Fluctuation and Intervention: A Tale of Two RMB Markets

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Road Map

- Introduction
- Empirical analysis
  - Stylized facts: CNH, CNY and CNH-CNY pricing differential
  - Determinantion mechanism of the level and volatility of CNH-CNY pricing differential
- Policy evaluation
  - Short- and long-run effects of the "August 11" exchange rate reform on the CNH-CNY pricing differential
- Conclusion and policy implication

Introduction

Two RMB markets

- Economic reforms in China: dual-track process of "crossing the river by touching the stone"(Lin, 1992; Lau, Qian and Roland, 2000). However, financial and currency market reforms are left behind.

- China's FX market: One currency (Renminbi) but two markets (onshore and offshore markets) since 2010 (Shu, He, and Cheng, 2015; Cheung and Rime, 2014);
  - Onshore market (CNY): managed floating regime with capital control (CNY is controlled by the central parity rate and trading band);
  - Offshore market (CNH): "free floating regime mainly determined by market demand and supply";

- Intervention-free RMB market is no longer there after the "August 11" Exchange Rate Reform in August 2015.

CNH comoves with CNY except for several periods.

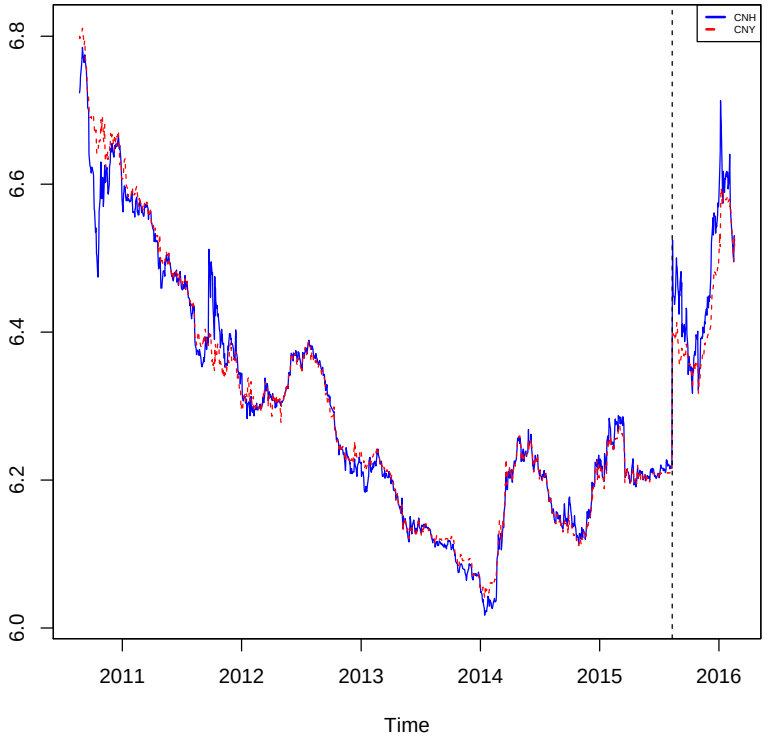


Figure 1: CNY v.s. CNH: Time Series

Introduction

RMB internationalization

- The progress of RMB internationalization has speeded up since 2014, leading to RMB's inclusion of SDR basket;
- To facilitate RMB internationalisation, PBOC initiated the reform of CNY central parity formation system on August 11, 2015, towards a market-based central parity formation system;
- Drastic fluctuation and depreciation took place in both CNY and CNH markets, even with PBOC's interventions.

RMB exchange rate reform: "crossing the river by touching the stone".

