Market Efficiency of Ruble-RMB Exchange Rates: Long-run Equilibrium, VAR Estimates and Granger Causality Tests

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ABSTRACT: China-Russia Ruble-RMB currency swap agreement may have long-run and short-run exchange risks for China. This paper mainly aims to investigate the informational efficiency of Ruble-RMB foreign exchange market. Methods used include the ADF and PP tests, the Perron test, the Johansen trace and Engle-Granger tests, vector autoregressive model and Granger causality test. Cointegration does not exist between the exchange rates of Ruble, dollar, euro, yen and pound to RMB, suggesting long-run informationally efficient. We constructed a first-differenced VAR for these exchange rates. We find a unidirectional Granger causality from euro-RMB exchange rate to Ruble-RMB exchange rate, suggesting short-run informationally inefficient. Hence, the Ruble-RMB foreign exchange market violates the efficient market hypothesis (EMH) and the Ruble-RMB currency swaps may not receive diversification benefits in the short run.
KEYWORD: Cointegration; exchange rate; efficient market hypothesis; Granger causality; structural break; vector autoregressive model

1 INTRODUCTION

China and Russia signed an agreement for Ruble-RMB currency swaps in mid-October 2014, with a total value of RMB 150 billion/RUB 815 billion. The agreement is for three years with a choice for the eventual extension. Ruble devalued by 32.5% from 20 October 2014-20 December, compared to RMB (China Foreign Exchange 2014). Hence, a high exchange rate uncertainty would exist if China has signed the swap agreement. However, we must obtain empirical evidence for the argument. Exchange rates of RMB against the world main currencies including US dollar, euro, Japanese yen and pound may have a long-run equilibrium.

Cointegration and Granger causality suggest the long-run equilibrium and the short-run dynamics, respectively (Engle & Granger 1987, Granger 1980). Cointegration and Granger causality violate the efficient market hypothesis (EMH) (Granger 1981). EMH implies that investors would achieve diversification benefits (Fama 1970). Therefore, the paper aims to investigate the information efficiency of Ruble-RMB foreign exchange market. Empirical evidence is implicative for examination of Ruble-RMB currency swap risks.

2 METHODS AND DATA

The Johansen trace method and Engle-Granger technique are used to test for long-run equilibrium represented by cointegration (Engle & Granger 1987, Johansen 1991). We test for unit roots using the ADF and PP tests (Dickey & Fuller 1979, Phillips & Perron 1988). We test for a structural break using the Perron test (Model C) (Perron 1997). Cointegration suggests presence of an error-correction model (ECM):

$$\Delta y_t = \lambda + \sum_{k=1}^{m} \pi_k \Delta y_{t-k} + \sum_{k=1}^{m} \xi_k \Delta x_{t-k} + \delta z_{t-1} + \varepsilon_t \quad (1)$$

Where y_t, x_t are $I(1)$ time-series variables. z_{t-1} is the error-correction (EC) term representing a long-run equilibrium. However, removing the EC term from an ECM, a short-run vector autoregression model (VAR) is still valid where there is no cointegration (Engle & Granger 1987). In addition, Granger causality (Granger 1969) from x_t to y_t **e**xists if all

$$\xi_k = 0 \quad (2)$$

Where ξ_k's are the coefficients of lagged $\mathbf{x}_t$ in the ECM. Wald-χ^2 statistics are used to drive the Granger causality test.

Exchange rates comprise those of Ruble to RMB (*RUB*) and US dollar to RMB (*DOLLAR*). They also include those of the euro to RMB (*EURO*), Japanese yen to RMB (*YEN*), and pound to RMB *(POUND*). Excluding weekends and holidays, data has 963 daily observations from 4 January 2011 to December 24, 2014 (China Foreign Exchange 2014).

Table 1. Statistics for the exchange rate of one hundred foreign currency to RMB.

