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Is the Renminbi a Safe Haven?*

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Abstract

We investigate the relationship between market uncertainty and the relative value of the Renminbi against currencies that the safe haven literature typically considers as the traditional safe haven currency candidates. Our sample spans the February 2011 to April 2016 period. Band spectral regression models enable us to capture that the relationship between market uncertainty and the relative value of the Renminbi is frequency dependent. While we find evidence of some degree of safe haven currency behavior of the Renminbi during the early part of our sample, our findings do not support the suggestion that the Renminbi is currently a safe haven currency or that the Renminbi is progressing towards safe haven currency status.

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1. Introduction

Financial market observers and participants have in light of the growing global importance and internationalization of the Renminbi for several years been musing about whether the Renminbi is becoming or has become a safe haven currency (e.g. Chong 2013, Harjani 2014, and Burland 2016).[1] While some market participants argue that the Renminbi is already a safe haven, others dismiss this notion and assert that the Renminbi is not sufficiently liquid, not easily convertible, and will not become a safe haven currency until Chinese economic and broader institutional reforms are implemented.[2] By contrast, the academic literature is hitherto silent on whether the Renminbi is a safe haven currency. Perhaps this is not surprising in case of the domestically traded Renminbi (CNY) as it does not meet obviously necessary criteria of easy convertibility and high liquidity to be considered a possible safe haven currency, rendering the question of safe haven currency status less meaningful. However, the offshore traded Renminbi (CNH)

[1] The growing importance and increasing internationalization of the Renminbi is well-known and well-documented (e.g. Fratzscher and Mehl 2011, Ito 2010, Kawai and Pontines 2016, Prasad 2016, and Shu, He, and Cheng 2015). The most widely publicized and visible manifestation of this internationalization is the much-heralded and symbolically significant 30 November 2015 announcement of the 1 October 2016 inclusion of the Renminbi into the SDR basket that officially makes the Renminbi a reserve currency alongside the USD, the JPY, the EUR, and the GBP. Perhaps more illustrative of the current state of the internationalization of the Renminbi are the economically significant facts that the Renminbi is currently traded in official offshore clearing centers in 17 locations outside of Mainland China, as of March 2016 the Renminbi is the fifth most used global payments currency by value (Swift 2016), on 26 May 2016 China issued in London its first Renminbi denominated sovereign bond (in the amount of CNY 3 billion), and the total investment quota for Renminbi Qualified Foreign Institutional Investors (RQFIIs) is increasing by roughly 50% as per the 7 June 2016 People's Bank of China announcement of the first allocation to the US (in the amount of CNY 250 billion).

[2] To illustrate the discrepancy of views regarding whether the Renminbi on the one hand is, or on the other hand cannot yet be, a safe haven currency, a Credit Agricole market strategist states that "the CNY has proven to be a safe haven in an environment of a strong USD and it will continue to perform this role" (Harjani 2014) while a leading scholar on the internationalization of the Renminbi, Eswar Prasad, posits that "the Renminbi will not be seen as a safe haven currency unless economic reforms are accompanied by broader legal, political and institutional reforms that are necessary to inspire the trust of foreign investors" (Drezner 2015).

has since July 2010 been convertible as well as increasingly liquid.[3,4] Simply put, nothing stops a market participant, regardless of location or type, from entering and exiting Renminbi denominated cash asset positions in the offshore market. For example, globally traded ETFs tied to Renminbi denominated corporate bonds issued outside of Mainland China ("dim sum bonds") are readily available, as are globally traded ETFs that mirror the performance of Chinese money market rates. Moreover, a market participant, whether individual, company, or financial institution, can open Renminbi bank accounts in an offshore Renminbi clearing center such as Hong Kong and transfer funds into and out of these accounts without any restrictions (although cross-border fund transfers to and from Mainland China are subject to regulations in Mainland China). As of April 2015 the daily turnover of Renminbi foreign exchange transactions in Hong Kong alone reached the equivalent of USD93 billion, thereby implying that the offshore Renminbi market is highly liquid (Hong Kong Monetary Authority 2016). Since there is no technical hindrance for market participants to consider and employ the Renminbi as a possible safe haven currency, a timely and highly topical research question is whether the Renminbi is becoming or has become a safe haven currency. This is the research question of our paper.

There is no consensus in the safe haven literature as to what constitutes a safe haven currency or, for that matter, which currencies exhibit safe haven currency behavior and when. For example, using daily data Ranaldo and Söderlind (2010) find that during

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[3] Although the offshore market for the Remninbi dates back to the Chinese State Council approval of personal Renminbi business in Hong Kong in November 2003, the official commencement of the offshore Remninbi market occurred with the 19 July 2010 signing of the memorandum of co-operation between the People's Bank of China and the Hong Kong Monetary Authority.

[4] For studies of pricing differentials and linkages between the onshore and offshore Renminbi markets see Burdekin and Tao (2016), Cheung and Rime (2014), and Funke, Shu, Cheng, and Eraslan (2015.

episodes of elevated market uncertainty prior to the global financial crisis the JPY, the CHF, the EUR, and the GBP were exhibiting safe haven currency behavior while Hossfeld and MacDonald (2015) find in their monthly frequency analysis of data spanning more than 26 years that the USD and even more so the CHF qualify as safe haven currencies. Coudert, Guillaumin and Raymond (2014) offer a daily data analysis of the evolution of 26 currencies from both advanced and emerging economies over the 1999 to 2013 period. They find that only the JPY and the USD exhibit safe haven currency properties. The results of Fatum and Yamamoto (2016), also a daily data study, suggest that during the global financial crisis the JPY exhibited the most pronounced safe haven behavior and, furthermore, that safe haven currency behavior is time-dependent, i.e. a given currency may qualify as a safe haven currency over a given period in time but not necessarily over another period in time. In the comprehensive and currently definitive study of what drives safe haven currency behavior, Habib and Stracca (2012) carry out a monthly frequency analysis of the behavior of 52 currencies over the span of almost a quarter of a century and show that only few country-specific factors such as the net foreign asset position and the size of the stock market, and for advanced countries the interest rate spread vis-à-vis the US, are somewhat systematic drivers of safe haven currency behavior.

To answer our research question we consider the relationship between market uncertainty and the relative value of the Renminbi against the USD, the JPY, the EUR, the GBP, and the CHF, i.e. against currencies that the aforementioned safe haven studies consider as possible traditional safe haven currency candidates, over the 28 February

2011 to 30 April 2016 sample period.[5] We define a safe haven currency as a currency that increases its relative value against other currencies as market uncertainty increases and follow Habib and Stracca (2012) and many others in using the VIX, the measure of implied volatility of S & P 500 options, as our main indicator of market uncertainty.[6]

In the focal part of our analysis we employ the band spectral regression (BSR) procedure originally developed by Hannan (1963) and Engle (1974, 1978).[7] By doing so we are able to take into account the possibility that the relationship between market uncertainty and the relative value of the Renminbi is frequency dependent. Specifically, we model the observed value of the Renminbi as a possible manifestation of both high-frequency movements driven by the reaction of market participants to contemporaneous changes in the perception of market uncertainty as well as low-frequency movements attributable to institutional aspects and long-term objectives of the Chinese monetary authorities.