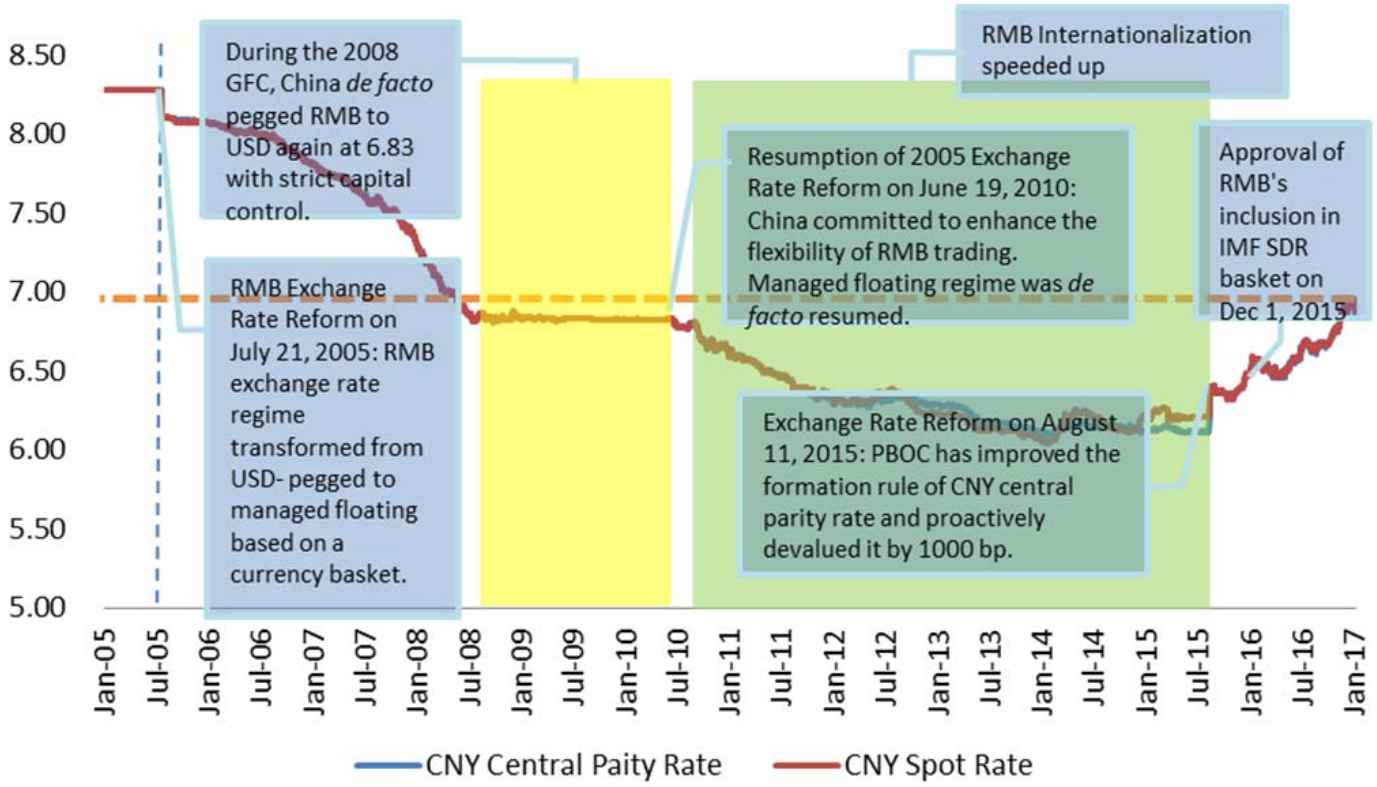
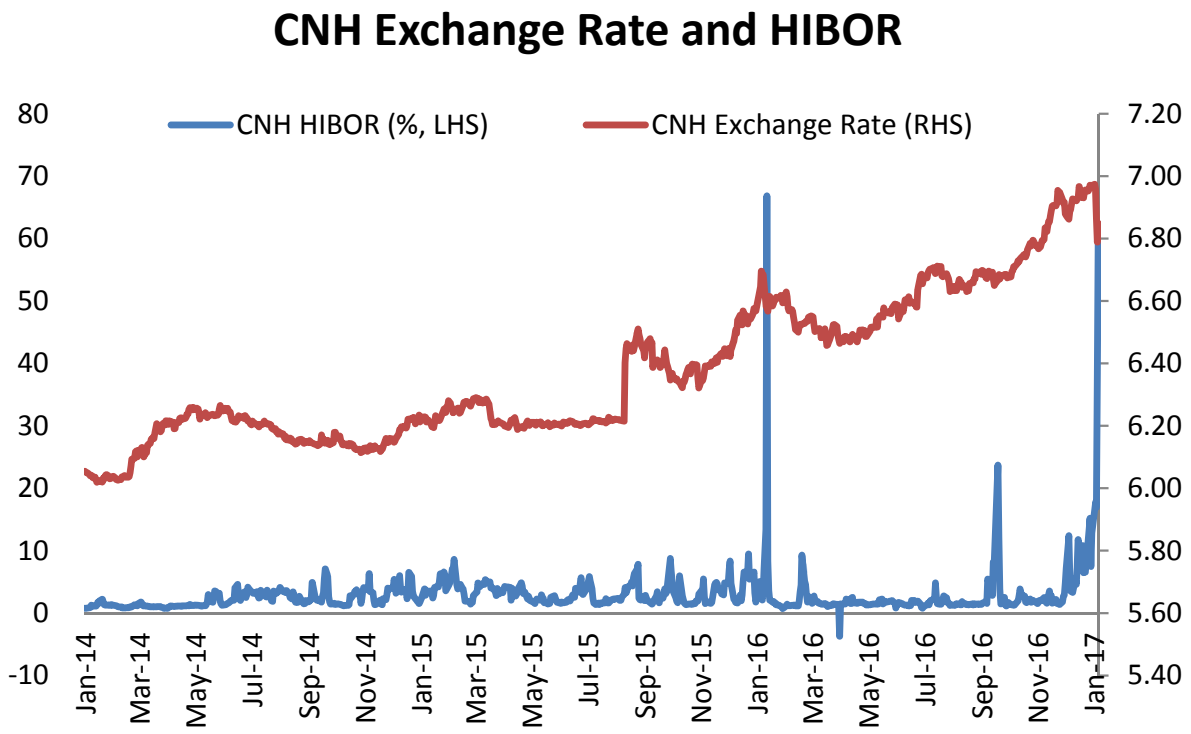


Figure 2: Milestones of RMB Internationalization

Seemingly proactive liquidity shortage in CNH market to prevent the depreciation trend of CNH. However, pessimistic mood keeps fermenting along the way.



Source: Wind.

Figure 3: Proactive Liquidity Shortage for Preventing CNH Depreciation

CNH is no longer an intervention-free market.