Variable	*DOLLAR*	*EURO*	*YEN*	*POUND*	*RUB*
Mean	627.80	837.99	7.05	1004.89	19.55
Median	628.60	829.65	7.41	1002.85	19.84
Maximum	663.49	964.45	8.37	1085.18	23.77
Minimum	609.30	748.48	5.05	915.62	8.82
Standard Deviation	13.45	45.00	1.01	34.74	2.44
Skewness	0.72	0.80	(0.17)	(0.02)	(0.98)
Kurtosis	2.70	3.14	1.38	2.37	5.02
Jarque-Bera	85.75	102.56	109.63	16.03	318.42
p-value	0.00	0.00	0.00	0.00	0.00

3 EMPIRICAL RESULTS

The five time-series variables each contain a unit root (Table 2, Table 3). Both the trace and Engle-Granger tests suggest no cointegration for these series (Table 4, Table 5). So we estimated a first-differenced VAR. *EURO* Granger caused *RUB* at the 5% confidence level but not vice versa.

Table 2. Unit root tests.

The log of a variable	Level	*p*	*k*	First difference	*p*	*k*
	ADF					
DOLLAR	-2.56	0.30	3	-16.19	0.00	3
EURO	-1.69	0.76	3	-11.10	0.00	6
YEN	-1.83	0.69	3	-9.10	0.00	9
POUND	-1.91	0.65	3	-11.20	0.00	6
RUB	1.49	1.00	17	-4.50	0.00	21
	PP					
DOLLAR	-2.21	0.48	15	-29.87	0.00	15
EURO	-1.72	0.74	3	-32.90	0.00	3
YEN	-1.66	0.77	3	-29.90	0.00	3
POUND	-1.90	0.65	5	-32.70	0.00	4
RUB	0.18	0.99	25	-28.40	0.00	26

Notes: *k* denotes lag length. For the ADF tests, *k* was chosen by the modified AIC. For the PP test, *k* was selected by the Newey-West method (Newey & West 1987). *k* was selected between 3 and 25 following (Ng & Perron 1995). *p* (-value) is in (MacKinnon 1996). Tests contained the trend and constant (Hamilton 1994, Hendry & Juselius 2000).

Table 3. Perron structural break tests.

The log of a variable	α	Standard Error	t^*_α	*p*	Lag	T_b
DOLLAR	0.99	0.00	206.41	0.00	11	283
EURO	0.98	0.01	152.46	0.00	8	411
YEN	0.99	0.01	151.27	0.00	10	493
POUND	0.99	0.01	161.90	0.00	8	631
RUB	0.97	0.01	100.45	0.00	10	897

Estimates were for α on y_{t-1}. *k* is the lag order. Tests fixed the *k* between 2 and 12 according to (Ng & Perron 1995). *t*-statistic represented that for the coefficient of the *k*th lagged term. *t*-statistic exceeded or equaled to 1.8 in terms of absolute value according to (Perron 1989). The fraction λ was 0.05; therefore, regressions were executed from T = 48 to 915 (T is the sample size). T_b was the possible break point detected. The critical values for T = 100 were -6.07, -5.48, and -5.17 at the 1%, 5%, and 10% confidence levels, respectively (Table 1, Panel d in (Perron 1997)).

Table 4. Engle-Granger cointegration tests.

The log of the dependent variable	Z_α	*p*-value*
DOLLAR	-16.2	0.67
EURO	-12.20	0.85
YEN	-9.11	0.94
POUND	-12.9	0.82
RUB	-2.6	1.00

Z_α is the test statistic. Null hypothesis: the series were not cointegrated. Test equations contained the trend and constant. The lag lengths were chosen using modified AIC. **p*-value in (MacKinnon 1996).

