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The RMB Central Parity Formation Mechanism: August 2015 to December 2016

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Abstract

We study the renminbi (RMB) central parity formation mechanism following the August 2015 reform using statistical models. We identify the roles of the onshore and offshore RMB exchange rates and the US dollar index in determining the central parity in a linear regression framework. The effect of the RMB currency basket index, however, is revealed after controlling for multiplicative offshore RMB volatility effects. The offshore RMB volatility exerts a dampening effect on the links between the central parity and its determinants. In the prediction comparison exercise, the three selected models statistically outperform the random walk benchmark. Among these four models, the selected multiplicative specification yields the smallest root-mean squared prediction error and mean absolute prediction error.

JEL Codes: F31, F33

Keywords: China's Exchange Rate Policy, Currency Basket, Multiplicative Interaction Model, Onshore and Offshore RMB Rates, Volatility

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1. Introduction

China's foreign exchange policy has been in the limelight since the turn of the 21st century. For instance, China was accused of manipulating the value of its currency, the renminbi (RMB), when China recorded huge trade surpluses in the early 2000s. Many countries, including the USA, complained that China enjoyed unfair advantages in the global market by keeping the RMB at an artificially low level.[1]

When China stepped up efforts after the 2007-8 global financial crisis to promote the use of its currency overseas,[2] the market started to analyze the implications of a globalized RMB. Benefiting from China's trade prowess, the RMB has ascended quite fast in the global financial system. According to the Bank for International Settlements' triennial central bank surveys, the average global RMB daily forex turnover has registered a significant gain to reach 202 billion in 2016 from 15 billion in 2007 (Bank for International Settlements, 2007, 2016). The growing importance of the RMB is also attested to by its swift advancement from being the 20th most commonly used world payments currency in January 2012 to the fifth most commonly used in August 2017 (SWIFT, 2013, 2017).

The coming of the RMB to the global stage has triggered concerns about potential financial spillovers from China through its exchange rate.[3] Because China always has a tight grip on its currency, we have to go beyond the observed RMB variations to gauge its foreign exchange policy. Specifically, one often watched policy tool is the RMB central parity formation mechanism. While it promotes the global use of its currency, China sets a daily US dollar central parity –that is, the fixing, and limits the onshore RMB exchange rate to vary within a two-percent band around the fixing. Market participants, for example, take clues from the fixing to infer China's policy stance.

On August 11, 2015, China issued a statement on revamping the RMB central parity formation mechanism. The modified procedure sets the daily RMB central parity rate against the US dollar with references to the previous day's closing rate, market demand and supply, and

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[1] Some studies on RMB misalignments are Cheung, Chinn, and Fujii (2007), Cline (2015), Frankel (2006), Funke and Rahn (2005), Fischera and Hossfeld (2014), Funke and Gronwald (2008), Korhonen and Ritola (2011), and Schnatz (2011).

[2] Some studies on RMB internationalization are Chen and Cheung (2011), Chen and Peng (2010), Cheung, Ma and McCauley (2011), Eichengreen (2013), Eichengreen and Kawai (2015), Frankel (2012), and Prasad (2016).

[3] See, for example, the International Monetary Fund (2016). Some recent empirical studies are Colavecchio and Funke (2008), Fong and Wong (2017), Fratzscher and Mehl (2014), Kawai and Pontines (2016), Fatum and Yamamoto (2016b), and Shu, He and Cheng (2015).

valuations of other currencies (People's Bank of China, 2015a). The new procedure was meant to improve the transparency of the fixing mechanism and assign market forces a big role in determining the daily central parity. The reference to a currency basket signifies China's intent on weakening the tie between the RMB and the US dollar, and shifting the market's focus from the bilateral RMB-US dollar rate to a multilateral-exchange-rate-based reference rate. Compared with a bilateral exchange rate, a currency basket index based on a weighted average of multiple bilateral exchange rates represents a better overall measure of the value of a currency. Further, the reference to a basket of currencies allows the RMB to be flexible relative to the US dollar and is a step toward RMB flexibility.

The IMF, for instance, viewed the change in the formation mechanism as "a welcome step as it should allow market forces to have a greater role in determining the exchange rate."[4] Nevertheless, the policy change coupled with the subsequent RMB depreciation triggered rippling global responses that were unanticipated by China. The volatile responses highlight the growing influence of China's foreign exchange policy and the increasing importance of the RMB in the world economy.

Against this backdrop, we study the empirical determinants of the RMB central parity after the August 2015 reform. Specifically, drawing clues from official announcements and market developments, we formulate our empirical models to assess the roles of the onshore and offshore RMB exchange rates, the US dollar index, the RMB currency basket index, and selected control variables. Anecdotal evidence indicates that the Chinese authorities tend to resort to administrative measures in face of market unrest and volatility. Thus, we consider a multiplicative interaction model of which the linkage between the central parity and its determinants is affected by market volatility. These empirical results shed insight on the official central parity formation mechanism.

To produce our results, we find that in a linear regression framework, the onshore and offshore RMB exchange rates and the US dollar play a significant role in determining the daily RMB central parity. The role of the RMB currency basket index is detected in a multiplicative interaction model that incorporates the offshore RMB volatility effect. The Chinese authorities, as observed in the past, dislike volatility and adjust their policy actions when the threat of

[4] See "IMF Press Line on PBC's Announcement on the change to the RMB fixing mechanism, August 11, 2015," https://www.imf.org/external/country/CHN/rr/2015/0811.pdf.

volatility is felt. Indeed, we find that the offshore RMB volatility exerts a dampening effect on the links between the central parity and its determinants. The results are robust to alternative specifications and the presence of control variables. In comparing the prediction abilities of a few selected models, it is found that the selected multiplicative interaction specification yields the smallest root-mean squared prediction error and mean absolute prediction error, although its prediction performance is only statistically better than the random walk benchmark but not the other specifications included in the comparison exercise.

In the next section, we offer some background information on the recent Chinese foreign exchange policy. Section 3 presents the results of estimating the empirical central parity models. Section 4 discusses empirical findings from alternative specifications, and reports results from a prediction comparison exercise. Some concluding remarks are provided in Section 5.

2. Background

Here, we provide a selective account of China's exchange rate policy since 2005.[5] Building upon its astonishing accomplishment in the trade arena, China has stepped up its efforts in liberalizing financial markets and the RMB exchange rate. In July 2005, China announced the adoption of a managed and regulated floating exchange rate regime based on market demand and supply, and with reference to a basket of currencies (People's Bank of China, 2005). Essentially, the adopted regime was meant to guide the formation of the daily official fixing announced by the China Foreign Exchange Trading System (CFETS), which is under the direct jurisdiction of the People's Bank of China.[6] The reference to a currency basket reflects China's attempt to play down the role of the US dollar in formulating its exchange rate policy. The valuation against a currency basket in principle provides a good measure of the overall strength of the RMB. And a policy of maintaining a stable value against a weighted average of multiple currencies can free the RMB from tracking the US dollar.

The policy introduced in 2005 was interrupted by the 2008-9 global financial crisis, and was resumed in July 2010 (People's Bank of China, 2010).

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[5] Liew and Wu (2007) document China's exchange rate policy up to the early 2000s, and Cheung, Chow and Qin (2017, chapter 3) offer an up-to-date account.

[6] At that time, the RMB was allowed to be traded within a 0.3% band around its daily fixing in the onshore market. The trading band was subsequently widened to ±0.5% on May 21, 2007, to ±1% on April 16, 2012, and to ±2% on March 17, 2014.

The official statement on reference to a currency basket, however, does not sway the market's focus on the bilateral US dollar-RMB exchange rate. It turns out that the *de facto* RMB movement resembles a crawling peg and, thus, reinforces the perception that the RMB is heavily managed against the US dollar (Frankel, 2009; Ma and McCauley, 2011; Sun, 2010).

When China reverted back to its version of a managed and regulated floating exchange rate regime in 2010, it stepped up the effort of promoting the use of the RMB overseas. The offshore RMB market was established in Hong Kong in the second half of 2010. Subsequently, other offshore RMB centers sprang up in financial markets around the world. In these offshore markets, the RMB is essentially traded like a convertible currency that is subject to global market forces, and is dubbed CNH. Compared with onshore trading of the RMB, offshore RMB trading allows China to gauge the international demand and supply of its currency in a less constrained setting (Cheung, 2015; He and McCauley, 2013; Maziad and Kang, 2012).

On August 11, 2015, the People's Bank of China instituted a modified central parity formation mechanism that sets the RMB central parity against the US dollar by referencing the previous day's closing rate, market demand and supply, and valuations of other currencies. The fixing procedure was re-structured to allow for an increasing role of market forces, and enhance the transparency of fixing. The official stance is that the policy change is part of the transition process toward RMB exchange rate flexibility.

The change in the fixing mechanism, accompanied by an unusually large depreciation of the RMB central parity rate from 6.1162 (August 10) to 6.4010 (August 13), was viewed as a decoy to start a currency war of depreciating the RMB, and induced volatility that roiled foreign exchange markets, particularly emerging ones, around the world.

China apparently was not prepared for the volatile market responses to the change in the fixing procedure. Since 2005, the People's Bank of China has mentioned the reference to a currency basket in its foreign exchange policy statements in fits and starts. The revamp of the central parity formation mechanism in August 2015 represents the latest attempt to shift the market's focus on the value of the RMB against the US dollar to one against a currency basket, which is a logical step toward flexibility. Given the recent history of a *de facto* peg to the US dollar, however, it is not unexpected that the migration to a currency basket approach has to battle a stiff headwind. The negative perception of the August 2015 policy reform and the subsequent turmoil in the global market, nevertheless, triggered strong policy reactions from China.

China, in the face of market turmoil and skepticism about its policy move, asserted its resolute intolerance to market volatility and unrest, and resorted to administrative measures and control policies to restore stability. China's abrupt interventions in the (onshore and offshore) RMB market and equity market in the summer of 2015 and the subsequent months, remind the world that China still tightly controls its economy. The inherent distrust of volatility appears to be at odds with the view that market volatility and risk are likely consequences of pricing assets based on market forces.

In December 2015, a few months after the August 2015 market turmoil, China posted the CFETS RMB currency basket, including both its component currencies and their weights in the basket, and reiterated the relevance of referencing the RMB to a currency basket (Guest Commentator of CFETS, 2015). While the publication of the currency basket is meant to enhance transparency, the market was rattled by the RMB weakness that extended into early January 2016 and the observed weak association between the RMB value against the currency basket and the fixing. The market participants perceived that the CFETS currency basket plays a limited role in guiding their RMB expectations, and revived their concern that the new RMB fixing mechanism is a disguised competitive devaluation policy.

