Singapore Management University
Institutional Knowledge at Singapore Management University

Research Collection School Of Economics School of Economics

1-2018

# Return and volatility spillovers between the Renminbi and Asian Currencies

Hwee Kwan CHOW-TAN
*Singapore Management University*, hkchow@smu.edu.sg

Follow this and additional works at: https://ink.library.smu.edu.sg/soe_research

Part of the Econometrics Commons

## Citation

CHOW-TAN, Hwee Kwan. Return and volatility spillovers between the Renminbi and Asian Currencies. (2018). *Journal of Finance and Economics*. 11, (1),.
**Available at:** https://ink.library.smu.edu.sg/soe_research/2241

This Journal Article is brought to you for free and open access by the School of Economics at Institutional Knowledge at Singapore Management University. It has been accepted for inclusion in Research Collection School Of Economics by an authorized administrator of Institutional Knowledge at Singapore Management University. For more information, please email cherylds@smu.edu.sg.

**Journal of Finance and Economics**
**Volume 11, No. 1 (2018), xx-xx**
**ISSN 2291-4951 E-ISSN 2291-496X**
**Published by Science and Education Centre of North America**

# Return and Volatility Spillovers between the Renminbi and Asian Currencies

**Hwee Kwan Chow**[1*]

[1] School of Economics, Singapore Management University, Singapore

*Correspondence: Hwee Kwan Chow, School of Economics, Singapore Management University, 90 Stamford Road, Singapore 178903. Email: hkchow@smu.edu.sg

Received: January 21, 2018 Accepted: March 24, 2018 Online Published: September xx, 2018

DOI: 10.12735/jfe.v11n1pxx URL: https://doi.org/10.12735/jfe.v11n1pxx

**Copyright** © Hwee Kwan Chow [**]

## Abstract

This paper examines the extent of interdependence between the Chinese Renminbi and Asian currencies after the global financial crisis. We combine the distinct influence of offshore Renminbi with the impact of the onshore rate on eight Asian currencies (including the Australian dollar). Diebold-Yilmaz spillover indexes reveal Asian foreign exchange markets are subject to considerable cross-border transmissions. In terms of the US dollar bilateral exchange rates, cross-border transfers of daily return are stronger compared to daily volatility reflecting currency management by regional authorities to curb excessive exchange rate volatility. Return spillovers from the Renminbi markets to individual Asian foreign exchange markets are generally on par with that from the euro, but are consistently higher than that from the yen. The results from country-specific regressions concur that overall the influence of the Renminbi on Asian currencies does not dominate the euro but surpasses that of the yen. Across the Asian currencies, their susceptibility to return spillovers from the Renminbi vary with the strength of the country's trade or financial links with China. The commodity price channel also plays a role in the cross-border transmissions of currency shocks.

**JEL Classifications:** F36, G15

**Keywords:** Asian currencies, offshore and onshore Renminbi, spillovers, transmission channels

## 1. Introduction

The past decade has recorded rapid growth in China's financial markets, along with a deepening of China's financial linkages with the rest of the world. For instance, the Shanghai stock market posted huge

[**] This is an open access article distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/).

Licensee: Science and Education Centre of North America

**How to cite this paper:** Chow, H. K. (2018). Return and volatility spillovers between the Renminbi and Asian currencies. *Journal of Finance and Economics*, *11*(1), xx-xx. https://doi.org/10.12735/jfe.v11n1pxx

growth driven by the leap in the number of new listings to rank fourth in the world in terms of domestic market capitalization as of March 2016. Notwithstanding remaining restrictions in China's capital account, the Renminbi is the 8th most traded currency in the world with a daily turnover of USD 202 billion according to 2016 Bank for International Settlements [BIS]' Triennial Central Bank Survey of foreign exchange market. The same survey also found the Renminbi-US dollar to be the 6th most actively traded currency pair. These developments in Chinese financial markets are made possible by the reforms undertaken in the domestic financial sector and the gradual liberalization of China's capital account.

In order to promote the international use of the Renminbi and yet maintain exchange rate stability, the Chinese authorities established offshore markets for its domestic currency.[1] These are free markets not subject to central bank interventions nor capital controls, resulting in an increase in cross-border bank linkages. The offshore Renminbi can be used for wide-ranging purposes including for offshore financial institutions to participate in the onshore interbank market; foreign firms to carry out foreign direct investment; and non-Chinese residents to invest in onshore bond and stock markets under the Qualified Foreign Institutional Investor scheme.

By comparison, the onshore foreign exchange market is still highly regulated by the authorities and the onshore Renminbi exchange rate is under a managed float regime to deter excessive volatility in currency movements. Specifically, the onshore Renminbi exchange rate is stipulated to track a basket of currencies and to fluctuate within a ±2% daily trading band. The onshore Renminbi exited from its US dollar peg in July 2005, but was repegged to the US dollar in October 2008 at the outbreak of the crisis before returning to a managed float in June 2010. The trading range limits were set at ±1% in mid-2010 but were widened to ±2% in March 2014. Fidrmuc and Siddiqui (2015) showed that the weight of the US dollar in the currency basket is on a gradual decline, so that the bilateral onshore Renminbi-US dollar rate exhibits somewhat bigger fluctuations over time.

Against this backdrop, Asia's financial markets have become more susceptible to spillovers from China even as their economies become more reliant on Chinese growth. Stock market returns in the region have become more correlated with equity returns in China post global financial crisis (GFC). Chow (2017) provided evidence that the level of influence which the Chinese bourse exerts on Asian bourses has risen to that of Japan. Similarly, the co-movement between currency returns in Asian and Chinese foreign exchange markets have been strengthening. The co-movement of Asian currencies with the Renminbi could be driven by Asian authorities who tend to stabilize their domestic currencies against Renminbi fluctuations given their strengthening trade, investment and financial linkages with China. Besides, adjustments in Asian currencies in response to Renminbi fluctuations can result from portfolio managers who view currencies in the region as being related (Shu, He, & Cheng, 2015). Event studies in Arslanalp, Liao, Piao, and Seneviratne (2016) reveal that Asian currencies are increasingly influenced by volatility in the Renminbi, particularly since June 2015 when China introduced a new exchange rate mechanism. The currencies of those Asian economies that have strong trade links with China are found to be particularly vulnerable.

On related literature, the region was found through Frankel-Wei regressions[2] to be on a soft dollar peg before and after the 1997 Asian currency crisis (McKinnon, 2000). Nevertheless, various studies including Kearney and Muckley (2007) found a notable yen influence. More recently, Ito (2010) and others used Frankel-Wei regressions to show the Renminbi exerts a substantial impact on exchange rate movements in Asia. Fratzscher and Mehl (2014) 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

---

[1] For a detailed account on the institutional background of the internationalization of the renminbi, see Funke, Shu, Cheng, and Eraslan (2015).

