The Two-Pillar Policy for the RMB

Urban Jermann [1] Bin Wei [2] Vivian Yue [3]

[1] University of Pennsylvania and NBER

[2] Federal Reserve Bank of Atlanta

[3] Emory University, Atlanta Fed and NBER

May 18, 2017

Second IMF-Atlanta Fed Workshop on China's Economy

Introduction

- Chinese currency (RMB) plays an increasingly important role in global economy
- Several recent currency reforms have made the RMB more market-determined
- However, the current exchange rate policy is still not very transparent

This Paper on Current Exchange Rate Policy

- First, we document empirical facts about the current two-pillar policy
- Second, we build a tractable model for the RMB under the current policy
- Third, using options on the RMB and dollar index, we estimate the model to assess financial markets' views
  - "fundamental exchange rate" is estimated to be about 3% higher than spot rate
  - an average probability of 79% to the policy still being in place three months later
  - the model can forecast the RMB & shed light on implementation of the policy

Related Literature

- Literature on exchange rate target-zones
  - Krugman (1991), Bertola and Caballero (1992), Bertola and Svensson (1993), Campa and Chang (1996), Malz (1996), Söerlind (2000), Hui and Lo (2009)
  - this paper is most closely related to Jermann (2015) who propose a no-arbitrage model to study the Swiss franc floor from an options perspective
- Recent studies on the RMB
  - Frankel and Wei (2007), Cheung et al (2016), etc.
- Recent studies on China's optimal monetary policy & capital control
  - Song, Storesletten, Zilibotti (2014), Chang, Liu, and Spiegel (2015), Chen, Higgins, Waggoner, and Zha (2016)

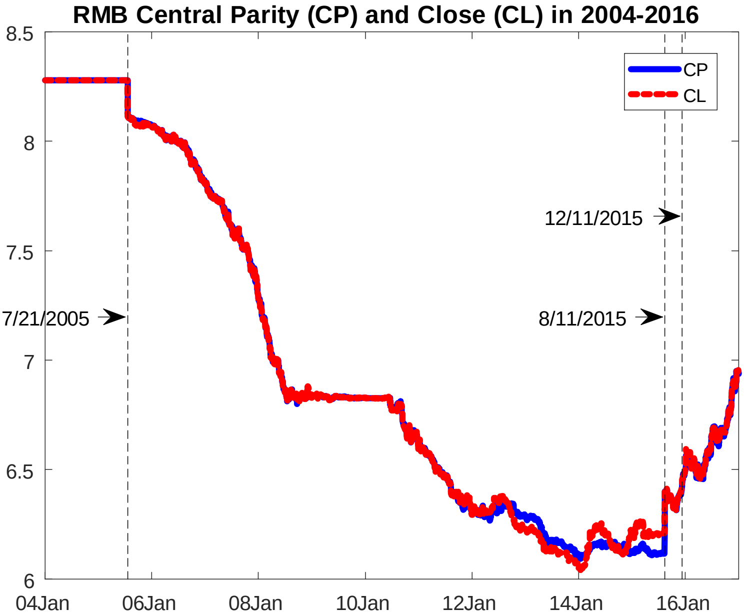
RMB Reforms

- July 21, 2005 — China moved from "dollar peg" to "a managed floating exchange rate regime based on market supply and demand with reference to a basket of currencies" (People's Bank of China Decree No. 16 [2005])
  - the policy was opaque
- August 11, 2015 — The PBC reformed the exchange rate policy to be more market-oriented
  - a requirement for the RMB's inclusion into the IMF's SDR
- December 11, 2015 — The PBC introduced RMB indices & the "two-pillar" policy
  - to mitigate depreciation expectations
    Current/Financial Account
  - we focus on 12/11/2015-12/31/2016 in the paper

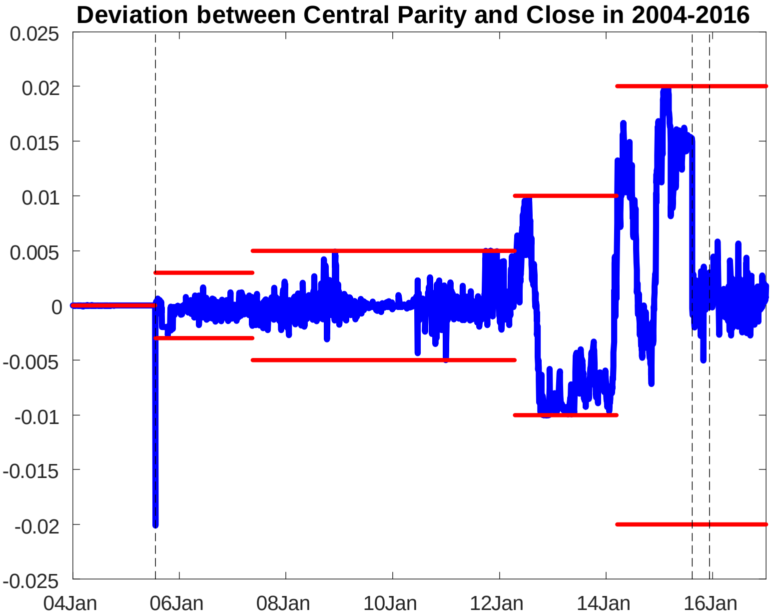
Current Managed Floating System

- The PBC announces the official central parity of the RMB to foreign currency exchange rates
- The trading price of the dollar against the RMB is allowed to float within a pre-specified band around the central parity

CNY/USD Exchange Rates



Widening Bands Around the Central Parity



What is the Two-Pillar Policy?

On August 11, 2015, it was stressed that quotes of the central parity of the RMB to the USD should refer to the closing rates of the previous business day to reflect changes in market demand and supply conditions.

On December 11, 2016, the CFETS released the RMB exchange-rate index, with an emphasis on enhancing the reference to the currency basket, in a bid to better maintain the overall stability of the RMB exchange rate vis-à-vis the currencies in the basket. Based on this principle, a formation mechanism for the RMB to the USD central parity rate of "the previous closing rate plus changes in the currency basket" has been preliminarily in place.