In response to the market's bafflement, central bank officials on several occasions expounded China's foreign exchange policy (People's Bank of China, 2016b; Wang, *et al*., 2016; Ma, 2016a) in the early 2016. They reiterated that the reference to demand and supply is in accordance with China's on-going reform policy of increasing the role of market forces in policy making, and the central parity is determined by factors that include the previous day's closing and the variation of the currency basket. Further, they perceived that the new policy is a controlled floating and not a pure flexible exchange rate arrangement, and controls and interventions are in place to counter volatility caused by, say, speculation. The repeated official explanations and disclosures, nevertheless, do not completely dispel the skepticism about the RMB policy.

The weakness of the RMB in the second half of 2016 was partially attributed to the safe-haven demand for the US dollar following the Brexit decision in June 2016. After its formal inclusion in the SDR currency basket on October 1, 2016, the dollar value of the RMB exhibited a pattern different from the CFETS currency basket index; the RMB continued its decline against the US dollar and, at the same time, was relatively stable against the CFETS basket of currencies.[7]

The RMB central parity formation mechanism is described by CFETS, which is authorized by the People's Bank of China to calculate and publish the central parity on its website. Specifically, the RMB central parity against the US dollar is a weighted average of a trimmed sample of exchange rates solicited from designated market makers. The trimmed sample is obtained by excluding the highest and lowest rates from the original sample. The weights are based on transaction volumes and other indicators of individual market markers. In accordance with the 2015 policy change statement, market makers are reminded to refer to the closing rate on the previous day, demand and supply conditions, and exchange rate movements of the major currencies to form their submitted rates.[8] There is, however, no explicit mention of the role of the RMB currency basket index.

3. Does the Currency Basket Matter?

Figure 1 plots the CFETS RMB currency basket index, and three variants of the RMB exchange rate against the US dollar, namely, the central parity rate (i.e., the daily fixing), CNY (the onshore RMB rate), and CNH (the offshore CNH rate). The sample period is from August 17, 2015, to December 31, 2016.[9] The sources of these variables and other variables used in the subsequent analyses are presented in Appendix A1. Visually, relative to the CFETS index, the three dollar-based rates display a relatively high level of comovement, with the period of April to October 2016 a possible exception.

Some descriptive statistics of these four rates, in log-difference forms to ensure these variables are stationary, are presented in Table 1.[10] Indeed, the change in fixing (ΔP) has a correlation coefficient of 0.349 with the change in CNY (ΔY) and of 0.516 with CNH (ΔH). The

[7] The decision of admitting the RMB to the SDR basket was announced in November 2015. Additionally, in January 2017, 11 currencies were added to the CFETS basket to enhance its degree of representativeness; see additional discussions in Section 5.

[8] See http://www.chinamoney.com.cn/english/bmkcpr/.

[9] We excluded the first four business days under the new fixing mechanism because the market and the RMB experienced unusually large fluctuations right after it was introduced. The RMB index value before December 2015 was computed based on the composition and weights of the announced currency basket.

[10] See the unit root and cointegration test results in the next sub-section.

correlation coefficient of ΔP and the change in CFETS RMB index (ΔB), however, is 0.046.[11] These correlation coefficients do not show a strong association between the RMB index and the RMB central parity rate. Further, the change in the central parity, ΔP, displays a stronger degree of association with either deviations from the onshore or offshore RMB rate (P - Y or P - H) than with the deviations from the CFETS RMB index (P - B). The observed weak association between the central parity and the RMB currency basket index prompts market participants' queries about the claimed currency basket management policy framework. Statistical evidence on the central parity formation mechanism is presented in the following sub-sessions.

3.1 The Basic Specification

Literally, according to the August 11, 2015 announcement, the RMB central parity rate is determined by the closing rate of CNY, "*in conjunction with demand and supply condition in the foreign exchange market and exchange rate movement of the major currencies*" (People's Bank of China, 2015a). The demand and supply condition factor is not explicit quantified. The demand and supply condition factor is not explicit quantified. Before the composition of the CFETS RMB currency basket was published in December 2015, there is no explicit operational definition of the *exchange rate movement of the major currencies*.

Against this backdrop, we conducted a simple pilot analysis. First, we regressed the change in fixing (ΔP) on the previous business day's change in CNY (ΔY) and a constant. The ΔY yielded a significant positive coefficient estimate of 0.43 and explained 11.9% of the variation in ΔP. The significant positive effect is in accordance with the policy statement, though the explanatory power is quite small compared with, say, that of the US dollar in the pre-August 2015 period. Next, we regressed the change in fixing (ΔP) on the previous business day's change in CFETS RMB index (ΔB) and a constant. The RMB index term is insignificant, and the regression gave a slight negative adjusted R^2 estimate. These two bivariate regressions only partially substantiate the announced central parity fixing mechanism.

To shed additional light, we conduct the following empirical analysis to infer possible demand and supply conditions considered by the authorities. The onshore rate and the offshore rate are quite closely related (Table 1). Compared with the onshore rate, the offshore rate is

[11] For the period April 1 to December 31, 2016, the correlation coefficient between ΔP and ΔB is -0.1, which is still in magnitude less than 0.597, the one between the ΔP and ΔH.

subject to a lesser degree of invention and, thus, reflects better market information.[12] If these two rates play a role in determining the central parity formation mechanism, what is their relative importance? To examine the effects of these two rates, we consider the specification:

$$\Delta P_t = \mu_1+\gamma_1(P_{t-1}-Y_{t-1})+\gamma_2(P_{t-1}-H_{t-1})+\gamma_3\Delta P_{t-1}+\gamma_4\Delta Y_{t-1}+\gamma_5\Delta H_{t-1}+\varepsilon_t, \quad (1)$$

where P, Y, and H are the central parity rate, the onshore CNY rate and the offshore CNH rate in logs, respectively. "Δ" is the first difference operator. Specification (1) is motivated by the fact that the three RMB rates, although determined differently, should be linked. Despite onshore and offshore market rates incorporating effects of demand and supply conditions in different markets, they are the prices of the same currency, the RMB. Arbitrage between the two rates, even limited, is possible, as it is known that China's capital controls are tight but not absolute.[13] Thus, it is appropriate to consider both the individual and combined effects of the onshore and offshore rates.

Statistically, each series individually is a unit root process, and they are cointegrated. The augmented Dicky-Fuller test shows that P, Y and H display unit root properties (Table 2). The empirical links between these three series are affirmed by the Johansen cointegration test. Both the trace and maximum eigenvalue statistics indicate that there are two cointegrating vectors in the tri-variate system (P, Y, H). Although the cointegrating coefficient estimates are not exactly unity, (P – Y) and (P – H), the two series of deviations from the central parity are stationary I(0) processes and thus can be viewed as restricted cointegrating relationships of (P, Y) and (P, H), respectively.

The results of estimating (1) and its variants are presented in Table 3. The one-lag specification is supported by the absence of significant serial correlation in the estimated residuals.[14] The individual effects of the CNY and CNH are given under, respectively, columns 1a and 1b. If China uses only the CNY rate to set the RMB central parity, then the results under column 1a show that the central parity exhibits a self-correcting mechanism as indicated by a significantly negative coefficient estimate of the lagged dependent variable, and is affected by the onshore rate through the error correction mechanism given by the deviation from the central

[12] Anecdotal evidence indicates that, before the second half of 2015, there was no invention in the CNH market. The information role of the offshore market and its links to the onshore rate are studied in, for example, Cheung and Rime (2014), Chung, Hui and Li (2012), Ding, Tse, and Williams (2014), Funke, Shu, Cheng and Eraslan (2015), and Leung and Fu (2014).

[13] Studies on China's capital controls include Chang, Liu and Spiegel (2015), Chen, and Qian (2016), Cheung, Steinkamp, and Westermann (2016), Gunter (1996), and Ma and McCauley (2008).

[14] Further, all the one-lag specification reported in the subsequent analyses passed the residual tests.

parity term (P – Y) and the short-term effect given by the first difference term ΔY. The first difference term can be interpreted as a variable that captures short-term demand and supply conditions in the onshore market.

Similar results are obtained under column 1b when only the CNH is considered. That is, individually, either CNY or CNH offers similar information about the formation mechanism of the RMB parity rate. An astute reader may note the CNH specification offers a slightly larger adjusted R^2 estimate (33.1%) than the CNY one (31.9%).

The last column in the table reports the combined effects of the onshore and offshore rates. The combined model, even with some insignificant coefficient estimates, yields better explanatory power, as given by the adjusted R^2 estimate, than its components. It is of interest to note that the onshore and offshore rates contribute differently to the central parity formation mechanism: CNY affects it through its deviations from the central parity and CNH through its changes. One way to interpret these results is that the central parity is set to reduce its gap from the onshore rate and to respond to market forces as conveyed by the offshore rate. Recall that the reformed formation mechanism is meant to set the central parity based on, among other things, the previous day's CNY closing.[15] The CNH has its role because the growing offshore market is subject to a lesser degree of distortions induced by controls and interventions (Overholt, Ma and Law, 2016).[16]

The results in the Appendix (Table A2) show that the onshore and offshore rates exhibit different effects in the pre-August 2015 period.[17] Specifically, before the policy change, the explanatory power of the onshore and offshore rates was quite low, and the adjusted R^2 estimate is smaller than 5%. The offshore CNH offers a larger adjusted R^2 estimate (4.1%) than the onshore CNY (1.6%), while the lagged change in the central parity ΔY is statistically insignificant. One possible interpretation is that before the August 2015, the central parity displayed a limited degree of association with lagged onshore and offshore rates. The reform policy has modified the formation mechanism, and assigned relatively important roles to the lagged onshore, offshore, and parity rates in determining the central parity. Using the adjusted R^2

[15] One referee noted that the onshore rate trading band around the fixing contributes to the observed CNY and (P-Y) effects.

[16] There are reports that China has intervened in the CNH market to narrow the gap between CNH and CNY since September 2015. Apparently, the information role of CNH remains despite these interventions. In addition, the Hong Kong Monetary Authority (2016, Box 3) shows that the CNH-CNY spread has mainly been driven by risk appetite (VIX) and funding liquidity (US Treasury yield) before and after August 2015.

[17] The sample starts from October 8, 2010, which is determined by the inception of CNH trading.

estimate as a gauge, the central parity is more transparent (predictable) after August 2015 than before.

