hampered by China's fixed exchange rate system which renders the renminbi variations as practically indistinguishable from US dollar movements most of the time. A judicious choice of the sample period is needed to overcome this identification problem. China abandoned its peg to the US dollar and announced a shift in its exchange rate regime to a basket peg in mid-2005. In October 2008, the renminbi was re-pegged to the US dollar at 6.83 RMB per dollar in response to the outbreak of the global financial crisis. Since June 2010, the renminbi has returned to a managed float against a basket of currencies. There are thus two periods where the renminbi was somewhat decoupled from the US dollar which could be used to unveil the relative impact of these two currencies on exchange rate movements in the region.[4] Hence, to overcome the identification problem, the empirical analysis is carried out over two sample periods from mid-2005 to mid-2008 and from mid-2010 to end-2012. In view of possible structural breaks related to the global financial crisis, we perform our estimation of these two periods separately. In this way, we can compare how exchange rate dynamics in the region might have changed between the pre- and post-crisis periods and determine whether the influence of renminbi has altered after the crisis.

Nonetheless, restricting the sample periods to such short time durations means employing higher frequency data in the analysis. As in most related studies, we use daily nominal exchange

[3] In this and some other studies, the German mark was replaced by its successor the euro which is the European Union's single currency.

[4] The renminbi appreciated against the USD by approximately 7% and 16% in the two time periods respectively.

rate series.[5] Degrees of freedom consideration arising from the shortness of each time period means lower frequency data such as monthly time series have to be eschewed. This imposes a constraint on applying the modified equation by Frankel and Wei (2008) that includes in equation (1) a term to capture exchange market pressure. This additional variable takes into account flexibility of the currency but its computation requires data on reserves which are available only at a lower frequency on a monthly basis. In any case, this paper is interested in uncovering unconditional correlations across regional currency movements regardless of whether they are the result of market forces or government interventions in the foreign exchange markets. Hence, it may not be as critical to estimate the currency weights conditioned on exchange market pressure.

Despite the switch in the Chinese exchange rate regime, the correlation coefficient between the renminbi and the US dollar movements remains very high, exceeding 0.9 in both sample periods. Such high collinearity between the variables could lead to multicollinearity problems in the estimation of equation (2) so that it is difficult to differentiate between the US dollar and the renminbi in terms of their effects on local currency movements. Hence, in many previous studies an auxillary regression of the renminbi variations against the US dollar variations is first performed. Residuals from this auxillary regression are then used to capture renminbi fluctuations independent of US dollar movements. Chen *et al.* (2009) and Ito (2010), amongst others, used such orthogonalised movements of renminbi as the Δe_t^{RMB} term in equation (2).

However, replacing the renminbi variable with residuals from the auxillary regression in the Frankel-Wei regressions will lead to biased estimation of the US dollar weight. Using only the part of renminbi movements that is orthogonal to US dollar fluctuations basically means that whenever there is ambiguity in separating the effect of the two currencies, the effect will be attributed to the US dollar. This "does not amount to running a clean and transparent horse race between the different reference currencies…".[6] Consequently, several papers such as Henning (2012) and Subramanian and Kessler (2012) estimated equation (2) with non-orthogonalised renminbi fluctuations. They found the weight estimates associated with the renminbi tend to be higher than those for the US dollar and concluded that the renminbi is already a dominant reference currency in the region.

There are nonetheless several potential problems with using the renminbi variable in the direct application of Frankel-Wei regressions, that is, as the Δe_t^{RMB} term in equation (2). First, the

[5] We note this is not inconsistent with the high frequency monitoring of exchange rates by central banks in the region.

[6] Subramanian and Kessler (2012, p. 5)

high collinearity between the US dollar and renminbi variables will typically inflate the standard errors of their coefficient estimates, thereby lowering the precision of the weight estimates. The extent by which the standard error of a regression coefficient is inflated is normally measured by the variance inflation factor and depends on the degree of collinearity between explanatory variables in the equation. If the standard errors are significantly inflated as would be the case of severe multicollinearity, the greater imprecision of the weight estimates will throw doubts on the inference regarding the regional influence of the US dollar and the renminbi. In the next section, we obtain the variance inflation factors associated with the Frankel-Wei regressions in order to assess the severity of multicollinearity problems in these equations.

Second and more importantly, the likely endogeneity of the renminbi variable could pose problems to the estimation of the Frankel-Wei regressions which invalidates the conclusions drawn on its relative regional influence of the renminbi vis-à-vis the US dollar. As a regional currency, it is plausible that fluctuations in the renminbi are themselves affected by movements in the other East Asian currencies. For instance, when the renminbi and the home currency are hit by common shocks say from outside the region, the correlation between these two variables will increase and the weight of the renminbi in the implicit currency basket will be large.[7] When an explanatory variable is simultaneously determined with the dependent variable, we end up with biased and inconsistent estimates of its coefficient. In this case, the statistical inference on currency weights are no longer valid. We empirically test for the endogeneity of the renminbi variable in the Frankel-Wei regressions in the next section to ascertain if they suffer from such simultaneity bias problems.

