

**Measuring RMB Integration and Interruption in the
Chinese Economic Area: Tests Using Data from Onshore
and Offshore Markets**

Kuo-chun YEH

Tai-kuang HO

Ya-chi LIN*

2020.01.06

* Kuo-chun Yeh is a Professor at the Graduate Institute of National Development, National Taiwan University, Taiwan. Tai-kuang Ho is a Professor at the Department of Economics, National Taiwan University, Taiwan. Ya-chi Lin is an Assistant Professor at the Department of Economics, Feng Chia University, Taiwan. Correspondence: E-mail: yaclin@fcu.edu.tw.

Measuring RMB Integration and Interruption in the Chinese

Economic Area: Tests Using Data from Onshore and Offshore

Markets

Abstract

Taiwan has had an offshore renminbi (RMB) market on the basis of a cross-strait MOU since September 1, 2014. The RMB markets in the so-called Chinese Economic Area have been completed. Due to political and economic disruptions, whether the three RMB markets are integrated remains in doubt. This paper evaluates integration and interruption of the RMB markets by comparing the traditional approach and the sigma-convergence (or log t) test. The latter provides a more precise indication for market return convergence than does the traditional unit root test. Policy implications to support monetary and financial stability in this area are provided.

JEL Classifications: F33, F34, F37.

Keywords: renminbi (RMB) offshore markets, global financial crises, sigma-convergence test, CNY, CNH, CNT.

1. Introduction

On August 31, 2012, Taiwan and mainland China signed the Cross-Strait Currency Settlement Cooperation MOU that established the basic principles and cooperative framework of a currency clearing mechanism for the two sides of the Taiwan Strait. This was a major milestone for cross-strait financial cooperation (Central Bank of Taiwan 2012, 2013). Following Hong Kong's example, Taiwan established an offshore renminbi (RMB) market with exchange rates and interbank loan rates on the basis of that MOU on September 1, 2014. The three RMB markets and the relevant interbank loan rates in mainland China, Hong Kong and Taiwan are determined CNY with SHIBOR, CNH with HIBOR, and CNT with TAIBOR. At that point, the RMB markets in the so-called Chinese Economic Area were completed.¹

Nevertheless, the markets were not perfect or fully integrated. Although RMB internationalization should be an excellent opportunity for Taiwan's financial development, it also has been a national security concern since mainland China's monetary policy can affect Taiwan's financial stability. Taiwan's political affairs, e.g., the 2016 Taiwan election, which lent support to independence, could reduce reliance on

¹ CNY is an acronym of the onshore RMB, and CNH and CNT indicate offshore RMB/USD exchange rates in Hong Kong and Taiwan, respectively. In this paper the Chinese Economic Area includes mainland China, Hong Kong, and Taiwan.

Measuring RMB Market Integration & Interruption

the Chinese economy. Postponing of the Cross-strait Service Trade Agreement has also impeded further financial integration. Thus, market segmentation continues due to regulations imposed by the governments of Taiwan and mainland China.

The second issue for market integration is interruptions from economic shocks, such as the aftermath of the global financial crises, the EU sovereign debt problem since 2010, mainland China's stock market crash and RMB exchange rate reform in 2015, controls on capital outflows since 2017, and the US-China trade war since 2018. Table 1 shows that RMB movements' effects on Asian currencies have grown stronger (Fratzscher & Mehl, 2014; Shu et al., 2015; Subramanian & Kessler, 2013; Arslanalp et al., 2016), and the RMB has become a key driver of emerging Asian countries, particularly after the global financial crisis of 2007-08 (Fratzscher & Mehl, 2014; Subramanian & Kessler, 2013). This phenomenon is referred to as "China's dominance hypothesis" (Fratzscher & Mehl, 2014). An IMF report (Arslanalp et al. 2016) warns that market spillovers from mainland China might increase, through both trade and financial linkages. Economies most likely to be affected by mainland China's financial spillovers are those with strong trade links with mainland China, especially Singapore, Korea, and Taiwan due to their strong financial connections with mainland China.

[Table 1]

Measuring RMB Market Integration & Interruption

Furthermore, other emerging RMB markets in London, Seoul, and Singapore, also would like to issue varieties of RMB financial products. In contrast, as Table 2 indicates, with an accumulated 300 billion RMB deposit pool due to its close trade links with mainland China, Taiwan can only be a pure RMB provider to earn the spreads from mainland China and other financial centers due to domestic restrictions. Furthermore, there is no a bilateral currency swap agreement to support Taiwan's RMB market. As the world's eighth most actively traded currency, the RMB has a 4% share of OTC foreign exchange turnover. The increased RMB share was primarily due to a significant expansion of offshore RMB trading (Bank of International Settlements, 2016).

[Table 2]

The above political and economic interruptions would restrict RMB market integration. Figure 1 shows 1-year SHIBOR, HIBOR and TAIBOR, which indicate divergence between SHIBOR and the other two offshore RMB markets, which could lead to failure of financial integration. From 2014 to 2017, several economic shocks occurred, such as mainland China's stock market crash and RMB exchange rate reform in 2015, the stock exchange circuit breaker mechanism in 2016, and controls on capital outflows since 2017. Although these shocks may not have a huge impact on SHIBOR due to government control, HIBOR and TAIBOR were sensitive to these shocks. This

Measuring RMB Market Integration & Interruption

implies that HIBOR and TAIBOR have strong connections with mainland China, whereas SHIBOR is under strict control and cannot fluctuate freely. Nevertheless, interest rates cannot precisely measure return convergence (if exchange rate revaluation is included), spillovers from recent economic and political shocks, causality of the markets, or impacts on Taiwan's monetary and financial stability. Thus the conventional approach may not be appropriate to evaluate RMB market integration.

[Figure 1]

Most existing studies measure market integration by either de jure or de facto measures. De jure measures are proxies for the prerequisites that lead to financial market integration and concern the restrictions on capital flow. De facto measures provide more valuable information and are more suitable for gauging market information (Yao et al. 2018), as discussed below. Ren et al. (2018) investigate linkages among the onshore-offshore exchange rate differential, interest rate spreads, and Hong Kong's RMB deposits. Interest rates are an important variable in RMB internationalization, and foreign exchange intervention has a significant and positive effect on the exchange rate differential. Feng & Zhang (2016) find a significant volatility spillover between the offshore and onshore RMB markets prior to June 2013, and the direction of spillover from CNY to CNH is stronger than the reverse. The

Measuring RMB Market Integration & Interruption

offshore RMB interest rate has been an independent system that is not determined by onshore markets. Using a specialized microstructure data set, Cheung & Rime (2014) find that the offshore CNH exchange rate has an increasing impact on the onshore CNY rate, and significant predictive power for the official RMB central parity rate. Funke et al. (2015) use extended GARCH models and explore factors driving the pricing differential between onshore and offshore exchange rates. They suggest that during the early stage of offshore market development, the expansion of liquidity and the deepening of offshore markets may facilitate the integration of onshore and offshore markets.

