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Liu, L. and Ni, Y.J

Department of Finance, Xiamen University, China, Department of
Finance, Xiamen University, China

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Foreign Exchange Market Pressure and Monetary Policy: An Empirical Study Based on China's Data

L.Lin¹

Department of Finance, Xiamen University, China

Ni Y.Juan²

Department of Finance, Xiamen University, China

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Abstract: The reform of exchange rate system in 2005 has settled down the floating exchange rate system with management in China. Until August this year, RMB/USD has appreciated about 16.65%. This paper measures the exchange market pressure (EMP) on RMB/USD, and use VAR model to analyze the relationship between EMP and domestic monetary policy . And from the results we find that the increase of China's domestic interest rate of is the main cause of RMB pressure of appreciation, but the foreign interest rate has little effects on the pressure and it can affect the growth rate of China's domestic credit. So,we deem that the theory of "ternary paradox" may not applicable to China, at least in the period of our investigation.

Keywords: EMP Monetary Policy Foreign Exchange Intervention VAR Model

¹ Phd. Student in International Finance.

² Phd. Student in Investment.

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I. Introduction

Since July 21, 2005, China started to implement a managed floating exchange rate system, which is on the basis of market supply and demand, and with reference to a basket of currencies. RMB exchange rate is no longer pegged to a single dollar, but forming a more flexible RMB exchange rate mechanism. Even though the RMB exchange rate is no longer pegged to a single U.S. dollar, by consideration of the U.S. dollar's international status, and China's most international trades are denominated in dollars, besides, around 70% of China's foreign exchange reserves are the dollar reserves. Until August 2008, the RMB has appreciated by 16.65% against the U.S. dollar. According to the international finance theory, the currency exchange rate exceeding a certain level will result in reduction of the exports. For China, in a long term, export has been considered as one of the "Troika", pushing up the economic growth. Excessive appreciation of the RMB is bound to crack down on Chinese exports, and China's economy will also be affected. Therefore, in order to avoid excessive fluctuations in exchange rate to impact on the domestic economy, China's monetary authorities have intervened on the foreign exchange market to maintain exchange rate's stability. Because the funds outstanding for foreign exchange have been rising resulting from the monetary authorities' intervention in the foreign exchange market, in the first five months of 2008, a total of new added RMB 2.3 trillion Yuan have been put into the market as the funds outstanding for foreign exchange, and in 2007, new added funds outstanding for foreign exchange amounted 2.9 trillion Yuan. The funds outstanding for foreign exchange directly increase the domestic base money, under the influence of the money multiplier, an imbalance will happen in the domestic money market (Xu Mingdong, 2007). In order to maintain the balance of the domestic currency market, the monetary authorities must implement the sterilization policy. From a practical perspective, the central bank continued to issue central bank bills and raise the deposit reserve ratio to offset the foreign exchange market intervention on the domestic money market.

From the central bank's point of view, on the one hand, they should maintain exchange rate stability in order to avoid excessive exchange rate movements impacting on the domestic economy; On the other hand, they should maintain the equilibrium of the domestic currency market to prevent excess liquidity to induce inflation and asset price bubbles. Therefore, by the consideration of two sides, the pressures on central bank to intervene in the foreign exchange market come from changes in exchange rate (appreciation) and the increase in foreign exchange reserves. As for the definition of foreign exchange market pressure, Girton and Roper (1977) considered the pressure of the foreign exchange market refers to a managed floating exchange rate system, through changes in foreign exchange reserves or exchange rate to eliminate the non-equilibrium of the monetary market. The foreign exchange market pressure they referred, is the sum of the reduction of foreign exchange reserves and exchange rate depreciation. Weymark (1997) considered, assumed that the expectation generated by the exchange rate policy exists, in the absence of the foreign exchange market intervention, foreign exchange market pressures are measured excess of total demand of a country's currency in the international market, and this

excess demand should be eliminated through the change of the exchange rate. The definition by Girton and Roper has its own limitations, and is now incompatible with the situation of the appreciation of RMB in China, whereas, the definition by Weymark is relatively close to the China's current economic realities, therefore we will follow the definition of Weymark.

As for the calculation of the foreign exchange market pressure, the ground-breaking literature is Girton and Roper's (1977). They used a simple monetary model of the international balance to construct the excess money demand index, and the money demand need be eliminate and maintain balance of money market, through exchange rate movements or changes in reserves. Roper and Turnovsky (1980) extended G-R model under the open economy IS-LM framework with fully capital mobility, rather than the simple monetary approach. Weymark (1995, 1997) modified and extended the G-R and the R-T model, she gave a more general analytical framework of analyzing of the foreign exchange market intervention and imbalances. Weymark's model is better to meet the requirements of empirical research.

As for the relationship between the foreign exchange market pressure and monetary policy, Evan Tanner (2001) used the VAR model to do empirical research on the relationship between foreign exchange market pressure and monetary policy on the 1990's some countries in Asia and Latin America, the money policy variables he chose were the changes in domestic credit, the spreads of domestic interest rates and U.S. interest rate. Evan Tanner (2002) took the same method to analyze 32 emerging market countries.

With regard to the measurement and analysis for Chinese foreign exchange market, Zhu Jie (2003) used Wemark's (1995) model to measure China's 1994-2002 foreign exchange market pressure and intervention index, but this paper didn't research the relationship between the foreign exchange market pressure and monetary policy. Bu Yongxiang(2008) adopted G-R definition on exchange market pressures, and used the monetary model to calculate the pressure of RMB appreciation from January 1994 to January 2008 and analyzed the relationship between the pressure of RMB appreciation and monetary policy, he found China's domestic credit and the pressure of RMB appreciation was in inverse relationship, while the level of domestic interest rates, economic growth were in positive relationship with the appreciation of the Renminbi, and he thought the increase of the United States interest rates is not the direct cause for the pressure of RMB appreciation. In addition, he believed that Chinese monetary policy kept high independence and the higher pressure of RMB appreciation stem from the domestic. But the two papers have some problems: (1) the foreign exchange market pressures should be calculated under a managed floating exchange rate system. but from 1994 to July 21 of 2005, China had been implemented an exchange rate regime pegged to the U.S. dollar, and for a long time RMB exchange rate against the U.S. dollar have remained unchanged. According to G-R definition, the foreign exchange market pressure is only an increase in foreign exchange reserves, and from a practical perspective, after 1994, even though China's foreign exchange reserves kept growing, and at a very long period of time the RMB didn't have any appreciation pressure, but because of the pressure from the western developed countries, in recent years, the RMB is showing an appreciation pressure; (2) they did not consider the foreign exchange market intervention and sterilization.