3. Data and Preliminary Analysis

The exchange rate variable used in our analysis is expressed as the amount of domestic currency that can be bought by one unit of special drawing right (SDR), i.e. we use the SDR in place of the Swiss France as numeraire.[8] Since the numeriare is an independent currency for gauging exchange rate variation, the use of the Swiss Franc is not as appropriate due to its high correlation with the euro. Given the way the exchange rate is defined, an increase in e denotes a depreciation of that currency against the SDR. We define the pre- and post-crisis periods as 22nd July 2005—30th June 2008 and 3rd August 2010—30th November 2012 respectively. Figures 1 depicts the plots of the daily exchange rates since 22nd July 2005 first for the reference currencies, namely US dollar (USD),

[7] Indeed, the large renminbi weight estimates obtained in some recent studies may well be the result of overestimation caused by the lack of exogeneity in the renminbi variable.

[8] The SDR is a currency basket issued by the IMF comprising the US dollar, euro, pound and yen. We follow Frankel and Wei (2008) in using the SDR as numeraire because, as highlighted in their paper, the SDR can capture the size of deviations from the reference point better than the Swiss Franc.

Euro (EUR), Japanese Yen (JPY), Renminbi (RMB) and then for the regional currencies, namely Indonesian Rupiah (IDR), Korean Won (KRW), Malaysian ringgit (MYR), New Taiwan Dollar (NTD), Philippine peso (PHP), Singapore dollar (SGD) and Thai Baht (THB). Two vertical bars mark the crisis period which correspond to the end and the start of the two sample periods.

Insert Figure 1 around here

Figure 1: Bilateral Exchange Rates against SDR (22nd July 2008—30th November 2012)

It is discernible from Figure 1 that like the euro and the renminbi, the pressure on most of the regional currencies namely Malaysian ringgit, Philippine peso, Singapore dollar and Thai baht, were generally positive in the pre-crisis period. By contrast, the Indonesian rupiah, Korean won and Taiwan dollar, as in the case of the US dollar and the yen, exhibited a general depreciation path before the crisis. At the onset of the global financial crisis, the Singapore dollar, Phillippine peso and Thai baht ended their appreciation path while the other Asian currencies depreciated, with the Indonesian rupian and Korean won falling sharply. The Japanese yen is the only reference currency that exhibited a clear appreciation path throughout the crisis period. As for the post-crisis period, the Taiwan dollar, Philippine peso, Singapore dollar were under appreciation pressure as in the case of the renminbi and the yen. Meanwhile, the Korean won, Malaysian ringgit and Thai baht seem to thread horizontally similar to the US dollar. The Indonesian rupiah is the only regional currency in this study that like the euro displayed a clear depreciating path post crisis. We also observe from Figure 1 that the fluctuations of the euro appear to be a mirror image of the US dollar movements.

We estimate the Frankel-Wei equation (2) with these regional exchange rate data for both pre- and post-crisis periods. There is a possibility that the error terms in these regressions suffer from heteroskedasticity that is they may have non-constant variance. If this be the case, it will no longer be appropriate to use ordinary least squares (OLS) standard errors to test for the statistical significance of the coefficients. The application of White's test for heteroskedasticity detected non-constant variance in the residuals in all the country-specific regressions except for Indonesia and Thailand in the pre-crisis period and Korea and Thailand in the post-crisis period. This means that apart from the four regressions, we cannot perform statistical significance test involving OLS standard errors. We use heteroskedastic-consistent standard errors in all the country-specific regressions in order to ensure valid statistical inference and the results are recorded in Table 1.

Insert Table 1 around here

Table 1: Estimates from Frankel-Wei Regressions

It is clear from Table 1 that the coefficient of determination is low, ranging from 0.09 to 0.43 and 0.05 to 0.53 in the pre- and post-crisis periods respectively. This means the fluctuations of the regional currencies are not adequately explained by the regression model and this is often interpreted as a sign of flexibility in the currencies. We observe that the US dollar coefficient is statistically significant only in two cases in the pre-crisis period. As for the post-crisis period, we obtain significant US dollar coefficient in four cases but these are negative in three of the cases. Concurring with the Frankel-Wei regression results from recent studies, the coefficients associated with the renminbi term are positive and statistically significant in the vast majority of cases. The lone exceptions in the pre- and post-crisis periods are the Thai baht and the Singapore dollar respectively. Further, the renminbi coefficients are generally larger when compared to the US dollar coefficients and the significance level of the renminbi coefficients are in the main higher than those corresponding to the US dollar. The results seem to suggest the renminbi is more influential than the US dollar in East Asia.

As explained in the previous section, we need to assess how severe the multicollinearity problems are in the regressions before we can place confidence in the findings. To this end, variance inflation factors of the coefficient estimates are computed by dividing the variance of the coefficient estimate by the variance of that coefficient when other explanatory variables are omitted from the equation. Table 2 records the variance inflation factors of the coefficient estimates associated with the US dollar and the renminbi in the Frankel-Wei regressions. With few exceptions, the variance inflation factors are way above the common threshold value of five when multicollinearity is deemed to be severe. It is also clear from the table that the variance inflation factors for the US dollar coefficients are particularly large and exceed the corresponding values for the renminbi in all cases. This implies the US dollar coefficient are not accurately estimated which could be the reason why many of them are either statistically insignificant or have unexpected signs. The high variance inflation factors suggest multicollinearity problems are not quite eliminated but remain rather severe in in these regressions so that conclusions based on the weight estimates have to be drawn with care.