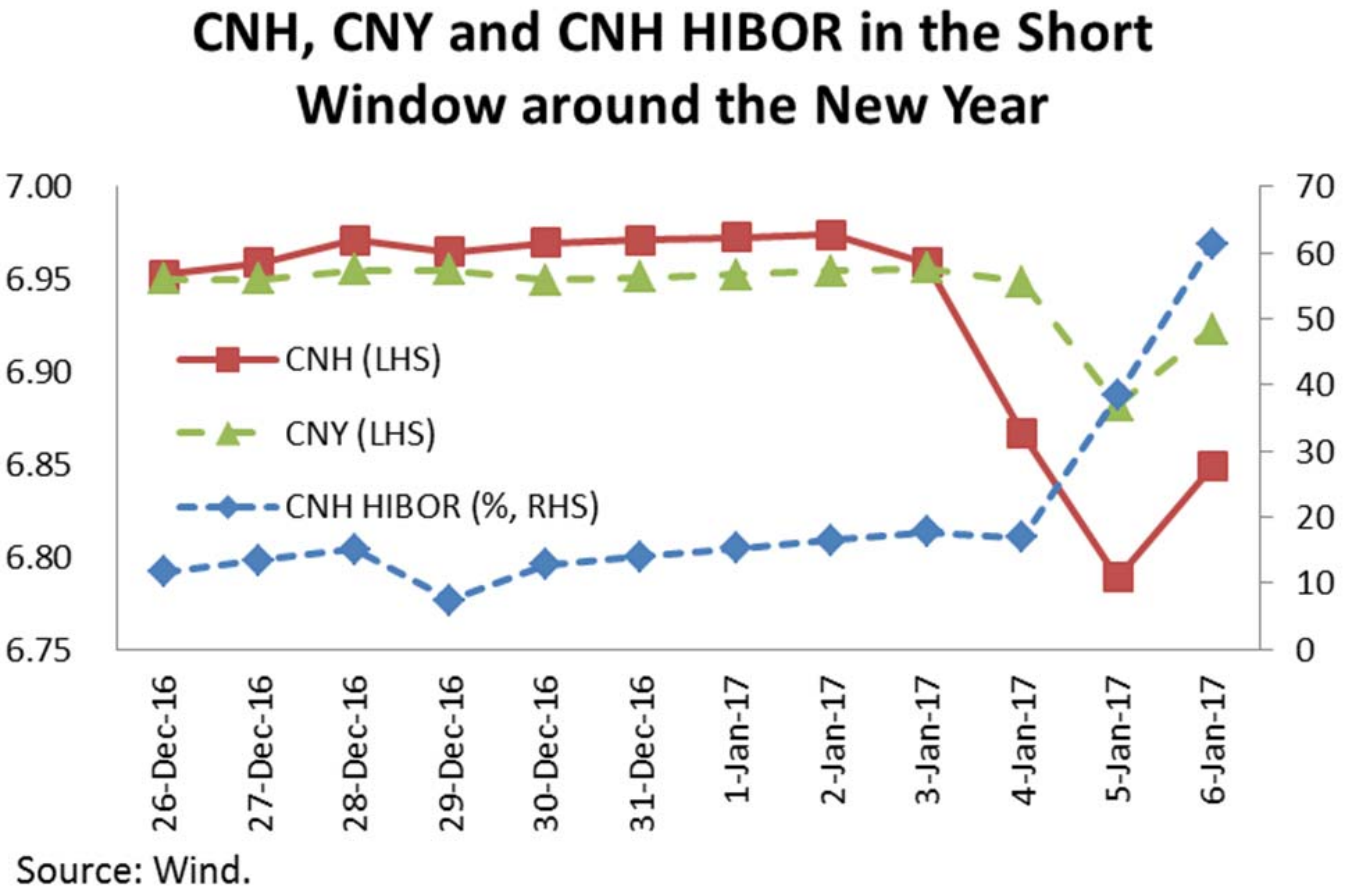


Figure 4: Intervention in CNH Market

Questions yet to be well answered:

- What are the key features of RMB markets and their linkage, before and after "August 11" Exchange Rate Reform?
  - The causal relationship between CNH and CNY (Maziad and Kang, 2012; Cheung and Rime, 2014)
  - CNH-CNY pricing differential (Funke, Shu, Cheng, and Eraslan, 2015)
- What is the determination mechanism of the pricing differential?
  - Fundamental variables and policy shocks
- Is the "August 11" Exchange Rate Reform effective? Any structural change in the formation rule of CNY central parity rate? (Cheung, Hui, and Tsang, 2016)
  - Short-run and long-run effects of the reform;
  - Currency basket.

Introduction

What does this paper do?

Correspondingly, we work on the following aspects:

- Characterize the movement and volatility of CNH-CNY pricing differential using symmetric and asymmetric GARCH models
  - Engle (1982); Bollerslev (1986); Baillie and Bollerslev (2002), Funke, Shu, Cheng and Eraslan (2015);
- Measure the short- and long-run effects of "August 11" exchange rate reform on CNH-CNY pricing differential and the formation system of CNY central parity rate, respectively
  - Wei (1994); Frankel and Xie (2010); Frankel and Wei (2007, 2008); Cheung, Hui and Tsang (2016).

Introduction

An overview of key findings

Throughout our sample period:

- Stationary CNH-CNY pricing differential;
- Causality relationship between CNH and CNY: CNH$\rightarrow$CNY in the short run but CNH$\leftrightarrow$CNY in the long run;
- Significant CNH-CNY volatility clustering;
- Stationary correlation between CNH and CNY series except for a short window after "August 11" exchange rate reform;
- Leverage effect of the CNH-CNY volatility;
- Structural change in the formation rule of CNY central parity rate.

- Four decoupling periods in two RMB markets (CNY v.s. CNH): |CNH-CNY pricing differential| > mean + 2×s.d.

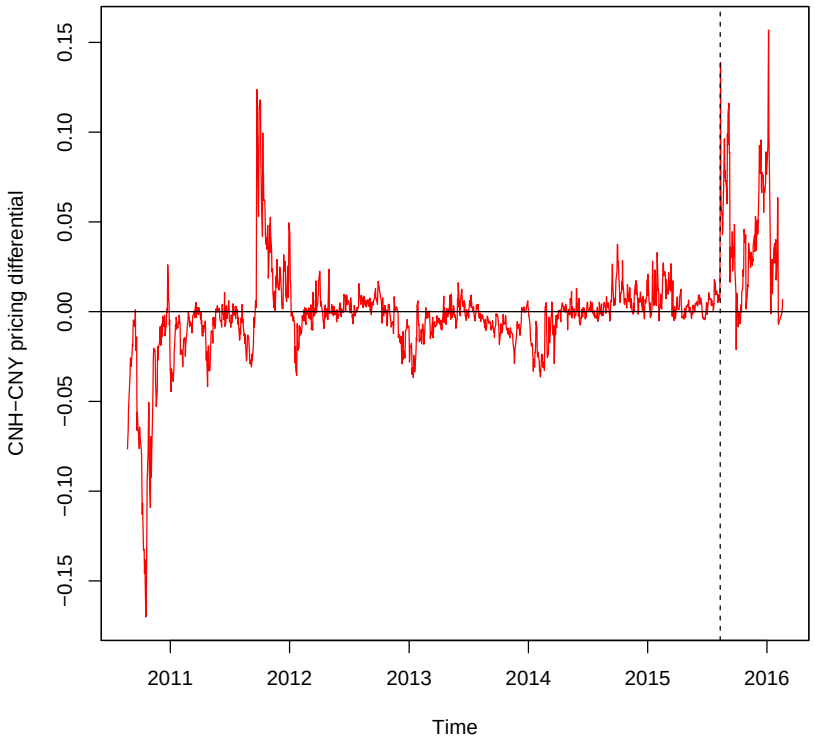


Figure 5: CNH-CNY Pricing Differential: Time Series

Introduction

Decoupling periods

Four decoupling periods accompany with extremely high CNH-CNY volatility:

- 1st: Aug 2010 to Nov 2010;
- 2nd: Sep 2011 to Oct 2011;
- 3rd: Aug 2015 to Sep 2015;
- 4th: Jan 2016 to Feb 2016.

- In the 1st decoupling period, CNH appreciates relatively to CNY. While, in the remaining three decoupling periods, CNH depreciates relatively to CNY.
- Thus, we employ the Threshold GARCH model to study the asymmetric effect of CNH-CNY pricing differential.

- The CNH-CNY pricing differential throughout the sample period is insignificantly different from zero.

