A Time-Varying Cointegration Study on the Onshore and Offshore Renminbi Exchange Rates

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Abstract

The price differentials between the onshore and offshore exchange rates, CNY/USD and CNH/USD, have been studied under the framework of cointegration. In order to deal with structural breaks, sub-sample approach has be implemented. However, there are two problems for this approach. First one is related to the determination of the cutting dates, which are so far pre-imposed according to additional information with subjective judgements. The second one is the estimated cointegration coefficients according to sub-sample approach might be biased. This paper aims at overcoming these two problems by adopting the recently developed time-varying cointegration approach that can, more generally, cope with time dependent feature of the equilibrium condition. In addition, we employ a robust time-varying cointegration test to avoid a possible under-rejection of no-cointegration with presenting of structure breaks. Based on the daily data from July 18th, 2013 to January 12th, 2017, we can obtain the time-varying cointegration coefficient with the confidence interval. Despite time-varying relation between the two spot exchange rates, we actually find that the relation is quite stable and coefficient characterizing the relation of the two rates is about unity. Moreover, we estimate the vector error correction mechanism (VECM) model. Our finding shows that the both spot exchange rates significantly adjust towards restoring the one-price condition, although CNH/USD adjusts more rapidly: almost two times faster than that of CNY/USD. Finally, we identify there are bidirectional Granger causalities between the two rates indicating both rates provide useful information for predicting other rates.

JEL Codes: C22, F31, G15
Keywords: time-varying cointegration, onshore and offshore exchange rates, CNY, CNH

1. Introduction

As other major reforms taking place in China during the transit period from the central planning economy to a market oriented one, China adopts a steady and gradualist approach in implementing internationalization of the Chinese currency, Renminbi. Outside of the mainland China, China promotes a full internationalization of Renminbi. Chinese central bank, the People's Bank of China, has signed Renminbi swap contracts with other central banks around the world. Moreover, in meeting demands of Renminbi in both current and capital accounts outside of mainland China, the People's Bank of China and Hong Kong Monetary Authority agreed to make Renminbi fully convertible and deliverable in Hong Kong in 2010. This creates an offshore clear centre for Renminbi noted as CNH. CNH market has been increased dramatically since then. CNH is freely tradable to other currencies and the bilateral exchange rate between CNH and US dollar and symbolised as Renminbi's offshore exchange rate, CNH/USD, subjects to free-floating exchange rate regime. Other Renminbi offshore markets have also been established, such as in Taipei, Singapore, London, and Frankfurt. Nevertheless, Hong Kong remains the largest. The exchange rates of CNH have been regarded as the representative of offshore exchange rates.

A well-developed offshore market is normally accompanied with an under-developed onshore market. This is indeed a case for Renminbi onshore market, known as CNY. The capital account remains not fully opened. Foreign financial institutions are still subject to restrictions in accessing business dominated in Renminbi. The current account has been opened but foreign exchange market is still under intensive interventions. Formally, the exchange rate regime of CNY is in principle a managing floating one. The monetary authority announces a central parity of the exchange rate every trading day and actual rate is allowed to move within a symmetric band around this parity. The band was 0.3% initially (in 2005). It has been gradually extended to ±0.5% (from May 2007), ±1% (from April 2012) and ±2% (from March 2014). Unlike a typical target zone regime, the central parity for CNY/USD is not fixed. The determination of the parity is according to the closing rate in the previous trading day and, since August 2015, a currency basket, in which the US dollar index is merely a part of. Ma and McCauley (2011) refer this regime as a "crawling peg". The current regime of CNY might not be able to generate the harmony effect, which is accompanied with a credible target zone regime, making market participants' expectations in the line with exchange rate within the band (Krugman, 1991). Thus, raises a doubt about its ability to stabilize appreciation/depreciation expectations. Yu, Zhang and Zhang (2017) argue that the regime of crawling peg would be difficult to influence the expectations. As an evidence, in responding to recent depreciation expectations, stabilizing the onshore exchange rate leads to reductions in foreign currency reserves. On the other hand, in dealing with appreciation expectations a number years ago, the monetary authority accumulated a huge amount of foreign currency reserves. Moreover, Yu, Zhang and Zhang (2017) further point out that this regime might be inconsistent to the goal of monetary policy given current economic situation in China.