The "previous closing rate" ... reflects the market demand and supply situation. The "changes in the currency basket" ... maintain the overall stability of the RMB to the currency basket.

Source: "China Monetary Policy Report" (2016Q1)

The Two-Pillar Policy

- The Two-Pillar Policy: "the previous closing rate plus changes in the currency basket"

$$S^{CP}_{t+1} = \Big[\underbrace{\overline{S}_{t+1}}_{\text{pillar I}}\Big]^{w} \times \Big[\underbrace{\overline{S}^{CL}_{t}}_{\text{pillar II}}\Big]^{1-w}$$

  - First pillar: $\overline{S}_{t+1}$ to achieve basket "stability"
  - Second pillar: S^{CL}_{t} to achieve "flexibility" (market demand/supply conditions)

- Empirical analysis:
  - define $\overline{S}_{t+1}$
    - RMB indices & reconstruction
    - RMB-index-implied USD basket ≈ dollar index (DXY)
  - empirical evidence for $w \approx 1/2$ since 12/11/2015

The Two-Pillar Policy

- The Two-Pillar Policy: "the previous closing rate plus changes in the currency basket"

$$S_{t+1}^{CP} = \Big[\underbrace{\overline{S}_{t+1}}_{\text{pillar I}}\Big]^{w} \times \Big[\underbrace{\overline{S}_{t}^{CL}}_{\text{pillar II}}\Big]^{1-w}$$

  - First pillar: $\overline{S}_{t+1}$ to achieve basket "stability"
  - Second pillar: S_t^{CL} to achieve "flexibility" (market demand/supply conditions)

- Empirical analysis:
  - define $\overline{S}_{t+1}$
    - RMB indices & reconstruction
    - RMB-index-implied USD basket ≈ dollar index (DXY)
  - empirical evidence for $w \approx 1/2$ since 12/11/2015

RMB Indices

- The PBC introduced three RMB indices on 12/11/2015
  - trade-weighted indices: CFETS, BIS, SDR
  - index levels at 12/31/2014 are set to 100.
- Consider a RMB index

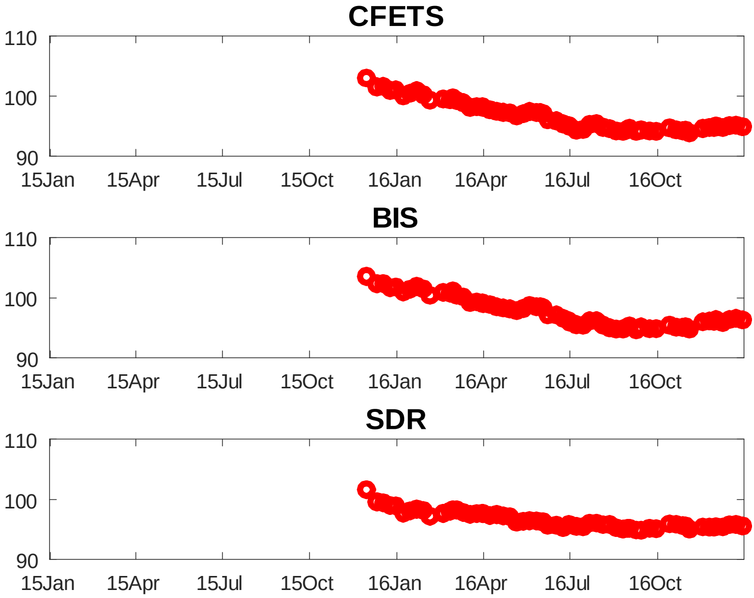
$$B_t = C_B \left(S_t^{CP,USD/CNY} \right)^{w_{USD}} \left(S_t^{CP,EUR/CNY} \right)^{w_{EUR}} \cdots$$

  - $S_t^{CP,USD/CNY}$, $S_t^{CP,EUR/CNY}$, $\cdots$ are central parity rates
- The index is in units of foreign currencies per CNY
  - it represents the value of the CNY. If the index declines, the CNY declines in value.

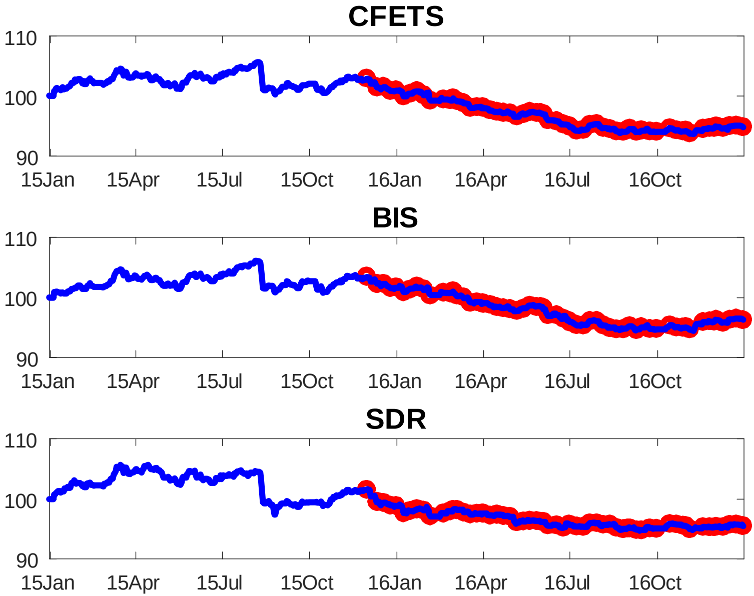
Weights in RMB Indices (as of December 2016)

Currency in CFETS basket	weight	Currency in BIS basket	weight	Currency in SDR basket	weight
USD	0.224	EUR	0.187	USD	0.4685
EUR	0.1634	USD	0.178	EUR	0.3472
JPY	0.1153	JPY	0.141	JPY	0.0935
KRW	0.1077	KRW	0.085	GBP	0.0908
AUD	0.044	TWD	0.056		
HKD	0.0428	GBP	0.029		
MYR	0.0375	SGD	0.027		
SGD	0.0321	MXN	0.023		
GBP	0.0316	MYR	0.022		
THB	0.0291	INR	0.022		
RUB	0.0263	CAD	0.021		
CAD	0.0215	THB	0.021		
SAR	0.0199	RUB	0.018		
AED	0.0187	AUD	0.015		
ZAR	0.0178	CHF	0.014		
CHF	0.0171	BRL	0.014		
MXN	0.0169	IDR	0.013		
TRY	0.0083	SAR	0.01		
Others	0.026		0.104		

