Information Flow between Forward and Spot Markets: Evidence from the Chinese Renminbi

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Background and Motivations

- Two main strands of empirical research in international finance:

  - Uncovered interest parity (the interest rate differential) and simple risk-neutral market efficiency of FX (spot) market

  - FX spot rate predictability (by forward rates)/(plus covered interest rate parity) unbiased forward rate hypothesis (also FX forward market efficiency)

Background and Motivations

- The main underlying hypotheses:

  (speculative) Market efficiency (under risk neutrality and rational expectations)

  ↓

  Uncovered interest parity (plus covered interest rate parity)

  ↓

  Unbiased forward rate (UFR) hypothesis

$$f_{t,\tau} = E(s_{t+\tau} \mid \Omega_t), \quad \tau > 0$$

Background and Motivations

- UIP: If the interest rate differential is a constant, then the (future)FX spot rate is unpredictable and the spot rate follows a random walk (martingale)

- Mixed evidence on UFR in the literature.

- The question is essentially whether the forward exchange rate contains useful information about the future path of the spot exchange rate

Background and Motivations

- On July 21, 2005, the abolition of decade-long fixed RMB/$ nominal exchange rate; accelerated internationalization of the RMB since summer 2009

- trading band allowing the RMB to move up or down daily by 0.3% (2005); widened to 0.5% (2010), 1% (2012), and most recently to 2% (2014)

- more market-based RMB exchange rates calls for better understanding of RMB exchange rate movements under the new regime

Contributions

- More thoroughly examine the market efficiency of the RMB-dollar market by more adequately allowing for potentially multiple structural breaks due to significant foreign exchange policy changes in China since 2005 (including a proposed new econometric method)

- Exploit the information of term structure of RMB/$ forward rates; both in sample and out of sample perspectives; importance of additional information from longer maturity (i.e., 6-month and 12-month) forward rates in driving the spot rate movement

Main Empirical Findings

- The forward rate is an unbiased predictor of the future spot rate also holds to a large extent in the Chinese currency market

- Forward rates with either shorter or longer maturities can substantially explain the in-sample variation of the spot exchange rate while only the forward rate with a shorter maturity is useful out-of-sample.

- The market is subject to structural breaks; market dynamics change over time

Literature Review

- Earliest studies' model testing UFR: regress the log of the future spot rate, s_{t+1}, on the log of the current forward rate, f_t ; Generally supportive evidence

- Follow-up studies' model testing UFR : regress Δs_{t+1} on Δf_t ; better allow for time series properties; often find negative evidence

- More recent studies' model testing UFR: incorporating long run relationship (cointegration); find more evidence consistent with UFR (Clarida and Taylor, 1997)

Literature Review

- Some relevant studies on the interaction between RMB NDF and onshore CNY
  - Gu and McNelis, 2013: the role of NDF to pass the information of JPY/$ volatility to the RMB spot market
  - Zhao, de Haan, Scholtens, & Yang, 2013
  - Ding, Tse, & Williams, 2014: positive, in sample

- Some relevant studies on CNH and CNY
  - Cheung and Rime, 2014; Ding, Tse, & Williams, 2014

Econometric Framework

- **Vector error correction model (VECM)**

$$\Delta Y_t = \alpha\beta' Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \mu + \varepsilon_t \quad (t = 1, \ldots, T) \qquad (2)$$

- **Competing models:**
  - VECR (with unity coefficient restrictions imposed)
  - VAR in first differences (VARD)
  - Random walk (RW)
  - Forward premium regression (FPR)

    $SPOT_t - SPOT_{t-k} = \alpha + \beta^*(f_{k,t-k} - SPOT_{t-k}) + \varepsilon_t,$
  - Forward rate model (FR)

Econometric Framework

- Diebold and Mariano's (1995) forecast evaluation test: forecasts from *A* and B are equal Comparing mean squared forecast errors (MSFE) of *A* vs. *B* models

