Exchange Rate Intervention by Central Bank: Based on the Influence of the Hong Kong Offshore RMB Exchange Rate

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Abstract. We calculate exchange intervention index to reflect the open market operation of central bank, introduce the Hong Kong’s offshore RMB exchange rate (CNH) to establish Central bank reaction function and further analyze the influence that CNH has on the exchange intervention activities of China's Central Bank. We discover that the influence is not quite evident due to the insufficient development of financial market. Thus, we study the relationship between offshore Deutsche Mark rate and the exchange intervention of Deutsche Bundesbank on the basis that Mark has been completed the whole development of international currency offshore market.

Introduction

In the early 21st century, China has promoted RMB internationalization to relieve the negative influence of excessive reliance on USD. Introducing Hong Kong offshore RMB exchange rate (CNH) is a critical step of revolution. Based on the experience of international currency, the offshore RMB exchange rate must have a strong co-movement effect on onshore RMB exchange rate (CNY) so that the exchange rate intervention by China’s Central Bank will be more difficult to be carried out due to weaker effectiveness. However, most existing researches only analyze the co-movement between CNH and CNY from the perspective of the pricing of exchange rate in the sport market and the results are different. Depending on the previous researches, it can be discovered that the offshore RMB exchange rate will generate a more evident influence on the onshore rate and will eventually make a huge influence on the exchange rate policy by central bank. Although the exchange rate intervention is a critical method used by central bank, literature seldom focused on the influence that CHN could bring.

The Model

With the development of economic integration, the connection between different foreign exchange markets becomes increasingly tighter. Accordingly, we built up the central bank's reaction function which includes onshore and offshore exchange rates to analyze the influence of offshore exchange rate on intervention. In addition, since central bank’s exchange rate intervention is normally disturbed by the former behavior so the exchange rate intervention from the former period is also considered into the reaction function. The reaction function model is as Eq. (1). $I_t$ measures the open market operation. $\alpha_0$ is a constant. $e_{i-1}^{on}$ is the fluctuation of the onshore exchange rate. $e_{i-1}^{off}$ is the fluctuation of the offshore exchange rate. $I_{i-1}$ is the lagged exchange rate intervention. $\epsilon_i$ is the disturbing term.

$$I_t = \alpha_0 + \alpha_1 e_{i-1}^{on} + \alpha_2 e_{i-1}^{off} + I_{i-1} + \epsilon_i$$ (1)
Empirical Test

Monthly data from August, 2010 to December, 2013 are used to build the reaction function to study the influence from CNH on the exchange rate intervention policy of Chinese central bank. The estimating Eq. is as Eq. (2).

\[ \text{abs}I_t^{C} = c_0 + c_1 \times \text{abs}\Delta e_t^{cnr} + c_2 \times \text{abs}\Delta e_t^{cnr} + \text{abs}I_{t-1}^{C} + \epsilon_t^{C} \]  

(2)

\[ \text{abs}\Delta e_t^{cnr}, \ \text{abs}\Delta e_t^{cnr} \text{ are absolute values of log return of onshore, offshore exchange rates. CNH} \]

exchange rate is from Bloomberg and calculated by the mean value to transform daily data into monthly data. \text{abs}I_t^{C} \text{ is absolute value of exchange rate intervention index. abs}I_{t-1}^{C} \text{ is the lagged}

absolute value of exchange rate intervention index. We refer to Weymark's exchange rate pressure index module (1995, 1997) by testing exchange rate intervention index to reflect the central bank's operations in the open market.

Exchange rate intervention rate index regards foreign exchange market pressure as the central concept. The definition of EMP was first published by Girton and Roper (1977). They defined EMP (the Eq. (3)) as unbalance in the foreign exchange market which must be eliminated by foreign reserves or the change of exchange rate. Weymark (1995, 1997) believes this definition depends on a highly restricted currency module and therefore mentions that the pressure in the foreign exchange market should generally represent as the excessive demand of one currency in the international market under the participation of current exchange rate policy.

\[ \text{EMP}_t = \Delta e_t + \eta \Delta r_t \]  