Official RMB Indices



Official and Reconstructed RMB Indices



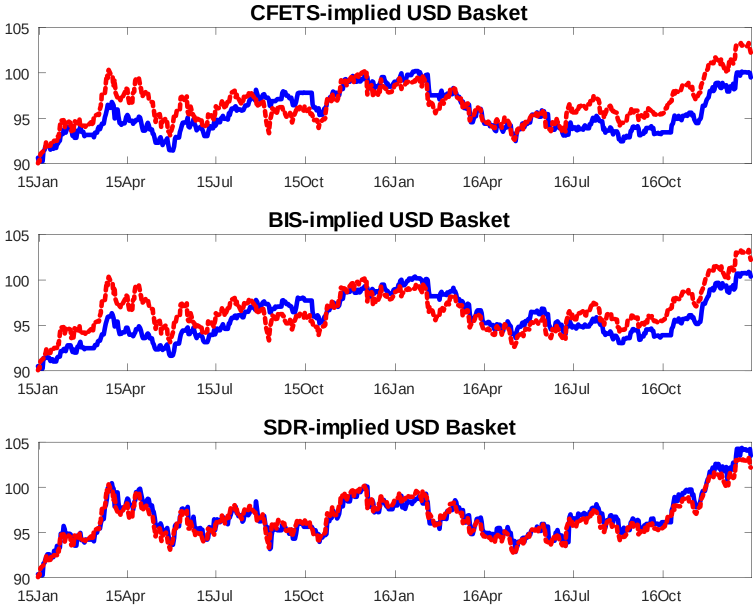
RMB-index-implied USD Basket

- RMB index implies a USD basket of non-RMB currencies:

$$
\begin{aligned}
B_t &= C_B \left(S_t^{CP,USD/CNY}\right)^{w_{USD}} \left(S_t^{CP,EUR/CNY}\right)^{w_{EUR}} \cdots \\
&= S_t^{CP,USD/CNY} \left[\underbrace{C_B \left(\frac{S_t^{CP,EUR/CNY}}{S_t^{CP,USD/CNY}} \right)^{\frac{w_{EUR}}{1-w_{USD}}} \cdots}_{\text{USD basket}} \right]^{1-w_{USD}} \\
&= \chi \frac{1}{S_t^{CP}} \left(X_t\right)^{1-w_{USD}}
\end{aligned}
$$

  - X_t is RMB-index-implied USD basket
  - $S_t^{CP} \equiv S_t^{CP,CNY/USD}$ is CNY/USD central parity rate
  - χ is scaling constant
- X_t is highly correlated with the USD index (DXY)

RMB-index-implied USD Basket and US Dollar Index



The Two-Pillar Policy

- Under the two-pillar policy, $\overline{S}_{t+1}$ is the rate that achieves "stability" of the baseket:

$$
\begin{aligned}
& B_t = \chi \frac{X_t^{1-w_{USD}}}{S_t^{CP}} = \chi \frac{X_{t+1}^{1-w_{USD}}}{\overline{S}_{t+1}} \\
\Longrightarrow \quad & \overline{S}_{t+1} = S_t^{CP} \left(\frac{X_{t+1}}{X_t} \right)^{1-w_{USD}}
\end{aligned}
$$

- Therefore, the central parity under the two-pillar policy is a weighted average of the basket target and last day's close

$$
S_{t+1}^{CP} = \left(\overline{S}_{t+1}\right)^{w} \left(S_t^{CL}\right)^{1-w}
$$

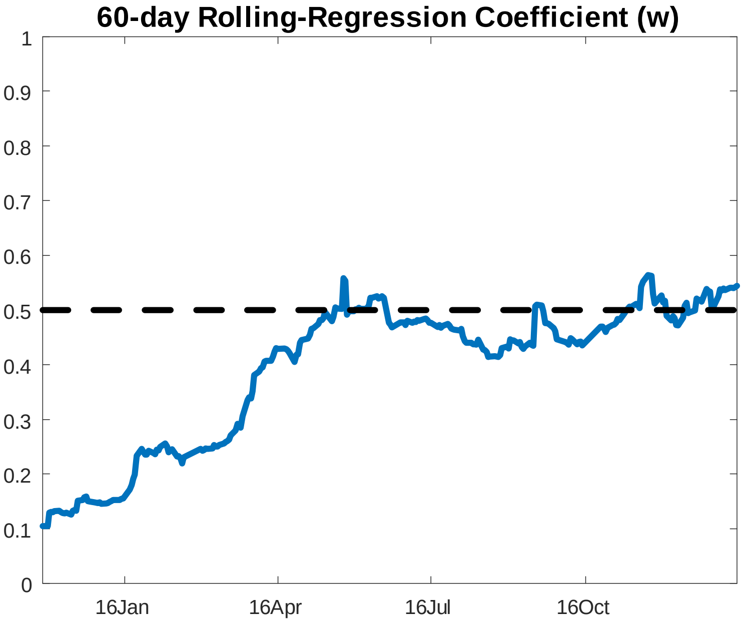
  - First pillar: $\overline{S}_{t+1}$ achieves basket "stability"
  - Second pillar: S_t^{CL} incorporates market conditions

The Two-Pillar Policy: Empirical Evidence

Regression between 12/11/2015-12/31/2016

$\log\left(\frac{S^{CP}_{t+1}}{S^{CP}_{t}}\right) =$	$\underbrace{\alpha}_{w}$	$\ln\left(\frac{\overline{S}_{t+1}}{S^{CP}_{t}}\right) +$	$\underbrace{\beta}_{1-w}$	$\ln\left(\frac{S^{CL}_{t}}{S^{CP}_{t}}\right);$	R^2
CFETS	0.52		0.45		0.81
BIS	0.48		0.48		0.75
SDR	0.48		0.46		0.78