Table 1: Summary statistics of CNH, CNY and CNH-CNY pricing differential

Statistic	N	Mean	St. Dev.	Min	Max	Skewness	Excess Kurtosis	JB test	ADF test
CNH	1,410	6.307	0.167	6.017	6.785	0.58	-0.48	92.52(0.00)	-1.51(0.78)
CNY	1,410	6.306	0.168	6.041	6.811	0.77	-0.09	141.68(0.00)	- 0.99(0.94)
CNH−CNY	1,410	0.001	0.028	−0.170	0.157	-0.03	8.83	4595.80(0.00)	-4.76(0.01)

Note: JB test denotes Jarque-Bera test of normality. P values are in parentheses.

In the short run (Lag = 1), CNH Granger causes CNY, but CNY doesn't Granger cause CNH. While, in the long run (Lag = 11), CNH Granger causes CNY, and CNY Granger causes CNH.

Table 2: Results of Granger Causality Tests

Order	Null Hypothesis	F-statistics	P-value
Lag = 1	CNH does not Granger-cause CNY	422.270	0.00
Lag = 1	CNY does not Granger-cause CNH	1.697	0.19
Lag = 11	CNH does not Granger-cause CNY	431.178	0.00
Lag = 11	CNY does not Granger-cause CNH	2.130	0.02

Note: JB test denotes Jarque-Bera test of normality. P values are in parentheses.

Empirical Analysis

Benchmark GARCH model: setting

Based on Engle (1982), Bollerslev (1986), and Funke et al. (2015), we construct the following GARCH (p,q) model:

$$D_t = \mu + \sum_{i=1}^{r} \phi_i D_{t-i} + a_t \quad (1)$$

$$a_t = \sigma_t \epsilon_t \quad (2)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i a_{t-i}^2 + \sum_{j=1}^{p} \beta_i \sigma_{t-j}^2 \quad (3)$$

where D_t is the CNH-CNY pricing differential and μ is the intercept. a_t is the innovation to CNH-CNY. ϵ_t is i.i.d. with mean zero and unit variance. σ_t^2 is the conditional variance of CNH-CNY.

Table 3: Benchmark GARCH Model: Full Sample

	Model (1)	Model (2)
Mean equation		
μ	-0.0001(0.64)	-0.0001(0.46)
ϕ_1	–	0.910***(0.00)
Variance equation		
α_0	$2.647e^{-06}$***(0.00)	$2.647e^{-06}$***(0.00)
α_1	0.415***(0.00)	0.149***(0.00)
β_1	0.627***(0.00)	0.831***(0.00)
Diagnostic tests		
Log Likelihood	4261.303	4927.785
Ljung-Box test(10) of a_t^2	17.311(0.07)	3.684(0.96)
Ljung-Box test(15) of a_t^2	21.750(0.11)	5.647(0.99)
LM ARCH test (1)	20.556(0.06)	5.095(0.95)
AIC	-6.039	-6.983
BIC	-6.024	-6.964

Empirical Analysis

Benchmark GARCH model: estimation results

- Volatility clustering phenomena during the decoupling periods

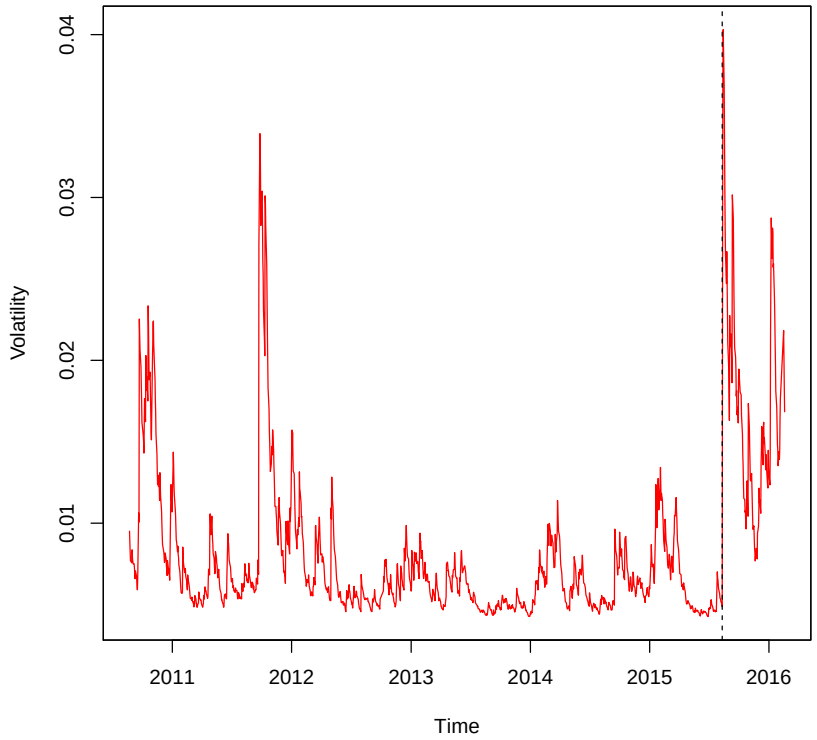


Figure 6: Benchmark GARCH Model: Volatility

Empirical Analysis

Benchmark GARCH model: volatilities of CNH and CNY

- CNH is more volatile than CNY.

