The Dynamic Relationship between Onshore and Offshore Market Exchange Rate in the Process of RMB Internationalization
-- An Empirical Analysis Based on VAR-DCC-MGARCH-BEKK Model

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Abstract. Using a VAR-DCC-MGARCH-BEKK model, this paper empirically tests the dynamic relationship between onshore and offshore market exchange rate. The results show that: Firstly, the guiding effect of offshore RMB forward exchange market on onshore RMB spot and forward exchange rate market is obvious, but not vice versa; there exists a bi-directional mean spillover effect between onshore RMB spot and forward exchange rate market and offshore RMB spot exchange rate market respectively. Secondly, in addition the onshore RMB spot exchange rate market volatility spillover effect is greater than the offshore RMB spot exchange rate market, other offshore market exchange rate volatility effects are greater than the other way round. Thirdly, with the process of internationalization of RMB, the dynamic relations between onshore and offshore market become more and more obvious.

Introduction

In December 1, 2015, the International Monetary Fund announced that the RMB will join SDR in October 1, 2016 in this environment, research the linkage of onshore and offshore market has practical significance. The Establishment and development of the offshore market can provide a buffer for the gradual opening capital account in the onshore market, while provide outside contacts for the onshore RMB cross-border business. The onshore and offshore market cannot being effectively docking and co-developing, the existence and development of the offshore market will increase the risk of the onshore market. Thus, the study of how onshore and offshore RMB exchange rate affect each other and the two markets' mean spillover effects and volatility spillovers have important theoretical significance to promote the liberalization of our capital account, to maintain the coordinated development of two markets and the promoting the internationalization of the RMB.

The domestic and foreign scholars have do much in the exploration of the contact between onshore market and offshore market of RMB and from the research perspectives contains two categories, the first category is a separate study in the mean spillover effects or volatility spillover effects of onshore and offshore markets., Rhee and Lee found that after the reform of Won, DNF market has one-way mean spillover effects and volatility spillover effect on the spot market. Que Ma Bin use the VAR-GJR-MGARCH-BEKK model for empirical analysis and there exists certain mean spillover effects and volatility spillovers in the RMB onshore and offshore market, the fluctuation influence of offshore exchange rate to onshore exchange rate is stronger than the latter on the former. Chen Yun used AG-DCC-MVGARCH empirical analysis and there exists of asymmetric dynamic correlation between onshore and offshore markets, and the risk between them will be aggravated when facing adverse shocks.

Overall, existing achievements have an important reference value to this study but still have some limitations: first, the target market is limited. Previous literatures mainly focused on the onshore RMB spot exchange rate market and the NDF market, merely related to onshore RMB forward market and offshore RMB spot market. Second, the limitation of the models. Using Granger causality test alone or GARCH class models alone will easily ignored the intrinsic links of the spillover effects of two markets and could not dynamically testify their relevance.

On the basis of existing research results at home and abroad, this paper reflects the rapid development of the onshore RMB market and Hong Kong offshore RMB foreign exchange market. The main contributions are shown as follows: first, from four perspectives, CNY and CNH, CNY and NDF, DF and CNH, DF and NDF comprehensively analyze the spillover effects between onshore and offshore markets; second, using the VAR model investigate the mean spillover effect of onshore and offshore market, and on the basis of VAR model respectively established MGARCH-BEKK model and DCC-MGARCH model empirical analysis of the fluctuations spillover effects and dynamic correlation of onshore and offshore market. In addition, in the BEKK model and DCC-GARCH model, using t distribution to replace the return sequence to imitate on the market, which is a complementary of previous studies.

The theoretical model

Mean spillover effect on VAR model. As for the exchange return rate, establish a mean equation based on the condition of two variable VAR model, to exam the mean spillover effect between the onshore and offshore markets, as shown as follows:

The exchange return rate= (), indicates the return rate of onshore market, indicates the return rate of offshore market exchange rate, is the coefficient matrix and a random disturbance. Since the empirical section of this article for the maximum lag order of 2, for a better understanding, respectively unfold the binary VAR (1) VAR (2) model as follow:

Binary VAR. From the analysis, we can know that in the first-order lag in the VAR model equation, it measures the mean spillover effect of the offshore market for onshore market and vice versa.

Binary VAR. From the analysis, we can know that in the second-order lag in the VAR model equation, it measures the mean spillover effect of the offshore market for onshore market and vice versa.