(3)

\[ \Delta e_t \text{ is the change ratio of the exchange rate by direct quotation, } \Delta e_t = \ln(e_t / e_{t-1}) \times \Delta r_t \text{ is the change ratio of foreign reserves, } \Delta r_t = (r_t - r_{t-1}) / B_{t-1} \times 100. B_{t-1} \text{ is the monetary base lagged for one period of time. } r_t \text{ is foreign reserves. } \eta = -\partial \Delta e_t / \partial \Delta r_t \text{ is the elastic coefficient of exchange rate on foreign reserves.} \]

Weymark defined exchange rate intervention index as Eq. (4).

\[ \omega_t = \frac{\eta \Delta r_t}{\Delta e_t + \Delta r_t} \]  

(4)

We assume that foreign interest rate, price level and internal production are all exogenes. PPP makes sense in the long term. The freedom of capital flows is prohibited and there is incomplete substitute of internal and external capitals, which ensures the intervention by central bank. Accordingly, China’s macro-economy model is built up as Eq. (5)- (10).

\[ m_t^d = \beta_1 y_t - \beta_2 i_t + p_t + \epsilon_t^{\pi} \]  

(5)

\[ p_t = a_0 + \alpha_1 p_{t-1} + \alpha_2 e_t + \epsilon_t^{p} \]  

(6)

\[ i_t = i_t^* + E[e_{t+1} \mid t] - e_t + \delta_i \]  

(7)

\[ \Delta m_t^d = \Delta d_t + \Delta \epsilon_t \]  

(8)

\[ \Delta r_t = -\rho_r \Delta e_t \]  

(9)

\[ \Delta m_t^s = \Delta m_t^d \]  

(10)

Eq. (5) is the money demand function, which represents that the nominal money demand \( m_t^d \) is determined by the domestic output \( y_t \), the domestic interest rate \( i_t \) and the domestic price level \( p_t \). \( \epsilon_t^{\pi} \) is the random term. Real money demand is divided into two categories, including transactive and speculative demand, in which the former one is the increasing function of income and the latter one is a decreasing function of interest rate.
Eq. (6) is the price equation, in which the exchange rate is determined by the domestic price \( p_t \) and the current foreign price \( p_t^* \) according to PPP. Since China applies the managed floating exchange rate system, in the short term domestic price level is influenced by the current exchange rate level \( e_t \) and the current foreign price. PPP holds in the long run, that is, \( a_0 = 0, \ a_1 = a_2 = 1 \) but in the short run PPP does not necessarily hold. \( e_{t}^p \) is the random term.

Eq. (7) is interest rate equation. Currently, the domestic capital market is not completely open and there is rather strict control over short-term capital flows, which lead to difference in the domestic and foreign interest rates. Therefore, to a certain extent, the increase in the domestic interest rate \( i_t \) attracts foreign capital inflows, and thus make currency appreciated. \( i_t^* \) is foreign interest rates. \( \delta_t \) indicates an exogenous risk premium.

Eq. (8) reflects the change in money supply \( m_t^r \) is determined by the changes of net domestic credit \( \Delta d_t \) and foreign reserves \( \Delta r_t \). Define \( \Delta d_t = (d_t - d_{t-1}) / B_{t-1} \), in which \( d_t \) is the current domestic credit amount and \( B_{t-1} \) is lag of basic money.

Eq. (9) is the response function of the central bank to exchange rate changes. The greater the coefficient \( \rho_t \) is, the higher the degree of intervention is.

Eq. (10) shows that the change of money demand and money supply are the same.

All above variables are in logarithmic form. Based on the above equations, we assume that the risk premium \( \Delta \delta_t = k \Delta r_t = -k \rho_t \Delta e_t \), in which \( k \) is the coefficient of sterilization and then we get the exchange rate intervention index as Eq. (11).

\[
\omega_t = \frac{\Delta r_t}{\frac{1}{\eta} \Delta e_t + \Delta r_t} = \frac{\Delta r_t}{\frac{\alpha_2 + \beta_2}{(1 + \beta_2 k)} \Delta e_t + \Delta r_t}
\]  

(11)

