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The Renminbi Central Parity: An Empirical Investigation

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Abstract

On August 11 2015, China revamped its procedure of setting the official central parity of the renminbi (RMB) against the US dollar. Our empirical investigation shows that the intertemporal dynamics of China's central parity are not the same before and after this policy change. They are more variable and have a few new determining factors. Both the deviation of the RMB offshore rate from the central parity and the US dollar index are the two significant determinants of the central parity both before and after the policy change. The VIX index has explanatory power before August 2015, but not after. After August 2015, the onshore RMB rate and the difference between the one-month offshore and onshore RMB forward points show a significant impact on the central parity. While the US dollar index effect remains, we find no evidence of a role for the RMB exchange rate against the currency basket revealed by China in December 2015 in the fixing process.

JEL Codes: F31, F33, G15, G17, G18

Keywords: China, RMB, exchange rate policy, central parity rate, on-shore and off-shore rates

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1. Introduction

On August 11 2015, China made a relatively brief announcement on improving its mechanism of setting the official central parity of its currency, the renminbi (RMB), against the US dollar. In essence the new formation mechanism is meant to afford market forces a bigger role in setting the daily official rate – also known as the fixing – by referring to the previous day's closing rate of the RMB, market demand and supply, and the valuation of other major currencies (People's Bank of China, 2015). The change, nevertheless, stirred up unrest in the global financial market after investors witnessed a 1.9% RMB depreciation on the first day of the new fixing procedure and a cumulated depreciation of 4.4% in the first three trading days.

China has undoubtedly underestimated the market response. The IMF's view that the change is "a welcome step as it should allow market forces to have a greater role in determining the (RMB) exchange rate" does not help to dispel the pessimistic market sentiment (International Monetary Fund, 2015a). Repeated official reassurances and administrative measures, including reported interventions in both the onshore and offshore markets, have also failed to rein in market volatility and restore confidence. The inability to articulate its exchange rate policy has instilled, if not reinforced, the concern that China adopted the new fixing procedure to obfuscate its intention of devaluing its currency to revive its weakened economy.

The global concern reflects the culmination of China's recent and ongoing efforts to promote the cross-border use of its currency, and its gradual integration into the international financial market. Investors' acute responses to the perceived policy of devaluing the RMB were prompted by a combination of China's slowed economic growth, the stock market gyration experienced in the early summer of 2015, and the corresponding abrupt intervention attempts.

Despite the change in the market mood, the IMF Executive Board officially endorsed in November 2015 China's endeavors in reforming its exchange rate policy with its decision to admit the RMB as the fifth currency to the Special Drawing Rights currency basket.[1] Soon after the IMF announcement, China published a RMB exchange rate index, and advocated the appropriateness of looking at the RMB value relative to a currency basket instead of relative to the US dollar. The market, again, was flummoxed and raised concerns that the reference to the index is a disguise to mitigate criticisms against further RMB depreciation against the US dollar.

Even before the August 2015 policy change, the RMB has been at times the focal point of rigorous policy debate. For instance, at the turn of the 21st century, RMB undervaluation or misalignment has been an intensely debated issue when China was running a huge trade surplus and hoarding a high level of foreign exchange reserves. Some empirical studies on the RMB misalignment are Cheung, Chinn, Fujii (2007), Cline (2015), Frankel (2006), Funke and Rahn (2005), Korhonen and Ritola, (2011), and Schnatz (2011). When China stepped up efforts after the 2007-8 global financial crisis to promote the overseas use of its currency, the global economy anxiously embraced the coming of a globalized RMB.[2] In addition, despite the fact that the RMB is heavily managed, there are attempts to characterize its dynamics, and its interactions with the offshore market rate.[3]

Against this backdrop, we study the formation mechanism of the central parity of the RMB against the US dollar. The central parity, *à la* official fixing, is taken as a signal of China's foreign exchange policy. As part of the ongoing financial liberalization process, China has revamped its daily fixing mechanism and expanded the trading band around the fixing in the last two decades. With China's increasing economic power and financial links, market participants constantly look for clues to infer its policy on exchange rate valuation and convertibility. It is why the new fixing procedure has triggered such intense attention and rattled the international community.

Despite China re-iterating that the RMB exchange rate value should be assessed with reference to a basket of currency,[4] anecdotal evidence all points to a prominent role for the US dollar exchange rate in determining the value of the RMB. For instance, the policy debate on RMB undervaluation typically

[1] The four incumbent currencies are the US dollar, euro, British pound and Japanese yen.

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

[3] See, for example, Cheung and Rime (2014), Ding, Tse, and Williams (2014), Funke, et al. (2015), Frankel (2009), and Hong Kong Monetary Authority (2016).

[4] Zhou Xiaochuan, the Governor of China's central bank in a recent interview (Wang, Zhang and Huo, 2016) made a statement: "During the reform of the exchange rate regime, we will significantly enhance the reference to a basket of currencies."

refers to a stable but low US dollar value of the Chinese currency. The RMB's dollar rate or fixing is usually highlighted in media discussions of the implications of a weakening RMB for capital flows and other asset classes. Frankel (2006, 2009) and Sun (2010), for example, show that, even after the 2005 exchange rate policy reform, the RMB was managed against the US dollar – or the US dollar has a very large relative weight in determining the RMB value.

To anticipate our results, we find that the behavior of China's central parity has changed following the August 2015 policy change: it is more variable and has a few new determining factors. Both the deviation of the offshore RMB rate from its onshore central parity and the US dollar index are two significant determinants of the central parity both before and after the policy change. The fear factor VIX index has explanatory power before August 2015, but not after. In accordance with the announcement of the policy change, the onshore RMB rate shows a significant impact on the central parity. We do not, however, find evidence of a role for the RMB exchange rate against the basket of currencies revealed by China in December 2015 in the fixing process.

To put the exercise in perspective, we recap recent developments in China's exchange rate policy including the nascent offshore RMB market in the next section. In Section 3, we examine the interaction between the central parity, the onshore rate, and the offshore rate of the RMB with an emphasis on the effects of the onshore and offshore RMB exchange rates on the officially determined daily fixings. We specifically compare and contrast behavior before and after the policy change introduced in August 2015, and consider the possible role of the announced RMB index. In the same section, we use a rolling regression approach to illustrate the instability of coefficient estimates, and evaluate the forecasting performance of the identified determinants.

Section 4 incorporates selected economic factors and assesses their marginal contribution to model performance, and forecasting ability. Some concluding remarks are offered in Section 5.

2. Exchange Rate Policy – Some Recent Developments

Since the inception of the 1979 reform initiative, China has embarked upon a long – and still ongoing – process of transitioning from a centrally planned economy to a market-based economy. Despite its phenomenal accomplishments in manufacturing and trade, China has taken a cautious attitude toward reforming and liberalizing its relatively fragile financial sector. On the RMB, China has experimented with several approaches to managing its exchange rate value to suit its economic objectives. Before the reforms, the foreign exchange market was tightly controlled. The exchange rate was dictated by the government to serve the accounting and planning needs of the centrally planned economic program, and to support the national development policy.

Since 1979, market forces have been gradually introduced in the design of foreign exchange policy. Between 1979 and 1993, China adopted dual exchange rate arrangements – an officially determined rate and a rate that is more responsive to market forces.[5] In 1994, the dual rate system was replaced with a unified rate, which was maintained at a relatively stable level until 2005. The RMB was allowed to trade within a defined band around its daily official fixing announced by the People's Bank of China. Initially, the daily trading band against the US dollar was set at 0.3% around the fixing. The policy, on the one hand, permits the presence of market forces, and on the other, retains the authorities' ability to manage and stabilize the RMB. The China Foreign Exchange Trade System (CFETS) was established in April 1994 to organize and support interbank RMB trading.[6]

In July 2005, China re-tuned its exchange rate policy and 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). The reference to demand and supply is in accordance with China's re-iterated stance of increasing the role of market forces in policy making.

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[5] In the early part of this period, the internal settlement rate based on trade cost considerations in conjunction with Foreign Exchange Retention Scheme was introduced. Then, it was replaced with the swap rate determined in foreign currency swap (adjustment) centers. Strictly speaking there was a third exchange rate – the parallel market rate either against the US dollar or the Hong Kong co-existence during that historical period.

[6] While it is usual known as CFETS, its complete name is China Foreign Exchange Trade System & National Interbank Funding Center. See, for example, http://www.chinamoney.com.cn/en/index.html for information functions and services provided by CFETS.

Theoretically speaking, a measure of the RMB value against a currency basket with appropriate weights of its components is preferred to one against the US dollar only. Further, by referencing to a basket of currencies, the RMB can be out of the US dollar's shadow, and transition towards flexibility. Under a currency basket setting, depending on the performance of component currencies, the RMB can appreciate or depreciate against the US, and, thus, it is flexible against the US dollar in both directions.

Despite the official statement on a currency basket setting, the *de facto* RMB movements give a strong impression of targeting the US dollar – or the US dollar has a very large weight in the currency basket (Frankel, 2006, 2009; Sun, 2010). After the 2005 policy refinement, the RMB gradually appreciated until July 2008. Some studies characterize the arrangement as effectively similar to a crawling peg arrangement (Ma and McCauley, 2011).

From July 2008 to June 2010 – in the midst of the 2008-9 global financial crisis, China resorted to a stable exchange rate policy that maintained the value of the RMB quite close to the level of RMB 6.83 against one US dollar.

On June 19, 2010, China announced further reforms to its exchange rate formation mechanism based on measures taken in 2005 (People's Bank of China, 2010). In essence, it repeated the 2005 declared policy of managing the RMB against a basket of currencies. Following this, the RMB resumed its gradual appreciation path.

Even under a tightly managed trading environment, the almost certain, albeit gradual, appreciation trend has invited substantial bets on one-way RMB appreciation. These one-way bets lead to hot money flows that do not necessarily reflect market demand and supply and build up undesirable economic implications. To add flexibility to the exchange rate and strengthen the role of demand and supply forces, China has gradually widened the trading band around the daily US dollar fixing from an initial ±0.3% to ±0.5% on May 21, 2007, to ±1 % on April 16, 2012, and ±2 % on March 17, 2014. A wide band increases the probability of two-way fluctuations and, hence, the risk of making one-way bets. Indeed, when the trading band was enlarged in 2012 and 2014, the RMB experienced two-way volatility that inflicted pain on one-way bet positions.