Given the differences in fundamentals, market mechanisms, and market segmentation, one could argue that it is hard to keep one-price principle for CNY and CNH (Funke et al. 2014). By employing cointegration approach, Ding et al. (2013) fail to identify the equilibrium relation between CNY/USD and CNH/USD. However, the counter argument can be formulated due to the unique crawling peg regime. The central parity and the actual CNY/USD exchange rate would be adjusted according to market expectations. Any arbitrage occurred from one price principle would be eventually taken by market participants. Cheung and Rime (2014) and Owyong et al. (2015), which employ the subsample cointegration approach, identify the equilibrium relation but notice the relation might subject to change based on the selected sub-samples. This result is not surprising given the fact that many institutional reforms, which may generate regime shifts, occurred during the internationalization of Renminbi. These regime shifts can be characterized as structural breaks. Xiao and Phillips (2002) note that residual based cointegration test may under-reject the null of no-cointegration, if the study is not taken structural breaks into consideration. More importantly, with sub-sample cointegration approach, we cannot isolate the changes in cointegration coefficients due to the regime shifts, which is actually what we are interested in, from the estimates based on the sub-sample, since the estimates contain the information about the changes due to the changes in independent variables as well (Change et al., 2014).[1] On way to obtain cointegration coefficients, which are independent to independent variables, is to reduce the length of sub-sample into a single time point. Namely make cointegration coefficients truly time dependent.

In this paper, we, therefore, employ a time-varying cointegration approach to take care of shifts in equilibrium relation between two spot exchange rates in the line with Neto (2012). Besides the traditional residual based no-cointegration test, this paper also adopts the fully modified least squared (FMLS) based CUSUM time-varying cointegration test developed by Neto (2014) to overcome a possibility of under-rejection of cointegration relation caused by structural breaks.

Note that in economics, the cointegration approach is suitable for studying economic equilibrium condition that reflects long-run relation(s) among economic variables in considerations. A long time span is crucial for applying cointegration approach due to the fact that the real economic adjustment would usually take years to reach equilibrium. However, such an equilibrium condition among financial variables, also known as arbitrage relations in finance, would not require such long-run time span, due to the fact that financial markets could deal with arbitrage much faster than that of real economic variables. Thus, employing cointegration approach to study the equilibrium relation in finance can rely on high frequency data, such as daily data, in a relative short time span (Zivot and Wang, 2014). Using daily data from July 18th, 2013 to January 12th, 2017, our exercise identifies a time-varying cointegration relation between the onshore and offshore spot exchange rates. Despite the time-varying feature, the parameter descripting the relation between CNH/USD and CNY/USD rates is about unity. So that onshore and offshore exchange rates follow the law of one price in equilibrium. In addition, we also find interaction between two spot exchange rates is actual two-way: Both spot rates would adjust accordingly to eliminate the arbitrage. However, adjusting speed of offshore rate of CNH/USD is more than double of that of onshore rate of CNY/USD.

The remaining part of this paper is organized as the following: A literature review concerning analyses on onshore-offshore foreign exchange rates in China is given in section 2. Methodology is introduced in section 3. Section 4 presents data, results and interpretations. Final remarks are given in section 5.