3.2 The Dollar, the Currency Basket and Volatility

Taking clues from the official statement of the central parity formation mechanism, we examine the roles of the US dollar and the RMB currency index using

$$\Delta P_t = \mu_1+\gamma_1(P_{t-1}-Y_{t-1})+\gamma_2(P_{t-1}-H_{t-1})+\gamma_3\Delta P_{t-1}+\gamma_4\Delta Y_{t-1}+\gamma_5\Delta H_{t-1}+\gamma_6\Delta U_{t-1}+\varepsilon_t, \quad (2)$$

$$\Delta P_t = \mu_1+\gamma_1(P_{t-1}-Y_{t-1})+\gamma_2(P_{t-1}-H_{t-1})+\gamma_3\Delta P_{t-1}+\gamma_4\Delta Y_{t-1}+\gamma_5\Delta H_{t-1}+ \gamma_7\Delta B_{t-1}+\varepsilon_t, \text{ and} \quad (3)$$

$$\Delta P_t = \mu_1+\gamma_1(P_{t-1}-Y_{t-1})+\gamma_2(P_{t-1}-H_{t-1})+\gamma_3\Delta P_{t-1}+\gamma_4\Delta Y_{t-1}+\gamma_5\Delta H_{t-1}+\gamma_6\Delta U_{t-1}+\gamma_7\Delta B_{t-1}+\varepsilon_t. \quad (4)$$

The US dollar index (U) compiled by the Intercontinental Exchange is used to capture the US dollar effect on the central parity.[18] Both the US dollar index and the RMB currency basket index (B) in logs are in first difference to achieve stationarity. The estimation results are given under columns "2" to "4" in Table 4.

The inclusion of the US dollar index noticeably improves the model's performance. It is statistically significant with the expected positive sign and increases the adjusted R^2 estimate by approximately one-third to 56.7% from 42.5%. The marginal contribution of the US dollar index, however, is less than that observed in the pre-August 2015 period. According to Table A2 (Column "2") in the Appendix, the US dollar index variable markedly increases the regression explanatory power from 4% to 34%. The decline in the marginal explanatory power of the US dollar index variable is in accordance with the stated official policy stance of weakening the link between the US dollar and the RMB.

Despite the decrease in its marginal impact, the US dollar effect has still been felt in the post-policy change period. The presence of the US dollar effect, however, is not surprising for a few reasons. First, the US dollar remains the prominent international currency that accounts for the lion's share of global foreign exchange transactions. According to the latest survey, as much as 95% of the RMB trading around the world was against the US dollar (Bank for International Settlements, 2016). Further, the US dollar is the key vehicle for international transactions, and it accounts for close to 90% of the aggregate global foreign exchange trading volume. Thus, the US dollar has its special role in the global currency market. Second, China is saddled with a

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[18] The index is a weighted average of the US dollar exchange rates against other major currencies supplied by approximately 500 banks. The CNY and CNH are not included in the index. The variation of this index is similar to other trade-weighted index, such as the Fed's dollar index and the Wall Street Journal USD index.

history of managing the value of its currency against the US dollar. It is conceivable that participants in both domestic and foreign markets have to take time to change their habits of making references to the US-RMB value.

The RMB index has the expected negative sign but is statistically insignificant and offers no marginal explanatory power.[19]

The absence of the CFETS RMB index effect is unexpected, given the authorities' repeated messages on the importance of focusing on the RMB value against the currency basket, rather than zooming in on only the bilateral US-RMB rate.[20] It is, however, not easy to support the official assertion given the apparent lack of comovement between the CFETS RMB index and the central parity noted in Table 1 and the absence of statistical evidence in Table 4.

Is the RMB index effect hidden behind market volatility/uncertainty? The results of estimating

$$\Delta P_t = \mu_1+\gamma_1(P_{t-1}-Y_{t-1})+\gamma_2(P_{t-1}-H_{t-1})+\gamma_3\Delta P_{t-1}+\gamma_4\Delta Y_{t-1}+\gamma_5\Delta H_{t-1} +\gamma_6\Delta U_{t-1}+\gamma_7\Delta B_{t-1}+\gamma_8 Z_t+\varepsilon_t, \quad (5)$$

are presented under the column labeled "5" in Table 4. The volatility variable Z_t is given by the CNH conditional volatility estimated from a GARCH specification and is based on information available at time t-1.[21] The choice of CNH volatility is motivated by the information role of the offshore market that reflects market views on RMB valuation outside China.

The Z_t variable yields a negative sign; a high level of CNH volatility/uncertainty strengthens the daily RMB fixing against the USD, which can alleviate negative market sentiment. The effect, however, is not statistically significant. The inclusion of the Z_t variable does not have any material impacts on the coefficient estimates of other variables and the adjusted R^2 estimate of the model.

In passing, we note that if the CNY, instead of CNH, conditional volatility is used in (5), the CNY conditional volatility variable displays a positive but insignificant effect on the central

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19 The RMB index variable still offers no marginal explanatory power when it is added to complement CNY variables in Model 1a of Table 3 (People's Bank of China, 2016b).

20 Given the low correlation (0.074) between the USD index and the CFETS RMB currency basket index, multicollinearity is not a concern. Further, since 2005, there has been a marked diversion between the USD index and the BIS RMB currency basket index (Ma and McCauley, 2011).

21 Technically speaking, the GARCH volatility estimate is not pre-determined as it is estimated using information from the entire sample. Thus, we examined the predictive power and not the forecast performance of the model. In the pilot analysis, we found that the estimate used here and the GARCH volatility estimate obtained using rolling samples, with an initial sample from August 17 to December 14, 2015, have a correlation of 0.92.

parity.[22] Results pertaining to a few other volatility proxies including one that is given by the difference of CNH and CNY conditional volatilities are discussed in the next Section.

The results attest to the relevance of the onshore and offshore RMB exchange rates and the US dollar for characterizing the central parity. The weak and insignificant effect of the CFETS RMB currency basket index is qualitatively similar to the one reported in Cheung, Hui and Tsang (2016). These inferences are (indirectly) supported by some statistical model selection criteria; for instance, both the Akaike and Schwarz information criteria (AIC and SIC) select specification (2), even though the inclusion of the CFETS RMB index (specification (4)) increases the adjusted R^2 estimate by a margin of 0.1% over (2).

3.3 The Interaction Effect

The transition to a managed float for a country with China's economic history and size is unprecedented. It is well known that the Chinese authorities distrust market volatility. In reforming foreign exchange policy, the People's Bank of China has taken "tactical" adjustments and retreats from time to time in the face of unfavorable market disruptions. When the perceived volatility and risk are heightened, the authorities do not hesitate to resort to controls and, if necessary, even retribution. Such a behavior is likely to affect the observed relationship between the central parity and its underlying economic determinants.

In view of this, we stipulate that the authorities will adjust the operation of the central parity formation mechanism according to market conditions. Specifically, we anticipate that the role of market forces will be weakened when market volatility is high. The volatility-dependence behavior is unlikely to be captured by regression (5) when the volatility enters in a linear manner.

In the following, we use a multiplicative interaction model modified from (5) to capture volatility-dependence behavior. The multiplicative interaction model that uses the CNH conditional volatility as the conditioning variable is given by

$$\begin{aligned}\Delta P_t = {} & \mu_1+\gamma_1(P_{t-1}-Y_{t-1})+\gamma_2(P_{t-1}-H_{t-1})+\gamma_3\Delta P_{t-1}+\gamma_4\Delta Y_{t-1}+\gamma_5\Delta H_{t-1}+\gamma_6\Delta U_{t-1}+\gamma_7\Delta B_{t-1} \\ & +\gamma_8 Z_t+\gamma_{11}Z_t*(P_{t-1}-Y_{t-1})+\gamma_{21}Z_t*(P_{t-1}-H_{t-1})+\gamma_{31}Z_t*\Delta P_{t-1}+\gamma_{41}Z_t*\Delta Y_{t-1} \\ & +\gamma_{51}Z_t*\Delta H_{t-1}+\gamma_{61}Z_t*\Delta U_{t-1}+\gamma_{71}Z_t*\Delta B_{t-1}+\varepsilon_t. \qquad (6)\end{aligned}$$

[22] As noted by one referee, the offshore RMB market has experienced a decline in liquidity since late 2015. The liquidity drop can impair the information role of the offshore market, including the volatility signal. Indeed, our results show that the CNY market plays a significant role in determining the central parity, though the offshore market variables including CNH and US dollar variables still play a role. It is possible that, say, late 2017 onward, the onshore market variables play an even more significant role.

The specification offers a simple setup that allows effects of explanatory variables to vary with the volatility factor.[23] The results of estimating several variants of (6) are reported in Table 5.

Before looking at some specific findings, we make a few observations. First, the coefficient estimates of the interaction terms have signs that are opposite to the corresponding ones without the volatility condition variable. The signs of the latter group of variables are the same as those presented in previous tables. That is, the pricing mechanism of these variables weakens as volatility increases; a result that is in accordance with our previous mention of China's response to heightened volatility. Second, each specification with interaction terms in Table 5, compared with its corresponding one in Table 3 and Table 4, has a larger adjusted R^2 estimate and better AIC and SIC values. That is, models with interaction terms offer a good fit. Third, by dropping the two insignificant deviations from the central parity interaction terms, we obtained the parsimonious specification

$$\Delta P_t = \mu_1+\gamma_1(P_{t-1}-Y_{t-1})+\gamma_2(P_{t-1}-H_{t-1})+\gamma_3\Delta P_{t-1}+\gamma_4\Delta Y_{t-1}+\gamma_5\Delta H_{t-1}+\gamma_6\Delta U_{t-1}+\gamma_7\Delta B_{t-1}$$
$$+\gamma_8 Z_t+\gamma_{31}Z_t*\Delta P_{t-1}+\gamma_{41}Z_t*\Delta Y_{t-1}+\gamma_{51}Z_t*\Delta H_{t-1}+\gamma_{61}Z_t*\Delta U_{t-1}+\gamma_{71}Z_t*\Delta B_{t-1}+\varepsilon_{t,} \qquad (7)$$

which is presented under column 5. Among the specifications reported in Table 5, (7) has the highest adjusted R^2 estimate, and the best AIC and SIC values.[24] Note that all the variables under column 5, including the volatility variable Z_t are statistically significant with their expected signs. Further, the BDS test (Brock, *et al*., 1987; Brock, *et al*., 1996) detects no significant nonlinearity in the estimated residuals, indicating that these fitted interaction models reasonably capture data nonlinearity, if there is any.

One finding that stands out from Table 5 is the significance of the CFETS RMB currency basket index. Once the volatility condition is multiplicatively factored in, a negative γ_7 suggests that a stronger RMB index (RMB appreciates against the currency basket; positive ΔB) is associated with a stronger RMB valuation (RMB appreciates against the US dollar; negative ΔP). The link between the RMB index and the bilateral central parity weakens as volatility increases. The results lend support to the official claim about the role of currency basket valuation, and to the supposition that volatility tends to weaken the central parity link with its determinants.

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[23] See Brambor, *et al.* (2006) for an introduction to multiplicative interaction models. Hainmueller, *et al.* (2016) study two possible empirical drawbacks - nonlinear effects and insufficient common support of a multiplicative interaction model.

[24] Dropping Z*(P–Y) and Z*(P–H), rather than (P–Y) and (P–H) results in a better fit.