In July 2010, the Hong Kong Monetary Authority and the People's Bank of China signed the Memorandum of Co-operation on Renminbi business, which allows the trading of spot and forward RMB and RMB-linked structural products in Hong Kong.[7] The Memorandum cleared the path for trading offshore RMB. Since then, the RMB transacted in Hong Kong has been essentially traded like a convertible currency that is subject to global market forces, and market practitioners have labelled the RMB traded offshore CNH, instead of the usual trading symbol CNY. China's stringent capital controls make it possible to have a wedge between the onshore CNY and offshore CNH rates. That is, the RMB is under an alternative 'dual' exchange rate system.[8]

In 2015, China succeeded in lobbying its currency to be admitted to the International Monetary Fund's Special Drawing Rights currency basket.[9] Before the admission decision was announced in November,[10] China revised its RMB-US dollar central parity formation mechanism. Specifically, the People's Bank of China announced that the daily fixing will be set with reference to the previous day's closing rate of the RMB, market demand and supply, and valuations of other currencies.[11] On the announcement date (August 11), the central parity fell by 1.9% to 6.2298, marking the largest one-day drop since the adoption of the managed float in 2005. The CNH and CNY exchange rates fell by 2.8% and 1.9% also on that day.

Less than two weeks after the admission announcement, the People's Bank of China reproduced a CFETS commentary on its website.[12] In essence, the commentary points out that the RMB value should be assessed relative to a basket of currencies instead of only against the US dollar. The reference to a currency basket was openly announced back in 2005 and again in 2010. What is new

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[7] See Hong Kong Monetary Authority (2010). Before July 2010, non-deliverable RMB forwards instead of deliverable forwards are commonly traded in the market. The market dynamics and price disparity of the on- and off-shore forward exchange rate markets are examined by Leung and Fu (2014) and Chung et al. (2012) respectively.

[8] However, such system does not fall under the category of multiple currency practice according to Sections 2, 3 and 4 of the IMF's Article VIII. Also, see International Monetary Fund (2015b).

[9] The Special Drawing Rights is a supplementary reserve asset created by the IMF under the Bretton Woods regime in 1969.

[10] The new SDR basket comes into use ten months later on October 1, 2016.

[11] CFETS is authorized by the People's Bank of China to calculate and publish the central parity (a la the fixing) of the RMB. Before August 11, 2015, the fixing is based on a trimmed weighted average of prices from designated liquidity providers, and the weights are set discretionally; see http://www.chinamoney.com.cn/fe/Channel/2781516.

[12] http://www.pbc.gov.cn/english/130721/2988680/index.html.

is that the commentary includes a RMB index together with its component currencies and their weights – henceforth, we call it the CFETS RMB index.[13] The market was puzzled by the development; it was not clear if making a reference to a currency basket implies the central bank is set to manage the exchange rate against the CFETS basket, or use it as an excuse to depreciate the currency against the US dollar.

The August 2015 episode, together with expectations of the RMB to follow other emerging market currencies to be weakened after the US interest rate hike in December, rattled the global community and stirred volatile market reactions. Wild fluctuations in the RMB rate were linked to capital outflows and an equity market drop that triggered the suspension of the then newly introduced circuit breaker. The unexpected serious market response heightened the growing importance of the RMB in the international monetary system, and increasing demands by market for a more transparent China's exchange rate policy.[14] The investment community, in addition to routine official statements, makes use of the available information including the official central parity to infer policy intentions.

3. Central Parity, On-Shore and Off-Shore Rates

Despite the fact that China has steadily strengthened the role of market forces in setting its exchange rate policy, it retains a tight grip on the RMB exchange rate. Market participants scrutinize official central parity rates for hints of shifts in the policy stance or inconsistencies among official views on the currency. Even when officials re-iterate the goal of currency stability, if the central parity and the related market rates tell a different story, the market will be flummoxed and rattled.

A natural question to ask is: To what extent is the central parity rate predictable? Since 2005, each refinement of the central parity formation mechanism has referred to market forces, the role of the closing rate of the previous day, and has referenced a currency basket (People's Bank of China,

[13] The thirteen component currencies and their weights are: USD (26.4%), EUR (21.39%), JPY (14.68%), HKD (6.55%), GBP (3.86%), AUD (6.27%), NZD (0.65%), SGD (3.82%), CHF (1.51), CAD (2.53%), MYR (4.67%), RUB (4.36%), and THB (3.33%). There is no discussion on how these currencies are selected and their weights assigned. The RMB indexes based on the Bank for International Settlements (BIS) and SDR weights are included for comparison purposes.

[14] International Monetary Fund (2016a, Chapter 2; 2016b, Chapter 2), for instance, note that China's impacts on the rest of world are likely to grow with its increasing financial links with the global economy.

2005, 2010, 2015). What are the *de facto* roles of these factors? As noted in the previous section, the RMB has had two exchange rates – the onshore and the offshore ones - since the second half of 2010. Compared with the onshore rate, the offshore rate is subject to a lesser degree of invention and, thus, reflects better market information.[15] If these two rates play a role in determining the central parity formation mechanism, what is their relative importance?

3.1 Preliminary Discussions

Four variants of the RMB exchange rate are presented in Figure 1.[16] Panel A includes three US dollar rates of the RMB; namely the central parity rate, the onshore CNY rate, and the offshore CNH rate. The sample period is from October 8, 2010 to August 10, 2015. In addition to the three US dollar rates, the CFETS RMB index is added to Panel B, that covers the period of August 17, 2015 to April 15, 2016. The sample choices are dictated by the arrival of CNH trading and the change of the central parity formation mechanism in 2015. Because the market experienced unusual turbulence, we exclude the first four business days under the new fixing mechanism.

The plot of the RMB rates in Panel A and B shows discernably different patterns. For simplicity, we call the first sample the pre-change period, and the second one the post-change period. A few observations are in order.

First, the central parity rate shows a general appreciation trend until the end of 2013, and is relatively stable afterward in the pre-change period. Between 2014 and the first half of 2015, the central parity was mostly lower than both CNY and CNH – the market rates indicate a weaker RMB than the official fixing rate. In the post-change period, the central parity rate actually exhibits a general depreciation tendency. The change in the official rate trajectory can be a source of concern about the fate of a strong RMB policy.

15 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 is illustrated in, for example, Cheung and Rime (2014), Ding, Tse, and Williams (2014),

16 The data used for this Figure and in the rest of the article are described in the Appendix. The corresponding descriptive statistics are included in the Appendix.

Second, in the pre-change period, the onshore and offshore rates (CNY and CNH) tend to move in tandem; with a few exceptions of noticeably large disparities. As a result, their deviations from the central parity rate usually have the same sign. Indeed, the changes in CNY and CNH are quite closely related and have a correlation coefficient of 0.564, and the difference between CNH and the central parity on average is smaller and more volatile than the CNY-central-parity difference.

In the post-change period, however, the CNH in general indicates a weaker RMB than the CNY, which tracks the central parity quite well. The observation is suggestive of a pessimistic view prevailing in the offshore market after the 2015 summer turmoil that worried investors overseas. In contrast to the pattern in the pre-change period, the difference between CNH and the central parity after the policy change is both larger and more volatile than the CNY-central-parity differential.

Third, among the three dollar rates, the CNH displays the highest level of volatility, followed by CNY, and the central parity rate. In the pre-change period, the standard errors of the percentage changes of CNH, CNY, and the central parity are, respectively, 0.16, 0.11, and 0.08. The observed volatility differentials reflect the extent to which these rates are managed. These three rates in the post-change period are more variable than in the pre-change period. The high level of variability is in accordance with the heightened level of uncertainty recorded in the post-change market.

Fourth, the CFETS RMB index does not exhibit a readily recognized pattern relative to, say, the central parity rate.[17] The index rate in fact does not co-move much with the three RMB rates; the sample correlation coefficients between the index and the three RMB rates are no larger than 0.15. Since the index gives the RMB value relative to a basket of currencies, its behavior can be quite different from the RMB's dollar exchange rate.

The variability of the CFETS RMB index in the post-change period is lower than that of CNH, but, surprisingly, higher than that of the CNY and the central parity.[18] The reference to a basket of currencies does not necessarily yield a RMB valuation that is more stable than a bilateral rate. While it

[17] The CFETS methodology is adopted to calculate the CFETS RMB index using raw data from Bloomberg for the sample (December 31, 2014=100, in reverse scale). An increase in the index indicates RMB appreciation.

[18] In the post-change period, the standard errors of the percentage changes of CNH, CNY, the central parity, and the CFETS RMB index are, respectively, 0.32, 0.18, 0.15, and 0.24.

is not inconsistent with the idea that the reference to a basket of currencies does not mean pegging to a basket (Wang, Zhang and Huo, 2016), the variable differential makes the market speculate on what type of exchange rate stability China is targeting.

At the stage of preliminary analyses, it was affirmed that the dynamic behavior of the central parity rate has changed since August 2015. The set of explanatory variables and their coefficient estimated were statistically different before and after the policy change.[19] To facilitate discussions, we present the estimation results from periods before and after the policy change separately.

3.2 Pre-Change Period

Figure 1 shows that the interaction between these RMB exchange rates could have changed after the central parity formation mechanism was modified in August 2015. To formally examine the effects of onshore and offshore rates on the central parity in the pre-change period, we consider the specifications:

$$\Delta P_t = \alpha + \beta_1(P_{t-1} - Y_{t-1}) + \beta_2\Delta P_{t-1} + \beta_3\Delta Y_{t-1} + \varepsilon_t, \quad (1)$$

$$\Delta P_t = \alpha + \beta_1(P_{t-1} - H_{t-1}) + \beta_2\Delta P_{t-1} + \beta_3\Delta H_{t-1} + \varepsilon_t, \quad (2)$$

where P, Y, and H are, respectively, the central parity rate, the onshore CNY rate, and the offshore CNH rate in logs.