2. Literature review

Studies concerning the interaction between Renminbi's onshore and offshore exchange rates have been focused on one-price principle in a form of price differentials. In the early years, when the Renminbi was not sufficiently available for the settlements of trade outside of

[1] The discussion in Change et al. (2014) is based on the rolling window approach. But the principle would, in general, be able to apply to sub-sample approach.

mainland, the nondeliverable forward (NDF) contracts, which are settled in US dollar and begun to trade in the end of 1998, played a great role. Since the NDF contracts provide a practical information about offshore exchange rate, the price differentials are investigated between NDF exchange rate and the onshore CNY spot rate. Yang and Leatham (2002), Huang and Wu (2006), and, Owyong, Wong, and Horowitz (2015) find cointegration relations. Tong, Wang, and Yang (2016) attempt to capture the impacts from policy changes. Their study identifies the cointegration relations and structural breaks. However, Ding, Tse, and Williams (2014) find no such cointegrated relation between the two rates of CNY and NDF. Maziad and Kang (2012) employ bivariate GARCH to study mean spillovers, shock spillovers, and volatility spillovers. This study is merely based on returns of exchange rates (log differences). It implicitly assumes no equilibrium condition at levels, although no cointegration test is implemented.

As the launch of the offshore CNH clearing centre in 2010, offshore deliverable forward (DF) contacts become popular. As pointed out by Leung and Fu (2014), the DF contracts have several advantages over the NDF contracts. One of them is that the NDF contracts settle at the central parity in onshore market rather than the actual CNY/USD exchange rate. Significant basis risk could arise due to derivations of actual spot CNY/USD exchange rate from the parity. The price differentials between the onshore and offshore exchange markets can, thus, be characterized as interactions of implied yields form both onshore and offshore DF contracts. The implied yields are computed via the covered interest rate parity. Leung and Fu (2014) find that onshore and offshore DF implied yields for all maturities are cointegrated.

In the onshore CNY/USD exchange market, the central parity is determined and announced by the monetary authority in each business day and actual onshore exchange rate can be deviated from this parity but has to be within a symmetric band around the parity. Officially, this parity should be determined based on the market closing rate in previous trading day and a currency basket index, the CFETS (Chinese Foreign Exchange Trade System) renminbi index. Cheung, Hui, and Tsang (2017) find that this index only has an impact on the parity when volatility of the offshore market is taking into a consideration. Otherwise, the US dollar index instead has significant impacts on formulating the central parity. The cointegration relations between central parity and offshore rate as well as between onshore and offshore exchange rates are explicitly assumed. Their result predicts that the Chinese monetary authority would adjust policy decisions according to the volatilities in the offshore exchange market.

However, the central parity is not actual exchange rate at which one may trade Renminbi with other currencies. A natural approach would be studying price differentials between spot CNH/USD and CNY/USD rates directly. Funke et al. (2015) examine the underlying driving forces for exchange rate differential, which implicitly assumes one-price principle: the fixed one-to-one relation between CNH/USD and CNY7USD rates, despite they discover time-varying volatilities. Cheung and Rime (2014) and Owyong, Wong, and Horowitz (2015) employ cointegration approach and identify the cointegration relation between onshore and offshore rates. To deal with possible time-varying feature, the same exercises are repeated in subsamples. The cutting dates are chosen according to changes in wideness of the band around the central parity. Cheung and Rime (2014) only allow the short-run adjustments while Owyong, Wong, and Horowitz (2015) allow both long-run and short-run coefficients to be different across subsamples. Although their results show that the point estimates of cointegration coefficients are different, it is impossible to know whether such differences are statistically significant or not. More importantly, as pointed out by Change et al. (2014), if the cointegration coefficient is truly time varying, the estimates based on rolling windows or sub-samples might be biased.