On the basis of Phillips & Sul (2007) and Lin & Yeh (2016, 2017), this paper addresses the following three research areas.

First, existing studies have limited investigation of CNY onshore and CNH offshore markets, and this study is the first to include the CNT offshore market. We use the log t test by Phillips & Sul (2007) to provide a more precise determination for convergence of the RMB markets than the traditional unit root test. We measure the damage of RMB market integration since the endorsement of the MOU between Taiwan and mainland China in 2014 to point towards a means to improve RMB market integration. Although theoretically it is not a problem to include other RMB markets

Measuring RMB Market Integration & Interruption

outside the Chinese Economic Area, it is not currently possible due to limited data on interbank loan rates in Singapore, Seoul, London and the U.S.

Second, we would like to confirm whether political and economic shocks have affected RMB market integration since 2014. To support Taiwan's national security, we find evidence on whether mainland China's financial dynamics can be transmitted to Taiwan via the offshore RMB market.

Finally, some policy implications are presented based on the empirical results, indicating some supporting measures that need to be revised or strengthened. Our empirical tests indicate RMB market divergence has been caused by shocks since 2014. Thus governmental actions are needed to reduce divergence due to political changes and the possibility of mainland China's economic recession.

This paper makes two contributions to the existing literature. First, as mentioned above, our study is the first to include the CNT offshore market. Second, since both mainland China's interbank offered interest rates and exchange rates are influenced by government policy, the conventional approach to investigate levels of return convergence would be inappropriate. Thus the sigma-convergence test is applied to measure co-movement of the RMB returns according to the viewpoint of volatility, i.e. the convergence of return dispersion. That is, the level values may be different from

each other due to various restrictions or national risks, but spillover effects can be seen through the volatility of RMB returns.

Our results show that RMB markets in the Chinese Economic Area are integrated according to the log t test, while there is no evidence of return convergence by the conventional approach. Then RMB onshore and offshore market return converge under the sub-sample before mainland China's stock market crash in 2015, implying that the integration of onshore and offshore markets facilitated the early stage of offshore market development. Moreover, RMB market convergence has not been affected by Taiwan's "New Southbound Policy" that seeks to decrease reliance on the Chinese economy, following the 2016 change in Taiwan's political party in power.

This paper is structured as follows. Section 2 presents and explains our modeling approach. Section 3 uses the log t test to show the degree of convergence of RMB markets between Taiwan, Hong Kong and the Chinese mainland under various shocks since 2014. Section 4 concludes with findings of this paper and provides policy suggestions.

2. The Model

Convergence of the RMB market returns can indicate the degree of long-run regional RMB market integration, as well as asymmetric reactions to shocks in the economies.

Measuring RMB Market Integration & Interruption

In this paper we measure convergence by the interbank loan rates minus the expected RMB devaluations according to the uncovered interest parity (UIP). The conventional approach applies the use of unit-root tests for UIP based on single equations, and it also accepts the rejection of the unit-root hypothesis as supporting evidence for financial integration (Obstfeld & Taylor, 2002; Goldberg et al., 2003; Ferreira & León-Ledesma, 2007). Due to the low power of single equation tests, panel tests have been applied to examine the unit-root hypothesis.

In short, rejecting the unit-root hypothesis of the conventional approach implies neither that the RMB returns across countries converge to a return nor that the dispersion of returns decreases over time. Thus the existing evidence for market integration is not conclusive. For the EU case, Ehrmann et al. (2011) study the convergence of European bond markets from 1993 to 2008, finding substantial convergence of interest rate levels in response to major macroeconomic announcements. Eliminating exchange rate risk and adopting a common monetary policy were the primary drivers of bond market convergence in the euro area.

Phillips & Sul (2007) show that the above hypothesis is to test the sigma-convergence test (or log t test), which indicates the variance convergence of the cross-sectional returns over time. If various market returns can be decomposed to the

multiplication of a common and idiosyncratic component, then an alternative strategy for testing return convergence is to examine if an idiosyncratic component, such as risk premium, converges. This provides a more precise indication for return convergence than does the traditional unit root test. Moreover, there are several advantages to the test by Phillips & Sul (2007), including not being subject to the choice of a reference country, not relying on any particular assumptions concerning trend stationarity or stochastic non-stationarity series, and more being appropriate to examine market integration across countries in cases with heterogeneous time-varying risk premiums across countries. For instance, Lin & Yeh (2016, 2017) measure the damage of financial crises on EMU's financial integration, by adopting the log t test on real interest rate convergence. Borsi & Metiu (2015) also adopt the log t test to investigate real income per capita convergence between 27 EU countries from 1970 to 2010. There is no overall real income per capita convergence in the EU, but club convergence exists in the Central and Eastern European countries and the older EU members.

The model of this paper is based mainly on Phillips & Sul (2007) but revised to explain the three RMB markets. With risk-averse investors, the hold of uncovered interest parity (UIP) implies that interest-rate differentials equal the sum of the expected depreciation rate of domestic currency and a time-varying risk premium:

$$i_{j,t} - i_t^* = E_t(s_{j,t+1} - s_{j,t}) + \omega_{j,t+1}, \quad (1)$$

Measuring RMB Market Integration & Interruption

where $s_{j,t}$ is the log of the nominal exchange rate (domestic currencies per US dollar, e.g., subscript j means CNY, CNH and CNT); $i_{j,t}$ and i_t^* denote domestic (e.g., subscript j represents SHIBOR, HIBOR and TAIBOR) and interest rates of a foreign country (the U.S is defined), respectively; $E_t(\cdot)$ denotes a conditional expectation based on the information set at time t ; and $\omega_{j,t}$ is the time-varying risk premium. Flood & Marion (2000) point out that the time-varying risk premium $\omega_{j,t}$ depends on the measure of investors' risk aversion, expected currency risk, and worldwide relative holdings of domestic and foreign bonds. In other words, the risk premium reflects the relative risk of holding domestic and foreign assets.

