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Research on the correlation between offshore and onshore RMB spot exchange rates based on VAR-ECM model

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Abstract: *This paper selects the daily data of offshore and onshore RMB spot exchange rates from 2012 to 2022 to establish a first-order VAR model to study the correlation between offshore and onshore RMB spot exchange rates. On this basis, an ECM model is established to further analyze the error correction term of the previous period and the impact of the fluctuation of the other party in the same period.Through empirical research, it is found that there is a cointegration relationship between the spot exchange rate of offshore RMB and onshore RMB and they are Granger causality. On the whole,there is a positive relationship between them. Specifically, the offshore and onshore RMB spot exchange rates have a certain time lag in the transmission of market information, which will lead to the emergence of arbitrage opportunities. Through the analysis of variance decomposition and error correction model results, it is found that the impact of the onshore RMB market on the offshore RMB spot exchange rate fluctuation is close to 50%, while the offshore impact on the onshore RMB exchange rate fluctuation is less than 30%, indicating that the onshore RMB is currently in the dominant positionthe of exchange rate influence mechanism.Based on this conclusion, it is suggested that government pay attention to the impact of onshore RMB market, continuously improve the order of the onshore RMB market, promote the healthy development of offshore and onshore RMB markets, thus promoting the internationalization of the RMB.*

Keywords: *RMB exchange rate; VAR-ECM model; offshore market; onshore market*

1. Introduction

With the deepening of the internationalization of RMB, the issue of the RMB exchange rate has also attracted more and more attention. Different from developed countries in Europe and the United States, the onshore exchange rate of RMB is strictly controlled, and the current degree of free convertibility needs to be further strengthened, which also causes the inconsistency between the offshore and onshore exchange rates of RMB. In this context, it is of great significance to study the relationship between the offshore exchange rate and the onshore exchange rate of RMB, which plays a positive role in promoting international trade, promoting the internationalization of RMB, and guiding foreign exchange transactions.

Hong Kong has become the largest offshore RMB market [1], and the research on offshore RMB mainly focuses on it. Based on this, this paper selects USD /CNH to represent the spot exchange rate of offshore RMB, and matches it, selects USD/CNY as the spot exchange rate of onshore RMB,.And then we study the relationship between them by establishing a VAR - ECM model.

2. Data description and descriptive analysis

2.1. Data description

This paper selects the onshore RMB spot exchange rate and the offshore RMB spot exchange rate as the research objects, and selects the data of USD/CNY and US SD/CNH for empirical analysis.

Considering the differences of the trading time between offshore RMB market and onshore RMB market,this paper chooses the sample retaining the trading days in common, and selects the closing price data for research to maintain the consistency of data.

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The original data comes from the Wind database. After the above processing, the final effective sample size is 2379, and the time span is from May 2, 2012 to February 25, 2022.

For convenience, this article uses USDCNY to represent the spot exchange rate of onshore RMB, and USDCNH to represent the spot exchange rate of offshore RMB.

2.2. Descriptive analysis

In the past ten years, the average onshore exchange rate of USD/CNY was 6.524847, while the average offshore exchange rate was 6.52756. In contrast, the offshore exchange rate was about 26 basis points higher than the onshore exchange rate. The skewness of both the offshore exchange rate and the onshore exchange rate is positive, showing a right-skewed distribution characteristic, indicating that the probability of occurrence of the maximum value of the US dollar to RMB exchange rate at the right end is greater than that of the minimum value of the exchange rate at the left end The standard deviation of USDCNH is larger than that of USDCNY , indicating that the fluctuation of the exchange rate of offshore RMB is larger than that of onshore RMB exchange rate. The specific descriptive statistics are shown in Table 1.

Table 1: Descriptive Statistics.

vars	n	mean	sd	median	min	max	skew	kurtosis
USDCNH	2379	6.52756	0.306499	6.4789	6.0194	7.1947	0.292876	-1.12481
USDCNY	2379	6.524947	0.305342	6.4733	6.0412	7.1785	0.316544	-1.13967

Figure 1 shows the time series chart of the offshore and onshore RMB spot exchange rate. It can be seen from the figure that the trends of the two are basically the same, indicating that the offshore market and the onshore market are generally consistent.