Insert Table 2 around here

Table 2: Variance Inflation Factors of US dollar and Renminbi Coefficient Estimates

Moreover, there may be more serious problems with the weight estimates if the renminbi term in equation (2) is not an exogenous variable. If this be the case, the regression coefficients estimates produced will be biased and inconsistent producing invalid statistical inference. To

ascertain the endogeneity or otherwise of the Δe_t^{RMB} term, we carry out the widely used Hausman specification test (Davidson and MacKinnon, 1993). The test results tabulated in Table 3 indicate that with few exceptions namely Indonesia and Philippines in the pre-crisis period and Singapore in the post-crisis period, there is strong evidence that the Δe_t^{RMB} term is an endogenous variable. It follows that most of the Frankel-Wei regression results recorded in Table 1 are no longer valid and there is a need to disentangle the simultaneity bias in the regression equations. In the next section, we propose an alternative empirical method for assessing the regional influence of the reference currencies.

Insert Table 3 around here

Table 3: Hausman test for the presence of simultaneity (p-values)

3. An Alternative Model of Exchange Rate Dynamics

In view of their endogeneity, we use a Vector Autoregressive (VAR) model to estimate the relationships among the exchange rates series. Such models circumvent the simultaneity bias problem by allowing for mutual interaction of the variables. We run the following country-specific VAR model for each of the seven Asian currency:

$$\Delta e_t = \beta_0 + \sum_{k=1}^{p} \beta_k(L)\Delta e_{t-k} + \varepsilon_t \quad (3)$$

Where $\Delta e_t = (\Delta e_t^{US}, \Delta e_t^{JPY}, \Delta e_t^{RMB}, \Delta e_t^{i})'$; $\beta_k(L)$ is a 4×4 matrix of lag polynomials, and β_0 is a vector of constants.[9] We employ a VAR model in differences instead of levels due to the nonstationarity of the exchange rate series. The results of Phillip-Perron unit root tests (Phillips and Perron,1988) as recorded in Table 4 show that all the exchange rate data series used in this study are integrated of order one. Thus, we model the first differences of the log exchange rate series.

Insert Table 4 around here

Table 4: Phillip-Perron Unit Root Tests (p-values)

The fitting of a VAR model typically requires the estimation of many highly collinear parameters so that it is difficult to recover the weights or δ coefficients from equation (3). It is usual

[9] For parsimony, we omitted the Δe_t^{EUR} variable since an unanticipated shock to this variable produces insignificant or only marginally significant impulse responses from the Asian currency in almost all cases. The results including this variable are available upon request.

in the VAR framework to assess the impact of innovations in the variables through impulse response analysis instead. We derive impulse response functions that trace dynamic effects of innovations in reference currencies on the domestic currency. In other words, we examine the responses of local currency to unanticipated foreign currency appreciations and depreciations.[10]

We estimate country-specific VAR models using daily data from each of the seven East Asian countries over the two periods when the renminbi was on a soft peg. As for the number of lags (p) in the model, the Akaike Information Criterion (AIC) selects an optimal lag lengths 3 and 2 for most countries in the pre and post crisis periods respectively. However, the application of autocorrelation LM tests reveals the presence of serial correlations in the residuals in some models. This renders post-estimation inferences invalid and indicates longer lag lengths are required. The lag lengths finally adopted for Indonesian rupiah, Korean won, Malaysian ringgit, New Taiwan dollar, Philippine peso, Singapore dollar and Thai baht are 8, 9, 3, 3, 3, 3, 3 and 4 respectively for the pre-crisis period. Corresponding lag lengths for the post-crisis period are 2, 8, 2, 2, 2, 4, 2 and 3. With these lag lengths, serial correlation have been mostly eliminated in each case which suggests the underlying dynamics have been adequately captured by the model.

To perform impulse response analysis and variance decomposition, we first apply Cholesky decomposition which recovers the underlying structural shocks by recursive orthogonalization. The following causal ordering of variables $(\Delta e_t^{US}, \Delta e_t^{JPY}, \Delta e_t^{RMB}, \Delta e_t^{i})$ is adopted to reflect the typical timing assumptions of global, regional and local shocks to a small, open economy. The implicit assumptions here are that firstly, unanticipated "global" shocks to the US dollar have contemporaneous effects on all the other currencies in the system. Secondly, unanticipated "regional" shocks to the yen or the renminbi have contemporaneous effects on the local currency but not on the US dollar.[11] Thirdly, unanticipated home currency shocks have no contemporaneous effects on the other currencies in the system.[12] These contemporaneous restrictions are plausible in view of the high frequency (daily) data used in the analysis.

