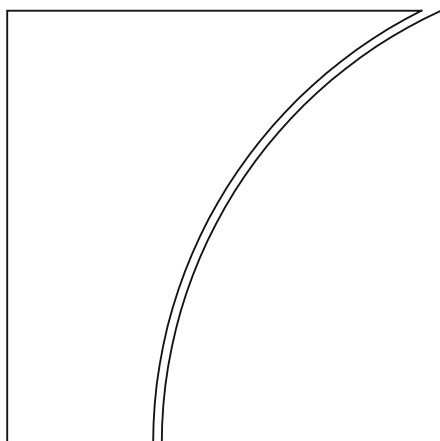




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# Recent RMB policy and currency co-movements

by Robert N McCauley and Chang Shu

Monetary and Economic Department

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JEL classification: F31, F33

Keywords: exchange-rate determination; renminbi (CNY) policy, renminbi zone, spillovers, renminbi internationalisation

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## Recent RMB policy and currency co-movements

Robert N McCauley and Chang Shu<sup>1</sup>

### Abstract

This study investigates how variation in the determinants of the renminbi's daily fixing since the August 2015 exchange rate reform maps on to variation in the co-movement of the renminbi with regional and other emerging market currencies. We first identify three post-reform periods of RMB management: transition, basket management and countercyclical management. The co-movement with regional and Latin American currencies peaked in the basket period, when the daily fixing was most predictable and multilateral. By contrast, the decline in co-movement in the countercyclical management period between May and July 2017 leaves it premature to speak of a renminbi zone. The dependence of the co-movements on renminbi management has important implications for renminbi internationalisation.

Keywords: exchange-rate determination; renminbi (CNY) policy, renminbi zone, spillovers, renminbi internationalisation

JEL classification: F31, F33

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## 1. Introduction

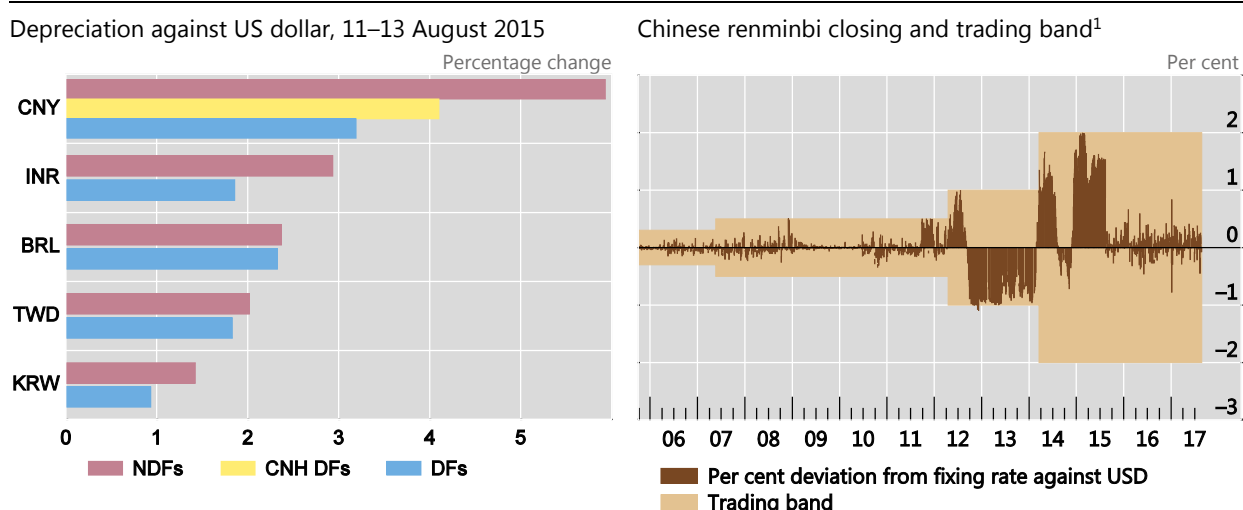
The proposition that the renminbi substantially co-moves with regional and other emerging market (EM) currencies was gaining traction by 2015. Such co-movement is generally interpreted as the renminbi's influence on other currencies, rather than the other way around. Since the work of Ho et al (2005), which pre-dated the renminbi's unpegging from the dollar in July 2005, Shu et al (2007), Ito (2010), Shu (2010), Pontines and Siregar (2012), Chen et al (2013) and Shu et al (2015) found co-movement between currencies in Asia and the renminbi. Fratzscher and Mehl (2014) termed this the "China dominance hypothesis", likening the renminbi's role in Asia to that of the Deutsche mark in Europe in the 1980s. Subramanian and Kessler (2013) entitled their study, "the renminbi bloc is here: Asia down, rest of the world to go?" Nonetheless, there were studies questioning this view: Ito (2008), Balasubramaniam et al (2011), and Kawai and Pontines (2016).

More recent studies find stronger evidence for the renminbi's impact by including in their samples the very striking co-movements observed during the second week of August 2015 (Eichengreen and Lombardi (2017), Ito (2017) and Marconi (2017)). During 11-13 August 2015, the onshore renminbi depreciated by 4% against the dollar, a record since the early 1990s, and offshore renminbi rates weakened even more. Many EM currencies shared the big move in a week dominated by the renminbi news (Graph 1, left-hand panel). These currencies depreciated, especially Asian currencies, notwithstanding reported foreign exchange (FX) market intervention by EM central banks to censor the move.

The depreciation accompanied what the central bank, People's Bank of China (PBoC), described as a reform of the mechanism to set a daily centre for the band of

Renminbi movements

Graph 1



NDFs = non-deliverable forwards; CNH DFs = offshore Chinese renminbi deliverable forwards; DFs = deliverable forwards.

<sup>1</sup> The trading band was from +/- 0.3% to +/- 0.5% on 21 May 2007, and then to +/- 1% on 16 April 2012. The recent change to +/- 2% was on 17 March 2014.

Source: Bloomberg.

permissible trading of the renminbi against the dollar. The new mechanism is designed to increase the influence of market forces and multilateral rates, by making reference to the previous day close and a currency basket in setting the central parity.

A key but implicit relationship in these studies is between the nature of renminbi management and the extent of its co-movement with other currencies (Ma and McCauley (2011)). At the limit, when the renminbi is practically pegged to the dollar, as in July 2008 to June 2010, one cannot distinguish its co-movement. More generally, if the management of the renminbi changes over time, it pays to identify those changes and to measure co-movement over sub-periods.