Our findings for the full sample period suggest that an increase in market uncertainty is on average associated with a decrease in the value of the Renminbi relative to the USD and the JPY and an increase in the value of the Renminbi relative to the GBP and the EUR. Put differently, our full sample results suggest that the Renminbi is "less safe" than the USD and the JPY but "safer" than the GBP and the EUR. This provides evidence consistent with some degree of safe haven currency behavior of the Renminbi.

[5] The CHF was maintained at CHF/EUR 1.20 from September 6, 2011 to January 15, 2015 and, therefore, results pertaining to the CHF during most of our sample period may not reflect market participant actions and possible currency behavior.

[6] While the definition of a safe haven currency varies across studies, our definition of a safe haven currency is consistent with Habib and Stracca (2012) and Ranaldo and Söderlind (2010).

[7] This procedure is conceptually similar to the more well-known Band Pass Filter proposed by Baxter and King (1999) in that it allows for the observed relationship among the variation in different variables to vary across different frequencies. While BSR models are new to the safe haven literature they have recently been applied to the study of exchange rate returns by Hau (2014).

However, when considering more recent sub-samples separately, using the 30 November 2015 SDR basket inclusion announcement and three other key institutional events as possible sample demarcation points, we find that the relative value of the Renminbi vis-à-vis all traditional safe haven currency candidates decreases as market uncertainty increases. The results of our BSR models reveal that during the recent period the relative weakening of the Renminbi as uncertainty increases is due to the high-frequency variation of the Renminbi while the low-frequency variation is generally associated with Renminbi appreciation as uncertainty increases. These findings underline the relevance of distinguishing between high versus low frequency variation in our particular context and lend credence to the suggestion that as market participants consider the Renminbi to be less safe off-setting currency management actions are undertaken as market uncertainty rises. Overall our findings do not support the suggestion that the Renminbi is currently a safe haven currency and in that sense question the notion that the Renminbi is progressing towards safe haven currency status.

We extend our analysis to consider the possibility of non-linearity effects in the form of non-temporal threshold effects pertaining to different levels of market uncertainty. We also carry out several robustness checks, including analyzing different sub-samples, controlling for interest rate differentials, as well as changing the number of frequency bands in the BSR analysis.

The rest of the paper is organized as follows. Section 2 describes the data. Sections 3 and 4 present the empirical framework and the results, respectively. Section 5 provides robustness checks. Section 6 concludes.

2. Data

Our analysis employs daily data on exchange rates, measures of market uncertainty, and interest rates. All data series cover the 28 February 2011 to 30 April 2016 period.[8]

To measure market uncertainty we follow recent studies such as Habib and Stracca (2012) and others in using the Chicago Board Options Exchange (CBOE) Volatility Index (VIX) as our main indicator of global risk. The VIX is a forward-looking, model-free measure of the near-term (30-day) implied volatility of S&P 500 index options.[9] To check the robustness of our results we follow Fatum and Yamamoto (2016) in using as alternative measures of market uncertainty the VXO (the CBOE measure of near-term implied volatility of S&P 100 index options) and the VXJ (the Osaka University Center for the Study of Finance and Insurance near-term implied volatility measure of Nikkei 225 index options). Table 1 provides summary statistics for the three market uncertainty measures.

The exchange rate data consists of bilateral CNH and CNY spot exchange rates vis-à-vis the USD, the JPY, the GBP, the EUR, and the CHF, and is obtained from Datastream. Figure 1 displays the evolution of these exchange rate series and Table 2 provides summary statistics. Figure 2 shows the CNY/USD rate juxtaposed against the CNH/USD rate (top figure) as well as the CNH/CNY movements (bottom figure).

Interest rate data, also obtained from Datastream, consists of 3-month LIBOR rates for the US, Japan, Great Britain, the Euro-area, and Switzerland, along with 3-

[8] Our starting date is determined by availability of the CNH/USD series.
[9] For excellent primers on the VIX see Whaley (2009) and Gonzalez-Perez (2015).

month SHIBOR and CNH-HIBOR rates for China.[10] Summary statistics regarding interest rates are available from the authors upon request.

3. Econometric Methodology

As a preliminary analysis we first use OLS with heteroskedasticity- and auto-correlation consistent (HAC) errors to estimate the following standard time-series model:

$$(1) \qquad \Delta s_t = \alpha + \beta \Delta VIX_t + \gamma \Delta s_{t-1} + \varepsilon_t$$

where Δs_t is the first-difference in the log of the spot exchange rate (in units of CNH per non-Chinese currency) and ΔVIX_t is the first-difference of the VIX.

In the focal part of our empirical analysis we take into account the possibility that the relationship between market uncertainty and the relative value of the CNH is frequency dependent, thereby explicitly modeling the observed value of the CNH as a possible manifestation of both high-frequency movements driven by the reaction of market participants to contemporaneous changes in risk perception as well as low-frequency movements attributable to institutional aspects and long-term objectives of the Chinese monetary authorities. To do so we employ the band spectral regression (BSR) procedure originally developed by Hannan (1963) and Engle (1974, 1978).

The BSR procedure is outlined as follows. For a given series X, where X is the (Tx1) vector $X = [x_1, x_2, \dots, x_T]'$ expression of the time series $x_t,\ t = 1, 2, \dots, T$, we first extract the frequency variations by applying the discrete Fourier transformation

[10] The Shanghai Interbank Offered Rate (SHIBOR) and the CNH Hong Kong Interbank Offered Rate (CNH-HIBOR), respectively, are the Chinese onshore and offshore equivalents of LIBOR.

(2) $$X^* = WX$$

where W is a $T \times T$ matrix with (j,k)th element described as

(3) $$W_{jk} = \frac{1}{\sqrt{T}} exp\left[ij(k-1)\frac{2\pi}{T}\right]$$

with $i = \sqrt{-1}$. As a result of this transformation the (Tx1) vector X* has jth element x_j^* which captures the variation at frequency $\omega_j = \frac{2j\pi}{T}$, and equals the variations that occur at every T/j period. Second, we choose a frequency band of interest $B = [\omega_L, \omega_H]$ by multiplying X* and a selector matrix A

(4) $$X_B^* = AWX$$

where the jth diagonal element of A is one if frequency ω_j is in B and zero otherwise.[11] To estimate the effects of changes in market perception of risk on the relative value of the CNH across different frequency bands we transform the standard time-series regression model (without intercept) into the following separate band-specific time-series regressions

(5) $$\Delta s_j^B = \beta \times \Delta VIX_j^B + u_j^B, \quad j = \omega_L, \ldots, \omega_H$$

[11] Since all off-diagonal elements of the selector matrix A are zero the resulting matrix described in Equation (4) constitutes a data set with a reduced number of observations in any given band compared to the non-transformed full sample.

where, as shown by Engle (1974, 1978), the coefficient estimate and associated tests have standard properties and can be estimated using OLS.[12]

In order to also consider whether the relationship between the relative value of the CNH and market uncertainty is conditional on the level of market uncertainty we extend our analysis to incorporate the non-temporal threshold testing procedure originally developed by Hansen (2000) and recently applied to the exchange rate literature by Fatum and Yamamoto (2016) and Hossfeld and MacDonald (2015). The non-temporal threshold model is described as follows:

(6) $$\Delta s_t = \alpha_L + \beta_L \Delta VIX_t + \gamma_L \Delta s_{t-1} + \varepsilon_{Lt} \text{ if } VIX_t \leq q$$

$$\Delta s_t = \alpha_H + \beta_H \Delta VIX_t + \gamma_H \Delta s_{t-1} + \varepsilon_{Ht} \text{ if } VIX_t > q$$

where q is the VIX threshold value to be estimated by the maximand of the likelihood ratio statistics over all permissible values, and subscripts L and H denote low and high uncertainty regimes, respectively.[13] The non-temporal test of Hansen (2000) is similar to a standard temporal parameter change test for a single unknown breakpoint (e.g. Andrews 1993). However, instead of analyzing a temporally-ordered data set, the Hansen (2000) procedure dictates that we sort the data in a non-temporal fashion according to, in our

[12] To illustrate the applicability of the BSR in our particular context of daily data, the spectral band $B = [\frac{1}{2}\pi, \pi]$, for example, is associated with variation that occurs at a frequency of 4 days or higher, thus possibly ascribed to market participant behavior. Similarly, the spectral band $B = [0, \frac{1}{16}\pi]$, for example, is associated with variation that occurs at a frequency of 32 days or lower, thus possibly ascribed to institutional behavior.