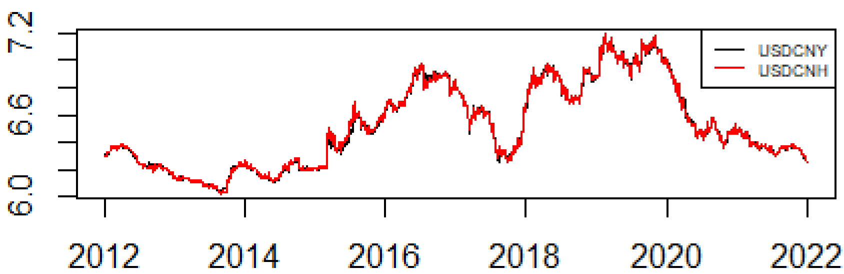

Figure 1: Time series chart of offshore and onshore RMB exchange rates.

To further observe the difference between USDCNY and USDCNH , the gap between USDCNH and USDCNY is visualized, as shown in Figure Figure 2. It can be seen that the maxium gap appeared in 2015, exceeding 1000 bp , which is closely related to the exchange rate reform[2] on August 11, 2015 . On the whole, the gap remained within a relatively stable range in the past decade.

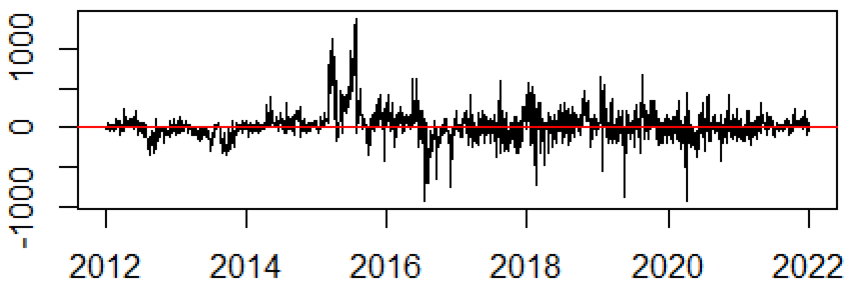

Figure 2: Difference between offshore RMB and onshore RMB (unit: basis points).

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3. Model construction and solutions

3.1. Stationarity test

The stationarity of the series is tested by the unit root, and the ADF test is used here. The results are shown in

Table 2. It can be found that the p -values of the ADF test results of the two series are significantly greater than 0.5, indicating that the assumption that the series are non-stationary is accepted at the 95% confidence level, therefore, both the USDCNY and USDCNH series are non-stationary series.

Table 2: Original sequence A DF test.

data.name	statistic	p.value
USDCNY	-0.1328	0.574
USDCNH	-0.1209	0.5778

In this condition, we conduct the difference operation of the original series. After the first-order difference, it is found that the two series are stationary series. The results are shown in *Table 3*p -value of the ADF test of the two sequences after the first-order difference is 0.01 (less than 0.05) , which rejects the hypothesis that the sequences are non-stationary, indicatingnthe two sequences of USDCNY and USDCNH are both stationary series after the first-order difference.

Table 3: First-order difference post-sequence A DF test.

data.name	statistic	p.value
USDCNY	-34.897	0.01 _
USDCNH	-36.7368	0.01 _

3.2. Cointegration test

Through the above test, it is found that the two sequences USDCNY and USDCNH are stationary after the first-order difference, that is, both are integrated of order on. To further consider the long-term relationship between the two, a cointegration analysis was performed.

Here, the EG two-step method is used for cointegration test [3].

First establish the regression model of USDCNY and USDCNH :

$$USDCNY_t = \alpha + \beta USDCNH_t + \varepsilon_t$$

Then the stationarity of the residuals is tested, and the ADF test results are shown in Table 4. It can be seen that the p-value is less than 0.05, indicating that the residual series is stationary.