[2] Frankel and Wei (1994) developed and popularized a method for estimating the implicit weights assigned to major international currencies in a currency basket.

factor. Chow (2014) used VAR models on standardized exchange rates to show the role played by the Renminbi in exchange rate determination in Asia has increased after the global financial crisis. Applying structural VAR analysis, Shu, He, Dong, and Wang (2016) found the Renminbi is one of the key drivers of Asian exchange rates particularly in the short run. However, all these studies focused on the influence of the onshore Renminbi exchange rate.

This paper aims to examine the susceptibility of Asian currencies to spillovers from both the onshore and offshore Renminbi. We use spillover indexes proposed in Diebold and Yilmaz (2009, 2012) to analyze the return and volatility shock transmissions in foreign exchange markets. The spillover indexes measure the extent and direction spillovers are taking place amongst the bilateral USD rates of eight Asian currencies (including the Australian dollar) and currencies from systemic international foreign exchange markets namely, the Renminbi, the yen and the euro. The inclusion of euro-dollar rate is important in view of Asia's economic and financial integration with world markets. Indeed, fluctuations in the major currency pairs of euro-dollar and yen-dollar are expected to exert a considerable impact on regional currencies. After all, these are the two most actively traded currency pairs in the world as of April 2016 (Bank for International Settlements, 2016). We investigate how much of the spillover effects in the Asian currencies can be attributed to the onshore and offshore Renminbi markets as compared to the euro and yen foreign exchange markets. To pre-empt the results, we found that overall return spillovers from the Renminbi to Asian currencies are mostly on par with the euro, but are consistently higher than those from the yen post GFC.

A natural question that arises is what factors lead to the cross-border transmission in foreign exchange markets. While the overall level of return spillovers is sizable, we found daily volatility transfers to be relatively weaker possibly hindered by exchange rate management of the regional authorities to prevent excessive volatility in their domestic currencies. Return spillovers from the Renminbi to the various Asian currencies appear to be varying with the strength of the Asian country's trade and financial links with China. We use the direct trade linkage measure that gauge their exposure to China's final demand through trade, as well as the direct financial linkage measure proposed in Arslanalp *et al*. (2016). The susceptibility of Asian foreign exchange markets to offshore Renminbi spillovers is also found to be linked to the commodity price channel. To further corroborate our findings, we carry out another part of empirical analysis using country-specific Frankel-Wei type regressions that measure the extent of co-movement between individual Asian currencies and the individual major international currencies. In this way, we assess the influence of a major currency by combining its direct effect with its indirect effect through other regional currencies. The results from this part of the analysis are consistent with the earlier findings using direct spillovers.

The rest of this paper proceeds as follows. The next section provides a preliminary analysis of the data statistics as well as a discussion of the Diebold-Yilmaz (2012) technique for measuring the extent of spillovers in returns and volatilities. An analysis of the spillover indexes computed for the Asian currencies is presented in Section 3. This is followed by Section 4 that provides evidence from country-specific regressions. Section 5 concludes with a summary.

# 2. Data Description and Methodology of Spillover Indexes

## 2.1. Data Description and Preliminary Analysis

We obtain data on the bilateral exchange rates against the US dollar (USD) for the Eurozone and eleven countries in the region. The currencies included in this study are namely onshore Renminbi (CNY), offshore Chinese Renminbi (CNH), euro (EUR), Japanese yen (JPY), Australian dollar (AUD), Indonesian rupiah (IDR), Korean won (KRW), Malaysian ringgit (MYR), Philippine peso (PHP), Singapore dollar (SGD), Thai baht (THB) and Taiwan dollar (TWD). We classify the currencies into two groups, the first four are considered major international currencies from systemic foreign exchange markets while the rest are referred to as Asian currencies.[3] The US dollar exchange rate is used because the US dollar is the preeminent currency in the world, with many international prices and cross-border financial transactions expressed in USD. Inclusion of the euro-dollar rate is to account for Asia's strong economic and financial linkages with extra-regional economies. To conserve degrees of freedom, we include only one extra-regional currency. In any case, the euro-dollar is the only extra-regional currency pair that has an average daily trading turnover that is higher than that of the yen-dollar pair.

The nominal exchange rate is defined such that an increase reflects an appreciation of the currency against the US dollar. Our sample period is from 6th September 2010 to 1st September 2017. The unavailability of data on the offshore Renminbi-dollar exchange rate prevents an earlier start date. Hence, our examination of spillovers of the US dollar bilateral exchange rates focuses on the post GFC period. All the exchange rate series are of daily frequency and drawn from the Bloomberg database. Table 1 records the summary statistics of the daily return and daily volatility of the twelve US dollar bilateral exchange rates under study.

**Table 1.** Summary statistics for daily return and volatility

| | **CNY** | **CNH** | **EUR** | **JPY** | **AUD** | **IDR** | **KRW** | **MYR** | **PHP** | **SGD** | **THB** | **TWD** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Daily Return*** ($r_{it}$) | | | | | | | | | | | | |
| **Mean** | 0.00 | 0.00 | 0.00 | -0.01 | -0.01 | -0.02 | 0.00 | -0.02 | -0.01 | 0.00 | 0.00 | 0.00 |
| **Median** | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | -0.01 | 0.02 | -0.01 | 0.00 | 0.01 | 0.00 | 0.00 |
| **Std. Dev.** | 0.15 | 0.20 | 0.58 | 0.60 | 0.67 | 0.54 | 0.53 | 0.47 | 0.31 | 0.37 | 0.29 | 0.27 |
| **Skewness** | -0.84 | -1.14 | 0.02 | 0.00 | -0.11 | 0.40 | -0.24 | 0.45 | -0.13 | -0.14 | 0.05 | 0.11 |
| **Kurtosis** | 24.00 | 29.42 | 4.59 | 7.18 | 4.31 | 16.81 | 4.11 | 7.51 | 4.52 | 7.30 | 4.48 | 6.37 |
| ***Daily Volatility*** ($v_{it}$) | | | | | | | | | | | | |
| Mean | 0.85 | 0.44 | 2.15 | 2.18 | 2.38 | 1.66 | 1.73 | 1.70 | 1.45 | 1.68 | 1.70 | 1.30 |
| Median | 0.80 | 0.44 | 2.16 | 2.19 | 2.38 | 1.64 | 1.75 | 1.73 | 1.45 | 1.67 | 1.70 | 1.26 |
| Std. Dev. | 0.62 | 0.61 | 0.49 | 0.51 | 0.45 | 0.78 | 0.48 | 0.62 | 0.49 | 0.48 | 0.41 | 0.52 |
| Skewness | 0.44 | -0.30 | -0.10 | 0.10 | -0.04 | 0.40 | -0.02 | -0.27 | -0.28 | 0.21 | 0.08 | 0.44 |
| Kurtosis | 3.79 | 4.43 | 3.35 | 3.52 | 3.23 | 3.23 | 3.54 | 3.35 | 4.60 | 3.21 | 2.93 | 3.30 |