[10] For simplicity, we do not incorporate asymmetric effects of reference currencies on Asian currencies even though Pontines and Serigar (2010) found some asymmetric influences in terms of an aversion to an appreciation of the renminbi in the case of the Philippine peso and Thai baht.

[11] For instance, while an unanticipated shock to the US dollar can have an immediate impact on the renminbi, it is less plausible that such a shock to the renminbi will affect the US dollar on the same day.

[12] There is a distinction between the home currency variable and an unanticipated shock to the variable so that the causal ordering can in general be applied to endogenous variables. Hence, notwithstanding the endogeneity of the renminbi variable, it can respond to an unanticipated shock to the home currency only with a lag.

Nonetheless, the causal ordering used assumes unanticipated shocks to the renminbi do not have a contemporaneous impact on yen movements. Given that both are regional currencies, it is plausible for the yen to be influenced by unanticipated shocks to the renminbi contemporaneously. For robustness checks, we repeat the VAR analyses with another alternative causal ordering of the variables, specifically $(\Delta e_t^{US}, \Delta e_t^{RMB}, \Delta e_t^{JPY}, \Delta e_t^{i})$ where the ordering of the two regional currencies is reversed. However, the findings corresponding to the alternative Cholesky decomposition turn out to be qualitatively similar.[13]

Panels a to c in Figures 2 and 3 depict the responses of the home currency to a one standard deviation shock in the US dollar, yen, and renminbi in the pre- and post crisis periods respectively. The impulse responses are plotted in levels and extend to 10 months, by which time the impulses have stabilized. We bootstrap 1000 replications of the VAR residuals to obtain robust standard errors for the impulse responses and construct two standard deviation bands which are displayed in the figures. As usual, the impulses are said to be not statistically significant at the 5% level whenever the associated band includes the zero line.

Insert Figures 2 and 3 around here

Figure 2: Home Currency Impulse Responses to Reference Currency Shock(Pre-crisis)

Figure 3: Home Currency Impulse Responses to Reference Currency Shock(Postcrisis)

With the lone exception of the Singapore dollar post-crisis, the US dollar shock plays a significant role in determining movements in all the East Asian currencies in both sample periods (see Panel (a) of Figures 2 and 3). This finding of a predominant US dollar influence is expected in view of its reserve currency status as well as its role as a vehicle currency since trade and financial transactions in the region are still mostly denominated in the US dollar. In comparison, the plots in Panel (b) of Figures 2 and 3 reveal that one standard deviation shock to the yen either produces insignificant or negatively significant responses in the Asian currencies.

During the pre-crisis period, only the Malaysian ringgit responds significantly to an unanticipated shock to the renminbi while all the other six Asian currencies exhibit statistically insignificant responses to an innovation from the renminbi (see panel (c) of Figure 2). Hence, using this methodology, we find that there are no strong co-movements between the renminbi and the East Asian currencies before the onset of the global financial crisis. In contrast, we observe from Figure 3

[13] To conserve space, we do not report the results of this alternative ordering but they are available upon request from the author.

that a one standard deviation shock to renminbi movements produces significant positive responses in all Asian currencies. We note that the responses of domestic currency to a shock to the renminbi shock are marginally insignificant only in the case of Indonesian rupiah. This suggests that in exchange rate management, the monetary authorities of the Asian countries may to some extent be benchmarking towards the renminbi particularly after the global financial crisis.

However, the differences observed across the two time periods could possibly be attributed to changes in the external environment. In particular, it is well recognized that the level of global risk appetite is a key factor determining the amount of foreign capital inflows which in turn impacts East Asian exchange rates. Hence, we control for this factor in our cross-period comparisons by including a risk indicator as an exogenous variable in each country-specific VAR model. Specifically, the Chicago Board Option Exchange S&P500 volatility Index is used to capture risk on-risk off behavior in the financial markets. This produces qualitatively similar results in the impulse response analysis leading to the same inference that the renminbi has gained regional influence post-crisis.

Overall, although the results point to the US dollar retaining its dominance as a reference currency, there is evidence of an emerging renminbi influence on regional currencies. This finding can be attributed to the strengthening trade ties between China and the East Asian countries over time. In order to compare trade patterns before and after the crisis, we examine for each country trade shares amongst its four most important trading partners within the region. The trade shares are computed based on 2006 and 2011 bilateral exports and imports trade data for pre- and post-crisis periods respectively. The trading partners and their trade shares, which are reported in Table 5, vary across the East Asian countries. Nonetheless, we observe from Table 5 that China's trade share rose invariably as we move from the pre- to post-crisis period. Without exception, China gained importance as a trading partner between the two time periods and is the top regional trading partner for all countries except Singapore post-crisis.

Insert Table 5 around here

Table 5: Major bilateral regional trade partners and trade shares

East Asia's trade integration with China has deepened due to the latter's growing role as the hub of regional trade network through the formation of vertical supply chains. Such vertical trading chain networks stretches across the East Asian countries with each specializing in particular stages of production and China playing the role of an assembly hub for final goods.[14] In addition, trade

[14] IMF (2011) provides a detailed analysis of how trade networks in Asia have evolved.

between the region and China has accelerated through the establishment of free trade agreements (FTAs) such as the ASEAN-PRC FTA and the Preferential Trade Agreement between China and Taiwan. Moreover, trade competition between the East Asian countries versus China has heightened and the impact of renminbi fluctuations on exports competitiveness of East Asian countries has climbed steadily over time (Mattoo *et al*., 2012). It has thus become more important for East Asian monetary authorities to maintain stability of their currencies vis-à-vis the renminbi in order to stabilize the trading environment for the local firms as well as retain their trade competitiveness in third markets.