At the pre-test stage, we found that the three exchange rate series are individually unit root processes, and are cointegrated. Even though the cointegrating coefficient estimates are not exactly unity, the two deviation-from-the-central-parity series; that is, $(P_{t-1} - Y_{t-1})$ and $(P_{t-1} - H_{t-1})$ are stationary I(0) processes.[20] Thus, the two deviation series can be viewed as restricted cointegrating relationships of (P, Y) and (P, H), respectively.

19 These results are available upon request.
20 These pre-test results are reported in the Appendix, for brevity.

With these pre-test results, we interpret equation (1) as an error-correction specification of P derived from the bivariate system (P, Y) with a one-lag structure and the restricted error correction term $P_{t-1} - Y_{t-1}$. While the one-lag structure is presented for simplicity, empirical tests for results reported below affirm that it is appropriate to use this specification. We choose to present the results based on the restricted error correction term because it is likely to be the one considered by the market and policymakers. We also conducted the empirical analyses using the estimated error correction terms; the results that are available upon request are qualitatively similar to those presented here.

Equation (2) carries a similar interpretation for the (P, H) bivariate case.

The results of estimating these two equations are presented in Table 1. The central parity, in the presence of either the CNY or the CNH variables, does not depend on its own history; the ΔP_{t-1} is statistically insignificant under Columns I and II of Table 1.[21] In the case of CNY, the coefficient estimates of $P_{t-1} - Y_{t-1}$ and ΔY_{t-1} are, respectively, negative and positive. The negative $P_{t-1} - Y_{t-1}$ effect implies the central parity is gyrating towards the CNY. Further, the central parity variation, as indicated by the positive ΔY_{t-1} effect, follows the direction of CNY. Similarly, $P_{t-1} - H_{t-1}$ and ΔH_{t-1} by themselves give effects similar to those of the CNY variables. That is, individually, CNY and CNH affect the central parity via the empirical long-run error correction link and the short-term channel represented by their changes.

Column III presents the results of estimating the model that includes both CNY and CNH variables:

$$\Delta P_t = \alpha + \beta_1(P_{t-1} - Y_{t-1}) + \beta_2(P_{t-1} - H_{t-1}) + \beta_3\Delta P_{t-1} + \beta_4\Delta Y_{t-1} + \beta_5\Delta H_{t-1} + \varepsilon_t. \quad (3)$$

In this case, the central parity is significantly affected by variations in the CNH; the other variables are insignificant. Further the adjusted R-squares estimate is smaller than the pure CNH specification. One possible cause of these insignificant estimates is the high correlation between $P_t - Y_t$ and $P_t - H_t$; in the pre-change sample; the sample correlation coefficient of these two variable is 0.94. The high level of correlation can lead to multicollinearity that weakens the significance of coefficient estimates.

21 The time series $\{\Delta P\}$ by itself follows an AR(1) process: $\Delta P_t = -7.24E\text{-}05 + 0.067\Delta P_{t-1}$; Adj. $R^2 = 0.004$.

Column IV presents the result of seeking a parsimonious specification. Taking both parameter significance and explanatory power into consideration, the parsimonious specification is given by:

$$\Delta P_t = \alpha + \beta_1(P_{t-1} - H_{t-1}) + \beta_2\Delta H_{t-1} + \varepsilon_t, \quad (4)$$

which has two explanatory variables: the change in the CNH, and the CNH deviation from the central parity. They explain 4.2% of the variation in the central parity. The result underpins the informational role of offshore markets and confirms the relevance of the information content of the offshore RMB rate on the official RMB central parity.

In passing, we note that one-lag specification is supported by the absence of significant serial correlation in the estimated residuals, and the parsimonious specification under Column IV attain the lowest AIC and SIC values.

3.3 Post-Change Period

In addition to specifications (1) to (3), the behavior of the central parity in the post-change period is studied using:

$$\Delta P_t = \alpha + \beta_1(P_{t-1} - Y_{t-1}) + \beta_2(P_{t-1} - H_{t-1}) + \beta_3\Delta P_{t-1} + \beta_4\Delta Y_{t-1} + \beta_5\Delta H_{t-1} + \beta_6\Delta B_{t-1} + \varepsilon_t \quad , \quad (5)$$

where B is the CFETS RMB index. Note that the index and the bilateral central parity rate do not have the same unit of measurement. (5) is used to study the implications of changes in the index value for variations in the central parity.[22] The estimation results for the post-change period are presented in Table 2.

Similar to the case of the pre-change period, the central parity does not depend on its own history in Table 2; the ΔP_{t-1} is statistically insignificant under Columns I and II.[23]

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[22] Unit root tests showed that B is an I(1) process. Because of the difference in measurement units, the term "P – B" – the deviation from the central parity - is not considered.

[23] In the post-change sample, {ΔP} follows an AR(1) process: an AR(1) process: $P_t =$ $P_t = 7.24E\text{-}05 + 0.210$ P_{t-1}; Adj. $R^2 = 0.038$. This AR(1) specification has an AR coefficient estimate and an adjusted R-squares estimate larger than the corresponding ones of the pre-change period AR(1) specification reported in footnote 25.

For equation (1), only ΔY_{t-1} exhibits a statistically impact (Column I). The explanatory power, however, is noticeably larger than the corresponding specification in Table 1. The significance and good explanatory power echo the co-movement pattern of the central parity and CNY observed in Panel B of Figure 1. However, it is surprising that the deviation term P-Y is insignificant.

In the case of CNH, both $P_{t-1} - H_{t-1}$ and ΔH_{t-1} are statistically significant with expected signs. That is, even Panel B of Figure 1 indicates that the offshore rate is quite variable relative to the central parity, the former still shows a significant impact on the latter via both the empirical long-term and short-term channels. Is the observed CNH effect a spillover phenomenon, and attributable to a link between CNH and CNY? The answer apparently is "no." In the post-change period, changes in CNH and CNY have a sample correlation coefficient of 0.43, which is much smaller than in the pre-change period value of 0.94.

Column III presents the results of including both CNY and CNH variables. The variables ΔY_{t-1}, $P_{t-1} - H_{t-1}$ and ΔH_{t-1} retain their statistical significance with the expected signs – though the significance of ΔY_{t-1} is marginal. The evidence indicates that the ability of offshore rates to explain variations in the central parity is beyond the one offered by the onshore rate. However, after the August 2015 policy change, variations in the onshore rate CNY have become a relevant factor in explaining the central parity movements.

Despite the hype surrounding the reference to a basket of currencies, Column V shows that the CFETS RMB index does not help to explain changes in the central parity; ΔB has a relatively small and statistically insignificant coefficient estimate. Replacing the CFETS RMB index with either the BIS or the SDR RMB index also gives insignificant results.[24] Further if the sample starts on, say, December 14, 2015; that is after the publication of the CFETS RMB index, the estimates are still insignificant. It may be hard to compare valuation based on a basket of currencies to that based on a single currency. While it is both practically and theoretically appropriate to assess the value of RMB relative to a currency basket, it is not clear if China intends to peg its currency to a basket of currencies or use the RMB index to guide its exchange rate policy.

[24] When the CFETS RMB index was introduced, both the BIS and the SDR RMB indexes were reported at the same time (http://www.pbc.gov.cn/english/130721/2988680/index.html).

The parsimonious specification for the post-change period, presented under Column VI, is given by:

$$\Delta P_t = \alpha + \beta_1(P_{t-1} - H_{t-1}) + \beta_2\Delta Y_{t-1} + \beta_3\Delta H_{t-1} + \varepsilon_t, \quad (6)$$

which includes three significant variables: ΔY_{t-1}, $P_{t-1} - H_{t-1}$ and ΔH_{t-1}.

Here we note two differences between results from the pre- and post-change periods. By comparing the adjusted R-squares estimates in Tables 1 and 2, it is apparent that, after the change in its formation mechanism, the central parity becomes easier to be modelled. The parsimonious specification, for example, can explain 37.3% of the variation in the post-change period (Column VI, Table 2), but only 4.2% in the pre-change period (Column IV, Table 1). One possible reason for the improved performance is that, by incorporating information about the closing rate of the RMB in the previous day into the new central parity formation mechanism, changes in CNH and CNY, which have retained a high degree of co-movement in the post-change period (their correlation coefficient estimate in the post-change period is 0.546) have been assigned explicit roles in determining the central parity.

Another difference is that CNY becomes a new factor in explaining the central parity in the post-change period. Before the policy change, the empirical evidence only points to a link between CNH and the central parity. The offshore RMB market is commonly perceived to be a place to garner market intelligence about demand and supply with minimal distortions induced by official controls. The informational role of CNH is confirmed by its role in explaining the central parity. The results in Table 2 confirm that the role of CNY has strengthened since the introduction the new quotation mechanism of central parity rate. The offshore rate CNH, nevertheless, still aggregate information on demand and supply forces overseas.

3.4 Rolling Regression

Despite China’s progressive efforts in liberalizing its financial markets and reforming its exchange rate formation mechanism, the currency’s direct exposure to global market forces is rather limited. The

CNH market in which the pricing of the RMB is relatively free from official controls has only been around since 2010. It is conceivable that the nascent offshore market and its interaction with the onshore market have been evolving in the last few years. The empirical evidence reported in the previous subsections only represents the average relationships between the central parity and the other RMB rates. To assess the evolution of these relationships, we study the coefficient estimates obtained from rolling regressions.

For the pre-change period, we consider the parsimonious specification reported under Column IV, Table 1. The rolling regression results based on a moving window of 200 observations are presented in Figure 2. The time-varying effects of $P_{t-1} – H_{t-1}$, the error correction term, and ΔH_{t-1}, the change in CNH, are well illustrated by the estimates of their coefficients from rolling regressions. The $P_{t-1} – H_{t-1}$ effect is mostly negative; especially after an initial volatile period. These rolling regression estimates are usually not statistically significance; when they are significant, they are negative. The low frequency of observed significance is attributable to the rolling sample size which is small relative to the variability of the $P_{t-1} – H_{t-1}$ effect on the central rate. The change in CNH, on the other hand, always displays a positive impact, which is quite often significant.

Figure 3 presents the rolling regression results for the post-change period. The estimates are based on the parsimonious specification VI reported in Table 2. Because the post-change period has a very small sample size, the rolling regression uses a moving window of only 20 observations. Thus, we have to interpret the observed variability and statistical significance with caution. The graphs of these rolling regression estimates again demonstrate the time-varying character of the effects of these variables on the central parity. These rolling estimates usually have signs that are in line with those reported in Table 2, though their significance fluctuates over time. One noticeable observation is the apparent sign change exhibited by the ΔY variable near the end of the sample period.