We think China's foreign exchange market pressure is the pressure of appreciation of Renminbi and increase in foreign exchange reserves caused by the international market's excess demand for Renminbi in a managed floating exchange rate system. We modify Weymark's (1997) model to measure China's foreign exchange market pressure and intervention index. After

measuring the pressure of the foreign exchange market, we use the VAR model to analyze the relationship between the foreign exchange market pressure and monetary policy in China from July 2005 to August 2008. The remainder of this paper is arranged as follows: in section II, we construct a measurement model apt to China's reality of foreign exchange market pressure, we mainly refer to Weymark (1995, 1997). In section III, we adopt cointegration, OLS, GMM and State-Space model to calculate the relevant variables, then we use the model to measure the foreign exchange market pressure and intervention index. In section IV, we introduce VAR model to analyze the relationship between the foreign exchange market pressure and monetary policy. Section V, conclusion and some policy suggestions.

II. The model

We refer to Weymark's model, (1995, 1997) of the foreign exchange market pressure but we modify it in accordance with China's reality. We assume: 1) the domestic price level is influenced by the foreign price level and the exchange rate, but the theory of purchasing power parity may not hold; 2) foreign price level and domestic output are exogenous; 3) incomplete capital flows, monetary authorities can achieve the sterilized intervention; 4) domestic residents hold RMB in order to meet the demand of transactions, and foreign residents hold the RMB in order to satisfy the speculative demand (expecting that RMB will appreciate).

Based on the above assumptions, we set up the model as follows:

$$p_t = a_0 + a_1 p_t^* + a_2 e_t \quad (1)$$

$$i_t = i_t^* + E(e_{t+1} | t) - e_t + \delta_t \quad (2)$$

$$m_t^d = p_t + b_1 y_t - b_2 i_t + v_t \quad (3)$$

$$m_t^s = m_{t-1}^s + \Delta d_t + \Delta r_t \quad (4)$$

$$\Delta r_t = -\rho_t \Delta e_t \quad (5)$$

In equation (1), p_t and p_t^* are respectively the domestic and foreign price level in logarithms in period t , e_t is the exchange rate in period t expressed in terms of the domestic currency cost of one unit of foreign currency, if $a_0 = 0, a_1 = a_2 = 1$, equation (1) is the expression of purchasing power parity. In equation (2), i_t and i_t^* are respectively the domestic and foreign interest rate. The notation $E(e_{t+1} | t)$ represents that conditional on the information available in period t , rational agents expect the exchange rate in logarithms to take on in period $t + 1$. δ is risk premium, in order to meet the flow of capital assumptions, and we add risk premium to the uncovered

interest parity. We will specify on δ later. In equation (3) and (4), m^d, m^s represent the domestic money demand and supply in logarithms respectively, y represents real domestic output in logarithms, v_t random stochastic variable. Δd_t represents the change in domestic credit expressed as a proportion of the previous money balance, that is $\Delta d_t = (h_t D_t - h_{t-1} D_{t-1}) / M_{t-1}$. Δr_t represents the change in foreign exchange reserves expressed as a proportion of the previous money balance, that is $\Delta r_t = (h_t R_t - h_{t-1} R_{t-1}) / M_{t-1}$. where h is the money multiplier, and h is not fixed, D is domestic credit, M_{t-1} represents money balance at period $t-1$, R is foreign exchange reserves. In equation (5), ρ_t is the policy authority's response coefficient, it varies over time.

Substituting equation (1) and (2) into (3), we obtain:

$$m_t^d = a_0 + a_1 p_t^* + (a_2 + b_2) e_t + b_1 y_t - b_2 i_t^* - b_2 E(e_{t+1} | t) - b_2 \delta_t + v_t \quad (6)$$

It is assumed that money market equilibrium is always re-established within one period. And central bank implements sterilized intervention policy, so this means that:

$$\Delta m_t^s - \Delta d_t^s = \Delta m_t^d \quad (7)$$

Δd_t^s represents the change of sterilized domestic credit (return of the money supply) express as a proportion of previous money balance.

from (4) and (7), we get:

$$\Delta m_t^d + \Delta d_t^s = \Delta d_t + \Delta r_t \quad (8)$$

The first-order difference of equation(6), combined with equation(8), we obtain:

$$\Delta d_t + \Delta r_t - \Delta d_t^s = a_1 \Delta p_t^* + (a_2 + b_2) \Delta e_t + b_1 \Delta y_t - b_2 \Delta i_t^* - b_2 \Delta E(e_{t+1} | t) - b_2 \Delta \delta_t + \Delta v_t \quad (9)$$

For the convenience of calculation, we set the change of risk premium $\Delta \delta_t = k \Delta r_t$ (Weymark, 1997), where k is the portion of sterilization, $k \in [0, 1]$.

From (9), we solve Δe_t :

$$\Delta e_t = \frac{(1 + kb_2) \Delta r_t + \Delta d_t - \Delta d_t^s - [a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* - b_2 \Delta E(e_{t+1} | t) + \Delta v_t]}{a_2 + b_2}$$

(10)

According to the calculating formula of the foreign exchange market pressure (EMP) (Weymark, 1995, 1997):

$$EMP_t = \Delta e_t + \eta \Delta r_t \quad (11)$$

$$\text{Where } \eta = -\frac{\partial \Delta e_t}{\partial \Delta r_t}$$

From (10) we obtain $\eta = -(1 + kb_2)/(a_2 + b_2)$, substituting it into (11) yields:

$$EMP_t = \Delta e_t - (1 + kb_2)/(a_2 + b_2) \Delta r_t \quad (12)$$

From $\Delta r_t = -\rho_t \Delta e_t$ and equation (12), we get,

$$EMP_t = [1 + \rho_t(1 + kb_2)/(a_2 + b_2)] \Delta e_t \quad (13)$$

According to Weymark's formula for calculating foreign exchange market intervention $\omega_t = 1 - \Delta e_t / EMP_t$, then foreign exchange market intervention index can be calculated as:

$$\omega_t = \frac{\rho_t(1 + kb_2)}{a_2 + b_2 + \rho_t(1 + kb_2)} \quad (14)$$

In a fully floating exchange rate system, the monetary authorities do not intervene the foreign exchange market, it means $\rho_t = 0$, then $EMP_t = \Delta e_t$, intervention index $\omega_t = 0$, pressure on the foreign exchange market can be eliminated through the exchange rate movements.

