MEASURING THE UNDERVALUATION OF CHINESE EXCHANGE RATE AND SOME EXTENSIONS

by

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Abstract

This paper presents an empirical analysis of the long term equilibrium value of the Chinese real effective exchange rate and its major economical fundamentals which determine its long run and short run movements. The empirical analysis, building on an econometrical Vector Error Correction Model (VECM) approach, derives a Behavioral Equilibrium Exchange Rate (BEER) and a Permanent Equilibrium Exchange Rate (PEER). Two different model specifications are retained, according to different combinations of those economical fundamentals. Results indicate that productivity differentials, net foreign asset position, terms of trade, foreign reserves, and degree of openness trade all have significant influences on the Chinese RMB effective exchange rate.

Both specifications lead to the same conclusion that there indeed existed some time period that Chinese real effective exchange rate was undervalued from 1985 to 2007; however, there also existed almost equal amount of the time in which it was overvalued. The maximum undervaluation of Chinese real effective exchange rate is around 16 per cent (BEER) when net foreign asset position is included, and only 9 per cent with its permanent fundamental components (PEER). When we include foreign reserves in the estimation equation, percentage deviations of both BEER and PEER are much more dramatic. With this medium-size misalignment, an immediate reform to flexible exchange rate regime or revaluation seems unnecessary. Moreover, assessing the existence and the extent of the undervaluation of the exchange rate is not straightforward. We must not ignore the fact that choices of estimation models and fundamental variables have some degree of subjectivity. Some suggestions about the reform of Chinese exchange rate system are provided at the end of the paper.

I. Introduction

The China's exchange rate debate has emerged as one of the most talked about topics in international economics. The focus of the study of the Chinese RMB exchange rate has transferred from debate on whether it should appreciate or depreciate to the overall improvement of the RMB exchange rate regime.

Since 1994, Chinese government has frequently adjusted the official exchange rate to make it emerge to the swap rate (borrowing rates between financial institutions). On July 21st. 2005, the central bank of China[1] announced that the current fixed exchange rate system would be abandoned, and China would adopt a managed float exchange rate system, where the central bank can intervene to stabilize the exchange rate by selling or buying currencies. This is a more flexible exchange rate regime policy compared to the previous fixed rate regime system: switching from the dollar peg to a basket of currencies. Under the new regime institution, the RMB would be allowed to fluctuate by 3 per cent a day against the euro, yen and other non-dollar currencies. At the same time, the RMB was revaluated by 2.1 per cent.

However, many scholars, especially the US government, still complain about the undervaluation of Chinese currency. Preeg (2003) claims that the exchange rate manipulation by Chinese government has resulted in about 40 per cent undervaluation of the RMB exchange rate in the 1990s, and hence unfair competitive advantage. In his paper, he listed many consequences that caused by this exchange rate misalignment of

[1] Known as the People's Bank of China.

Chinese RMB to the US, such as job losses, productivity and output growth declining, current account deficit, etc[2].

Besides the argument of by how much is RMB undervalued, there are some other more important issues regarding to this. What are the consequences of this misalignment to China herself, to Asia, US, or to the world economy? Should China change its exchange rate regime because of the misalignment in the recent future? If so, how does China deal with her huge foreign reserves? Again, what are the consequences? These questions, I believe, are what do matter and do need to be solved and are discussed at the end of this paper.

In this paper, an empirical analysis is used to estimate how much the RMB has been misaligned from 1985 to 2007. Most data are collected from International Monetary Fund (IMF); a full description of the data set is provided in the Appendix. Section II presents some literature review and introduces some other approaches to examine the exchange rate misalignment. Section III describes the model, the fundamental variables used, and the econometrical estimation method. Empirical results are specified in section IV. The conclusion and some extensions about it are provided in section V.