Based on Equation (1), this work derives the relationship between the three RMB markets as follows:

$$r_{CNY,t}^e - \omega_{CNY,t+1} = r_{CNH,t}^e - \omega_{CNH,t+1} = r_{CNT,t}^e - \omega_{CNT,t+1}, \quad (2)$$

where $r_{j,t}^e = i_{j,t} - E_t \Delta s_{t+1}$, in which Δ is the first difference operator. If investors are risk neutral, and the risk premium is zero, then Equation (2) degenerates to the standard UIP model in the expectation form

$$r_{CNY,t}^e = r_{CNH,t}^e = r_{CNT,t}^e, \quad (3)$$

The realization of UIP implies that international trade barriers are removed, so the asset market and goods market are integrated.

Conventional literature evaluates validity by testing the stationarity of return differentials given that returns $r_{j,t}^e$ are I (1) and the risk premium is stationary. Obviously, rejecting the unit-root hypothesis with an ADF statistic implies neither that

returns converge to the same level in the long run nor that return differentials converge to a common mean. Moreover, rejecting the joint unit-root hypothesis with a panel unit-root test implies the series under investigation could mix with the I (1) and I (0) series. If the common factor diverges faster than the convergence of idiosyncratic components, the return differentials may retain non-stationary characteristics. An alternative strategy to examine the convergence of returns is to test their sigma convergence, which is equivalent to testing whether the dispersion of returns across countries declines over time (Phillips & Sul, 2007). This is a rigorous test for return convergence, and hence rejecting the hypothesis that the unit root does not imply sigma-convergence (Pesaran, 2007). The approach by Phillips & Sul (2007) assumes that the series converge relatively over time when the time series share the same stochastic or deterministic trend elements in the long run. To capture convergent behavior in panel data that do not involve stochastic or divergent deterministic trends, Kong et al. (2019) introduce the notion of weak sigma-convergence. The macroeconomic data usually contain systematic factors, so Phillips & Sul (2007) approach will be more suitable in this study.

Assume $r_{j,t}$ is decomposed into a time-varying return of systematic risk, $\lambda_{j,t}\mu_t$, and the return of idiosyncratic risk, $a_{j,t}$, so

$$r_{j,t} = a_{j,t} + \lambda_{j,t}\mu_t, \tag{4}$$

where μ_t is the systematic risk factor for returns, and $\lambda_{j,t}$ is time varying factor loading coefficients that capture the individual effects on systematic risk. The systematic risk factor can be measured by the cross-sectional mean of returns, \bar{r}_t , which is an I (1) process based on our data. Hence, the systematic risk factor also is an I(1) process. To

separate the common component from idiosyncratic components, the return is re-written as:

$$r_{j,t} = \left(\frac{a_{j,t}}{\mu_t} + \lambda_{j,t} \right) \mu_t, \quad (5)$$

Since μ_t follows an I(1) process, the term $a_{j,t}/\mu_t$ converges to zero in the long run. According to Equation (5), this paper decomposes a return into two components:

$$r_{j,t} = b_{j,t} \mu_t, \quad (6)$$

where $b_{j,t} \equiv \left(\frac{a_{j,t}}{\mu_t} + \lambda_{j,t} \right)$ is an idiosyncratic component, depending on the currency-specific risk premium, the inter-temporal marginal rate of substitution or the financial regulations of market j . Based on Equation (6), return differentials are given as follows:

$$r_{j,t} - r_{k,t} = (b_{j,t} - b_{k,t}) \mu_t, \quad (7)$$

where $b_{j,t} - b_{k,t}$ is the relative risk premium between market j and k . Financial integration implies that the idiosyncratic risk in different assets converges asymptotically. That is, the idiosyncratic components $b_{j,t}$ and $b_{k,t}$ converge to some common b as $t \rightarrow \infty$, implying that financial integration holds. However, the common factor μ_t is non-stationary. When the speed of divergence for the common factor is faster than that of the convergence of the idiosyncratic components, the return differentials may retain non-stationary characteristics. Conventional co-integration tests will have low power to detect asymptotic co-movement of the idiosyncratic components. Therefore, it is worth examining if convergence holds for the idiosyncratic component ($b_{j,t}$) instead of the mixture of idiosyncratic and common

components ($r_{j,t}$). Phillips & Sul (2007) provide the log t test to examine the convergence of $b_{j,t}$.

The convergence of returns holds if $b_{j,t} \rightarrow b$ for $j = 1, \dots, N$, which means there is a common trend in returns and the common trend, $b\mu_t$, can be either stochastic or deterministic.

To design a statistical test for convergence, Phillips & Sul (2007) adopt a semi-parametric approach and assume the following general form for the loading coefficient $b_{j,t}$

$$b_{j,t} = b_j + \sigma_{j,t} \omega_{j,t}, \quad \sigma_{j,t} = \frac{\sigma_j}{L(t)t^\alpha}, \quad t \geq 1, \quad \sigma_j > 0 \text{ for all } j,$$

where α is the decay rate; $L(t)$ is the slowly varying function; and $L(t) \rightarrow \infty$, as $t \rightarrow \infty$. When $b_j = b$ for all j , the null hypothesis of convergence is the weak inequality constraint $\alpha \geq 0$. The conditions for convergence in the model can be characterized as

$$\text{plim}_{k \rightarrow \infty} b_{j,t+k} = b \text{ if and only if } b_j = b, \text{ and } \alpha \geq 0,$$

$$\text{plim}_{k \rightarrow \infty} b_{j,t+k} \neq b \text{ if and only if } b_j \neq b, \text{ or } \alpha < 0,$$

There is no restriction on α under divergence when $b_j \neq b$. However, the case of divergence with $b_j \neq b$ and $\alpha \geq 0$ may be of substantial interest, since it allows for the possibility of local convergence to multiple equilibria. This case is important in empirical applications where there is evidence of club convergence.

Further, to examine the joint hypothesis of return convergence,

$H_0: b_j = b$ and $\alpha \geq 0$, against the alternative hypothesis of no return convergence in at

least one market, $H_A: b_j \neq b$ for all j , or $\alpha < 0$.