We see from Table 1 that the mean and median daily return over the sample period are close to zero for all the currencies. the distribution of daily return of the individual currencies generally appear symmetric and slightly leptokurtic. Extreme values in the onshore and offshore Renminbi-US dollar pairs as well as the Indonesian rupiah-US dollar pair alleviated the level of kurtosis in these three exchange rate time series. These are related to China's introduction of a new exchange rate mechanism in August 2015 and the widening of Indonesia's current account deficit in the second quarter of 2013 respectively. Iliquid offshore Renminbi market resulting from restrictive conversion quota ceiling in the last quarter of 2010

[3] For ease of exposition, we classify the Australian dollar as an Asian currency.

and 2011 also contributed to higher kurtosis. However, market liquidity in the offshore Renminbi market has since improved considerably.

Unlike their daily return, the currencies exhibit varying mean levels of daily volatility. On average, daily volatility of the euro, yen and Australian dollar are discernibly higher than that of the rest of the currencies. This is unsurprising since the three currencies are on a free float exchange rate regime and they are actively traded in world currency markets. The other currencies in the sample tend to be subject to foreign exchange intervention and other restrictions on bilateral exchange rate fluctuations. At the other end of the scale, the onshore and offshore Renminbi have the lowest mean daily volatility. Again, this is expected since the offshore Renminbi is correlated to the onshore Renminbi which in turn is managed by the authorities to fluctuate within a narrow band. The distribution of daily volatility of the individual currencies do not exhibit skewness nor excess kurtosis as a consequence of the log transformation. We perform log transformation because the annualized standard deviation has a skewed and leptokurtic distribution in each case and hence, not suited for a VAR model formulation.[4]

## 2.2. Diebold-Yilmaz Spillover Indexes

Diebold and Yilmaz (2009, 2012) proposed a framework for measuring spillovers across asset markets that uses the decompositions from a vector autoregression (VAR) model. In the earlier paper, forecast error variances were decomposed through Cholesky factor identification to orthogonalize the shocks. This technique was applied to study the connectedness across global stock markets including nine from Asia. However, the findings on the direction of shock transmission was found to depend on the casual ordering of the variables in the VAR model. Hence, in the second paper that studies the linkages across different asset markets within the US, the authors adopted the Pesaran and Shin (1998) generalized variance decomposition framework which is invariant to the casual ordering of variables. On related literature, Barunik, Kocenda and Vacha (2017) applied this method to positive and negative semivariances to study volatility connectedness of six most actively traded currencies in the world, while Zhou, Zhang, and Zhang (2012) used the spillover indexes to investigate volatility transmissions between China and world equity markets. In the rest of this section, we describe the methodology for computing the Diebold-Yilmaz spillover indexes.

To model the relations between the return or volatility of currencies, we first model them with a vector autoregressive (VAR) model:

$$v_t = \beta_0 + \sum_{k=1}^{p} \beta_k (L) v_{t-k} + \varepsilon_t \tag{1}$$

where $v_t$ is a vector comprising the return or volatilities of the $N$ currencies under study. For each currency, the relative importance of shocks to the return (volatility) of other currencies to the return (volatility) of the home currency is assessed through generalized variance decomposition analysis. We examine the variance decompositions at a horizon whereby the forecast error decompositions due to the various disturbances have stabilized. For the chosen horizon, each row in the variance decomposition table gives the proportion of forecast error variance due to innovations to the return or volatility for the currency listed in the column. As such, the diagonal terms reflect the importance of domestic shocks while the off-diagonal terms reflect the contributions from shocks to other currencies.

Since generalized variance decompositions allow for correlated shocks and thus do not typically sum to one for each row, the variance share is divided by the row sum to produce the normalized variance share:

[4] For robustness checks, we repeat the analysis on volatility spillovers using the annualized standard deviation without taking log transformation. The results obtained, which are available from the author upon request, are qualitatively similar.

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N}\theta_{ij}^{g}(H)} \tag{2}$$

The total spillover index *S(.,.)* that measures overall cross-market spillovers is defined as the sum of all off-diagonal normalized variance shares, that is:

$$S(.,.) = \frac{\sum_{\substack{i,j=1 \\ i\neq j}}^{N}\tilde{\theta}_{ij}^{g}(H)}{N}\cdot 100 \tag{3}$$

For each index, we can distinguish between receiving spillovers from other markets vis-a-vis transmitting spillovers to other markets by computing the two directional spillover indexes. The inward spillovers received by market *i* from other markets (*S(i,.)*) is the row sum of the off-diagonal normalized variance shares, that is:

$$S(i,.) = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{N}\tilde{\theta}_{ij}^{g}(H)}{N}\cdot 100 \tag{4}$$

Conversely, the outward spillovers transmitted from market *i* to other markets (*S(.,i)*) is the column sum of the off-diagonal normalized variance shares, that is:

$$S(.,i) = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{N}\tilde{\theta}_{ji}^{g}(H)}{N}\cdot 100 \tag{5}$$

The difference between the transmitting spillovers to other markets and receiving spillovers from other markets gives us currency *i*'s net spillover index *S(i)* that is:

$$S(i) = S(.,i) - S(i,.) \tag{6}$$

To measure the spillovers in return and volatility of the Asian currencies, we examine twelve US dollar bilateral exchange rates, that is, *N=12* in this study. The return of an individual currency *i*, denoted by $r_{it}$ , is defined as the first difference of the logarithmic transformation of individual exchange rate series.

$$r_{it} = 100(\ln(C_{it}) - \ln(C_{it-1})) \tag{7}$$

where $C_{it}$ is the closing exchange rate level for currency *i* in day *t*. Following Parkinson (1980), the daily variance of the exchange rate is computed as

$$\widetilde{\sigma_{it}}^{2} = 0.361(\ln(H_{it}) - \ln(L_{it}))^{2} \tag{8}$$

where $H_{it}$ and $L_{it}$ are the highest and lowest exchange rate levels for currency *i* in day *t*. The measure of volatility used in our analysis is the logarithmic transformation of the annualized daily percent standard deviation given by

$$v_{it} = \ln(100\sqrt{(365\widetilde{\sigma_{it}}^{2})} \tag{9}$$

The spillover indexes computed using the return and volatility of the currencies reveal the pattern of cross-border transmissions of currencies movements in the region.