Table 4: Residual series A DF test.

statistic	-14.675
p.value	0.01

Through the EG two-step test, we found that there is a cointegration relationship between USDCNY and USDCNH . To ensure the robustness of the results, the EG two-step test was performed again by exchanging the order of USDCNY and USDCNH , and the results were the same. The testing process is the same as above, so it will not be repeated here.

3.3. Establishment of binary vector autoregressive model

Above test shows that there is a long-term equilibrium relationship between USDCNH and USDCNY , and there is a cointegration effect. Based on this long-term equilibrium relationship between the offshore and onshore RMB spot exchange rates.So the impact of the spurious regression caused by the non-stationary series modeling can be ignored, and the original series can be directly used for modeling. The following uses the original data of USDCNH and USDCNY to establish a dynamic binary VAR model to further study the interaction mechanism between them.

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$$\begin{cases} USDCNY_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} USDCNY_{t-p} + \sum_{i=1}^{p} \gamma_{1i} USDCNH_{t-p} + \varepsilon_{1t} \\ USDCNH_t = \alpha_2 + \sum_{i=1}^{p} \beta_{2i} USDCNH_{t-p} + \sum_{i=1}^{p} \gamma_{2i} USDCNY_{t-p} + \varepsilon_{2t} \end{cases}$$

3.4 Determine the lag order

In order to select an appropriate lag order, the information criterion is used here for judgment. The maximum lag order is 15, and the results show that the AIC criterion, the HQ criterion, the SC criterion and the FPE criterion are all first-order optimal.So the lag order of the model is determined to be first-order. The specific test results are shown in Table 5.

Table 5: Information criterion test results.

	AIC(n)	HQ(n)	SC(n)	FPE(n)
1	-8.3716	-8.37069	-8.36899	0.000231
2	-8.37134	-8.36996	-8.36742	0.000231
3	-8.3711	-8.36926	-8.36587	0.000231
4	-8.37076	-8.36847	-8.36422	0.000232
5	-8.37049	-8.36774	-8.36265	0.000232
6	-8.37118	-8.36797	-8.36202	0.000231
7	-8.37084	-8.36717	-8.36038	0.000232
8	-8.37102	-8.3669	-8.35925	0.000231
9	-8.37079	-8.3662	-8.35771	0.000232
10	-8.37075	-8.3657	-8.35636	0.000232
11	-8.37036	-8.36486	-8.35467	0.000232
12	-8.36998	-8.36402	-8.35298	0.000232
13	-8.3714	-8.36499	-8.3531	0.000231
14	-8.37104	-8.36416	-8.35143	0.000231
15	-8.37069	-8.36336	-8.34977	0.000232

3.5. Granger causality test

It can be found in Table 6 that for the original hypothesis that the offshore RMB spot exchange rate is not the Granger cause of the onshore RMB spot exchange rate, the corresponding value of the F statistic is 126.37, and the corresponding p value is 2.20 E -16 which falls outside of Rejection and strongly rejects the original hypothesis, indicating that the offshore RMB spot exchange rate is the Granger reason for the onshore RMB spot exchange rate. For the original hypothesis that onshore RMB spot exchange rate is not the Granger reason of offshore RMB spot exchange rate, the value of the corresponding F statistic is 2.5029, and the corresponding p value is 0.02025, which also shows that the original hypothesis is rejected, and the onshore RMB spot exchange rate is the Granger reason of the offshore RMB spot exchange rate. Therefore , USDCNH and USDCNY both are Granger causality with each other.

Table 6: Granger causality test.

H 0	F-Test	p-value
USDCNH do not Granger-cause USDCNY	126.37	2.20E-16
USDCNY do not Granger-cause USDCNH	2.5029	0.02025

3.6. Impulse response analysis

In order to further study the dynamic relationship between the offshore RMB and the onshore RMB, an impulse response analysis is considered to observe the response of the offshore RMB and the onshore RMB when they are impacted by themselves or the other party.