[13] The permissible threshold values exclude the first and last 1% of the ordered sample.

context, market uncertainty, as measured by the VIX in levels. Doing so allows us to in a non-temporal modeling framework endogenously identify the market uncertainty threshold, or thresholds, if any, around which safe haven currency behavior changes, thereby testing whether the relationship between market uncertainty and safe haven currency behavior depends on the level of market uncertainty.[14]

4. Results

The results pertaining to the full sample estimation of Equation (1) are displayed in Table 3.1. As these preliminary results indicate, an increase in uncertainty is on average significantly associated with a depreciation of the CNH vis-à-vis the USD and the JPY, respectively, and significantly associated with an appreciation of the CNH vis-à-vis the GBP. Our preliminary results do not suggest a statistically significant relationship between changes in market uncertainty and the value of the CNH relative to the EUR or the CHF.[15]

As discussed earlier, the 30 November 2015 announcement of the 1 October 2016 inclusion of the CNY in the SDR basket marks an important symbolic date in regards to the internationalization and global role of the Chinese currency. For this reason we consider how changes in uncertainty might influence the relative value of the CNH vis-à-vis the traditional safe haven currency candidates separately before and after the inclusion announcement. Tables 3.2 and 3.3, respectively, display the results of the standard regression model estimated separately across the sub-samples February 2011 to November 2015 and December 2015 to April 2016. Table 3.2 shows that prior to the

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[14] For additional details see Fatum and Yamamoto (2016).

[15] As noted earlier, the management of the CHF vis-à-vis the EUR during most of our sample period is likely muting possible safe haven currency manifestations.

inclusion announcement an increase in uncertainty is, very similar to our full sample results, on average significantly associated with a depreciation of the CNH against the USD and the JPY, while the CNH prior to the inclusion announcement is significantly associated with an appreciation of the CNH against both the EUR and the GBP. As before, we find no discernible effects of uncertainty on the CNH/CHF rate. The post-announcement results reported in Table 3.3 are noticeably different in that the uncertainty coefficient estimate is now positive across all five CNH currency pairs and highly significant in all but one instance (the VIX coefficient estimate for the CNH/GBP rate is insignificant). These findings imply that recently an increase in uncertainty is on average no longer associated with an appreciation of the CNH against any of the traditional safe haven currency candidates. It is noteworthy that the magnitude of the coefficient estimates for the CNH/USD and CNH/JPY rates both quadruple such that a one unit increase in the uncertainty level is during the more recent time-period associated with roughly four times larger percent depreciation of the CNH against both the USD and the JPY compared to the pre-announcement period.

Overall the results of our preliminary estimations suggest that the CNH is clearly less "safe" than the USD and the JPY, and while the CNH appears to be "safer" on average than the EUR and the GBP during the early part of our sample period, an increase in uncertainty is on average no longer associated with an appreciation of the CNH against any of the five traditional safe haven currency candidates considered. These results, therefore, do not support the notion that the CNH is progressing towards safe haven currency status. Instead, our findings suggest that recently the relative value of the

CNH is vulnerable to an increase in perceived market uncertainty and, consequently, the CNH is not a safe haven currency.[16]

The preliminary analysis does not consider the possibility that the observed value of the CNH is a manifestation of both high-frequency movements driven by the reaction of market participants to contemporaneous changes in risk perception as well as low-frequency movements attributable to institutional aspects and long-term objectives of the Chinese monetary authorities. To account for the possibility that the relationship between market uncertainty and the relative value of the CNH is frequency dependent we estimate the BSR model described by Equation (5). The results of carrying out the band spectral analysis across the full sample period are reported in Table 4.1. As the table shows, the results pertaining to high- as well as low-frequency variation suggest that as uncertainty increases the CNH depreciates vis-à-vis the USD and the JPY. By contrast, the CNH appreciates against the GBP. These findings are virtually uniform across all bands considered. The results for the CNH/EUR rate are inconclusive. Consistent with the results of the preliminary analysis, these BSR findings thus suggest that for the little more than five year period under study as a whole, the CNH is "safer" than the GBP but not a safe haven in comparison to the USD or the JPY.

Our next step is to employ the BSR model to consider possible safe haven manifestations of the CNH separately before and after the 30 November 2015 SDR basket inclusion announcement. The results of estimating the BSR model separately across the two sub-samples, February 2011 to November 2015 and December 2015 to April 2016, respectively, are displayed in Tables 4.2 and 4.3. Table 4.2 shows that prior

[16] As the extant safe haven literature has so far not taken the Renminbi into consideration as a possible safe haven currency candidate it is difficult to compare our findings to other studies.

to the inclusion announcement the high- and low-frequency variation results are generally very similar and suggest, in line with the full sample findings, that as uncertainty increases the CNH depreciates against the USD and the JPY, while it appreciates against the GBP and for the pre-announcement sample also against the EUR.

As Table 4.3 shows, the results pertaining to the second sub-sample are markedly different. First and foremost, the high- and low-frequency variation results no longer conform. Specifically, the results pertaining to high-frequency variation uniformly across all bands considered suggest that increased uncertainty is associated with a significant depreciation of the CNH in all of the five CNH currency pairs considered. By contrast, the low-frequency results generally suggest that as uncertainty increases the CNH appreciates against all currencies in our sample with the notable exception of the JPY where all but one low-frequency variation band result suggest that the JPY appreciates against the CNH as uncertainty goes up.[17]

These findings are particularly interesting as they are consistent with the proposition that market participants more recently consider the CNH to be increasingly less safe, i.e. the high-frequency variation results reveal a clear pattern of loss of relative value of the CNH as uncertainty increases. Certainly, this does not lend support to a suggestion that the SDR inclusion announcement has led to progression in regards to the Chinese currency approaching safe haven currency status. Moreover, the finding that

[17] As noted earlier, Habib and Stracca (2012) carry out a monthly frequency analysis of the behavior of 52 currencies over the span of almost a quarter of a century and find the net foreign asset position (NFA) to be the best possible explanation for safe haven status. While we are not able to incorporate variables such as NFA into our daily data analysis context it is interesting to note that over the 2011 to 2014 period (the most recent period for which NFA data are available) the NFA position of China has gradually increased by roughly 10% in total compared to an overall increase of more than 25% in the NFA position of Japan. This is only a casual observation, of course, but nevertheless one that is consistent with the suggestion that the NFA position is an important driver of safe haven status and, perhaps, one reason why the relative value of the JPY in particular increases against the CNH as market uncertainty increases.

low-frequency variation, possibly attributable to institutional aspects such as Chinese currency management actions aimed at maintaining the horizontal band, suggests that uncertainty increases are associated with CNH appreciation, in tandem with high-frequency variation being associated with CNH depreciation, suggests that as market participants consider the CNH as less safe the effects of the off-setting currency management aimed at appreciating the Chinese currency as market uncertainty increases become more pronounced.