## 3. Spillover Indexes of Asian Currencies

We first model the return of the twelve currencies using a VAR model with two lags to produce the generalized variance decompositions. The optimal lag length two is selected based on the Akaike Information Criterion (AIC).[5] The short lag length is not unexpected since the cross-border impact of

[5] Sensitivity tests conducted by estimating VAR models with different lags reveal the findings are robust to different lag lengths.

foreign exchange market are generally observed to be short-lived in the literature (See *inter alia* Shu *et al*., 2016).

**Table 2.** Generalized variance decompositions of return and volatility (%)

| | CNY | CNH | EUR | JPY | AUD | IDR | KRW | MYR | PHP | SGD | THB | TWD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Daily Return*** ($r_{it}$) | | | | | | | | | | | | |
| **CNY** | 50.82 | 22.02 | 2.71 | 1.00 | 3.08 | 0.79 | 2.54 | 2.87 | 2.58 | 4.83 | 3.26 | 3.50 |
| **CNH** | 18.77 | 46.68 | 3.82 | 1.06 | 5.39 | 0.49 | 2.33 | 2.63 | 2.23 | 8.57 | 4.58 | 3.46 |
| **EUR** | 1.04 | 3.78 | 48.72 | 4.62 | 12.60 | 0.13 | 1.12 | 0.73 | 1.31 | 18.70 | 6.79 | 0.46 |
| **JPY** | 1.00 | 1.75 | 7.16 | 75.65 | 3.27 | 0.07 | 0.15 | 0.14 | 0.01 | 7.79 | 2.93 | 0.08 |
| **AUD** | 1.55 | 4.43 | 10.10 | 1.68 | 39.28 | 1.08 | 3.33 | 3.79 | 3.07 | 21.02 | 8.60 | 2.08 |
| **IDR** | 0.92 | 1.29 | 1.73 | 0.64 | 3.69 | 62.04 | 3.18 | 7.44 | 5.05 | 5.39 | 5.52 | 3.10 |
| **KRW** | 1.80 | 3.01 | 5.32 | 1.70 | 8.68 | 1.74 | 32.61 | 7.95 | 6.05 | 13.09 | 6.81 | 11.24 |
| **MYR** | 1.96 | 2.75 | 4.10 | 0.97 | 8.29 | 4.28 | 7.96 | 33.44 | 9.08 | 12.45 | 7.25 | 7.47 |
| **PHP** | 2.00 | 2.26 | 3.48 | 0.75 | 6.04 | 3.62 | 7.47 | 11.10 | 40.95 | 8.80 | 7.49 | 6.04 |
| **SGD** | 2.14 | 5.59 | 11.85 | 3.28 | 16.62 | 1.44 | 4.50 | 5.82 | 3.76 | 31.12 | 10.35 | 3.54 |
| **THB** | 2.19 | 4.11 | 5.88 | 1.87 | 9.30 | 1.87 | 3.49 | 5.91 | 5.53 | 14.10 | 42.32 | 3.43 |
| **TWD** | 2.68 | 4.08 | 5.24 | 2.05 | 7.41 | 1.73 | 11.84 | 7.74 | 5.13 | 12.27 | 5.96 | 33.88 |
| ***Daily Volatility*** ($v_{it}$) | | | | | | | | | | | | |
| **CNY** | 79.65 | 11.63 | 0.03 | 0.54 | 0.33 | 0.38 | 0.65 | 0.98 | 0.21 | 2.13 | 1.34 | 2.11 |
| **CNH** | 8.42 | 63.63 | 1.39 | 0.34 | 2.30 | 3.67 | 1.18 | 2.22 | 1.42 | 9.03 | 2.11 | 4.30 |
| **EUR** | 0.01 | 0.25 | 50.65 | 5.20 | 16.46 | 0.71 | 2.66 | 1.23 | 3.69 | 15.61 | 2.77 | 0.76 |
| **JPY** | 0.03 | 0.06 | 7.43 | 76.38 | 8.10 | 1.47 | 1.09 | 0.23 | 0.55 | 2.52 | 1.00 | 1.14 |
| **AUD** | 0.16 | 0.62 | 15.29 | 5.14 | 43.56 | 0.41 | 3.07 | 3.04 | 5.11 | 18.41 | 4.40 | 0.79 |
| **IDR** | 0.24 | 2.38 | 1.01 | 1.34 | 0.62 | 81.60 | 1.02 | 2.41 | 1.87 | 2.71 | 4.05 | 0.76 |
| **KRW** | 1.95 | 2.24 | 3.94 | 1.65 | 3.99 | 0.86 | 53.64 | 3.37 | 7.57 | 9.23 | 3.05 | 8.51 |
| **MYR** | 0.83 | 2.24 | 2.56 | 0.18 | 3.66 | 3.09 | 3.76 | 59.43 | 5.75 | 12.57 | 3.94 | 1.99 |
| **PHP** | 0.25 | 1.15 | 3.79 | 0.58 | 3.33 | 2.78 | 4.92 | 5.76 | 61.79 | 6.77 | 7.78 | 1.10 |
| **SGD** | 0.53 | 2.34 | 10.26 | 1.34 | 14.41 | 2.29 | 4.01 | 8.09 | 5.15 | 43.66 | 6.67 | 1.25 |
| **THB** | 0.54 | 0.16 | 3.15 | 0.70 | 4.79 | 3.18 | 3.38 | 3.47 | 7.16 | 9.56 | 62.84 | 1.07 |
| **TWD** | 1.93 | 5.25 | 1.67 | 1.75 | 1.00 | 1.83 | 7.39 | 1.71 | 1.44 | 2.40 | 0.56 | 73.07 |

The VIX index which is the Chicago Board Options Exchange Market Volatility Index that measures the implied volatility of S&P 500 index options is included as an exogenous variable.[6] As the VIX index is commonly used to represent international investors' appetite for risks, we use it to abstract common

[6] An exogenous variable that reflects China's monetary stance is not included as shocks to China's monetary policy are not expected to have an impact on Asian countries in our sample period since the renminbi does not (yet) play a role in global financing (Shu *et al*., 2016).

shocks to the various foreign exchange markets. The variance decomposition for almost all variables stabilized very quickly within 5 days. As such, each row in Table 2 records the normalized variance shares at the 10-day horizon for the country listed in the row.

The total return spillover index is 55.2%, that is, more than half of the forecast error variance decomposition is due to cross-market spillovers despite the de facto managed exchange rates regimes in the region. This suggest sizable international transmission of financial shocks in the region post GFC. Of the major currencies, the domestic variance shares in ascending order of magnitude are 46.7%, 48.7%, 50.8% and 75.7% for the offshore Renminbi, euro, onshore Renminbi and yen respectively. This suggests the Renminbi, both the onshore and offshore rates, experience a similar (higher) level of cross-border spillovers as the euro (yen). Compared to the yen, even the onshore Renminbi has a distinctly lower domestic variance share hence recording more intense spillovers despite it being less actively traded in the world currency markets. Apart from the Indonesian rupiah which has a high 62.0% share, the domestic variance shares of the other Asian currencies are less than half ranging from 31.1% for Singapore dollar to 42.3% for Thai baht. The low levels suggest a small role for domestic shocks and that Asian foreign exchange markets are subject to considerable cross-border spillovers.