In a perfectly fixed exchange rate system, the monetary authorities directly intervene the foreign exchange market in order to guarantee a fixed exchange rate, it means $\rho_t = \infty$, Monetary authorities eliminate exchange rate changes by the changing the foreign reserves. Then $EMP_t = \infty * \Delta e_t$, Pressure on the foreign exchange market are infinite times of exchange rate variations, and $\omega_t = 1$.

From the above two extreme cases, in a managed floating exchange rate system we can obtain monetary authorities' response coefficient $0 < \rho_t < \infty$, The foreign exchange market intervention index $0 < \omega_t < 1$. Exchange market pressures can be eliminated through changes in exchange rates or changes in foreign reserves or both two.

Conclusively, the foreign exchange market pressure and exchange rate fluctuations are positively correlated. In other words, if the exchange rate appreciates, $EMP < 0$; if depreciates, $EMP > 0$.

III. China's foreign exchange market pressure

According to the model presented in the foregoing section, before we yield foreign exchange market (EMP) and foreign exchange market intervention index (ω_t), we need to calculate only response coefficient ρ_t and the structural parameters k , a_2 , b_2 .

(i) Estimating structural parameters

China's 70% of foreign exchange reserves are dollar reserves, and for a long period RMB has been pegged to the U.S. dollar, so we only consider the RMB against the U.S. dollar and U.S. economic data. The period of analysis span is from July 2005 to August 2008 and we use monthly data, and we choose China CPI and the U.S. CPI (base period is July 2005) to represent the domestic and foreign price level; for the exchange rate, we choose the nominal exchange rate of RMB against the U.S. dollar; set $\log(\xi_t + \Delta\xi_t)$ to represent $E(e_{t+1} | t)$, where ξ_t is the nominal exchange rate of RMB against the U.S. dollar in period t ; for domestic and foreign interest rate, we respectively choose Chinese three-month Treasury interest rate level and the U.S. dollar three-month interest rates of certificate of deposits; M2 represents domestic money balance; monthly Return of the money represents the sterilized domestic credit; GDP represents the domestic output (because only the quarterly GDP data is available, we linearly interpolate on the quarterly data to estimate monthly data by using Matlab 7.0). To adjust the monthly data by price level, we get the real domestic output. All data we used are from the CEInet statistical database except for Return of the money which is from WIND Database. All the data have been seasonal adjusted. We use Eviews6.0 to process the data.

For equation (1), we do stationary test on the related data, we found that logarithm domestic and foreign price level, the logarithm exchange rate are non-stationary, all they are follow I(1), as the following table shows:

Table 1 ADF Unit Root Test

Variable	ADF	Prob.
e	3.44	1.00
Δe	-4.58	0.0007*
p	1.04	0.996
Δp	-5.47	0.0001*
p^*	-0.103	0.942
Δp^*	-4.84	0.0004*

Note: * denotes the test statistics reject null hypothesis, at significance level of 1%

LM series correlation test shows no series correlation, then the Johansen cointegration test on

the variables indicates there exists one cointegrating relation, that means there is long-run equilibrium relationship among the variables, which is:

$$p = 1.078p^* + 1.303e \quad (15)$$

$$t \text{ value } (3.27) \quad (7.69)$$

The first-order difference on two sides of equation (2) yields:

$$\Delta i_t = \Delta i_t^* + \Delta E(e_{t+1} | t) - \Delta e_t + k(\Delta r_t - \Delta r_{t-1}) + \theta_t \quad (16)$$

We carry the stationary test (ADF test) on the above variables, and find the logarithm expected exchange rate is I(1) under significance level of 1%; foreign interest rate I(1) under significance level of 5% ; change in reserve I(0) under significance level of 1%. Therefore, to regress on equation (16) won't get spurious regression, and E-G cointegration test also proved this point. We get $k = 0.5$ (t value is 2.25) by regression. It can be interpreted as the size sterilized intervention accounts for half of the total size of foreign market intervention. This result is slightly different from Xu Dongming's(2007). They thought the sterilization coefficient arrived above 0.8 from the exchange rate reform in 2005 to the first quarter of 2007. We think, the different estimated model and observed period may cause the difference.

E-G cointegration test is to do unit root test on the residual series, if the residual series is non-stationary, then the regression is the spurious regression, and if that it indicates there are some problems in model specification. The ADF test finds that at 1% significant levels residual series is I(0), that means residual is stationary.

Substituting the estimated equation (15) and (16) into equation (3), then the equation we should estimate is:

$$\Delta d_t + (\Delta r_t - \Delta r_{t-1}) - \Delta d_t^s = \Delta p_t + b_1 \Delta y_t - b_2 \Delta i_t + v_t \quad (17)$$

By GMM estimation method, we get: (t value in bracket)

$$b_1 = 4.48(7.19)$$

$$b_2 = 0.34(2.21)$$

E-G cointegration test (PP test) indicates the residual series is stationary.

(ii) Estimating monetary authority's response coefficient

As for $\Delta r_t = -\rho_t \Delta e_t$ (ρ_t is time-variant), we adopt the state space model to estimate ρ_t .

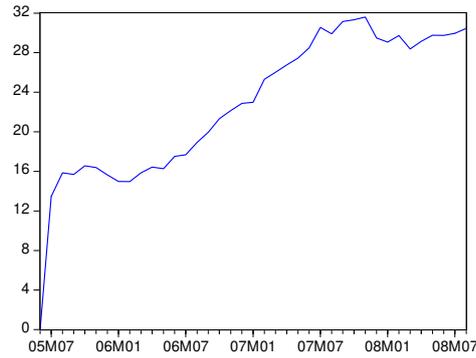
We implement the state space model by Eviews 6.0, and the data used is same as that in above section.

$$\text{Measurement equation: } \Delta r_t = -\rho_t \Delta e_t + u_t$$

$$\text{State equation: } \rho_t = 1^* \rho_{t-1}$$

The figure below describes the movement of the ρ_t :

Figure 1 policy authority's response coefficient



(iii) Estimating the foreign market pressure (EMP)

We have resolved the response coefficient ρ_t and model structural coefficients k , a_2 , b_2 in above estimation section.