The common factor μ_t is unknown and could not be detected, but it may be removed by dividing the cross-section mean of returns

$$h_{j,t} = \frac{r_{j,t}}{N^{-1} \sum_{j=1}^N r_{j,t}} = \frac{b_{j,t}}{N^{-1} \sum_{j=1}^N b_{j,t}} .$$

By dividing the cross-sectional mean of $r_{j,t}$, the relative transition coefficient, $h_{j,t}$, is derived, which removes the systemic components. In addition, $h_{j,t}$ converges to unity under the null of convergence. Since $h_{j,t}$ converges to unity for the null convergence, it is expected that the cross-sectional variance of $h_{j,t}$ decreases over time if the null is true. The cross-sectional variance of $h_{j,t}$, H_t , is derived by $H_t = \frac{1}{N} \sum_{j=1}^N (h_{j,t} - 1)^2$. The log t regression model is constructed by regressing $\log H_t$ and some corrected term, such as $\log(\log t)$ or $\log H_t$, on $\log t$. The log t regression model of Phillips & Sul (2007) is shown as Equation (8)

$$\log \frac{H_1}{H_t} - 2 \log(\log t) = \xi_0 + \xi_1 \log t + u_t , \quad (8)$$

for $t = T_0, \dots, T$, where $H_t = N^{-1} \sum_{j=1}^N (h_{j,t} - 1)^2$. The long-run convergence of returns is rejected if ξ_1 is significantly negative. Data for this regression starts at $T_0 = [cT]$ for some $c > 0$. Phillips & Sul (2007) suggest $c \in [0.2, 0.3]$ is a satisfactory choice in terms of both size and power. The fitted coefficient of $\log t$ is $\widehat{\xi}_1 = 2\widehat{\alpha}$, where $\widehat{\alpha}$ is the estimate of α in H_0 . The long-run convergence of returns is rejected if ξ_1 is significantly negative.

Under the null hypothesis of convergence, the cross-sectional variance of variables under investigation decreases over time, so the convergence test is also called the sigma-convergence test. Phillips & Sul (2007) also demonstrate that removing cyclical components from the data improves the finite sample size and power of the tests. The Hodrick-Prescott filter is widely used in macroeconomics to separate the cyclical component of a time series from raw data. It is used to obtain a smoothed non-linear representation of a time series that is more sensitive to long-term than to short-term fluctuations. The current study also adopts the Hodrick-Prescott trend of $r_{j,t}$ in order to construct h_t . The frequency of our data is daily, and the parameter λ is suggested to be from 10000 to 10^8 . The parameter λ in the HP filter is set to 10^6 in our study.

3. Empirical Results

We mainly focus on integration and spillovers between the two offshore (CNT and CNH) and the CNY onshore markets. As mentioned above, it is not possible to include other RMB markets outside the Chinese Economic Area due to data limitations of interbank loan rates. The data of the RMB markets from September 1 2014 to December 20 2018 are from WIND.² We use this date as the starting point because the beginning day of

² The data of RMB markets retrieved from WIND is from September 1 2014 to December 20 2018. The RMB market return is equal to nominal interest rate minus the one-year forward expected depreciation of exchange rates, therefore the market return of our sample ranges from September 1 2014 to December 20 2017.

CNT, though the other two markets started earlier. Our dataset comprises daily data.

When trying to make various sample periods according the events, we use the Chow test to evaluate the options, and the results of the log t test and club convergence do not change substantially. Details are available on request, and this research could be easily expanded by revising the data.

3.1 Traditional unit root, co-integration and causality tests

Table 3 shows the traditional tests, including unit root, co-integration and Granger causality, whose drawbacks have been described above. But these are to be compared with the sigma-convergence test, since the main focus of this paper to determine the degree of RMB market integration.

[Table 3]

Nevertheless, traditional tests still show some interesting points to consider the issues. First of all, weak evidence to support co-integration (except the 1-month data) cannot confirm integration of the RMB markets in the Chinese Economic Area. This means a more powerful tool is needed to verify this point. The Granger causality test confirms the return relationship between Hong Kong and Taiwan, but there is no strong evidence to confirm mainland China's policy impact on Taiwan's RMB market. In contrast, the markets of Hong Kong and Taiwan, with their greater degrees of freedom

are closely related to each other. Therefore, a more precise approach, such as the sigma-convergence test, is needed.

3.2 Sigma-convergence test in different sample periods

In this subsection the full sample sigma-convergence test is run first, and then the test is redone by separating the full sample into various periods according to important political and economic events. Compared with the co-integration test, the sigma-convergence test is better able to find evidence of financial integration, so it is more appropriate to examine return convergence to determine whether these events have interrupted market integration since 2014. Furthermore, the possibility of club convergence is also explored to investigate reasons for failure of financial integration. Note that the log t model combines all the individual series into one cross-sectional variance and determines the convergence of the variance. Therefore, the number of the sample countries does not affect the power of the test.

Figure 2 shows the cross-sectional variance of the relative transition coefficient, H_t , in 2014-2017. Note that it indicates market volatility by considering trends rather than comparing the absolute values, so that the negative (positive) slope of H_t indicates less (more) volatility and integration of the markets.

[Figure 2]

Measuring RMB Market Integration & Interruption

We therefore can observe the RMB market integration chronologically. At the beginning of the RMB markets in Chinese Economic Area, the cross-sectional variance H_t falls rapidly. It goes into a valley and then turns to increase after mainland China's stock market crash and the "811" exchange rate reform in the mid-2015. In 2016Q1, mainland China's government abruptly implemented a stock deal circuit breaker in order to decrease stock price volatility. However, Figure 2 shows this measure had an opposite effect and stock prices became more volatile if investors believed the deals would stop. Also in 2016, mainland China's outbound merger and acquisition activity reached \$221 billion, soaring by 246 percent (PwC, 2017) as technology, consumer products and media and entertainment transactions attracted very large investment. Therefore, H_t falls in the beginning of 2016 and then turns to increase. Beginning in 2017Q1 the Chinese government imposed capital outflow restrictions to combat corruption, so H_t began to fall again.

The log t test, as shown in Table 4, investigates whether the cross-sectional variance increases over time. In the full sample case of Column 1, return convergence among the three RMB markets does exist in 2014-2017 because ξ_1 is positive when parameter c is from 0.24 to 0.3. That is, we can say the RMB markets in the Chinese Economic Area have been integrated under some conditions despite several internal and external shocks. Note that in the modeling c is the fraction that the data for regression

starts from, so the interval above should be empirically reasonable.

[Table 4]

To check the above full sample results, in Column 2 we extract the sample from September 1 of 2014 to June 30 of 2015. Data for time period imply relative tranquility after the global tsunami and the first European debt crisis and before the onset of the second European debt and mainland China's stock crash. The values of ξ_1 are all positive and return convergence is proved. The results of Columns 1 and 2 coincide with the past findings that indicate significant spillover between offshore and onshore markets, but the influence weakens after the exchange rate reform (Funke et al., 2015; McCauley & Shu, 2018).