3.5 Forecasting Performance

In this subsection, we assess the ability to predict the central parity. For each model considered in Table 1, we generate one-step ahead forecasts from rolling regressions with a moving window of 200 observations. For models of the post-change period in Table 2, a window size of 20 is used. The out-of-sample forecast results are presented in Table 3.

Panel A gives the results pertaining to the pre-change period. The model identifiers refer to Column labels in Table 1. The root mean squared forecast error (RMSE), mean absolute forecast error (MAE), and proportion of correct direction of change forecast (DoC) of each model are presented. The results derived from a random walk with drift (RW) specification that is commonly used as the benchmark in assessing exchange rate forecasting performance are included at the bottom of the panel. The Diebold-Mariano test statistics for testing whether a model's forecasting performance according to one of the three reported measures is better than the RW benchmark are given underneath individual forecasting measures. A brief description of the Diebold-Mariano test statistic is given in Appendix.

The parsimonious specification that includes only $P_{t-1} – H_{t-1}$ and ΔH_{t-1} as predicting variables yields the smallest RMSE and MAE, and its MAE is statistically smaller than that of the RW. That is, the forecasting performance of the parsimonious specification is better than the RW benchmark based on these two criteria, and is statistically better based on a comparison of mean absolute forecast errors. The Model II that includes the CNH related variables also outperforms the RW benchmark with a statistically significant Diebold-Mariano MAE test statistic. In passing we note that Model I that includes only onshore information does not do well. Its forecasting performance based either RMSE and MAE is significantly, albeit only marginally, worse than the RW benchmark.

The column labelled "DoC" presents the proportion of forecasts that correctly predict the direction of the central parity movement and, underneath these sample proportions, the Diebold-Mariano MAE test statistics for the hypothesis that the reported proportion is significantly different from ½. When the proportion statistic is significantly larger than ½, the forecast is said to have the ability to predict the direction of change. On the other hand, if the statistic is significantly less than ½, the forecast tends to give the wrong direction of change.

The three models that include the CNH related variables – $P_{t-1} – H_{t-1}$ and ΔH_{t-1} correctly predict the direction of change above the ½ threshold. However, the predictive ability is deemed not to be statistically significant. The forecasts from either the RW benchmark or the Model I have less than a one-half chance of predicting the correct direction.[25]

In sum, the evidence suggests that, during the pre-change period, the offshore market offers some useful information on the central parity dynamics. The models that include information on the change of the offshore RMB rate, and the difference between the offshore rate and the central parity, usually generate forecasts better than the random walk benchmark and, in some cases, the outperformance is statistically significant.

The forecasting results from the post-change period depict a different story about the predictive powers of onshore and offshore RMB rates. Specifically, in Panel B of Table 3, the onshore variables are included in the best performing specification; Model III gives the smallest RMSE and MAE and the largest DoC measures. The two onshore rate related variables $P_{t-1} – Y_{t-1}$ and ΔY_{t-1} are included in the three specifications (Models I, III, and V) that outperform that the RW benchmark under the MAE criterion.

All the models under consideration have a good chance of correctly predicting the direction of change of the central parity. The proportion of forecasts with the right direction is between 68% and 76%; these sample proportions are statistically better than the 50% mark, and are larger than from the RW benchmark. That is, it is relatively easy to predict the direction of change of the central parity rate with the formation mechanism introduced in August 2015.

The results in Table 3 reinforce the inferences about the shift in the role of the onshore RMB rate on the central parity determination process, and the explanatory power and predictability of the central parity.[26]

25 The forecasting performance of the AR(1) model given in footnote 25 is worse than the RW benchmark; its RMSE, MAE, and DoC are 0.481, 0.361, and 0.469.

26 The forecasting performance of the AR(1) model of ΔP_t for the post-change period again is not good; its RMSE, MAE, and DoC are 1.077, 0.789, and 0.573.

4. Economic variables

4.1 US dollar, VIX and Offshore Expectations

The parsimonious specifications (4) and (6) that capture the response of the central parity rate to developments in onshore and offshore RMB rates in the pre-change and post-change periods are used to investigate the marginal impact of selected economic variables. Specifically, for data in the pre-change period, we consider the augmented regression:

$$\Delta P_t = \alpha + \beta_1(P_{t-1} - H_{t-1}) + \beta_2\Delta H_{t-1} + \beta_3 Z_{t-1} + \varepsilon_t, \quad (7)$$

And, for data in the post-change period the augmented regression:

$$\Delta P_t = \alpha + \beta_1(P_{t-1} - H_{t-1}) + \beta_2\Delta Y_{t-1} + \beta_3\Delta H_{t-1} + \beta_4 Z_{t-1} + \varepsilon_t, \quad (8)$$

where the variable Z includes other economic factors that affect the central parity. At this stage of preliminary analyses, we assess the relevance of a number of possible factors. Tables 4 and 5, for brevity, report results obtained from variables that yield statistically significant effects.[27]

The three economic variables that offer marginal explanatory power are the US dollar index compiled by the Intercontinental Exchange,[28] the so-called fear index VIX, and the difference between the offshore and onshore one month forward points in deliverable forwards.[29] The individual effect of these additional variables is assessed before their combined effect is evaluated.

The results in Tables 4 and 5 show that the effect of the change in the US dollar index (ΔU_{t-1}) is quite robust across the pre-change and post-change periods. In both sample periods, a stronger US dollar

[27] We found that the economic variables, including emerging market currencies volatility, A-share index and volatility, A-H share premium and China's CDS spread, did not have significant marginal explanatory for the central parity.

[28] The index is a weighted average of the US dollar exchange rates against other major currencies supplied by around 500 banks. 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.

[29] A positive CNH-CNY forward-point differential implies the offshore RMB is expected to be weaker than the onshore one in the future. The forward point differential can be considered as a proxy of interest rate differential. SHIBOR is not a good indicator of onshore market interest rates (which have often been flat over significant periods of time), while the offshore money market occasionally suffers low liquidity (hence wild fluctuations). According to covered interest parity, the difference between the spot and forward exchange rates (i.e., forward point) is governed by the interest differential between the currencies.

index implies that the Chinese authorities set a stronger US dollar fixing against the RMB. The effect is apparently more prevalent in the pre-change period; the US dollar index has a noticeably larger marginal explanatory power over the parsimonious specification in the pre-change period than in the post-change period (Table 4, IV and IVa-i, and Table 5, VI and VIa-i).

The ΔH effect appears unstable in the presence of these economic variables. The US dollar index effect displaces the ΔH_{t-1} effect in the pre-change period. The presence of ΔU_{t-1} renders ΔH_{t-1} statistically insignificance in Table 4. While the ΔH effect in the post-change period remains when the US dollar index is added to the regression, its effect becomes insignificant when a combination of these economic variables is included.

The difference between the central parity and the CNH ($P_{t-1} - H_{t-1}$), nevertheless, retains its significance. That is, the information relevant for the central parity contained in the change in CNH itself is dominated by that embedded in the US dollar index. However, the information in $P_{t-1} - H_{t-1}$ is different from the US dollar index.

The VIX effect is mainly detected before the new central parity formation mechanism (Table 4). During the pre-change period, a larger VIX implies a weaker RMB fixing. Even though the S&P 500 volatility index, VIX, measures the market's expectations of US equity market volatility, it is arguably the most widely used indicator of investors' level of risk aversion in financial markets, and is commonly known as the fear index. Rey (2013), for example, discusses the use of VIX as an indicator of the global financial cycle and note the dependence of foreign exchange rates on the global financial cycle.

The so-called risk-on and risk-off phenomenon refers to the observation that capital tends to flow towards risky assets when the fear index is low and flows out when it is high. Some previous studies that report the VIX effect on (emerging market) currencies including the RMB are Cairns, Ho, and McCauley (2007), Cheung and Rime (2014), Fatum, Rasmus and Yohei Yamamoto (forthcoming). Since the RMB is an emerging market currency, it is expected to be heavily affected by market's attitude toward risk. The VIX effect in Table 4 is in accordance with this line of reasoning.

The VIX, however, does not exert any influence on the central parity in the post-change period (Table 5).

The offshore forward rate, which is more freely traded than its onshore counterpart, is considered a barometer of the market's view on the RMB. We incorporate the difference between offshore and onshore RMB forward points in deliverable forwards to gauge the possible reaction to the discrepancy between the market's assessment and the semi-official view on the near future path of the RMB. Our findings suggest that the discrepancy only displays some marginal explanatory in the post-change period. Specifically, when the offshore forward point suggests a RMB value lower than onshore forward point, the authorities tend to set a stronger RMB fixing against the dollar; it favors leaning against market expectations.

The result can be attributed to the possibility that China has become conscientious in managing expectations in the offshore market following the policy change in August 2015. Panel B of Figure 1 reveals that the offshore RMB rate is in general weaker than the onshore rate and the central parity. The phenomenon is attributed to pessimism in the offshore market due to uncertainty arising from the currency depreciation following the August 2015 policy change, and China's inability to soothe RMB skeptics. It was reported in the news that China intervened in the offshore market to stabilize the RMB and narrow the gap between the onshore and offshore rates. Thus, the response of the central parity to the offshore view on the future value of the RMB can be part of the effort to reconcile the rates in these two markets.

In sum, our results show that, before and after the policy change in 2015, the US dollar's general strength has implications for determining the central parity. The effect of the CNH variable is weakened in the presence the US dollar index – the change in the CNH rate becomes a non-factor while the CNH deviation from the central parity still plays a role. The policy change, nonetheless, has modified the role of other variables. In the previous section, we noted that CNY has become a factor after the change. In the current section, it is found that the VIX effect subsides and the role of offshore expectations emerges in the post-change period.