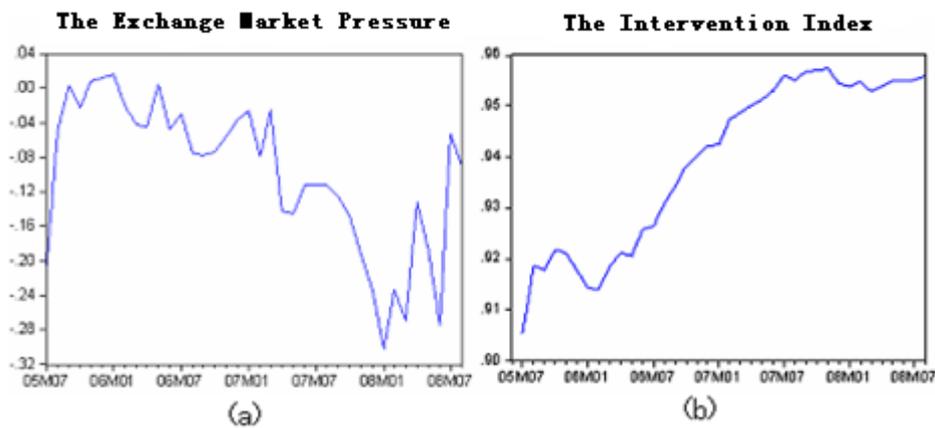
From the above, we get:

$$EMP_t = [1 + \rho_t(1 + kb_2)] / (a_2 + b_2) \Delta e_t,$$

$$\omega_t = \frac{\rho_t(1 + kb_2)}{a_2 + b_2 + \rho_t(1 + kb_2)}$$

Substituting the estimated coefficients into correspondent formulas yields foreign market pressure (EMP) and foreign market intervention index ω_t .

Figure 2 Foreign market pressure (EMP) and foreign market intervention index



From Figure 2, we can see that, since the exchange rate system reform, China's foreign exchange market pressure are negative most of the period, only a very few months are positive. From July 2005 to January 2008 the absolute value of EMP kept increasing, and since January 2008 it began to decrease. It demonstrates that, before January of 2008, the foreign exchange market pressure is rising, and the pressure is mostly appreciation pressure. From the foreign

exchange market intervention index, when the foreign exchange market pressure is increasing, the foreign exchange market intervention index is also rising. To compare the two graph, we find the foreign exchange market pressure and intervention index are consistent in the trend.

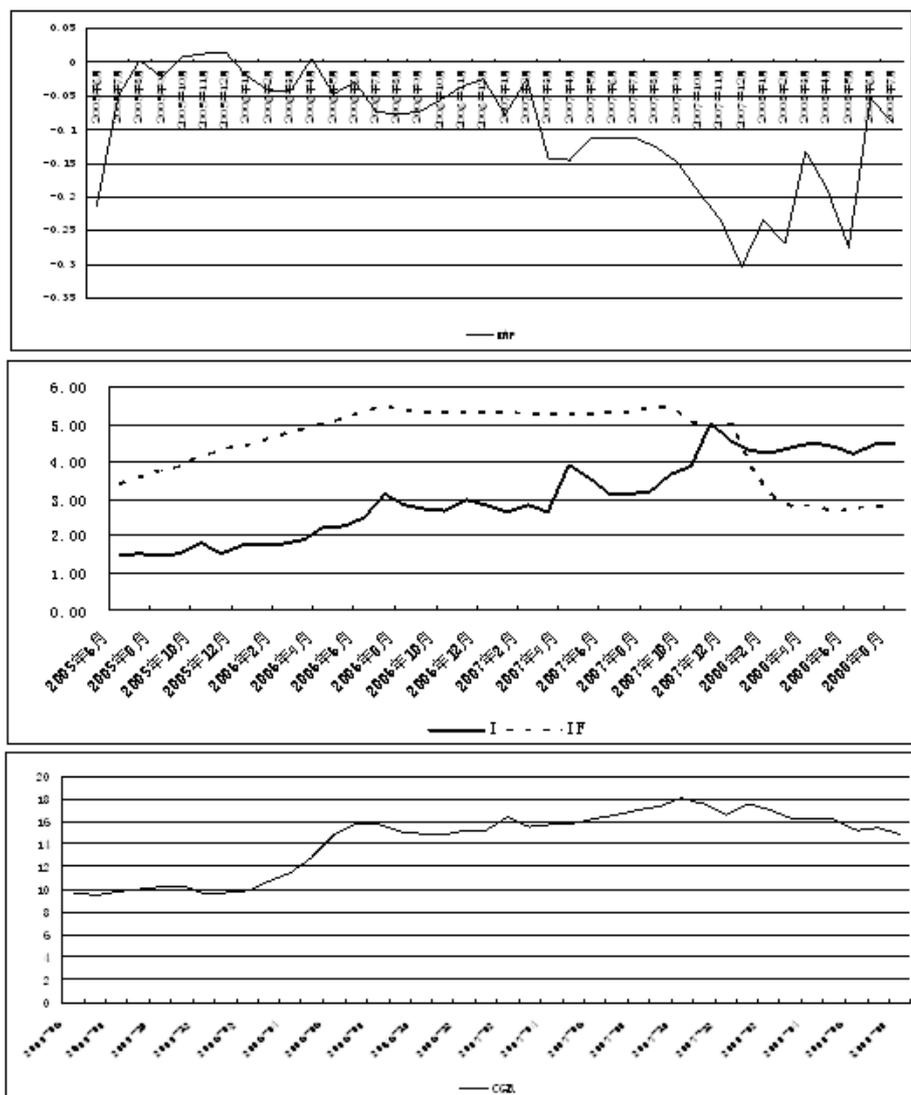
IV. China's foreign exchange market pressure and monetary policy

The above-mentioned foreign exchange market pressure model shows that domestic interest rate, domestic credit and foreign interest rate will have an impact on the EMP. From a theoretical point of view, when the domestic interest rate higher than foreign interest rate by a certain extent, it would lead to capital flows, and increase foreign exchange market pressure; domestic credit growth will increase the monetary supply, and rising of the foreign exchange market pressure will lead to lower interest rate spreads between home and abroad and increase in domestic credit.

From a practical point of view, since the exchange rate system reform, RMB exchange rate is keeping appreciating steadily with slightly fluctuations. The period of analysis span is from July 2005 to August 2008. Exchange market pressures are from the above calculation results; three-month Treasury bills interest rate stands for domestic interest rates (expressed by I), U.S. dollar three-month interest rates of certificate of deposits stands for foreign interest rate (IF); domestic and foreign currency credit year-on-year growth rate of monthly data denotes the domestic credit growth rate (CGR). All data are from the CEInet statistics, and seasonal adjusted.

The figure 3 shows the trend of EMP , I , IF and CGR with seasonal adjustment, from July 2005 to August 2008.