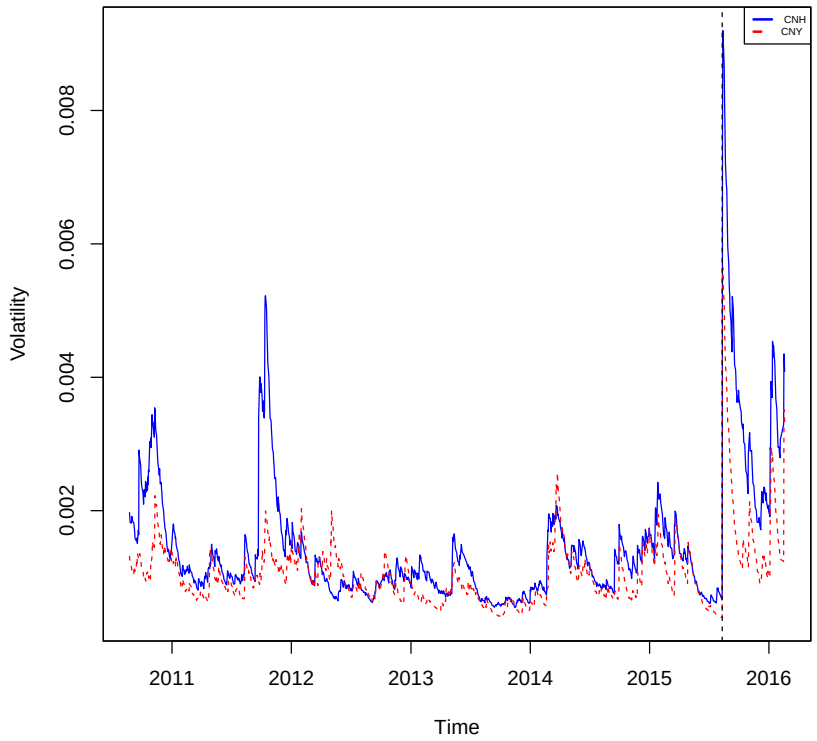


Figure 7: Volatilities of CNH and CNY

Empirical Analysis

Threshold GARCH model: setting

The Threshold GARCH model is set as

$$D_t = \mu + \sum_{i=1}^{1} \phi_i D_{t-i} + a_t \tag{4}$$

$$a_t = \sigma_t \epsilon_t \tag{5}$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{I} (\alpha_i + \gamma_i N_{t-i}) a_{t-i}^2 + \sum_{j=1}^{1} \beta_j \sigma_{t-j}^2 \tag{6}$$

where N_{t-i} is an indicator for negative a_{t-i}, that is,

$$N_{t-i} = \begin{cases} 1 & \text{if } a_{t-i} < 0, \\ 0 & \text{if } a_{t-i} \geqslant 0, \end{cases}$$

For simplicity, we assume $I = 1$. Thus, the effect of a positive shock on the volatility is α_1, but that of a negative shock is $\alpha_1 + \gamma_1$.

Empirical Analysis

Threshold GARCH model: estimation results

Leverage effect: The effect of a relative depreciation shock (an increase in CNH-CNY) is larger than that of a relative appreciation shock.

Table 4: Benchmark Threshold GARCH Model

	Model (1)
Mean equation	
μ	-0.003(0.23)
ϕ_1	0.923***(0.00)
Variance equation	
α_0	0.000002(0.10)
α_1	0.181***(0.00)
β_1	0.865***(0.00)
γ_1	-0.121***(0.00)
Diagnostic tests	
Log Likelihood	4910.382
Ljung-Box test(10) of a_t^2	2.208(0.99)
Ljung-Box test(15) of a_t^2	4.123(0.99)
LM ARCH test (1)	0.0026(0.95)
AIC	-6.957
BIC	-6.934

Policy Evaluation

Policies and market reforms

Policy dummies:

- Trading constraints: Trading band (TB) and Depletion of conversion quota ($Quota_1$ and $Quota_2$)
- Capital account liberalization: Outward RMB capital flows (OF), Shanghai Free Trade Zone (SHFTZ) and Shanghai-Hongkong stock connect scheme (SHSCS);
- Currency market reforms: RMB cross-border payment system (CPS) and exchange rate formation system reform (EX_811)

Policy Evaluation

Evidence of intervention

The Expectation-driven Self-fulfilling Exchange Rate Depreciation Spiral formed up after August 11, 2015 plus **the Sharp Proactive Devaluation** (2% in CNY central parity rate) in August 11, 2016 and January 6, 2016, jointly triggered the great fluctuations in August 2015 and January 2016, respectively.

The PBoC intervened CNH market with different strategies during the two periods:

- From **August 11, 2015** to September 2015:
  PBoC pegged CNH to (the central parity of) CNY;
- From **January 16, 2016** to early February, 2016:
  PBoC artificially "pushed up" CNH HIBOR to prevent the large scale of short sales. ("Yesterday Once More" in January 2017 with stronger intervention in CNH market.)

Policy Evaluation

Evidence of intervention

PBoC intervened the offshore market by pegging CNH to (the central parity of) CNY, as proved by an extremely high correlation between CNH and CNY since August 11, 2015.

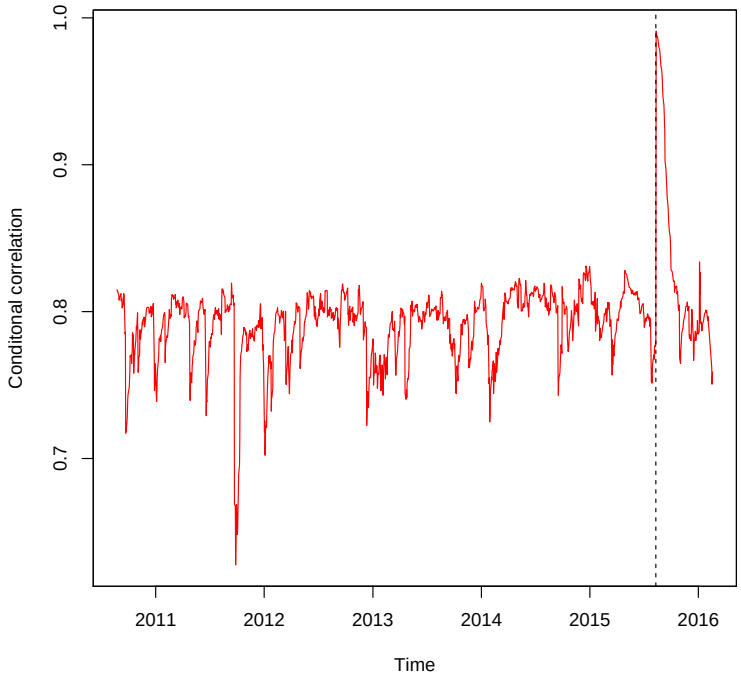


Figure 8: Time-Varying Correlation between CNH and CNY

Policy Evaluation

Evidence of intervention

PBoC artificially "pushed up" the CNH HIBOR to prevent the large scale of short sales, as proved by the surge of CNH HIBOR in January 2016.