- Forecast encompassing tests

Data

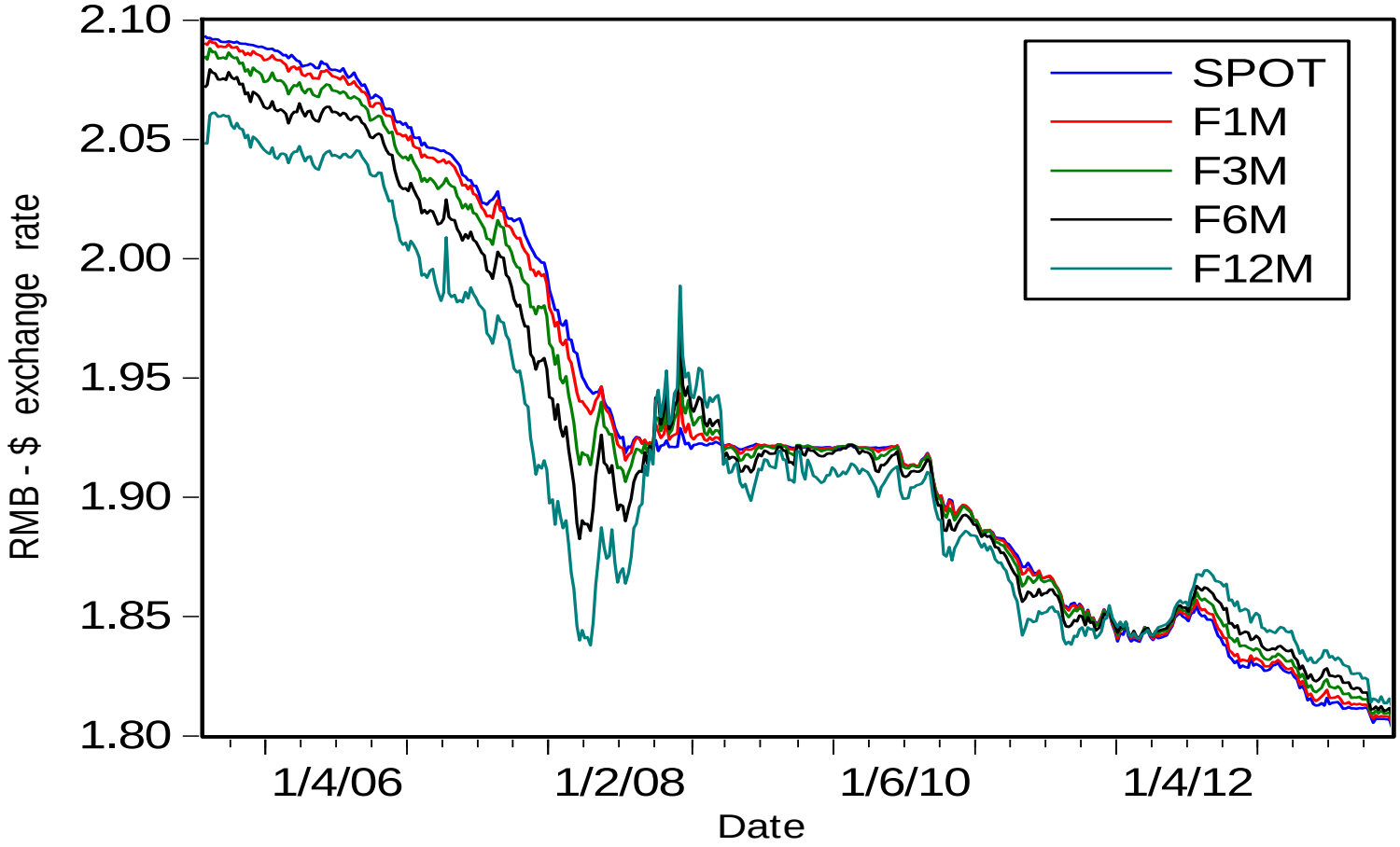
- Chinese RMB-U.S. dollar exchange rate

  Weekly, July 21, 2005 to December 15, 2013

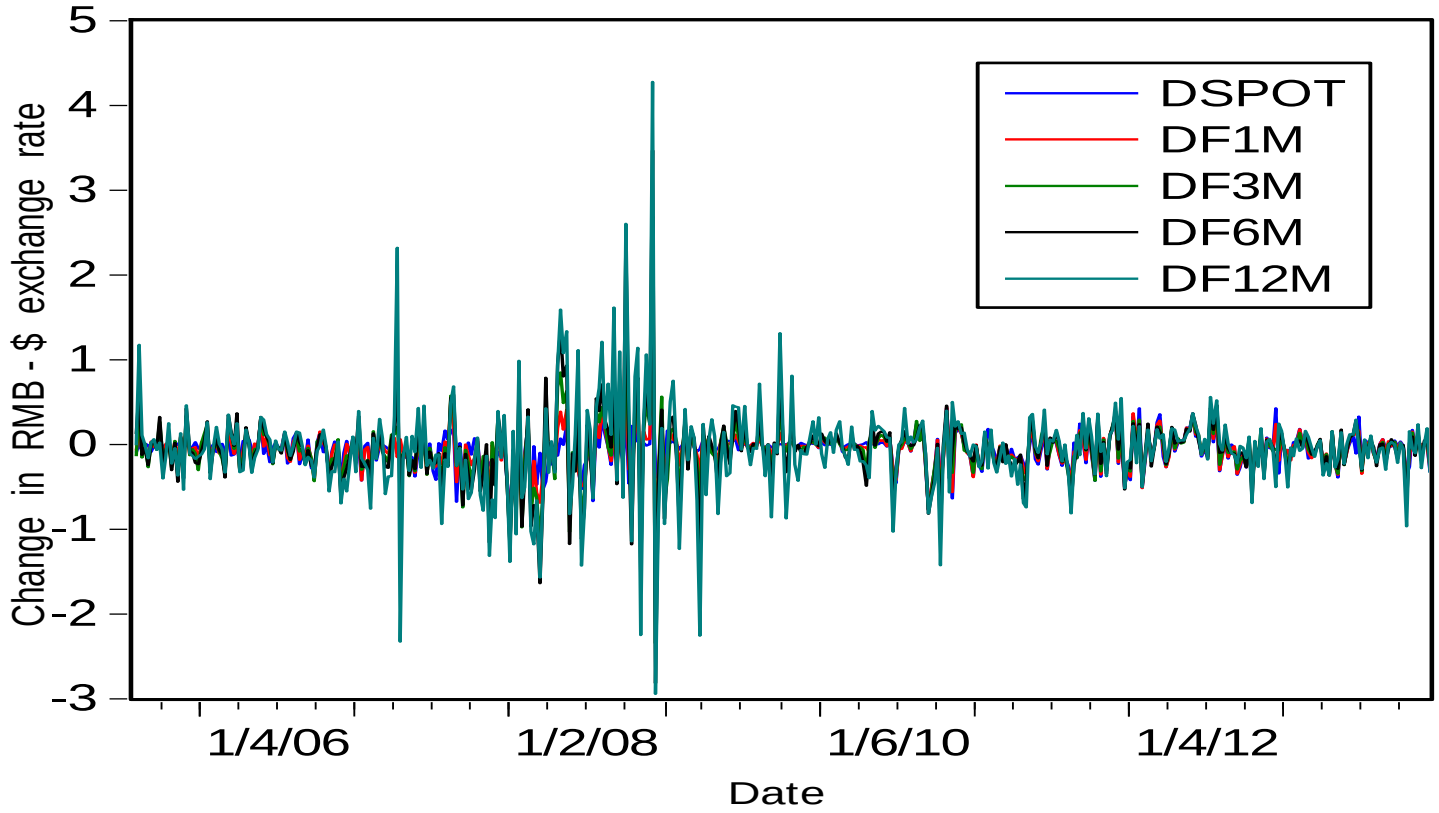
Source: Datastream

$$Y_t = (SPOT_t, F1M_t, F3M_t, F6M_t, F12M_t)$$

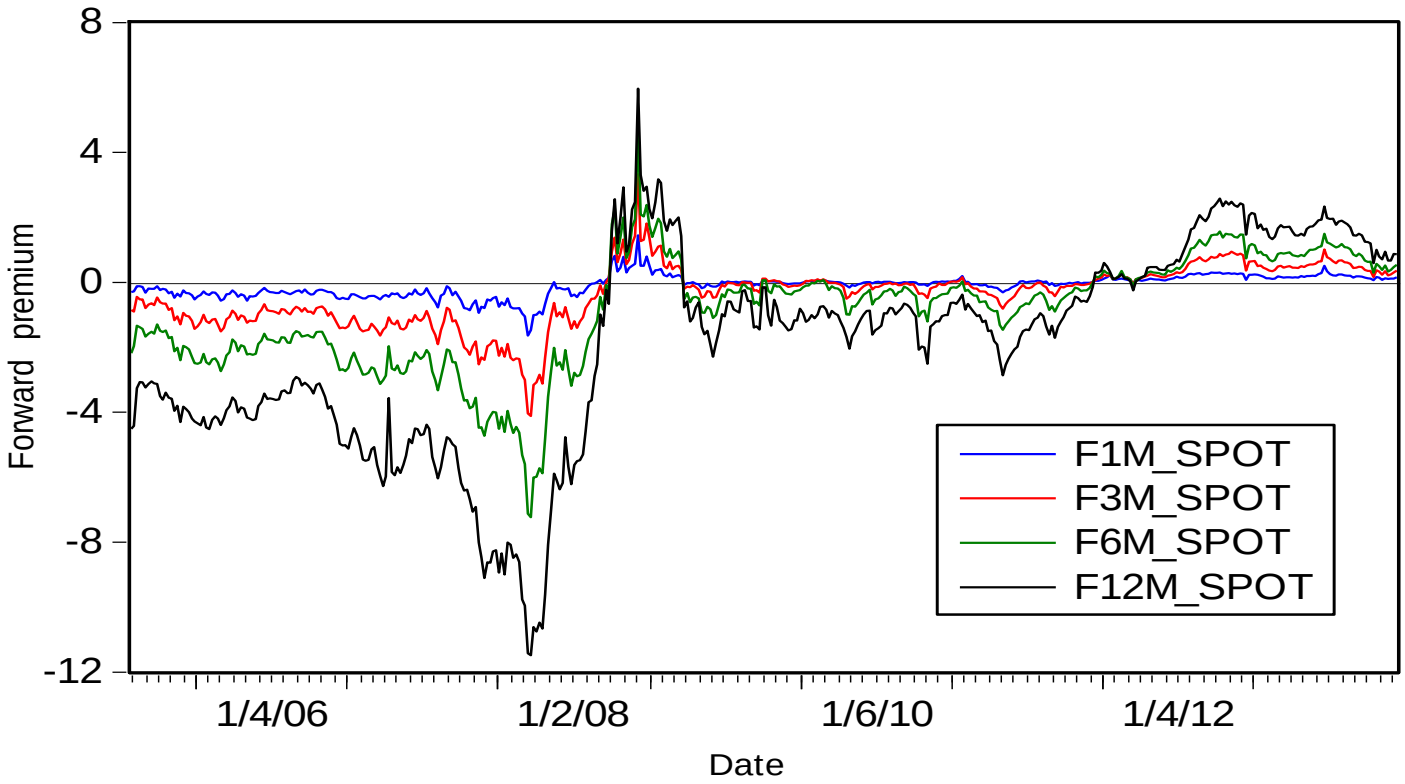
RMB-dollar exchange rate (log levels)



Change in RMB-dollar exchange rate (%)