Figure 3 EMP , I , IF and CGR



Form the figure above, firstly to focus on the EMP , we find that, since the exchange rate system reform, except for only a very few months in which there exists depreciation pressure, in most of months there exists appreciation pressure, and the appreciation pressure are moving up to the peak in January of 2008, then slightly declining. Secondly, to keep light on the interest rate, we know that, domestic interest rate (I) is climbing from June of 2005 to January of 2008, and the interest spread rate between China and the U.S. is becoming narrower, even from January of 2008 until August, the spread is reverse, and China's interest rate starts to surpass the U.S. interest rate. Then, we come to the domestic credit, and find that, in this period, the domestic credit is going up, and the growth rate is especially high in 2006, while other times relatively stable. To compare the four graphs, we find that EMP , domestic interest rate and domestic credit growth rate are moving in the same direction, whereas, in the opposite direction with foreign interest rate. Therefore, we can make the following conjecture: During this period, the increase in domestic interest rates may have led to increasing pressure on foreign exchange market; foreign interest rates will reduce the foreign exchange market pressures. Domestic interest rate does not seem to affect domestic credit growth rate.

Therefore, we are going to do empirical research on the four variables to analyze the specific

relationship among them in the given period. Since most of the period the foreign exchange market pressure is appreciation pressure, for convenient purpose, we weed out a few the depreciation pressure data (actually these depreciation pressure data are only the relative depreciation of last, but compared with the initial time still appreciation,), and use the absolute value, then we still use EMP to express it.

We construct empirical model and use Eviews6.0 to process the data:

(i) Stationary test on the series (ADF test)

Table 2 Output of ADF test

Variable	ADF	propability
<i>EMP</i>	-2.735964	0.0803***
ΔEMP	-7.372298	0.0000*
<i>CGR</i>	-1.851960	0.3506
ΔCGR	-4.376739	0.0013*
<i>I</i>	-0.783079	0.8120
ΔI	-7.194207	0.0000*
<i>IF</i>	-0.949431	0.7608
ΔIF	-3.199884	0.0280**

Note: * denotes the test statistic rejects null hypothesis, at significance level of 1%; ** denotes that at significance level of 5%; *** denotes that at significance level of 10%

From the ADF test output, we see that, at significance level of 10%, all these variables are $I(1)$, thus, we can build VAR model with these variables.

Using matrix to describe VAR model:

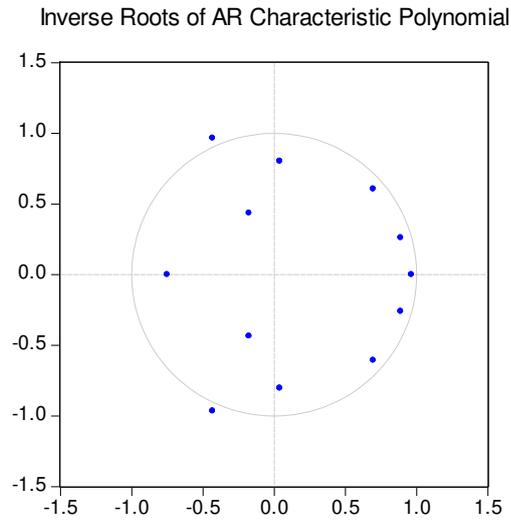
$$\begin{bmatrix} EMP_t \\ CGR_t \\ I_t \\ IF_t \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} & \dots & b_{1j} \\ b_{21} & \ddots & & \\ b_{31} & & & \\ b_{41} & \dots & \dots & b_{4j} \end{bmatrix} \begin{bmatrix} EMP_{t-j} \\ CGR_{t-j} \\ I_{t-j} \\ IF_{t-j} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{bmatrix}$$

(ii) Construction and test of VAR(4) model

To construct VAR(4) model by using Eviews 6.0, lag length we set is 4, then to diagnose this model.

(1) Model stability test

Figure 4 Stability of VAR model



From figure 4, 2 unit roots lie outside the unit circle, so it shows the model is not stable. But the following cointegration test shows there are cointegrated relations among these variables.

(2) Granger Causality Tests

Table 3 Output of Granger causality tests

	Null hypothesis	χ^2 value	d.f.	Prob.
<i>EMP</i> equation	<i>CGR</i> isn't the Granger causation of <i>EMP</i>	5.820620	3	0.1207
	<i>I</i> isn't the Granger causation of <i>EMP</i>	9.349947	3	0.0250**
	<i>IF</i> isn't the Granger causation of <i>EMP</i>	10.78493	3	0.0129**
	ALL isn't the Granger causation of <i>EMP</i>	36.67564	9	0.0000
<i>CGR</i> equation	<i>EMP</i> isn't the Granger causation of <i>CGR</i>	15.11253	3	0.0017*
	<i>I</i> isn't the Granger causation of <i>CGR</i>	5.494566	3	0.1390
	<i>IF</i> isn't the Granger causation of <i>CGR</i>	22.10010	3	0.0001*
	ALL isn't the Granger causation of <i>CGR</i>	33.18533	9	0.0001
<i>I</i> equation	<i>EMP</i> isn't the Granger causation of <i>I</i>	3.967243	3	0.2650
	<i>CGR</i> isn't the Granger causation of <i>I</i>	6.789113	3	0.0789***
	<i>IF</i> isn't the Granger causation of <i>I</i>	2.546093	3	0.4670
	ALL isn't the Granger causation of <i>I</i>	8.770381	9	0.4587
<i>IF</i>	<i>EMP</i> isn't the Granger causation of <i>IF</i>	3.531265	3	0.3167

equation	CGR isn't the Granger causation of IF	0.901589	3	0.8250
	I isn't the Granger causation of IF	0.167261	3	0.9827
	ALL isn't the Granger causation of IF	20.80877	9	0.0135

Note: * denotes rejection of the hypothesis at the 1% level, ** denotes rejection of the hypothesis at the 5% level, ***

denotes rejection of the hypothesis at the 10% level,

From the above table we can see that: at significance level of 5%, domestic interest rate (I) and foreign interest rate (IF) are Granger causations of foreign exchange market pressure (EMP), but the domestic credit growth rate is not; at significance level of 1%, exchange market pressure (EMP) and foreign interest rate (IF) are Granger causations of domestic credit growth rate (CGR), domestic interest rate (I) is not Granger causation of domestic credit growth rate (CGR), this is mainly because, from June of 2005 to August of 2008, the return generated by the Chinese asset price rising exceeded the costs caused by the increase of interest rate, thus, the response of domestic credit to interest rate is very weak. As for foreign interest rate (IF) can cause the growth rate of domestic credit is due to domestic credit includes foreign currency credit (mainly U.S. dollars), and for a very long time U.S. interest rate is higher than domestic interest rate, and U.S. interest rates is relatively stable, with the expectation of appreciation of RMB, the narrower interest rate margin between china and the U.S. could enable enterprises to increase the demand for U.S. dollar credit (Guo Fenglin, 2006); at significance level of 10%, domestic credit growth rate isn't the Granger causation of domestic interest rate (I), that is because, in order to prevent inflationary pressure caused by excessive domestic credit growth, the monetary authorities tried to raise interest rates to ease the credit. The foreign exchange market pressure (EMP) and foreign interest rates (IF) are not Granger causations of domestic interest rates (I); Finally, foreign interest rates (IF) isn't impacted by China's domestic variables, which are in line with the reality, the U.S.'s interest-rate policy is mainly focus on the its domestic economic situation.