Figure 3 shows the impulse response of the onshore RMB spot exchange rate when it is impacted by the offshore RMB spot exchange rate. It can be seen that the influence was always positive. The influence mainly expanded between the first period and the second period and then remained relatively stable. This shows that the response of the offshore RMB exchange rate changes to the onshore RMB exchange rate

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was the most severe in the early period, and the gap at the beginning of the period reflects the asymmetry of information, which may create arbitrage space. After the information spread, the response remained relatively stable, and the arbitrage space also tended to disappeal. Subsequent research can further study the investment strategies on this basis.

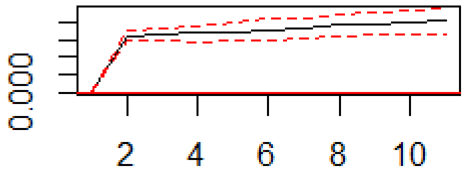

Figure 3: Impulse response of USDCNY to USDCNH.

Figure 4 shows the impulse response of the onshore RMB to itself. It can be found that the response of the onshore RMB exchange rate to its own changes peaked in the sixth period.

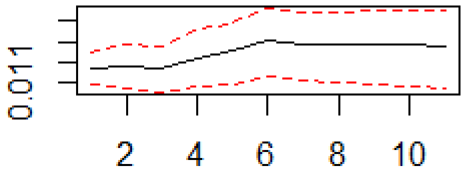

Figure 4: Impulse response of USDCNY to itself.

Figure 5 shows the impulse response of offshore RMB to changes in the spot exchange rate of onshore RMB. It can be seen that this response is also positive, and the start time of the response is shorter than that Figure 3, indicating that the offshore RMB exchange rate is more sensitive to the changes of the onshore RMB exchange rate, but the response process is more moderate than that in Figure 3, and tends to be stable after reaching the peak in the fifth period.This reflects that foreign RMB investors can transmit information faster and can respond quickly to changes in the RMB exchange rate in mainland China, but the process is relatively gentle, and it takes five periods to transmit the information completely. In contrast, domestic investors can finish information transmition within one period. This also reflects the differences in the structure of domestic and foreign RMB investors, which can be used as a direction for follow-up research.

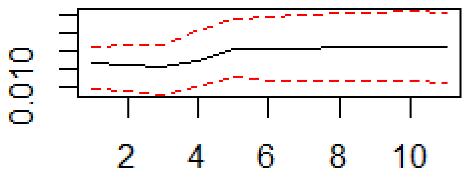

Figure 5: Impulse response of USDCNH to USDCNY.

Figure 6*: Impulse response of USDCNH* shows the impulse response of the offshore RMB spot exchange rate to itself, which is different from the previous three figures. It can be seen that the impulse response of the offshore RMB spot exchange rate to itself decreases first and then tends to be stable, and the response reaches the peak in the first period. This once again confirms that foreign RMB investors are sensitive to the information. And comparing Figure 5 and Figure 6*: Impulse response of USDCNH* it can be found that the fifth phase is a turning point.

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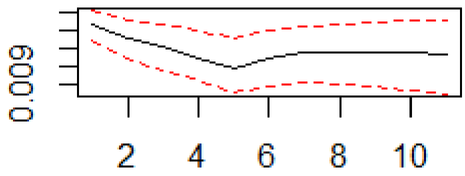

Figure 6: Impulse response of USDCNH to itself.

Through the analysis of impulse response, we can see we can see that the response and information transmission speed between offshore and onshore RMB market are different.. At the same time, it is found that the fifth period is a magical turning point in the response time of the offshore RMB spot exchange rate. The hidden investment or arbitrage opportunities remain to be further explored.

3.7. Variance decomposition

In order to consider the contribution between variables [4], the variance decomposition of Table 7and Table 8.

For the spot exchange rate of offshore RMB, it maintained at around 50% impacted by itself and almost the same level impacted by the spot exchange rate of onshore RMB. As time progresses, its own influence gradually weakens. The impact of the USDCNY is gradually increasing. Overall, they remained within the stable range. It shows that the offshore RMB market is sensitive to both offshore and onshore marketsThis result is consistent with the above analysis.