More Empirical Evidence (CFETS)



A Model for the RMB

A Model for the RMB

- Under the model, with probability p, the two-pillar policy regime continues tomorrow

$$
\begin{aligned}
S^{CL}_{t+1} &= H(\widetilde{S}_{t+1}, S^{CP}_{t+1}, b) \\
&\equiv \max\left[\min\left[\widetilde{S}_{t+1}, S^{CP}_{t+1}(1+b)\right], S^{CP}_{t+1}(1-b)\right]
\end{aligned}
$$

  - $\widetilde{S}_t$: "equilibrium exchange rate" with the policy in place
  - b: band's width around the central parity

- With probability $1-p$, the policy ends tomorrow:

$$S^{CL}_{t+1} = V_{t+1}$$

  - V_t: "fundamental exchange rate" without the policy

$$V_t = \frac{1+r^{\$}}{1+r^{C}} E^{Q}_{t}\left[V_{t+1}\right]$$

A Model for the RMB

- Under the model, with probability p, the two-pillar policy regime continues tomorrow

$$\begin{aligned} S_{t+1}^{CL} &= H(\widetilde{S}_{t+1}, S_{t+1}^{CP}, b) \\ &\equiv \max\left[\min\left[\widetilde{S}_{t+1}, S_{t+1}^{CP}(1+b)\right], S_{t+1}^{CP}(1-b)\right] \end{aligned}$$

  - $\widetilde{S}_t$: "equilibrium exchange rate" with the policy in place
  - b: band's width around the central parity

- With probability $1-p$, the policy ends tomorrow:

$$S_{t+1}^{CL} = V_{t+1}$$

  - V_t: "fundamental exchange rate" without the policy

$$V_t = \frac{1+r^{\$}}{1+r^{C}} E_t^{Q}[V_{t+1}]$$

A Model for the RMB (Cont'd)

- By no arbitrage, the equilibrium exchange rate satisfies

$$\begin{aligned} \widetilde{S}_t &= \frac{1+r^{\$}}{1+r^C} E_t^Q \left[p \cdot H(\widetilde{S}_{t+1}, S_{t+1}^{CP}, b) + (1-p) \cdot V_{t+1} \right] \\ &= \frac{1+r^{\$}}{1+r^C} p E_t^Q H(\widetilde{S}_{t+1}, S_{t+1}^{CP}, b) + (1-p) V_t \end{aligned}$$

  - intuitively, it is the expected value of the RMB in two regimes, appropriately adjusted for the yields
- The current observed spot rate is

$$S_t^{CL} = H(\widetilde{S}_t, S_t^{CP}, b)$$

- By rescaling, $\widetilde{S}\left(S_t^{CP}, V_t\right) \equiv S_t^{CP} \widehat{S}(\widehat{V}_t)$ where $\widehat{V}_t \equiv \frac{V_t}{S_t^{CP}}$

$$\widehat{S}(\widehat{V}_t) = \frac{1+r^{\$}}{1+r^C} p E_t^Q \left[\frac{S_{t+1}^{CP}}{S_t^{CP}} H\left(\widehat{S}\left(\widehat{V}_{t+1}\right), 1; b\right) \right] + (1-p) \widehat{V}_t$$

A Model for the RMB (Cont'd)

- By no arbitrage, the equilibrium exchange rate satisfies

$$\begin{aligned}\widetilde{S}_t &= \frac{1+r^{\$}}{1+r^{C}} E_t^{Q}\left[p \cdot H(\widetilde{S}_{t+1}, S_{t+1}^{CP}, b) + (1-p)\cdot V_{t+1}\right] \\ &= \frac{1+r^{\$}}{1+r^{C}} p E_t^{Q} H(\widetilde{S}_{t+1}, S_{t+1}^{CP}, b) + (1-p) V_t\end{aligned}$$

  - intuitively, it is the expected value of the RMB in two regimes, appropriately adjusted for the yields
- The current observed spot rate is

$$S_t^{CL} = H(\widetilde{S}_t, S_t^{CP}, b)$$

- By rescaling, $\widetilde{S}\left(S_t^{CP}, V_t\right) \equiv S_t^{CP}\widehat{S}(\widehat{V}_t)$ where $\widehat{V}_t \equiv \frac{V_t}{S_t^{CP}}$

$$\widehat{S}(\widehat{V}_t) = \frac{1+r^{\$}}{1+r^{C}} p E_t^{Q}\left[\frac{S_{t+1}^{CP}}{S_t^{CP}} H\left(\widehat{S}\left(\widehat{V}_{t+1}\right), 1; b\right)\right] + (1-p)\widehat{V}_t$$

A Model for the RMB (Cont'd)

- By no arbitrage, the equilibrium exchange rate satisfies

$$\begin{aligned}\widetilde{S}_t &= \frac{1+r^{\$}}{1+r^{C}} E_t^{Q}\left[p \cdot H(\widetilde{S}_{t+1}, S_{t+1}^{CP}, b) + (1-p)\cdot V_{t+1}\right] \\ &= \frac{1+r^{\$}}{1+r^{C}} p E_t^{Q} H(\widetilde{S}_{t+1}, S_{t+1}^{CP}, b) + (1-p) V_t\end{aligned}$$

  - intuitively, it is the expected value of the RMB in two regimes, appropriately adjusted for the yields

- The current observed spot rate is

$$S_t^{CL} = H(\widetilde{S}_t, S_t^{CP}, b)$$

- By rescaling, $\widetilde{S}\left(S_t^{CP}, V_t\right) \equiv S_t^{CP} \widehat{S}(\widehat{V}_t)$ where $\widehat{V}_t \equiv \frac{V_t}{S_t^{CP}}$

$$\widehat{S}(\widehat{V}_t) = \frac{1+r^{\$}}{1+r^{C}} p E_t^{Q}\left[\frac{S_{t+1}^{CP}}{S_t^{CP}} H\left(\widehat{S}\left(\widehat{V}_{t+1}\right), 1; b\right)\right] + (1-p)\widehat{V}_t$$