3. Methodology

In this paper, we employ the smooth time-varying cointegration model first developed by Bierens and Martins (2010) that estimate the long-run time-varying parameters with Chebyshev time polynomials. This model is based on a framework in the line with Johansen's procedure that, in principle, allows more than one cointegration relations. Neto (2012) greatly simplifies this approach if there is only one equilibrium relation in considerations. The independent variables in the cointegration relation are transformed into the Hadamard products by Chebyshev time polynomials and the estimation can be implemented by the Fully Modified Least Squared (FMLS) estimation proposed in Phillips and Hansen (1990). There are two approaches to test the time-varying cointegration. First approach is adopted in Neto (2012). This approach uses the traditional residual-based no-cointegration test (Engle and Granger, 1987, Engle and Yoo, 1987, and MacKinnon, 2010) together with a time-invariant Wald test. However, Neto (2014) notes that this residual based approach may under-reject the null of no-cointegration with possible structural breaks as pointed out in Xiao and Phillips (2002). Neto (2014), thus, proposes an alternative time-varying cointegration test, FMLS based CUSUM time-varying cointegration test in the line with Xiao and Phillips (2002). In this paper, we shall implement both tests.

In more details, the cointegration relation is characterized as

$$CNH_t = \beta_t CNY_t + z_t \tag{1}$$

for t=1, …, T, and where *CNH* indicates offshore Chinese Renminbi/US dollar exchange rate, CNH/USD. *CNY* is the onshore Renminbi/US dollar exchange rate, CNY/USD. *CNH* can be regarded as a market rate while *CNY* is, at least partially, controlled by the monetary authority. In general, the cointegration coefficient β should be 1 indicating one-to-one changes in exchange rates and the one-asset one-price principle. However, this might not be the case, since two rates are subject to different determining mechanisms in terms of demands, interventions, expectations, speculations, and policy regime shifts. β is likely to be different from 1, and at the same time, time-varying. Since we would like capture the nonlinearity of time dependence, we make the parameter with a time subscript, β_t. The cointegration relation as (1) is usually interpreted as an equilibrium condition. z_t represents the residuals from (1) representing the deviations from the equilibrium.

The Chebyshev time polynomials, $G_0, G_1, \ldots G_m$, are defined as

$$G_i = \begin{cases} 1 & \text{for } i = 0 \\ \sqrt{2}\cos(t^{-1} i\pi(t-0.5)) & \text{for } i > 0 \end{cases} \tag{2}$$

for $i = 0, \dots, m$, and t=1, …, T. One can image that each G_i is a vector that contains values corresponding to t=1, …, T. i represents the order of Chebyshev polynomials which is less and equal to m.

In order to reflect nonlinearity of time dependence, the independent variable, *CNY*, in the equilibrium relation (1) is transferred according to Hadamard products by Chebyshev time polynomials: $G_i \odot CNY_t$. (1) now can be rewritten as:

$$CNH_t = \xi_0 \,(G_0 \odot CNY_t) + \xi_1 \,(G_1 \odot CNY_t) + \cdots + \xi_m \,(G_m \odot CNY_t) + z_t \qquad (3)$$

where ξs are m+1 parameters to be estimated. As a standard cointegration model, estimating (3) by the ordinary least squared (OLS) would possibly be affected by the endogeneity. The non-standard asymptotic distributions of the estimates lead to a difficulty to conclude any statistical significances. A number of efficient approaches have been proposed for obtaining median-unbiased and asymptotically normal estimates. This paper follows Neto (2012) to adopt fully modified least squared (FMLS) estimator suggested by Phillips and Hansen (1990) to estimate the parameters of ξs in (3).

The order of Chebyshev time polynomials, m, involved in (3) can be determined, according to Neto (2012), by chosen minimizing the Hannan-Quinn information criterion (HQC), where $HQC = Tlog(RSS/T) + 2(m+1)\log(\log(T))$. The maximum of m is set at 10 for availability of critical values for cointegration tests. The detailed discussion will be provided shortly. Neto (2012) and (2014) indicate that with a reasonable modest m, (3) can capture nonlinear time-varying feature. According to Neto (2012), the smooth time-varying coefficient β_t can be obtained according to

$$B = \xi_0 \, G_0 + \xi_1 \, G_1 + \cdots + \xi_m \, G_m \qquad (4)$$

Note vector B contains T βs. β_t is t-th value and matches the cointegration coefficient in period t. The standard deviation is also time-varying:

$$sd(B) = \sqrt{sd(\xi_0)^2 G_0^2 + sd(\xi_1)^2 G_1^2 + \cdots + sd(\xi_m)^2 G_m^2} \qquad (5)$$

$sd(\beta_t)$ is again the t-th value of $sd(B)$. The confidence intervals for β_t can be establish based on the convergence to the normal distribution.