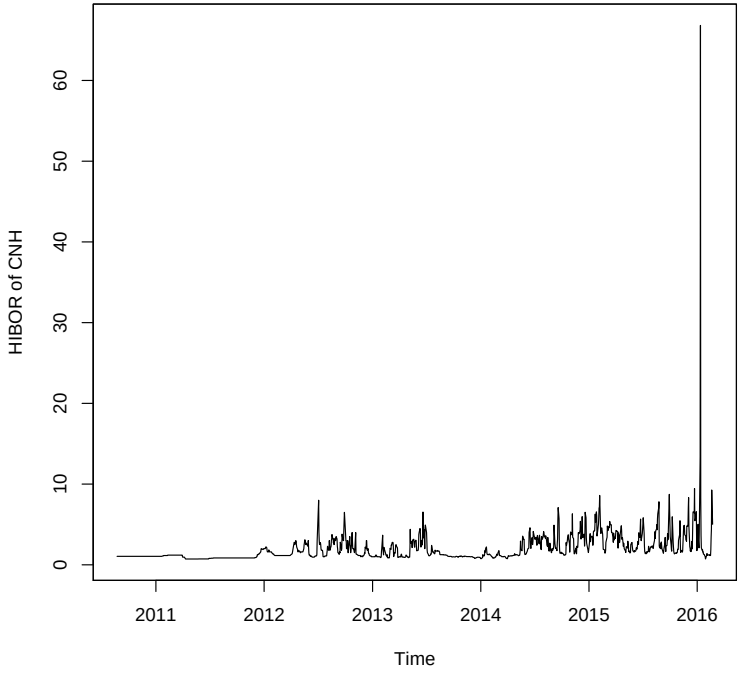


Figure 9: CNH HIBOR: Time Series

Policy Evaluation

Extended GARCH model: setting

Model setting for policy evaluation:

$$D_t = \mu + \sum_{i=1}^{r} \phi_i D_{t-i} + \varphi' x_t + a_t \tag{7}$$

$$a_t = \sigma_t \epsilon_t \tag{8}$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i a_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 + \gamma' y_t \tag{9}$$

where x_t is a $n \times 1$ vector of (weakly) exogenous explanatory variables in conditional mean equation; y_t is a $m \times 1$ vector of exogenous variables in conditional variance equation.

Table 5: Extended GARCH Models: Mean and Variance Equations with Controls

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
Mean equation							
μ	0.001(0.88)	0.001(0.87)	0.001(0.91)	0.00004(0.99)	-0.0005(0.98)	-0.090***(0.00)	-0.083***(0.00)
ϕ_1	0.930***(0.00)	0.927***(0.00)	0.931***(0.00)	0.940***(0.00)	0.934***(0.00)	0.998***(0.00)	0.998***(0.00)
Policy variables							
$Quota_1$	-0.008**(0.03)	-0.008*(0.08)	-0.008**(0.04)	-0.008**(0.02)	-0.008(0.28)	-0.010***(0.00)	-0.009**(0.02)
$Quota_2$	-0.007(0.33)	-0.007(0.31)	-0.007(0.32)	-0.006(0.42)	-0.006(0.67)	-0.006(0.48)	-0.008(0.21)
Fundamental variables							
CPR_Dist	-0.022***(0.00)	-0.022***(0.00)	-0.022***(0.00)	-0.023**(0.02)	-0.022*(0.07)	-0.026***(0.00)	-0.026***(0.00)
Contagion variables							
Interest rate (U.S.)	-0.015*(0.10)	-0.016***(0.00)	-0.016(0.16)	-0.015**(0.04)	-0.015(0.42)	0.002(0.77)	-0.003(0.79)
log(VIX)	0.0003(0.29)	0.0003(0.24)	0.0003(0.23)	0.0003(0.29)	0.0003(0.35)	0.0005*(0.08)	0.0004***(0.00)
Variance equation							
α_0	0.000000(0.99)	0.000001(0.96)	0.000001(0.94)	0.000001(0.85)	0.000002(0.95)	0.000002(0.85)	0.000002***(0.00)
α_1	0.133***(0.00)	0.134(0.36)	0.131(0.22)	0.141***(0.00)	0.121*(0.07)	0.227***(0.00)	0.164***(0.00)
β_1	0.863***(0.00)	0.863***(0.00)	0.861***(0.00)	0.844***(0.00)	0.857***(0.00)	0.752***(0.00)	0.830***(0.00)
Policy Variables							
OF	0.000001***(0.00)						
TB		0.000001***(0.00)					
FTZ			0.000002***(0.00)				
SHSCS				0.000005***(0.00)			
PS					0.000008***(0.00)		
EX_811						0.000084(0.17)	
Fundamental variables							
CPR_Dist							0.000004***(0.00)
Diagnostic tests							
Log Likelihood	4345.35	4342.363	4347.75	4366.41	4337.44	4417.45	4362.95
Ljung-Box test(10) of a_t^2	6.671(0.76)	6.146(0.80)	7.199(0.71)	11.676(0.31)	4.999(0.89)	31.440(0.00)	6.603(0.76)
Ljung-Box test(15) of a_t^2	8.252(0.91)	7.795(0.93)	8.499(0.90)	13.112(0.59)	7.096(0.95)	38.276(0.00)	8.462(0.90)
LM ARCH test (1)	0.030 (0.86)	0.024(0.88)	0.037(0.85)	0.074(0.79)	0.019(0.89)	0.004(0.95)	0.006(0.94)
AIC	-6.968	-6.964	-6.972	-7.002	-6.956	-7.084	-6.997
BIC	-6.923	-6.918	-6.927	-6.957	-6.910	-7.039	-6.951

Policy Evaluation

A closer look at the reform: setting

What is the intervention effect of "August 11" Exchange Rate Reform on the level of CNH-CNY pricing differential? We explore this question based on the following econometric approach:

$$D_t = \theta_0 + \frac{\omega_1}{1-\delta_1 L} P_t^T + \omega_2 S_t^T + \frac{1-\theta_1 L}{1-\psi_1 L} a_t \tag{10}$$

where the pulse input,

$$P_t^T = \begin{cases} 1 & t = T \\ 0 & t \neq T \end{cases} \tag{11}$$

and the step input,

$$S_t^T = \begin{cases} 1 & t \geqslant T \\ 0 & t \neq T \end{cases} \tag{12}$$

Policy Evaluation

A closer look at the reform: estimation results

Table 6: Intervention Effect of "August 11" Reform

Parameters	ARMA(1,1)	ARMA(1,1)+ Pulse	ARMA(1,1)+ Step	ARMA(1,1) + General
Intercept	0.0003	0.001	-0.005	-0.009
	(0.005)	(0.005)	(0.004)	(0.005)
ψ_1	0.949***	0.949***	0.940***	0.951***
	(0.009)	(0.009)	(0.010)	(0.011)
θ_1	-0.054***	-0.052**	-0.083***	-0.056**
	(0.030)	(0.031)	(0.030)	(0.029)
ω_1		-0.004		-0.044***
		(0.007)		(0.007)
δ_1				-0.528***
				(0.071)
ω_2			0.058***	0.088***
			(0.008)	(0.011)
Log-likelihood	4571	4571	4599	4634
AIC	-9137	-9135	-9190	-9256