Modeling the Two-Pillar Policy

- Consider the two-pillar policy that balances between "stability" and "flexibility"

$$
\begin{aligned}
S_{t+1}^{CP} &= \underbrace{\left[S_t^{CP} \left(\frac{X_{t+1}}{X_t} \right)^{(1-w_{USD})} \right]^{w}}_{\text{pillar I: basket stability}} \underbrace{\left[S_t^{CP} \left(\frac{V_{t+1}}{V_t} \right)^{\gamma} \right]^{1-w}}_{\text{pillar II: market condition}} \\
&\equiv S_t^{CP} \left(\frac{X_{t+1}}{X_t} \right)^{\alpha} \left(\frac{V_{t+1}}{V_t} \right)^{\beta}
\end{aligned}
$$

- Under the policy

$$
\widehat{S}(\widehat{V}_t) = \frac{1+r^{\$}}{1+r^{C}} p E^{Q} \left[\left(\frac{X_{t+1}}{X_t} \right)^{\alpha} \left(\frac{V_{t+1}}{V_t} \right)^{\beta} H(\widehat{S}(\widehat{V}_{t+1})) \right] + (1-p) \widehat{V}_t
$$

$$
\frac{\widehat{V}_{t+1}}{\widehat{V}_t} = \left(\frac{X_{t+1}}{X_t} \right)^{-\alpha} \left(\frac{V_{t+1}}{V_t} \right)^{1-\beta}
$$

Model Solution in Continuous Time

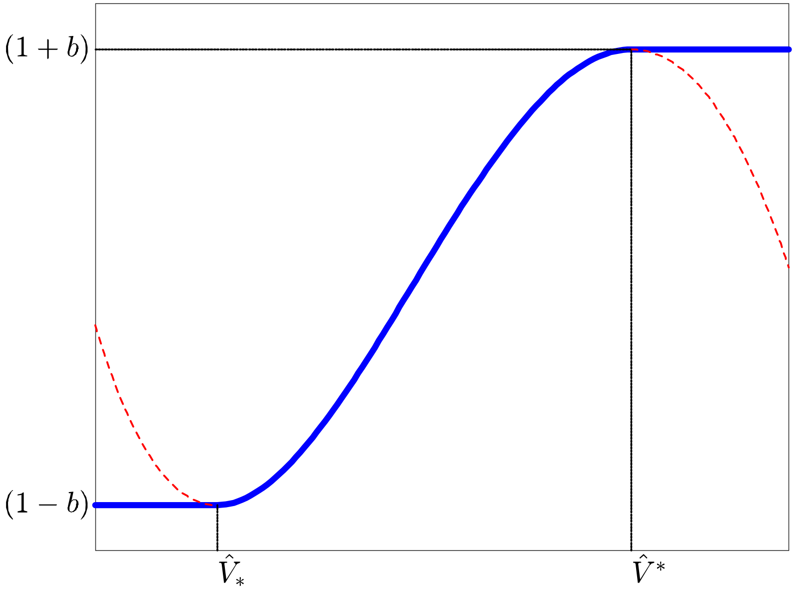
- The model is particularly tractable in continuous time where under the CNY risk-neutral measure Q

$$\begin{aligned}
\frac{dV_t}{V_t} &= (r_{CNY} - r_{USD})\,dt + \boldsymbol{\sigma}_V\, dW_{V,t} \\
\frac{dX_t}{X_t} &= (r_{DXY} - r_{USD} - \rho\boldsymbol{\sigma}_X\boldsymbol{\sigma}_V + \boldsymbol{\sigma}_X^2)\,dt \\
&\quad + \boldsymbol{\sigma}_X\left(\rho\, dW_{V,t} + \sqrt{1-\rho^2}\, dW_{X,t}\right)
\end{aligned}$$

- The equilibrium exchange rate is derived in closed form:

$$\widehat{S}(\widehat{V}_t) = \begin{cases} 1-b, & \text{if } \widehat{V} \le \widehat{V}_*; \\ C_0\widehat{V} + C_1\widehat{V}^{\eta_1} + C_2\widehat{V}^{\eta_2}, & \text{if } \widehat{V}_* < \widehat{V} < \widehat{V}^*; \\ 1+b, & \text{if } \widehat{V} \ge \widehat{V}^*, \end{cases}$$

Equilibrium Exchange Rate under the Model



Model-Implied CNY Option Prices

- Under this model, prices of call or put option with maturity τ and strike K is given by

$$
\begin{aligned}
C(K;\tau) &= e^{-r_{CNY}\tau} E_t^Q \left[\begin{array}{c} p^\tau \max\left(H\left(\widetilde{S}_{t+\tau}, S_{t+\tau}^{CP}; b\right) - K, 0\right) \\ +(1-p^\tau)\max\left(V_{t+\tau} - K, 0\right) \end{array} \right] \\
P(K;\tau) &= e^{-r_{CNY}\tau} E_t^Q \left[\begin{array}{c} p^\tau \max\left(K - H\left(\widetilde{S}_{t+\tau}, S_{t+\tau}^{CP}; b\right), 0\right) \\ +(1-p^\tau)\max\left(K - V_{t+\tau}, 0\right) \end{array} \right]
\end{aligned}
$$