Table 7: USDCNH variance decomposition.

period	USDCNY	USDCNH
1	0.455934	0.544066
2	0.470165	0.529835
3	0.479897	0.520103
4	0.494939	0.505061
5	0.514242	0.485758
6	0.523949	0.476051
7	0.529097	0.470903
8	0.533019	0.466981
9	0.536191	0.463809
10	0.539101	0.460899

Compared with the offshore RMB, the variance decomposition results of the onshore RMB are quite different. As shown in Table 8, the level that the onshore RMB spot exchange rate was affected by the offshore RMB spot exchange rate is 0 in the first period.And than it was affected by the offshore RMB spot exchange rate from the second period and gradually increased over time, but the level always maintained below 30%. While its own influence reaches 100% in the first phase, and then gradually decreases but it always remains above 70%. This shows that the onshore RMB is less affected by the fluctuation of the offshore RMB exchange rate, and the reaction is relatively slow, and the onshore RMB exchange rate is mainly affected by itself.

Table 8: USDCNY variance decomposition.

period	USDCNY	USDCNH
1	1	0
2	0.869352	0.130649
3	0.827682	0.172318
4	0.810432	0.189568
5	0.801193	0.198807
6	0.794979	0.205021
7	0.788207	0.211793
8	0.780719	0.219282
9	0.773781	0.226219
10	0.767308	0.232692

Through two different variance decomposition results, we can find the difference between offshore

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RMB exchange rate and onshore RMB exchange rate, which also reflects the difference between the two markets.The relatively loose regulation of the offshore market leads to the results that information is reflected quickly and sensitively, and it can respond almost equally to the information in the offshore and onshore markets; while the onshore RMB market is less affected by the offshore market due to strict regulation, and there is a certain time lag.In the future, with the advancement of RMB marketization process, the volatility spillover effect of offshore RMB on onshore RMB will be further enhanced.

3.8. ECM Model Construction[i]

In Section 3.2, it is found that there is a cointegration relationship between U SDCNH and USDCNY . On this basis, in order to further research the impact of current period fluctuation, previous period error fluctuation and pure random fluctuation, we established the error correction models of USDCNH and USDCNY respectively.

In accordance with subsection 3.2, the first error correction model is established.

According to:

$$USDCNY_t = \alpha + \beta USDCNH_t + \varepsilon_t \quad (1)$$

Available:

$$\varepsilon_{\mathrm{t}} = USDCNY_t - \beta USDCNH_t - \alpha \quad (2)$$

$$USDCNY_{t-1} = \alpha + \beta USDCNH_{t-1} + \varepsilon_{t-1} \quad (3)$$

Subtract $USDCNY_{t-1}$ in both sides of (1) to get:

$$USDCNY_t - USDCNY_{t-1} = \alpha + \beta USDCNH_t - USDCNY_{t-1} + \varepsilon_t \quad (4)$$

Substitute (3) into the right side of (4) to get:

$$USDCNY_t - USDCNY_{t-1} = \beta USDCNH_t - \beta USDCNH_{t-1} + \varepsilon_t - \varepsilon_{t-1} \quad (5)$$

Denote the estimated value of the previous period ε_{t-1} as ECM_{t-1}, so (5) can be sorted out:

$$\Delta USDCNY_t = \beta \Delta USDCNHG_t - ECM_{t-1} + \varepsilon_t \quad (6)$$

Establish an error correction model according to (6):

$$\Delta USDCNY_t = \beta_{1,0} USDCNH_t + \beta_{1,1} ECM_{1,t-1} + \varepsilon_{1,t} \quad (7)$$

A second error correction model can be built similarly:

$$\Delta USDCNH_t = \beta_{2,0} USDCNY_t + \beta_{2,1} ECM_{2,t-1} + \varepsilon_{2,t} \quad (8)$$

Use R language to solve functions.The model results are as follows:

$$\begin{cases} \Delta USDCNH_t = 0.84217 USDCNY_t \text{-} 0.27179 ECM_{2,t-1} + \varepsilon_{2,t} \\ \Delta USDCNY_t = 0.46822 USDCNH_t \text{-} 0.29139 ECM_{1,t-1} + \varepsilon_{1,t} \end{cases} \quad (9)$$

By comparing the results of (9), it can be found that there is a positive relationship between offshore RMB and onshore RMB, but the degree of impact is different. The offshore RMB spot exchange rate is more affected by the onshore RMB spot exchange rate than the onshore RMB spot exchange rate is affected by the offshore RMB spot exchange rate. In contrast, the error correction coefficients of the two equations vary little, indicating that the spot exchange rates of offshore RMB and onshore RMB are similarly adjusted by the error of the previous period, and the adjustment range is less affected by the current fluctuation of the other party.