4.2 Rolling Regressions

The parsimonious specification reported in Column IVc, Table 4 is used to conduct the rolling regression analysis. The moving window size is 200 observations. Figure 4 plots the coefficient estimates obtained from the rolling regression estimation. These rolling estimates, especially those of $P_{t-1} – H_{t-1}$ and $VIX_{t-1,}$ display considerable variability. The pattern of the estimates of $P_{t-1} – H_{t-1}$ is quite similar to the one depicted in Figure 2. The effect of the VIX_{t-1} variable has apparently experienced a structural shift around 2013 from “positive” to “negative.” The US dollar index effect, in accordance with the regression results in Table 4, is quite significant throughout the pre-change period.

The estimates from the rolling regression based on the parsimonious specification reported in Column VIc, Table 5 and a window size of 20 are plotted in Figure 5. The patterns of the rolling estimates of $P_{t-1} – H_{t-1}$ in Figure 3 and 5 are quite similar. For Y_{t-1}, the inclusion of additional economic variables does not have a material impact on the pattern of its coefficient estimate over time though the sign of the estimate varies in these two figures. The significance of the coefficient estimates of U_{t-1}, is less prevalent in the post-change period than in the pre-change period. The rolling coefficient estimates of FP_{t-1} stay in the negative region for most of the post-change period and display a few spikes.

The graphs of these rolling regression estimates demonstrate the time-varying character of the effects of these variables on the central parity. The coefficient patterns of the CNH and CNY variables that remain significant are not materially affected in the presence of these additional economic factors.

4.3 Forecasting Results

The forecasting performance of the model specifications considered in Tables 4 and 5 are presented in Table 6, which has a layout similar to that of Table 3. Again, one-step ahead forecasts derived from rolling regressions with a moving window of 200 observations for the pre-change period, and 20 observations for the post-change period are compared. The forecast performance of the random walk model is included again for easy reference.

Before the policy change, the parsimonious model that has three explanatory variables; namely, P – H, ∆U and ∆VIX gives the smallest RMSE and MAE numbers, which are statistically smaller than the corresponding ones of the RW benchmark (Panel A, Table 6). Comparing the RMSEs and MAEs in the Panel, we have the impression that the noticeable improvement in the forecast is attributable to the inclusion of the US dollar index variable. The strong link between the US dollar valuation and the setting of the central parity in the pre-change period is well underpinned by the results in this and previous subsections.

The combined Model IVb correctly predicts the direction of change over 70% of times, and the predictive power is significantly better than flipping a coin. Again the US dollar index variable is likely the main source of the strong directional predictive ability.

With the exception of Model IVa-iii under the RMSE and DoC criteria, all models that include one or more of the three economic variables significantly out-forecast the random walk specification.

In contrast with the case of the pre-change period, the inclusion of relevant economic factors to the post-change specifications does not tend to improve their forecasting performance. The best MSAE, MAE and DoC numbers in Panel B of Table 6 come from the parsimonious Model VIc in Table 5. However, the forecasting performance of Model VIc is no better than the best performers in Panel B of Table; it is not uncommon that a model incorporating only CNH and CNY variables out-performs the corresponding one augmented by economic variables. The results highlight the possibility that a better fitted model specification does not necessarily yield better forecasting results. And evaluations based on regression fit and forecasting can give different results.

5. Concluding Remarks

China’s financial sector has a limited degree of linkages with the global financial market. Nevertheless, China is accelerating its financial integration with the world, and the global economy is increasingly affected by developments there. The volatile market reaction to China’s change in its central parity formation mechanism is a case in point. The reverberations in the global financial market attested to China's global roles are reflecting its growing economic power.

The intertemporal dynamics of China's central parity are not the same before and after the policy change; they are more variable but easier to explain after the policy change. Our empirical results show that the deviation of the RMB offshore rate CNH and the US dollar index are the two factors that help to explain changes in the central parity both before and after the policy change. Between late 2010 and August 2015, the fear factor as measured by the VIX index is another explanatory factor. Since the policy change in August 2015, the RMB onshore rate CNY and the difference between the one-month CNH and CNY forward points have become two additional determinants.

Since the introduction of the managed floating exchange rate regime in 2005, China has from time to time reiterated its intention of setting its exchange rate based on market supply and demand and with reference to a basket of currencies. The objective is to have a managed floating that enhances exchange rate flexibility in response to market forces and emphasizes the stability of the RMB value against a basket of currencies rather than against the US dollar only.

Our findings, however, suggest that, before and after the 2015 policy change, the RMB central parity is affected by conditions in the offshore RMB market as measured by the gap between the CNH and the official fixing and the value of the US dollar against other major currencies. If the official fixing is indicative of policy intentions, adjustments to CNH deviations from the fixing, and even to differences between the one-month CNH and CNY forward points and the VIX index, can be interpreted as responses to market forces overseas.

While the significance of CNY in the post-change period is in line with its role highlighted in the August 2015 policy change announcement, the US dollar index effect is not exactly in line with the goal of loosening the RMB link to the US dollar. The empirical evidence suggests that the RMB's value tends to follow the general valuation of the US dollar. Apparently, it is the RMB exchange rate against the US dollar, and its stability, which is still the focus of market participants.

With the 2015 policy change and the subsequent publication of the CFETS currency basket, China has given the market the impression that it wishes to strengthen the reference to a basket of currencies, and weaken the link to the US dollar. Instead of maintaining a stable US dollar value, China claims to manage the RMB currency basket exchange rate at a stable level. Since August 2015, however, the RMB exchange rate against the CFETS currency basket is more volatile than the RMB fixing against the US dollar. In fact, the volatilities of the three RMB currency basket exchange rates; namely the CFETS, the BIS, and the SDR basket are greater than that of the RMB-US dollar fixing rate.

The difficulty of modelling exchange rates using either a structural approach or a time series framework is well known. It is unclear if China's exchange rate policy is underpinned by, say, a quantity-based model. While the empirical settings in the previous sections do not represent the full picture underlying the central parity formation mechanism, our attempt reveals some possible economic influences on China's central parity formation mechanism. Even before the recent policy change, about one-third of the daily central parity variability is attributable to a few exchange rate and economic variables, and the central parity is quite predictable. The ability to explain the variability and predict changes has been enhanced by the policy change.

An interesting question is about the role of the currency basket. Managing a currency basket in an open and transparent way can be tricky for an economy of China's economic power and financial strengthen. As China's influence on global financial markets is expected to increase over time, managing a stable level of a currency basket exchange rate can lead to repercussions for smaller economies, which have their currencies in the basket. If the ultimate policy objective is to maintain a stable currency basket exchange rate for the RMB, then the existing evidence indicates that China is experimenting and exploring ways to achieve such stability and emerge from the shadow of the US dollar. China, during the transition period, has to carefully choose the basket of currencies and their weights to avoid moving away from the adversity of referencing to the US dollar to one of referencing to a currency basket.

Appendix

I. Data Definitions and Sources

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
VIX_t	VIX index	Bloomberg
FP_t	CNH-CNY 1-month forward-point differential	Bloomberg

II. Descriptive statistics and correlations

(A) Descriptive statistics

	Pre-Change Period October 8, 2010 - August 10, 2015				Post-Change Period August 17, 2015 - April 15, 2016			
			Serial correlations				Serial correlations	
	Mean	SD	AR(1)	AR(2)	Mean	SD	AR(1)	AR(2)
ΔP_t	-0.0001	0.0008	0.0673	0.0040	0.0001	0.0015	0.2101	-0.0608
ΔY_t	-0.0001	0.0011	-0.0372	-0.0340	0.0001	0.0018	0.1138	-0.0790
ΔH_t	-0.0001	0.0016	-0.0657	0.0102	0.0000	0.0032	0.0139	-0.0273
ΔB_t	--	--	--	--	-0.0002	0.0024	0.1552	-0.1084
(P_t-Y_t)	-0.0009	0.0079	0.9913	0.9846	-0.0009	0.0016	0.5306	0.4440
(P_t-H_t)	-0.0005	0.0092	0.9852	0.9753	-0.0056	0.0057	0.8365	0.7277
(P_t-B_t)	--	--	--	--	-2.7487	0.0247	0.9942	0.9855
ΔU_t	0.0002	0.0048	-0.0306	0.0156	-1.2E-04	0.0057	-0.0436	-0.0662
ΔVIX_t	-0.0006	0.0726	-0.0970	-0.0177	0.0004	0.0963	0.0934	-0.0124
ΔFP_t	1.7E-06	0.0080	-0.3872	-0.0780	-0.0002	0.0129	-0.1711	-0.2940

(B) Correlations

	Pre-Change Period October 8, 2010 - August 10, 2015	Post-Change Period August 17, 2015 - April 15, 2016
ΔP_t & ΔY_t	0.420	0.583
ΔP_t & ΔH_t	0.256	0.216
ΔY_t & ΔH_t	0.564	0.546
ΔP_t & ΔB_t	--	0.110
ΔY_t & ΔB_t	--	0.147
ΔH_t & ΔB_t	--	0.114
(P_t-Y_t) & (P_t-H_t)	0.938	0.430
(P_t-Y_t) & (P_t-B_t)	--	-0.188
(P_t-H_t) & (P_t-B_t)	--	0.269

(P_t-H_t) & ΔU_t	-0.064	-0.131
(P_t-H_t) & ΔVIX_t	-0.008	-0.180
(P_t-H_t) & ΔFP_t	0.004	-0.020
ΔH_t & ΔU_t	0.299	0.308
ΔH_t & ΔVIX_t	0.168	0.125
ΔH_t & ΔFP_t	0.039	0.028
ΔY_t & ΔU_t	0.084	0.163
ΔY_t & ΔVIX_t	0.015	0.082
ΔY_t & ΔFP_t	0.223	0.405
ΔU_t & ΔVIX_t	0.222	-0.312
ΔU_t & ΔFP_t	-0.057	0.069
ΔVIX_t & ΔFP_t	-0.052	-0.021

Note: The CFETS RMB index (B_t) is constructed using the CFETS' methodology, December 31, 2014=100 (in reverse scale). Increases in CFETS index indicate the appreciation of RMB to the basket of currencies, while decreases in RMB Central Parity Rate (P_t), CNH (H_t) and CNY (Y_t) represent the appreciation of RMB to the US Dollar. B_t, P_t, H_t, Y_t, U_t and VIX_t are in logarithm in the Table.