II. Literature Review

A large number of previous works has examined the misalignment of Chinese exchange rate in different ways, and their results vary widely. The simplest, and perhaps the most inaccurate, measurements are the "Big Mac Index," and "Tall Latte Index." These two indices are constructed based on the relative prices of two worldwide food or

[2] More is discussed in section V.

drink. The theory behind is the well known Purchasing Power Parity (PPP) condition. In 2007, the price of a "Big Mac" sold in the US was $3.22; whereas in China, it was only $1.41. Hence, the exchange rate should be 4.01Yuan/$. Given the actual nominal exchange rate 7.3Yuan/$, Chinese RMB was 56 per cent undervalued. However, according to "Tall Latte Index," the undervaluation was only 1 per cent. Despite their opposite results, the method of only looking at one good to estimate the overall price level and hence the exchange rate is extremely biased. Food culture, taste, consumption construction are quite different across countries, so the value of a certain good is likely to vary accordingly. Why should a hamburger or a cup of coffee be sold at the same price around the world?

Another way is PPP of a whole basket of goods, a relative fair way to examine the exchange rate. Based on the data provided by the World Bank (WDI Online), the PPP conversion factor to nominal exchange rate ratio is plotted in Figure 1. The ratio is below 1.0 since 1984, and is roughly constant around 0.36 after 1994. However, the PPP exchange rate calculation is controversial because of the difficulties of setting specific baskets of goods to compare purchasing power across countries, since people in different countries typically consume different baskets of goods. Hence, We should not simply conclude that RMB is undervalued by around 60 percent, and this ratio is not necessarily equal to one to be considered a fair value.

Another more reliable alternative model is the Behavioral Equilibrium Exchange Rate (BEER) approach[3]. A substantial body of empirical research has been done using this method. Zhang (2001) estimated the equilibrium exchange rate during the 1952 to 1997 period using annual data, and argued that Chinese Yuan was indeed fluctuated

[3] Illustration about the model will be introduced in the next section.

around the equilibrium rate and close to its equilibrium value in 1997. In his study, he included five fundamental factors: real exchange rate, investment, government consumption, growth rate of exports, and trade openness.

Funke and Rahn (2005) also used BEER approach by examining quarterly data from 1994 to 2002 and concluded that the undervaluation of RMB was only 15 per cent in 2002. The fundamental variables they used are: productivity differentials and net foreign assets.

Wang, Hui and Abdol (2006) selected terms of trade, productivity differentials, foreign exchange reserve, and money supply as the factors that influence the real exchange rate. They claimed that there had been little misalignment during the last 25 years (1980 ~ 2004). The maximum undervaluation happened in 1993, and it was only 5 per cent.

This paper examines the exchange rate misalignment using BEER approach by estimating the equilibrium real effective exchange rate. Empirical estimation is based on time series data during 1985 to 2007 period. Taking existing works as references, six fundamental factors, X_ts, are included in this paper: real effective exchange rate *reer*, productivity differential *prod*, net foreign asset position *nfa*, terms of trade *tot*, degree of trade openness *open*, and foreign reserves *res*. Descriptions of all these variables are listed in section III. The variable selection based on whether they impact the equilibrium exchange rate in the long-run and short-run. Furthermore, the availability of data is another consideration.

The differences of this paper from previous works are: 1) In order to emphasize the impact of foreign exchange reserves, two combinations of these fundamental variables

are discussed. Since *nfa* and *res*, in some sense, both reflect the influences of the change in foreign asset affects the real exchange rate, we can only include one of them in the equation (In order to avoid the multicollinearity problem). 2) The most recent dataset are used to estimate the newest change in equilibrium real exchange rate after the exchange rate regime reform in 2005. In order to get enough observations for a time series regression, quarterly data are more appropriate than annual data set. 3) Analysis about the exchange rate regime and its related issues are discussed at the end of the paper. 4) The impulse response of the REER to the disturbances of these fundamental variables is analyzed respectively, in order to show the impact of the disturbances of each fundamental. The degree of misalignment itself doesn't really tell us anything. It's the solutions to this and the questions behind it make the number meaningful.

III. The Model

1. Estimation Method

The Behavioral equilibrium exchange rate (BEER) approach is based on a reduced form specification, Vector Error Correction Model (VECM), which links the real exchange rate to a broad set of economic fundamentals by applying standard cointegration techniques. Specifically, if two variables X_t and Y_t are both have unit roots I(1), and there exists a parameter b such that $Z_t = Y_t - bX_t$ is stationary I(0); then X_t and Y_t are cointegrated.