The marginal effect of the RMB index ΔB on the central parity ΔP conditional on Z and its standard error, are given by

$$\partial \Delta P_t / \partial \Delta B_{t-1|Zt} = M_{t|Zt} = \gamma_7 + \gamma_{71} Z_t, \tag{8}$$

and

$$M_{t|Zt,\, se} = [var(\hat{\gamma}_7) + Z_t^2\ var(\hat{\gamma}_{71}) + 2Z_t cov(\hat{\gamma}_7, \hat{\gamma}_{71})]^{1/2}. \tag{9}$$

Expressions (8) and (9) show that the RMB index effect and its significance cannot be read directly from the two coefficient estimates γ_7 and γ_{71}; instead, they vary with the CNH volatility, and their variances and covariance.

To gauge a quantitative sense of the effect, we use the estimation results reported under column 5 of Table 5 to generate Figure 2. The estimated marginal effect (the solid red line) changes from negative to positive, and its two-standard-error (broken green and blue lines) confidence band widens as Z_t increases. The ΔB effect is statistically and negatively significant when the Z_t is less than the value of 0.00281. The histogram of Z_t included near the bottom of the figure indicates that it is quite heavily distributed in the range in which ΔB has a significantly negative sign. Indeed, 76.5% of the observed Z_t are less than 0.00281; that is, the RMB index variable displays a significant negative marginal effect on the central parity for 76.5% of the sample. The statistical significance result is found among a large proportion of data points.

For comparison purposes, we plot the marginal effect of the US dollar index, ΔU, on the central parity, ΔP, conditional on Z in Figure 3. As volatility variable Z_t increases beyond 0.00320, the US dollar index effect turns negative from positive. Apparently, the confidence band in this figure is narrower than the one in Figure 2. The significant marginal effect estimates constitute 91.4% of the sample observations. Again, the significance of the US dollar effect is observed among a majority of observations on Z and ΔU.

The marginal effects of other determining factors can be assessed in a similar fashion. For brevity, we included the graphs of marginal effects of the onshore and offshore RMB rates (ΔY and ΔH) in the Appendix (Figures A3.1 and A3.2). The profiles of these two marginal effect graphs are similar to the one depicted in Figure 3. The estimated marginal effects of these two RMB rates are usually significant with the expected sign; the onshore exchange rate and the offshore rate exhibit a significantly positive impact on the central parity for, respectively, 91.1% and 99.1% of the sample observations.

Among these four RMB exchange rates, only the CFETS RMB index has a proportion of observations that display significant marginal effects discernibly less than 90%. This may be a reason that the RMB index effect is hard to detect when the multiplicative volatility condition is not explicitly accounted for.

In sum, the multiplicative interaction model reveals evidence that the implementation of the central parity formation mechanism varies according to market conditions. Empirically, the central parity depends on its own previous value, the previous CNY closing rate, the value against the CFETS currency basket, the overseas demand and supply conditions captured by the CNH and the US dollar value.

While the roles of the onshore CNY, the offshore CNH, and the US dollar index are easy to identify, the role of the RMB index is illusive. Our analysis, nevertheless, shows that once market volatility is allowed for, we can unveil the link between the RMB index and the central parity. Indeed, the CNH volatility measure tends to weaken the effects of determining factors on the central parity; a finding that is in line with the conjecture that when volatility and risk are high, the Chinese authorities will strengthen administrative measures and, temporarily, scale back the role of market forces. Although the central bank considers the role of a currency basket index, it does not stick to the currency basket value all of the time (Ma, 2016b).

4. Additional Analyses

In this section, we present additional analyses to shed light on the robustness of the results reported in the previous section.

4.1 Macro and Financial Variables

The parsimonious specification (7) (column 5, Table 5) explains over 60% of the variation of daily central parity rate changes. The explanatory power is mainly driven by information on the different RMB rates. Do other economic variables help in explaining the central parity? The question is addressed using the following regression equation:

$$\Delta P_t = \mu_1+\gamma_1(P_{t-1}-Y_{t-1})+\gamma_2(P_{t-1}-H_{t-1})+\gamma_3\Delta P_{t-1}+\gamma_4\Delta Y_{t-1}+\gamma_5\Delta H_{t-1}+\gamma_6\Delta U_{t-1}+\gamma_7\Delta B_{t-1} +\gamma_8 Z_t+\gamma_9 W_{t-1}+\gamma_{31}Z_t{*}\Delta P_{t-1}+\gamma_{41}Z_t{*}\Delta Y_{t-1}+\gamma_{51}Z_t{*}\Delta H_{t-1}+\gamma_{61}Z_t{*}\Delta U_{t-1} +\gamma_{71}Z_t{*}\Delta B_{t-1}+\gamma_{91}Z_t{*}W_{t-1}+\varepsilon_{t}. \quad (10)$$

Essentially, (10) is the specification (7) augmented by W that contains economic variables and its interaction term Z*W. In this subsection, we discuss the results when a) ΔFP, the difference between offshore and onshore RMB one-month forward points in deliverable forwards, b) ΔlnVIX, the change in the well-known fear index, c) ΔlnVXY, the JP Morgan emerging market currency volatility index, d) FRD, a one-zero dummy variable to capture the possible effect of a drop in China's foreign exchange reserves on the announcement date, and e) FRI, a one-zero dummy variable for an increase in China's foreign exchange reserves on the date of announcement are individually added to the regression exercise.[25]

The FP variable is included to gauge the authorities' response to different offshore and onshore market views on the future value of the RMB.[26] The two volatility indexes are commonly used to represent the global financial cycle, which deems to be associated with the so-called risk-on and risk-off phenomenon and affect movements of (emerging market) currencies (Cairns, Ho, and McCauley, 2007; Cheung and Rime, 2014; Fatum and Yamamoto, 2016a; and Rey, 2013). The dummy variables of foreign exchange reserves are used to assess whether the parity rate responds to the change in market demand and supply conditions, which could be triggered by announced changes in China's holding of reserves.

The results of estimating (10) are presented in Table 6. The effects of these macro and financial variables appear weak. Only the offshore and onshore RMB forward differential variable, ΔFP, is statistically significant (column 1). The resulting specification, however, yields a smaller adjusted R^2 estimate and worse AIC and SIC values than the model without the two ΔFP-related variables. The VIX and VXY-based variables are insignificant, but their presence improves the adjusted R^2 estimate.[27] The two dummy variables of foreign exchange reserves are insignificant, either individually or jointly. Given these results, we deem the effects of these macro and financial variables are weak, and the parsimonious specification (7) that incorporated

[25] We also experimented with variables that capture changes in and volatility of stock prices and fund flows through the Shanghai-Hong Kong Stock Connect and found these variables have no significant effect. These results are hence not discussed for brevity.

[26] A positive ΔFP suggests the offshore RMB is expected to be weaker than the onshore one in the future. In addition, according to covered interest parity, the forward point differential can be considered as a proxy of the interest rate differential.

[27] It is noted that the VXY variable is significant when it is added to the linear specifications presented in Table 4 but is insignificant in the presence of multiplicative volatility factors. The VIX variable, however, is insignificant when it is added to the specifications in Table 4.

volatility-dependence behavior offers a reasonable characterization of the central parity formation mechanism.

4.2 Asymmetric behavior

The market turmoil triggered by the introduction of the central parity formation mechanism in August 2015 and the subsequent depreciation trend smacked of China's inability to effectively communicate with the market. The observed deviation of the RMB performance from official elaborations confuses market participants, and generates different interpretations of the true motivation behind the policy change.

One common view in the media is that the new mechanism with reference to a currency basket is an effort of devaluing the currency to boost the stalled economy. The central parity is perceived to be set with the depreciation bias and responds asymmetrically to the dollar (or the RMB index) movement. To shed insight on possible asymmetric responses to depreciation and appreciation pressures, we re-estimate specification (7) by allowing the coefficient estimates to assume different values when the US dollar appreciates. The results are reported in Table 7. The Table also presents coefficient estimates that allow for asymmetric responses to the direction of change of the CFETS RMB currency basket index.

The results indicate that the appreciation of the US dollar alters the effects of five of the thirteen variables, namely, P-H, ΔB, ΔU, Z*ΔB and Z*ΔU on the central parity. When these five variables interact with a US dollar appreciation dummy variable, the interaction terms have statistically significant coefficient estimates that have a sign opposite to their counterparts without the US dollar interaction variable (Column 1, Table 7). That is, when the US dollar appreciates, the impacts (in term of magnitude) of these variables on the central parity weaken. For instance, the response of the central parity to the RMB index is likely to be stronger when the US dollar depreciates than appreciates. The finding lends support to the view that the dollar movement has an implication for the operation of the central parity formation mechanism. While both the adjusted R^2 and AIC estimates support this model specification, the SIC estimate favors model (7) that accounts for the implications of the appreciation and depreciation of the US dollar.

The results presented under Column 2 of Table 7 indicate that with the exception of P-H, the parameter estimates of the model are not significantly influenced by the direction of change of the RMB index. Both the AIC and SIC estimates favor model (7) over the specification that differentiates the parameter values across the two states of RMB index depreciation and appreciation. That is, the central parity formation mechanism is mostly invariant to the depreciation and appreciation of the CFETS RMB index.

We also investigated whether an increase in market uncertainty, as represented by the condition of ΔlnVIX > 0 or ΔlnVXY>0, alters the model estimates. The results, which are given in the Appendix (Table A4) for brevity, suggest these two conditions do not have a statistically significant implication for parameter estimates. That is, the central parity formation mechanism adjusts to the CNH volatility but not to the risk measures represented by VIX and VXY.

4.3 A Few Additional Specifications

We examined a few other specifications. These regression results are discussed here but are *not reported for brevity*; they are available upon request.

The multiplicative interaction model (7) implicitly assumes effects of explanatory variables vary with the conditioning variable Z_t. We considered a simple threshold regression in which the impact of explanatory variables depends on whether the conditional volatility variable Z_t is large or small.

Our results indicate that a) the RMB currency basket index garners a significantly negative coefficient estimate under a low volatility regime but an insignificant positive coefficient when the volatility is high; b) the US dollar index has effects in both regimes but is larger in the low volatility regime; and c) the other explanatory variables are usually statistically significant in the low volatility regime but not necessary in the high volatility regime. The regime-specific results are qualitatively similar to those reported for equation (7) in the previous section. Nevertheless, the adjusted R^2 estimates of these simple threshold specifications are lower than the corresponding ones in Tables 5 and 6.

We also considered threshold regression specifications using either (P-H) or (P-Y) as the threshold variable. The specifications using the threshold variable (P-Y) perform worse than those based on the (P-H) threshold variables. The results of these threshold regression specifications, however, are worse than those reported in the previous section.[28]

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[28] Recall that VIX and VXY are not significant in Table 6. In addition, Fatum and Yamamoto (2016b) find only limited evidence of threshold effects using VIX as the threshold variable.