From the above model, to estimate exchange rate intervention index is to estimate \( \eta \) which depends on the parameters \( k, \alpha_2, \beta_2 \). According to Eq. (5) and (6), \( \alpha_2 \) and \( \beta_2 \) are 0.43 and 0.983, respectively. Because \( \eta = -1.264 \) and \( k = 0.8 \) (Tang, 2012), the exchange rate intervention index can be obtained. In order to eliminate the effect of outliers, the exchange rate intervention index is limited in the range of \((-1, 1.5)\), shown in Figure 1. The mean value before the exchange rate reform was 1 and after the reform the mean value became 0.91178, which indicates that the degree of intervention after the reform has declined. However, affected by the 2008 subprime crisis, the central bank once again strengthened intervention in the foreign exchange market. With the improvement of the economic situation and the promotion of the second exchange rate reform, the central bank reduced intervention to some extent and RMB appreciated a little bit. After 2011, the central bank intervention showed different characteristics. From September 2011 to October 2012, there were eight overshooting, 6 of which were under the depreciation pressure and stemmed from the negative growth of foreign reserves.

![Figure 1. Exchange Rate Intervention Index.](image-url)
The influence of CNH on China’s central bank exchange rate intervention. The results of stationary test show that all variables are I(0). The tolerance coefficients of onshore and offshore exchange rates $\Delta e_{i}^{en}$ and $\Delta e_{i}^{inh}$ is 0.449. We first set up the response function of the central bank to the onshore foreign exchange market, and then introduce the offshore exchange rate to study the intervention behavior. The lagged exchange rate intervention index in each case had no significant effect on the current intervention index, so it was removed from the reaction function. In the sample, the coefficient of $abs\Delta e_{i}^{en}$ is significant, and that of CNH is not. Furthermore, we introduce the onshore exchange rate threshold model and CNH to test the intervention behavior under appreciation and depreciation respectively. The results show that the exchange rate fluctuation causes the central bank to intervene in the onshore market, and the reaction mechanism is not the same under appreciation and depreciation. In the case of appreciation, the exchange rate fluctuation increases the negative impact on the central bank's intervention, and it does not significantly affect intervention under depreciation. The response coefficients of the offshore exchange rate are not significant in all cases, which shows that there is no significant relationship between the current offshore exchange rate fluctuation and the central bank’s exchange rate intervention behavior.

**Experience from German Central Bank**

As we mentioned above, the influence of the offshore RMB exchange rate market on the onshore market has not yet been evidently shown. In addition, because of lack of data, we fail to further analyze the dynamic changes in the central bank's exchange rate intervention. Therefore, we use Deutsch Mark for example which went through complete development of the international currency, in order to observe the different influences from the offshore exchange market on the central bank’s intervention in each development stage. Because the Eurodollar market and the German domestic foreign exchange market are highly synchronized, we use the New York foreign exchange market as the Mark exchange rate.

We use daily data of exchange rate intervention from December 1, 1981 to December 31, 1995 and the onshore and offshore exchange rate data are from Frankfurt and New York markets respectively. The German central bank’s intervention function is as Eq. (12).

$$absI_{i}^{DM} = \phi_{0} + \phi_{1}absr_{i-1}^{DM} + \phi_{2}abs25_{i}^{DM} + \phi_{3}absr_{i-1}^{NY} + \phi_{4}absI_{i-1}^{DM} + \phi_{5}absI_{i}^{US} + \epsilon_{i}^{DM}$$

In order to compare with China, we also take the absolute value of the variables in the German central bank’s reaction function. Among them, $absI_{i}^{DM}$ ($absI_{i}^{US}$) are the absolute values of the open market operations of German and USA central banks. $absr_{i}^{DM}$ ($absr_{i}^{NY}$) are the onshore (offshore) GM exchange return rates, which represent the short-term goal of central bank’s intervention. $abs25_{i}$ is the 25-day moving average in the Frankfurt exchange market, which presents the mid-term goal of central bank’s intervention. Table 1 shows that all explanatory variables are significantly less than 0.8, consistent with the modeling requirements of multiple linear regression models.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$absr_{i}^{DM}$</th>
<th>$absr_{i}^{NY}$</th>
<th>$abs25_{i}^{DM}$</th>
<th>$I_{i}^{DM}$</th>
<th>$I_{i}^{US}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
<td>0.262</td>
<td>0.249</td>
<td>0.12</td>
<td>0.119</td>
<td>0.091</td>
</tr>
</tbody>
</table>

We divide the whole sample into two stages, the initial stage (1981.12.1~1985.9.21) and the prosper stage (1985.9.22~1995.12.31). Table 2 shows that in the initial stage of the offshore market, the offshore exchange rate fluctuation does not affect the behavior of the central bank’s intervention,
but with the growth of the offshore market, the influence will become more significant.