Similarly, a VAR model is fitted to the daily volatility of the twelve currencies. The optimal lag length of the model, as determined by the AIC, turns out to be two. Generalized variance decompositions produced from the model are used to compute the normalized variance shares at the 10-day horizon and these are also recorded in Table 2. The total volatility spillover index over the sample period is 37.5%, around 18 percentage points lower than the total spillover index for the return of currencies. Concomitantly, we observe a larger domestic variance shares in terms of volatility spillovers for all the individual currencies without exception. The domestic variance shares of all the currencies including the major ones exceed 50%, apart from the Australian dollar which has a 43.6% share. This suggests cross-market transmission of financial shocks play a distinctly smaller role in terms of the daily volatility vis-à-vis the daily return of Asian currencies. A plausible explanation is the monetary authorities in the Asian countries manages their domestic currencies to avoid excessive volatility in their exchange rates. Indeed, the management of domestic currency to avoid excessive volatility will likely have some limiting effect on return fluctuations, thereby somewhat hampering cross-border return transmissions as well.

Turning to directional spillovers, we record in Table 3 the outward spillover index *S(.,i)*, inward spillover index *S(i,.)*, and the net spillover index *S(i)* of the return and volatility of individual currencies. Like before, the inward and outward return spillover indexes are consistently higher than corresponding indexes for volatility transfers. This is expected in view of the larger role played by domestic shocks in accounting for the daily volatility of the currencies. Since the international transmissions are more evident in the daily return rather than the daily volatility of the currencies, we focus the rest of our discussion on return spillovers.

**Table 3.** Directional spillover indexes of return and volatility of currencies (%)

| | CNY | CNH | EUR | JPY | AUD | IDR | KRW | MYR | PHP | SGD | THB | TWD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Daily Return*** ($r_{it}$) | | | | | | | | | | | | |
| ***S(.,i)*** | 3.00 | 4.59 | 5.11 | 1.63 | 7.03 | 1.44 | 3.99 | 4.68 | 3.65 | 10.58 | 5.79 | 3.70 |
| ***S(i,.)*** | 4.10 | 4.44 | 4.27 | 2.03 | 5.06 | 3.16 | 5.62 | 5.55 | 4.92 | 5.74 | 4.81 | 5.51 |
| ***S(i)*** | -1.09 | 0.15 | 0.84 | -0.40 | 1.97 | -1.73 | -1.62 | -0.87 | -1.27 | 4.84 | 0.99 | -1.81 |
| ***Daily Volatility*** ($v_{it}$) | | | | | | | | | | | | |
| ***S(.,i)*** | 1.24 | 2.36 | 4.21 | 1.56 | 4.92 | 1.72 | 2.76 | 2.71 | 3.33 | 7.58 | 3.14 | 1.98 |
| ***S(i,.)*** | 1.70 | 3.03 | 4.11 | 1.97 | 4.70 | 1.53 | 3.86 | 3.38 | 3.18 | 4.70 | 3.10 | 2.24 |
| ***S(i)*** | -0.46 | -0.67 | 0.10 | -0.41 | 0.21 | 0.19 | -1.10 | -0.67 | 0.14 | 2.88 | 0.04 | -0.26 |

It is clear from Table 3 that the inward and outward spillover indexes for EUR are similar to (higher than) corresponding values for CNH (CNY). Meanwhile, both directional indexes for the yen are distinctly lower than those for the euro and the Renminbi. In fact, the yen has the lowest (second lowest) inward (outward) spillover index amongst all the currencies in our sample. Of the Asian currencies, Singapore (Indonesia) recorded the highest (lowest) inward and outward return spillover indexes. The outward spillover indexes for Singapore dollar and Australian dollar are particularly high at 10.6% and 7.0%. Return spillovers from the Singapore dollar to the rest of the Asian currencies are particularly large, exceeding 12% for all except IDR and PHP (see Table 2). It appears Singapore, as an international financial center, serves as a conduit for international transmissions transferring shocks from and to other countries. On a net basis, majority of the currencies receive spillovers from other markets. The exceptions are the euro, Australian dollar, Singapore dollar and the Thai baht which have positive net spillover indexes. The directional spillover indexes of the offshore Renminbi are close to balance.

For a more detailed comparison of the return spillovers from the major currencies to individual Asian currencies, we refer again to Table 2. Since the onshore and offshore Renminbi markets are essentially for the same asset and responding to the same set of economic news, we combine their spillover effects and refer to this total effect simply as spillovers from the Renminbi. Spillovers from the Renminbi to an individual Asian currency is less intense compared to the euro only for AUD, KRW and SGD. These three currencies are from countries with more developed financial markets that have greater exposure to arbitrage opportunities. In particular, return spillovers from the euro is higher than that from the Renminbi by around 4% for the Australian dollar and the Singapore dollar. This finding is a reflection of the openness of the foreign exchange markets in Australia and Singapore that have strong financial linkages with extra-regional markets. As of April 2016, the AUD-dollar and SGD-dollar currency pairs are the $4^{th}$ and $9^{th}$ most actively traded in the world (Bank for International Settlements, 2016). Conversely, return spillovers from the Renminbi are higher than from the euro for the rest of the Asian currencies but the differences are small, exceeding 1% only for the case of the Taiwan dollar.

While return spillovers from the Renminbi does not dominate that of the euro, the reverse is true for the yen. Without exception, return spillovers from the Renminbi to individual Asian currencies are more intense relative to the yen. The differences in the level of return spillovers between the Renminbi and yen is between 3% to 5%, apart from the Indonesian rupiah whose difference is 1.6%. The variance shares of individual Asian currencies that are attributed to the Renminbi in descending order of magnitude are 7.7%, 6.8%, 6.3%, 6.0%, 4.8%, 4.7%, 4.3% and 2.2% for the SGD, TWD, THB, AUD, KRW, MYR, PHP and IDR respectively. Does this intra-Asia distribution of return spillovers correspond to some key channels of cross-border transmission?