Forward Premia (%)



Results of Unit Root Tests

	Lag determined by AIC		Lag determined by BIC	
	ADF	Lag order	ADF	Lag order
SPOT	−1.267	2	−1.422	0
F1M	−1.339	0	−1.339	0
F3M	−1.289	0	−1.289	0
F6M	−1.306	1	−1.291	0
F12M	−1.474	0	−1.474	0
(F1M – SPOT)	−2.377	4	−2.654	2
(F3M – SPOT)	−2.124	2	−2.305	1
(F6M – SPOT)	−1.875	1	−2.102	0
(F12M – SPOT)	−1.417	1	−1.561	0

The Determination of Cointegration Ranks (*r*)

Ho:	Trace	Critical value (95%)	λ-max	Critical value (95%)	Ho:	AIC	BIC
$r = 0$	203.081	68.52	74.577	33.46	$r = 0$	−67.226	−66.736
$r \leq 1$	128.503	47.21	49.040	27.07	$r = 1$	−67.357	−66.971
$r \leq 2$	79.463	29.68	43.607	20.97	$r = 2$	−67.437	−67.127
$r \leq 3$	35.856	15.41	34.074	14.07	$r = 3$	−67.515	−67.194
$r \leq 4$	**1.782**	3.76	**1.782**	3.76	$r = 4$	**−67.579**	**−67.236**
					$r = 5$	−67.579	−67.226