As indicated in (4), if all ξs excepting ξ_0 are zero, $\beta_t = \beta = \xi_0$. In other words, the time-varying cointegration relation (1) reduces to an ordinary cointegration relation with a fixed coefficient β. Thus, the time-invariant parameter can be tested by a Wald test according to a null of

$$H_0\colon \xi_1 = \xi_2 = \cdots = \xi_m = 0 \qquad (6)$$

Phillips and Hansen (1990) shows that under the framework of the FMLS, the Wald statistic for testing (6) follows asymptotically a Chi-squared distribution.

Note that time-varying cointegration (1) nests the time-invariant cointegration relation in which β is a fixed constant. A common alternative for obtaining the time-vary parameter β_t is to estimate cointegration in a series of sub-samples as rolling windows. However, this approach is subject to some basic and practical problems. For the practical one, in order to obtain the nonlinear time-varying β_t, we are facing two opposite concerns about the size of sub-sample. On the one hand, we need to have sufficient observations to carry out meaningful cointegration estimations in each individual sub-samples. On the other hand, for obtaining accurate β_i in each rolling interval, we need to narrow down the time span. It is hard to find a practical balance. More important issue is the basic problem of this approach: No matter how accurate β obtained from rolling window estimations, estimated β_i is biased estimator of β_t.[2] As pointed out by Change et al. (2014), if the time-varying feature of parameter is true, the estimated β_i according to the corresponding rolling interval consists two components. With our research specification, they are the cointegration parameter β_t at t and changes in β caused by changes in *CNY*. In other words, when (6) is rejected, the rolling window based β_i would be biased unless either we can be sure that *CNY* would not lead to any changes in cointegration coefficient β or the rolling intervals reduce to single time points, respectively.[3]

Concerning cointegration test, we first follow Neto (2012) to carry out the residual-based no-cointegration test. This paper employs Engle-Grange tau test (Engle and Granger, 1987, and Engle and Yoo, 1987) based on the critical values provided in MacKinon (2010). Since the critical values provided Mackinon (2010) are only up to 12 stochastic trends involved in the estimation including the dependent variable, and there are m+1 independent variables in (3), the maximum of m would be set at 10.

Alternatively, we may carry out the FMLS based CUSUM time-varying cointegration test according to Neto (2014) which is in the line with Xiao and Phillips (2002). This alternative is essential if possible structural breaks appear in the sample in consideration, since in these situations, residual based test might under-reject the null of no-cointegration. The statistic of FMLS based CUSUM test is defined as

$$CS_T(m) = \max_{k=1,\dots T} \frac{1}{\sqrt{T\widehat{\omega}}} \left|\sum_{t=1}^{k} \hat{z}_t^{+}(m)\right| \tag{7}$$

where $\hat{z}_t^{+}$ is FMLS residuals from (3) and $\widehat{\omega}$ is a conditional variance of z on e. which is defined as $\Delta CNY_t = e_t$ for t=1,…,T. The null hypothesis of this test is time-varying cointegration. We reject the null, if *CS* is larger than the upper tail critical values provided in Neto (2014). Since the critical values only up to m=10, the maximum of m, the order of the Chebyshev polynomials, would be set at 10 again.