Overall, the BSR results lend support to the suggestion that the relative value of the Chinese currency is indeed a manifestation of the combined effects of high- and low-variation reactions to uncertainty changes. This insight is important as it underlines the relevance of distinguishing between high versus low frequency variation in our particular context of studying how a heavily managed yet highly traded currency responds to changes in market uncertainty.

Finally, we extend the analysis to consider the presence of threshold effects pertaining to the level of market uncertainty as measured by the VIX.[18] When doing so we find only limited evidence of threshold effects. Specifically, the results of estimating Equation (6) over the full sample as well as separately across the pre- and post-SDR inclusion announcement sub-samples point to evidence of a single significant threshold for the CNH/GBP rate for the full sample (at VIX=18.9) as well as for the pre-announcement sample (at VIX=13.4). In both instances is it the case that our subsequent estimation results pertaining to low versus high levels of VIX suggest that the effects of increased uncertainty is associated with more pronounced CNH appreciation vis-à-vis the GBP as uncertainty exceeds the endogenously determined threshold. We find evidence of

[18] The results of the threshold analysis are not shown for brevity but available upon request.

a significant threshold for the CNH/JPY rate for the post-announcement sample (at VIX=25.2) and, again, our sub-sequent estimation results suggest that the previously discussed uncertainty effect in the form of loss of relative value of the CNH against the JPY as uncertainty increases is magnified once uncertainty exceeds the threshold value (i.e. the CNH/JPY threshold pertains to an acceleration of loss of relative value of the CNH when uncertainty is high).[19]

Overall, the results of this extension do not suggest that threshold effects are of much importance. This finding is at odds with Fatum and Yamamoto (2016) and Hossfeld and MacDonald (2015) who both apply the non-temporal threshold procedure to the study of safe haven currency behavior and both find important threshold effects. This discrepancy, however, may not seem surprising given that unlike the two aforementioned studies our analysis pertains to a time-period when market uncertainty at no point reached abnormally high levels.

5. Robustness

In order to test the robustness of our results we redo the empirical analysis using CNY in place of CNH, consider different sub-samples, control for interest rate differentials, employ two alternative measures of market uncertainty, replace the VIX uncertainty measure with the residuals from a predictive estimation of the VIX, and change the specification of frequency bands in the BSR analysis.[20]

[19] We further extend our analysis to test for, but find no support for, multiple thresholds. For details on the multiple threshold procedure see Fatum and Yamamoto (2016). Even though it would be technically straightforward to augment the BSR models to encompass the non-temporal threshold procedure we choose not to do so as the resulting number of observations per frequency band and threshold regime would be insufficient for facilitating a meaningful analysis.

[20] The results of the robustness checks are available upon request.

First, we redo the empirical analyses using bilateral CNY rates in place of the bilateral CNH rates. The results of the standard time-series and threshold analyses are largely inconclusive as few VIX coefficient estimates are significant. This is not surprising considering that there is less variation in the bilateral CNY rates compared to the market driven bilateral CNH rates. The CNY-based BSR results, however, are qualitatively quite similar to those using the CNH rates, across the full sample as well as pairwise across the pre- and post-SDR basket inclusion announcement sub-samples. A noticeable difference when comparing the two sets of BSR results is that the magnitude of the VIX coefficient estimates associated with high-frequency variation for the CNY-based estimations is generally lower than the corresponding estimates for the CNH-based estimations, again consistent with the latter being more reflective of short-term changes in market sentiment. Overall the CNY-based results are, as expected, muted in regards to providing evidence of a reaction of market participants to contemporaneous changes in risk perception.

Second, we consider three alternative sub-sample demarcation points instead of the baseline 30 November 2015 SDR basket inclusion announcement break-point. These are, respectively, 15 March 2014, when the People's Bank of China announced a doubling of the CNY deviation band (to 4% around a central CNY/USD rate), 10 April 2014, when the Shanghai-Hong Kong Stock Connect program was announced (a key step in the internationalization of the CNY that, taking effect 17 November 2014, made the Shanghai Stock Exchange directly accessible to market participants outside of Mainland China and the Hong Kong Stock Exchange directly accessible to market participants inside Mainland China), and 24 August 2015, when the Chinese stock market fell by

8.5% (this event, sometimes referred to as the Chinese "Black Monday", was accompanied by a reversal of the capital inflows into China under the aforementioned Stock Connect program). The sub-sample results according to these alternative demarcation dates are virtually identical to our baseline sub-sample findings. This is a particularly important robustness result as it gives additional credence to the suggestion that recently market participants are less willing to hold the Chinese currency as market uncertainty increases and, as a consequence, the Chinese currency does not currently have safe haven currency status.

Third, we include in all our regression models the country-specific interest rate differential vis-à-vis China as an additional explanatory variable. The addition of interest rate controls does not qualitatively change our results.[21,22]

Fourth, we redo our analysis using instead of the VIX two alternative measures of market uncertainty. These alternative measures of market uncertainty are the VXO (the CBOE measure of near-term implied volatility of S&P 100 index options) and the VXJ (the Osaka University Center for the Study of Finance and Insurance near-term implied volatility measure of Nikkei 225 index options). The standard time-series and the BSR analyses using the VXO and the VXJ instead of the VIX generally provide qualitatively similar findings with the exception of more mixed low-frequency results in case of the VXO and for the CNH/USD in particular in case of the VXJ. With respect to the threshold analysis our findings are qualitatively consistent across the three market uncertainty measures apart from the baseline evidence of a significant threshold for the

[21] Since the CNH-HIBOR is only available from 20 June 2013 and onwards we use the SHIBOR rate for estimations pertaining to both sub-samples as well as the full sample and in a separate estimation use the CNH-HIBOR rate for the second sub-sample.

[22] Habib and Stracca (2012) include interest rate differentials in their exchange rate models to address the possibility that carry trade reversals are masking as safe haven behavior.

CNH/GBP rate not being repeated when the VXJ measure is employed. Overall, our baseline findings are generally very robust to replacing the VIX with either of the alternative uncertainty measures VXO and VXJ.

Fifth, we address the possibility that market uncertainty as measured by the VIX exhibits some degree of predictability in the sense that the lagged variable of VIX is statistically significant in a simple predictive regression. We do so by replacing the VIX uncertainty measure in our baseline regression models with the residuals from a predictive estimation of the VIX. Not surprisingly, given that the predictive component of the VIX is very minor, our results are completely robust to this change in specification.

Sixth and final, to ensure that our BSR results are not driven by the specification of frequency bands we redo the BSR analysis after re-sorting the data series into as many as a total of 28 bands (compared to the 10 frequency bands of our baseline BSR analysis). Although individual band results are, by construction, not comparable across the two sets of BSR estimations, the overall pattern across the full sample as well as across the pre- and post-SDR basket announcement sub-samples in regards to direction and significance of the market uncertainty coefficient estimates for the five bilateral CNH rates is stable.