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4. Conclusion

This paper conducts empirical research by constructing a VAR -ECM model, and finds that the relationship between the spot exchange rate of offshore and onshore RMB is close, and the two are Granger causality.

In the long run, there is a cointegration relationship between the two. From a short-term perspective, the spot exchange rates of offshore RMB and onshore RMB are affected to different degrees by their respective influences, and they are affected to a similar degree by the error correction of the previous period, and are also affected to different degrees by themselves.

When it is impacted by itself, the offshore market reacts quickly and the response reaches a peak immediately, and then drops to a stable state.While the onshore market slowly rises to a peak and then remains stableWhen it is impacted by the other party, the offshore RMB market gradually rises to the highest level above a certain initial value, and then remains stable.While the onshore RMB market started to respond from 0 after period one and quickly peaks and then remains stable. The response time difference in this period reflects the gap between the information transmission between the offshore market and the onshore market, indicating that a certain lag exists in the information transmission of the spot exchange rate of RMB in the onshore market compared with the offshore market [5]. The lag of information response in this period will lead to the existence of space for speculation and arbitrage [6]

Through variance decomposition, the importance of the onshore market is found. Whether it is for the offshore market or the onshore market, the spot exchange rate of RMB is greatly affected by the onshore market. The spot exchange rate of RMB in the onshore market is maintained at more than 70% under the influence of self generation, and the spot exchange rate of RMB in the offshore market is about 50% under the influence of the spot exchange rate of RMB in the onshore market.This reflects the current dominant position of the onshore RMB market. However, with the continuous improvement of the internationalization of the RMB in the future, the volatility spillover effect of the offshore market will continue to grow, and the spot exchange rate gap between the onshore and offshore RMB will be further narrowed.

Finally, by constructing an error correction model for comparison, it is found that the offshore RMB spot exchange rate and the onshore RMB spot exchange rate are less affected by the error correction of the previous period, and are greatly affected by the current period of the other party.

Based on the above empirical research, this paper proposes to pay attention to the impact of the onshore RMB exchange rate, improve the order of the onshore RMB market, promote the healthy development of the offshore and onshore RMB markets, and then promote the internationalization of the RMB.

References

[1] Zhang Hongdi, Zhong Zhuzan. An empirical study on the linkage between the onshore RMB market and the Hong Kong offshore RMB market [J]. Financial Education Research, 2014, 27(04): 8-14.
[2] Ma Yu, Zhang Lina. Research on the volatility spillover effect and time-varying correlation between RMB onshore and offshore markets——Based on the data before and after the "8.11" exchange rate reform[J].Statistics and Information Forum, 2018,33(08):49 -59.
[3] Edited by Wang Yan. Time series analysis of statistical series based on R application based on R[M]. Beijing: Renmin University of China Press. 2015.
[4] Xing Yafei. Research on the Correlation between Offshore and Onshore RMB Exchange Rates [D]. Liaoning University, 2017.
[5] Hai-Chuan Xu,Wei-Xing Zhou,Didier Sornette. Time-dependent lead-lag relationship between the onshore and offshore Renminbi exchange rates[J]. Journal of International Financial Markets, Institutions & Money,2017,49:
[6] Abdukayum Sermet, Yusuf Abulaiti. Research on the Linkage Relationship between RMB Offshore Market Exchange Rate and Onshore Market Exchange Rate——Based on VAR Model[J]. Economic Perspective, 2019(02):45 -54.

[i] Section 3.8 is different from the model parameters in Section 3.3, but the same symbols are used in modeling.