Policy Evaluation

A closer look at the reform: effect visualization

The intervention effect of "August 11" reform on CNH-CNY:

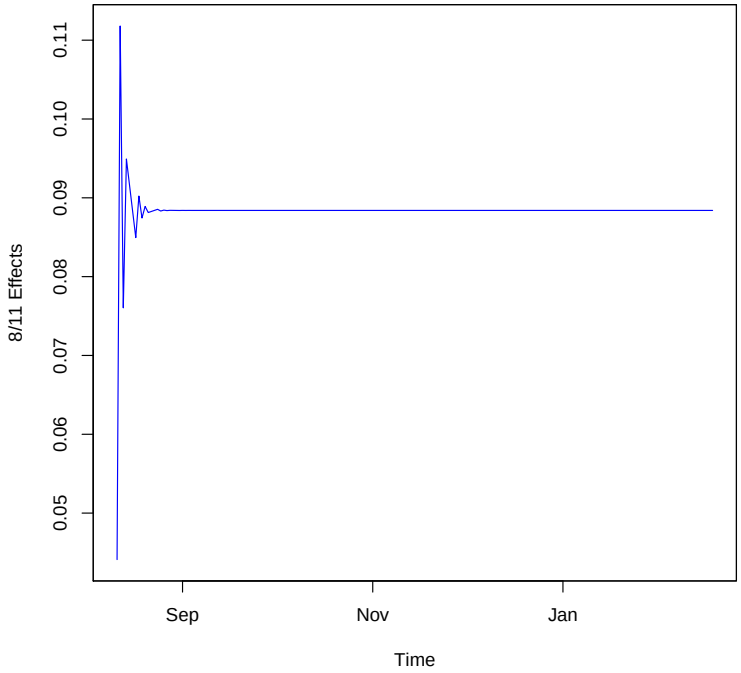


Figure 10: The Effect of "August 11" Reform

Policy Evaluation

Currency basket of CNY central parity pricing

Of course, the formation rule of CNY central parity rate has changed since the reform. To characterize the change, we estimate de-facto weight of major currencies in currency basket following Frankel and Wei, 2007 & 2008, Frankel and Xie, 2010.

- Use OLS regression to select the major currencies in the currency basket;
- Estimate the currency weights using general (or simple) rule for the time-varying (or fixed) currency weights to extract the signal. See the state space model below:

$$\Delta e_{rmb/cur,t} = \omega_0 + \sum_{i=1}^{6} \omega_{i,t} \Delta e_{i/cur,t} + \varepsilon_t \quad (13)$$

$$\omega_{i,t} = \omega_{i,t-1} + v_{i,t}, i = 0, 1, 2, ..., 6 \quad (14)$$

- Forecast the central parity based on existing information.

Step 1: Select the major currencies

Table 7: *De Facto* Currency Basket Weights: OLS

	Model (1)	Model (2)	Model (3)	Model (4)
US dollar	0.938***	0.874***	0.874***	0.834***
	(0.00)	(0.00)	(0.00)	(0.00)
Euro		0.051***	0.042***	0.027***
		(0.00)	(0.00)	(0.00)
Japanese yen		0.032***	0.031***	0.028***
		(0.00)	(0.00)	(0.00)
British pound		0.017*	0.015	0.004
		(0.02)	(0.06)	(0.56)
Canadian dollar			0.005	-0.009
			(0.45)	(0.20)
New Zealand dollar			0.015*	0.003
			(0.02)	(0.68)
Swiss franc			-0.002	-0.0005
			(0.048)	(0.87)
Singapore dollar				0.091***
				(0.00)
Malaysia ringgit				0.024***
				(0.00)
Russia ruble				0.006**
				(0.02)
Thailand baht				-0.004
				(0.64)
Constant	$-3.968e^{-05}$	$-4.547e^{-05}$	$-4.470e^{-05}$	$-4.381e^{-05}$
	(0.18)	(0.11)	(0.11)	(0.45)
Adj. R^2	0.975	0.977	0.977	0.981

Policy Evaluation

Formation rule of CNY central parity rate: simple rule

Step 2: Estimate the currency weights

- Data: from November 30, 2015 to July, 2016
- Simple rule: lagged CNY closing rate and basket index proxied by CFETS RMB index

$$e_{cpr/usd,t} = \omega_0 + \omega_1 e_{cny/usd,t-1} + \omega_2 e_{CFETS,t-1} + \varepsilon_t \quad (15)$$

$$\omega_{i,t} = \omega_{i,t-1} + v_{i,t}, i = 0, 1, 2 \quad (16)$$

Policy Evaluation

Formation rule of CNY central parity rate: simple rule

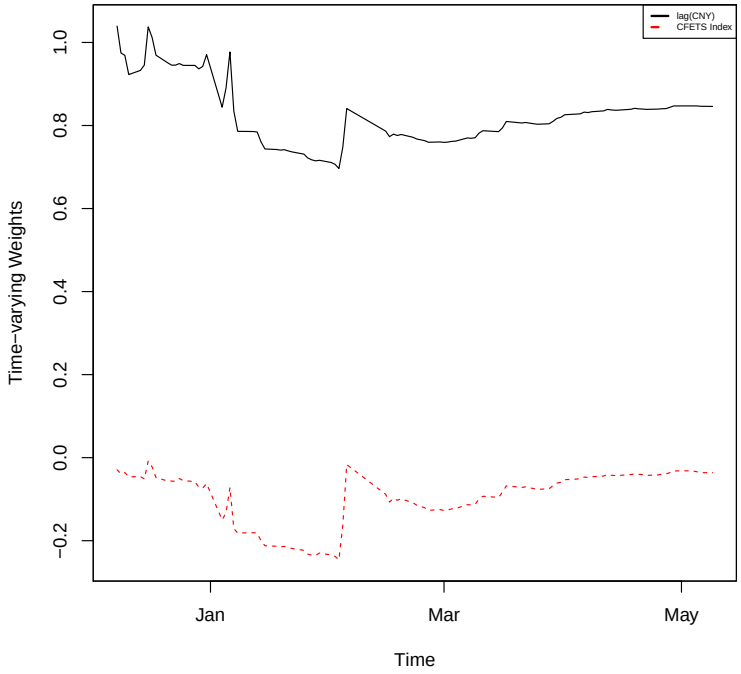


Figure 11: Time-varying weights of central parity rate formation rule: simple rule