Ito (2017) and Marconi (2017) make the link by defining sub-periods in renminbi management, but their periodisation is not persuasive. Ito (2017) breaks the “managed float” period since June 2010 into sub-periods before and after the peak of the RMB/USD rate in January 2014. Such use of the bilateral rate disregards the role of the renminbi’s effective exchange rates in the PBoC’s characterisations of its policy.<sup>2</sup> Marconi (2017) defines four periods using the width of the RMB trading band announced by the PBoC, as shown in Graph 1, right-hand panel. In addition, she treats the post-August 2015 period as one sub-period. With this periodisation, the co-movement of other currencies with the renminbi turns out to be about equal over the sub-periods, except one.<sup>3</sup>

Our contribution is to draw the link between the predictability of the renminbi management and the strength of its co-movement with other EM currencies in Asia and Latin America. In defining the periods of renminbi management, we differ from Cheung et al (2017), who search for a single reaction function for the renminbi fixing. Instead, we join Clark (2017) in defining sub-periods that differ in the weights attached to the previous day’s close and currency basket – two elements emphasised by the PBoC. For the months since August 2015, we use a widely read interview of the PBoC Governor and a news report as prior break-points and regression analysis to confirm behavioural shifts. We then demonstrate that co-movements vary systematically over the resulting sub-periods. In particular, when the fixing most predictably reflected major currency moves, then the co-movements generally increased significantly.

The rest of this working paper proceeds as follows. Section 2 provides a primer on the renminbi complex of onshore and offshore rates and deliverable and non-deliverable forwards. Section 3 characterises features of three phases of renminbi management since August 2015. Then Section 4 discusses the interpretation of the co-movements of currencies in terms of fundamentals and policy. Section 5 then traces how changing RMB policy alters its co-movements with other EM currencies, relying on econometric tests of the evolving co-movements through different phases of the daily renminbi fixing. Section 6 concludes and draws implications for the uneven progress of renminbi internationalisation.

<sup>2</sup> Reports of the PBoC have regularly discussed the renminbi’s effective exchange rate since 2005. The fixing reform in August 2015 made the reference to effective exchange rates explicit. In December 2015, PBoC (2015) announced trade-based basket weights for the renminbi, alongside the BIS effective and the SDR value of the renminbi. The PBoC announced revised weights in December 2016. See Annex A for the compositions of the basket.

<sup>3</sup> Oddly, Marconi (2017) reports that the width of the band is *negatively* related to the volatility of the dollar/renminbi rate. Marconi (2017) also examines at co-movement at times of US dollar strength and weakness, following Ho et al (2005) and Pontines and Siregar (2012).

## 2. A primer on the renminbi foreign exchange complex

Trading in the Chinese renminbi has grown rapidly over the past decade both in the onshore and offshore markets. According to the Bank for International Settlements (BIS) triennial survey, by April 2016 the renminbi had become the most actively traded emerging market currency, with an average daily trading volume of \$202 billion (Table 1). Global trading rose by 65% in the three years to April 2016, almost doubling the renminbi's global share from 2.2% to 4%. In London, for which comparable reports span the longest period, renminbi trading has grown tenfold as a share of the market from 0.2% in April 2009 to a peak of 2.1% in October 2015 and has since slipped to 1.5% in April 2017.

This rapid growth reflects the expansion of the offshore renminbi markets, referred to as the CNH market. Renminbi FX spot and derivatives transactions have increasingly taken place in offshore locations since renminbi internationalisation began in earnest in 2010. Hong Kong, London, Singapore and New York have become the top centres. The daily turnover of spot transactions traded offshore had grown to USD 42.7 billion by 2016, 1.7 times of turnover in the onshore (CNY) market. Deliverable forwards reached USD 16.4 billion in the CNH market, dwarfing the CNY market's USD 1.3 billion.

### RMB market turnover

Average daily turnover in billions of US dollars

Table 1

	OTC spot	OTC FX swaps	OTC DFs	OTC NDFs <sup>1</sup>	Options <sup>2</sup>	Futures	OTC currency swaps	Total
<b>CNY</b>								
2013	20.1	10.5	2.6	0.0	0.3	0.0	0.0	33.5
2016	24.9	27.0	1.3	0.0	2.0	0.0	0.2	55.4
<i>% change, 2013-2016</i>	23.9	156.5	-51.4		569.3			65.1
<b>CNH</b>								
2013	13.9	29.4	8.4		16.8	0.0	0.5	69.0
2016	42.7	59.0	16.4		15.8	0.3	2.5	136.7
<i>% change, 2013-2016</i>	207.9	100.8	94.3		-5.6	578.4	383.6	98.1
<b>NDF</b>								
2013				17.1				17.1
2016				10.4				10.4
<i>% change, 2013-2016</i>				-39.4				-39.4

DFs = deliverable forwards; NDFs = non-deliverable forwards. Currency totals are reported on a "net-net" basis, ie adjusted for local and cross-border inter-dealer double-counting. Onshore is defined as all trades executed in the jurisdiction where a currency is issued on a "net-gross" basis (ie adjusted for local inter-dealer double-counting); offshore is calculated as the difference between the total for the currency on a net-net basis and onshore transactions.

<sup>1</sup> NDF turnover is against all currencies. <sup>2</sup> OTC options plus exchange-traded options.

Sources: Euromoney TRADEDATA; Futures Industry Association; The Options Clearing Corporation; BIS derivatives statistics and Triennial Central Bank Survey; authors' calculations.

Pricing gaps exist between the CNH and CNY markets. This pricing gap can be big and volatile even when there is no obvious market stress.<sup>4</sup> The pricing gaps can arise from differing responses to domestic and global conditions and narrow arbitrage channels (Funke et al (2015)). First, central bank intervention at times constrains the CNY market, where onshore participants trade. By contrast, market participants considered the CNH market to have been free of intervention before September 2015. Since then the PBOC reportedly has taken action in the offshore market when the onshore-offshore gap was large. Second, with no controls on capital movements, the CNH market is more tightly linked to global markets, and thus potentially more affected by external factors. The existence of effective, albeit leaky, capital controls in mainland China leads to two partially segmented markets where arbitrageurs cannot easily enforce the law of one price.

With renminbi internationalisation, the offshore CNH markets has grown at the expense of a third RMB market, non-deliverable forwards (NDFs). The BIS Triennial Survey shows that the RMB NDF shrank by close to 40% between 2013 and 2016, and its share in total RMB trading fell from 14% to 5%. This is in contrast to developments in other NDF markets (McCauley and Shu (2016b)): among the major NDF markets, NDFs gained share in the Brazilian real and Korean won, and retained shares in the Indian rupee, Russian rouble and Taiwan dollar in the same period. The NDF remains the modal FX instrument for major EM currencies other than the Mexican peso, Polish zloty, South African rand and the Turkish lira.

### 3. Evolving renminbi management

This section first describes the August 2015 reform of the daily fixing of the renminbi. Then it identifies three sub-periods since then, using PBoC statements. Finally, it shows that the determinants of the daily fix differ across the sub-periods.