When China is hit by a negative shock, countries with strong trade ties with China would tend to have lower exports, thereby affecting the value of their domestic currencies. Arslanalp *et al*. (2016) used direct trade links that includes direct exports of final goods and services to China and exports of intermediate goods to a third country that will be reexported to China for final demand. That is, the direct trade linkage measure is computed as the value added produced by a country and exported for final demand in China as a proportion of the former's GDP. This reflects China's rebalancing from investment and export led growth towards a consumption and services driven growth model. This is accompanied by the shifting of Asia's export product profile from intermediate goods to goods that meet China's final consumption demand. Indeed, advanced economies like Taiwan and Korea, which have been exporting upstream intermediate products suffer losses in market share to China as the latter moves up the value chain and started onshoring production (Salgado, 2016). The direct trade linkage measure for Taiwan, Malaysia, Singapore, Korea, Thailand and Australia (ranked in descending order of magnitude) are reported to be greater than 4% of GDP in 2014. These countries are classified as having strong direct trade linkages with China. Only Philippines and Indonesia have a direct trade linkage measure that is lower than 4%.

Another channel of transmission is through financial linkages, whereby changes in international investor positions on the Renminbi will likely result in similar adjustments of their holdings of related Asian currencies. The economic prospects of the Asian economies are much affected by growth spillover effects from China influencing common investors' decision on whether to hold regional assets. Indeed, as China's capital account is not fully open, the assets of those Asian markets that foreign investors have better access to may be used as proxies for getting exposure to Renminbi assets. Such "China play" assets will naturally lead to a tight correlation between the Asian currency and offshore Renminbi. Arslanalp *et al*. (2016) also computed a direct financial linkage measure that sums up a country's portfolio claims, cross-border bank claims and direct investments on China and Hong Kong as a proportion of its GDP. Hong Kong is included because it serves as a financial gateway to China. The direct financial linkage measures for Taiwan, Singapore and Korea are reported in the paper to be higher than 10%. In fact, all the countries in our sample have a direct financial linkage measure of above 5%, except for the Philippines and Indonesia.

We observe the direct trade and direct financial linkage measures for Philippines and Indonesia are relatively limited, hence their currencies are relatively insulated from spillovers from the Renminbi. Conversely, Singapore and Taiwan feature prominently in both the trade and finance direct linkage measures which explains the greater susceptibility of their currencies to spillovers from the Renminbi. A possible explanation for the Thai baht's susceptibility to spillovers from the Renminbi could be Thailand's reliance on services import demand from China mostly in the form of tourism. Similarly, Arslanalp *et al*. (2016) found that exposure to China's final demand through trade is the main channel of transmission for China's spillovers to Asian stock markets while direct financial links play an increasingly important role post GFC.

Although Australia's direct trade and financial links with China are not particularly strong, the Australian dollar registers large spillovers from the Renminbi plausibly through the commodity price channel. Indeed, Asian countries that are net commodity exporters will tend to suffer from lower commodity prices arising from a negative shock to China. However, the price sensitivities of commodities to China's growth outlook are rather heterogenous, being higher for metal prices than for food or oil prices (Salgado, 2016). While the former is associated with the decline in heavy industry and construction in China, the latter linked to robust Chinese demand of consumption-related imports. This could plausibly explain the Australian dollar's susceptibility to offshore Renminbi spillovers since the value of Australia's commodity exports to China is high at 5.9% of its GDP in 2014, of which a large portion is iron ore exports. By comparison, spillovers through the commodity price channel is limited for net commodity exporters like Indonesia and Malaysia which mainly export palm oil and/or coal to China.

In summary, return spillovers from the Renminbi to individual Asian currencies in the post GFC period are sizeable and dominate those from the yen. Despite differences in econometric methodology, our results are in line with the finding in Shu, He, and Cheng (2015) that the combined influence of onshore and offshore Renminbi play an important role in determining Asian currencies. Furthermore, our findings that the extent of spillovers from Renminbi fluctuations vary directly with the strength of trade and financial links with China as well as the level of specific types of commodity exports are consistent with conclusions drawn on factors determining sensitivities of Asian currencies in Arslanalp *et al*. (2016).

## 4. Co-movement with Major International Currencies

When considering the influence of an international currency from a systemic foreign exchange market such as the Renminbi, euro or yen, we can combine its direct effect with its indirect effect through other regional currencies. To this end, we use country-specific regressions to estimate the extent of co-movement between individual Asian currencies and the individual major currencies in the post GFC period. The return series from the twelve currencies are first standardize so that they have mean 0 and variance 1 in order to facilitate comparisons of relative impact. We denote the standardized return series for currency *i* by $s_{it}$ and estimate the following Frankel-Wei type regressions:

$$s_{it} = \gamma + \delta_{CNY} s_{CNY,t} + \delta_{CNH} s_{CNH,t} + \delta_{EUR} s_{EUR,t} + \delta_{JPY} s_{JPY,t} + \sum_{j=1}^{2} \phi_j s_{it-j} + \gamma VIX_t + \varepsilon_t$$

$$\text{where } \varepsilon_t \sim N(0, \sigma_t^2) \qquad (10)$$

$$\sigma_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2$$

The $\delta$ coefficients in the regression equation estimate the individual major currencies' direct effect and indirect effect through other Asian currencies on currency *i*. If an Asian currency is sensitive to movement in a major currency, we expect their correlation to be significantly positive. While the major currencies may also be influenced by developments in the regional foreign exchange markets, the effect from any single Asian currency is not likely to be significant due to the lower trading volumes of individual Asian-dollar rates. The exceptions are Australian dollar and Singapore dollar whose return spillovers to offshore Renminbi exceed 5%, as shown in Table 2 in the previous section.[7] It follows that apart from these two currencies, the simultaneity bias is likely to be negligible in the country-specific regressions. Lagged dependent variables of order one or two are included in the mean equation to cater for dynamic effects of the various currencies. As in the VAR model, the VIX term which serves as a gauge for the level of investors' risk aversion is included in the regression to capture common shocks in the foreign exchange markets. A generalized autoregressive conditional heteroskedastic, GARCH(1,1), model is used in the variance equation to allow for a heteroskedastic error term in the regressions. The estimation results for the country-specific regressions of the eight Asian currencies are recorded in Table 4.