(3) Johansen Cointegration Testing

Auto correlation LM test shows the variables are not correlated. By VAR Lag Order Selection Criteria, the LR test statistics indicate to select lag order of 3, while FPE, AIC, SC and HQ select lag order of 4. But to do cointegration test by selecting lag order of 4 won't come to solution, thus, we select 3 as the lag order. Then we do cointegration test with lag order of 3, the result indicates there exists two cointegrated vectors.

Table 4 Johansen cointegration tests

Hypothesized No. of CE(s)	Eigenvalue	Trace statistics (prob.)	$\lambda - \max$ statistics (prob.)
None	0.967003	118.3633 (0.0000*)	78.46110 (0.0000*)
At most 1	0.657279	39.90216 (0.0025*)	24.62927 (0.0154**)
At most 2	0.484995	15.27289 (0.0540)	15.26231 (0.0347**)
At most 3	0.000460	0.010588 (0.9178)	0.010588 (0.9178)

Note: * denotes rejection of the hypothesis at the 1% level, ** denotes rejection of the hypothesis at the 5% level.

Trace test and $\lambda - \max$ test indicate that there are two cointegrated vectors. Trace test shows there are two cointegrated vectors at the 1% level, while $\lambda - \max$ test shows three are three cointegrated vectors at the 5% level. And we think there are two cointegrated vectors at the 1% level.

As the variables are cointegrated, we get the output of VAR (4), as follows:

Table 5 output of VAR (4)

	EMP	CGR	I	IF
EMP(-1)	-0.505283 [-1.81436]	0.935980 [3.17749]*	-0.068538 [-0.34146]	-0.186811 [-1.47064]
EMP(-2)	-0.363405 [-0.83593]	1.614319 [3.51074]*	0.472087 [1.50668]	-0.335856 [-1.69376]
EMP(-3)	0.447883 [1.00943]	0.735370 [1.56692]	0.135824 [0.42472]	-0.099441 [-0.49135]
CGR(-1)	-0.266713 [-0.96906]	0.802207 [2.75564]*	-0.147381 [-0.74296]	0.043977 [0.35031]
CGR(-2)	0.692615 [1.96407]*	0.488430 [1.30947]	0.510940 [2.01026]*	-0.125643 [-0.78112]
CGR(-3)	-0.500025 [-2.02658]*	-0.646325 [-2.47658]*	-0.339861 [-1.91113]	0.079379 [0.70533]
I(-1)	0.995948 [2.20391]*	-0.097791 [-0.20459]	1.081595 [3.32077]*	-0.006978 [-0.03385]

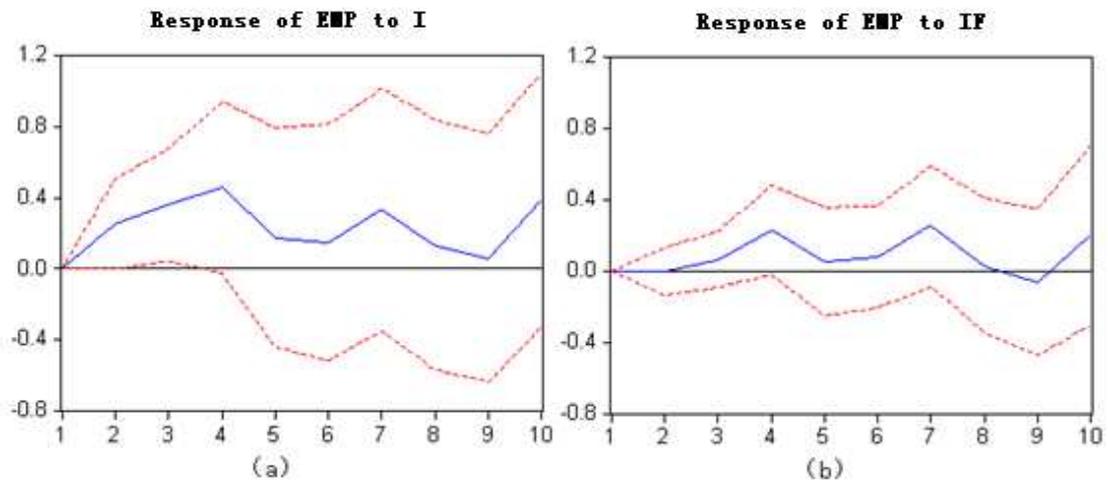
I(-2)	0.602886 [0.93478]	-1.425299 [-2.08934]*	-0.565144 [-1.21577]	-0.018322 [-0.06228]
I(-3)	0.741963 [1.14270]	-0.376796 [-0.54864]	0.104590 [0.22349]	0.113002 [0.38155]
IF(-1)	-0.025100 [-0.04272]	2.740922 [4.41030]*	0.051349 [0.12125]	0.873204 [3.25818]*
IF(-2)	1.254550 [1.21264]	-1.303546 [-1.19124]	0.892363 [1.19675]	-0.756909 [-1.60400]
IF(-3)	-0.439322 [-0.52769]	-0.930315 [-1.05647]	-0.945454 [-1.57564]	0.716946 [1.88800]
C	-8.858831 [-3.05599]*	6.134761 [2.00079]*	0.437908 [0.20959]	1.147598 [0.86793]