Dynamic Correlation Coefficient-DCC-GARCH model. The DCC-GARCH model assumes the correlation coefficient is a constant and does not change over time which is hard to realize, thus Engle improved the underlying assumptions in the model and got a correlated coefficient model related to dynamic conditions, abbreviated as DCC-GARCH model. Therefore, this paper using DCC-GARC model to describe the time-varying characteristics of the RMB correlation coefficient between the onshore and offshore markets. DCC-GARCH model show as follow:

Volatility spillover effect model GARCH-BEKK model. Since the DCC model is limited in the study of the time-varying correlation coefficient of volatility and could not make a concrete analysis of the volatility effect in the two markets, therefore, BEKK model proposed by Engle and Kroner simulates the volatility effects in both markets. BEKK model is shown as follow:

Where,

，C=，A=，B=

Namely,

Empirical test and analysis

The collection and management of data. In order to study the linkage relationship between the onshore and offshore market, this paper selected four variables, CNY represents onshore spot exchange rate of RMB, CNH refers to Hong Kong offshore RMB spot exchange rate, DF represents the RMB onshore deliverable forward, NDF represents Hong Kong offshore RMB non-deliverable forward rate. For a convenience discussion, the DF and NDF, this paper selects the most actively traded of the DF and NDF 12-month period.

Figure 1 is the rata trend chart of CNY, CNH, DF12 AND NDF12 four variable data from January 4, 2013 to November 25, 2015.

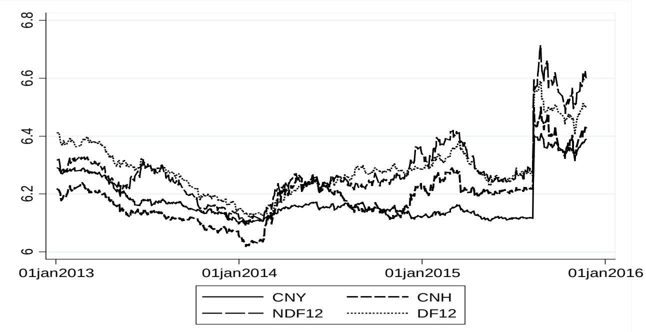

Figure 1 the exchange rate trend chart of CNY, CNH, DF12 and NDF12

Due to unstable exchange rate time series, we get the analysis in Table 1

	The average value	Standard deviation	Skewness	Kurtosis	JB value	ADF
CNY	0.0023040	0.1263879	8.271254	113.9127	3.6e+05***	-6.924***
CNH	0.0049594	0.1890168	5.569211	87.66217	2.1e+05***	-6.494***
DF12	0.0019872	0.1541877	5.017867	64.37861	1.1e+05***	-7.474***
NDF12	0.0064762	0.2300607	5.982938	98.69653	2.6e+05***	-6.585***

Table 1 the descriptive statistics and stability test of exchange rate of return sequence

***,**,*respectively indicate in the obvious level of 1%,5%,10% reject the null hypothesis; JB value is Jarque-Bera normality test statistic; ADF value is the test statistic value amount of unit root.

Table 1 shows all the mean exchange rate of return is positive, indicating that the onshore and offshore markets RMB exchange rate market in the devaluation condition. Table 1 shows the peak value is relatively high, indicates the tail is thicker. JB statistics and significant results showed that the return of the normal sequence reject the null hypothesis. Under the level of 1%, the critical value of ADF value is -3.43, Table 1 shows that the return sequence are stable.

The test of mean spillover effects

Table 2 the test of VAR model of CNY &CNH，CNY&NDF12，DF12&NDF12，DF12&CNH

		1	2	3	4
CNY&CNH	AIC	-2.48678	-2.57161	-2.56289	-2.57806*
	SBIC	-2.44665	-2.50473*	-2.46926	-2.45766
CNY&NDF12	AIC	-2.10492	-2.12848*	-2.12602	-2.12268
	SBIC	-2.06479*	-2.06159	-2.03238	-2.00228
DF12&NDF12	AIC	-1.66517	-1.73288*	-1.72844	-1.71931
	SBIC	-1.62504	-1.666*	-1.6348	-1.59892
DF12&CNH	AIC	-1.91742	-1.98783*	-1.97776	-1.97307
	SBIC	-1.87728	-1.92095*	-1.88412	-1.85268

Note: * represents the minimum lag fourth order.