Table 5. Johansen multivariate cointegration trace tests.

r	Lag	Trace	*p**	5% O-L	5% C&L	JB	Adj. Q-statistic (lag, *p*-value)
0	4	69.7	0.52	88.8	90.5	141568 (0.00)	39(5, 0.74)
≤1		44.4	0.68	63.9	65.1		
≤2		22.2	0.91	42.9	43.7		
0	8	93.2	0.02	88.8	92.3	86499 (0.00)	47(9, 0.43)
≤1		46.0	0.60	63.9	66.4		
≤2		27.5	0.65	42.9	44.6		
0	14	79.4	0.20	88.8	95.1	71512 (0.00)	44(15, 0.56)
≤1		44.6	0.67	63.9	68.4		
≤2		27.0	0.68	42.9	45.9		
0	20	83.1	0.12	88.8	98.0	47453 (0.09)	70(21,0.01)
≤1		41.4	0.80	63.9	70.5		
≤2		24.4	0.82	42.9	47.4		

5% O-L denotes 5% asymptotical critical value (Osterwald-Lenum 1992). C&L is 5% Cheung-Lai finite-sample critical value (Cheung & Lai 1993). *p (-value) in (MacKinnon, Haug & Michelis 1999). JB and Adj. Q-statistic denotes multivariate Jarque-Bera normality statistic and Portmanteau autocorrelation test adjusted *Q*-statistic, respectively.

Table 6. VAR estimates and Granger causality tests.

Variable in the log and first difference	Lagged term	Estimates	*t*-statistic	Granger causality (χ^2, *p*-value)
Dependent: *RUB*				
RUB	1	0.03	0.88	
	2	0.02	0.57	
	3	-0.03	-0.77	
	4	-0.06	-1.74	
	5	-0.15	-3.66	
	6	-0.12	-2.90	
	7	-0.03	-0.56	
	8	0.12	2.53	
	9	0.15	3.18	
	10	0.17	3.72	
DOLLAR	1	0.33	0.63	3.35, 0.97
	2	0.00	-0.01	
	3	-0.15	-0.28	
	4	0.19	0.35	
	5	0.35	0.65	
	6	0.09	0.17	
	7	0.32	0.59	
	8	-0.64	-1.20	
	9	0.34	0.63	
	10	0.27	0.53	
EURO	1	0.13	1.52	20.4, 0.03
	2	-0.01	-0.11	
	3	0.08	0.96	
	4	0.04	0.51	
	5	0.15	1.68	
	6	0.25	2.89	
	7	0.08	0.86	
	8	-0.10	-1.10	
	9	0.10	1.13	
	10	-0.16	-1.77	
YEN	1	0.04	0.74	13, 0.22
	2	-0.02	-0.38	
	3	0.08	1.42	
	4	-0.07	-1.23	
	5	-0.01	-0.17	
	6	0.06	1.02	
	7	0.08	1.35	
	8	-0.01	-0.11	
	9	0.15	2.51	
	10	0.00	0.02	
POUND	1	0.05	0.58	6.54, 0.76
	2	-0.03	-0.27	
	3	-0.03	-0.37	
	4	-0.06	-0.58	
	5	-0.01	-0.07	
	6	-0.04	-0.47	
	7	0.08	0.81	
	8	-0.18	-1.89	
	9	-0.10	-1.08	
	10	-0.05	-0.50	
Constant		0.00	-1.14	

Lags were chosen using AIC. *R*-squared=0.11. Adj. *R*-squared=0.06. *F*-statistic=2.25. Akaike AIC=-6.34. Schwarz SC=-6.08. Autocorrelation LM statistic=32 (lag=1, *p*-value=0.15).

4 CONCLUDING REMARKS

China has increased the number of its currency swap partners. Recent RMB-Ruble swap agreement suffers a considerable Ruble devaluation, showing existence of risks for the currency swaps. The risk arises from market efficiency across international exchange rates. Cointegration analysis does not suggest a long-run equilibrium between the exchange rates of the Ruble, dollar, euro, yen and pound to RMB. Despite this, we find Granger causality from euro-RMB exchange rate to Ruble-RMB exchange rate, which shows a violation of EMH. Therefore, Ruble-RMB swap risks exist for China at least in the short run.

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