Following the official and market discussions, we employed the CFETS currency basket to assess the role of an RMB index. Despite the CFETS currency basket assigning a weight of 26.4% to the US dollar and 6.55% to the Hong Kong dollar (which is officially linked to the USD), the correlation between the CFETS index and the US dollar index is quite small and has a value of 0.074. Thus, the regression incorporating these two indexes in regression does not suffer from multicollinearity, and can differentiate their respective impacts on the central parity.

Nonetheless, we modified the currency basket by dropping the US dollar and the Hong Kong dollar from the CFETS index and re-did the exercise. We found qualitatively similar results, in particular for the effects of the US dollar index, the RMB currency basket index, and CNH volatility.

The cases in which the CFETS RMB index was replaced with either the RMB index based on the Bank for International Settlements or the IMF SDR weights were also considered.[29] The specifications with these alternative RMB indexes perform less well than those with the CFETS RMB currency basket index. That is, in terms of explaining the observed central parity, the CFETS index does a better job.

We re-did the exercise with a shorter sample period from December 14, 2015 to December 31, 2016 in which the CFETS RMB currency basket is public information. The findings, particularly pertaining to the US dollar index, the CFETS RMB index and the CNH volatility, are qualitatively the same as those reported in the previous section.

We also explored the potential role of the difference between the offshore and onshore RMB conditional volatilities. The relative volatility measure in principle can be a proxy for the relative level of market uncertainty in the offshore and onshore markets. Our regression results however do not show the relative volatility measure helps to improve the model performance. One possible reason is that the volatility of a heavily managed CNY is less informative than the market-oriented CNH.

4.4 Forecast Performance

In this subsection, we compare the ability of the specifications reported under a) column "2" in Table 4, b) column "5" in Table 5, and c) column labeled "1" in Table 6 to predict the

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[29] These two alternative RMB indexes are included in the December 2015 posting for comparison purposes (http://www.pbc.gov.cn/english/130721/2988680/index.html).

central parity. The first model is the representative of linear models, the second one is the representative of multiplicative interaction models, and the third one is the second model augmented with the significant offshore-onshore RMB forward differential variable (column "1" Table 6). For brevity, we call them Model A, Model B, and Model C henceforth. We also include a random walk with drift (RW) specification that is commonly used as a benchmark for assessing exchange rate predictability. For each selected specification, we generate one-step ahead forecasts from rolling regressions with a moving window of 100 observations.[30]

The root-mean squared prediction errors (RMSEs) of Model A, Model B, Model C, and RW are, respectively, 1.010, 0.970, 0.986, and 1.534. The RW model yields an RMSE that is noticeably larger than those of the three selected specifications. Allowing for multiplicative interaction terms lowers the RMSE to 0.970 from 1.010. The augmented multiplicative interaction that includes the significant offshore and onshore RMB forward differential, ΔFP, variables gives an RMSE that is smaller than Model A, but does not improve upon Model B. The mean absolute prediction errors (MAEs) of these specifications give similar performance comparison results; the MAEs of Model A, Model B, Model C, and RW are, respectively, 0.716, 0.680, 0.701, and 1.203.

Do these squared and absolute prediction errors imply the abilities of these models to predict the central parity are significantly different? To address this question, we employ the Mariano and Preve (2012) procedure, which is a multivariate version of the Diebold–Mariano test, to compare the relative predictive performance of the three selected specifications and the RW model.

The comparisons of the three selected models against the RW are presented in Panel A of Table 8. The significance of the Mariano and Preve S statistic and its finite-sample corrected version S_c statistic is evaluated at the 5% and 10% levels using simulated critical values derived from 100,000 Monte Carlo replications.[31] The results based on either RMSEs or MAEs strongly indicate the performance of the RW model is statistically worse than the selected models. Both

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[30] Similar results were obtained when the moving window size was modified to, say, 120.

[31] See Mariano and Preve (2012) for the calculation of the S and S_c statistics and their simulated critical values. The process generating a loss differential series of length (260) is a 1-dimensional MA(2) with Gaussian noise for pair-wise comparisons, and 2 or 3-dimensional MA(2) with Gaussian noise for all competing models. The parameter $\rho = 0.5$ (the simultaneous correlations between the residuals of selected models and random walk models range between 0.45 - 0.58) is used to control for the contemporaneous correlation of the noise, and the parameter $\psi = 0.5$ for the strength of the serial correlation (the AR(1) coefficients (in absolute values, in ARMA(1,1) model) range between 0.39 - 0.55 for the residuals of the three selected models).

the S and S_c statistics reject the null hypothesis of equal prediction power when the four models are considered. In pair-wise comparison cases, the RW model performs worse than each one of the three selected specifications.[32] That is, the exchange rate and control variables offer significant prediction power for the central parity.

The Mariano and Preve method, however, cannot statistically differentiate the predictive performance of Models A, B, and C. The S and S_c statistics in Panel B of Table 8 do not reject the null hypothesis that these three specifications have the same prediction power for the central parity. Specifically, the null hypothesis is not rejected when all three specifications are considered together or when any two of them are compared. While the multiplicative interaction model B (per equation (7)) yields smaller RMSE and MAE numbers, our statistical procedure cannot verify that its performance is indeed *statistically* better than the selected linear model or the model that is augmented with ΔFP variables.

5. Concluding Remarks

We study the empirical determinants of the RMB central parity against the US dollar between August 2015 and December 2016. In a linear regression framework, we identify the roles of the onshore and offshore RMB exchange rates, and the US dollar index but not the CFETS RMB currency basket index. The results illustrate the enhanced role of the onshore RMB rate, the weakened US dollar effect, and the improved transparency that are expounded by the August 2015 policy change.[33]

We show that the RMB index effect not detected in the linear framework can be unveiled with a multiplicative interaction model. Specifically, after controlling for multiplicative CNH volatility, the CFETS RMB index displays a significant effect in 76.5% of the observations in our sample. Further, the CNH volatility dampens the marginal effect of the CFETS RMB index, and this may cause the observed disconnect between the RMB index and the central parity in linear models. The CNH volatility also attenuates the links between the central parity and the other determining factors. These findings are in accordance with the anecdotal evidence that China is prone to strengthen control and administrative measures in face of unwanted volatility.

[32] The usual Diebold and Mariano (1995) test also confirmed the inferior forecast performance of the random walk specification.

[33] See, also, Cheung, Hui and Tsang (2016).

Our exercise is an empirical attempt to model RMB central parity movements. Although we used statistical criteria such as the AIC, SIC and adjusted R^2 estimate to guide our inferences, there is no guarantee that the true but unobservable central parity formation mechanism is given by the identified specification. The empirical results, nevertheless, lend some credibility to the official claim about the policy intent of making the central parity formation mechanism transparent and responsive to market forces (and not just the US dollar). By accounting for volatility, the exercise offers a way to reconcile the market's skeptical view and the repeated official messages about the reference to a currency basket.

We should note that in addition to the level movement, it is of interest and important to understand the volatility/variance dynamics of the RMB central parity. Nevertheless, it is beyond the scope of the current study to extend the setup to investigate simultaneously the mean and volatility dynamics. Future studies on both the mean and volatility dynamics of the central parity formation mechanism are warranted.

One limitation of the exercise is the sample period ends at December 2016. Even before we completed our paper, China expanded the number of constituent currencies of the CFETS currency basket to 24 from 13 in 2017 (China Foreign Exchange Trade System, 2016).[34] By broadening the coverage, China reduces the US dollar weight to 22.4% in the new currency basket from 26.4% in the original basket.[35] The coverage expansion is in line with the strategy of diluting the US dollar role in setting the central parity, and re-directing the market focus away from the bilateral US-RMB foreign exchange rate.

Then, in February 2017, the People's Bank of China shortened the reference period of the currencies used in calculating the central parity from 24 to 15 hours. The reduction was meant to better reflect changes in the forex market. China further modified its way to guide the RMB exchange rate in May 2017 by adding to the central parity formation mechanism a "counter-cyclical factor," which was then phased out in the beginning of 2018.[36]

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[34] The 11 currencies added to the currency basket are the South African rand, the Korean won, the United Arab Emirates dirham, the Saudi riyal, the Hungarian forint, the Polish zloty, the Danish krone, the Swedish krona, the Norwegian krone, the Turkish lira, and the Mexican peso (China Foreign Exchange Trade System, 2016). It is stated that CFETS will annually assess its currency basket and the assessment frequency may be more frequent.

[35] The combined weight of the US dollar and currencies pegged to it (e.g., the Hong Kong dollar, the United Arab Emirates dirham, and the Saudi riyal) is decreased to 30.5% from 33%.

[36] The added factor is meant to reduce excess RMB volatility and curb excessive one-way movements. However, for some market participants, the opaqueness of the counter-cyclical factor gives the authorities a way to control the RMB.

Undeniably, China's exchange rate policy has evolved very fast. It is foreseeable that China will continue its effort to liberalize its market and move toward (managed) convertibility, albeit at an uneven pace. Given China's history of a *de facto* peg to the US dollar, the prominent global role of the US dollar, and over 90% of RMB foreign exchange transactions being against the US dollar, it is reasonable to anticipate that patience will be required to transit and migrate to a truly flexible RMB regime. At this point, the jury is still out on the effects of the more recent changes on the RMB behavior.

Our empirical evidence based on observations up to the end of 2016 documents the role of the US dollar and, at the same time, lends support to the August 2015 proclamation of the currency basket policy. Since China's foreign exchange rate policy is evolving over time, it is warranted to examine the central parity formation mechanism when sufficient new information and data are available.

Appendix

A1. Data Description

Notation	*Variable*	*Source*
P_t	The RMB central parity rate	Bloomberg
Y_t	CNY exchange rate	Bloomberg
H_t	CNH exchange rate	Bloomberg
B_t	CFETS RMB Index	Based on raw data from Bloomberg
U_t	USD index	Bloomberg
Z_t	CNH conditional volatility estimated from a GARCH specification	Based on raw data of H_t from Bloomberg
VIX_t	VIX index	Bloomberg
VXY_t	JP Morgan emerging market currency volatility index	Bloomberg
FRD_t	A one-zero dummy variable to capture the possible effect of a drop in China's foreign exchange reserves	Based on statistics from State Administration of Foreign Exchange (SAFE)
FRI_t	A one-zero dummy variable for an increase in China's foreign exchange reserves	Based on statistics from SAFE
FP_t	CNH-CNY 1-month forward-point differential	Bloomberg

A2. The Roles of Onshore, Offshore, and US Dollar Rates Before August 2015

	1a	1b	1	2
$(P_{t-1}-Y_{t-1})$	-0.007***		-0.007	-0.009
	(-2.989)		(-0.479)	(-0.950)
$(P_{t-1}-H_{t-1})$		-0.005**	-1.99E-04	0.004
		(-2.298)	(-0.016)	(0.447)
ΔP_{t-1}	0.024	0.017	0.020	0.019
	(0.614)	(0.449)	(0.505)	(0.550)
ΔY_{t-1}	0.069***		-0.009	0.042*
	(2.720)		(-0.303)	(1.736)
ΔH_{t-1}		0.093***	0.097***	-0.007
		(4.769)	(3.965)	(-0.296)
ΔU_{t-1}				0.096***
				(18.895)
Constant	-7.77E-05***	-7.43E-05***	-7.81E-05***	-9.90E-05***
	(-3.426)	(-3.331)	(-3.371)	(-5.159)
Adj. R^2	0.016	0.041	0.040	0.344
AIC	-11.487	-11.514	-11.511	-11.891
SIC	-11.470	-11.497	-11.485	-11.861
# Observations	1,179	1,179	1,179	1,179

Note: The table presents the results of estimating the RMB central parity equations (1) and (2) using data from October 8, 2010 to August 10, 2015. ***, **, and * respectively indicate significance at the 1%, 5%, and 10% level. Robust t-statistics are given in parenthesis underneath coefficient estimates. Adjusted R^2 estimates are provided in the row labelled "Adj. R^2." See, also, Cheung *et al*. (2016).