In following Neto (2012), we may construct the vector error correlation mechanism (VECM) model, in which we assume time-invariant short-run adjustments:

[2] Change et al. (2014) argue this bias is due to omitted variables bias. However, under the current framework, the orthogonal property of Chebyshev polynomials prevents collinearity among the independent variables in (3) (Neto, 2014). Thus, omitted variables bias would not be an issue if we estimate traditional time-invariant cointegration relation.
[3] See discussions in Change et al. (2014).

$$\Delta CNH_t = c_{CNH} + \alpha_{CNH} z_{t-1} + \sum_{i=1}^{p} \rho_i^{CNH} \Delta CNH_{t-i} + \sum_{i=1}^{p} \rho_i^{CNY} \Delta CNY_{t-i} \qquad (8)$$
$$\Delta CNY_t = c_{CNY} + \alpha_{CNY} z_{t-1} + \sum_{i=1}^{p} \gamma_i^{CNH} \Delta CNH_{t-i} + \sum_{i=1}^{p} \gamma_i^{CNY} \Delta CNY_{t-i}$$

CNH is weakly endogenous, if α_{CNH} is negatively significant. This would mean the offshore rate adjusts to eliminate deviations from the equilibrium condition (3). Analogically, *CNY* is weakly endogenous, if α_{CNY} is positively significant. The implication would be the same that the onshore rate adjusts to eliminate deviations from the cointegration condition (3). The Granger causality tests can be tested based on the system of (8) in which the optimal *p* can be determined according to AIC and/or SIC.

4. Results

The data of two exchange rates are from July 18th, 2013 to January 12th, 2017. Both rates are the daily closing rates. The data are available at the Investing.com. Figure 1 plots two rates. First note that two rates are somehow moving tightly together. The rates seem subjecting to a decreasing (appreciation) trend until the first quarter of 2014 and since then the trend, if any, is changed to upward (depreciation) one. Also noting, there might have, at least, one structural break characterized by a harsh devaluation in August 2015.[4]

Figure 1 is about here

Due to situation just descripted, when we carry out the unit-root tests, we also test the unit-root with a structural break. These tests are reported in the upper panel of the Table. Augmented Dickey-Fuller, ADF, (Dickey and Fuller, 1979) and PP (Phillips and Perron, 1988), both have the unit root as the null, cannot reject the null for two rates. But the null can be rejected with the first-order differences. KPSS (Kwiatkowski ed al., 1992) tests, with the stationarity as the null, reject the null for two rates but not the first-order differences. At the same time, The ADF unit-root tests with a structural break do not reject the null of unit-root for two rates. Thus, we can conclude that two rates, *CNH* and *CNY*, are $I(1)$ processes.

Table is about here

The middle panel in Table 1 reports the cointegration tests. The optimal *m*, the order of Chebyshev time polynomials, is 10. The residual based tau statistic is -8.73 which is significant at 1% for rejecting no-cointegration null. The FMLS based CUSUM statistic, *CS*, is 0.81 that is smaller than the 90% upper tail with a critical value of 4.64. Thus we would not reject the time-varying cointegration even at 90%. The Wald test rejects the null specified in (6). Thus, reject the time-invariant parameter hypothesis. As a summary, we identify a time-varying equilibrium condition between *CNH* and *CHY*. This result helps to clarify the recent results concerning the two spot rates (see Ding et al. 2013 and Cheung and Rime, 2014).

[4] The People's Bank of China expressed that the Renminbi's exchange rate flexibility would be further enhanced on 11th of August 2015. This created worry concerning devaluations of the currency.

The time-varying parameter with a 95% confidence interval is plotted in Figure 2. Although the null of time-varying parameter is not rejected, the coefficient is rather stable at unity as shown in Figure 2. This means, in general, one-asset one-price principle is valid for the Chinese currency, Renminbi, despite offshore exchange rate, *CNH*, is regarded as market oriented while the onshore rate, *CNY,* is subject to policy interventions.