To check the impact of a series of internal and external shocks since the mid-2015, in Column 3 we extend the subsample to May 20 2016 and return convergence is rejected. The ending point May 20 2016 is the date for changeover of Taiwanese political power, which adopted the so-called "New Southbound Policy" to reduce economic reliance on mainland China. In addition to foreign economic events (e.g., the second European debt crisis), the Chinese stock market turbulence began in June 2015. One third of the value of A-shares on the Shanghai Stock Exchange was lost within one month. The Chinese government accordingly reduced interest rates and undertook

Measuring RMB Market Integration & Interruption

several measures that caused Chinese stocks to begin increasing substantially in mid-July. The 811 exchange rate reform in 2015 also made the CNY depreciate by 4%. The contraction of overall offshore liquidity pool increased Hong Kong offshore RMB financing costs, and the interest rate spreads between the onshore and offshore markets widened gradually. The above economic and political shocks enlarged the return differentials of the RMB markets (HKEX, 2017).

Although return convergence in Column 3 is rejected, “club convergence” may exist. The clustering algorithm of Phillips and Sul (2007) can be used to investigate whether club convergence exists in Table 5. For the subsample in Column 3 of Table 4, no club convergence exists among the three RMB markets. This implies the events in 2015-16 had a strong negative impact on the integration of the RMB markets. The three RMB markets were fully divergent after a series of shocks after mid-2015 and then recovered gradually. Taiwan’s attempt to reduce reliance on the Chinese economy seems unsuccessful by comparing Table 5 and Columns 1 and 3 in Table 4. This is because Column 3 (before Taiwan’s political power change) implies divergence but Column 1 (full sample) indicates convergence, indicating that Taiwan’s diversification effort did not stop integration of the RMB markets.

[Table 5]

We summarize the main points above as follows: (1) From the beginning of the CNT to the end of 2017, integration of the three RMB markets was possible; (2) a series of shocks in 2015-16 seriously interrupted RMB market integration; (3) Taiwan's diversification policy to decrease reliance on the Chinese economy may have had limited effects on RMB market integration.

3.3 Impact of global factors

Economies most likely to be affected by mainland China's financial spillovers are those with strong trade links with mainland China, as well as Taiwan and Hong Kong due to their strong financial links (Arslanalp et al., 2016). Taiwan-China exchanges have increased since 1987, but the US economy still has a significant impact on the financial markets of Taiwan and Hong Kong. One issue related to US and mainland China's trade competition is which country has the most influence on the three RMB markets. This subsection investigates the return convergence by including US monetary policy (e.g. US Treasury Bill Rate, TBR hereafter), as well as the global factor (e.g. LIBOR) for comparison. Note that data on public RMB interbank interest rates in US and UK is not available. To evaluate the impact of international capital mobility on the RMB returns, we use TBR and LIBOR as proxy of US and global factors due to their roles of the benchmark interest rate at which major global lend to one another. Further exploration will be possible if more complete RMB interbank loan market data is

available in the future.

Thus there are five series in our log t test to determine if the two RMB offshore markets converge to either onshore CNY or the traditional financial centers. As shown in Figure 3, the cross-sectional variance decreased since 2014, perhaps due to reduced impact of the global financial tsunami. The variance increased slightly again in 2016Q3 and then decreased in 2017Q1, following the Chinese government's capital outflow restrictions to limit corruption.

[Figure 3]

Following the same principle in Table 4, the log t test in Table 6 shows slightly different results. The return convergence is demonstrated in the subsample of 2014-2016 (Column 3) and the full sample of 2014-2017 (Column 1). Thus from a global perspective, international financial integration in the Chinese Economic Area remains after the global tsunami and various regional shocks. In general, global financial factors might still dominate the RMB markets.

[Table 6]

But the reason that return convergence is rejected in Column 2 of Table 6 should be clarified. By applying the clustering algorithm from Phillips & Sul (2007) in Table 7, the return of CNY, CNT and CNH converge, while LIBOR and TBR are independent

in 2014-2015. This result is consistent with Table 4 even though the periods are slightly different, so the impact of the global financial tsunami and the European debt problem might remain after the two global factors are included. When the Euro-American financial centers were disrupted by the financial crises, RMB markets had the chance to converge as a group, indicating mainland China's rising financial strength.

[Table 7]

4. Concluding Remarks

As the world's second largest economy, China's financial development also increases uncertainty about its impact on global financial markets, including volatility of equity prices, exchange rates, and bond yields. The strict controls on RMB exchange rates and capital flows, on the one hand, raise concern about adverse manifestations as the "beggar-thy-neighbor" effect. On the other hand, these controls might also limit the spillover effects transmitted through financial channels to the rest of the world.

Most recent research on mainland China's growing influence on East Asian markets, indicates that mainland China's regional influence is increasingly transmitted through financial channels. The means of financial spillover from mainland China, including trade, financial and commodity price channels. With similar trade patterns and implicitly coordinated policies, Asian countries and China are moving toward

integration.

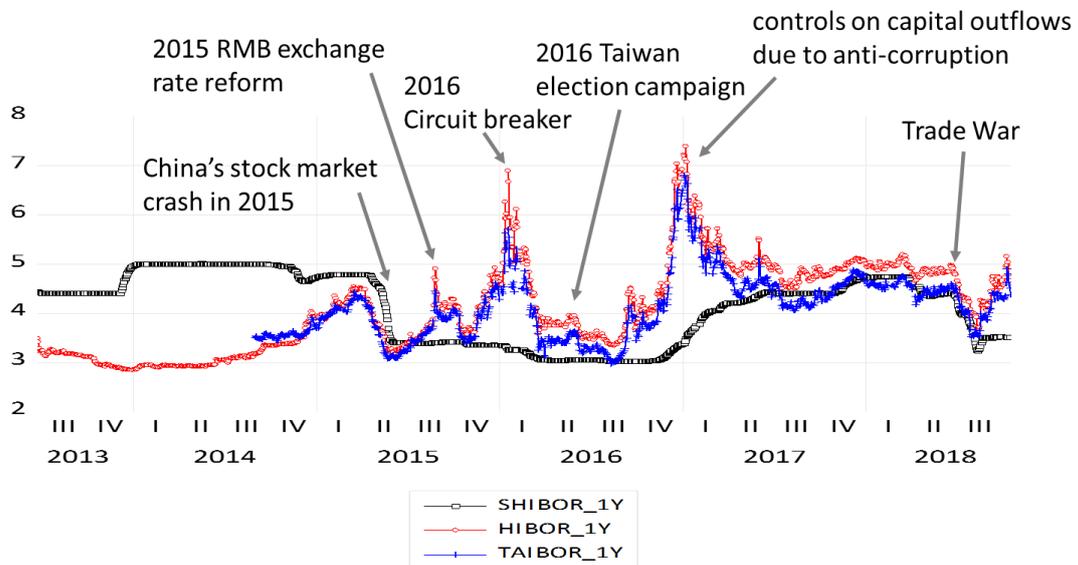
This study investigates whether the RMB return convergence holds according to a long-term UIP, which would imply integration between RMB onshore and offshore markets. There is evidence of mainland China's financial linkages with RMB markets in Hong Kong and Taiwan, but the results also imply that mainland China's growing influence has not yet reached the levels of traditional financial centers, consistent with the literature. Note that our sample period is from the start of CNT in 2014 to the end of 2017. It is not a problem to renew the data to analyze the impact of the US-China trade dispute on the RMB market integration.