#### 3.1 The August 2015 fixing reform

The August 2015 fixing reform took place against the background of the renminbi under pressure against the US dollar and considerable strengthening in effective terms. In the weeks leading up to the reform, the renminbi would often close near the (weak) margin of the 2% wide band, and the subsequent fixing would still occur not far from the previous fixing (Graph 1, right-hand panel). Yet it had gained by close to 15% since mid-2014 in effective terms.

The stated aim of the reform was twofold: to increase the influence of the market and that of major currency movements. The new fixing regime would take yesterday's close as a starting point, and thus help close the gap between the market value and fix. And the new regime would strengthen the link between the fixing and the effective exchange rate of the renminbi. Thus, the fixing would take into account the dollar's movement against major currencies since the previous fixing.

<sup>4</sup> To take one example, while on 24 January 2014 the offshore rate of 6.0391 renminbi to the US dollar was 97 pips (hundredths of Chinese cent or fen) below the onshore rate of 6.0488, by 7 February the gap had widened to nearly 400 pips (6.026 offshore vs. 6.063 onshore, or 2/3 of 1%). But only a few weeks later, the differential had declined again to 21 pips.

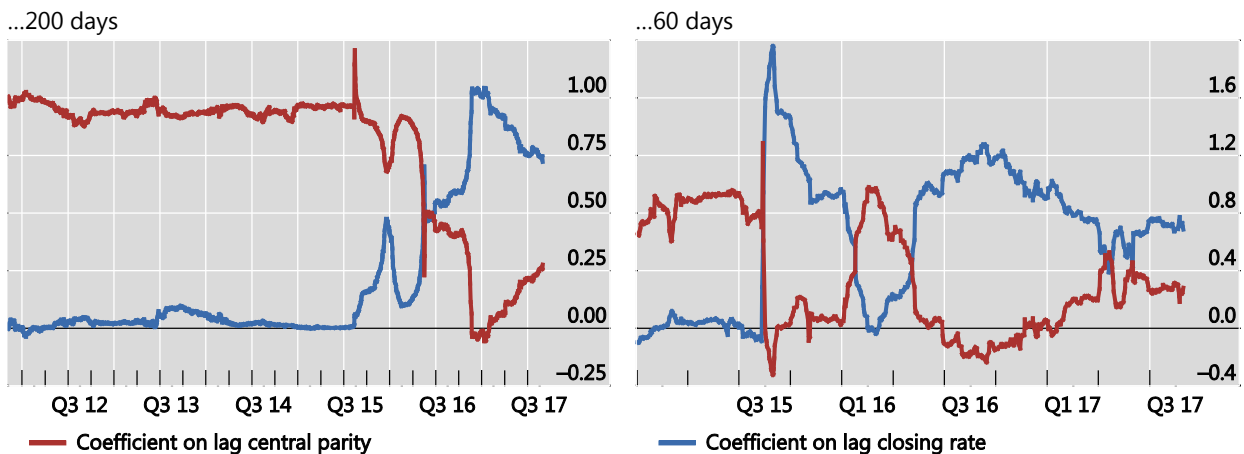


As a result of the reform, today's fixing now occurs not far from yesterday's market closing (Graph 1, right-hand panel). Graph 2, left-hand panel, updates a simple 200-day rolling regression introduced in July 2015 (IMF (2015)). Before August 2015, the fixing put zero weight on the previous day's close; after, a weight that reached one in 2016. On this measure, introduced ex ante, the fixing came after August 2015 to reflect market outcomes. That said, since the reform, market participants report official intervention that at times resists the rate's trading away from the fixing.<sup>5</sup> The fixing may be closer to the market, but the authorities can influence the market.

## Role of yesterday's fixing/closing CNY rate in today's fixing rate

Coefficient estimated over window of...

Graph 2



Note: Coefficients estimated from  $\log \text{fixing}(t) = a * \log \text{fixing}(t-1) + b * \log \text{closing rate}(t-1) + c$

Sources: Update of IMF (2015) using Bloomberg; BIS calculations.

### 3.2 Three phases since August 2015

The renminbi exchange rate policy has evidently evolved and varied in its focus on the two elements since the fixing reform. Public statements of the PBoC allow us to identify three phases of renminbi management since August 2015. (Below, we also consider another phase that captures some subtle changes in fixing behaviour.)

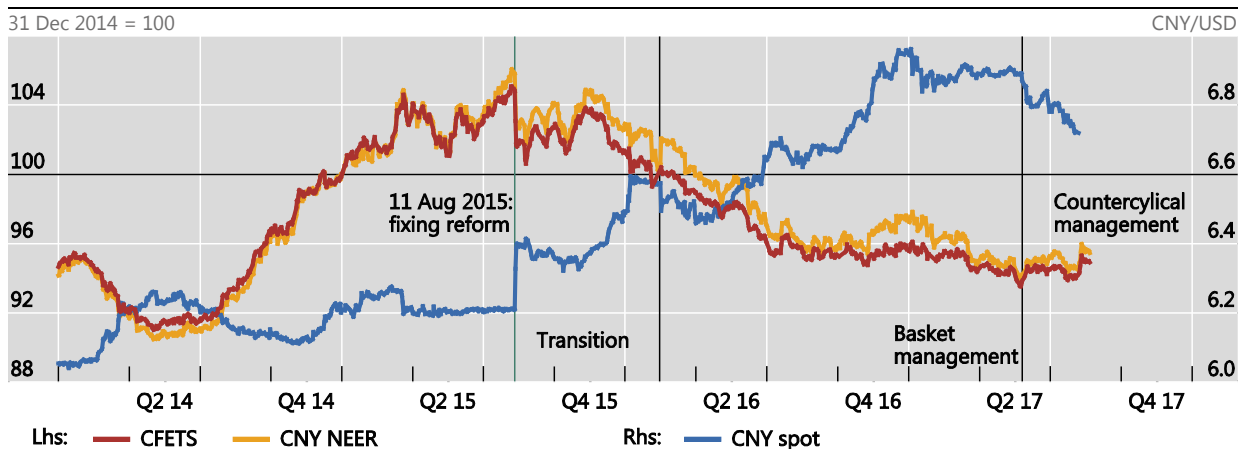
*Stabilisation and transition, August 2015-February 2016:* In the few months after the fixing reform,<sup>6</sup> market participants sought to understand the new fixing mechanism and its implications for the renminbi's trend. From mid-August into the fourth quarter, the bilateral rate against the dollar showed stability, while the effective renminbi moved around (Graph 3). In November 2015, the renminbi/dollar started to depreciate, and took a big step down around the turn of the year, which unsettled market participants. January 2016 featured highly volatile global financial markets. Yet by the time of the G20 meeting in Shanghai in February, market participants focused on a clear characterisation of the fixing mechanism, and a new phase began.

<sup>5</sup> The IMF staff (2015) discussed a rule-bound intervention policy to constrain such resistance.