If a long-run equilibrium between X_t and Y_t can be described by

$$Y_t = a + bX_t \tag{1}$$

Then $z_t = Z_t - a$ is the equilibrium error, which measures the extent to which the value of Y_t deviates from its equilibrium value $a + bX_t$. If z_t is I(0), then the equilibrium error is stationary and fluctuating around zero. Consequently, the presence of a cointegrating vector can be interpreted as the presence of a long run equilibrium relationship[4]. Thus, the error correction representation takes the form

$$q(L)\Delta Y_t = d + f(L)\Delta X_{t-1} - gZ_{t-1} + a(L)e_t, \tag{2}$$

which can be rewritten as

$$\Delta Y_t = d + f_1\Delta X_{t-1} - g(Y_{t-1} - bX_{t-1}) + e_t. \tag{3}$$

Hence, we can estimate the long run equilibrium value of Y_t by estimating b. What matters to our equilibrium estimation is what in the bracket of equation (3).

2. Fundamental Factors and Measurements

1) Real Effective Exchange Rate

The effective or trade-weighted exchange rate is an index that measures the average movement of one currency against other currencies. It is an important economic indicator, and usually used to measure certain country's international competitiveness in foreign trade[5]. In this study, the weighted average is taken over the bilateral trade volumes of China against the United States, Japan, South Korea, Germany, Singapore, United Kingdom, and Australia. They are 0.33, 0.27, 0.17, 0.10, 0.05, 0.04, and 0.04 respectively. Trade with these countries accounts to 47% of China's total trade in 2004 and 2005. These trade weights are based on cumulated export and import volumes[6].

$$reer = \sum_{i=1}^{7} W_i Ln\left(E_i^N \times \frac{CPI}{CPI_i^f}\right) \tag{4}$$

[4] See Marno Verbeek, ***A Guide to Modern Econometrics.***
[5] Williamson J, "The Renminbi Exchange Rate and the Global Monetary System," 2003.
[6] Trade Volumes are taken from China Data Online (CDO).

where W_i is the weight, and E_i^N is the bilateral nominal exchange rate. CPI_i^f is the foreign consumer price index. Note that the subscript i represents different countries, and the superscript f denotes foreign data.

Figure 2 shows the movement of the RMB real effective exchange rate provided by IMF and the REER calculated using the above formula. We can see that the estimated REER moves in the same direction with the actual one. It proves that our estimation result matches the actual movements very well.

2) Productivity Differentials

The impact of the productivity differential on the real exchange rate is expected to follow the well-known "Balassa-Samuelson" effect[7], which states that relatively larger increases in productivity in the tradable goods sector are associated with a real appreciation of the currency of a country[8]. For developing countries, productivity tends to increase more quickly in the tradable goods sector than in the services sector because of their trading and economy growth pattern. Given that the prices of tradable goods are set by international competition, an increase in productivity in this sector leads to an increase in domestic wages. In the non-tradable goods sector, where productivity has not grown at the same pace, the prices of domestic goods relative to those from abroad will be increased, which results in an appreciation of the real exchange rate.

$$prod = \sum_{i=1}^{7} W_i Ln\left(\frac{CPI / PPI}{CPI_i^f / PPI_i^f}\right) \tag{5}$$

The productivity differentials can be captured by the relative price of tradable and non-tradable goods. However, there are no such divisions in price index in China. The

[7] Balassa (1964) and Samuelson(1964).
[8] Kravis and Lipsey 1983.

commonly used proxy is to use the relative ratio of consumer price and producer (whole sale) price. Weights here are the same trade weights as in real effective exchange rate equation. As explained above, we are expecting that $prod$ has a positive effect on the real exchange rate.