Furthermore, China has taken concrete steps aimed at broadening the use of the renminbi such as allowing companies to settle cross-border trades in renminbi, as well as easing restrictions to allow offshore banks to transfer renminbi among themselves in order to facilitate the issuance of renminbi denominated financial products. Of particular significance are liberalization measures that allow offshore banks and central banks to invest in China's interbank bond market. Offshore money managers are also given greater latitude in investing in renminbi denominated stocks, bonds and other assets. Foreign firms would certainly be more amenable to accepting payments in renminbi now that the barriers to invest the currency are eradicated. As the usage of the renminbi in pricing and settling intra-regional trade widens, market forces will tend to increase its co-movements with East Asian currencies. In light of these developments, it is not surprising to find the renminbi is gaining influence on East Asian currencies.

5. Concluding Remarks

Several researchers found through the use of Frankel-Wei regressions that there is substantial renminbi influence on East Asian currencies and some have even raised the possibility that a *de facto* "renminbi bloc" has emerged in the region. This paper reviews the evidence in two ways using exchange rate data from seven East Asian countries. First, we consider and empirically test for likely problems with the application of Frankel-Wei regressions in estimating weights of the US dollar and the renminbi in the implicit currency baskets. While the use of renminbi movements that are orthogonal to US dollar leads to biased weight estimates, the use of non-orthogonalised renminbi fluctuations could lead to severe multicollinearity and/or endogeneity problems in the regressions. The presence of these problems results in imprecise and/or invalid inference, throwing doubts on the assessment of relative regional influence of the renminbi vis-à-vis the US dollar.

Second, we examine the determination of seven East Asian exchange rates with respect to innovations in the US dollar, the yen and the renminbi. We assess inter-currency relationships

looking for evidence of a "renminbi bloc" through the use of country-specific VAR models. This methodology that allows for mutual interaction of the exchange rate variables is chosen to circumvent the difficulties of simultaneity bias potentially present in the Frankel-Wei regressions. In other words, our investigation of exchange rate determination in the region accounts for observed co-movements with the renminbi arising from common shocks hitting the system in the sample period. As anticipated, we found the US dollar retains its dominant influence in a dollar-dominated East Asia. However, our results also show that notwithstanding the absence of a "renminbi bloc", the renminbi has clearly gained regional influence in the period after the global financial crisis, not least because of the growing role of China as a hub of regional trade. Going forward, as China continues to push for internationalization of the renminbi and the deregulation and opening of its financial markets, the renminbi is likely to gain regional currency status.

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Figure 1: Bilateral Exchange Rates against SDR (22nd July 2008—30th November 2012)

