The anatomy of a peg: lessons from China's parallel currencies

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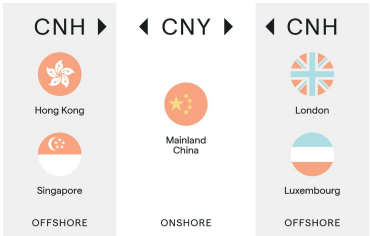
July 2024

China's large-scale monetary experiment



- CNY: mainland currency, Chinese
- CNH: parallel currency, anyone
- Officially convert 1:1

Why? Internationalisation strategy

- Foreigners can use CNH freely for payments or to convert to other currencies.

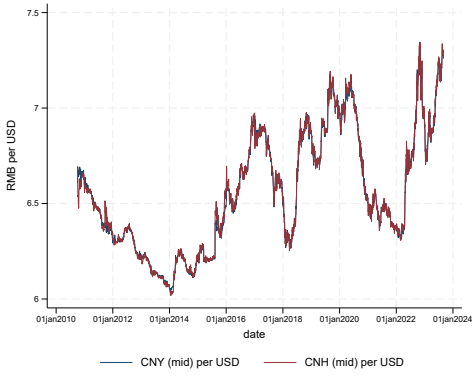
Open current account, closed capital account

- Chinese firms can export/import without restrictions in CNH and convert to CNY against invoices.
- Restrictions and quotas on conversion for capital flows that are closely monitored: FDI, investment, household transfers, bank borrowing/lending.
- Large scale parallel currencies.

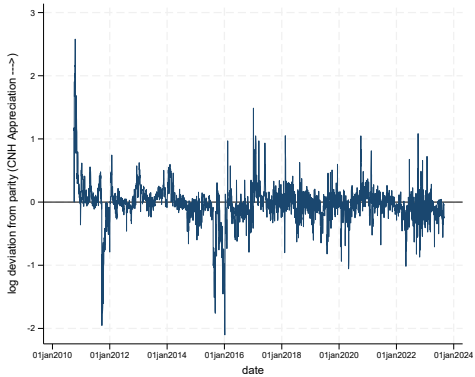
Gresham's law: the peg to parity and success

Tension: if $\ln(E) \neq 0$ for too long, capital controls will fail by arbitrage

CNH ($\hat{E}$) and CNY ($\tilde{E}$) to USD



CNY to CNH (E)



$E \uparrow$ is a depreciation of CNY vs CNH; $\hat{E} \uparrow$ is a depreciation of CNH vs USD; $\tilde{E} \equiv E \times \hat{E} \uparrow$ is a depreciation of CNY vs USD.

THIS PAPER

1) How does the system work?
   - Controlling scarcity of M to target E.
   - Why let E fluctuate? E as a pressure valve for $\hat{E}$.
   - A transitory, exogenous shock increase in money supply by 1% depreciates the exchange rate by 0.11pp.
   - Estimate elasticity of reserve demand vs deposit demand, confirm scarcity.

2) Monetary anatomy of a peg:
   - Policy rule: money supply elastically accommodates changes in money demand
   - Money adjustment is insufficient to maintain peg, other policies.

3) Liquidity anatomy of a peg:
   - Liquidity policies matter for exchange rate, like discount window.
   - In extreme, role of capital controls.

2. The CNH monetary regime

MONETARY POLICY OPERATIONS: TEXTBOOK

Central Bank

Assets	Liabilities
(A) Govt. Bonds	(D) Reserves
(B) Lending Facilities	(E) Bills
(C) FX and Other Assets	(F) Equity, Others

Commercial Banking System

Assets	Liabilities
(G) Govt. Bonds	(K) Deposits
(H) Central Bank Bills	(L) CB Facilities
(I) Reserves	(M) Equity, Others
(J) Loans, Others	

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- Open market operation: (A) up, (D) up, (G) down, (I) up.

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- Open market operation: (A) up, (D) up, (G) down, (I) up. Then, "multiplier" (J) up and (K) up.

MONETARY POLICY OPERATIONS: CENTRAL BANK BILLS

Central Bank

Assets	Liabilities
(A) Govt. Bonds	(D) Reserves
(B) Lending Facilities	(E) Bills
(C) FX and Other Assets	(F) Equity, Others

Commercial Banking System

Assets	Liabilities
(G) Govt Bonds	(K) Deposits
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(J) Loans, Others	

- Swap reserves for bills: (D) up, (E) down, (H) down, (I) up.

MONETARY POLICY OPERATIONS: LENDING FACILITY

Central Bank

Assets	Liabilities
(A) Govt. Bonds	(D) Reserves
(B) Lending Facilities	(E) Bills
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Commercial Banking System

Assets	Liabilities
(G) Govt. Bonds	(K) Deposits
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(J) Loans, Others	

- Lending reserves to banks: (B) up, (D) up, (I) up, (L) up.