3) Net Foreign Assets

There are no direct data on net foreign asset position available for all countries. In this paper, we follow the alternative method suggested by Lane and Milesi-Ferretti (2001). We use the Accumulative Current Account[9] (ACA) to serve as the net foreign asset, and divide it by the Gross Domestic Product (GDP) to adjust for the size of the economy.

$$nfa = \frac{ACA}{GDP} \tag{6}$$

Since nfa here is measured by the accumulative current account to GDP ratio, if the current account is in surplus, the country's net foreign asset position increases correspondingly. Equally, a deficit decreases the net foreign asset position. Specifically, the net foreign asset affects the real exchange rate through two channels. First, a deficit in current account creates an increase in the net foreign debt of a country, which has to be financed by foreign investors. In order to attract those investors, the currency of the debtor country has to depreciate given certain interest rates. Second, the balance of payments channel assumes that a current account deficit accumulates net foreign debts. The interest payments need to be financed by an improvement of the trade balance. This also requires a depreciation of the currency to increase the attractiveness of its exports. Therefore, an increase in nfa should cause an appreciation of the currency.

[9] The quarterly ACA are derived using the same method above. ACA data are added up from 1982 Q1.

4) Terms of Trade

Terms of trade is measured as the ratio of domestic export price index to domestic import price index[10].

$$tot = \sum_{i=1}^{7} W_i Ln\left(\frac{P_{EX} / P_{IM}}{P_{EX,i}^{f} / P_{IM,i}^{f}} \right) \tag{7}$$

Improvement in terms of trade is expected to have two opposite effects on the real exchange rate. First, a positive effect on current account; and hence, as the same reason above, the domestic currency will appreciate. In addition, due to income effect, the demand for imports will increase accordingly. This will result in a depreciation of the currency in order to finance the rising import expenses. The overall effect is ambiguous and depends on the relative price elasticity of demand for imports and exports. However, the empirical results in this study indicates that tot indeed has a positive effect on the real exchange rate when net foreign asset position is included, implying that the price elasticity of imports is relatively less elastic than that of exports in China.

5) Openness to trade

Openness to trade is another important factor which influences the real exchange rate in China. Lots of empirical works have found that, for developing countries as a whole, domestic currencies are likely to depreciate with trade liberalization; even though, some partial or non-credible trade liberalization are associated with real appreciation[11]. Trade restrictions increase the domestic price of tradable goods, and hence raise the overall price level and real exchange rate[12]. Since 1990, China has hastened her steps towards free trade. Many reforms regarding trade policies have been implemented in

[10] Price index of imports and exports are taken from DataStream.
[11] See Li (2003) "Trade Liberalization and Real Exchange Rate Movement."
[12] See Goldfajn and Valdes (1999) for details.

order to join the WTO. Therefore, the measurement to these trade policies, the openness to trade, *open*, must have great influences to the exchange rate.

$$OPEN = \frac{EX + IM}{GDP} \tag{8}$$

In this paper, we use the total volume of trade (sum of export and import volumes) normalized by GDP to adjust for economy size to proxy this variable[13]. Also, we expect its impact upon real exchange rate is negative.

6) Foreign Exchange Reserves

Strictly speaking, foreign exchange reserves only refer to the foreign currency deposits held by central banks and monetary authorities. However, this term in popular usage commonly includes foreign exchange and gold, SDRs and IMF reserve positions, or in other words, assets of central banks hold in different reserve currencies[14]. Foreign exchange reserves are important indicators of a country's ability to repay foreign debt and for currency defense, and are used to determine credit ratings of nations. Furthermore, for countries adopting managed float exchange rate regime, like China, foreign exchange reserves also serve as a tool to control the value or stability of domestic currencies.

This variable here refers to the total stock of net foreign assets accumulated by the People's Bank of China. An increase in the foreign exchange reserves holdings implies that the demand for the home currency is higher, resulting in the real exchange rate appreciation. Again, we divide the foreign reserves (FR) by GDP to adjust for the economy size. We are going to explore this variable a deep further in section V.

[13] The same measurement has been used by many empirical works, see Elbadawi (1994) as an example.
[14] See "The Accumulation of Foreign Reserves," 2006, by an International Relations Committee Task Force.

$$res = \frac{FR}{GDP} \tag{9}$$

Figure 3 shows the movement of all fundamental variables over time. Since all data are seasonal adjusted, most of them have smooth movements. However, it is interesting to see that the openness to trade exhibits seasonal fluctuations.