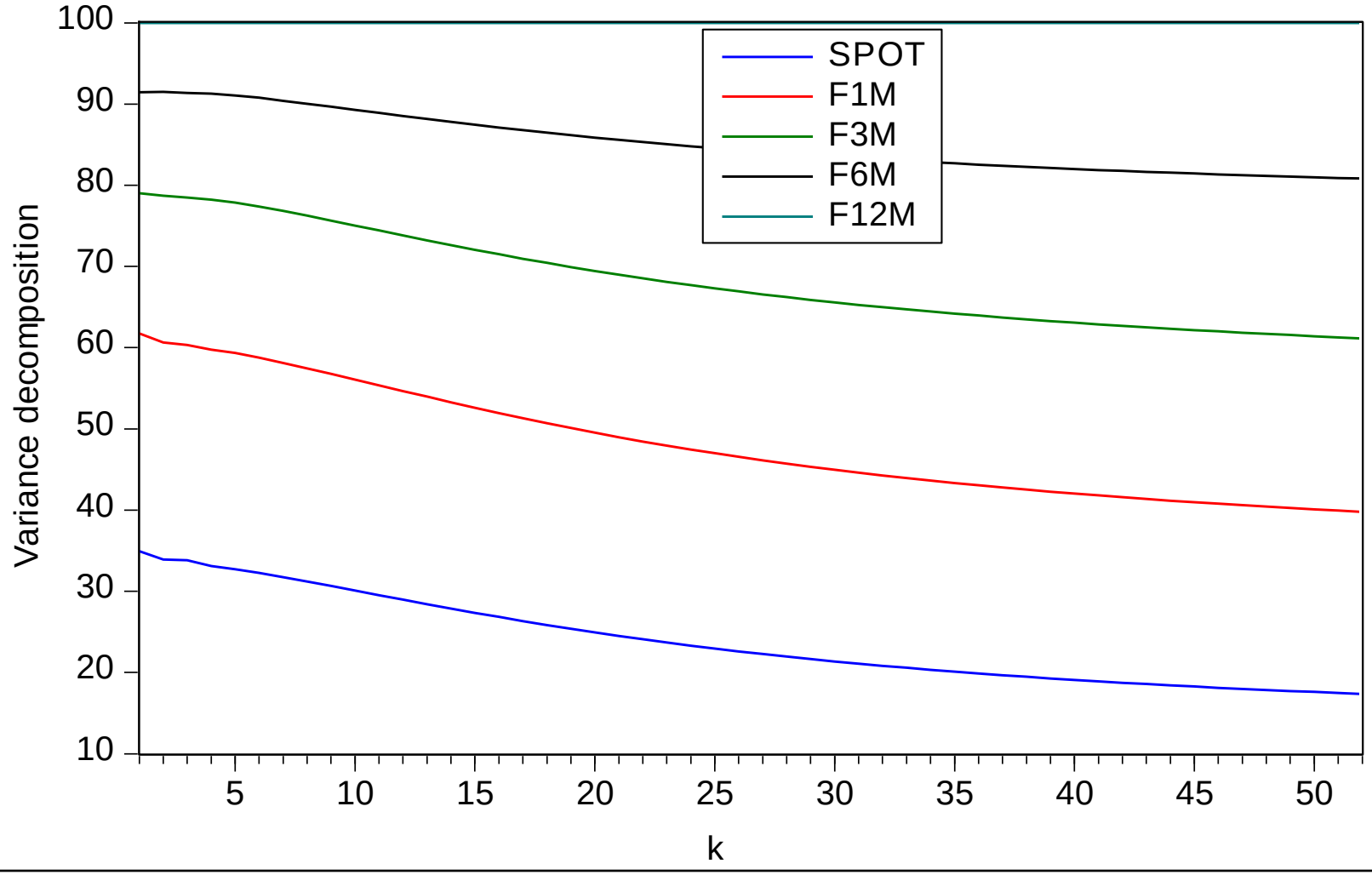
Parameter Estimation Results for the Vector Error Correction Model