When the AIC and SBIC criteria inconsistent, in order to facilitate the evaluation of model, we choose to base on SBIC criteria. Table 2 shows the optimal lag order of CNY and CNH, DF12 and NDF12, DF12 and CNH of VAR equations are 2, CNY and NDF12 is 1.

Estimation of VAR model

Table 3 the mean spillover effect of CNY&CNH, DF12&NDF12, and DF12&CNH

	CNY（-1）	CNY（-2）	CNH（-1）	CNH（-2）
CNY	0.33581***（0.000）	0.01100（0.802）	0.14135***（0.000）	-0.04726（0.103）
CNH	0.51803***（0.000）	-0.34142***（0.000）	0.00016（0.997）	-0.09123（0.050）
	DF12（-1）	DF12（-2）	NDF12（-1）	NDF12（-2）
DF12	-0.00740（0.874）	-0.04874（0.233）	0.30667***（0.000）	0.06537**（0.029）
NDF12	0.15294*（0.052）	-0.01934（0.778）	0.09229*（0.048）	-0.13508***（0.007）
	DF12（-1）	DF12（-2）	CNH（-1）	CNH（-2）
DF12	0.18456***（0.000）	0.06528（0.134）	0.19764***（0.000）	-0.05990*（0.096）
CNH	0.39442***（0.000）	-0.18550***（0.001）	0.02333（0.596）	-0.12073***（0.008）

Note: the value in parentheses corresponds to the p value of t statistics; ***, **,* denote 1%, 5%, 10% obvious level significantly.

Analysis of VAR model estimation results. First, the mean spillover effect of CNY AND CNH: Table 3 shows under the situation of one period lagged, the mean spillover effect of CNH to CNY and CNY to CNH should obvious in the level of 1%, indicating there exists a two-way mean spillover effect in the CNH and CNY markets. In the case of two periods lagged, the mean spillover effect of CNY to CNH is obvious in the level of 1%, while the mean spillover effect of CNH to CNY is not significant.

Second, the mean spillover effect of CNY and NDF12: Table 3 shows that in the one period lagged situation, the mean spillover effect of CNY to NDF12 is not significant, but NDF12 to CNY at 1% level is significant, indicating that there is a one-way mean spillover effect of NDF12 to CNY market.

Third, the mean spillover effect of DF12 and NDF12: Table 4 shows in the situation of one period lagged, the mean spillover effect of NDF12 market to DF12 market is significant in 1% level, and DF12 to NDF12 is significant in the level of 10% and is greater than the mean spillover effect of NF12 to NDF12. In the case of two periods lagged, the mean spillover effect of NDF12 to DF12 is significant in the level of 5%, while that of DF12 to NDF12 is not significant.

Fourth, the mean spillover effect of DF12 and CNH: Table 4 shows in the case of one period lagged, there exists a two-way mean spillover effect between CNH and DF12, the impact of onshore forward markets is gradually increased.

The test of dynamic correlation coefficient. The estimation of DCC-GARCH model can be done in two steps, first establish the GARCH(1,1) model to make parameter estimation of the four variables, and then evaluate the maximum likelihood of the DCC model, and its results are shown in Table 4:

Table 4 the parameter estimation results of DCC model

			log-likelihood values
CNY&CNH	0.02376 (0.000)	0.62153 (0.000)	1400.9143
DF12&NDF12	0.11993 (0.000)	0.04031 (0.000)	970.354912
CNH&DF12	0.01627 (0.000)	0.98372 (0.000)	1109.58205
CNY&NDF12	0.05980 (0.026)	0.20207 (0.086)	1256.6991

Calculate the time-varying correlations between various market by the use of the factors and estimates in Table 4, which changes as in Figure 2to5:

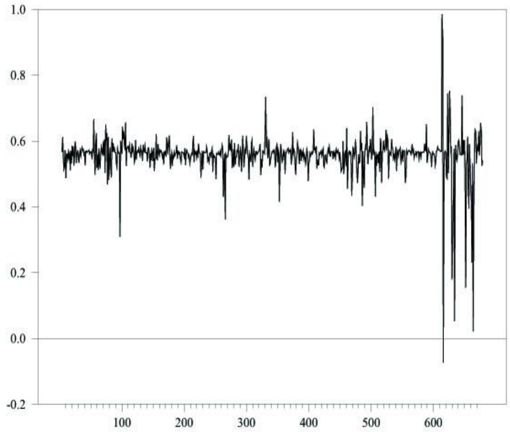

Figure 2 CNY&CNH Dynamic Correlation Coefficient Time Varying Map

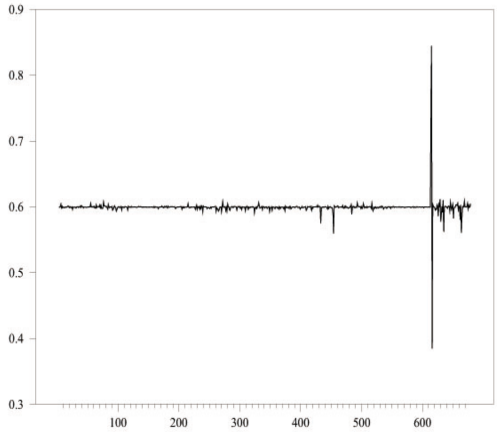

Figure 3 DF12 &NDF12 Dynamic Correlation Coefficient Time Varying Map

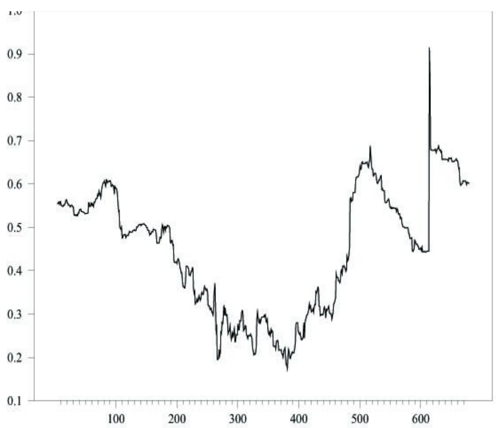

Figure 4 CNH&DF12 Dynamic Correlation Coefficient Time Varying Map

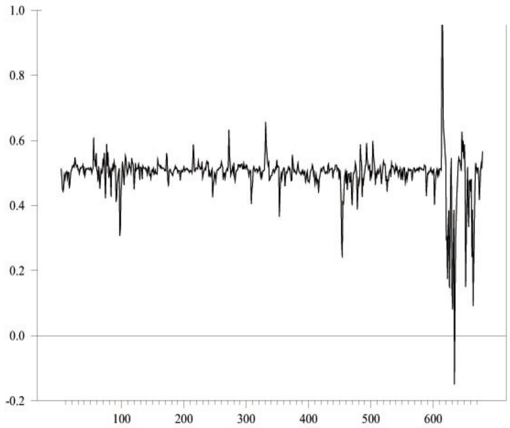

Figure 5 CNY&NDF12 Dynamic Correlation Coefficient Time Varying Map

shows t ... s <1 subject to the constraints. On CNY and CNH market, =0.02376, indicating that the influence of the pre mean residual is rarely influence the CNH and CNY dynamic correlation coefficient =0.62153 shows the correlation coefficient of CNH and CNY mainly rely on its pre-dynamic conditional heteroskedasticity, that means the correlation coefficient between onshore and offshore RMB spot return rate is greatly influenced by its early days and have a strong continuing change. Figures 2, 3, 4, and 5 are separately given pairwise correlation coefficient of dynamic market exchange rates, the dynamic correlation coefficient of DF12 and NDF12, CNY and NDF generally above 0.5, indicating that the relations between onshore and offshore markets are increasingly close; with the development and improvement of Hong Kong's offshore spot market, the dynamic correlation coefficient of CNH, CNY and DF12 is gradually increasing.

Conclusions

This paper can draw three main conclusions: first, in the perspective of mean spillover effect, NDF market has an obvious guiding function on CNY and DF market, and its contrary is not true; CNF, DF market separately have two-way mean spillover effects with CNH market and expressed as onshore rate is greater than offshore rate. Second, in the perspective of volatility spillover effect, expect the volatility spillover effect of CNY market is more than CNH market, various other market offshore exchange rate is greater than the impact of the latter on the former. Third, in the aspect of dynamic correlation coefficient with the accelerated process of internalization of the RMB, the linkage relationships between the onshore and offshore markets become increasingly significant.

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