MONETARY POLICY OPERATIONS: CNH

People's Bank of China

Assets	Liabilities
(a) CNY Assets	(c) CNY Onshore Reserves
(b) FX Assets	(d) CNY Clearing Bank Reserves
	(e) CNH Bills
	(f) Equity, Others

Offshore Clearing Banks

Assets	Liabilities
(g) CNY Clearing Bank Reserves	(i) CNH Commercial Bank Sight Deposits
(h) Other Assets	(j) CNH HKMA Deposits
	(k) CNY Equity, Others

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Hong Kong Commercial Banks CNH

Assets	Liabilities
(q) Deposits at Clearing Banks	(t) Deposits
	(u) PLP Balances
(r) PBoC CNH Bills	(v) HKMA Facilities
(s) Loans, Others	(w) Equity, Others

MONETARY POLICY OPERATIONS: CNH

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- PBoC weekly manages M through bills: (e) down (d) up; (g) up (i) up ; (q) up, (r) down.

MONETARY POLICY OPERATIONS: CNH

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Hong Kong Monetary Authority CNH

Assets	Liabilities
(l) Deposits at Clearing Banks	(p) Equity, Others
(m) PLP Balances	
(n) Liquidity Facilities	
(o) Other Assets	

Hong Kong Commercial Banks CNH

Assets	Liabilities
(q) Deposits at Clearing Banks	(t) Deposits
	(u) PLP Balances
(r) PBoC CNH Bills	(v) HKMA Facilities
(s) Loans, Others	(w) Equity, Others

- PBoC weekly manages M through bills: (e) down (d) up; (g) up (i) up ; (q) up, (r) down.
- HKMA hourly manages M through lending facility: (l) down (m) up; (q) up (u) up.

3. Money and the exchange rate

Offshore Banking and the Exchange Rate

- Risk neutral competitive banks raise deposits onshore or offshore subject to withdrawal shocks met with reserves. Focus on liquidity management, take capital and return on assets/loans as given.

- Their problem is to maximize

$$\underbrace{R^x x^o - c^o}_{\text{Loans and capital}} + \underbrace{R^{m,o} m^o - R^{d,o} d^o - \phi^o(m^o/d^o)d^o}_{\text{Onshore liquidity}} + \underbrace{\mathbb{E}(E')\left(R^m m - R^d d - \phi(m/d)d\right)}_{\text{Offshore liquidity}}.$$

- Properties of liquidity cost per deposit: $\phi(.)$:
  1) bounded $0 = \phi(1) \leq \phi(m/d)d < \infty$
  2) decreasing, and marginal benefit is $0 = \phi'(1) \leq -\phi'(.) \leq \infty$
  3) In equilibrium, banks operate $\phi(.)D < R^m M$ and marginal benefit $-\phi' M/D.)$ is decreasing in reserve-deposit ratio so liquidity is finite.

Bank indifference between CNH-CNY reserves

- Optimality

$$\left(\frac{\mathbb{E}(E')}{E}\right)\left(R^m - \phi'(M/D)\right) = \underbrace{R^{m,o} - \phi^{o'}(m^o/d^o)}_{=1,\text{ normalisation}} = \text{value of CNY reserve}$$

  → $\mathbb{E}(E') = 1 \implies$ credible peg.

  → R^m CNH reserve gross rate (1 in data, no interest rate shocks).

  → M/D is offshore reserve-deposit ratio ($\phi''(.) > 0$)

  → onshore policy independent of E, normalise.

- Simplified:

$$\phi'(M/D) = R^m - E$$

  → Interest semi-elasticity of reserve demand $\varepsilon_m \equiv \partial ln(M)/\partial R^m$ – negative of elasticity wrt E.

  → Scarce reserves: for M to matter for E, we need $\varepsilon_m < \infty$.

DEPOSITORS

- Chinese households demand for deposits (isoelastic convenience benefit) given rate of deposits R^d and v as a preference (money demand) shock, with interest semi-elasticity ε_d

$$\left(\frac{\mathbb{E}(E')}{E}\right) R^d = k - v(D_{dom})^{-\alpha}$$

- Foreign households individually hold deposits subject to UIP condition (foreign return $\hat{R}$).

$$R^d = \left(\frac{\mathbb{E}(\hat{E}')}{\hat{E}}\right)(\hat{R})$$

Capital controls over foreign deposits $\hat{D}$ and $D = \hat{D} + D_{dom}$

- Bank deposit supply

$$\left(\frac{\mathbb{E}(E')}{E}\right)\left[R^d + \underbrace{\phi(M/D) - \left(\frac{M}{D}\right)\phi'(M/D)}_{\text{liquidity cost of issuing a deposit}}\right] = 1$$

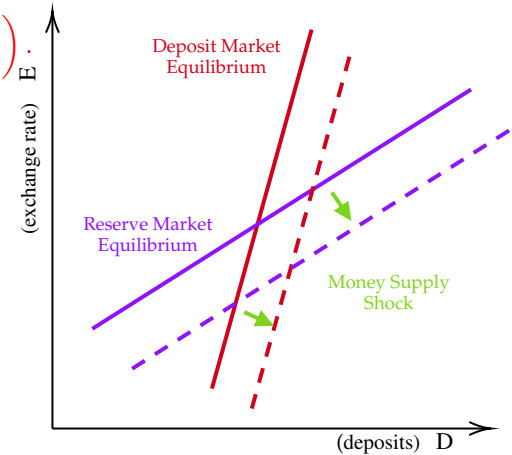
Analysis

$$E(1-k+v(D-\hat{D})^{-\alpha}) = \phi\left(\frac{M}{D}\right) - \left(\frac{M}{D}\right)\phi'\left(\frac{M}{D}\right).$$

