The Two-Pillar Policy for the RMB

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The views expressed herein are those of the authors and do not necessarily reflect the views of the Federal Reserve System.
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
  - 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
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

RMB Central Parity (CP) and Close (CL) in 2004-2016

- 7/21/2005
- 8/11/2015
- 12/11/2015
Widening Bands Around the Central Parity

Deviation between Central Parity and Close in 2004-2016
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.

The Two-Pillar Policy

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

\[ S_{t+1}^{\text{CP}} = \left[ \overline{S}_{t+1} \right]^w \times \left[ \overline{S}_{t}^{\text{CL}} \right]^{1-w} \]

- First pillar: $\overline{S}_{t+1}$ to achieve basket “stability”
- Second pillar: $S_{t}^{\text{CL}}$ 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
The Two-Pillar Policy

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

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- define \( S_{t+1} \)
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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

  \[ B_t = C_B \left( S_{t \text{CP,USD/CNY}}^{\text{USD}} \right)^{\text{WUSD}} \left( S_{t \text{CP,EUR/CNY}}^{\text{EUR}} \right)^{\text{WEUR}} \cdots \]

- \( S_{t \text{CP,USD/CNY}}, S_{t \text{CP,EUR/CNY}}, \cdots \) 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.
<table>
<thead>
<tr>
<th>Currency in CFETS basket</th>
<th>weight</th>
<th>Currency in BIS basket</th>
<th>weight</th>
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Official RMB Indices

CFETS

BIS

SDR
Official and Reconstructed RMB Indices

CFETS

BIS

SDR
RMB-index-implied USD Basket

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

\[ B_t = C_B \left( S_{t, \text{USD/CNY}} \right)^{w_{\text{USD}}} \left( S_{t, \text{EUR/CNY}} \right)^{w_{\text{EUR}}} \ldots \]

\[ = S_{t, \text{USD/CNY}} \left[ C_B \left( \frac{S_{t, \text{EUR/CNY}}}{S_{t, \text{USD/CNY}}} \right)^{w_{\text{EUR}}} \ldots \right]^{1-w_{\text{USD}}} \]

\[ = \chi \frac{1}{S_{t, CP}} (X_t)^{1-w_{\text{USD}}} \]

- \( X_t \) is RMB-index-implied USD basket
- \( S_{t, CP} \equiv S_{t, \text{CNY/USD}} \) is CNY/USD central parity rate
- \( \chi \) is scaling constant

- \( X_t \) is highly correlated with the USD index (DXY)
RMB-index-implied USD Basket and US Dollar Index

CFETS-implied USD Basket

BIS-implied USD Basket

SDR-implied USD Basket
The Two-Pillar Policy

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

$$B_t = \chi \frac{X_t^{1-w_{USD}}}{S_{t}^{CP}} = \chi \frac{S_{t+1}^{1-w_{USD}}}{\bar{S}_{t+1}}$$

$$\Rightarrow \quad \bar{S}_{t+1} = S_{t}^{CP} \left( \frac{X_{t+1}}{X_{t}} \right)^{1-w_{USD}}$$

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

$$S_{t+1}^{CP} = (\bar{S}_{t+1})^w (S_{t}^{CL})^{1-w}$$

- First pillar: $\bar{S}_{t+1}$ 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

\[
\log\left(\frac{S_{t+1}^{CP}}{S_t^{CP}}\right) = \alpha \ln\left(\frac{\bar{S}_{t+1}}{S_t^{CP}}\right) + \beta \ln\left(\frac{S_{t}^{CL}}{S_t^{CP}}\right) \quad ; \quad R^2
\]

<table>
<thead>
<tr>
<th></th>
<th>CFETS</th>
<th>BIS</th>
<th>SDR</th>
</tr>
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<tr>
<td>(\alpha)</td>
<td>0.52</td>
<td>0.48</td>
<td>0.48</td>
</tr>
<tr>
<td>(\beta)</td>
<td>0.45</td>
<td>0.48</td>
<td>0.46</td>
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<tr>
<td>(R^2)</td>
<td>0.81</td>
<td>0.75</td>
<td>0.78</td>
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</table>
More Empirical Evidence (CFETS)

60-day Rolling-Regression Coefficient (w)
A Model for the RMB
A Model for the RMB

- Under the model, with probability \( p \), the two-pillar policy regime continues tomorrow:

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

- \( \widetilde{S}_t \): "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

\[
V_t = \frac{1 + r^S}{1 + r^C} E_t^Q [V_{t+1}]
\]
A Model for the RMB

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

$$S_{t+1}^{\text{CL}} = H(\tilde{S}_{t+1}, S_{t+1}^{\text{CP}}, b)$$
$$= \max \left[ \min \left[ \tilde{S}_{t+1}, S_{t+1}^{\text{CP}} (1 + b) \right], S_{t+1}^{\text{CP}} (1 - b) \right]$$