<sup>6</sup> Unlike Marconi (2017) this period excludes data for the big moves of 11-17 August 2015.

## Phases of RMB management

Graph 3



Source: Bloomberg, BIS.

On 11 December, the China Foreign Exchange rate Trade System (CFETS), a People's Bank of China affiliate, published an effective exchange rate index for the renminbi based on the currencies traded on the CFETS against the renminbi (People's Bank of China (2015)). This criterion for inclusion led to commentary at the time that the index was flawed – the currency of large trading partner South Korea would only be added later (Annex A) – but the graphs showing how it tracked the BIS effective renminbi suggested that any lacunae were not material.

In this period the central bank reportedly squeezed the CNH market. Since its inception in 2010, this market was viewed as only indirectly influenced by the central bank. Yet in late September a sudden CNH appreciation coincided with a spike in CNH interest rates, and these were widely interpreted as a squeeze to narrow the CNH-CNY rate gap. A similar episode of an apparent double squeeze in the CNH and money market also occurred in January 2016, again when the CNH was trading at a depreciated rate relative to the CNY.

*Basket management, February 2016 to May 2017:* We take the interview that Governor Zhou (2016) gave to an influential domestic financial magazine – with an English translation posted on the PBoC website on 14 February – to mark the beginning of this phase. He emphasised the importance of multilateral exchange rates, suggesting that maintaining stability of the currency basket would be the “keynote” of the renminbi policy framework. At the same time, the influence of yesterday's close evidently gained from February (rising blue line on Graph 2, right-hand panel). Within major global banks, analysts became able to provide trading desks with accurate forecasts of the fixing during this period. Such predictability led market participants to shift their attention elsewhere; the effective depreciation of the renminbi in the first half of 2016 was little remarked.

In the third and fourth quarters of 2016, a resurgent dollar meant that stability of the renminbi in effective terms was associated with bilateral depreciation. Much commentary focused on the approach of the RMB/USD to 7, and official foreign exchange reserves' falling below \$3 trillion. While at times in 2017 the renminbi/dollar hardly moved, on balance the effective exchange rate remained stable.

“Countercyclical” management, May 2017-July 2017: On 25 May, Bloomberg reported that the PBoC had introduced a “countercyclical factor” into the fixing mechanism (Reuters Staff (2017)). Market participants interpreted the source for the report as one of the banks that participates in the panel that provides quotes that the CFETS uses to fix the central parity. Subsequently, the *Monetary Policy Report Quarter 2* (PBoC (2017, pp 23-26)), released 11 August, devoted a box to the rationale. The countercyclical adjustment aimed to stem “procyclicality” and “irrational expectations” that lead to “herding”, a self-reinforcing “one-sided market” and “overshooting”. The idea was that depreciation of the exchange rate during a day should not necessarily be validated by incorporation in the next fixing if the economic fundamentals do not warrant it. This change in the mechanism coincided with general dollar depreciation and the renminbi strengthened against the dollar in May-July 2017, while remaining basically stable against its trade-weighted basket.

The three phases differ in the relationship between the renminbi’s volatility against the dollar and the renminbi basket. In the transition and countercyclical management phases, the volatility of the trade-weighted basket exceeded that of the bilateral dollar rate. Only in the basket management period did the volatility of the basket fall below that of the bilateral rate against the dollar.

Renminbi descriptive statistics in three phases after August 2015

Table 2

	Transition (18/8/2015-13/2/16)	Basket management (14/2/2016-25/5/2017)	Countercyclical management (26/5/2017-1/8/2017)
Bilateral dollar rate			
Mean	6.432	6.730	6.789
Mean change	0.010	0.018	-0.048
Annualised volatility	2.9	2.9	2.5
CFETS basket			
Mean	116.026	109.467	107.547
Mean change	-0.011	-0.024	0.013
Annualised volatility	4.0	2.7	2.7

Sources: CFETS; authors’ estimation.

### 3.3 Model for renminbi fixing

To demonstrate that the periods that we have defined show different reaction functions for the renminbi fixing, we run a simple regression:

$$(1) \text{fix}_t - \text{fix}_{t-1} = \alpha_0 + \beta_1 * (\text{close}_{t-1} - \text{fix}_{t-1}) + \beta_2 * \Delta \text{cfets}_t + \varepsilon_t.$$

In Equation (1),  $\text{fix}_t$ ,  $\text{close}_{t-1}$  and  $\text{fix}_{t-1}$  are today’s RMB fixing rate, yesterday’s closing rate, and yesterday’s fixing rate, respectively. For its part,  $\Delta \text{cfets}_t$  denotes the percentage change in the RMB basket as specified by the PBoC. Thus, the daily fixing rate announced at 09:15 this morning is regressed on the percentage change of yesterday’s close from yesterday’s fixing, as well as the overnight change in the renminbi basket. We estimate Equation 1 with ordinary least squares using daily data between 18 August 2015 and 1 August 2017.

While adopting a straightforward framework, we improve the precision of the modelling by carefully choosing the information set available to the policymakers. We

use the daily close rate from Shanghai at 16:30 local time (GMT 08:30), as reported by the CFETS. In calculating the renminbi basket, we use exchange rates at the Tokyo open (09:00 Tokyo time and GMT 00:00), as reported by the Bank of Japan. This is one hour ahead of the time when the CFETS sets the fixing based on the participating banks' submission at 09:00 Shanghai time (GMT 01:00).

The estimates show the market, or at least the daily close, rose in February 2016, and only declined marginally from May 2017 (Table 3). In particular, only about a third of yesterday's change from fixing to close was reflected in today's fixing between August 2015 and February 2016; after that, all of it was. With the onset of the countercyclical management in May 2017, this ratio declined to 0.86.<sup>7</sup> Along with a lesser pass-through of market movements, this last period also shows a significant constant with a negative sign, indicating on average the fixing was stronger than called for the by market movements. This is consistent with the fixing leaning against depreciation expectations in this period. Overall, the role of the closing was strongest in the basket management period, somewhat less strong in the countercyclical management period, and weakest in the transition period.

For the present purposes, the key difference that sets the periods apart is the role of the effective exchange rate. In particular, the coefficient on the daily change of the CFETS basket is zero in the transition and countercyclical periods but highly significant in the basket management period. Then, the fixing systematically offset a fifth of the renminbi's movements against its basket. In other words, the fixing took account of the dollar's movement against major currencies to adjust the bilateral fixing to stabilise the renminbi's effective exchange rate.

In sum, we find that the authorities' self-description can be used to estimate different reaction functions to movements in the market value of the renminbi and to movements of major currencies against the dollar. Unlike Cheung et al (2017), we allow the evolving self-description to express itself in different weights on the two elements of the fixing reform. Taking into account this evolution, the estimated reaction function shows a quite high adjusted R-squared since February 2016. Two-thirds to three-quarters of the variance in the fixing is accounted for by the previous day's market move and broader exchange rate changes.