Opportunities could arise from China's rebalancing and the recent US-China trade dispute, as some lower-income countries (e.g., Vietnam and Cambodia) have benefitted from China's move up the value chain or as China increases its investments abroad. However, for countries such as Taiwan with close trade and financial links to mainland China, Hong Kong, and the US, policy buffers could be used to mitigate these risks and build resilience, discharging macroeconomic support measures judiciously. As Arslanalp et al. (2016) indicates, macro-prudential policies and structural reform agendas have been proposed to safeguard financial stability and to diversify growth sources to reduce reliance on mainland China. Taiwan could employ the former,

Measuring RMB Market Integration & Interruption

especially if volatile asset prices lead to substantial capital outflows or greater vulnerabilities, such as those in the corporate sector. Furthermore, structural reform may be effective, especially to diversify sources of growth by means such as promoting the services sector to reduce reliance on cross-strait trade, or developing closer links with countries outside the Chinese Economic Area.

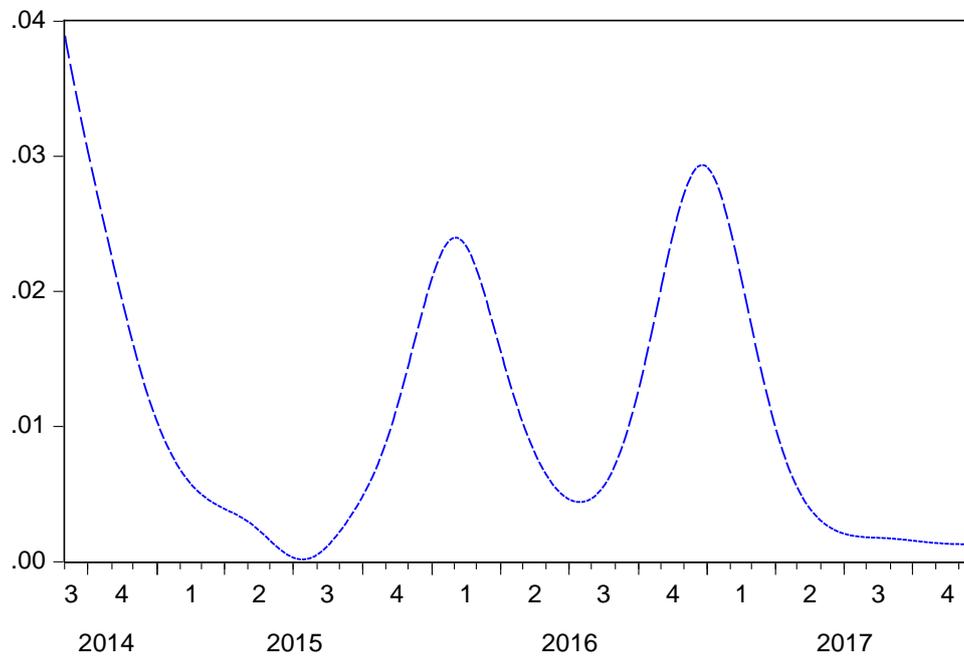
Figure 1. 1-year RMB Interbank Loan Rates: SHIBOR, HIBOR, and TAIBOR



Note : The vertical and horizontal axes are percentage and time, respectively.

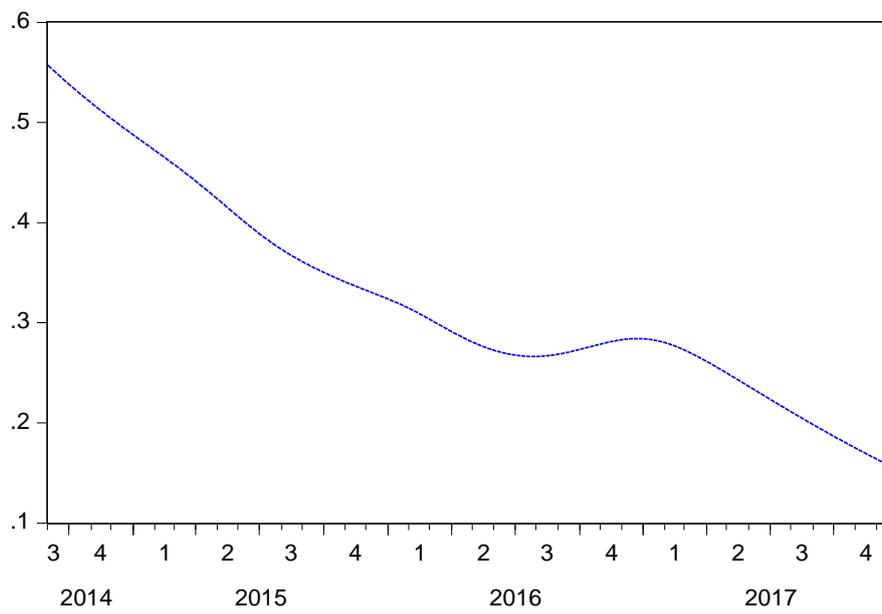
Source: WIND

Figure 2. Cross Section Variance of the Relative Transition Coefficients of Three RMB Market Returns.



Source: Authors' computation.

Figure 3. Cross Section Variance of the Relative Transition Coefficients of Returns for the Three RMB Markets, LIBOR and the US TBR



Source: Authors' computation.

Table 1. Research about China's influence on Asian markets

Author	Transmission Channel
Branson & Healy (2005)	China's trade pattern is quite similar to ASEAN's, and their policies are already implicitly coordinated. This means that ASEAN and China are already moving toward integration in practical effect.
IMF (2011)	China's capacity to both transmit and originate real shocks is rising. Significant positive effects on others' output and trade require a comprehensive transformation that reduces China's household and corporate savings rates and raises depressed factor prices.
He & Liao (2012)	Asian economies share a strong region-specific business cycle. Policy responses showed a high degree of synchronization across the economies over the period.
Shu, He & Cheng (2015)	China's influence is transmitted through financial linkages including its exchange rate movements and monetary policy.
Mwase et al. (2016)	No asset market is immune to economic and financial developments in China; effects are felt most acutely in foreign exchange and equity markets. Countries most affected are those with deeper trade with China, especially Asian countries integrated in the global supply chain, commodity exporters, and emerging markets with weaker fundamentals.
Arslanalp et al. (2016)	Financial spillovers from China to regional markets are increasing, particularly in equity and foreign exchange markets, and are stronger for economies with greater trade linkages with China. Major equity markets in Asia are increasingly influenced by China's equity market, although not yet to the level of the US influence.