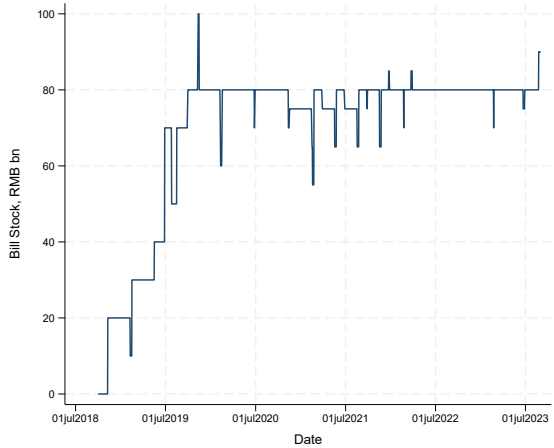
$$\left(R^m - \phi'(M/D)\right) = E$$

- Equilibrium for (E, D), intersection of reserve and deposit market conditions.
- Money demand shock, v or $\hat{D}$ shift DM curve, raises E and D.
- Money supply shock M:

$$d\log(E)/d\log(M) = (\varepsilon_m + (M/D)\varepsilon_d)^{-1}$$

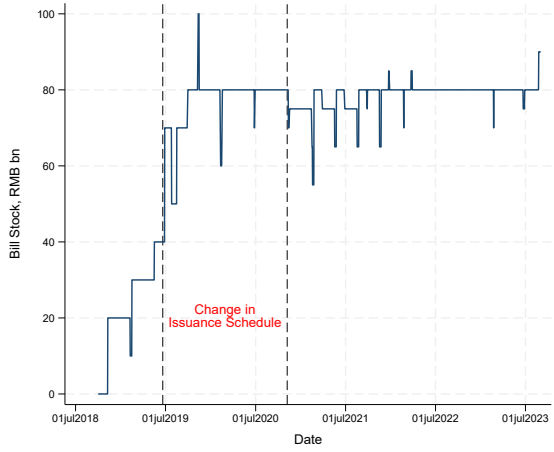


EXOGENOUS HIGHER CNH MONEY SUPPLY



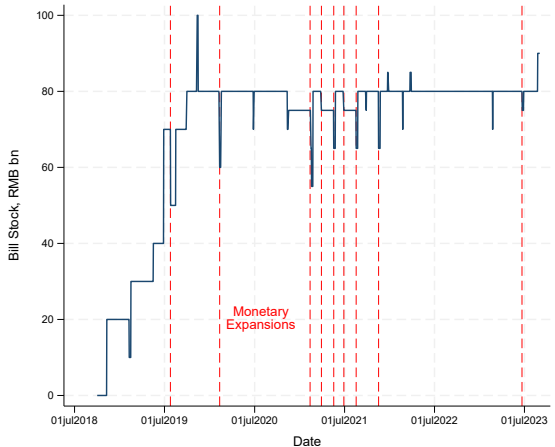
Bill issuance: November 2018 goal was 40bn of 3M bills and 10bn of 12M bills.

EXOGENOUS HIGHER CNH MONEY SUPPLY

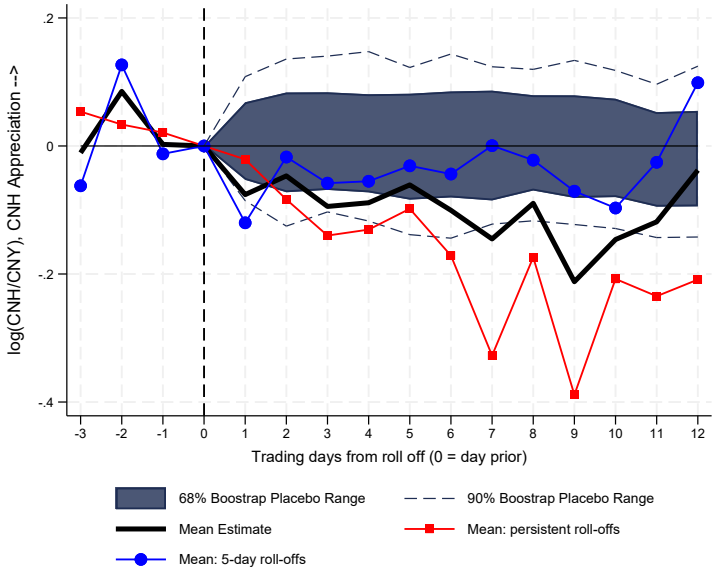


8 Aug 2019: new goal of 20bn of 3M and 6M and 40bn of 12M. 6 Nov 2020: switch to 10bn of 3M and 6M and 60bn of 12M

EXOGENOUS HIGHER CNH MONEY SUPPLY



Response of E to M



A 1% increase in M lowers E by 0.11pp.