6. Conclusion

In this paper we investigate whether the Chinese Renminbi is a safe haven currency. We do so by assessing how changes in market uncertainty as measured by the VIX influences the relative value of the Renminbi traded in off-shore markets vis-à-vis the USD, the JPY, the GBP, the EUR, and the CHF, i.e. against currencies traditionally considered as possible safe haven currencies. Using daily data spanning the February 2011 to April

2016 sample period and standard econometric techniques our initial findings for the period as a whole suggest that an increase in market uncertainty is associated with a decrease in the value of the Renminbi relative to the USD and the JPY while the opposite is the case when comparing the Renminbi to the GBP and the EUR. Put differently, our preliminary results suggest that the Renminbi is, on average, “less safe” than the USD and the JPY but “safer” than the GBP and the EUR.

We dissect our data across different sub-samples and employ band spectral regressions that allow us to model the observed exchange rate values as possible manifestations of both high- and low-frequency variation responses to uncertainty movements, thereby accommodating the specific circumstances pertaining to the Renminbi where the relative value of the Renminbi is likely influenced by the reaction of market participants to contemporaneous changes in perception of market uncertainty as well as by actions attributable to institutional aspects and long-term objectives of the Chinese monetary authorities. The findings of our standard econometric technique suggest that recently an increase in market uncertainty is no longer associated with an appreciation of the Renminbi relative to any of the traditional safe haven currencies. This is in and of itself an important finding as it questions the notion that the CNH is progressing towards safe haven currency status. The results of the BSR models add further insight by revealing that during the recent period the relative weakening of the Renminbi as uncertainty goes up is due to the high-frequency variation of the Renminbi while the low-frequency variation is generally associated with Renminbi appreciation as uncertainty increases.

For completeness we also consider the possibility of non-linearities in the form of non-temporal threshold effects pertaining to different levels of market uncertainty. The results of this extension do not suggest that non-temporal uncertainty thresholds are of particular importance in our context, perhaps unsurprisingly considering that we analyze a period during which markets are relatively tranquil.

Overall, our findings show that more recently the relative value of the Renminbi vis-à-vis traditional currencies decreases as market uncertainty increases. Moreover, our findings underline the relevance of distinguishing between high versus low frequency variation in our particular context of studying how a heavily managed yet increasingly traded currency responds to changes in market uncertainty. While our results are not direct evidence that more recently market participants consider the Renminbi less safe and, as a consequence, off-setting currency management actions are undertaken as market uncertainty rises, they are nevertheless consistent with this proposition. Most importantly, at a minimum, our results overall do not support the suggestion that the Renminbi is currently a safe haven currency on par with the traditional safe haven currencies.

References

Andrews, D.W.K., 1993. Tests for parameter instability and structural change with unknown change point. Econometrica 61, 821-856.

Baxter, M., King, R.G., 1999. Measuring business cycles: approximate band-pass filters for economic time series. Review of Economics and Statistics 81, 575-593.

Burdekin, R.C.K., Tao, R., 2016. An empirical examination of factors driving the offshore Renminbi market. China Economic Journal (forthcoming).

Burland, R., 2016. Yuan to become a safe haven currency? FX Street February 17, 2016.

Cheung, Y-W., Rime, D., 2014. The offshore Renminbi exchange rate: microstructure and links to the onshore market. Journal of International Money and Finance 49, 170-189.

Chong, F., 2013. Is RMB approaching safe haven status? Asia Today International June 26, 2013.

Coudert, V., Guillaumin C., Raymond H., 2014. Looking at the other side of carry trades: are there any safe haven currencies? CEPII Woking Paper 2014-03.

Drezner, D.W., 2015. The modest rise of the redback. The Washington Post December 2, 2015.

Engle, R.F., 1974. Band spectrum regression. International Economic Review 15, 1-11.

Engle, R.F., 1978. Testing price equations for stability across spectral frequency bands. Econometrica 46, 869-881.

Fatum, R., Yamamoto, Y., 2016. Intra-Safe Haven Currency Behavior During the Global Financial Crisis. Journal of International Money and Finance 66, 49-64.

Fratzscher, M., Mehl, A., 2011. China's dominance hypothesis and the emergence of a tri-polar global currency system. Economic Journal 124, 1343-1370.

Funke, M., Shu, C., Cheng, X., Eraslan, S., 2015. Assessing the CNH-CNY pricing differential: role of fundamentals, contagion, and policy. Journal of International Money and Finance 59, 245-262.

Gonzalez-Perez, M.T., 2015. Model-free volatility indexes in the financial literature: a review. International Review of Economics and Finance 40, 141-159.

Habib M.M., Stracca L., 2012. Getting beyond carry trade: what makes a safe haven currency? Journal of International Economics 87, 50-64.

Hannan, E.J., 1963. Regression for time series with error of measurement. Biometrika 50, 293-302.

Hansen, B.E., 2000. Sample splitting and threshold estimation. Econometrica 68, 575-603.

Harjani, A., 2014. Has the yuan become a ‘safe haven’ trade? CNBC October 8, 2014.

Hau, H., 2014. The exchange rate effect of multi-currency risk arbitrage. Journal of International Money and Finance 47, 304-321.

Hong Kong Monetary Authority, 2016. Hong Kong The Global Offshore Renminbi Business Hub.

Hossfeld, O., MacDonald, R., 2015. Carry funding and safe haven currencies: A threshold regression approach. Journal of International Money and Finance.

Ito, T., 2010. China as number one: how about the Renminbi? Asian Economic Policy Review 5, 249-276.

Kawai, M., Pontines, V., 2016. Is there really a Renminbi bloc in Asia? Journal of International Money and Finance 62, 72-97.

Prasad, E., 2016. China’s effort to expand the international use of the Renminbi. Report prepared for the U.S.-China Economic and Security Review Commission. Brookings February 2016.

Ranaldo, A., Söderlind P., 2010. Safe haven currencies. Review of Finance 14, 385-407.

Shu, C., He, D., Cheng, X., 2015. One currency, two markets: the Renminbi’s growing influence in Asia-Pacific. China Economic Review 33, 163-178.

Swift, 2016. RMB Tracker April 2016.

Whaley, R.E., 2009. Understanding the VIX. Journal of Portfolio Management 35, 98-105.