RMB fixing in three phases after August 2015<sup>1</sup>

Table 3

	Transition (18/8/2015-13/2/2016)	Basket management (14/2/2016-25/5/2017)	Countercyclical management (26/5/2017-4/8/2017)
Constant	-0.018	-0.035***	-0.111***
CNY (close - fix) <sub>t-1</sub>	0.364***	0.992***	0.856***
Change in CFETS	-0.009	0.193***	-0.119
No. of observations	118	303	48
Adjusted R-squared	0.234	0.668	0.753
Durbin-Watson statistics	1.203	1.828	1.864

<sup>1</sup> \*\*\* indicates significance at 1% level.

Source: authors' estimation.

<sup>7</sup> Given the 0.041 standard error, the estimated  $\beta_1$  of 0.992 for the basket management period is not statistically different from 1. By contrast, the estimate of 0.856 for the countercyclical management period is statistically significantly below 1.

## 4. How to interpret co-movement of RMB and EM FX?

Before we measure the association of renminbi exchange rate changes and those of other currencies, it is worthwhile considering the interpretation of the association. Galati (2001) found that trade links, business cycle correlations, exchange rate policy and portfolio biases explained the co-movement of currencies with the Deutsche mark against the dollar. Subramanian and Kessler (2013) found trade links matter. Eichengreen and Lombardi (2017) found that financial links as proxied by stock market correlations matter. In sum, trade links, correlation of business cycles, financial links and monetary policy explain co-movements. These four forces turn up in either market movements or currency management. Let us consider each in turn.

As China has grown and its roles as competitor, partner and supplier vis-à-vis trading partners have gained importance, one would expect the links between their currencies and the renminbi to strengthen. Currencies of the economies that are in the same product chain as China may respond to common shocks in the same way as the renminbi. In addition, the currencies of commodity producers for whom China is the main marginal consumer, eg Brazil or Chile, may respond to Chinese news.<sup>8</sup>

In principle, the gravity model for international trade implies a reciprocal relationship. In practice, China's significant weight in the global economy ("mass") suggests that the renminbi should exert more influence on other EM currencies than the EM economies exert on it. For instance, consider Korea, the largest of China's EM neighbours. Based on 2011-13 trade, the BIS weight on the renminbi in Korea's effective exchange rate is no less than 30%. By contrast the weight on the Korean won in the renminbi's effective rate is just 8.5%.<sup>9</sup> The disparity is greater elsewhere in Asia.

The second force that leads to closer associations of renminbi and other EM currencies is correlation of business cycles. To some extent, the deeper trade links lead to more aligned business cycles. Galati (2001), however, found that correlation of cyclical fluctuations explained the co-movement of a currency with the Deutsche mark against the dollar, even controlling for trade links. In Asia, He and Liao (2012) showed that EM business cycles were strongly interdependent.

The third force that leads to greater currency co-movement is financial links and portfolio behaviour. The ongoing renminbi internationalisation may allow financial links to strengthen and the currency co-movements to tighten. In particular, the link between the Shanghai and Hong Kong SAR stock markets could raise equity market correlations. With regard to bond markets, research from around the turn of the century found China's bonds moved idiosyncratically (McCauley and Jiang (2004)). More recently, Glick and Hutchison (2013) and Shu et al (2016) found still weak links between bond yields in China and elsewhere. With the recent bond connect scheme, one can anticipate that the Chinese bonds will track international bond market developments more and eventually influence other, especially neighbouring, bond markets.

A fourth force is similarity of monetary policy, in particular, follow the leader behaviour in interest rate setting. Hofmann and Bogdanova (2012) find that

<sup>8</sup> See Stuermer (2017). Baum et al (2015) find the largest effects of Chinese macro news on the commodity currencies, the Australian and New Zealand dollars. They do not consider EM currencies.

<sup>9</sup> The weights are from the BIS effective exchange rates for the Korean won and renminbi. See <http://www.bis.org/statistics/eer.htm?m=6%7C187>.

deviations of EM central banks from (previously tracking) Taylor rules are associated with the Federal Reserve's deviation from its Taylor rule. If Asian central banks put less weight on the Federal Reserve policy and more on the PBoC policy, one would expect it to show up in currency co-movements.

These four forces underlie either market movements or exchange rate policy. For example, since 1992, the Bank of England has not intervened in the foreign exchange market. So trade links, business cycle correlation, financial links and Bank of England monetary policy (in relation to those of the ECB and the Federal Reserve) have had full sway. Most of the time, the pound shares most of the euro's movements against the dollar, in rough alignment with the larger UK trade share with Europe than with North America.

Elsewhere, and not least in Asia, authorities more or less manage their exchange rate in order to achieve price stability or to maintain competitiveness. In Asia, Singapore stands out in its *basket, band, crawl* (aka BBC) policy of managing the exchange rate in a Taylor-rule like manner. Other authorities include the renminbi in the basket of currencies that they track more implicitly, again with the aim of maintaining either price stability or competitiveness in highly open economies. As trade with China has increased, explicit or implicit weights on the renminbi have risen.

In sum, the co-movement of currencies reflect multiple factors. Trade links and business cycle alignment may matter most, but policy reactions and financial links play important roles.

## 5. Mapping RMB management to currency co-movements

This section examines how the renminbi broadly co-moved with other EM currencies before and after August 2015. Then it examines such co-movement in the three different phases of renminbi management since August 2015, as discussed above.

### 5.1 Methodology and data

We use the workhorse model of Haldane and Hall (1991) and Frankel and Wei (1994):

$$(2) \Delta em_t = \alpha_0 + \beta_1 * \Delta rmb_t + \beta_2 * \Delta eur_t + \beta_3 * \Delta jpy_t + \beta_4 * \Delta vix_t + \varepsilon_t.$$

In Equation (2),  $\Delta em_t$  is the daily percentage change of an EM currency vis-à-vis the US dollar, and  $\Delta rmb_t$ ,  $\Delta eur_t$  and  $\Delta jpy_t$  are the daily changes of, respectively, the renminbi, euro and Japanese yen vis-à-vis the US dollar. We consider three RMB rates: CNY, CNH and NDF rates. The first two are taken as the spot rate, and the last as the 1-month NDF rates. We analyse EM currencies with a significant NDF market, including six Asian currencies (ie the Indonesian rupiah, Indian rupee, Korean won, Malaysian ringgit, Philippine peso and Taiwan dollar) and five non-Asian currencies (ie the Brazilian real, Chilean peso, Colombian peso, Peruvian sol and Russian rouble).

We estimate the regression over panels and for individual currencies, focusing on  $\beta_1$  – the co-movement coefficient between the renminbi and other EM currencies.