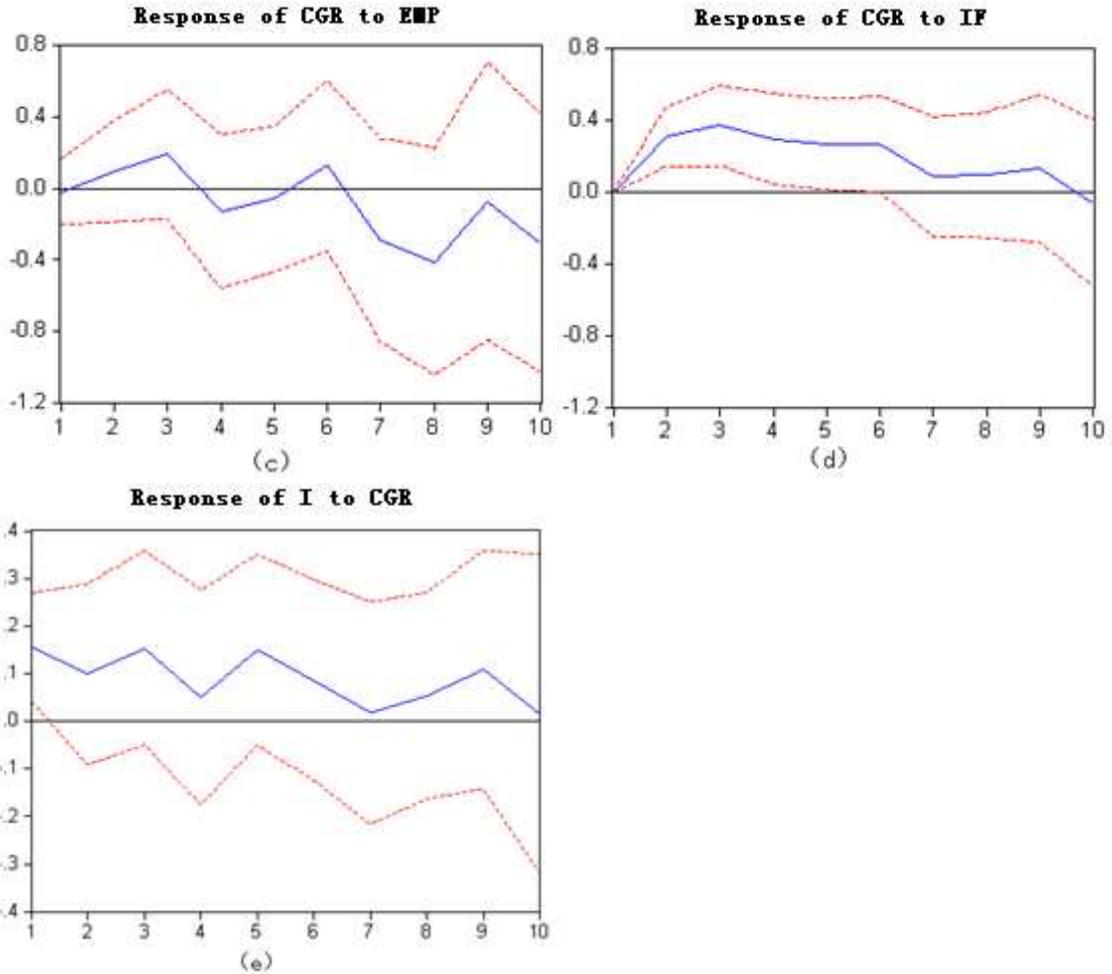
Note: The value in bracket is t value;* denotes the rejection of null hypothesis, at significance level of 5%.

(4) Impulse Responses

Granger causality tests indicate, I and IF are Granger causations of EMP , EMP and IF are Granger causations of CGR , CGR is Granger causation of I . We respectively observe the responses of EMP to a positive shock of I and IF , the responses of CGR to a positive shock of EMP and IF , and the response of I to a positive shock of CGR .

Figure 5 Impulse responses of EMP , CGR , I





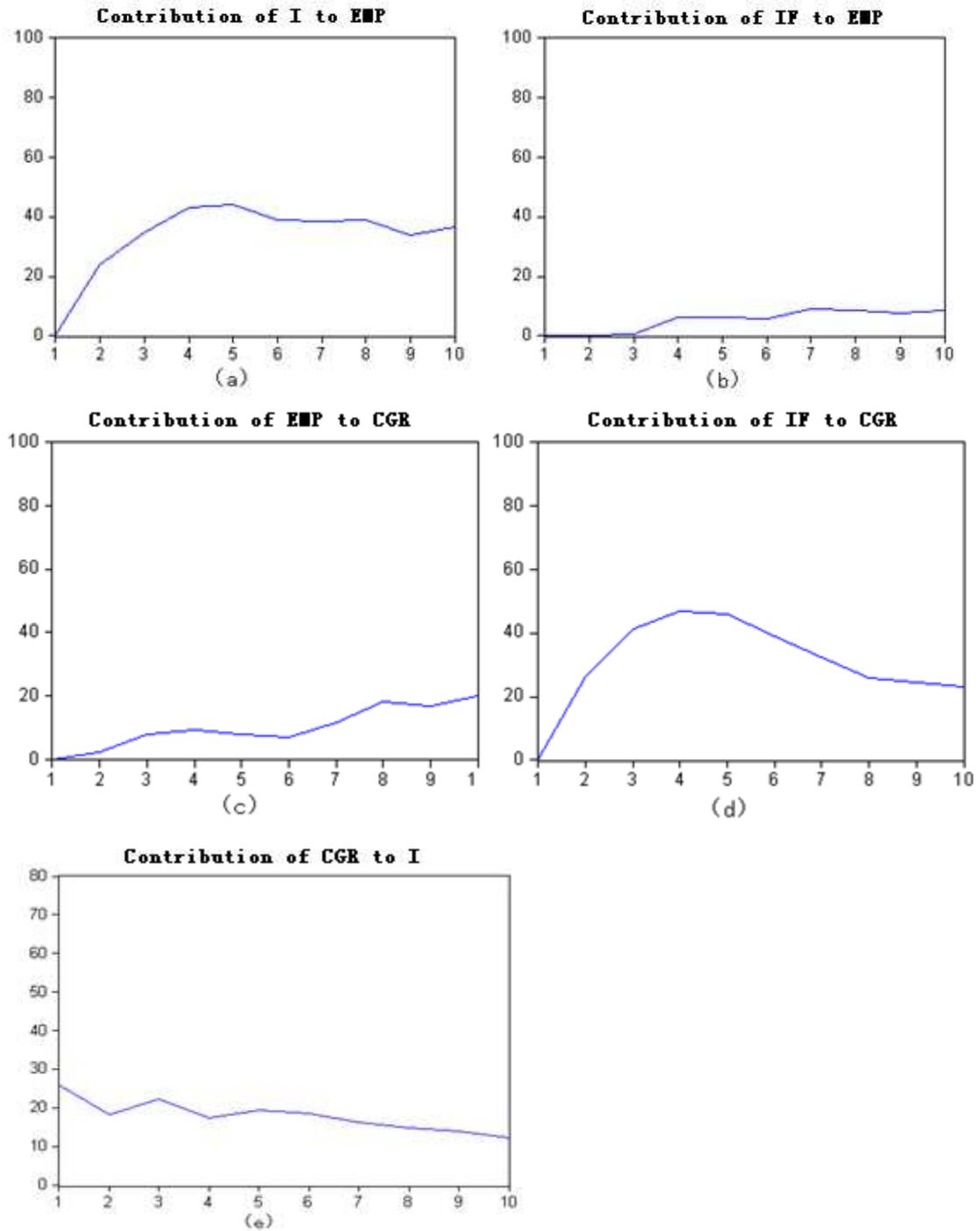
From Figure 5 (a) and (b) we can see that: to set a positive shock on domestic interest rate and foreign interest rate, the foreign exchange market pressure will increase as domestic interest rates increase, and reach the peak at the fourth period; And a positive shock on foreign interest rate generally decreases the foreign exchange market pressure at the beginning, but from the third period the foreign exchange market pressure will increase. From Figure 5 (a) and (b) we can see: to set a positive shock on EMP and foreign interest rate, the domestic credit will increase in the beginning three periods, so that to alleviate the appreciation pressure of RMB. A positive shock on foreign interest rate causes the domestic credit to increase, that is mainly because, the interest rate of the U.S. dollar three month certificate of deposit are higher than interest rate of RMB Certificate of deposit. From Figure 5 (e), it can be seen: to set a positive shock on domestic credit, interest rates will also increase, and this is because, the monetary authorities is to prevent asset price bubbles and inflation caused by excessive credit.