Figure 1. Exchange Rates and VIX Series

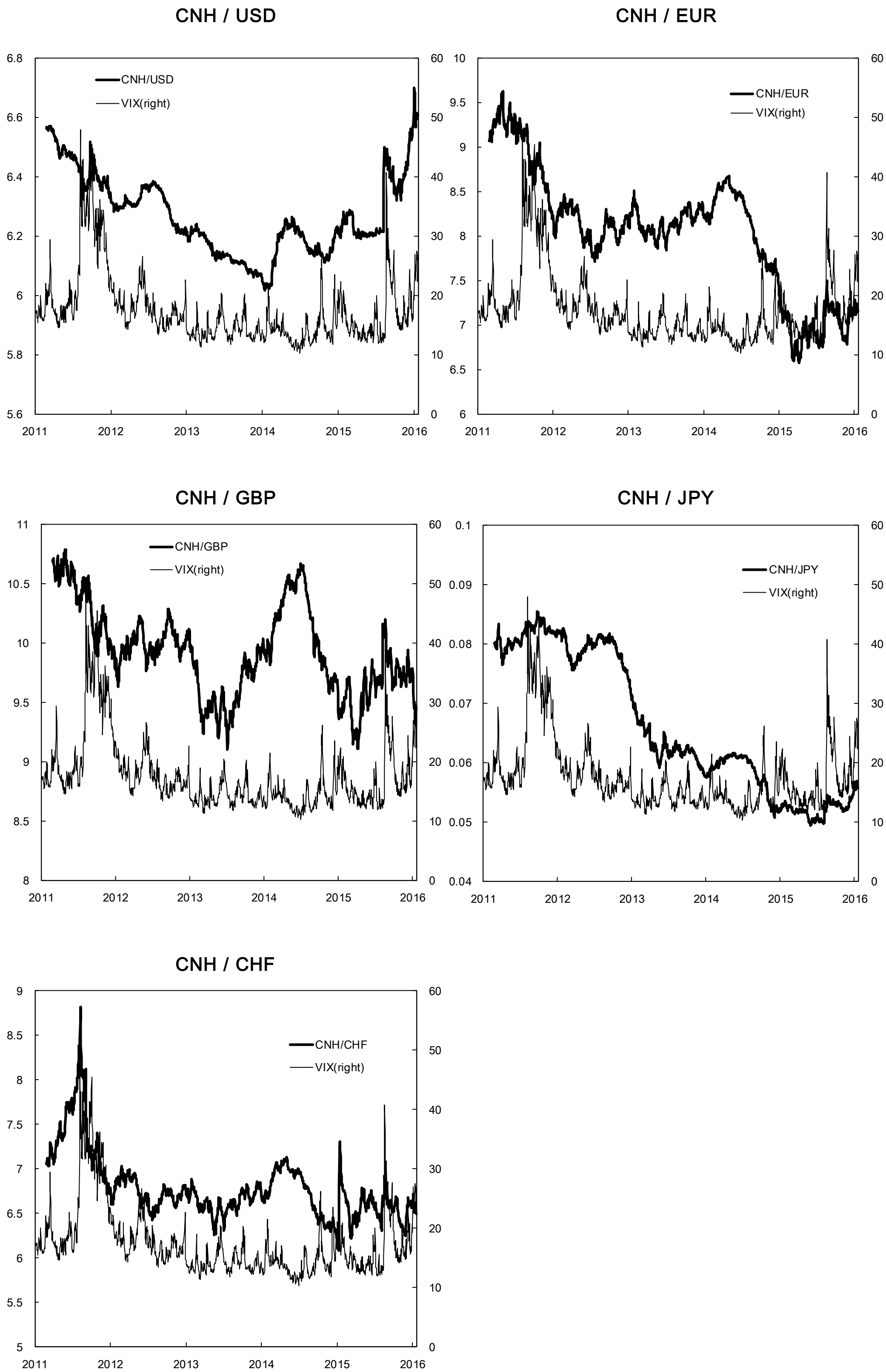
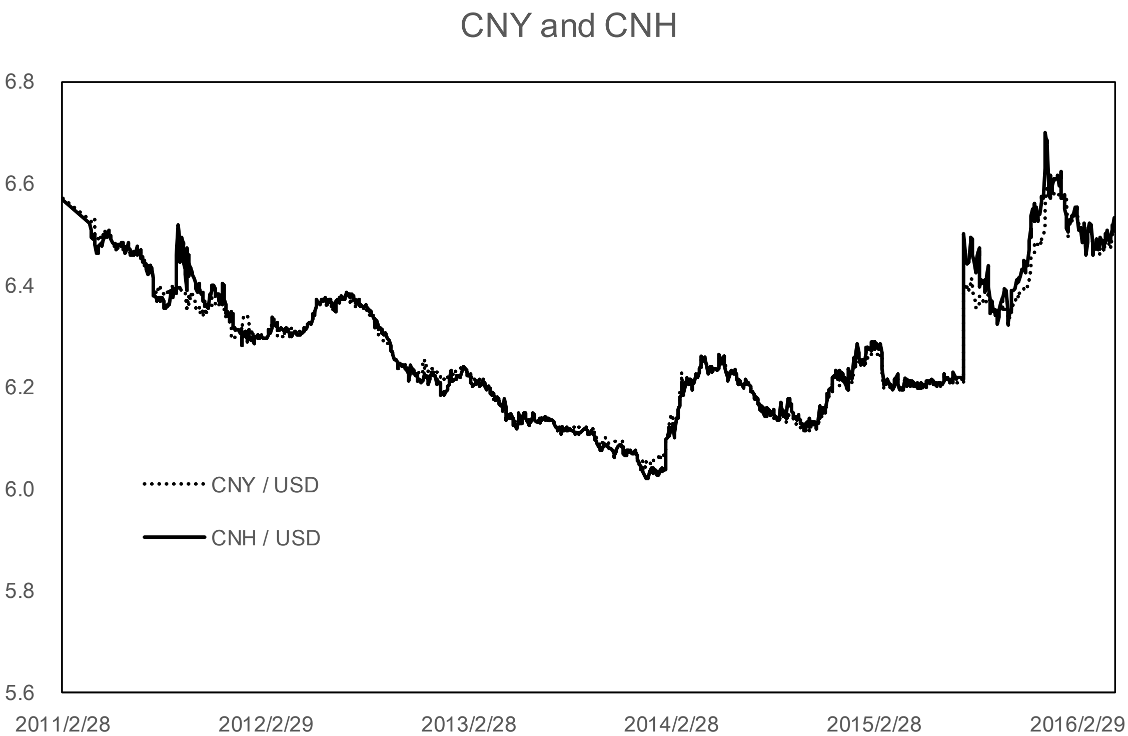