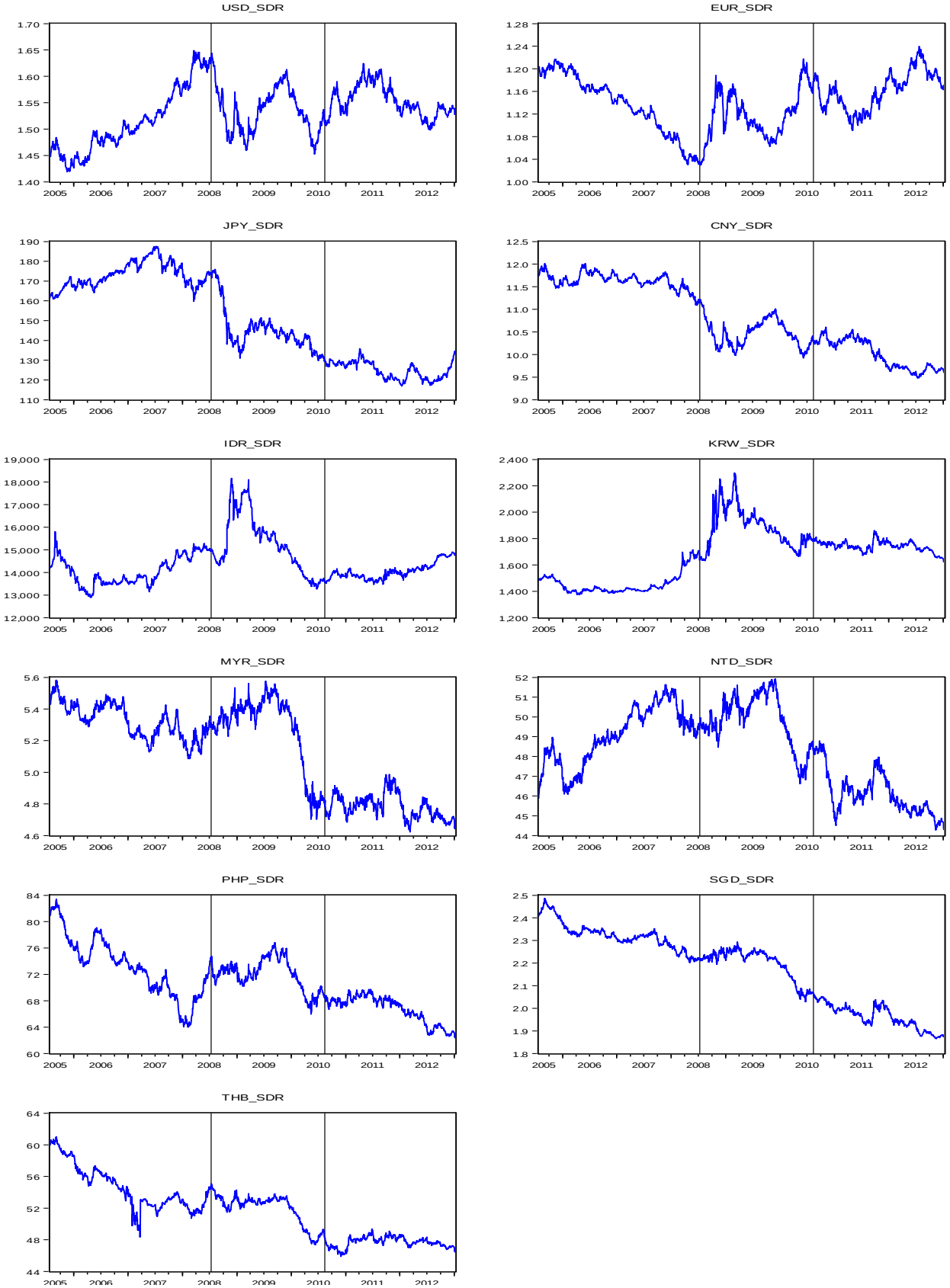

Table 1: Estimates from Augmented Frankel-Wei Regressions

	Constant	USD	EUR	YEN	RMB	R-square
Pre-crisis						
IDR	0.000	0.020	-0.347**	-0.118**	0.337**	0.12
		(0.28)	(0.19)	(0.05)	(0.17)	
KRW	0.0002	0.043	-0.072	-0.133	0.633***	0.21
		(0.27)	(0.27)	(0.11)	(0.16)	
MYR	0.000	-0.028	-0.143	-0.097**	0.656***	0.38
		(0.18)	(0.14)	(0.04)	(0.15)	
NTD	0.000	0.277**	-0.070	0.001	0.483***	0.43
		(0.13)	(0.10)	(0.03)	(0.11)	
PHP	-0.0001	0.377*	-0.052	-0.091**	0.304*	0.25
		(0.21)	(0.13)	(0.04)	(0.17)	
SGD	-0.0001	0.096	-0.095	-0.040	0.217**	0.20
		(0.12)	(0.09)	(0.03)	(0.09)	
THB	-0.0001	0.309	-0.093	0.031	0.339	0.09
		(0.30)	(0.15)	(0.04)	(0.25)	
Post-crisis						
IDR	0.0001	0.696**	0.216	0.014	0.427**	0.43
		(0.28)	(0.15)	(0.04)	(0.17)	
KRW	0.000	-1.02***	-0.439	-0.239***	1.125***	0.14
		(0.29)	(0.20)	(0.05)	(0.19)	
MYR	0.000	-0.722***	-0.253*	0.162***	1.086***	0.25
		(0.23)	(0.14)	(0.04)	(0.18)	
NTD	0.000	-0.037	-0.084	-0.058	0.749***	0.53
		(0.16)	(0.12)	(0.03)	(0.10)	
PHP	0.000	0.095	-0.028	-0.088**	0.594***	0.32
		(0.22)	(0.13)	(0.03)	(0.15)	
SGD	-0.0001	-0.426**	-0.258**	-0.167***	0.192	0.05
		(0.18)	(0.13)	(0.04)	(0.14)	
THB	0.000	0.032	-0.154	0.076**	0.509***	0.38
		(0.16)	(0.10)	(0.03)	(0.12)	

Note: ***, **, * denote coefficients are statistical significant at 1%, 5% and 10% respectively.

Table 2: Variance Inflation Factors of US dollar and Renminbi Coefficient Estimates

	PRECRISIS		POSTCRISIS	
	USD	Renminbi	USD	Renminbi
IDR	18.10	8.85	70.81	26.83
KRW	22.08	9.03	17.87	7.51
MYR	27.39	19.41	19.60	11.62
NTD	13.02	7.91	27.55	10.78
PHP	18.42	13.17	31.83	15.89
SGD	15.24	10.19	8.64	5.60
THB	27.31	27.81	20.02	10.83

Table 3: Hausman test for the presence of simultaneity (p-values)

	Pre-crisis	Post-crisis
IDR	0.2594	0.164(**)
KRW	0.0000(***)	0.0001(***)
MYR	0.0000(***)	0.0000(***)
PHP	0.3792	0.0029(***)
SGD	0.0008(***)	0.9319
THB	0.0918(*)	0.0012(***)
NTD	0.0000(***)	0.0001(***)

Note: ***, **, * denote statistical significance at 1%, 5% and 10% respectively.