Since $\frac{M}{D} = \frac{196}{730}$ and $\varepsilon_d \approx 10$, Benati et al (2021) , then

$$\varepsilon_m = \frac{11/196}{0.0011} - \left(\frac{196}{730}\right)\varepsilon_d = 48.$$

Same number as US in 2007 under scarce reserve system. Also matches time series exercise.

E AS A PRESSURE VALVE FOR $\hat{E}$

UIP condition:

$$R^d(E) = \left(\frac{\mathbb{E}(\hat{E}')}{\hat{E}}\right)(\hat{R})$$

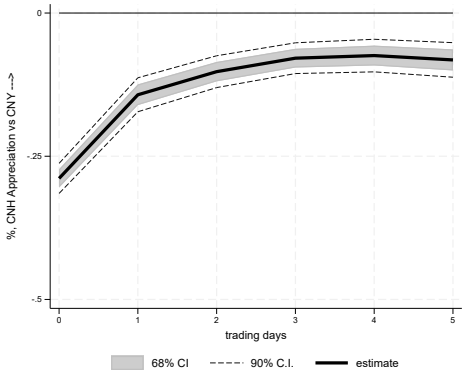
Since R^d moves in same direction as E no matter the shock. then $\hat{E}$ and E should comove negatively.

Implication:

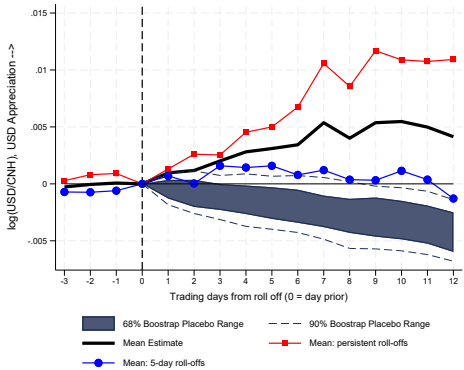
- When the yuan is depreciating against USD, CNH depreciates more than CNY...
- ...and vice versa when appreciating...
- ... failure to perfectly maintain the peg is a tool to slow an FX adjustment.

Testing the co-movement between E and $\hat{E}$

Dynamic conditional corr. $\log(E)$ on $\log(\hat{E})$



Response of $\hat{E}$ to M



4. Monetary anatomy of the peg

ESTIMATING THE POLICY RULE FOR MONEY SUPPLY

Simple policy rule

$$\log(M'/M) = \eta \log(E).$$

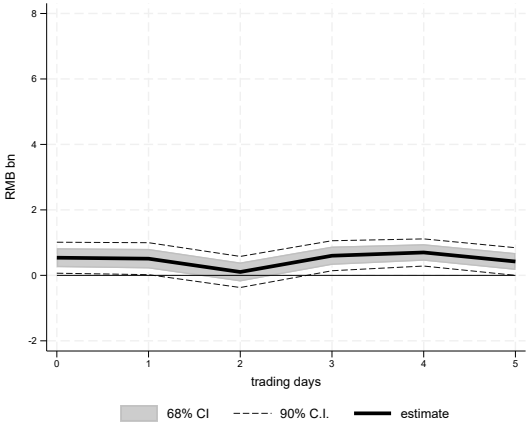
Is (i) $\eta > 0$ and, if so, (ii) is η big enough to maintain the peg?

But E also driven by policy changes and other supply shocks. IV strategy based on CNY:

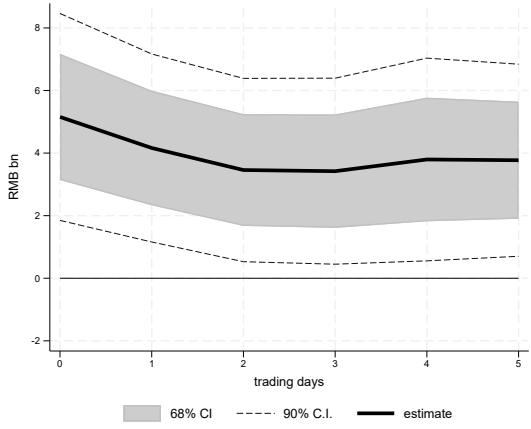
- CNY-USD exchange rate ($\tilde{E}$) trades in a 2% corridor around a central parity rate ($\bar{E}$).
- $\bar{E}$ set in the morning and not set in response to E.
- Most of time $\bar{E}$ tracks the previous close of CNY-USD. Sometimes it does not. Unfilled pressure on CNY rate to change.
- Since CNH is not controlled, it will adjust in anticipation of CNY
- Use deviation of $\bar{E}$ today from $\tilde{E}$ yesterday as instrument for E, F-stat is 20.