In order to estimate the model, VECM requires that all variables must follow a unit root non-stationary process. To prove this, the Augmented Dicky-Fuller unit root tests are applied, and the results are listed in table 1. As we can see, at 5 per cent confidence level, we can not reject the null hypothesis that all variables follow a unit root process. However their first differences, denoted as ΔX are stationary since we can reject the null hypoesthesia at 5 per cent confidence level. Then we can conclude that all variables are I(1). Thus, there is a possibility that these variables can be related by a cointegration equation, and the VECM model can be used to estimate the long run equilibrium value of the real effective exchange rate.

Section IV Empirical Results

1. Combination one

$$beer = b_0 + b_1 prod + b_2 open + b_3 nfa + b_4 tot \tag{9}$$

First, we need to do the cointegration test by Johansen (1992), results are provided in Table 2. Table 2 tells us that from r ≤ 1, we start to accept the null hypothesis at 5 per cent confidence level; then the rank of cointegration is 1 in this case, which means that there exists a long run equilibrium relationship between these variables. Table 3 shows us the results of the VECM estimation. All the coefficients are significantly from zero

since their z-statistics are large. This also confirms that all fundamental variables have significant effects upon the real exchange rate, and our model is successfully designed.

According to the values of parameter b, the expression for BEER can be written as follows:

$$beer = 1.8367 + 1.6911 \times prod - 1.7582 \times open + 0.8216 \times nfa - 0.7541 \times tot \quad (10)$$

All signs of the coefficients are just as we expected. Productivity differentials and net foreign asset position have positive effects on the real exchange rate, while degree of openness and terms of trade have negative effects upon the real effective exchange rate.

Figure 4 presents the fluctuations of the real effective exchange rate around its long run equilibrium level (BEER). Figure 5 illustrates its percentage deviation. The largest deviation happened in 2004Q1 (16.09 per cent), just before Chinese government announced that she would adopt a managed float rate regime based a basket of currencies, coupled with a move to partial convertibility on current account[15]. Then the maximum overvaluation, 29 per cent, happened after this announcement, in 2005Q4. Therefore, it is also the evidence that our model matches the historical movement of real exchange rate very well.

There is a problem associated with the long run equilibrium condition of the BEER since all our fundamental variables included in the estimation function are not necessarily in their equilibrium level. This may influence the long run stability of our model, and our results may exhibit business cycle movements so that it is hard to get the real trend of our dependent variable. One way to solve this problem is by using the Hodrick-Prescott (HP) filter to split the long run trend and the short run fluctuations of

[15] See Lu and Zhang, 2000 for details.

these variables[16]. In other words, we decompose the time series data into permanent and transitory components. Then we use smoothed permanent components to calculate our Permanent Effective Exchange Rate (PEER). Its locus is plotted in figure 6, and figure 7 presents its percentage deviation from its equilibrium level.

Since the permanent values reflect the long run equilibrium rate more precisely, we will focus our analysis on figure 7. We can separate the period from 1985 to 2007 into 3 stages. From 1985 to 1992, the RMB is undervalued with the maximum undervaluation happened in 1985, and that is exactly the period when Chinese government was trying to adjust their official exchange rate to make it in accordance with the swap rate. From 1992 to 2001 and from 2003Q3 to 2007Q4, the real exchange rate was slightly overvalued with the maximum overvaluation occurred in 1997Q2 (4 percent). This result is consistent with our findings in REER case, and again, reflects the actual history. From 2002 and 2003Q2, the real exchange rate was closed to its equilibrium level.

During our whole sample period, the maximum undervaluation of Chinese exchange rate happened in the past, 1985, in stead of 2004Q1 in our REER case. This might be a sign that the undervaluation of Chinese currency in recent years is mainly business cycle phenomena. Without some other disturbances, the Chinese real exchange rate should have been closed to its long run equilibrium level. Also, the overall misalignment is much smaller. In other words, it is the short run fluctuations rather than the long run trend itself of the real exchange rate leads to the misalignment.