A3. Marginal Effects of Onshore and Offshore RMB Rates

Figure A3.1 Marginal effect of ΔY on ΔP

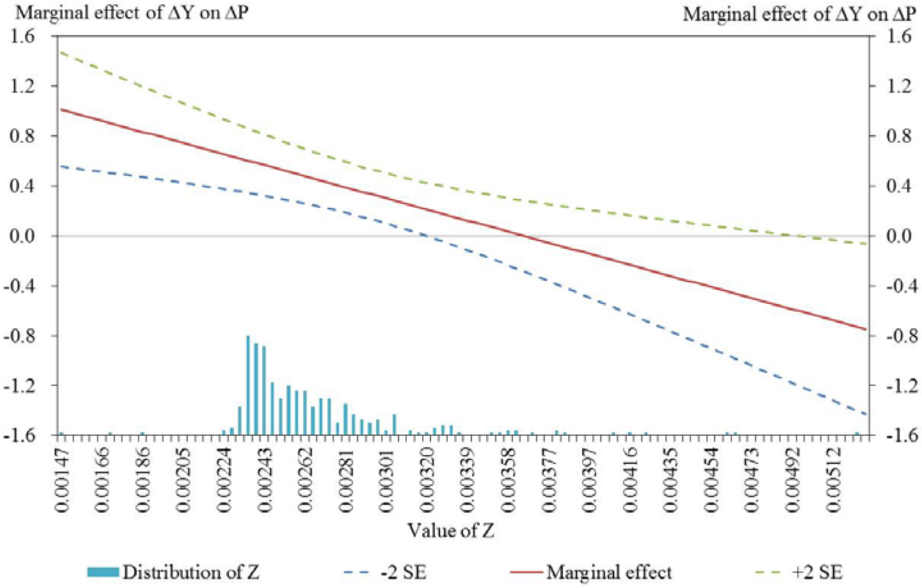
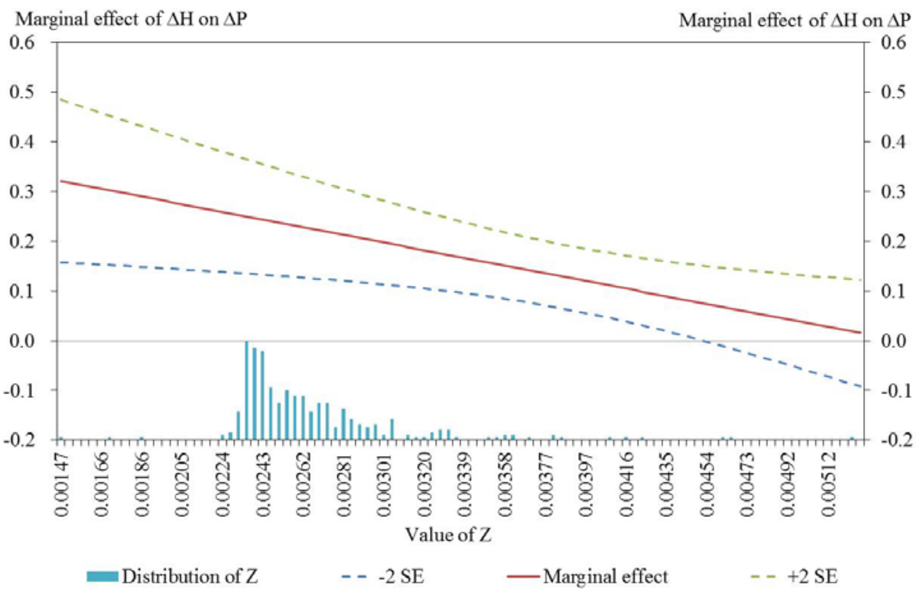


Figure A3.2 Marginal effect of ΔH on ΔP



Marginal effects of	% of significant observations	threshold of Z
ΔY	91.1	0.00316
ΔH	99.1	0.00450

A4. Results of estimating the RMB central parity equation (7) that allows for asymmetric responses to positive changes in lnVIX or lnVYX

	1				2			
	No Dummy		+ve $\Delta lnVIX_{t-1}$ Dummy		No Dummy		+ve $\Delta lnVXY_{t-1}$ Dummy	
$(P_{t-1}-Y_{t-1})$	-0.373	***	0.303		-0.350	***	0.231	
	(-2.889)		(1.241)		(-2.594)		(1.031)	
$(P_{t-1}-H_{t-1})$	-0.024		-0.035		-0.083	***	0.070	*
	(-0.941)		(-0.925)		(-2.921)		(1.900)	
ΔP_{t-1}	-1.214	***	0.730		-0.809	*	-0.648	
	(-3.967)		(1.039)		(-1.683)		(-1.015)	
ΔY_{t-1}	1.381	***	0.309		1.374	*	0.613	
	(3.011)		(0.437)		(1.871)		(0.672)	
ΔH_{t-1}	0.521	***	-0.156		0.373	**	0.048	
	(2.777)		(-0.347)		(2.213)		(0.157)	
ΔB_{t-1}	-0.726		-0.371		-1.389	***	0.662	
	(-1.469)		(-0.507)		(-3.336)		(0.858)	
ΔU_{t-1}	0.466	***	0.352		0.698	***	-0.029	
	(2.977)		(1.091)		(3.679)		(-0.088)	
Z_t	-0.627	***	0.720		-0.421	*	0.265	
	(-2.926)		(1.469)		(-1.839)		(0.548)	
$Z_t*\Delta P_{t-1}$	342.394	***	-315.226		186.572		211.103	
	(3.375)		(-1.184)		(1.048)		(0.894)	
$Z_t*\Delta Y_{t-1}$	-379.841	**	-16.289		-399.542		-131.485	
	(-2.564)		(-0.069)		(-1.567)		(-0.429)	
$Z_t*\Delta H_{t-1}$	-106.209	**	40.905		-68.744	*	13.151	
	(-2.444)		(0.287)		(-1.680)		(0.145)	
$Z_t*\Delta B_{t-1}$	231.332		101.059		470.797	***	-270.436	
	(1.300)		(0.383)		(3.192)		(-0.966)	
$Z_t*\Delta U_{t-1}$	-109.984	*	-129.695		-201.198	***	12.396	
	(-1.964)		(-1.091)		(-2.849)		(0.103)	
Constant	1.39E-03	**	-1.78E-03		5.44E-04		8.88E-06	
	(2.460)		(-1.421)		(0.942)		(0.007)	
Adj. R^2	0.635				0.645			
AIC	-10.447				-10.474			
SIC	-10.129				-10.156			
# Observations	336				336			

Note: The table presents the results of estimating the RMB central parity equation (7) that allows for asymmetric responses to positive changes in lnVIX or lnVYX. ***, **, and * respectively indicate significance at the 1%, 5%, and 10% level. Robust t-statistics are given in parenthesis underneath coefficient estimates. Adjusted R^2 estimates are provided in the row labelled "Adj. R^2".

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Table 1. Descriptive Statistics: Means, Standard Errors, and Correlations

	ΔP	ΔY	ΔH	ΔB	(P - Y)	(P - H)	(P - B)
Mean	0.00024	0.00025	0.00022	-0.00018	-0.00064	-0.00381	-2.70005
SD	0.00207	0.00168	0.00272	0.00198	0.00150	0.00464	0.05408
Correlation							
ΔP	1.000						
ΔY	0.349	1.000					
ΔH	0.516	0.501	1.000				
ΔB	-0.046	0.231	0.044	1.000			
(P - Y)	-0.509	-0.336	-0.277	0.228	1.000		
(P_{t-1} - H)	-0.389	-0.279	-0.415	0.056	0.462	1.000	
(P - B)	0.049	0.080	0.045	0.006	0.079	0.400	1.000

Note: The table presents selected descriptive statistics of the four RMB exchange rates, namely the RMB central parity against the US dollar (P), the onshore RMB exchange rate (Y), the offshore RMB exchange rate (H), and the CFEETS RMB currency basket index (b), in logs. The sample period covers August 17, 2015 to December 31, 2016.

Table 2. Unit Root and Johansen Tests

2.a Unit root tests

	ADF test
P	0.433
Y	0.885
H	0.076
(P -Y)	-7.120 ***
(P - H)	-4.869 ***

Note: Augmented Dicky-Fuller test statistics for regression specifications selected by AIC are presented. ***, **, and * indicate the rejection of the unit root null hypothesis at the 1%, 5%, and 10% level, respectively. ΔP, ΔY, and ΔH reject the unit root null hypothesis at 1%.

2.b Johansen Cointegration Tests

Null hypothesis	Eigenvalue	Trace Statistic	Max-Eigen Statistic
No cointegrating vector	0.191283	104.0124***	29.79707***
At most 1 cointegrating vector	0.091628	32.67759***	15.49471
At most 2 cointegrating vectors	0.001153	0.387672	3.841466

Note: Johansen trace and maximum eigenvalue statistics for the tri-variate system (P, Y, H) specification selected by AIC are presented. ***, **, and * indicate the rejection of the null hypothesis at the 1%, 5%, and 10% level, respectively. The two cointegrating vector estimates are a) P -0.999Y, and b) P-1.074H

Table 3. The Roles of Onshore and Offshore RMB Exchange Rates

	1a	1b	1
$(P_{t-1}-Y_{t-1})$	-0.451***		-0.378 ***
	(-5.736)		(-3.345)
$(P_{t-1}-H_{t-1})$		-0.091***	-0.033
		(-4.159)	(-1.633)
ΔP_{t-1}	-0.255***	-0.188***	-0.208 ***
	(-3.847)	(-4.084)	(-2.609)
ΔY_{t-1}	0.475***		0.219
	(5.678)		(1.428)
ΔH_{t-1}		0.352***	0.270 ***
		(9.271)	(5.369)
Constant	-9.71E-05	-1.34E-03	-1.84E-04
	(-0.918)	(-1.088)	(-1.586)
Adj. R^2	0.319	0.331	0.425
AIC	-9.891	-9.909	-10.054
SIC	-9.846	-9.863	-9.986
# Observations	336	336	336

Note: The table presents the results of estimating the RMB central parity equation (1). ***, **, and * respectively indicate significance at the 1%, 5%, and 10% level. Robust t-statistics are given in parenthesis underneath coefficient estimates. Adjusted R^2 estimates are provided in the row labelled "Adj. R^2."