Response of M to E (PLP lending)

Local Projection – Least Squares

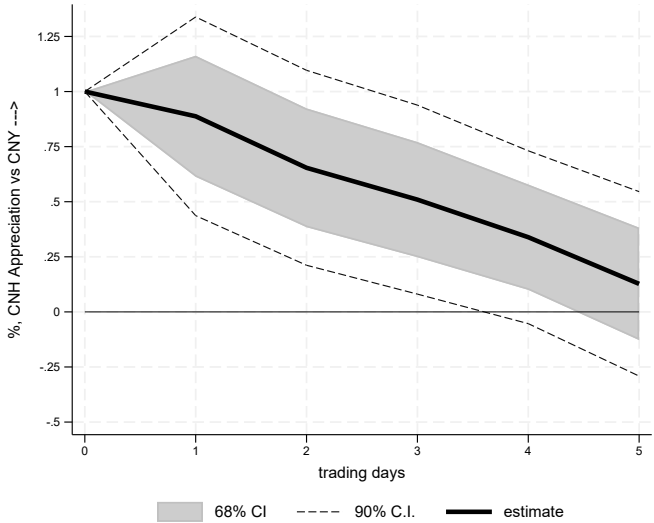


Local Projection – Instrumental Variables



If z is PLP drawing, then plot from regression $y_{t+h} = \beta_h e_t + \gamma_h e_{t-1} + \delta_h y_{t-1} + \text{error}$

Is the money response enough to restore parity?



After 5 days, 0.83 of 1% increase in the exchange rate has reverted. Channels:

- 0.53 can be accounted for by the shock dissipating (incl CNY adjustment),
- ¥5bn money response: using earlier estimate accounts for 0.05
- Remaining 0.25: other liquidity policies that shift $\phi(M/D)$

5. A liquidity anatomy of the peg

DIGGING DEEPER ON THE LIQUIDITY COSTS $\phi(.)$

- Expected liquidity costs $\phi(.)$: random withdrawal shock $\Omega(\omega)$, match in interbank market with prob. $\Psi_+(\theta), \Psi_-(\theta)$, tightness θ, pay bargained rate $R^f(\theta)$, or go to discount window R^z.

$$\phi(M/D)D = - \underbrace{\Psi_+(\theta)}_{\text{prob. find borrower}} \times \underbrace{(R^f(\theta) - R^m)}_{\text{lending profit}} \times \underbrace{\int_{\bar{\omega}}^{\infty} s(\omega) d\Omega(\omega)}_{\text{liquidity surpluses}}$$

$$- \left[\underbrace{\Psi_-(\theta)(R^f(\theta) - R^m)}_{\text{interbank borrowing}} + \underbrace{(1 - \Psi_-(\theta))(R^z - R^m)}_{\text{CB borrowing}} \right] \underbrace{\int_{-1}^{\bar{\omega}} s(\omega) d\Omega(\omega)}_{\text{liquidity deficits}}$$

- A rise in money demand only partially offset by a rise in money supply (E rises) leads to:
  a) an increase in the tightness in the interbank market θ;
  b) an increase in the interbank rate $R^f(\theta)$;
  c) greater use of the discount window liquidity facilities.

A) INTERBANK MARKET TIGHTNESS: BILL AUCTION SUBSCRIPTIONS

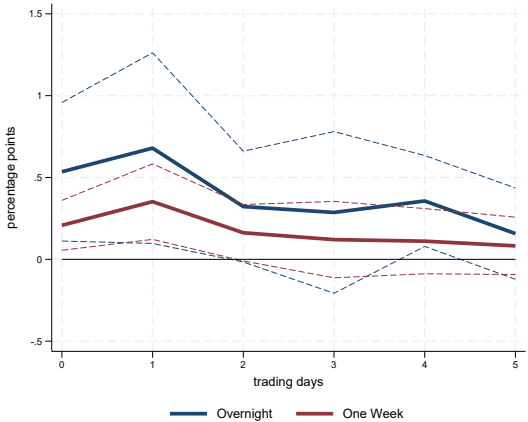
Regression of bill auction subscription rate (bids / bills auctioned) on the exchange rate

Bill maturities	All	12M	6M	3M
	(1)	(2)	(3)	(4)
$\frac{1}{5}\sum_0^4 \log(E_{t-h})$	-2.76***	-3.38***	-2.78***	-3.38***
	(0.93)	(1.10)	(0.93)	(1.12)
Number of Auctions	35	19	16	19
R^2	0.142	0.335	0.131	0.324

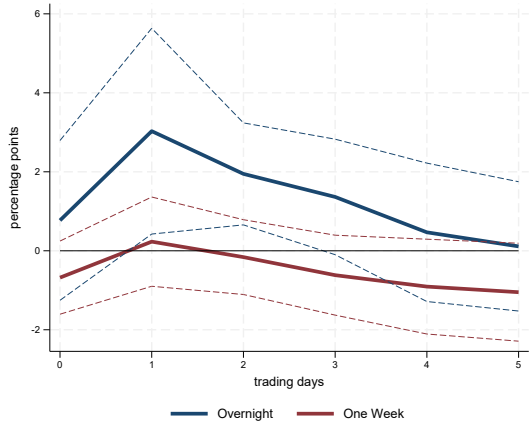
Heteroskedasticity robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, ***$p < 0.01$