2. Combination Two

$$beer = b_0 + b_1 prod + b_2 open + b_3 res + b_4 tot \tag{11}$$

[16] This method is followed by Clark and Macdonald (1998).

According to Lane (2001), foreign exchange reserves are part of the net foreign asset position. In his paper, nfa is given by the sum of the net debt position, the net equity stock position and the net FDI stock position:

$$nfa = FDIA + EQA + DEBTA + res - FDIL - EQL - DEBTL \quad (12)$$

where ***FDIA***, ***EQA*** and ***DEBTA*** are the stocks of direct investment, portfolio equity and debt assets; FDIL, EQL, DEBTL are the stocks of direct investment, portfolio equity and debt liabilities. Therefore, in order to avoid multicollinearity problem, we can not include both net foreign asset position and foreign exchange reserves in the equition.

Table 4 tells us that from r ≤ 1, we start to accept the null hypothesis at 5 per cent confidence level; then the rank of cointegration is 1 in this case. Table 5 shows us the results of the VECM estimation. All the coefficients are significantly from zero since their z-statistics are large. This also confirms that all fundamental variables have significant effects upon the real exchange rate, and our model is successfully designed.

According to the values of parameter b, the expression for BEER can be written as follows:

$$beer = 1.5475 + 4.6830 \times prod - 2.2601 \times open + 43.0400 \times res + 1.546326 \times tot \quad (13)$$

Figure 8 presents the fluctuations of the real effective exchange rate around its long run equilibrium level (BEER). Figure 9 illustrates the percentage deviation. The main differences from last case are that the deviations are much larger and in most of the time period, the real exchange rate was overvalued. The largest overvaluation happened in 1993Q4 (65 per cent), this is consistent with the first combination. One of the largest undervaluation (25 per cent) happened in the end of 1990 and the beginning of 1991; the other one was in 2006Q1.

Furthermore, all signs of the coefficients are just as we expected. As in combination one, productivity differentials has a positive effect, while degree of openness has a negative effect upon the real effective exchange rate. For terms of trade, the sign is different from previous case. Regarding to the foreign exchange reserves, the sign is positive. As we can see in figure 10, the trend of foreign reserves to GDP ratio is increasing over time. From the graph, we can again separate the accumulation of the foreign exchange reserves into three stages. First stage, before 2000, the foreign exchange reserves to GDP ratio was relatively more fluctuated but had a raising trend. Its trend is in accordance with the trend of real effective exchange rate, just like our estimation results revealed. With the openness of trade in China, more and more foreign capital inflows came in, which contributed to the increase of foreign reserves.

After 2000, there were fewer fluctuations along the way of the foreign exchange reserves accumulation. This ratio was increasing smoothly until 2006. We can see that the movements of the real exchange rate and the foreign reserves are still match. Part of the reason of more rapid increase of *res* is due to the fear of the financial crisis, like Asian financial crisis in 1997. Also, huge amount of "hot money" came in constantly for speculative motives.

After 2006, the foreign exchange reserves to GDP ratio dropped dramatically. Even though the amount of foreign reserves was still increasing over time, the GDP was increasing at an even higher speed. This also reflects a fact that the magnitude of foreign reserves relative to GDP volume in China is not growing as fast as some scholar stressed.

As before, figure 11 and figure 12 tell us the real effective exchange rate movements with its permanent components. Unlike in combination 1, the only

undervaluation happened after 2004, and this misalignment is enlarging. Before 2004, the maximum overvaluation happened in 1985, around 28 per cent.

During our whole sample period, the degree of overall misalignment is higher than that of combination 1. One of the reasons is that we only include the foreign exchange reserves in our estimation, and ignore other important components of the net foreign asset position. As we can see in equation (12), there are many other factors need to be adjusted when we replace nfa with res. Hence, the negative effect of foreign exchange reserves on the real exchange rate is amplified. The equilibrium value calculated using res is lower, which causes more frequent overvaluation. We might conclude that it is the other components of the net foreign assets that make Chinese real exchange rate undervalued. Also, from the above results we can get to the conclusion that the first combination is more precise.