We examine it across renminbi management phases, currencies, regions and instruments.

The US dollar, the most important currency for all EM currencies outside of Europe, is used as the numeraire. Thus the null hypothesis is that the currency in question moves only idiosyncratically against the dollar (Verdelhan (2018)). And, unlike using the SDR, Swiss franc or the New Zealand dollar as numeraire, currencies with an estimated  $\beta_1$  in excess of half can immediately be interpreted as lying more in the renminbi zone than in the dollar zone. The widely used fear index – VIX index – is included to control for global factors, since some EM currencies are known to depreciate during “risk-off” episodes (De Bock and de Carvalho Filho (2015)).

## 5.2 Before and after August 2015: benchmark results

We first test whether August 2015 marks a break in the co-movement of the renminbi and EM currencies. Equation (3) is run for panels and individual currencies to compare responses in January 2014-August 2015 and August 2015-July 2017.

The panel estimation suggests that in aggregate both the Asian and the non-Asian currencies show a greater response to the CNY after August 2015 (Table 4). For Asian currencies,  $\beta_1$ , already significant before the reform, rises from 0.42 to 0.77.

The rise in  $\beta_1$  for the non-Asian currencies is even more notable from statistical insignificance before to a highly significant at 0.97 after August 2015. The rise in the adjusted R-squared for both panels point to a better fit of the model.

Individual currency regressions generally show a strengthening of the effect of the CNY, often at the expense of the yen and in some cases at the expense of the euro (Table 5). The estimates show that renminbi impact has gained both in the extensive and intensive margins. For all the five non-Asian currencies,  $\beta_1$  is not significant before the reform, but becomes significant after the reform; the  $\beta_1$ s for Asian currencies are significant before the reform, and increase in magnitude in all the six cases since. Among these currencies, the Korean won and Malaysian ringgit have the biggest rise in  $\beta_1$  in the period after.

Co-movements of CNY with other currencies: before and after August 2015<sup>1</sup> Table 4

	Before 8.11 1/1/2014-10/8/2015		After 8.11 18/8/2015-1/8/2017	
	Asia	Non-Asia	Asia	Non-Asia
CNY	0.42***	-0.06	0.77***	0.97***
EUR	0.08***	0.14***	0.19***	0.06
JPY	0.13***	-0.06	-0.07***	-0.09***
VIX	0.0003	0.001	0.003***	-0.003
Adjusted R-squared	0.08	0.004	0.13	0.04
Country effect	Yes	Yes	Yes	Yes
Number of countries	6	5	6	5
Number of observations	2,480	2,036	2,457	2,500

<sup>1</sup> \*\*\* indicates significance at the 1% level.

Source: authors' estimation.

CNY co-movements with individual currencies across different periods<sup>1</sup>

Table 5

	Asia					
	IDR	INR	KRW	MYR	PHP	TWD
Before 8.11	0.67***	0.12	0.53***	0.49***	0.30***	0.37***
After 8.11	0.73***	0.44***	1.26***	1.02***	0.40***	0.72***
Transition	0.89***	0.18*	0.65**	1.26***	0.43***	0.43**
Basket management	0.51***	0.43***	1.34***	0.84***	0.24**	0.81***
Countercyclical management	0.30**	0.22	0.83**	0.26*	0.28	0.54**
	Non-Asia					
	BRL	CLP	COP	PEN	RUB	
Before 8.11	-0.09	-0.004	-0.20	-0.06	0.04	
After 8.11	0.99***	0.68***	1.03***	0.30***	1.85***	
Transition	0.60	0.59**	0.74	0.09	1.67***	
Basket management	0.94**	0.61***	0.94**	0.18	1.50***	
Countercyclical management	0.56	0.04	-0.24	0.21	0.09	

<sup>1</sup> \*, \*\*, \*\*\* indicate significance at 10%, 5% and 1% levels, respectively.

Source: authors' estimation.

Separate regressions suggest that the onshore CNY's relationship with EM currencies strengthened more than those of the offshore CNH or NDF (Table 4). The  $\beta_1$  between the CNH and non-Asian currencies became significant in the post-reform period, but, at 0.24, it increases to a small extent compared to that of the CNY. The  $\beta_1$  on the CNH actually declines in the Asian panel after the reform. The case is similar for the NDF.

One interpretation is that the August 2015 reform strengthened the pricing signal in the onshore rate. For its part, the decline in the relative impact of the CNH rates may reflect the noise introduced by liquidity squeezes in September 2015, January 2016 and January 2017. These not only diluted its former status as a purely market determined rate, but also introduced sharp movements not shared by the onshore rate (Funke et al (2015)). For its part, the NDF has suffered a progressive loss of market share in the renminbi complex (Graph 4 in McCauley and Shu (2016b)). The upshot is that what happens in Shanghai now seems more important for EM currencies than what happens in Hong Kong SAR or elsewhere offshore.



Co-movements of CNY, CNH and NDF rates with other currencies before and after August 2015

Table 6

	Before 8.11 1/1/2014-10/8/2015		After 8.11 18/8/2015-1/8/2017	
	Asia	Non-Asia	Asia	Non-Asia
	CNY	0.42***	-0.06	0.77***
CNH	0.53***	0.14	0.36***	0.24***
NDF	1.37***	1.36	0.93***	0.56***

<sup>1</sup> \*\*\* indicates the significance level at the 1% level.

Source: authors' estimation.

### 5.3 Three phases since August 2015: benchmark results

Despite the evident shift in the co-movement of the renminbi and other EM currencies after August 2015, the process has not been monotonic. In particular,  $\beta_1$  generally falls below 0.5 for the countercyclical period, putting in doubt claims of a renminbi zone. The dollar zone has staged a comeback in the latest data.

This is evident in estimation of Equation (3) over the three sub-periods since the fixing reform (Table 7). The CNY has the greatest co-movements with EM currencies during the basket management period. For the Asian panel, the  $\beta_1$  is similar for the transition and basket management periods, 0.64 and 0.69, but drops to 0.40 in the countercyclical management period. For the non-Asian panel,  $\beta_1$  is highly significant at 0.83 in the basket management period, but becomes insignificant in the countercyclical management period. An F test confirms a break of the basket and countercyclical management periods for the Asian panel ( $F(11, 2228)=4.31$ ; significant at the 1% level). The case is more on the borderline for the non-Asian panel ( $F(10, 1839)=1.58$ , compared to the critical value of 1.66 at the 10% significance level).

There are clearer indications of a break in  $\beta_1$  in the last two periods. This is confirmed for the non-Asian panel given  $\beta_1$ 's significance in the basket management period, but insignificance in the countercyclical management period.