B) INTERBANK RATE RESPONSE TO A MONEY DEMAND SHOCK

Local Projection - Least Squares



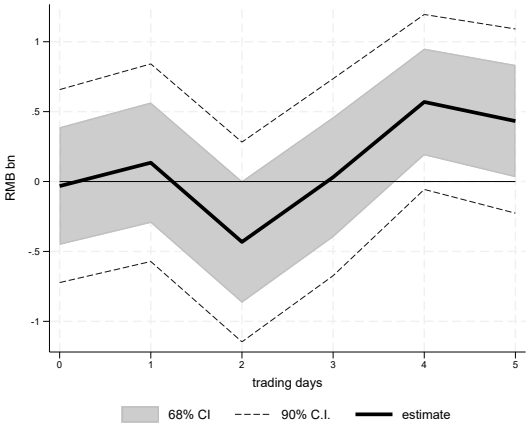
Local Projection - Instrumental Variables



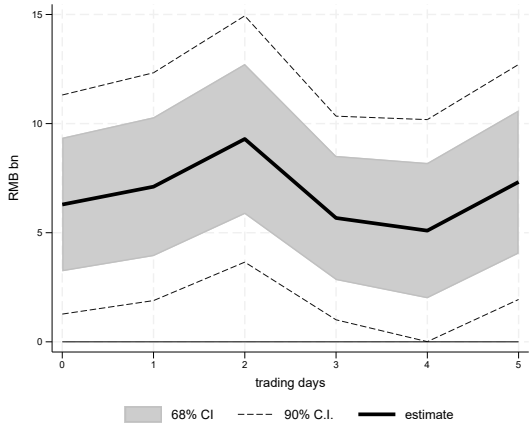
z is interbank rate facility drawing, plot from regression $z_{t+h} = \beta_h e_t + \gamma_h e_{t-1} + \delta_h z_{t-1} + \text{error}$

C) Discount window drawings

Local Projection - Least Squares



Local Projection - Instrumental Variables



z is intraday facility drawing, plot from regression $z_{t+h} = \beta_h e_t + \gamma_h e_{t-1} + \delta_h z_{t-1} + \text{error}$

LIQUIDITY POLICIES: LENDING RATE

- Marginal benefit of innovation in equilibrium:

$$-\phi'(M/D) = (1 - \Psi_-(\theta))(R^z - R^m)\Omega(\bar{\omega})$$

- Liquidity policies: restrict access to the lending facility (higher R^z or higher ρ) raise the marginal benefit of reserves ($-\phi'(M/D)$ higher), appreciate the CNH.

- A test
  - → Prior to 5 April 2016, the R^z was set as previous day's overnight R^f plus 50bp. On that day, the rule was changed to the average of the previous three days overnight rate plus 50bp. The three day lagged overnight rate starts significantly raising E:

$$\log(E_t) = ... + Post_t \times (\underbrace{0.57^{**}}_{(0.28)} R^f_{t-1} - \underbrace{0.52}_{(0.37)} \times R^f_{t-2} + \underbrace{\mathbf{1.25^{***}}}_{\mathbf{(0.29)}} \times \boldsymbol{R^f_{t-3}} + \underbrace{0.15}_{(0.27)} \times R^f_{t-4}) + \text{error}_t.$$

  - → Another case study: on 22nd of July of 2022, the spread was cut to 25bp: comparing 10 days before to 10 days: 2bp reduction in E and a 10bp reduction in R^f

LIQUIDITY POLICIES: CONTROLS

- Three controls
  - $\rightarrow$ W_d control on deposit flows (conversion of CNY in CNH) $d \int_{-1}^{\infty} \omega d\Omega(\omega) = W^d$
  - $\rightarrow$ W^m control on reserve flows
  - $\rightarrow$ G bill stocks or FXI: swap CNY bills for CNH bills
  - $\rightarrow$ Tightness now:

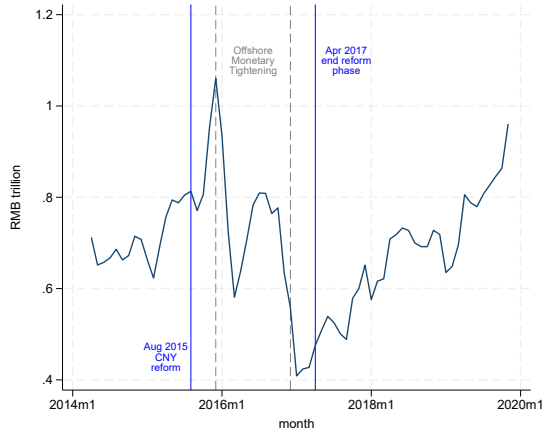
$$\theta = \frac{-\int_{-1}^{\bar{\omega}} s(\omega) d\Omega(\omega; W^d)}{\int_{\bar{\omega}}^{\infty} s(\omega) d\Omega(\omega, W^d) - G + W^m}.$$

- Tightening liquidity controls or a bill exchange raise the marginal benefit of reserves ($-\phi'(M/D)$ higher) and can offset negative shocks to money demand in order to keep the peg. They come with:
  1) more use of the intraday facility;
  2) an increase in the interbank rate $R^f(\theta)$.
  3) a return to parity of the peg E.