Explanatory variable	Individual model of VECM $\Delta SPOT_t$	$\Delta F1M_t$	$\Delta F3M_t$	$\Delta F6M_t$	$\Delta F12M_t$	Log likelihood
			Panel A. Full sample 07/25/2005-12/11/2013			
μ	-0.009^{***}	-0.005^{**}	-0.002	0.001	0.006	14768.73
α_1	0.027	0.309^{**}	0.226	0.151	-0.462	
α_2	0.190^{***}	0.026	-0.207^{*}	-0.272^{*}	-0.206	
α_3	-0.000	-0.000	0.000	0.001^{*}	0.001^{**}	
α_4	-0.231^{***}	-0.186^{**}	-0.186^{*}	-0.159	0.063	
CI vector 1	$SPOT_{t-1} - 1.454F1M_{t-1} + 0.492F3M_{t-1} - 0.084F6M_{t-1} + 0.046F12M_{t-1}$					
CI vector 2	$SPOT_{t-1} - 2.680F1M_{t-1} + 2.232F3M_{t-1} - 0.447F6M_{t-1} - 0.099F12M_{t-1}$					
CI vector 3	$SPOT_{t-1} - 5.558F1M_{t-1} + 13.305F3M_{t-1} - 9.602F6M_{t-1} + 1.831F12M_{t-1}$					
CI vector 4	$SPOT_{t-1} - 1.789F1M_{t-1} + 0.339F3M_{t-1} + 0.894F6M_{t-1} - 0.457F12M_{t-1}$					
			Panel B. Sub-sample 07/25/2005-02/20/2008			
μ	-0.027	-0.036^{*}	-0.038	-0.039	-0.094^{**}	4568.32
α_1	0.204	0.943^{***}	0.911^{**}	0.648	-0.887	
α_2	0.080^{***}	0.055^{**}	0.029	0.038	0.067	
α_3	-0.011	0.063	0.086	0.084	0.258	
α_4	-0.274^{**}	-0.303^{**}	-0.365^{**}	-1.417	-0.134	
CI vector 1	$SPOT_{t-1} - 1.688F1M_{t-1} + 0.935F3M_{t-1} - 0.311F6M_{t-1} + 0.060F12M_{t-1}$					
CI vector 2	$SPOT_{t-1} - 5.966F1M_{t-1} + 7.376F3M_{t-1} - 2.283F6M_{t-1} - 0.006F12M_{t-1}$					
CI vector 3	$SPOT_{t-1} + 0.176F1M_{t-1} - 3.960F3M_{t-1} + 4.362F6M_{t-1} - 1.460F12M_{t-1}$					
CI vector 4	$SPOT_{t-1} - 3.351F1M_{t-1} + 3.744F3M_{t-1} - 1.441F6M_{t-1} + 0.027F12M_{t-1}$					
			Panel C. Sub-sample 12/31/2009-12/11/2013			
μ	-0.004	0.001	0.010	0.023^{***}	0.046^{***}	9336.60
α_1	-0.145	0.127	0.269	0.182	-0.020	
α_2	-0.048	0.056	-0.186	-0.146	0.608	
α_3	0.028	-0.006	-0.072^{*}	-0.160^{***}	-0.284^{***}	
α_4	0.004	0.005	0.005	-0.003	0.030	
CI vector 1	$SPOT_{t-1} - 0.918F1M_{t-1} - 0.360F3M_{t-1} + 0.224F6M_{t-1} + 0.056F12M_{t-1}$					
CI vector 2	$SPOT_{t-1} - 2.041F1M_{t-1} + 1.422F3M_{t-1} - 0.384F6M_{t-1} + 0.002F12M_{t-1}$					
CI vector 3	$SPOT_{t-1} - 0.329F1M_{t-1} - 1.541F3M_{t-1} + 0.538F6M_{t-1} + 0.414F12M_{t-1}$					
CI vector 4	$SPOT_{t-1} + 0.372F1M_{t-1} - 7.631F3M_{t-1} + 8.884F6M_{t-1} - 2.671F12M_{t-1}$					