III. Unit Root Tests

	Pre-Change Period October 8, 2010 – August 10, 2015	Post-Change Period August 17, 2015 - April 15, 2016
P_t	-2.200	0.604
Y_t	-1.505	0.606
H_t	-1.193	0.128
B_t	--	-1.677
(P_t-Y_t)	-1.855 *	-3.900 **
(P_t-H_t)	-2.406 **	-4.038 ***
(P_t-B_t)	--	-2.210
U_t	-1.690	-1.823
VIX_t	-0.708	-0.163
FP_t	-3.107	-2.775

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 1%, 5% and 10% level.

IV: Diebold – Mariano statistics

The Diebold – Mariano statistics (Diebold and Mariano, 1995) are used to evaluate the forecast performance of the different model specifications relative to that of the naive random walk. Given the exchange rate series x_t and the forecast series y_t, the loss function L for the mean square error is defined as:

$$L(y_t) = (y_t - x_t)^2. \quad \text{(A4.1)}$$

Testing whether the performance of the forecast series is different from that of the naive random walk forecast z_t, it is equivalent to testing whether the population mean of the loss differential series d_t is zero. The loss differential is defined as

$$d_t = L(y_t) - L(z_t). \quad \text{(A4.2)}$$

Under the assumptions of covariance stationarity and short-memory for d_t, the large-sample statistic for the null of equal forecast performance is distributed as a standard normal, and can be expressed as

$$\bar{d}\left\{\frac{1}{T^2}\sum_{\tau=-(T-1)}^{(T-1)} l\left(\frac{\tau}{S(T)}\right)\sum_{t=|\tau|+1}^{T}\left(d_t-\bar{d}\right)\left(d_{t-|\tau|}-\bar{d}\right)\right\}^{-\frac{1}{2}}, \qquad \text{(A4.3)}$$

where $l\left(\frac{\tau}{S(T)}\right)$ is the lag window, $S(T)$ is the truncation lag, and T is the number of observations. Different lag-window specifications can be applied, such as the Barlett or the quadratic spectral kernels, in combination with a data-dependent lag-selection procedure (Andrews, 1991).

For the direction of change statistic, the loss differential series is defined as follows: d_t takes a value of one if the forecast series correctly predicts the direction of change, otherwise it will take a value of zero. Hence, a value of $\bar{d}$ significantly larger than 0.5 indicates that the forecast has the ability to predict the direction of change; on the other hand, if the statistic is significantly less than 0.5, the forecast tends to give the wrong direction of change. In large samples, the studentized version of the test statistic,

$$\left(\bar{d}-0.5\right)/\sqrt{0.25/T}, \qquad \text{(A4.4)}$$

is distributed as a standard Normal.

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Table 1. Central Parity Estimation Results (Pre-Change Period)

	I	II	III	IV
$(P_{t-1}-Y_{t-1})$	-0.007		-0.007	
	(-2.989)		(-0.479)	
$(P_{t-1}-H_{t-1})$		-0.005	-1.99E-04	-0.005
		(-2.298)	(-0.016)	(-2.309)
ΔP_{t-1}	0.024	0.017	0.020	
	(0.614)	(0.449)	(0.505)	
ΔY_{t-1}	0.069		-0.009	
	(2.720)		(-0.303)	
ΔH_{t-1}		0.093	0.097	0.095
		(4.769)	(3.965)	(5.099)
Constant	-7.77E-05	-7.43E-05	-7.81E-05	-7.55E-05
	(-3.426)	(-3.331)	(-3.371)	(-3.364)
Adj. R^2	0.016	0.041	0.040	0.042
AIC	-11.487	-11.514	-11.511	-11.515
SIC	-11.470	-11.497	-11.485	-11.502

Note: The table presents the results of estimating (1), (2), (3) and (4) in the text. See the text and Appendix for definitions of variables. Robust t-statistics based on White-Huber (heteroskedasticity) standard errors are given in parenthesis underneath coefficient estimates. Adjusted R-squares estimates are provided in the row labeled "Adj. R^2". The sample period is from October 8, 2010 to August 10, 2015. Holidays are excluded in the estimation. The lag structure is determined by information criteria.

Table 2. Central Parity Estimation Results (Post-Change Period)

	I	II	III	V	VI
$(P_{t-1}-Y_{t-1})$	-0.103		-0.060	-0.038	
	(-1.088)		(-0.640)	(-0.384)	
$(P_{t-1}-H_{t-1})$		-0.064	-0.047	-0.048	-0.050
		(-3.065)	(-2.256)	(-2.277)	(-2.368)
ΔP_{t-1}	-0.118	0.056	-0.101	-0.106	
	(-1.024)	(0.621)	(-0.977)	(-0.996)	
ΔY_{t-1}	0.467		0.292	0.310	0.258
	(2.457)		(1.517)	(1.510)	(1.776)
ΔH_{t-1}		0.195	0.126	0.127	0.132
		(3.974)	(2.814)	(2.782)	(2.810)
ΔB_{t-1}				-0.037	
				(-0.907)	
Constant	-2.89E-05	-2.82E-04	-2.49E-04	-2.40E-04	-2.18E-04
	(-0.250)	(-1.624)	(-1.525)	(-1.441)	(-1.308)
Adj. R^2	0.293	0.313	0.378	0.377	0.373
AIC	-10.446	-10.476	-10.562	-10.554	-10.567
SIC	-10.369	-10.399	-10.447	-10.420	-10.490

Note: The table presents the results of estimating (1), (2), (3), (5) and (6) in the text. See the text and Appendix for definitions of variables. Robust t-statistics are given in parenthesis underneath coefficient estimates. Adjusted R-squares estimates are provided in the row labeled "Adj. R^2". The sample period is from August 17, 2015 to April 15, 2016. Holidays are excluded in the estimation. The lag structure is determined by information criteria.

Table 3. Forecasting the RMB Central Parity Rate

Panel A: Pre-Change Period

	RMSE	MAE	DoC
Model IV (Parsimonious model)	0.474	0.348	0.514
	(0.906)	(3.251)	(0.885)
Model III (Full model)	0.480	0.352	0.518
	(-0.418)	(1.494)	(1.138)
Model II	0.477	0.350	0.516
	(0.138)	(2.219)	(1.012)
Model I	0.488	0.364	0.476
	(-1.822)	(-1.478)	(-1.518)
RW	0.478	0.359	0.473

Panel B: Post-Change Period

	RMSE	MAE	DoC
Model VI (Parsimonious model)	1.020	0.624	0.685
	(-0.044)	(1.800)	(4.432)
Model V (Full model)	0.761	0.521	0.706
	(2.395)	(4.004)	(4.934)
Model III	0.729	0.498	0.755
	(2.731)	(4.450)	(6.105)
Model II	0.903	0.672	0.678
	(1.360)	(1.688)	(4.265)
Model I	0.903	0.601	0.713
	(1.262)	(2.757)	(5.101)
RW	1.011	0.759	0.573

Note: Columns labelled "RMSE", "MAE" and "DoC" report the root mean squared prediction errors, mean absolute prediction errors, and direction of changes statistics of the one-step ahead forecasts of the RMB central parity rate generated by models listed under the first column. The model specifications correspond to those in Table 1 (for the Pre-Change Period, Panel A) and Table 2 (for the Post-Change Period, Panel B). The forecast sample of the pre-change period is from July 15, 2011 to August 10, 2015 and the one of the post-change period is from September 15, 2015 to April 15, 2016. The robust Diebold-Mariano t-statistics for testing the model's forecasting performance relative to that of a random walk are given in parentheses underneath RMSE and MAE statistics. A positively significant statistic implies the random walk forecast has a larger forecast error. For DoC, numbers in parentheses are robust Diebold-Mariano t-statistics for testing the hypothesis of the model's ability to forecast directional change is 0.5, and a significantly positive statistic indicates that the forecast has the ability to predict the direction of change. See the text and Appendix for additional information.

Table 4. Central Parity Estimation Results: with augmented variables (Pre-Change Period)

	IV	IVa-i	IVa-ii	IVa-iii	IVb	IVc
$(P_{t-1}-H_{t-1})$	-0.005	-0.004	-0.006	-0.005	-0.004	-0.004
	(-2.309)	(-1.961)	(-2.382)	(-2.311)	(-2.001)	(-2.087)
ΔH_{t-1}	0.095	0.011	0.082	0.095	0.008	
	(5.099)	(0.602)	(4.340)	(5.119)	(0.399)	
ΔU_{t-1}		0.095			0.094	0.094
		(18.951)			(18.731)	(19.876)
ΔVIX_{t-1}			0.002		0.001	0.001
			(4.631)		(1.954)	(2.022)
ΔFP_{t-1}				-0.002	0.002	
				(-0.413)	(0.816)	
Constant	-7.55E-05	-9.69E-05	-7.48E-05	-7.55E-05	-9.63E-05	-9.69E-05
	(-3.364)	(-5.212)	(-3.372)	(-3.366)	(-5.190)	(-5.243)
Adj. R^2	0.042	0.341	0.063	0.041	0.343	0.343
AIC	-11.515	-11.888	-11.536	-11.514	-11.889	-11.892
SIC	-11.502	-11.871	-11.519	-11.497	-11.864	-11.874

Note: The table presents the results of estimating (7) with alternative augmented variables specified in the text. See the text and Appendix for definitions of variables. Robust t-statistics are given in parenthesis underneath coefficient estimates. Adjusted R-squares estimates are provided in the row labeled "Adj. R^2". The sample period is from October 8, 2010 to August 10, 2015. Holidays are excluded in the estimation. The lag structure is determined by information criteria.