EPISODE 1): THE 11/8/2015 DEPRECIATION AND CONTROLS

CNH/USD and CNY/USD exchange rates

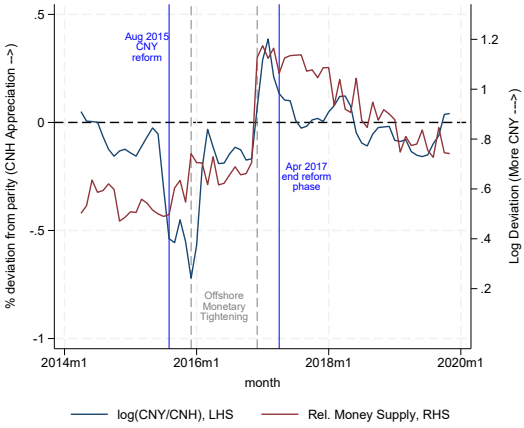
RMB flows from onshore to offshore



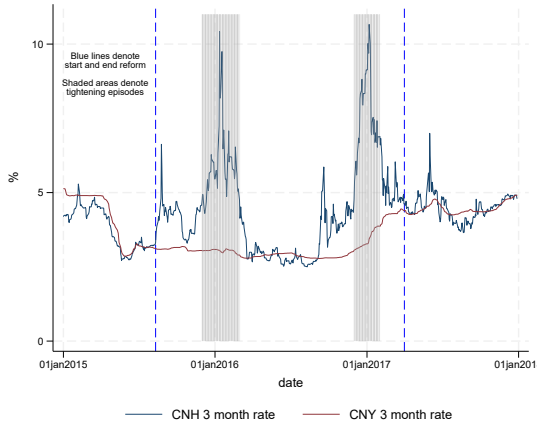
Episode 1): the 11/8/2015 depreciation and controls

Deposits fall, interbank rate rises

Relative stock of CNH-CNY deposits and e

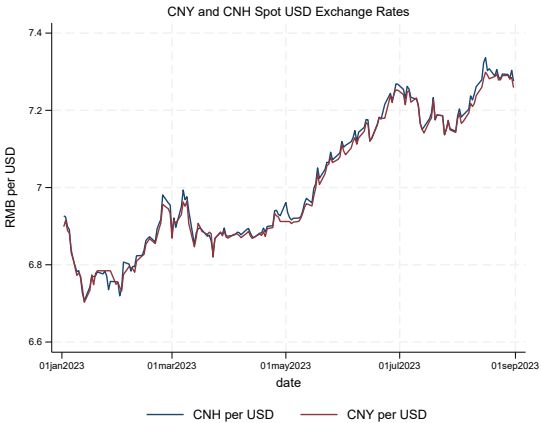


3-month interbank rates for CNH and CNY

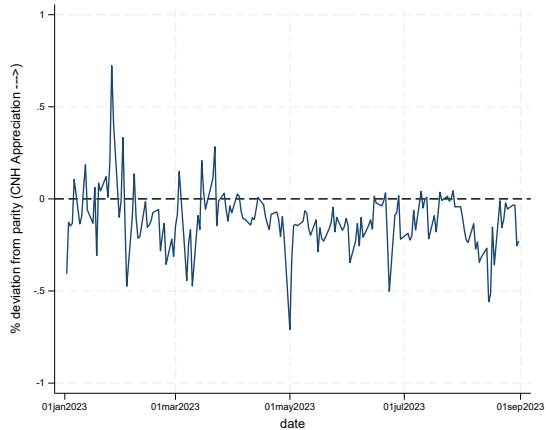


Episode 2) Summer 2023 and monetary/liquidity policies

CNH/USD and CNY/USD exchange rates



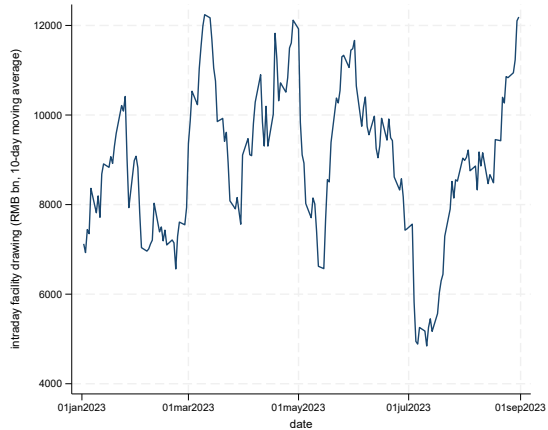
CNH/CNY exchange rate



Episode 2) Summer 2023 and monetary/liquidity policies

3-month interbank rates for CNH and CNY

Intraday liquidity facility borrowing



5. Conclusion

Conclusion

- China has offshore currency to enforce capital controls while allowing for an open current account and internationalization of the yuan.
  - $\rightarrow$ Gresham's law – need to maintain a peg. How?

- Monetarist anatomy of a peg:
  - $\rightarrow$ Scarce reserves (elasticity of 50) $\implies$ money influences exchange rate.
  - $\rightarrow$ This money supply changes only accounts for one sixth of adjustment to maintain peg.