Figure 2. CNY/USD, CNH/USD, and CNH/CNY Series



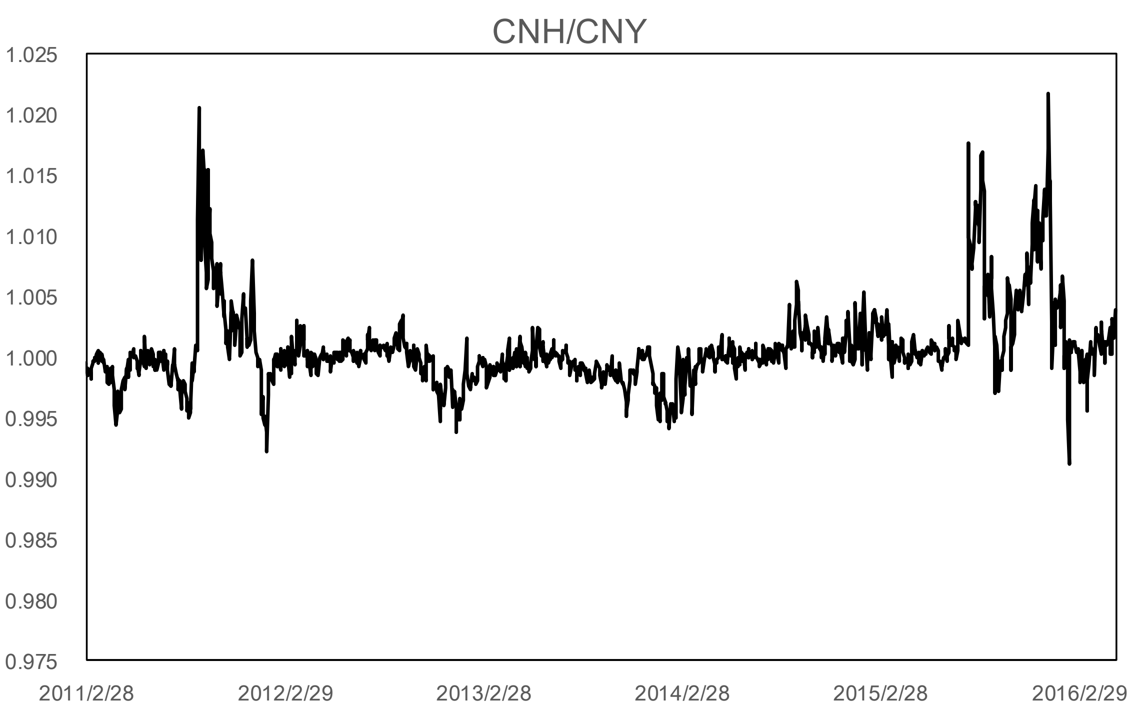


Table 1	**Descriptive Statistics for VIX, VXO, and VXJ Series**								
	2011/2/28 to 2016/4/30			2011/2/28 to 2015/11/29			2015/12/1 to 2016/4/30		
	VIX	VXO	VXJ	VIX	VXO	VXJ	VIX	VXO	VXJ
Start of Period	20.7	19.63	21.05	20.7	19.63	21.05	14.67	14.84	20.28
End of Period	15.7	16.04	29.15	15.12	15.85	20.83	15.7	16.04	29.15
Percent Change	-24.15	-18.29	38.48	-26.96	-19.26	-1.05	7.02	8.09	43.74
Mean	17.51	17.01	24.36	17.40	16.81	23.94	18.72	19.32	29.29
Max	48.00	50.13	72.88	48.00	50.13	72.88	28.14	30.78	51.45
Min	10.32	8.51	13.84	10.32	8.51	13.84	13.1	13.05	19.16
Std. Dev.	5.83	6.04	6.36	5.94	6.11	6.15	4.19	4.61	6.72

Table 2	**Descriptive Statistics for Exchange Rate Series**														
	2011/2/28 to 2016/4/30					2011/2/28 to 2015/11/29					2015/12/1 to 2016/4/30				
	CNH/USD	CNH/EUR	CNH/GBP	CNH/JPY	CNH/CHF	CNH/USD	CNH/EUR	CNH/GBP	CNH/JPY	CNH/CHF	CNH/USD	CNH/EUR	CNH/GBP	CNH/JPY	CNH/CHF
Start of Period	6.57	9.07	10.68	0.08	7.07	6.57	9.07	10.68	0.08	7.07	6.44	6.84	9.70	0.05	6.26
End of Period	6.49	7.43	9.50	0.06	6.77	6.45	6.83	9.71	0.05	6.26	6.49	7.43	9.50	0.06	6.77
Percent Change	-1.25	-18.11	-11.06	-24.39	-4.25	-1.80	-24.68	-9.10	-34.47	-11.38	0.64	8.67	-2.07	15.58	8.05
Mean	6.28	8.02	9.90	0.07	6.78	6.26	8.08	9.94	0.07	6.80	6.53	7.23	9.44	0.06	6.61
Max	6.70	9.63	10.79	0.09	8.81	6.57	9.63	10.79	0.09	8.81	6.70	7.43	9.94	0.06	6.80
Min	6.02	6.58	9.07	0.05	6.08	6.02	6.58	9.10	0.05	6.08	6.44	6.82	9.07	0.05	6.26
Std. Dev.	0.14	0.69	0.39	0.01	0.37	0.13	0.68	0.38	0.01	0.38	0.055	0.114	0.223	0.002	0.099

TABLE 3-1 **Standard Regression (2011/2/28 - 2016/4/30)**

Coefficients	CNH / USD	CNH / EUR	CNH / GBP	CNH / JPY	CNH / CHF
Δ VIX	30.73***	-31.63	-63.11***	184.59***	48.17
	(3.73)	(-1.07)	(-3.12)	(5.73)	(1.44)
CONST	-0.08	-1.59	-0.95	-2.14	-0.28
	(-0.14)	(-0.96)	(-0.70)	(-1.26)	(-0.13)
LAG	5.88	-2.84	-1.98	-2.20	6.08
	(0.62)	(-0.76)	(-0.58)	(-0.62)	(0.59)
Observations	1300	1300	1300	1300	1300
Sum of Squared Errors	47.513	455.413	310.824	483.180	774.189
R-Squared	0.018	0.002	0.010	0.050	0.006
Heteroskedasticity Test	0.000	0.000	0.002	0.000	0.000
Serial Correlation Test	0.858	0.927	0.879	0.136	0.491
ARCH Test	0.978	0.901	0.629	0.864	0.999

NOTES:

(a) ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

(b) t statistics based on White's heteroskedasticity robust standard errors in ( ) below the coefficient estimates.

(c) Heteroskedasticity test, serial correlation test, and ARCH test expressed in p-values.

TABLE 3-2 **Standard Regression (2011/2/28 - 2015/11/29)**

Coefficients	CNH / USD	CNH / EUR	CNH / GBP	CNH / JPY	CNH / CHF
Δ VIX	25.48***	-63.48**	-77.07***	153.50***	20.70
	(3.20)	(-2.02)	(-3.77)	(4.50)	(0.58)
CONST	-0.12	-2.41	-0.83	-3.59**	-0.92
	(-0.24)	(-1.41)	(-0.61)	(-2.06)	(-0.40)
LAG	7.32	-0.83	-0.05	-3.14	7.11
	(0.64)	(-0.21)	(-0.01)	(-0.81)	(0.66)
Observations	1195	1195	1195	1195	1195
Sum of Squared Errors	38.189	408.149	260.993	423.424	729.527
R-Squared	0.016	0.007	0.015	0.037	0.006
Heteroskedasticity Test	0.000	0.000	0.006	0.000	0.000
Serial Correlation Test	0.758	0.989	0.932	0.217	0.645
ARCH Test	0.997	0.910	0.919	0.754	0.999

NOTES:

Same as Table 3-1.

TABLE 3-3	**Standard Regression (2015/12/1 - 2016/4/30)**				
Coefficients	CNH / USD	CNH / EUR	CNH / GBP	CNH / JPY	CNH / CHF
Δ VIX	92.93**	282.55***	80.67	513.60***	320.92***
	(2.18)	(3.52)	(0.91)	(5.68)	(4.00)
CONST	0.93	10.02*	-1.99	14.52**	8.29
	(0.32)	(1.69)	(-0.30)	(2.13)	(1.41)
LAG	-0.80	-18.13	-11.78	1.12	-9.03
	(-0.08)	(-1.59)	(-1.21)	(0.13)	(-0.83)
Observations	104	104	104	104	104
Sum of Squared Errors	8.843	36.840	47.609	47.939	37.262
R-Squared	0.059	0.163	0.023	0.264	0.164
Heteroskedasticity Test	0.965	0.159	0.350	0.986	0.541
Serial Correlation Test	0.638	0.688	0.349	0.759	0.347
ARCH Test	0.700	0.723	0.673	0.773	0.166

NOTES:

Same as Table 3-1.