Table 4. The Roles of the US Dollar Index, the RMB Index and Volatility

	2	3	4	5
$(P_{t-1}-Y_{t-1})$	-0.397 ***	-0.352 ***	-0.353 ***	-0.367 ***
	(-3.442)	(-2.761)	(-2.811)	(-2.769)
$(P_{t-1}-H_{t-1})$	-0.029	-0.034 *	-0.031	-0.035 *
	(-1.520)	(-1.694)	(-1.603)	(-1.868)
ΔP_{t-1}	-0.214 ***	-0.224 **	-0.240 ***	-0.231 **
	(-2.800)	(-2.423)	(-2.690)	(-2.590)
ΔY_{t-1}	0.196	0.248	0.246	0.236
	(1.275)	(1.360)	(1.328)	(1.273)
ΔH_{t-1}	0.131 ***	0.268 ***	0.126 ***	0.120 ***
	(3.347)	(5.248)	(3.150)	(2.821)
ΔB_{t-1}		-0.034	-0.057	-0.052
		(-0.568)	(-0.969)	(-0.899)
ΔU_{t-1}	0.170 ***		0.171 ***	0.171 ***
	(8.207)		(8.196)	(8.058)
Z_t				-0.154
				(-0.628)
Constant	-1.78E-04 *	-1.80E-04	-1.71E-04 *	2.19E-04
	(-1.838)	(-1.545)	(-1.776)	(0.350)
Adj. R^2	0.567	0.424	0.568	0.567
AIC	-10.335	-10.050	-10.334	-10.330
SIC	-10.255	-9.970	-10.243	-10.227
# Observations	336	336	336	336

Note: The results of estimating the RMB central parity equations (2) to (5) are presented under columns labelled (2) to (5). The volatility measure (Z) is the estimate of the CNH conditional volatility obtained from a GARCH(1,1) model. ***, **, and * respectively indicate significance at the 1%, 5%, and 10% level. Robust t-statistics are given in parenthesis underneath coefficient estimates. Adjusted R^2 estimates are provided in the row labelled "Adj. R^2."

Table 5. A Multiplicative Interaction Model of the Central Parity Formation Mechanism

Model	1	2	3	4	5
$(P_{t-1}-Y_{t-1})$	-0.613	-0.571	-0.343	-0.234	-0.245 **
	(-1.224)	(-1.038)	(-0.722)	(-0.454)	(-1.990)
$(P_{t-1}-H_{t-1})$	-0.120	0.012	-0.111	-0.026	-0.047 **
	(-0.667)	(0.084)	(-0.616)	(0.184)	(-2.469)
ΔP_{t-1}	-0.923 **	-0.791 *	-1.267 ***	-1.202 ***	-1.174 ***
	(-2.423)	(-1.949)	(-3.435)	(-3.128)	(-3.643)
ΔY_{t-1}	1.311 **	1.073 *	1.936 ***	1.765 ***	1.689 ***
	(2.243)	(1.817)	(3.445)	(3.348)	(3.996)
ΔH_{t-1}	0.871 ***	0.525 ***	0.807 ***	0.447 ***	0.439 ***
	(6.360)	(3.942)	(6.171)	(3.640)	(3.516)
ΔB_{t-1}			-0.841 ***	-1.048 ***	-1.019 ***
			(-2.618)	(-3.093)	(-2.941)
ΔU_{t-1}		0.562 ***		0.634 ***	0.633 ***
		(4.338)		(4.459)	(4.225)
Z_t	-0.233	-0.386	-0.298	-0.483	-0.344 *
	(-0.673)	(-1.281)	(-0.822)	(-1.598)	(-1.721)
$Z_t*(P_{t-1}-Y_{t-1})$	108.762	75.360	50.125	-5.620	
	(0.659)	(0.435)	(0.325)	(-0.036)	
$Z_t*(P_{t-1}-H_{t-1})$	24.694	-17.055	18.223	-25.354	
	(0.390)	(-0.331)	(0.284)	(-0.507)	
$Z_t*\Delta P_{t-1}$	250.066 *	205.236	349.851 ***	328.006 **	318.467 ***
	(1.892)	(1.435)	(2.767)	(2.418)	(2.675)
$Z_t*\Delta Y_{t-1}$	-365.935 *	-294.939	-540.483 ***	-490.485 ***	-462.423 ***
	(-1.863)	(-1.498)	(-2.918)	(-2.872)	(-3.307)
$Z_t*\Delta H_{t-1}$	-178.219 ***	-106.917 ***	-160.476 ***	-83.578 ***	-80.410 **
	(-4.683)	(-2.979)	(-4.432)	(-2.619)	(-2.589)
$Z_t*\Delta B_{t-1}$			266.015 **	340.484 ***	329.476 ***
			(2.355)	(2.778)	(2.653)
$Z_t*\Delta U_{t-1}$		-147.942 ***		-174.365 ***	-174.380 ***
		(-3.131)		(-3.335)	(-3.165)
Constant	3.58E-04	8.06E-04	5.18E-04	1.05E-03	6.74E-04
	(0.387)	(1.015)	(0.539)	(1.321)	(1.326)
Adj. R^2	0.499	0.623	0.508	0.636	0.638
AIC	-10.174	-10.453	-10.187	-10.485	-10.495
SIC	-10.038	-10.294	-10.028	-10.303	-10.336
BDS test (p-value)	0.680	0.894	0.826	0.892	0.890
# Observations	336	336	336	336	336

Note: The results of estimating alternative versions of the RMB central parity equation (6) are presented under columns labelled (1) to (4). Column (5) reports the results from the parsimonious specification (7) given in the text. ***, **, and * respectively indicate significance at the 1%, 5%, and 10% level. Robust t-statistics are given in parenthesis underneath coefficient estimates. Adjusted R^2 estimates are provided in the row labelled "Adj. R^2."

Table 6. The Roles of Selected Macro and Financial Variables

Model	1	2	3	4	5
$(P_{t-1}-Y_{t-1})$	-0.232 *	-0.217 *	-0.222 *	-0.249 **	-0.251 **
	(-1.882)	(-1.778)	(-1.835)	(-2.095)	(-2.100)
$(P_{t-1}-H_{t-1})$	-0.045 **	-0.045 **	-0.043 **	-0.052 ***	-0.048 **
	(-2.381)	(-2.353)	(-2.174)	(-2.803)	(-2.582)
ΔP_{t-1}	-1.187 ***	-1.187 ***	-1.248 ***	-1.197 ***	-1.209 ***
	(-3.324)	(-3.394)	(-3.517)	(-3.809)	(-3.902)
ΔY_{t-1}	1.897 ***	1.716 ***	1.670 ***	1.614 ***	1.574 ***
	(4.280)	(4.393)	(4.050)	(3.807)	(3.710)
ΔH_{t-1}	0.272 *	0.474 ***	0.432 ***	0.443 ***	0.466 ***
	(1.730)	(3.395)	(3.408)	(3.407)	(3.581)
ΔB_{t-1}	-1.088 ***	-1.042 ***	-1.066 ***	-1.074 ***	-1.069 ***
	(-2.751)	(-2.976)	(-3.101)	(-3.183)	(-3.160)
ΔU_{t-1}	0.645 ***	0.601 ***	0.639 ***	0.677 ***	0.683 ***
	(3.916)	(3.814)	(4.401)	(4.534)	(4.571)
ΔFP_{t-1}	-0.053 **				
	(-2.098)				
$\Delta \ln VIX_{t-1}$		-0.006			
		(-0.810)			
$\Delta \ln VXY_{t-1}$			0.014		
			(0.464)		
FRD_{t-1}				0.002	0.002
				(0.503)	(0.474)
FRI_{t-1}					0.002
					(0.340)
Z_t	-0.309	-0.303	-0.358 *	-0.332 *	-0.328 *
	(-1.586)	(-1.472)	(-1.788)	(-1.771)	(-1.735)
$Z_t*\Delta P_{t-1}$	326.962 **	316.589 **	336.229 **	330.426 ***	335.305 ***
	(2.460)	(2.402)	(2.513)	(2.834)	(2.925)
$Z_t*\Delta Y_{t-1}$	-522.917 ***	-465.943 ***	-451.899 ***	-436.426 ***	-425.628 ***
	(-3.493)	(-3.676)	(-3.322)	(-3.053)	(-2.974)
$Z_t*\Delta H_{t-1}$	-30.737	-96.865 **	-80.226 **	-81.774 **	-86.274 ***
	(-0.650)	(-2.573)	(-2.535)	(-2.516)	(-2.647)
$Z_t*\Delta B_{t-1}$	354.647 **	333.032 ***	340.651 ***	350.464 ***	348.042 ***
	(2.488)	(2.641)	(2.760)	(2.925)	(2.898)
$Z_t*\Delta U_{t-1}$	-180.626 ***	-160.248 ***	-177.034 ***	-190.590 ***	-193.020 ***
	(-2.976)	(-2.808)	(-3.360)	(-3.444)	(-3.484)
$Z_t*\Delta FP_{t-1}$	14.967 *				
	(1.867)				
$Z_t*\Delta \ln VIX_{t-1}$		2.808			
		(1.032)			
$Z_t*\Delta \ln VXY_{t-1}$			-2.012		
			(-0.177)		
Z_t*FRD_{t-1}				-1.150	-1.107
				(-0.705)	(-0.678)
Z_t*FRI_{t-1}					-1.120
					(-0.577)

Constant	5.94E-04	5.91E-04	7.45E-04	6.41E-04	6.57E-04
	(1.198)	(1.130)	(1.448)	(1.370)	(1.394)
Adj. R^2	0.641	0.644	0.644	0.640	0.642
AIC	-10.497	-10.506	-10.505	-10.495	-10.494
SIC	-10.315	-10.324	-10.323	-10.313	-10.290
# Observations	336	336	336	336	336

Note: The results of estimating alternative versions of the RMB central parity equation (10) are presented. See the text for definitions of ΔFP, ΔlnVIX, ΔlnVXY, FRD, and FRI. ***, **, and * respectively indicate significance at the 1%, 5%, and 10% level. Robust t-statistics are given in parenthesis underneath coefficient estimates. Adjusted R^2 estimates are provided in the row labelled "Adj. R^2."