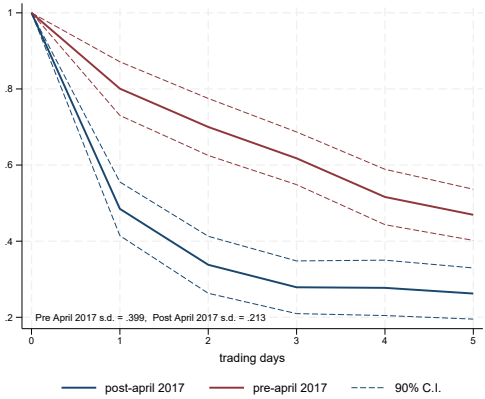
- Liquidity anatomy of a peg:
  - $\rightarrow$ Other policies that shift the benefit of liquidity used.
  - $\rightarrow$ Interbank market efficiency and discount window.
  - $\rightarrow$ Capital controls limit transfers of liquidity. Active in '15. Less so in '23.

Appendix

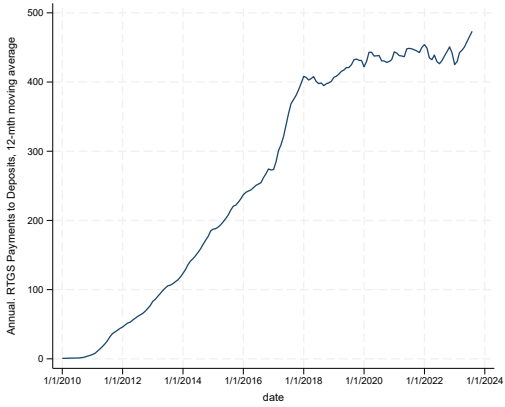
SUCCESS OF PEG AND CNH USAGE

Since 2017, not very persistent deviations, and CNH velocity is as high as the USD

Persistence of e pre and post April 2017



CNH velocity

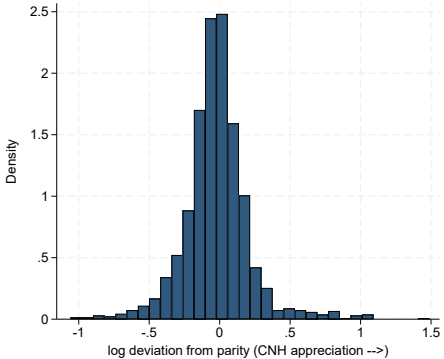


Capital controls and CNH as means of payment

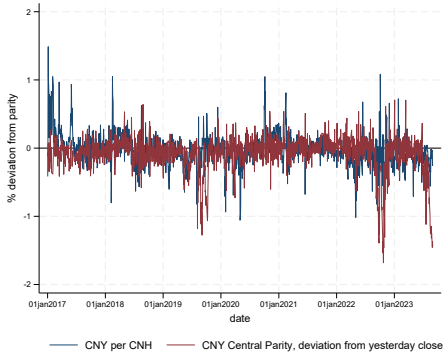
- Separate currencies, each with its settlement system, even if both convert one to one to physical currency.
- No limits in using CNH for payments or in converting to foreign currency or in who holds it.
- Only Chinese can use CNY, needed to invest in domestic assets and source of resources to invest abroad.
- Conversion is one to one but there are many limits to arbitrage:
  - $\rightarrow$ quotas for FDI and investment,
  - $\rightarrow$ quotas for household transfers
  - $\rightarrow$ firms can transfer CNH revenues to CNY against export invoices.
  - $\rightarrow$ some banks can borrow/lend in CNY/CNH with limits.

THE INSTRUMENT FOR EXOGENOUS SHOCKS TO DEMAND

Histogram of e



Instrument for deviations from parity



Other currencies: CNY, USD, HKD

- CNY monetary policy
  - → Combination of interest rates, money supply, and other tools. See Jermann, Yue and others.
  - → Ratio of CNY to CNH M1 is approx 200
  - → CNY policy focussed on onshore goals, does not respond to e.
- USD exchange rate
  - → With CNH is $\hat{e}$, "managed" by the PBoC to ensure smooth movement.
  - → Central parity rate: set $\bar{e}$ at start of day so that $|\hat{e} - \bar{e}| < 0.02$.
  - → In 2015-17, band was 1%, and before that, more of a peg.
  - → How it happens? Freely sell CNH for USD. While for CNY, sell my CNY for CNH first.
- HKD
  - → Currency of Hong Kong, completely separate, but also pegged to USD

LIQUIDITY POLICIES: DISCOUNT WINDOW

- Marginal benefit of innovation in equilibrium:

$$-\phi'(M/D) = (1 - \Psi_-(\theta))(R^z - R^m)\Omega(\bar{\omega})$$

- Financial innovation shock—lower $\Omega(\bar{\omega})$ or higher $\Psi_-(\theta)$—lowers the marginal benefit of offshore reserves, shift money multiplier D/M, leads to e deviating from peg. Another money demand shock, just like domestic and foreign deposit demand shocks. Goodhart's law.

- Liquidity policies: restrict access to the lending facility (higher R^z or higher ρ) raise the marginal benefit of reserves ($-\phi'(M/D)$ higher), offset financial innovation