Table 5. Central Parity Estimation Results: with augmented variables (Post-Change Period)

Model	VI	VIa-i	VIa-ii	VIa-iii	VIb	VIc
$(P_{t-1}-H_{t-1})$	-0.050	-0.050	-0.052	-0.044	-0.041	-0.051
	(-2.368)	(-2.452)	(-2.506)	(-2.117)	(-2.084)	(-2.514)
ΔH_{t-1}	0.132	0.088	0.134	0.113	0.058	
	(2.810)	(2.313)	(2.896)	(2.125)	(1.274)	
ΔY_{t-1}	0.258	0.261	0.257	0.342	0.358	0.416
	(1.776)	(1.725)	(1.751)	(3.124)	(3.481)	(4.318)
ΔU_{t-1}		0.078			0.088	0.089
		(4.234)			(4.374)	(4.408)
ΔVIX_{t-1}			-0.001		0.001	
			(-0.982)		(0.941)	
ΔFP_{t-1}				-0.020	-0.023	-0.026
				(-1.420)	(-1.666)	(-2.005)
Constant	-2.18E-04	-2.09E-04	-2.30E-04	-1.90E-04	-1.62E-04	-2.19E-04
	(-1.308)	(-1.390)	(-1.380)	(-1.145)	(-1.098)	(-1.466)
Adj. R^2	0.373	0.447	0.372	0.392	0.473	0.466
AIC	-10.567	-10.686	-10.559	-10.591	-10.722	-10.721
SIC	-10.490	-10.590	-10.463	-10.495	-10.588	-10.625

Note: The table presents the results of estimating (8) with alternative augmented variables specified in the text. See the text and Appendix for definitions of variables. Robust t-statistics are given in parenthesis underneath coefficient estimates. Adjusted R-squares estimates are provided in the row labeled "Adj. R^2". The sample period is from August 17, 2015 to April 15, 2016. Holidays are excluded in the estimation. The lag structure is determined by information criteria.

Table 6. Forecasting the RMB Central Parity Rate: with augmented variables

Panel A: Pre-Change Period

	RMSE	MAE	DoC
Model IVc	0.396	0.266	0.717
	(8.774)	(14.159)	(13.724)
Model IVb	0.399	0.270	0.728
	(8.427)	(13.565)	(14.420)
Model IVa-iii	0.477	0.350	0.520
	(0.196)	(2.423)	(1.265)
Model IVa-ii	0.459	0.335	0.533
	(2.873)	(4.920)	(2.087)
Model IVa-i	0.397	0.266	0.719
	(8.385)	(14.206)	(13.851)
Model IV (Parsimonious model)	0.474	0.348	0.514
	(0.906)	(3.251)	(0.885)
RW	0.478	0.359	0.473

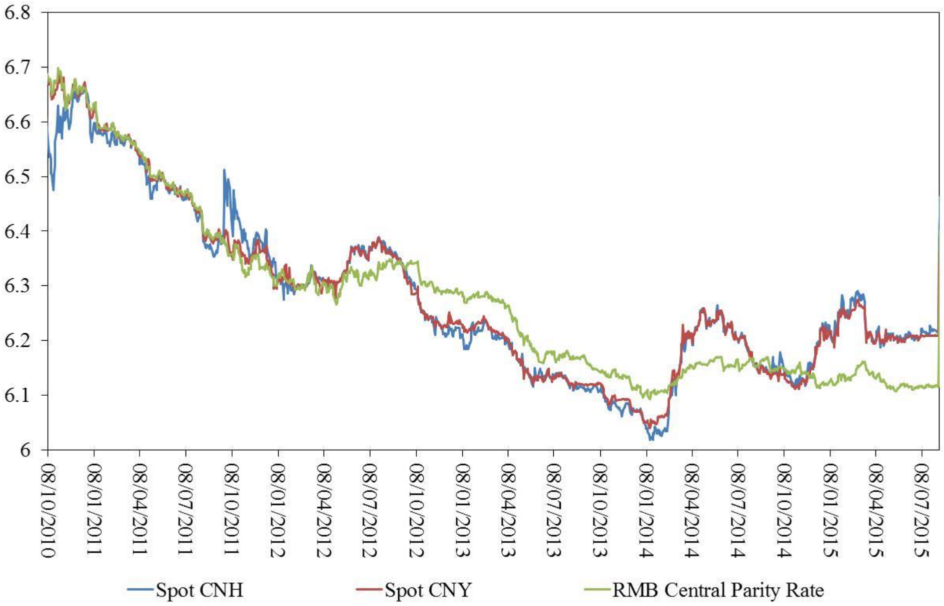
Panel B: Post-Change Period

	RMSE	MAE	DoC
Model VIc	0.890	0.544	0.734
	(0.717)	(2.895)	(5.603)
Model VIb	0.920	0.590	0.678
	(0.586)	(2.286)	(4.265)
Model VIa-iii	1.026	0.651	0.664
	(-0.078)	(1.472)	(3.930)
Model VIa-ii	0.999	0.631	0.615
	(0.063)	(1.746)	(2.760)
Model VIa-i	0.990	0.567	0.734
	(0.098)	(2.385)	(5.603)
Model VI (Parsimonious model)	1.020	0.624	0.685
	(-0.044)	(1.800)	(4.432)
RW	1.011	0.759	0.573

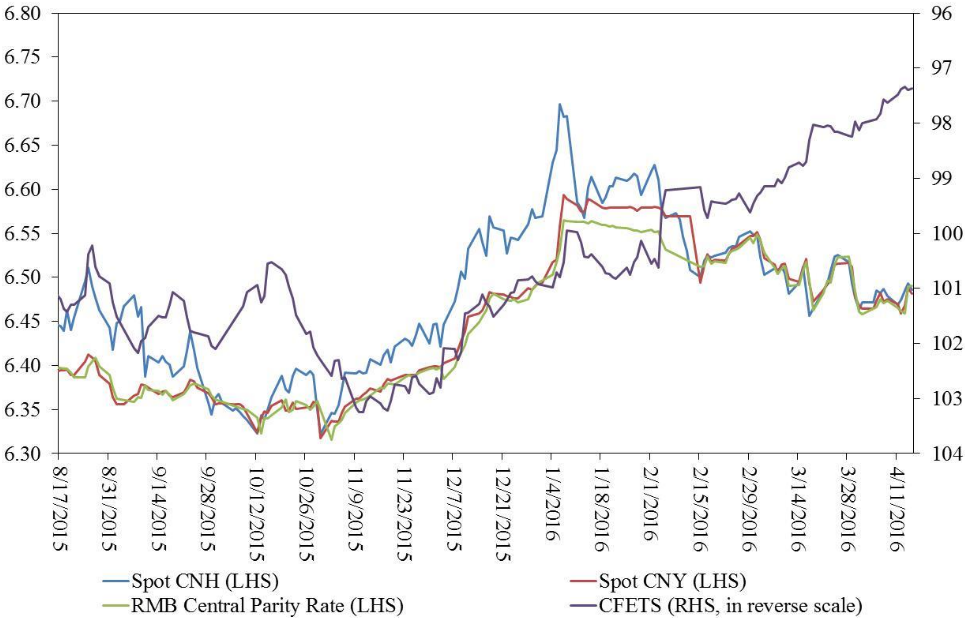
Note: Columns labelled "RMSE", "MAE" and "DoC" report the root mean squared prediction errors, mean absolute prediction errors, and direction of changes statistics of the one-step ahead forecasts of the RMB central parity rate generated by models listed under the first column. The model specifications correspond to those in Table 4 (for the Pre-Change Period, Panel A) and Table 6 (for the Post-Change Period, Panel B). See the Note to Table 3 and the text for additional information.

Figure 1. RMB Exchange Rate

Panel A: Pre-Change Period (October 8, 2010 to August 10, 2015)



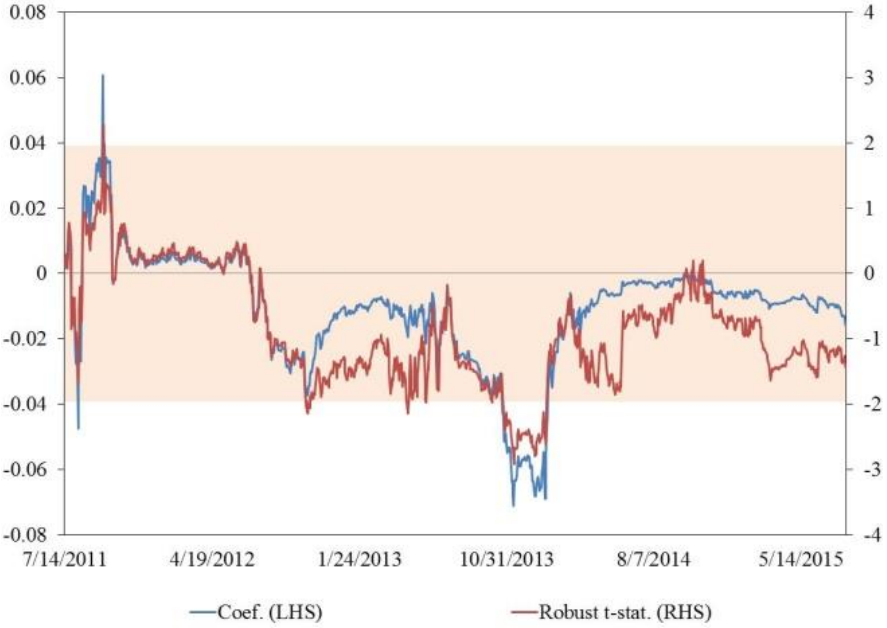
Panel B: Post-Change Period (August 17, 2015 - April 15, 2016)



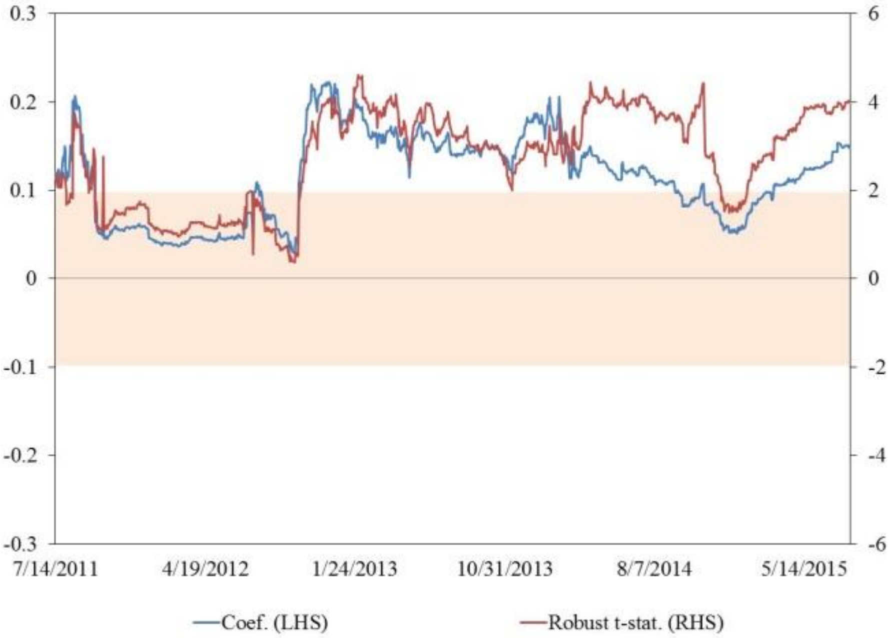
Note: The CFETS RMB index is constructed using the CFETS' methodology, December 31, 2014=100 (in reverse scale). Increases in CFETS index indicate the appreciation of RMB relative to the basket of currencies, while decreases in RMB Central Parity Rate (P_t), CNH (H_t) and CNY (Y_t) represent the appreciation of RMB relative to the US Dollar.