Source: Authors' compilation.

Table 2. Selected RMB Markets (bil. RMB)

	Hong Kong	Taiwan	Singapore	London	Seoul
Transaction share	71%	2.6%	5.1%	5.3%	2.8%
RMB deposit	851.1	319.4	225.0	20.0	30.2
RMB bond	68.7	31.2	12.7	10.0	-
RQFII	270	100	100	80	80
Currency swap	400	-	300	350	360

Source: SWIFT, central banks' information till 2015.

Table 3. Summary for Unit Root, Co-integration, and Granger Causality Tests

	1-month	3-month	6-month	1-year
Augmented Dickey–Fuller test				
r_{CNY} (since Oct.16, 2006)	-2.27	-0.66	0.93	-0.85
r_{CNH} (since Jun.24, 2013)	2.29	1.37	1.39	0.60
r_{CNT} (since Sep.01, 2014)	1.02	1.43	1.09	0.92
Co-integration test ²				
Trace	0.10 ***	0.06	0.06	0.05
Maximum Eigenvalue	0.10 ***	0.06	0.06	0.05
Granger causality test				
$r_{CNK} \rightarrow r_{CNY}$	0.76	0.13	0.04	0.26
$r_{CNT} \rightarrow r_{CNY}$	0.50	0.05	0.01	0.25
$r_{CNY} \rightarrow r_{CNH}$	5.58 *	5.22 *	3.04	2.92
$r_{CNT} \rightarrow r_{CNH}$	19.87 ***	6.87 **	5.35*	0.77
$r_{CNY} \rightarrow r_{CNT}$	3.65	4.28	4.40	9.73
$r_{CNH} \rightarrow r_{CNT}$	5.97 *	2.08	21.19***	37.43

Note:

1. *, **, *** imply significance at the 10%, 5%, 1% level, respectively.
2. The Johansen co-integration test statistics is based on the hypothesis of zero cointegration equation.

Source: Authors' computation.

Table 4. Results of the log t Test on Three RMB Market Returns

	2014/09/01 ~2017/12/20	2014/09/01 ~2015/6/30	2014/09/01 ~2016/5/20
C	ξ_1 (t-stat.)	ξ_1 (t-stat.)	ξ_1 (t-stat.)
0.20	-0.94 (-3.62)	1.34 (55.41)	-1.65 (-6.68)
0.21	-0.89 (-4.27)	1.37 (63.93)	-1.78 (-6.74)
0.22	-0.82 (-7.22)	1.40 (73.70)	-1.95 (-6.83)
0.23	-0.68 (-8.07)	1.43 (84.78)	-2.09 (-6.93)
0.24	-0.48 (-0.99)	1.48 (103.67)	-2.27 (-7.08)
0.25	-0.25 (-0.30)	1.51 (117.34)	-2.43 (-7.23)
0.26	0.04 (0.04)	1.54 (131.15)	-2.63 (-7.47)
0.27	0.31 (0.44)	1.57 (144.12)	-2.79 (-7.72)
0.28	0.53 (0.93)	1.60 (155.07)	-3.01 (-8.10)
0.29	0.75 (1.76)	1.63 (162.80)	-3.19 (-8.49)
0.30	0.94 (2.86)	1.68 (163.81)	-3.42 (-9.12)

Note:

1. Column1: Full sample; Column 2: Before the 2015 stock market crash; Column3: after 2015 stock market crash till 2016 Taiwan's political power rotation.
2. This sample includes the SHIBOR, HIBOR, TAIBOR interest rates deduct from the change of log CNY, CNH, CNY, respectively.
3. The log t regressions are based on Equation (8). None of these results can accept the null hypothesis of return convergence.
4. Discarding some initial fraction of the time series data allows attention to be focused on the more recent changes, especially when the sample size is larger. Based on the simulation experience of Phillips and Sul (2007), c in the interval, 0.2 to 0.3, is a satisfactory choice, in terms of size and power.
5. Results are based on the interbank offered interest rate of 1-year maturity. The results of 1-month, 3-month and 6-month maturity are the same.

Source: Authors' computation.

Table 5. Results of Club Convergence on Three RMB Market Returns: The Case of Column 3 in Table 4

	$\log t$	t-stat.	Countries or Regions
2014/09/01~2016/5/20			
Club convergence	--	--	None
Independent trend	--	--	CNY, CNH, CNT

Source: Authors' computation.

Table 6. Results of the log t Test on Three RMB Market, LIBOR and the US TBR Returns

	2014/09/01 ~2017/12/20	2014/09/01 ~2015/6/30	2014/09/01 ~2016/5/20
C	ξ_1 (t-stat.)	ξ_1 (t-stat.)	ξ_1 (t-stat.)
0.20	0.15 (3.10)	-0.27 (-34.99)	-0.01 (-2.03)
0.21	0.16 (3.12)	-0.26 (-38.28)	-0.01 (-1.52)
0.22	0.16 (3.14)	-0.26 (-41.82)	0.00 (0.14)
0.23	0.17 (3.17)	-0.25 (-45.60)	0.01 (5.18)
0.24	0.17 (3.21)	-0.25 (-51.67)	0.01 (7.75)
0.25	0.18 (3.24)	-0.24 (-55.95)	0.02 (5.91)
0.26	0.18 (3.29)	-0.24 (-60.37)	0.02 (4.72)
0.27	0.19 (3.34)	-0.24 (-64.89)	0.03 (4.16)
0.28	0.19 (3.38)	-0.23 (-69.43)	0.03 (3.72)
0.29	0.20 (3.43)	-0.23 (-73.94)	0.04 (3.51)
0.30	0.20 (3.48)	-0.22 (-80.45)	0.04 (3.36)

Note:

1. Time period definitions are the same as those in Table 4.
2. This sample includes the SHIBOR, HIBOR, TAIBOR interest rates deduct from the change of log CNY, CNH, CNY, and also LIBOR deduct from the change of log UK exchange rate and US Treasury Bill rate.
3. Log t regressions are based on Equation (8). None of these results can accept the null hypothesis of return convergence.
4. Discarding some initial fraction of the time series data allows attention to be focused on the more recent changes, especially when the sample size is larger. Based on the simulation experience of Phillips and Sul (2007), c in the interval, 0.2 to 0.3, is a satisfactory choice, in terms of size and power.
5. Results are based on the interbank offered interest rate of 1-year maturity. The results of 1-month, 3-month and 6-month maturity are the same.