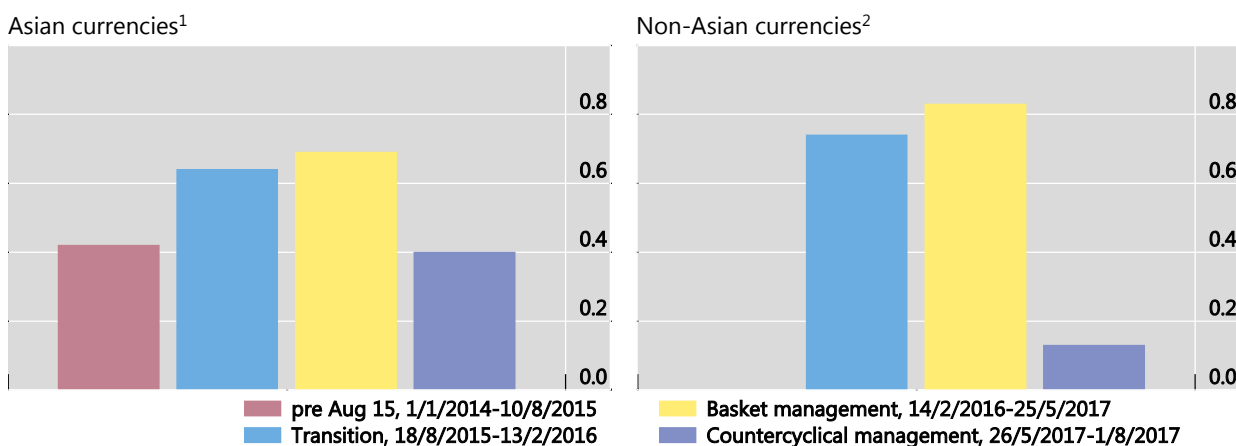
### Co-movements of CNY with other currencies in three phases after August 2015<sup>1</sup>

Table 7

	Transition (18/8/2015-13/2/2016)		Basket management (14/2/16-25/5/2017)		Countercyclical management (26/5/17-1/8/2017)	
	Asia	Non-Asia	Asia	Non-Asia	Asia	Non-Asia
CNY	0.64***	0.74***	0.69***	0.83***	0.40***	0.13
EUR	0.15***	0.05	0.27***	0.15	-0.01	0.05
JPY	-0.15***	-0.37***	-0.06***	-0.03	0.07**	0.08
VIX	0.01***	-0.003	0.001	-0.004	-0.002	0.01*
Adjusted R-squared	0.07	0.06	0.25	0.06	0.08	0.03
Country effect	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	6	5	6	5	6	5
Number of observations	782	641	1,280	1,621	1,058	238

<sup>1</sup> \*, \*\*, \*\*\* indicate significance at 10%, 5% and 1% levels, respectively.

Source: authors' estimation.



Note: Bars show estimated coefficient,  $\beta_1$  for the change in the RMB/USD rate from equation 2.

<sup>1</sup> Include IDR, INR, KRW, MYR, PHP and TWD. <sup>2</sup> Include BRL, CLP, COP, PEN and RUB.

Source: authors' calculations.

To test whether  $\beta_1$  significantly differs across periods, Equation (3) is estimated over the combined sample of the basket and countercyclical management periods, but adding an interactive term of a dummy variable taking the value of 1 for the countercyclical management with the daily change in the CNY. The interactive term is negative and highly significant, suggesting the  $\beta_1$  indeed drops in the final phase of post reform RMB management.

In sum, our panel analysis finds that both Asian and non-Asian currencies shared most of the renminbi's movements against the dollar in the transition and basket management phases (Graph 4). One can take this as evidence of a renminbi zone, in the sense of a sizeable group of currencies for which  $\beta_1 \geq 0.5$ . We do not find such evidence for the 19 months before August 2015, or for the latest, countercyclical, phase. Moreover, the differences between the periods are even starker for the non-Asian currencies than for the Asian ones. Thus, emerging market currencies *can* track the renminbi, but on the evidence reviewed, do not do so consistently.

The estimation over the three periods is also carried out at the individual currency level (Table 4). For four non-Asian currencies and two Asian currencies,  $\beta_1$  is significant in the basket management period, but becomes insignificant in the countercyclical management period. The Indonesia rupiah, Korean won, Malaysia ringgit and Taiwan dollar remain affected by the renminbi, but  $\beta_1$  also falls notably.  $\beta_1$  remains above 0.5 only for the Korean won and Taiwan dollar: a northeast Asian renminbi zone.

The trends are similar for the CNH rate (Table 8), although its  $\beta_1$ s with other EM currencies are smaller than those of the CNY in all the periods. The  $\beta_1$  for the renminbi NDF with other EM currencies shows interesting features. It remains broadly the same in the countercyclical factor period from the basket management period (Asian currencies: 0.78 vs 0.81; non-Asian currencies: 0.62 vs 0.68). The interactive term of the time dummy for the countercyclical period with the change in the NDF rate is not significant for non-Asian currencies. It is significant at the panel for Asian

currencies; at the individual currency level, the  $\beta_1$  for most NDFs do not decline. The exceptions are the Malaysian ringgit and Taiwan dollars.

One way of reading the results is that the CNY rate has the bigger impact on other currencies when its management puts more weight on multilateral exchange rates and predictability. In periods when the fixing is less understood, its global impact diminishes. The CNH used to be considered as better reflecting market conditions, and normally showed greater co-movements (Shu et al (2015)). Yet this role may have been eroded by liquidity squeezes in the CNH market. Such noise apart, its alignment with the onshore rate leaves its co-movements to follow those of the CNY rate. At times when the exchange rate policy is not clear, the NDF market appears to be considered more representative and to project greater influence.<sup>10</sup>

Co-movements of CNY, CNH and NDF rates with other currencies in three phases after August 2015<sup>1</sup>

Table 8

	Transition (18/8/15- 13/2/16)		Basket management (14/2/16-25/5/17)		Countercyclical management (26/5/17-1/8/2017)	
	Asia	Non-Asia	Asia	Non-Asia	Asia	Non-Asia
CNY	1.00***	1.04***	0.60***	0.75***	0.41***	0.35
CNH	0.42***	0.32**	0.28***	0.13*	0.28***	0.20
NDF	0.87***	0.15	0.82***	0.57***	1.05***	1.03***

<sup>1</sup> \*, \*\*, \*\*\* indicate significance at 10%, 5% and 1% levels, respectively.

Source: authors' estimation.

## 5.4 Robustness check: four periods?

We consider another phase in post-reform RMB management between 4 January 2017 and 25 May 2017, when renminbi/dollar rate was quite stable. Some interpreted this stability as an effort to avoid potential currency frictions with the new US administration. Others, as an effort to stabilise expectations against the background of large repayments of dollar debt by Chinese firms (McCauley and Shu (2016a)) and the decline of China's FX reserves to \$3 trillion. Market participants also reported that yesterday's fixing seemed to be gaining influence on today's fixing in this period (as indicated by the rising red line in Graph 2, right-hand panel).