  - option prices help identify (V, p, σ_V) ▸ b=0

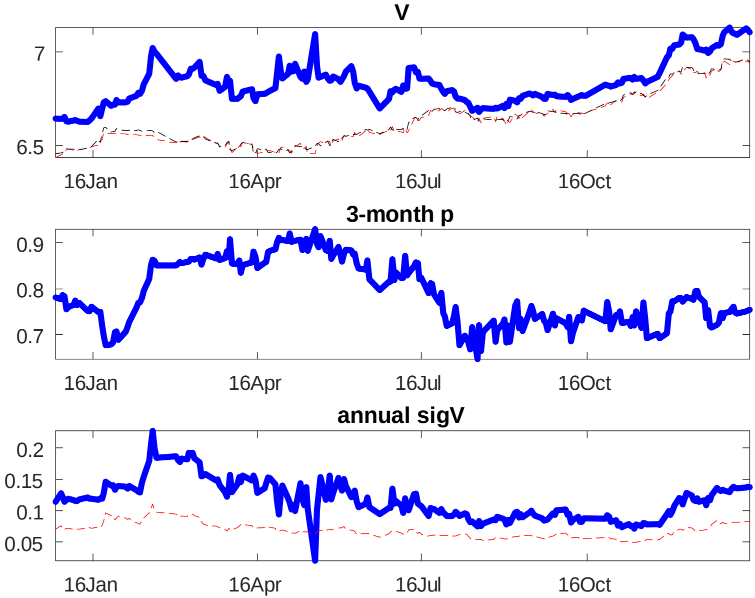
Model Estimation

- We estimate the model to fit spot and option prices in the data to estimate $(\mathrm{V}, \mathrm{p}, \sigma_{\mathrm{V}})$ for each date between 12/11/2015-12/31/2016
  - σ_{X} is estimated from dollar index options & futures
  - for simplicity, we set $\rho = 0$ in the estimation below
  - we use the effective band width: $\mathrm{b} = 0.5\%$
- We also estimate the weight "w" in extended estimation exercise

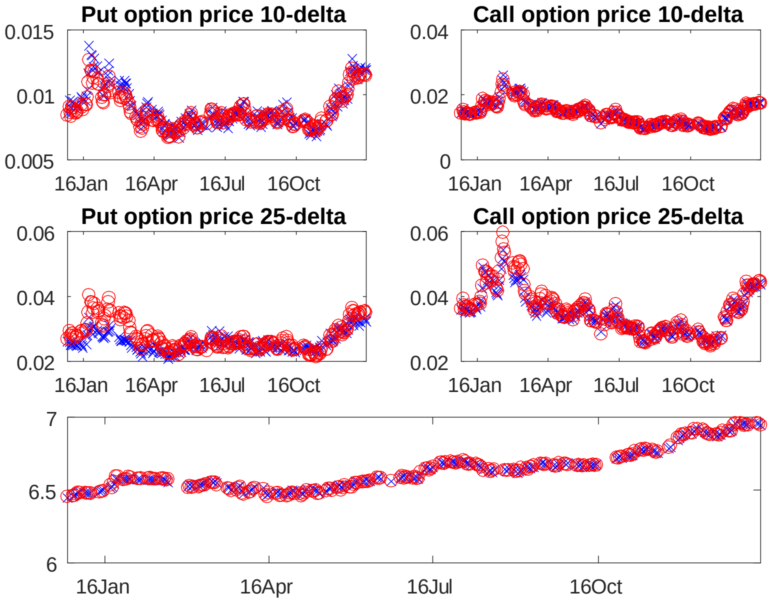
Data

- RMB central parity data & index data are obtained from CFETS
- Spot exchange rate data are obtained from Bloomberg as are the other data
- Interest rate data (SHIBOR, Libor rates, etc.)
- DXY index levels & options & futures
- CNY 3-month options & futures data

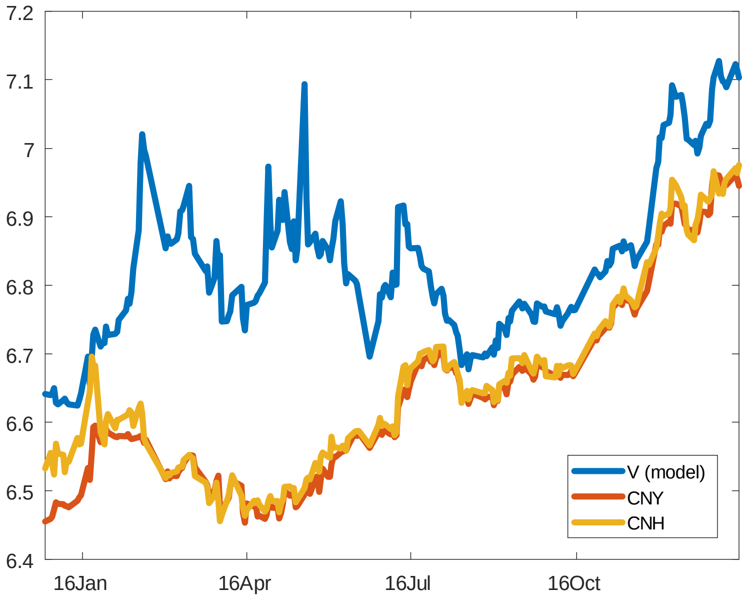
Estimation Results



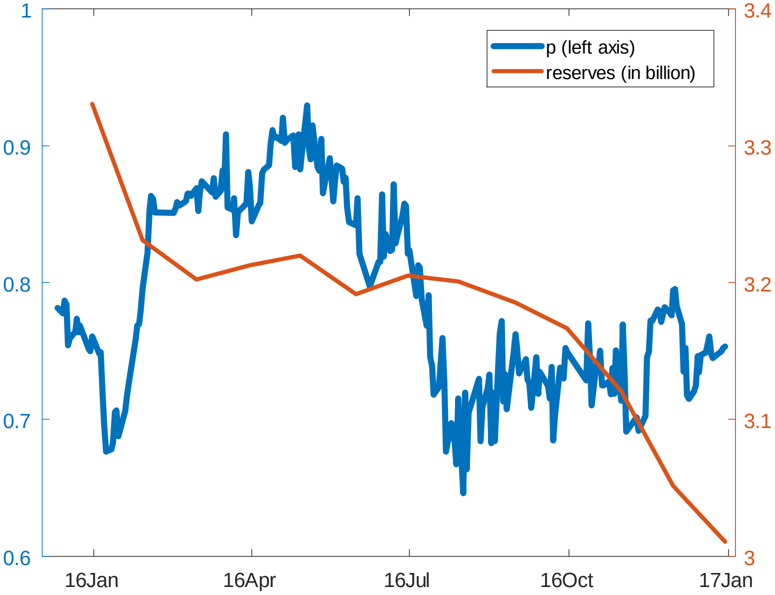
Model Fit


Put option price 10-delta
0.015
0.01
0.005
16Jan 16Apr 16Jul 16Oct
Call option price 10-delta
0.04
0.02
0
16Jan 16Apr 16Jul 16Oct
Put option price 25-delta
0.06
0.04
0.02
16Jan 16Apr 16Jul 16Oct
Call option price 25-delta
0.06
0.04
0.02
16Jan 16Apr 16Jul 16Oct
7
6.5
6
16Jan
16Apr
16Jul
16Oct