**Table 4.** Country-specific regressions using standardized variables

| | AUD | IDR | KRW | MYR | PHP | SGD | THB | TWD |
|---|---|---|---|---|---|---|---|---|
| **Mean Equation** | | | | | | | | |
| $s_{CNY,t}$ | -0.04 | 0.14*** | 0.21*** | 0.14*** | 0.21*** | -0.01 | 0.06** | 0.22*** |
| | (0.10) | (0.00) | (0.00) | (0.00) | (0.00) | (0.57) | (0.01) | (0.00) |
| $s_{CNH,t}$ | 0.21*** | -0.02 | 0.08* | 0.06* | 0.04 | 0.26*** | 0.16*** | 0.09** |
| | (0.00) | (0.52) | (0.07) | (0.06) | (0.18) | (0.00) | (0.00) | (0.04) |
| $s_{EUR,t}$ | 0.41*** | 0.01 | 0.07** | 0.04* | 0.08*** | 0.44*** | 0.27*** | 0.04 |
| | (0.00) | (0.55) | (0.01) | (0.06) | (0.00) | (0.00) | (0.00) | (0.19) |
| $s_{JPY,t}$ | 0.09*** | -0.05*** | -0.05* | -0.06** | -0.05** | 0.17*** | 0.08*** | -0.04 |
| | (0.00) | (0.00) | (0.06) | (0.01) | (0.04) | (0.00) | (0.00) | (0.16) |
| *VIX* | -0.01 | 0.00 | -0.01 | -0.01 | -0.00 | -0.00 | -0.01* | -0.01 |
| | (0.10) | (0.56) | (0.11) | (0.15) | (0.70) | (0.45) | (0.09) | (0.14) |
| *CONST* | 0.13* | -0.01 | 0.16* | 0.11 | 0.04 | 0.06 | 0.13* | 0.08 |
| | (0.08) | (0.91) | (0.08) | (0.05) | (0.60) | (0.43) | (0.05) | (0.21) |
| $s_{i,t-1}$ | – | -0.06* | -0.06*** | 0.05* | – | -0.02 | 0.07*** | 0.02 |
| | | (0.06) | (0.00) | (0.09) | | (0.22) | (0.00) | (0.47) |
| $s_{i,t-2}$ | – | – | – | – | – | -0.04** | – | 0.05* |
| | | | | | | (0.05) | | (0.07) |
| **Variance Equation** | | | | | | | | |
| ARCH(1) | 0.05*** | 0.28*** | 0.06*** | 0.13*** | 0.07** | 0.07*** | 0.11*** | 0.14*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| GARCH(1) | 0.93*** | 0.75*** | 0.93*** | 0.87*** | 0.88*** | 0.91*** | 0.83*** | 0.85*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| *CONST* | 0.01* | 0.01** | 0.01* | 0.01 | 0.05** | 0.01* | 0.05** | 0.02* |
| | (0.09) | (0.02) | (0.06) | (0.13) | (0.02) | (0.08) | (0.01) | (0.05) |

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

[7] In these two cases, the $\delta_{CNY}$ and $\delta_{CNH}$ coefficients should be interpreted respectively as correlations with the onshore and offshore renminbi rather than direct effects of renminbi rates on the Asian currency.

The coefficients for the lagged dependent variables are statistically significant in most cases, while the ARCH and GARCH terms in the variance equation are highly significant in all cases. Residual diagnostics, including ARCH LM(2) test and Ljung-Box Q test, performed on the individual regressions reveal none of the models suffer from heteroskedasticity nor serial correlation at the 5% significance level.

It is clear from Table 4 that the Asian currencies co-move with gyrations in either the onshore or offshore Renminbi or both. We observe that the coefficients of CNY are highly significant in all cases except for the Australian dollar and the Singapore dollar. A one standard deviation appreciation in the onshore Renminbi-dollar rate elicits a response ranging from 0.14 standard deviation from the Indonesian rupiah to 0.22 standard deviation from the Taiwan dollar. As for the Australian dollar and the Singapore dollar, their coefficients for CNH are highly significant. A one standard deviation appreciation in the offshore Renminbi-dollar rate is associated with a 0.21 and 0.26 standard deviation appreciation in the two currencies respectively. Three Asian currencies namely the Korean won, Malaysian ringgit and Thai baht have statistically significant coefficients for both the onshore and offshore Renminbi rates.

To determine the relative influence of the Renminbi vis-à-vis the other two major currencies, we combine the impact of onshore and offshore Renminbi by summing their coefficients. The sensitivity of the Asian currencies towards Renminbi as measured by the sum of their $\delta_{CNY}$ and $\delta_{CNH}$ coefficients in descending order of magnitude are as follows: TWD(0.31), KRW(0.29), SGD(0.25), PHP(0.25), THB(0.22), MYR(0.20), AUD(0.17) and IDR(0.17). We observe when indirect effects through other regional currencies are taken into account; there is not as much differentiation across the Asian currencies in terms of their susceptibility to fluctuations in the Renminbi. Although the Taiwan dollar (Indonesian rupiah) still ranks the most (least) sensitive corresponding to it receiving the highest (lowest) level of direct spillovers from the Renminbi foreign exchange markets.

Turning to the coefficients of EUR, these are statistical significant in all cases except for the Indonesian Rupiah and Taiwan dollar. The impact of the euro seems to be on par with the Renminbi for the Thai baht, as indicated by the closeness in the magnitudes of the coefficients. The combined Renminbi effect is smaller than that of the euro for the Australian dollar and the Singapore dollar by 0.24 and 0.19 standard deviations respectively. The reverse is true for the Indonesian rupiah, Korean won, Malaysian ringgit, Philippine peso and Taiwan dollar, the difference in the magnitude of the coefficients being particular large for the Taiwan dollar at 0.27 standard deviations. These findings are not at odds with those of the previous section. We recall the Diebold-Yilmaz indexes showed that the Renminbi generally registered larger spillovers than the euro on the Asian currencies and the Taiwan dollar is the most susceptible to Renminbi spillovers. The results from Diebold-Yilmaz indexes also indicated that direct spillover effects on the Asian currencies are larger for the euro than the Renminbi only for the two cases of the Australian dollar and Singapore dollar.

Finally, the coefficients of JPY are all statistically significant except for the Taiwan dollar. In the four cases of IDR, KRW, MYR and PHP, the coefficients are negative but their magnitudes are close to zero. A plausible explanation for the negative coefficients is the divergent movement in the yen-dollar rate versus these four Asian currencies during episodes of global risk aversion. Global liquidity and risk appetite largely determine the level of capital flows to emerging markets which in turn affect their exchange rates, resulting in "risk-on, risk-off" cycles. During the "risk-off" episodes, such as in August 2015 and January 2016, the yen-dollar rate tended to appreciate while emerging market currencies tended to depreciate. Overall, the very small magnitudes of the coefficients suggest the Indonesian rupiah, Korean won, Malaysian ringgit, Philippine peso and the Taiwan dollar do not co-move much with the yen post GFC.

The three remaining currencies of the Australian dollar, Singapore dollar and Thai baht, have statistically significant positive co-movement with the yen. However, when compared to the Renminbi, a one standard deviation appreciation in the yen is associated with a smaller impact on each of these three currencies. This corroborates with evidence from the previous section that US dollar bilateral rates in Asia are consistently more affected by fluctuations in the Renminbi-dollar rate vis-à-vis the yen-dollar rate. In other words, the influence of Renminbi-dollar rate on Asian currencies has surpassed that of the yen-dollar rate which is the world's second most actively traded pair.