Note an interesting date in July 2014. Before this date, the parameter β is less than or equal to 1 but after this date β is generally more than or equal to 1, although, such deviations are not statistically significant. This implies that before one-unit change in *CNY* would lead to less than one-unit changes in *CNH*. But after that date, it has been reversed, one-unit change in *CNY* would lead to more than one-unit changes in *CNH*.[5]

Figure 2 is about here

In addition, we also carry out the VECM study by using (lag of) the residuals, *z*, from (3) to character the deviation from the cointegration condition (3). We skip the detailed result but report the one concerning loading coefficients in the lower panel of Table 2. The loading coefficient of *CNH*'s equation is -0.11 and significant at 1%. This shows that *CNH* would certainly adjust to eliminate any deviation from the equilibrium condition (3). At the same time, the loading coefficient of *CNY* is rather small at 0.05 but significant at 5%. This indicates that the offshore exchange rate, *CNY*, is also adjusting towards eliminating any deviation from the cointegration condition (3). So we may reject weak exogeneities for both *CNY* and *CNH*. The finding, on one hand, is consistent to the general speculation that the onshore exchange rate leads the offshore rate due to the result of policy interventions. What we find here also shows that market information from the offshore exchange rate could affect the onshore rate (not the central parity) as well. This indicates that market conditions become one of the important considerations for formulating onshore exchange rate.

5. Concluding remarks

This paper contributes using the time-varying cointegration approach to deal with structure breaks and nonlinearity of time dependence and to study the law of one price principle of onshore and offshore exchange rates. Based on sample period from July 18th, 2013 to January 12th, 2017, we can identify an equilibrium condition between two exchange rates and such condition is rather stable although we allow such relation to be time dependent. This is somehow surprising result: Due to differences in the fundamentals and the market segments, it would hard to image the arbitrages can be eliminated. But it is not impossible even only via the current account. For instance, the Chinese firms together with a foreign business partner, who is accessible to the offshore foreign exchange market, can still make the hedge via importing and/or exporting assets like gold.

[5] The beginning of 2014 is the time when the trends of two spot exchange rates changed from a negative to a positive one. It is not clear whether such changes in the trend would lead to the behaviors of cointegration coefficients discussed above.

We also find both onshore and offshore exchange rates adjust towards eliminating the derivations from the one-price condition characterized by the rate differentials. Although, responds from offshore exchange rate are much strong than that of onshore rate, responds from onshore rate are significant. This is not a surprising result: The offshore exchange rate is freely floating and will be determined according to market expectations and conditions. The "crawling peg" of onshore exchange rate regime would take in these conditions and expectations gradually and slowly. This is the easy part to understand. The hard part is why offshore rate would also adjust according to the onshore rate. This is probably due to asymmetric information across onshore and offshore markets. The determination of (the central party of) CNY/USD exchange rate might reflect directly the intention on policy interventions. Given the size of onshore market, the offshore market would take in this information from the onshore market. Thus foreign exchange rate policy decisions would have a certain degree influences on market expectations which are important factors for determination of offshore exchange rate.

It is worth to point out that given China opening up the capital account in the future, the rate differentials might still occur due to asymmetric information across onshore and offshore market. This is a lesson that we could learn from the Eurodollar market (Leung and Fu, 2014).

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Table: Unit-root, no-cointegration, and time-invariant tests

Unit-root test:				
	CNH	Δ(*CNH*)	*CNY*	Δ(*CNY*)
ADF [a]	-2.24 (0.47)	-19.63^{***} (0.00)	-1.68 (0.76)	-27.03^{***} (0.00)
PP	-2.35 (0.40)	-26.39^{***} (0.00)	-1.59 (0.79)	-26.95^{***} (0.00)
KPSS	0.62^{***}	0.19	067^{***}	0.38^{*}
ADF with break	-3.85 (0.62)		-3.56 (0.79)	
Cointegration test:				
m[b]	10			
R^2/adj R^2	0.99/0.99			
ρ	0.82			
tau-statistic[c]	-8.73^{***} (0.00)			
CS	0.81 [4.64, 5.69, 8.01]			
Wald test	183.35^{***} (0.00)			
VECM:				
p[c]	9			
α(*CNH*)	-0.11^{***} [-3.18]			
α(*CNY*)	0.05^{**} [2.02]			
CNY not cause *CNH*	reject			
CNH not cause *CNY*	reject			