Model Implication: V vs. CNY and CNH



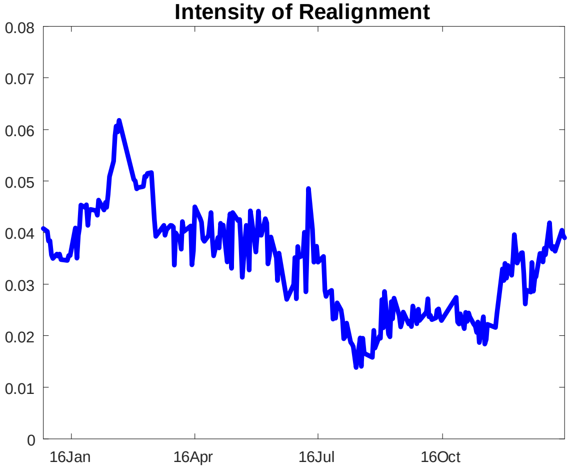
Model Implication: p vs. Foreign Reserves



Model Implication: Intensity of Realignment

- Combining estimates of V and p, we can construct model-implied "realignment intensity"

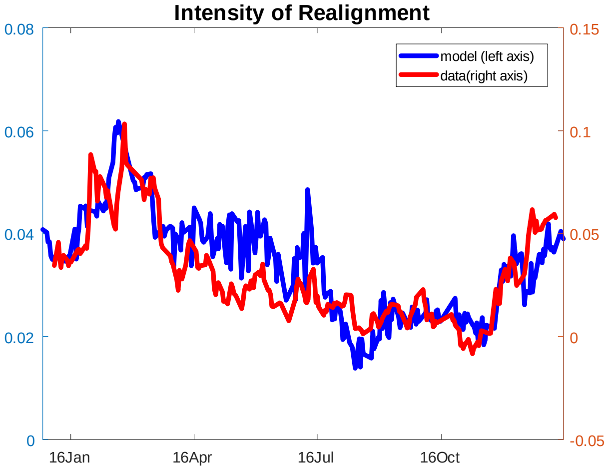
$$\left(1-p^{\tau}\right)\left(V_t - S_t^{CL}\right)$$



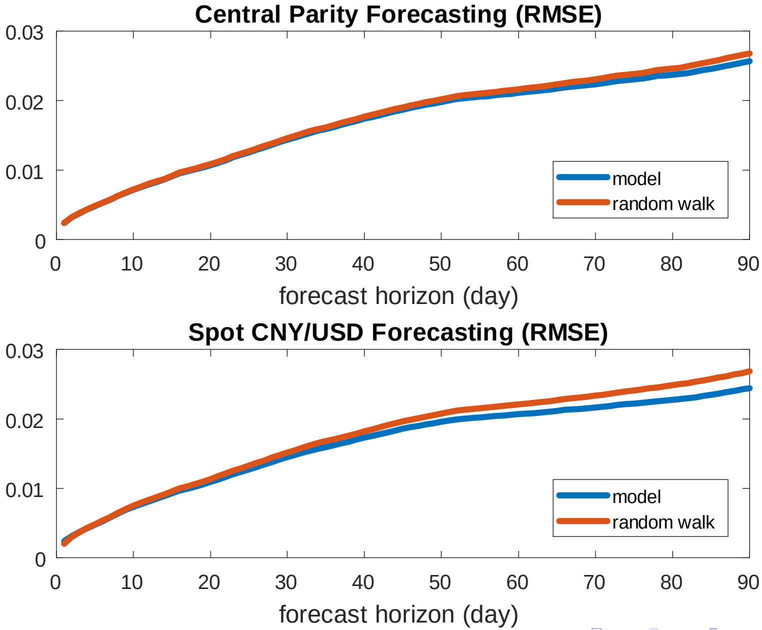
Model Implication: Intensity of Realignment

- Campa and Chang (1996) proposes a model-free "realignment intensity" measure for target zone $[\underline{S}, \overline{S}]$:

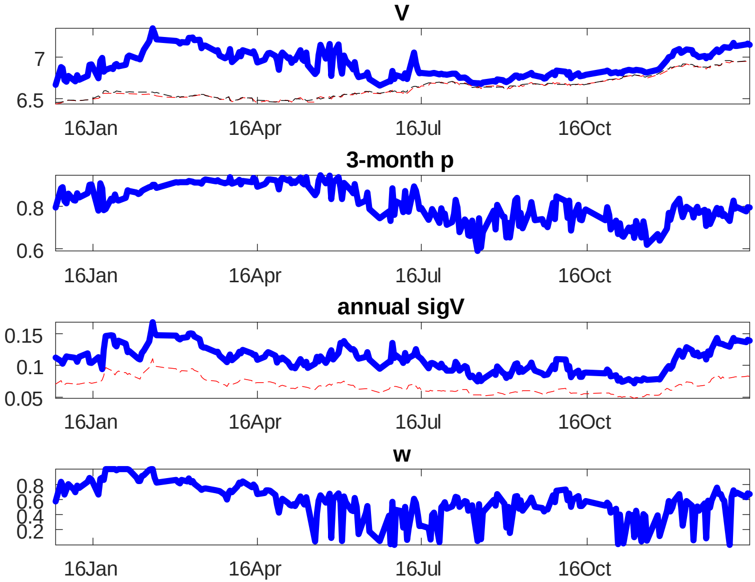
$$G = \int_{\overline{S}}^{\infty} (S_\tau - \overline{S}) f(S_\tau) dS_\tau \geq C(K, \tau)(1 + r_D) \frac{\overline{S} - \underline{S}}{K - \underline{S}} + K - \overline{S}$$