Source: Authors' computation.

Table 7. Results of Club Convergence on Three RMB Markets, LIBOR and the US TBR Returns: The Case of Column 2 in Table 6

	$\log t$	t-stat.	Countries or Regions
2014/09/01~2015/6/30			
Club convergence	1.43	(84.78)	CNY, CNH, CNT
Independent trends	--	--	LIBOR, TBR

Source: Authors' computation.

References

- Arslanalp, S., Liao, W., Piao, S., and Seneviratne, D. (2016). 'China's Growing Influence on Asian Financial Markets', IMF Working Paper 16/173.
- Bank of International Settlements (2016). 'Triennial central bank survey: Foreign exchange turnover in April 2016.' Monetary and Economic Department.
- Borsi, M. T. and Metiu, N. (2015). 'The Evolution of Economic Convergence in the European Union', *Empirical Economics*, 48(2), pp. 657-681.
- Branson, W. H., and Healy, C. N. (2005). 'Monetary and Exchange Rate Policy Coordination in ASEAN 1 (No. w11713)', National Bureau of Economic Research.
- Central Bank of Taiwan (2012). 'MOU for the Cross-strait Currency Settlement Mechanism', An online resource available at <https://www.cbc.gov.tw/content.asp?mp=1&CuItem=50689> (Last accessed: 2 March, 2016).
- Central Bank of Taiwan (2013). 'Taiwan Official RMB Market: Developments and Prospects', An online resource available at <http://www.cbc.gov.tw/fp.asp?fpage=cp&xItem=43203&ctNode=448&mp=1> (Last accessed: 2 March, 2016).
- Cheung, Y. W., and Rime, D. (2014). 'The offshore renminbi exchange rate: Microstructure and links to the onshore market', *Journal of International Money and Finance*, 49, pp.170-189.

Measuring RMB Market Integration & Interruption

- Ehrmann, M., Fratzscher, M., Gürkaynak, R. S. and Swanson, E. T. (2011). 'Convergence and Anchoring of Yield Curves in the Euro Area', *Review of Economics and Statistics*, 93(1), pp. 350-364.
- Feng, Y., and Zhang, T. (2016). 'Interest Rate Linkages between Offshore and Onshore Renminbi Markets', *Australian Economic Papers*, 55, pp.434– 450.
- Ferreira, A. L. and León-Ledesma, M. A. (2007). 'Does the Real Interest Parity Hypothesis Hold? Evidence for Developed and Emerging Markets', *Journal of International Money and Finance*, 26(3), pp. 364-382.
- Flood, R. P., and Marion, N. P. (2000). 'Self-fulfilling risk predictions:: an application to speculative attacks', *Journal of International Economics*, 50(1), pp.245-268.
- Fratzcher, M., and Mehl, A. (2014). 'China's dominance hypothesis and the emergence of a tri-polar global currency system', *The Economic Journal*, 124(581), pp.1343-1370.
- Funke, M, Shu, C, Cheng, X. and Eraslan, S. (2015). 'Assessing the CNH–CNY pricing differential: Role of fundamentals, contagion and policy', *Journal of International Money and Finance*, 59, pp. 245-262.
- Goldberg, L. G., Lothian, J. R. and Okunev, J. (2003). 'Has International Financial Integration Increased?' *Open Economies Review*, 14(3), pp. 299-317.
- He, D., and Liao, W. (2012). 'Asian business cycle synchronization'. *Pacific Economic Review*, 17(1), pp.106-135.
- HKEX (2017). The Liquidity Provision Mechanism for Offshore RMB Market-Current Status, Impact and Possible Improvements. Hong Kong Exchanges and Clearing Limited.

International Monetary Fund (2011). 'People's Republic of China: Spillover Report for the 2011 Article IV Consultation and Selected Issues'. IMF Country Report No. 11/193.

Kong, J., Phillips, P. C., and Sul, D. (2019). 'Weak σ -convergence: Theory and applications', *Journal of Econometrics*.

Lin, Y. C. and Yeh, K. C. (2016). 'The Impact of 2007/08 Financial Crisis on the Stability and Enlargement of the EMU', *Review of Development Economics*, 20(2), pp. 624-634.

Lin, Y.C. and Yeh, K.C. (2017). 'Measuring the end of the European financial crisis: A test for "ins" and "outs"', *Economics of Transition*, 25 (4), pp. 663-680.

McCauley, R. N. and Shu, C. (2018). 'Recent renminbi policy and currency co-movements', *Journal of International Money and Finance*. doi:10.1016/j.jimonfin.2018.03.006

Mwase, M., N'Diaye, M. P. M., Oura, M. H., Ricka, M. F., Svirydzenka, K., and Zhang, M. Y. S. (2016). 'Spillovers from China: financial channels', International Monetary Fund.

Obstfeld, M. and Taylor, A. M. (2002). 'Globalization and Capital Markets', *NBER Working Paper* 8846, An online resource available at <http://www.nber.org/papers/w8846.pdf> (Last accessed: 28 May, 2017).

Pesaran, M. H. (2007). 'A Pair-wise Approach to Testing for Output and Growth Convergence', *Journal of Econometrics*, 138(1), pp. 312-355.

Phillips, P. C. B. and Sul, D. (2007). 'Transition Modeling and Econometric Convergence Tests', *Econometrica*, 75(6), pp. 1771-1855.

Measuring RMB Market Integration & Interruption

- PwC (2017). 'M&A 2016 review and 2017 outlook', <https://www.pwccn.com/en/mergers-and-acquisitions/ma-press-briefing-jan2017.pdf>.
- Ren, Y., Chen, L., and Liu, Y. (2018). 'The Onshore–Offshore Exchange Rate Differential, Interest Rate Spreads, and Internationalization: Evidence from the Hong Kong Offshore Renminbi Market', *Emerging Markets Finance and Trade*, 54(13), pp.3100-3116.
- Shu, C., He, D., and Cheng, X. (2015). 'One currency, two markets: the renminbi's growing influence in Asia-Pacific', *China Economic Review*, 33, pp.163-178.
- Subramanian, A., and Kessler, M. (2013). 'The Renminbi Bloc is Here: Asia Down, Rest of the World to Go?' *Journal of Globalization and Development*, 4(1), pp.49-94.
- Yao, S., He, H., Chen, S., and Ou, J. (2018). 'Financial liberalization and cross-border market integration: Evidence from China's stock market', *International Review of Economics & Finance*, 58, pp.220-245.