Table 4: Phillip-Perron Unit Root Tests (p-values)

	PRECRISIS		POSTCRISIS	
	Levels	Ist Differences	Levels	Ist Differences
USD	0.96	0.00	0.33	0.00
EUR	0.98	0.00	0.50	0.00
JPY	0.20	0.00	0.22	0.00
RMB	0.47	0.00	0.74	0.00
IDR	0.67	0.00	0.76	0.00
KRW	1.00	0.00	0.06	0.00
MYR	0.17	0.00	0.07	0.00
NTD	0.20	0.00	0.27	0.00
PHP	0.40	0.00	0.82	0.00
SGD	0.85	0.00	0.56	0.00
THB	0.27	0.00	0.01	0.00

Figure 2: Home Currency Impulse Responses to Reference Currency Shock (Pre-crisis)

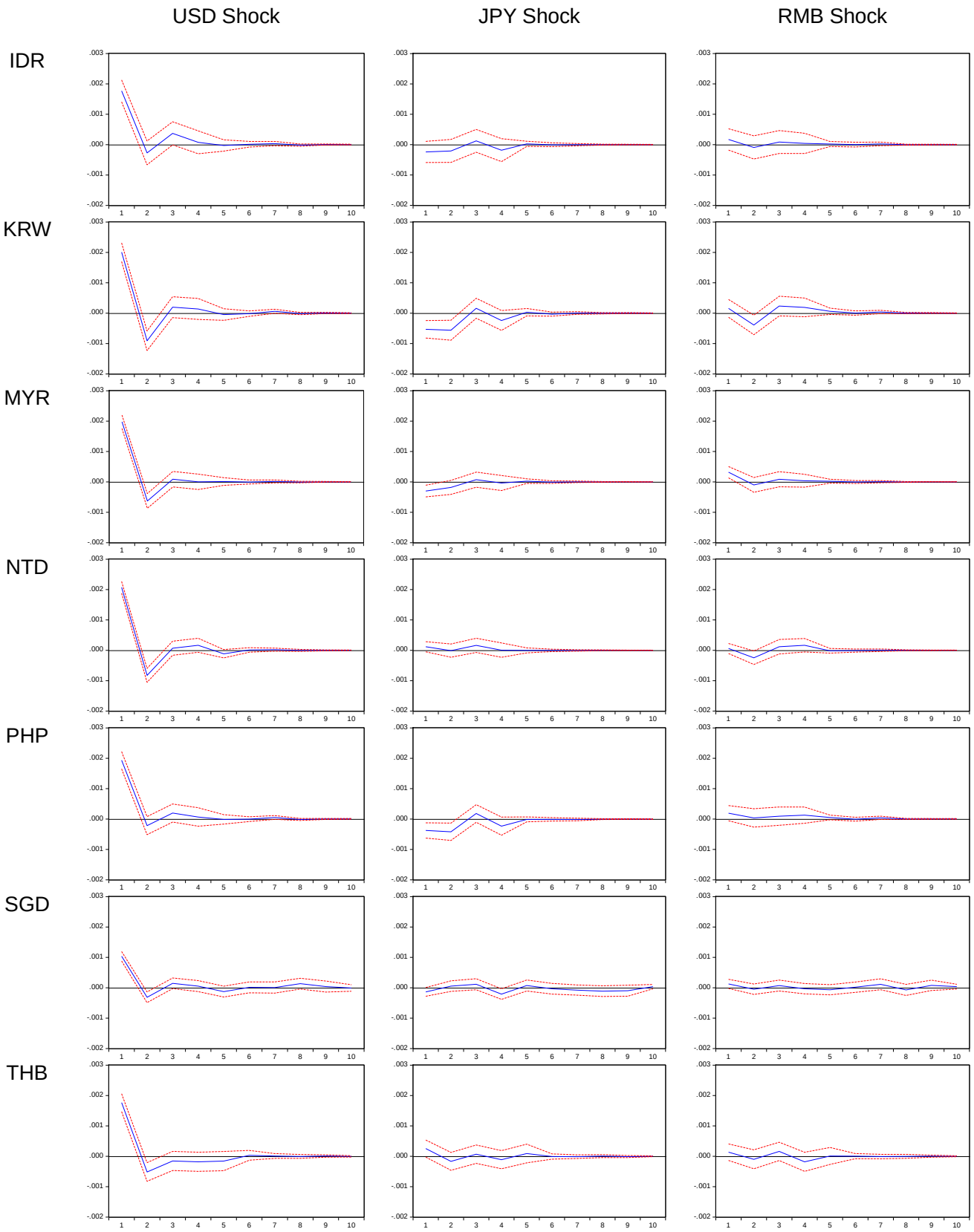

Figure 3: Home Currency Impulse Responses to Reference Currency Shock (Post-crisis)