(5) Variance Decomposition

While impulse responses analyze the effects of a shock to one endogenous variable on to the other variables, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR model. Thus, the variance decomposition provides the information about the relative importance of each random innovation in affecting the variables.

By doing variance decomposition, we get:

Figure 6 variance decomposition of EMP , CGR , I



From Figure 6 (a) and (b), the domestic interest rate makes the most significant contribution to the foreign exchange market pressure, in the fourth period and five period reaches the maximum 40%. And foreign interest rate makes a little significant contribution to the foreign exchange market pressure, even the largest is only 10%. This shows that the increasing domestic interest rate is the main reason for the increasing foreign exchange market pressure. From Figure 6(c) and (d), the contribution of foreign interest rate to domestic credit is most significant, and reaches the max-value about 50% at the fourth period. But the contribution of the foreign exchange market pressure to the domestic credit is relatively small, even the largest is only 20%.

From Figure 6(e), the contribution of domestic interest rate domestic credit to is declining, because that domestic interest rate initially increase due to the excessive credit growth, but afterwards the effect will become small.

V. Conclusion

Since the RMB exchange rate system reform in July 2005, the RMB exchange rate has been rising. Although there is no significant increase in the short term, but until August of 2008, the RMB/USD had appreciated about 16.65%. China's excess foreign exchange reserves and international market's expectation of appreciation of RMB, as well as other factors make the appreciation pressure of RMB to be still exist. In order to avoid the impact of China's economy, monetary authorities (central bank) maintain the stability of the RMB exchange rate by intervening in the foreign exchange market, at the same time sterilizing the money supply. However, from China's actual situations, with the central bank increasingly higher costs of sterilization, the sterilization has not played a positive and effective role. This led to a dilemma in the past two years, one is internal devaluation of RMB (excess liquidity is an important reason), facing the inflation pressure; the other is the external appreciation of RMB, RMB exchange rate against major currencies is rising.

In this paper, we measured China's foreign exchange market pressure and intervention index in the foreign exchange market from July 2005 to August 2008, and exchange market intervention has been found keeping at a high level. This shows that China's foreign exchange intervention is always in existence and strong. Then we utilized the VAR model to analyze the relationship among the foreign exchange market pressure, domestic credit growth rate, as well as domestic and foreign interest rates. We found that there is a long-term and stable relationship among these variables. Empirical results show that rising domestic interest rate is the major reason to cause Chinese foreign exchange market pressure increasing, this is because the rising domestic interest rate decreases the interest rate spread between the United States and China, especially in February of 2008 formed a spread upside down, together with the increasing United States economic uncertainty due to sub-prime crisis, China's economy is relatively stable, as well as appreciation expectation of RMB has led to foreign capital inflows through various channels, which increases the foreign exchange market pressure. With the increase of foreign exchange market pressure, to maintain the stability of the RMB exchange rate the monetary authorities intervened in the foreign exchange market, according to previous estimate of China's foreign exchange proportion of sterilized intervention accounted for around 50%, while the remaining part of the unsterilized money supply would more or less increase domestic credit. The increase in domestic credit would lead to the central bank to raise interest rates to prevent overheating the domestic economy (in the last two years, the rapid expansion of asset prices, and the recent high level of CPI). This would fall into a vicious cycle. However, we noted that meanwhile, interest rate of the U.S. dollar certificates of deposit is also an important reason for the increase in domestic credit. The increase in the U.S. dollar certificates of deposit interest rate led to increase in domestic credit, in order to prevent the economy from overheating, the monetary authorities would raise the domestic interest rate. Even though U.S. certificate of deposit interest rate will reduce exchange market pressure, but its effects far less than the effect of the rising domestic interest rate which enhances the foreign exchange market pressure, therefore the consequences of raising interest rate will fall into the

former vicious cycle. Thus, the key issue of the solution to the foreign exchange market pressure (the appreciation pressure of RMB) is how to maintain a proper spread between the domestic interest rate and foreign interest rate.

According to the theory of "ternary paradox", which indicates among the perfect mobility of capital, the stability of exchange rate and the independence of monetary policy only two can happen at the same time. However, from China's practical point of view, and combined with these empirical studies, China's capital account has not yet open, capital can't flows completely; In addition, we have implemented a managed floating exchange rate (not a full sense of the floating exchange rate system), the exchange rate is relatively stable. If refer to the theory of "ternary paradox", China's monetary policy should maintain its independence, which means the making of monetary policy should major take the domestic economic fundamentals into account. When monetary policy independence is high, in the case of overheating of the economy, to raise interest rates is the optimal selection. However, the conclusions from the above we know that higher interest rate is the main reason for increasing RMB appreciation pressure. When responding to the domestic economy imbalance, they further increase the external imbalance, and the speedup of the RMB appreciation has affected some of China's export-oriented enterprise, which is unfavorable to the China export-led economy. Therefore, the applicability of the theory of "ternary paradox" in China still is a matter for argument.

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