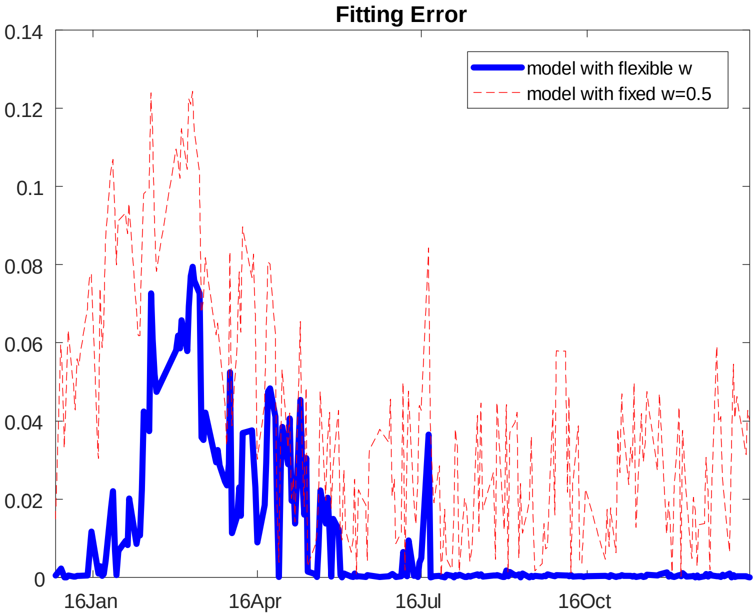
Model Implication: Forecastability



Extended Estimation: Weight



Extended Estimation: Fitting Errors



Contribution to Formation of Central Parity

- Consider the following three regressions:

$$
\begin{aligned}
\text{(I)} \quad &: \quad \log \frac{S^{CP}_{t+1}}{S^{CP}_{t}} = \gamma_1 \log \left(\frac{X_{t+1}}{X_t} \right)^{\alpha} + \varepsilon_{t+1} \\
\text{(II)} \quad &: \quad \log \frac{S^{CP}_{t+1}}{S^{CP}_{t}} = \gamma_1 \log \left(\frac{X_{t+1}}{X_t} \right)^{\alpha} + \gamma_2 \log \left(\frac{V_{t+1}}{V_t} \right)^{\beta} + \varepsilon_{t+1} \\
\text{(III)} \quad &: \quad \log \frac{S^{CP}_{t+1}}{S^{CP}_{t}} = \gamma_1 \log \left(\frac{X_{t+1}}{X_t} \right)^{\alpha_t} + \gamma_2 \log \left(\frac{V_{t+1}}{V_t} \right)^{\beta_t} + \varepsilon_{t+1}
\end{aligned}
$$

- R-squares from these regressions are (I) 0.248, (II) 0.403, and (III) 0.488, implying relative contributions to the central parity's dynamics:
  - 1st pillar: 50.8%
  - 2nd pillar: 31.8%
  - time-varying weight: 17.4%

Conclusion

- We provide empirical evidence for the current two-pillar exchange rate policy
- We construct a tractable model for the RMB and assess financial markets' views about the policy by estimating
  - fundamental exchange rate
  - 3-month survival probability of the current policy
  - weights put on both pillars
- The model can forecast well the central parity and spot rates

THANK YOU

Special Case

- In the special case with $b = 0$

$$\begin{aligned}
\widehat{S}\left(\widehat{V}_t\right) &= p \cdot \kappa + (1-p) \cdot \widehat{V}_t \\
C(K;\tau) &= p^{\tau} \cdot C_I(K;\tau) + (1-p^{\tau}) \cdot C_{II}(K;\tau) \\
P(K;\tau) &= p^{\tau} \cdot P_I(K;\tau) + (1-p^{\tau}) \cdot P_{II}(K;\tau)
\end{aligned}$$

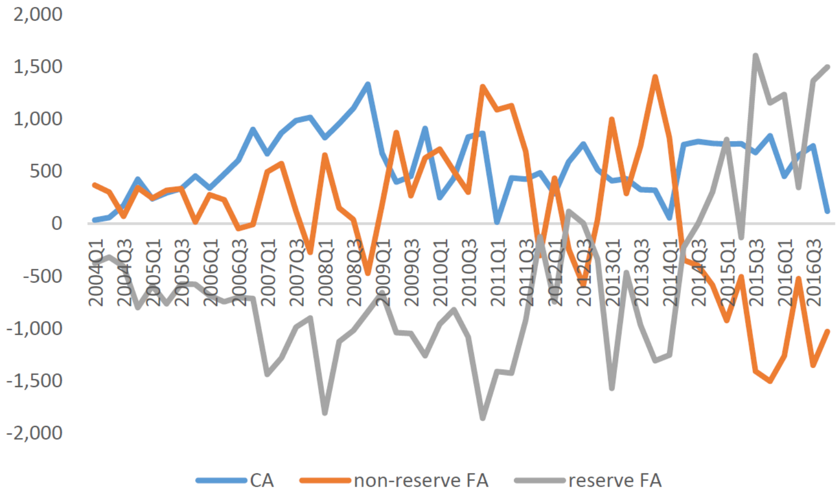
where

$$\begin{aligned}
C_I(K) &= e^{-r_{CNY}\tau} E_t^Q \max\left[S_{t+\tau}^{CP} - K, 0\right] \\
&= S_t^{CP} e^{(\mu_{CP} - r_{CNY})\tau} \Phi(d_{I,1}) - K e^{-r_{CNY}\tau} \Phi(d_{I,2}), \\
P_I(K) &= e^{-r_{CNY}\tau} E_t^Q \max\left[K - S_{t+\tau}^{CP}, 0\right] \\
&= -S_t^{CP} e^{(\mu_{CP} - r_{CNY})\tau} \Phi(-d_{I,1}) + K e^{-r_{CNY}\tau} \Phi(-d_{I,2}),
\end{aligned}$$

and $C_{II}(K)$ and $P_{II}(K)$ have similar expressions.

back

The Current Account & Financial Account



back