- $\tilde{S}_t$: “equilibrium exchange rate” with the policy in place
- $b$: band’s width around the central parity

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

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

- $V_t$: “fundamental exchange rate” without the policy

$$V_t = \frac{1 + r^S}{1 + r^C} E_t^Q [V_{t+1}]$$
A Model for the RMB (Cont’d)

- By no arbitrage, the equilibrium exchange rate satisfies

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

$$= \frac{1 + r^S}{1 + r^C} p E_t^Q H(\tilde{S}_{t+1}, S_{t+1}^{CP}, b) + (1 - p) V_t$$

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

- The current observed spot rate is

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

- By rescaling, \( \tilde{S}(S_t^{CP}, V_t) \equiv S_t^{CP} \tilde{S}(\hat{V}_t) \) where \( \hat{V}_t \equiv \frac{V_t}{S_t^{CP}} \)

$$\tilde{S}(\hat{V}_t) = \frac{1 + r^S}{1 + r^C} p E_t^Q \left[\frac{S_{t+1}^{CP}}{S_t^{CP}} H\left(\tilde{S}\left(\hat{V}_{t+1}\right), 1; b\right)\right] + (1 - p) \hat{V}_t$$
A Model for the RMB (Cont’d)

- By no arbitrage, the equilibrium exchange rate satisfies

\[
\widetilde{S}_t = \frac{1 + r^S}{1 + r^C} E_t^Q \left[ p \cdot H(\widetilde{S}_{t+1}, S^CP_{t+1}, b) + (1 - p) \cdot V_{t+1} \right]
\]

\[
= \frac{1 + r^S}{1 + r^C} p E_t^Q H(\widetilde{S}_{t+1}, S^CP_{t+1}, b) + (1 - p) V_t
\]

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- The current observed spot rate is

\[
S^CL_t = H(\widetilde{S}_t, S^CP_t, b)
\]

- By rescaling, \( \widetilde{S} (S^CP_t, V_t) \equiv S^CP_t \widetilde{S}(\hat{V}_t) \) where \( \hat{V}_t \equiv \frac{V_t}{S^CP_t} \)

\[
\widetilde{S}(\hat{V}_t) = \frac{1 + r^S}{1 + r^C} p E_t^Q \left[ \frac{S^CP_{t+1}}{S^CP_t} H \left( \frac{\widetilde{S}(\hat{V}_{t+1}), 1; b}{} \right) \right] + (1 - p) \hat{V}_t
\]
A Model for the RMB (Cont’d)

- By no arbitrage, the equilibrium exchange rate satisfies

\[
\tilde{S}_t = \frac{1 + r^S}{1 + r^C} E_t^Q \left[ p \cdot H(\tilde{S}_{t+1}, S_{t+1}^{CP}, b) + (1 - p) \cdot V_{t+1} \right]
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- The current observed spot rate is

\[
S_t^{CL} = H(\tilde{S}_t, S_t^{CP}, b)
\]

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

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

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

\[
S_{t+1}^{CP} = \left[ S_t^{CP} \left( \frac{X_{t+1}}{X_t} \right)^{(1-w_{USD})} \right]^w \left[ S_t^{CP} \left( \frac{V_{t+1}}{V_t} \right)^{\gamma} \right]^{1-w}
\]

pillar I: basket stability

\[
\equiv S_t^{CP} \left( \frac{X_{t+1}}{X_t} \right)^{\alpha} \left( \frac{V_{t+1}}{V_t} \right)^{\beta}
\]

pillar II: market condition

- Under the policy

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

\[
\frac{\hat{V}_{t+1}}{\hat{V}_t} = \left( \frac{X_{t+1}}{X_t} \right)^{-\alpha} \left( \frac{V_{t+1}}{V_t} \right)^{1-\beta}
\]
Model Solution in Continuous Time

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

\[ \frac{dV_t}{V_t} = (r_{CNY} - r_{USD}) dt + \sigma_V dW_{V,t} \]

\[ \frac{dX_t}{X_t} = (r_{DXY} - r_{USD} - \rho \sigma_X \sigma_V + \sigma_X^2) dt \]

\[ + \sigma_X \left( \rho dW_{V,t} + \sqrt{1 - \rho^2} dW_{X,t} \right) \]