## 5. Conclusion

Asian foreign exchange markets are subject to considerable cross-border transmissions, more so for the daily return vis-à-vis daily volatility of their US dollar bilateral exchange rates. Diebold-Yilmaz total spillover index show that the returns of Asian currencies are subjected to strong international transmissions of over 50% post GFC. By comparison, overall cross-border transfers of volatility are weaker by around 18%, possibly due to exchange rate management by the regional authorities to deter excessive volatility in the value of their domestic currencies. Focusing on returns, external spillovers explain about 60% to 70% of the variation in individual Asian foreign exchange markets except for Indonesia. Given the strengthening economic and financial linkages between the region and China, this paper focuses on the extent to which these external spillovers can be attributed to the Renminbi relative to the euro and the yen.

To this end, we combine the distinct impact of offshore Renminbi with the influence of the onshore rate since the onshore foreign exchange market is subject to trading restrictions and barriers to cross-border Renminbi movements still hold. This study confirms the exchange rate impact from Renminbi is significant on the Asian currencies. Without exception, greater spillover effects to the individual Asian foreign exchange markets can be attributed to the Renminbi markets as compared to the yen market. Moreover, the results from country-specific regressions concur that the influence of offshore Renminbi-dollar rate on Asian currencies has surpassed that of the yen-dollar rate. The combined impact of onshore and offshore Renminbi on the individual Asian currencies is generally on par with the euro, except for the case of Taiwan dollar where the Renminbi exerts a greater effect. By contrast, due to their strong links with extra-regional markets, Australian dollar and Singapore dollar record larger spillovers from and stronger co-movement with the euro vis-à-vis the Renminbi.

Of the Asian currencies, countries with close trade ties and strong financial linkages with China such as Singapore and Taiwan have currencies that are most susceptible to spillovers from the Renminbi. Conversely, foreign exchange markets of Asian countries such as Philippines and Indonesia that have relatively weak trade and financial linkages with China are relatively insulated from Renminbi spillovers. In the case of Australia which has moderate direct trade and financial linkages with China, high levels of commodity exports such as iron ore increases the susceptibility of its currency to Renminbi spillovers. Going forward, financial links with Asian countries will strengthen further as China continues to liberalize its financial markets, open its capital account and internationalize the Renminbi. This will further enhance the influence of the offshore Renminbi fluctuations on Asian currencies, calling for policy measures in the regional countries to closely monitor developments in China and to adopt policies such as macroprudential policies that mitigate such risks.

### References

[1] Arslanalp, S., Liao, W., Piao, S., & Seneviratne, D. (2016). *China's growing influence on Asian Financial Markets* (IMF Working Paper No. 1te: https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Chinas-Growing-Influence-on-Asian-Financial-Markets-44187.

[2] Barunik, J., Kocenda, E., & Vacha, L. (2017). Asymmetric volatility connectedness on the forex market. *Journal of International Money and Finance*, *77*, 39-56. https://doi.org/10.1016/j.jimonfin.2017.06.003

[3] Bank for International Settlements. (2016). *Triennial central bank survey: Foreign exchange turnover in April 2016*. Basel, Switzerland: Bank for International Settlements. Retrieved from https://www.bis.org/publ/rpfx16fx.pdf.

[4] Chow, H. K. (2014). Is the Renminbi Asia's dominant reference currency? A reconsideration. *China Economic Policy Review, 3*(1). https://doi.org/10.1142/S1793969014500022

[5] Chow, H. K. (2017). Volatility spillovers and linkages in Asian stock markets. *Emerging Markets Finance and Trade, 53*(12), 2770-2781. https://doi.org/10.1080/1540496X.2017.1314960

[6] Diebold, F. X., & Yilmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *The Economic Journal*, *119*(534), 158-171. https://doi.org/10.1111/j.1468-0297.2008.02208.x

[7] Diebold, F. X., & Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, *28*(1), 57-66. https://doi.org/10.1016/j.ijforecast.2011.02.006

[8] Fidrmuc, J., & Siddiqui, M. (2015). Exchange rate policy in China after the financial crisis: Evidence from time-varying exchange rate basket. *Review of Development Economics*, *19*(3), 608-623. https://doi.org/10.1111/rode.12161

[9] Frankel, J., & Wei, S.-J. (1994). Yen bloc or dollar bloc? Exchange rate policies of the East Asian economies. In T. Ito, & A. O. Krueger (Eds), *Macroeconomic linkages: Savings, exchange rates and capital flows* (p. 295-333). Chicago: University of Chicago Press.

[10] Funke, M., Shu, C., Cheng, X., & Eraslan, S. (2015). Assessing the CNH-CNY pricing differential: Role of fundamentals, contagion and policy. *Journal of International Money and Finance*, *59*, 245-262. https://doi.org/10.1016/j.jimonfin.2015.07.008

[11] Fratzscher, M., & Mehl, A. (2014). China's dominance hypothesis and the emergence of a tri-polar global currency system. *The Economic Journal*, *124*(581), 1343-1370. https://doi.org/10.1111/ecoj.12098

[12] Salgado, R. (2016). China's evolving trade with advanced upstream economies and commodity exporters. In *Regional Economic Outlook, April 2016, Asia and Pacific: Building on Asia's Strengths during Turbulent Times* (p. 77-101). Washington, DC.: International Monetary Fund. http://dx.doi.org/10.5089/9781498350921.086

[13] Ito, T. (2010). China as number one: How about the Renminbi? *Asian Economic Policy Review*, *5*(2), 249-276. https://doi.org/10.1111/j.1748-3131.2010.01169.x

[14] Kearney, C., & Muckley, C. (2007). Reassessing the evidence of an emerging Yen block in North and Southeast Asia. *International Review of Economics and Finance*, *16*(2), 255-271. https://doi.org/10.1016/j.iref.2004.11.007

[15] McKinnon, R. I. (2000). The East Asian dollar standard: Life after death? *Economic Notes*, *29*(1), 31-82. https://doi.org/10.1111/1468-0300.00024

[16] Pesaran, H. H., & Shin, Y. (1998). Generalized implulse response analysis in linear multivariate models. *Economics Letters*, *58*(1), 17-29. https://doi.org/10.1016/S0165-1765(97)00214-0

[17] Shu, C., He, D., Dong, J., & Wang, H. (2016). *Regional pull vs global push factors: China and US influence on Asia-Pacific financial markets* (BIS Working Paper, No. 579). Basel, Switzerland: Bank for International Settlements. Retrieved from BIS website https://www.bis.org/publ/work579.htm.

[18] Shu, C., He, D., & Cheng, X. (2015). One currency, two markets: The Renminbi's growing influence in Asia-Pacific. *China Economic Review*, 33, 163-178. https://doi.org/10.1016/j.chieco.2015.01.013

[19] Zhou, X., Zhang, W., & Zhang, J. (2012). Volatility spillovers between the Chinese and world equity markets. *Pacific-Basin Finance Journal*, *20*(2), 247-270. https://doi.org/10.1016/j.pacfin.2011.08.002