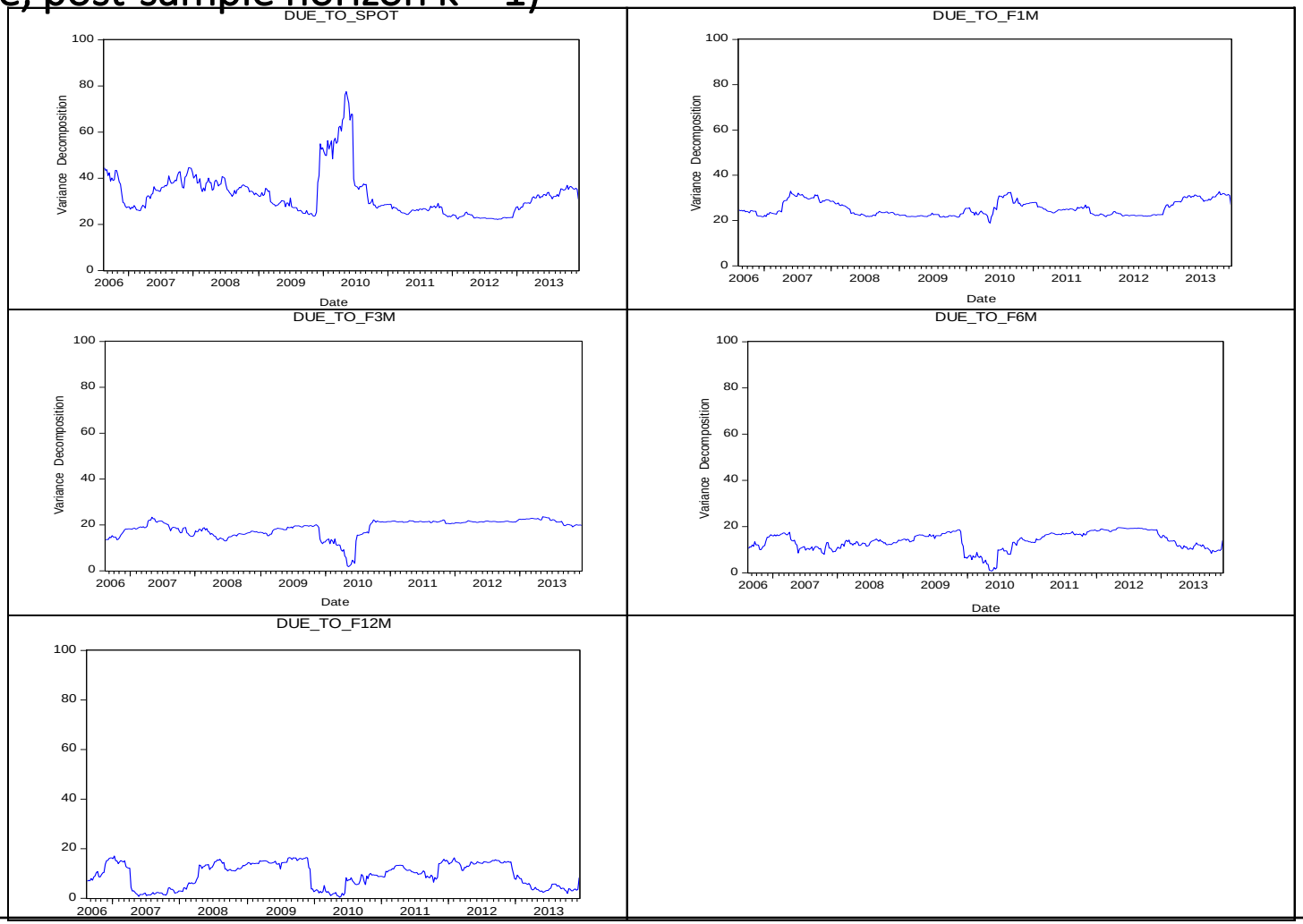
Forecast Error Variance Decompositions of the Spot rate

Horizon (week)	SPOT	F1M	F3M	F6M	F12M
1	34.93	26.82	17.29	12.42	8.54
	(32.58, 37.64)	(25.53, 28.50)	(16.39, 18.30)	(10.69, 13.77)	(6.18, 10.42)
4	33.10	26.66	18.46	13.07	8.72
	(29.40, 37.50)	(25.03, 28.74)	(17.01, 19.67)	(10.80, 14.98)	(5.47, 11.28)
13	28.42	25.54	19.26	14.95	11.84
	(23.44, 34.72)	(23.73, 27.80)	(16.98, 20.94)	(11.89, 17.41)	(8.00, 15.00)
26	22.60	23.95	20.37	17.42	15.65
	(17.86, 30.94)	(21.97, 26.51)	(17.79, 22.13)	(13.59, 19.74)	(10.59, 18.88)
52	17.36	22.42	21.36	19.67	19.18
	(13.36, 27.73)	(20.33, 26.12)	(18.48, 23.20)	(14.71, 21.94)	(12.54, 23.02)

Forecast errors variance decompositions of the spot rate (full sample)



Forecast error variance decompositions of the spot rate (1-year rolling sample, post-sample horizon k = 1)