Table 7. The Central Parity Formation Mechanism Allowing for Asymmetric Responses to Positive Changes in the US Dollar Index or the RMB Index

Model	1		2	
	No Dummy	+ve ΔU_{t-1} Dummy	No Dummy	+ve ΔB_t Dummy
$(P_{t-1}-Y_{t-1})$	-0.223 **	0.036	-0.139	-0.275
	(-2.225)	(0.161)	(-0.716)	(-1.116)
$(P_{t-1}-H_{t-1})$	-0.122 ***	0.151 ***	-0.076 ***	0.086 **
	(-4.810)	(4.461)	(-3.232)	(2.290)
ΔP_{t-1}	-0.478	-0.960	-1.774 ***	0.634
	(-0.991)	(-1.464)	(-4.558)	(0.698)
ΔY_{t-1}	1.137 **	0.452	2.348 ***	0.056
	(2.418)	(0.605)	(3.703)	(0.065)
ΔH_{t-1}	0.306	0.109	0.279	0.052
	(1.464)	(0.437)	(1.180)	(0.166)
ΔB_{t-1}	-2.085 ***	1.837 ***	-1.700 ***	0.722
	(-3.660)	(2.656)	(-2.840)	(0.962)
ΔU_{t-1}	1.126 ***	-0.988 **	0.767 ***	-0.512
	(4.878)	(-2.378)	(3.222)	(-1.313)
Z_t	-1.037 **	0.583	-0.197	-0.851 *
	(-2.379)	(0.975)	(-0.770)	(-1.778)
$Z_t*\Delta P_{t-1}$	48.615	328.406	521.166 ***	-206.731
	(0.269)	(1.384)	(3.528)	(-0.596)
$Z_t*\Delta Y_{t-1}$	-299.557 **	-41.860	-695.257 ***	-27.051
	(-2.055)	(-0.178)	(-2.920)	(-0.088)
$Z_t*\Delta H_{t-1}$	-49.176	-36.069	-2.771	-66.196
	(-0.781)	(-0.505)	(-0.038)	(-0.755)
$Z_t*\Delta B_{t-1}$	716.436 ***	-675.929 ***	572.569 **	-263.114
	(3.582)	(-2.772)	(2.591)	(-0.979)
$Z_t*\Delta U_{t-1}$	-362.838 ***	342.429 **	-234.859 ***	209.181
	(-4.313)	(2.245)	(-2.772)	(1.465)
Constant	2.07E-03 *	-3.28E-04	1.26E-04	2.67E-03 **
	(1.777)	(-0.211)	(0.192)	(2.083)
Adj. R^2	0.680		0.648	
AIC	-10.578		-10.483	
SIC	-10.260		-10.165	
# Observations	336		336	

Note: The table presents the results of estimating the RMB central parity equation (7) that allows for asymmetric responses to positive changes in the US dollar index or the CFETS RMB currency basket index. ***, **, and * respectively indicate significance at the 1%, 5%, and 10% level. Robust t-statistics are given in parenthesis underneath coefficient estimates. Adjusted R^2 estimates are provided in the row labelled “Adj. R^2”.

Table 8: Forecasting Performance: Multivariate DM Test

A. Comparison between the selected models and random walk specification

	Test	Squared Errors			Absolute Errors		
		Test statistics	Critical Values		Test statistics	Critical Values	
			10%	5%		10%	5%
Random Walk vs Model A	S	22.7397 **	2.8347	4.0542	37.9907 **	2.8347	4.0542
	S_c	22.3044 **	2.7804	3.9766	37.2634 **	2.7804	3.9766
Random Walk vs Model B	S	35.1777 **	2.8347	4.0542	45.4540 **	2.8347	4.0542
	S_c	34.5043 **	2.7804	3.9766	44.5839 **	2.7804	3.9766
Random Walk vs Model C	S	30.9937 **	2.8347	4.0542	37.9539 **	2.8347	4.0542
	S_c	30.4004 **	2.7804	3.9766	37.2274 **	2.7804	3.9766
Random Walk and Models	S	45.2878 **	6.8426	8.6630	54.1545 **	6.8426	8.6630
A, B, and C	S_c	44.4209 **	6.7116	8.4972	53.1179 **	6.7116	8.4972

B. Comparison between the selected models

	Test	Squared Errors			Absolute Errors		
		Test statistics	Critical Values		Test statistics	Critical Values	
			10%	5%		10%	5%
Model A vs Model B	S	0.3871	2.8347	4.0542	0.4605	2.8347	4.0542
	S_c	0.3797	2.7804	3.9766	0.4517	2.7804	3.9766
Model B vs Model C	S	0.6317	2.8347	4.0542	1.1039	2.8347	4.0542
	S_c	0.6196	2.7804	3.9766	1.0828	2.7804	3.9766
Models A, B and C	S	1.1505	4.9463	6.5372	1.6130	4.9463	6.5372
	S_c	1.1285	4.8516	6.4121	1.5822	4.8516	6.4121

Note: The Mariano and Preve S and S_c statistics are calculated using the "Squared Errors" and "Absolute Error" of one-step-ahead forecasts of the RMB central parity rate generated by a random walk specification and the selected models listed under the first column, using 100-day rolling window. The finite sample critical values at the 5% and 10% levels are generated from 100,000 Monte Carlo replications. See Mariano and Preve (2012).
The forecast sample runs from January 4, 2016 to December 30, 2016. Model A is the representative of linear models given by the specification under column "2" in Table 4, Model B is the representative of multiplicative interaction models given by the specification under column "5" in Table 5, and Model C is Model B augmented with the significant offshore-onshore RMB forward differential variable given by the specification under column "1" in Table 6).
"*" and "**" indicates that the null of equal predictive ability (EPA) is rejected at the level 10% and 5%.

Figure 1 RMB exchange rates & CFETS Index

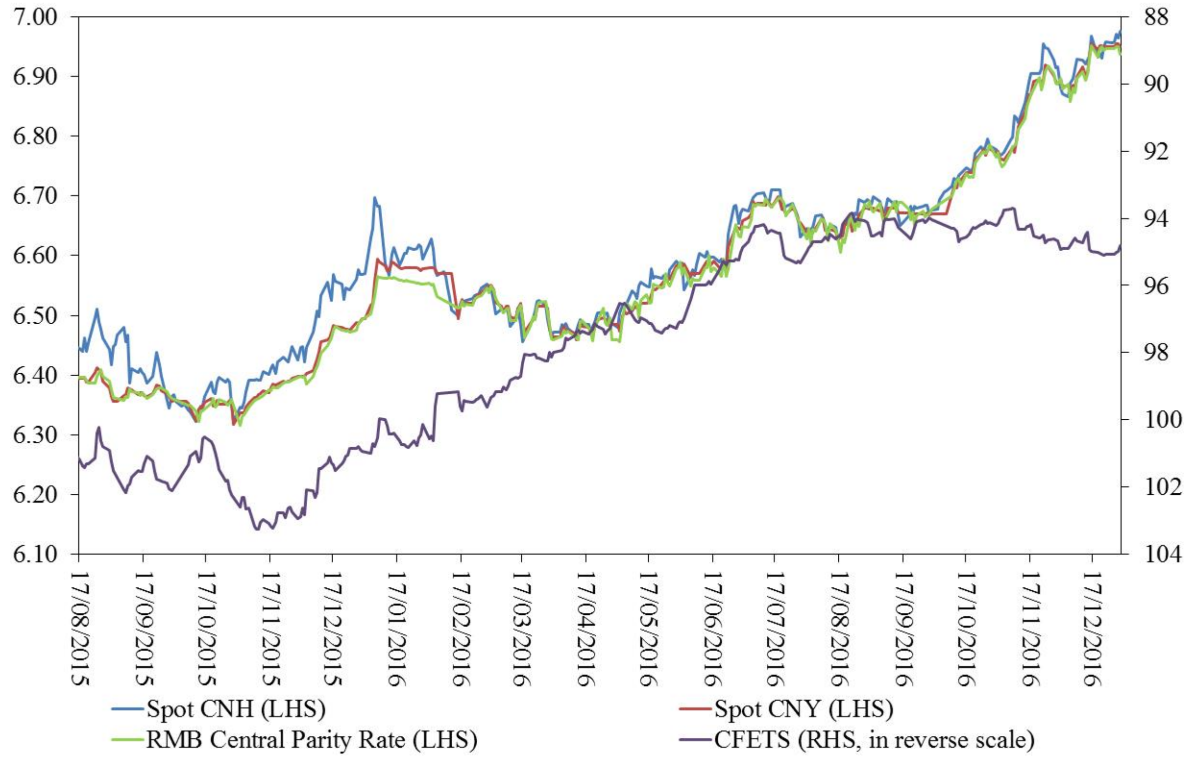

Figure 2 Marginal effect of ΔB on ΔP

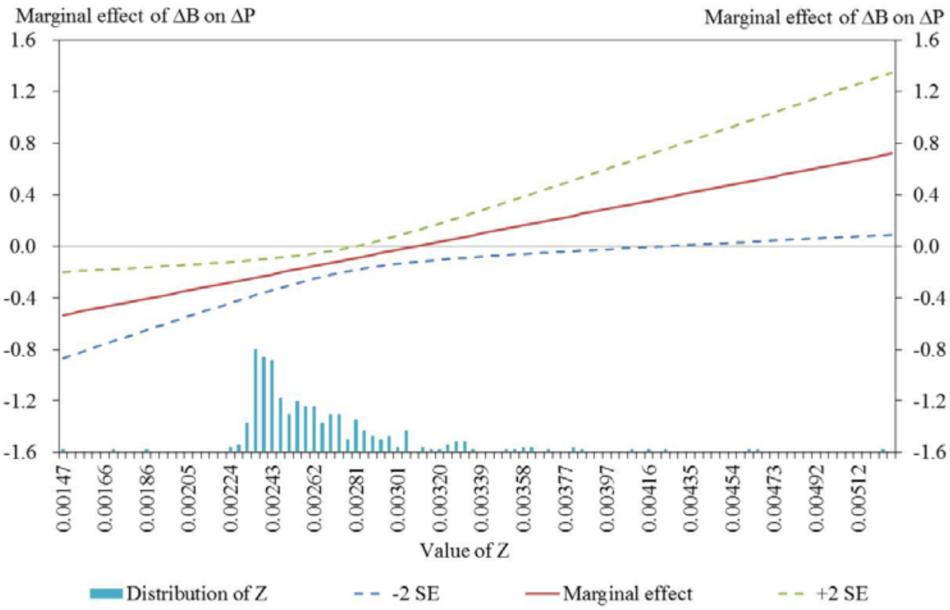

Figure 3 Marginal effect of ΔU on ΔP