TABLE 4-1 **Band Spectral Regressions (2011/2/28 - 2016/4/30)**

Coefficients	CNH / USD	CNH / EUR	CNH / GBP	CNH / JPY	CNH / CHF
High frequency variations					
$\frac{1}{2}\pi \leq \omega \leq \pi$	44.66***	-29.12	-61.71***	217.78***	67.83***
	(7.68)	(-1.61)	(-4.55)	(11.25)	(3.03)
$\frac{1}{4}\pi \leq \omega \leq \pi$	37.11***	-45.23*	-60.83***	169.67***	48.94
	(5.47)	(-1.94)	(-3.57)	(6.54)	(1.54)
$\frac{1}{8}\pi \leq \omega \leq \pi$	31.67***	-43.78	-61.16***	170.81***	38.34
	(4.32)	(-1.60)	(-3.29)	(5.68)	(1.17)
$\frac{1}{16}\pi \leq \omega \leq \pi$	28.76***	-39.81	-60.85***	170.00***	46.02
	(3.68)	(-1.45)	(-3.14)	(5.42)	(1.30)
$\frac{1}{32}\pi \leq \omega \leq \pi$	30.55***	-30.61	-58.02***	171.68***	52.36
	(3.86)	(-1.06)	(-2.91)	(5.52)	(1.49)
Low frequency variations					
$0 \leq \omega \leq \frac{1}{2}\pi$	15.50***	-39.07**	-66.01***	147.49***	21.95
	(3.57)	(-2.12)	(-4.80)	(8.30)	(0.95)
$0 \leq \omega \leq \frac{1}{4}\pi$	9.86**	10.82	-70.65***	235.10	52.14***
	(2.26)	(0.77)	(-6.64)	(19.81)	(3.83)
$0 \leq \omega \leq \frac{1}{8}\pi$	24.88***	49.31***	-76.84***	283.94***	130.37***
	(7.68)	(5.78)	(-12.62)	(37.83)	(15.59)
$0 \leq \omega \leq \frac{1}{16}\pi$	55.54***	56.76***	-89.82***	360.08***	93.08***
	(32.19)	(10.36)	(-23.59)	(84.90)	(12.54)
$0 \leq \omega \leq \frac{1}{32}\pi$	37.91***	-74.78***	-189.52***	509.82***	-17.07***
	(31.08)	(-23.63)	(-68.78)	(219.93)	(-2.80)

NOTES:

(a) ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

(b) t statistics based on White's heteroskedasticity robust standard errors in ( ) below the coefficient estimates.

TABLE 4-2 **Band Spectral Regressions (2011/2/28 - 2015/11/29)**

Coefficients	CNH / USD	CNH / EUR	CNH / GBP	CNH / JPY	CNH / CHF
High frequency variations					
$\frac{1}{2}\pi \le \omega \le \pi$	22.77***	-67.24***	-73.35***	178.63***	-5.95
	(4.50)	(-3.57)	(-5.25)	(9.76)	(-0.27)
$\frac{1}{4}\pi \le \omega \le \pi$	31.25***	-79.18***	-81.95***	145.23***	1.11
	(5.01)	(-3.21)	(-4.82)	(5.49)	(0.04)
$\frac{1}{8}\pi \le \omega \le \pi$	25.80***	-72.62**	-73.92***	142.94***	4.47
	(3.65)	(-2.49)	(-3.93)	(4.56)	(0.13)
$\frac{1}{16}\pi \le \omega \le \pi$	22.84***	-70.00**	-76.07***	140.38***	17.04
	(3.12)	(-2.41)	(-3.92)	(4.27)	(0.45)
$\frac{1}{32}\pi \le \omega \le \pi$	24.77***	-62.98**	-73.56***	143.41***	23.22
	(3.27)	(-2.06)	(-3.72)	(4.39)	(0.63)
Low frequency variations					
$0 \le \omega \le \frac{1}{2}\pi$	27.84***	-59.87***	-80.95***	127.32***	53.87**
	(6.06)	(-3.18)	(-5.99)	(6.75)	(2.10)
$0 \le \omega \le \frac{1}{4}\pi$	4.51	-10.28	-60.14***	183.02***	98.60***
	(1.00)	(-0.70)	(-5.60)	(14.31)	(6.59)
$0 \le \omega \le \frac{1}{8}\pi$	21.11***	1.39	-99.63***	232.15***	158.11***
	(6.17)	(0.16)	(-16.35)	(29.25)	(17.81)
$0 \le \omega \le \frac{1}{16}\pi$	54.19***	13.23**	-88.80***	315.85***	96.21***
	(30.05)	(2.48)	(-23.19)	(69.92)	(11.26)
$0 \le \omega \le \frac{1}{32}\pi$	37.32***	-81.77***	-168.52***	425.49***	18.94***
	(44.00)	(-25.72)	(-55.51)	(162.60)	(2.90)

NOTES:

Same as Table 4-1.

TABLE 4-3 **Band Spectral Regressions (2015/12/1 - 2016/4/30)**

Coefficients	CNH / USD	CNH / EUR	CNH / GBP	CNH / JPY	CNH / CHF
High frequency variations					
$\frac{1}{2}\pi \leq \omega \leq \pi$	137.05***	394.20***	143.02***	591.95***	480.92***
	(4.25)	(6.21)	(2.68)	(9.89)	(7.49)
$\frac{1}{4}\pi \leq \omega \leq \pi$	113.89***	425.76***	170.67**	570.07***	436.70***
	(2.64)	(5.96)	(2.05)	(7.37)	(5.93)
$\frac{1}{8}\pi \leq \omega \leq \pi$	109.20***	363.33***	156.86*	545.58***	361.96***
	(2.64)	(4.84)	(1.84)	(6.76)	(4.75)
$\frac{1}{16}\pi \leq \omega \leq \pi$	101.29**	321.09***	116.38	537.30***	345.00***
	(2.47)	(4.05)	(1.32)	(6.64)	(4.35)
$\frac{1}{32}\pi \leq \omega \leq \pi$	92.83**	301.75***	89.45	516.70***	330.80***
	(2.24)	(3.77)	(0.98)	(5.91)	(4.28)
Low frequency variations					
$0 \leq \omega \leq \frac{1}{2}\pi$	55.14**	215.16***	34.34	446.46***	195.59***
	(2.17)	(4.31)	(0.66)	(6.45)	(4.35)
$0 \leq \omega \leq \frac{1}{4}\pi$	28.08	-91.06***	-177.06***	340.50***	-8.29
	(1.47)	(-2.70)	(-6.04)	(7.12)	(-0.25)
$0 \leq \omega \leq \frac{1}{8}\pi$	-17.24	-139.70***	-394.71***	297.63***	87.39***
	(-1.27)	(-6.78)	(-19.08)	(7.92)	(3.35)
$0 \leq \omega \leq \frac{1}{16}\pi$	-72.88***	-159.54***	-525.88***	52.65**	-37.73***
	(-16.31)	(-12.72)	(-46.99)	(2.44)	(-3.55)
$0 \leq \omega \leq \frac{1}{32}\pi$	-11.65	-1129.26***	-1511.67***	-611.96***	-1153.11***
	(-1.44)	(-37.21)	(-194.62)	(-11.83)	(-42.45)

NOTES:

Same as Table 4-1.