The regression results, available on request, confirm our finding that the co-movements of the renminbi with other EM currencies have declined since the introduction of the countercyclical factor. It enriches the story by showing the smaller co-movement in the USD stability period. The evidence can be read to suggest that RMB influence on other currencies strengthens when the currency is managed in a more multilateral and predictable fashion.

<sup>10</sup> See Minikin and Cheung (2017) for a discussion of the NDF's revival.

## 5.5 Robustness check: new phase starts before announcements

It is suggested that both basket management and countercyclical management were already in place before their respective announcements. Graph 2, right-hand panel, shows the weight on the lagged fixing as rising even before the late May announcement. We re-define the three periods to reflect this possibility. Estimates based on the new sub-samples are broadly similar to the benchmark results (Annex B, Tables B1 and B2).

## 6. Concluding remarks

This study is the first to explicitly link co-movements between the renminbi and other EM currencies with RMB management. Focusing on the experience since the August 2015 fixing reform, the determination of the RMB fixing has changed tack across the transition, basket management and countercyclical management periods. It is during the basket management period that the fixing seems to have paid greatest attention to market movements, both bilateral and multilateral.

As the renminbi's management has evolved, its co-movement with Asian and non-Asian currencies has evolved. The period of most predictable and multilateral management of the renminbi corresponded to the highest co-movement. And interestingly, the period of minimum co-movement is observed not when the renminbi is most stable against the dollar, but rather during the period of the countercyclical management of the renminbi. One might venture the interpretation that a more calculable fixing led market participants and authorities elsewhere to incorporate onshore renminbi movements into the pricing of other currencies. At the same time, offshore renminbi markets seem to have lost their influence, or at least their co-movement with EM currencies, as the signal from the onshore market became clearer after August 2015.

The key message of our analysis is that it is premature to declare a stable renminbi zone, defined as a set of jurisdictions with currencies that share more than half of the renminbi's movements against the dollar (ie for which  $\beta_1$  exceeds 0.5). Such a zone has the force of trade links, business cycle correlations and possibly increased financial links behind it, but it evidently depends on a multilateral and predictable management of the renminbi's exchange rate. In the period since May 2017, our estimates of  $\beta_1$  suggest a strictly northeast Asian renminbi zone.

A finding of broader co-movement would have implications for renminbi internationalisation. Greater co-movements between EM currencies and the renminbi would help promote renminbi internationalisation to the extent that it attracts EM investors to hold renminbi-denominated bonds. They might do so because in their numeraire, namely their domestic currency, renminbi bonds would have lower realised exchange rate risk relative to dollar bonds.<sup>11</sup>

<sup>11</sup> Very limited evidence on the currency composition of official foreign exchange reserves shows a strong association between the dollar share of such reserves and the weight of the dollar in the movements of the domestic currency (McCauley and Chan (2014); Ito et al (2015)). This alignment of portfolios and domestic currency co-movement is also observed in largely private portfolios, ie in the dollar share of claims on BIS-reporting banks by country.

The same logic should apply to borrowers when the domestic currency moves with the renminbi against the dollar. Once  $\beta_1 > 0.5$  unhedged borrowing in the renminbi would pose less foreign exchange rate risk than unhedged borrowing in the dollar. McCauley and Chan (2014) show a strong, positive relationship between the dollar share of external bank liabilities and of international bond issuance, on the one hand, and the degree of co-movement of domestic currency with the dollar, on the other.<sup>12</sup>

Thus, over time, co-movement of the renminbi and other EM currencies can exert strong portfolio effects. These in turn could encourage the use of the renminbi both as a currency for international investment and for borrowing.

<sup>12</sup> Causation can run in both directions. The authorities may manage the currency to shield dollar borrowers from exchange-rate valuation losses. And portfolio managers may respond to the experience of lower exchange-rate risk in one currency by investing or borrowing in it. McCauley and Chan (2014) report that after Sweden's and Japan's currency joined the sterling area, their official foreign exchange reserves were shifted into sterling, which suggested portfolios adjusting to co-movements.

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## Annex A: Composition of CFETS renminbi baskets

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### CFETS 13-currency basket<sup>1</sup>

Table A1

USD	EUR	JPY	HKD	AUD	MYR	RUB	GBP	SGD	THB	CAD	CHF	NZD
26.4	21.39	14.68	6.55	6.27	4.67	4.36	3.86	3.82	3.33	2.53	1.51	0.65

<sup>1</sup> Since 11 December 2015.

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### CFETS 24-currency basket<sup>1</sup>

Table A2

USD	EUR	JPY	KRW	AUD	HKD	MYR	SGD	GBP	THB	RUB	CAD	
22.4	16.34	11.53	10.77	4.4	4.28	3.75	3.21	3.16	2.91	2.63	2.15	
SAR	AED	ZAR	CHF	MXN	TRY	PLN	SEK	NZD	DKK	HUF	NOK	
1.99		1.87	1.78	1.71	1.69	0.83	0.66	0.52	0.44	0.40	0.31	0.27

<sup>1</sup> Since 1 January 2017.

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## Annex B: Robustness check tables: phases start earlier

Renminbi fixing after August 2015 with phases starting earlier<sup>1</sup>

Table B1

	Transition (18/8/2015-13/1/2016)	Basket management (14/1/2016-25/4/2017)	Countercyclical management (26/4/2017-4/8/2017)
Constant	-0.018*	0.038***	-0.112***
CNY (close - fix) <sub>t-1</sub>	0.730***	0.864***	0.833***
Change in CFETS	-0.033	0.193***	0.0002
No. of observations	100	301	68
Adjusted R-squared	0.614	0.572	0.666
DW statistics	1.543	1.634	1.834

<sup>1</sup> \* and \*\*\* indicate significance at the 10% and 1% levels, respectively.

Source: authors' estimation.

Co-movements of CNY after August 2015, phases starting earlier

Table B2

	Transition (18/8/15-13/1/16)		Basket management (14/1/16-25/4/17)		Countercyclical management (26/4/17-4/8/17)	
	Asia	Non-Asia	Asia	Non-Asia	Asia	Non-Asia
CNY	1.00***	1.04***	0.60***	0.75***	0.41***	0.35
EUR	0.06	-0.01	0.30***	0.19***	0.07**	0.07
JPY	0.05	-0.40***	-0.07***	-0.07**	-0.08***	0.08
VIX	0.01***	0.001	-0.001	-0.01	0.00	-0.01*
Adjusted R-squared	0.09	0.05	0.23	0.06	0.06	0.01
Country effect	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	6	5	6	5	6	5
Number of observations	650	534	1,962	1,620	420	348

<sup>1</sup> \*\*, \*\*\* indicate significance at 5% and 1% levels, respectively.

Source: authors' estimation.

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