Policy Evaluation

Formation rule of CNY central parity rate: general rule

- General rule: lagged CNY closing rate and major currencies in the CFETS currency basket with time-varying weights.
- Econometric setting:

$$e_{cpr/cur,t} = \omega_{0,t} + \sum_{i=1}^{6} \omega_{i,t} e_{i/cur,t} + \omega_{7,t} e_{cny/cur,t-1} + \varepsilon_t \quad (17)$$

$$\omega_{i,t} = \omega_{i,t-1} + v_{i,t}, i = 0, 1, 2, ..., 7 \quad (18)$$

Policy Evaluation

Formation rule of CNY central parity rate: general rule

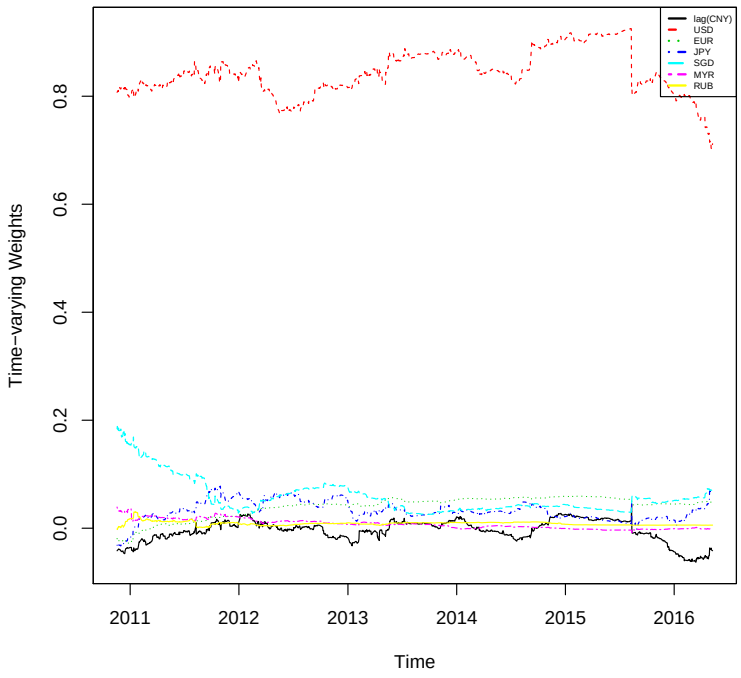


Figure 12: Time-Varying Weights in the General Rule of CNY Central Parity Rate

Policy Evaluation

Formation rule of CNY central parity rate: general rule

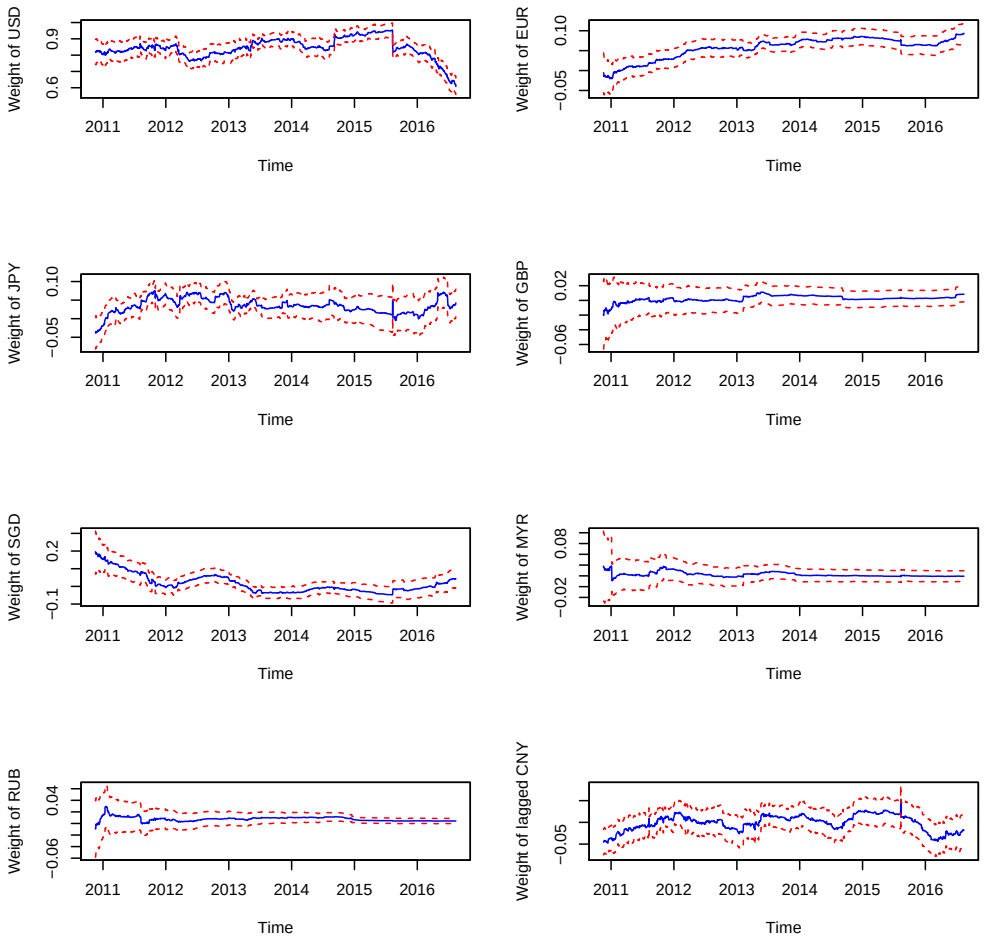


Figure 13: Time-Varying Weights in the General Rule of CNY Central Parity Rate

Conclusions

- The intervention-free RMB market (originally, CNH market) is disappearing;
- The CNH-CNY pricing differential is characterized by several stylized facts: volatility clusting and leverage effect.
- The linkage between two RMB markets are tightening along the way of RMB internationalization, however, weakening since the "August 11" Exchange Rate Reform, especially in the long-run;
- The formation system of CNY central parity rate has been fundamentally altered, with a decline of USD weight in its currency basket.