*** Significant at 1%, ** 5% and * 10%. Parentheses show *p*-values. Squared brackets in coinegration test display critical values of FMLS based CUSUM time-varying cointegration test for upper tails of 90%, 95%, and 99%, respectively in Neto (2014). Squared brackets in VECM show *t*-values. [a] Unit-root tests with maximum lags of 11 and lag selection criterion according to SIC. [b] Maximum *m* is set at 10. [c] Lag selection criterion according to AIC.

Figure 1: CNH and CNY

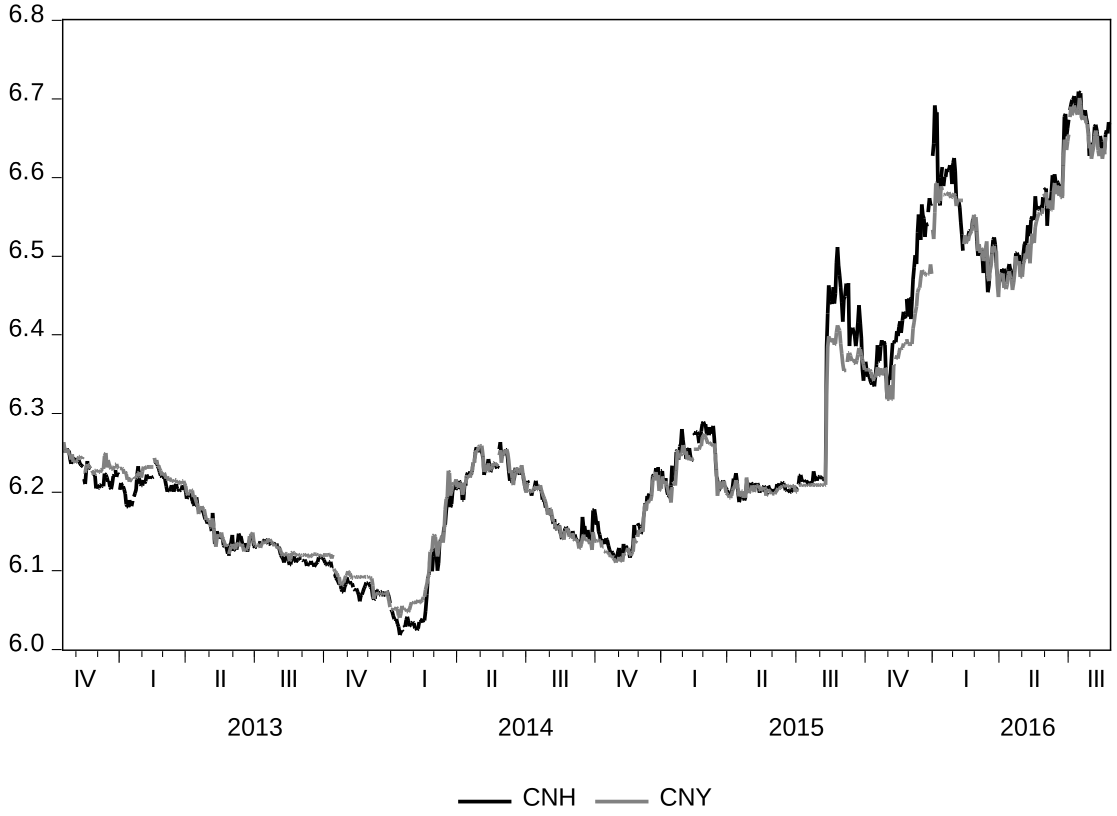

Figure 2: Time-varying parameter