Figure 2: Rolling estimates of coefficients and their respective robust t-statistics for Pre-Change Period (Model IV, Table 1)

Panel A: Coefficient of $(P_{t-1}-H_{t-1})$



Panel B: Coefficient of ΔH_{t-1}

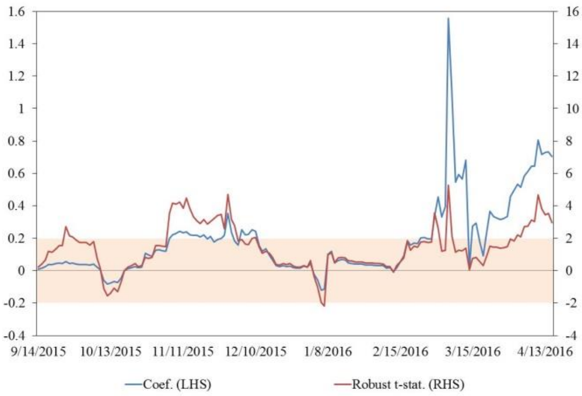


Note: The charts show the rolling coefficient estimates of $(P_{t-1}-H_{t-1})$, and ΔH_{t-1} and their corresponding robust *t*-statistics from estimating Model IV in Table 1. The rolling estimates are based on a moving window of 200 observations. The sample period is from October 8, 2010 to August 10, 2015; holidays excluded. The dates shown in x-axis are the end date of rolling samples. The orange region indicates the t-value is between -1.96 and 1.96.

Figure 3: Rolling estimates of coefficients and their respective robust t-statistics for Post-Change Period (Model VI, Table 2)

Panel A: Coefficient of (P_{t-1}-H_{t-1})

Panel B: Coefficient of ΔH_{t-1}

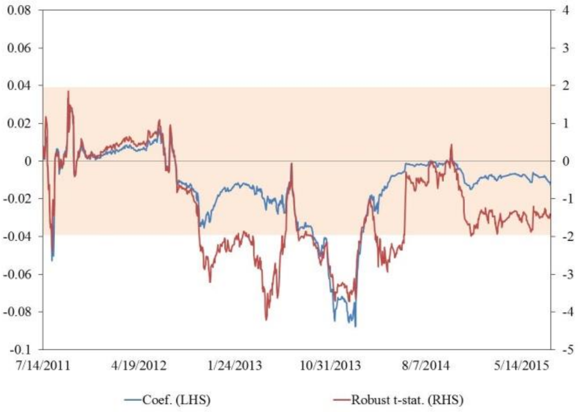


Panel C: Coefficient of ΔY_{t-1}

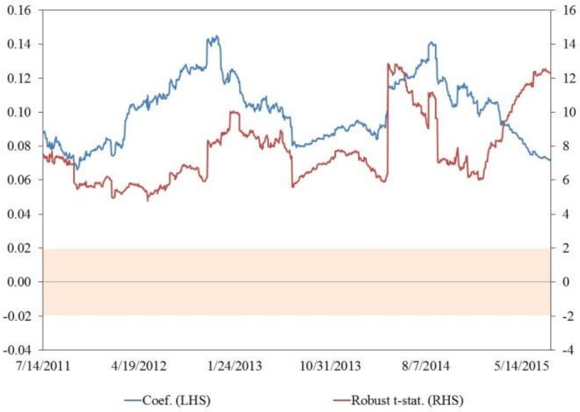
Note: The charts show the rolling coefficient estimates of (P_{t-1}-H_{t-1}), ΔH_{t-1} and ΔY_{t-1} and their corresponding robust *t*-statistics from estimating Model VI in Table 2. The rolling estimates are based on a moving window of 20 observations. The sample period is from August 17, 2015 to April 15, 2016; holidays excluded. The dates shown in x-axis are the end date of rolling samples. The orange region indicates the t-value in between -1.96 and 1.96.

Figure 4: Rolling estimates of coefficients and their respective robust t-statistics for Pre-Change Period (Model IVc, Table 4)

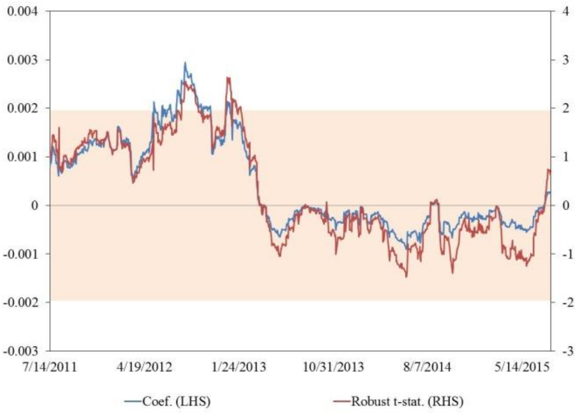
Panel A: Coefficient of (P_{t-1}-H_{t-1})



Panel B: Coefficient of ΔU_{t-1}



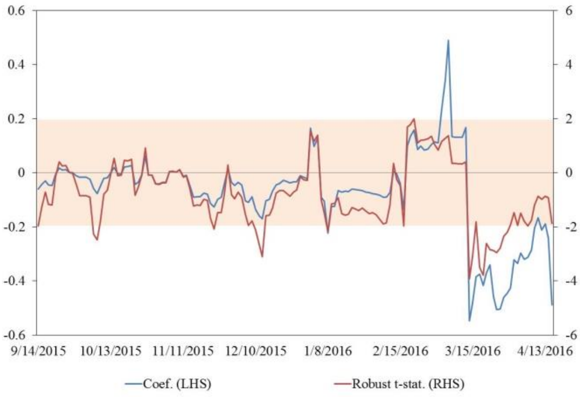
Panel C: Coefficient of ΔVIX_{t-1}



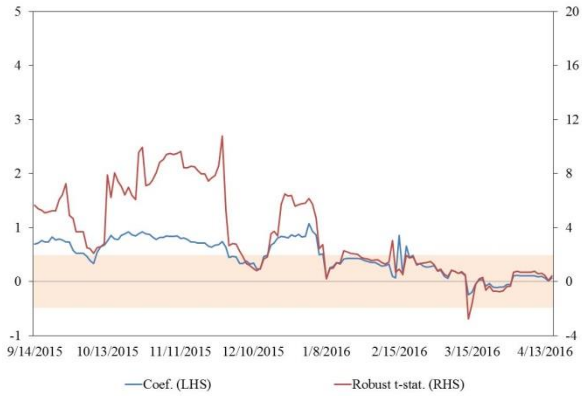
Note: The charts show the rolling coefficient estimates of (P_{t-1}-H_{t-1}), ΔU_{t-1} and ΔVIX_{t-1} and their corresponding robust *t*-statistics from estimating Model IVc in Table 4. The rolling estimates are based on a moving window of 200 observations. The sample period is from October 8, 2010 to August 10, 2015; holidays excluded. The dates shown in x-axis are the end date of rolling samples. The orange region indicates the t-value in between -1.96 and 1.96.

Figure 5: Rolling estimates of coefficients and their respective robust t-statistics for Post-Change Period (Model VIc, Table 5)

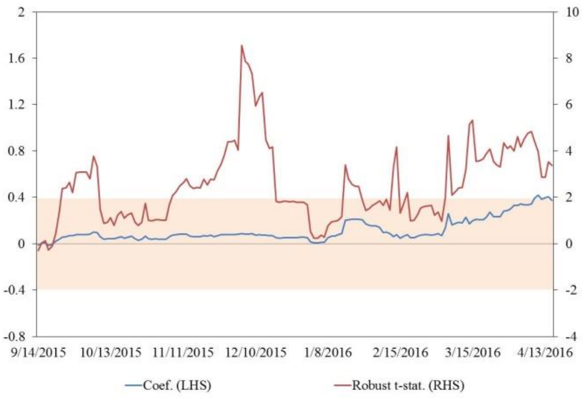
Panel A: Coefficient of (P_{t-1}-H_{t-1})



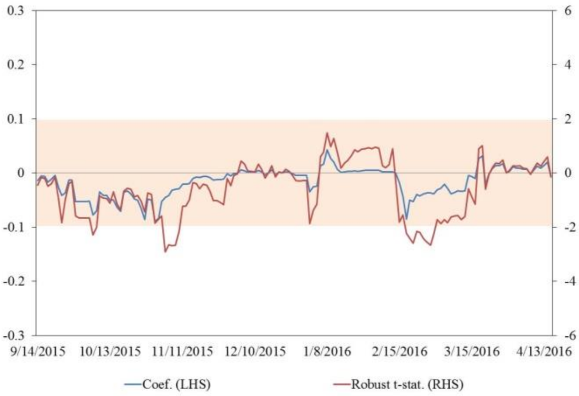
Panel B: Coefficient of ΔY_{t-1}



Panel C: Coefficient of ΔU_{t-1}



Panel D: Coefficient of ΔFP_{t-1}



Note: The charts show the rolling coefficient estimates of (P_{t-1}-H_{t-1}), ΔY_{t-1}, ΔU_{t-1} and ΔFP_{t-1} and their corresponding robust *t*-statistics from estimating Model VIc in Table 5. The rolling estimates are based on a moving window of 20 observations. The sample period is from August 17, 2015 to April 15, 2016; holidays excluded. The dates shown in x-axis are the end date of rolling samples. The orange region indicates the t-value in between -1.96 and 1.96.