Out-of-sample forecasts from the rolling estimation

k	VECM	VECR	VARD	RW	FPR	FR
			Panel A. Root mean squared forecast errors (RMSFE)			
1	0.0027	0.0026	0.0024	0.0022		
4	0.0062	0.0061	0.0052	0.0053	0.0047	0.0049
13	0.0154	0.0161	0.0114	0.0136	0.0125	0.0104
26	0.0687	0.0686	0.0229	0.0252	0.0251	0.0181
			Panel B. DM equality test statistics			
1 (vs. RW)	4.947^{***}	4.309^{***}	3.004^{***}			
4 (vs. RW)	2.457^{**}	1.938^{*}	0.276		-1.655^{*}	-1.123
4 (vs. FR)	3.909^{***}	3.903^{**}	0.916	1.123	-1.457	

Out-of-sample Forecasts from the Recursive Estimation

k	VECM	VECR	VARD	RW	FPR	FR
			Panel A. Root mean squared forecast errors (RMSFE)			
1	0.0021	0.0021	0.0021	0.0022		
4	0.0046	0.0046	0.0046	0.0053	0.0044	0.0049
13	0.0104	0.0107	0.0104	0.0136	0.0102	0.0104
26	0.0235	0.0244	0.0189	0.0252	0.0180	0.0181
			Panel B. DM equality test statistics			
1 (vs. RW)	−0.060	−0.057	−0.617			
4 (vs. RW)	-1.956^{*}	-1.824^{*}	-2.556^{**}		-2.619^{***}	1.123
4 (vs. FR)	−1.299	−1.395	−0.856	1.123	-2.753^{***}	
			Panel C. Encompassing test statistics			
1 (vs. RW)	60.925^{***}	51.577^{***}	48.102^{***}			
4 (vs. RW)	198.586^{***}	171.262^{***}	138.971^{***}		163.400^{***}	3.100^{***}
4 (vs. FR)	108.824^{***}	76.046^{***}	162.178^{***}	2.180^{**}	120.480^{***}	

Structural Break Tests in Cointegration Models Using the Model Selection Approach (AIC)

Type of breaks	Number of breaks			
	No break	One break	Two breaks	Three breaks
Break in μ only				
Value of BIC	−67.579	−67.613	−67.712	−67.754
1st break date		03/19/2008	04/16/2008	04/16/2008
2nd break date			12/03/2008	12/03/2008
3rd break date				06/10/2009
Break in μ and Γ				
Value of BIC	−67.579	−67.637	−68.334	−68.495
1st break date		12/03/2008	07/23/2008	04/23/2008
2nd break date			12/24/2008	10/01/2008
3rd break date				03/25/2009
Break in all coef.				
Value of BIC	−67.579	−67.685	−68.674	**−69.266**
1st break date		10/08/2008	07/23/2008	02/20/2008
2nd break date			12/24/2008	07/23/2008
3rd break date				12/24/2008

Summary Statistics of Dollar-based RMB Carry Trade Returns

Summary Statistics	Simple strategy	Model based strategies VECM	VECR	VARD	FPR
		Panel A. 1-Month Forward Market			
Ave. Ret.	1.369***	1.758***	0.858***	1.790***	2.003***
Std. Dev.	5.740	3.897	3.308	4.131	4.072
Sharpe Ratio	0.238	0.451	0.259	0.433	0.492
Skewness	0.082	1.496	0.625	0.653	1.253
		Panel B. 3-Month Forward Market			
Ave. Ret.	0.213	1.194***	0.568***	1.347***	0.939***
Std. Dev.	4.184	2.598	1.719	2.754	2.344
Sharpe Ratio	0.051	0.460	0.330	0.489	0.401
Skewness	0.285	1.813	0.625	1.840	1.974
		Panel C. 6-Month Forward Market			
Ave. Ret.	0.082	1.002***	0.617***	1.083***	1.008***
Std. Dev.	3.667	2.026	1.615	2.123	1.986
Sharpe Ratio	0.022	0.494	0.382	0.510	0.508
Skewness	0.136	1.581	2.124	1.840	1.505

Concluding Remarks

- UFR hypothesis largely holds for RMB even under the managed floating exchange rate regime. Forward rates are useful to predict the spot rate. Gains from exploiting RMB predictability are statistically significant but probably economically moderate