Table 2. German's central bank.

<table>
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<tbody>
<tr>
<td>( \phi_0 ) (Intercept)</td>
<td>25.14*** (2.375)</td>
<td>-1.796 (-0.522)</td>
</tr>
<tr>
<td>( \phi_1 ) (absr(_{t-1}^{DM} ))</td>
<td>-429.7*** (-3.124)</td>
<td>-399.7 (-1.041)</td>
</tr>
<tr>
<td>( \phi_2 ) (abs25(_{t-1}^{DM} ))</td>
<td>613.0*** (4.089)</td>
<td>427.6*** (5.710)</td>
</tr>
<tr>
<td>( \phi_3 ) (absr(_{t-1}^{NY} ))</td>
<td>612.5 (0.411)</td>
<td>752.3 (1.867)</td>
</tr>
<tr>
<td>( \phi_4 ) (absr(_{t-1}^{DM} ))</td>
<td>0.419*** (12.514)</td>
<td>0.175*** (8.131)</td>
</tr>
<tr>
<td>( \phi_5 ) (absr(_{t-1}^{US} ))</td>
<td>1.368*** (2.401)</td>
<td>0.232*** (7.581)</td>
</tr>
<tr>
<td>Sample Number</td>
<td>912</td>
<td>2469</td>
</tr>
<tr>
<td>R(^2)</td>
<td>0.222</td>
<td>0.06</td>
</tr>
<tr>
<td>F</td>
<td>51.72***</td>
<td>60.62***</td>
</tr>
</tbody>
</table>

Note: *, **, *** mean being significant at 10%, 5% and 1% significant level, respectively.

German experience and China's future. Germany began to accelerate the process of DM internationalization in the 1980s and the economic situation in that period was similar to China, which is of great importance for RMB internationalization. First of all, the nature of the DM offshore market - IBF is the same as the offshore RMB market - Hong Kong, which ensures the consistency of the nature of the two markets. In order to facilitate the non-residents to carry out financial transactions in the offshore currency, monetary authorities can choose to develop offshore financial markets in own country or overseas. For DM, IBF is built overseas and the nature is similar to the offshore RMB market in Hong Kong. Secondly, in order to promote the currency internationalization and the development of the offshore market, Germany and China have time synchronization. Thirdly, in the initial stage of DM internationalization, Germany ranked highly according to international trade, which is similar to the current situation in China. It is an important approach to promote internationalization by using currency in international trade in the initial stage. From 1980 to 1998 Germany ranked second in export and China ranked second after 2009. Lastly, the offshore DM is the only currency which has experienced a complete process of the international currency offshore market and has made great achievement.

In summary, it can be predicted that in the initial stage of the offshore RMB market, the impact on the central bank's intervention only comes from the onshore rather than offshore exchange rate fluctuation. However, with the further development of the offshore market, the offshore exchange rate fluctuation will have a substantial impact on the central bank's intervention which may be even more remarkable than the impact from the onshore fluctuation.

Conclusion

We build up a central bank reaction function to study the effect that CNH has on the exchange rate intervention. Exchange rate intervention index shows that China's central bank carries out a mighty intervention policy on the exchange market. Using monthly data from August 2010 to December 2013, we find out that CNY rather than CNH has a significant influence on the exchange rate intervention. Because the offshore RMB market in Hong Kong has just begun, we refer to the
experience from Germany to predict the future in China. We conclude that it is advisable to further expand RMB outflow to large the scale of offshore RMB. With the further development of the offshore RMB market, CNH will have a substantial influence on the central bank's intervention.

References