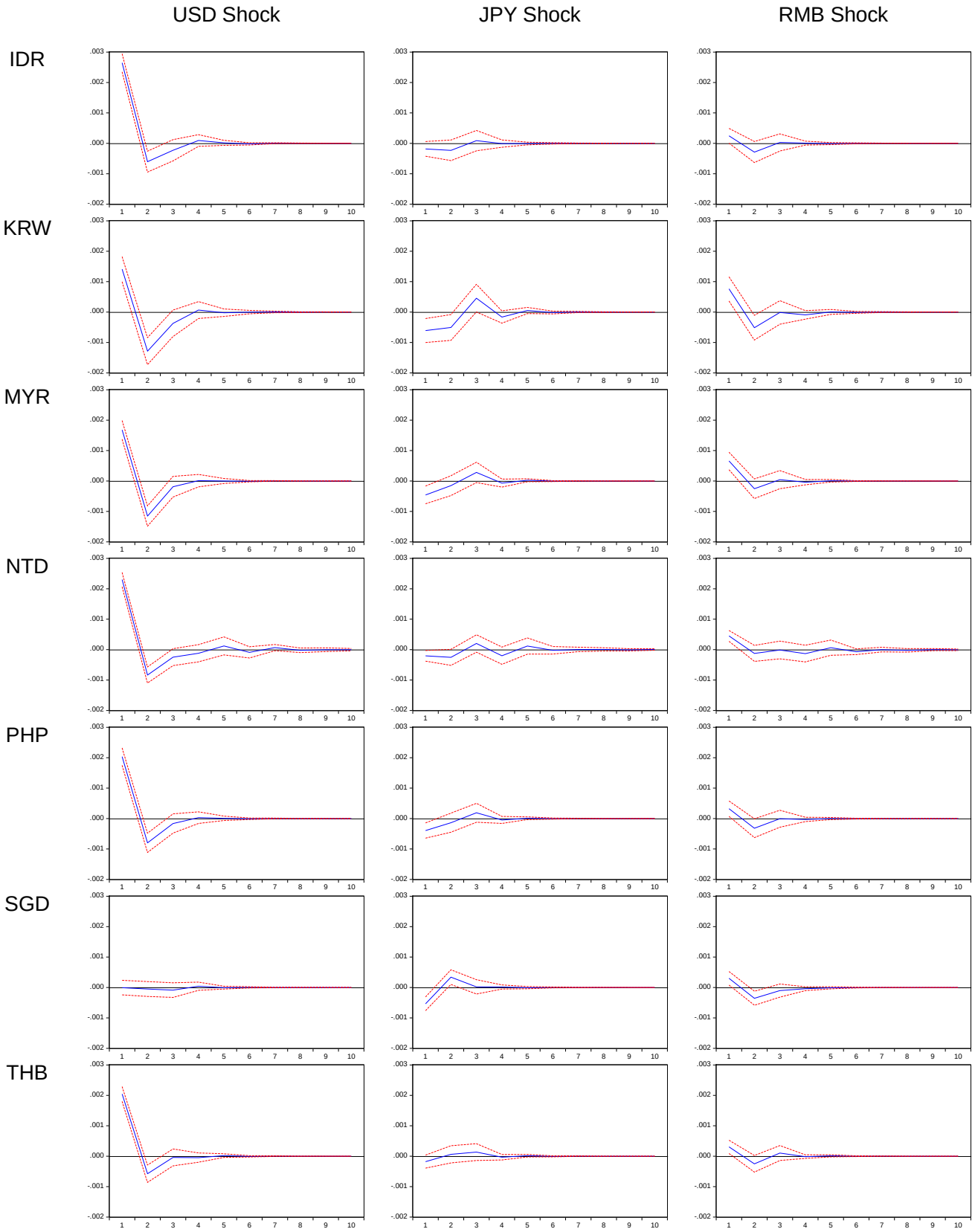

Table 5: Major Bilateral Regional Trade Partners and Trade Shares

	Pre-Crisis (based on 2006 trade figures)		Post-Crisis (based on 2011 trade figures)	
Indonesia	China	30%	China	35%
	Japan	27%	Japan	25%
	Korea	21%	Korea	21%
	Singapore	21%	Singapore	19%
Korea	China	49%	China	56%
	Japan	33%	Japan	28%
	Taiwan	9%	Hong Kong	8%
	Hong Kong	9%	Indonesia	8%
Malaysia	Singapore	35%	China	31%
	Japan	27%	Singapore	30%
	China	24%	Japan	27%
	Thailand	14%	Thailand	13%
Philippines	Japan	39%	Japan	33%
	China	22%	China	26%
	Singapore	20%	Taiwan	20%
	Taiwan	19%	Singapore	20%
Singapore	Malaysia	34%	Malaysia	32%
	China	28%	China	29%
	Indonesia	20%	Indonesia	22%
	Japan	18%	Hong Kong	17%
Taiwan	China	38%	China	48%
	Japan	31%	Japan	25%
	Hong Kong	20%	Hong Kong	16%
	Korea	11%	Korea	11%
Thailand	Japan	44%	Japan	40%
	China	26%	China	34%
	Malaysia	16%	Malaysia	15%
	Singapore	15%	Singapore	11%