- The equilibrium exchange rate is derived in closed form:

\[ \hat{S}(\hat{V}_t) = \begin{cases} 
1 - b, & \text{if } \hat{V} \leq \hat{V}^*; \\
C_0 \hat{V} + C_1 \hat{V}^{\eta_1} + C_2 \hat{V}^{\eta_2}, & \text{if } \hat{V}^* < \hat{V} < \hat{V}^*; \\
1 + b, & \text{if } \hat{V} \geq \hat{V}^*, \end{cases} \]
Equilibrium Exchange Rate under the Model

\[ (1 + b) \]

\[ (1 - b) \]

\[ \hat{V}_* \]

\[ \hat{V}^* \]
Model-Implied CNY Option Prices

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

$$
C(K; \tau) = e^{-r_{\text{CNY}} \tau} E_t^Q \left[ p^\tau \max \left( H \left( \tilde{S}_{t+\tau}, S_{t+\tau}^{\text{CP}}; b \right) - K, 0 \right) \\
+ (1 - p^\tau) \max \left( V_{t+\tau} - K, 0 \right) \right]
$$

$$
P(K; \tau) = e^{-r_{\text{CNY}} \tau} E_t^Q \left[ p^\tau \max \left( K - H \left( \tilde{S}_{t+\tau}, S_{t+\tau}^{\text{CP}}; b \right), 0 \right) \\
+ (1 - p^\tau) \max \left( K - V_{t+\tau}, 0 \right) \right]
$$

- Option prices help identify $(V, p, \sigma_V)$, $b = 0$
Model Estimation

- We estimate the model to fit spot and option prices in the data to estimate \( (V, p, \sigma_V) \) for each date between 12/11/2015-12/31/2016
  - \( \sigma_X \) is estimated from dollar index options & futures
  - for simplicity, we set \( \rho = 0 \) in the estimation below
  - we use the effective band width: \( b = 0.5\% \)
- 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

V

3-month p

annual sigV
Model Fit

Put option price 10-delta

Call option price 10-delta

Put option price 25-delta

Call option price 25-delta
Model Implication: V vs. CNY and CNH

![Graph showing model implications for V, CNY, and CNH over time from 16 Jan to 16 Oct](image)

- **V (model)**
- **CNY**
- **CNH**

The graph illustrates the trend and comparison of these variables over the specified period.
Model Implication: p vs. Foreign Reserves
Model Implication: Intensity of Realignment

- Combining estimates of $V$ and $p$, we can construct model-implied “realignment intensity”

$$(1 - p^\tau)(V_t - S_t^{CL})$$
Model Implication: Intensity of Realignment

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

$$G = \int_{S}^{\infty} (S_\tau - \bar{S}) f(S_\tau) dS_\tau \geq C(K, \tau) (1 + r_D) \frac{\bar{S} - S}{K - \bar{S}} + K - \bar{S}$$
Model Implication: Forecastability

Central Parity Forecasting (RMSE)

Spot CNY/USD Forecasting (RMSE)
Extended Estimation: Weight

- V
- 3-month p
- annual sigV
- w
Extended Estimation: Fitting Errors

Fitting Error

- model with flexible $w$
- model with fixed $w=0.5$
Contribution to Formation of Central Parity

Consider the following three regressions:

(I) : \[ \log \frac{S_{t+1}^{CP}}{S_t^{CP}} = \gamma_1 \log \left( \frac{X_{t+1}}{X_t} \right)^\alpha + \varepsilon_{t+1} \]

(II) : \[ \log \frac{S_{t+1}^{CP}}{S_t^{CP}} = \gamma_1 \log \left( \frac{X_{t+1}}{X_t} \right)^\alpha + \gamma_2 \log \left( \frac{V_{t+1}}{V_t} \right)^\beta + \varepsilon_{t+1} \]

(III) : \[ \log \frac{S_{t+1}^{CP}}{S_t^{CP}} = \gamma_1 \log \left( \frac{X_{t+1}}{X_t} \right)^{\alpha_t} + \gamma_2 \log \left( \frac{V_{t+1}}{V_t} \right)^{\beta_t} + \varepsilon_{t+1} \]

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 $b = 0$

\[
\hat{S}(\hat{V}_t) = p \cdot \kappa + (1 - p) \cdot \hat{V}_t
\]
\[
C(K; \tau) = p^\tau \cdot C_I(K; \tau) + (1 - p^\tau) \cdot C_{II}(K; \tau)
\]
\[
P(K; \tau) = p^\tau \cdot P_I(K; \tau) + (1 - p^\tau) \cdot P_{II}(K; \tau)
\]

where

\[
C_I(K) = e^{-r_{CNY} \tau} E_t^Q \max [S_{t+\tau}^{CP} - K, 0]
\]
\[
= S_{t}^{CP} e^{(\mu_{CP} - r_{CNY}) \tau} \Phi (d_{I,1}) - Ke^{-r_{CNY} \tau} \Phi (d_{I,2}),
\]
\[
P_I(K) = e^{-r_{CNY} \tau} E_t^Q \max [K - S_{t+\tau}^{CP}, 0]
\]
\[
= -S_{t}^{CP} e^{(\mu_{CP} - r_{CNY}) \tau} \Phi (-d_{I,1}) + Ke^{-r_{CNY} \tau} \Phi (-d_{I,2}),
\]

and $C_{II}(K)$ and $P_{II}(K)$ have similar expressions.
The Current Account & Financial Account

![Graph showing the Current Account (CA), non-reserve Financial Account (non-reserve FA), and reserve Financial Account (reserve FA) over time from 2004Q1 to 2016Q3.](image_url)