In order to analyze the dynamic response of REER to these fundamental variables, the impulse response functions are examined. The impulse response function measures the impact of a standard deviation strikes from random disturbance (innovations) on the present and future value of endogenous variables. Figure 13 presents the tendency of the equilibrium real exchange rate with respect to the change in each fundamental variable. Results provide a three year forecast (12 periods[17]) of the response (in percentage deviation) of REER to changes of six fundamental variables, including REER itself.

Two extreme cases are the response of the REER to REER itself and to tot: During the whole 12 quarters, a disturbance from the terms of trade does not really affect the equilibrium real exchange rate that much; however, REER responses to its own disturbance negatively, despite that during period 2 to 4 and 11 to 12 there is a 1 per cent

[17] Each period here represents a quarter.

increase back. This indicates the fact that it would be an obstacle to the sharp appreciation or depreciation of the RMB in the near future.

The disturbances from the net foreign asset position and foreign exchange reserves make equilibrium REER to rise in the long run, even though there are still some fluctuations around a rising tendency. On the contrary, the openness to trade has a long run negative effect upon REER with down ward trend fluctuations. The response to productivity differential shocks is strongly positive in the first two periods; however, after that the effects turn to negative sharply until period four. After four periods, the REER does not have strong response to the disturbance from *prod* , indicating that the productivity differential does not have long run effect on the real exchange rate.

In sum, these economic fundamental variables can not lead to tremendous rise or reduction to the real effective exchange rate since some of their effects in the future are balanced out, without the participation of other economic shocks.

Section V Conclusion and Extensions

1. Conclusions

In this paper, a BEER approach is used to estimate the equilibrium effect exchange rate based on the VECM model in order to capture the long run movements of the real exchange rate. The sample period is from 1985 Q1 to 2007 Q4. This study differs from previous empirical works by using the most recent data set and hence is able to examine the behavior of China′s real exchange rate after the reform in 2005. In addition, six fundamental variables, two different combinations are analyzed. Besides the

misalignment of the REER, its long run permanent value, the PEER, is also estimated by removing the cyclical components of each fundamental.

Results of these two combinations are consistent in a way that there were at least half of the time during 1985 to 2007, China's real exchange rate was overvalued. For REER case, the largest undervaluation (16 per cent) happened in 2004 in first cases when net foreign asset position is included in the model; Whereas in combination two, when the foreign exchange reserves to GDP ratio is included, the largest undervaluation (24 per cent) happened in 1990. When we remove the cyclical fluctuations from these fundamental variables, the undervaluations of PEER in both cases are much smaller: 8 per cent and 16 per cent, respectively. Hence, we conclude that the trend of the undervaluation of the Chinese currency is not away too far from its equilibrium value, and it is way not serious as some pervious works have estimated. Also, results also indicate that it is the short run fluctuations rather than the long run trend itself of the real exchange rate leads to the misalignment. In addition, compared to other components of net foreign assets, foreign reserves to GDP ratio is not the main reason for the undervaluation of Chinese real exchange rate.

Furthermore, the impulse response analysis of the REER to the change in each fundamental variable is examined. Results indicate that judging from the anticipation of these economic fundamentals on China's real exchange rate in the near future, there won't be tremendous fluctuations of the RMB real exchange rate without the participation of other economic shocks.

2. Some Extensions

2.1 About Revaluation

In the past two years, RMB to dollar rate has revalued around 20 per cent. Until July 6, 2008, Yuan per Dollar rate has appreciated from 8.28 Yuan per US Dollar to 6.86 Yuan per US Dollar. Also, China's rapid economic growth, rising productivity, exports and foreign direct investment inflows all are factors cause a currency to appreciate in general. In addition, the rapid increase in foreign exchange reserves in PBC is another evidence of the RMB appreciation. Facing the upward pressure on Chinese RMB, PBC has to sell its currency in the foreign exchange market to get foreign exchange in return in order to keep the strong Chinese currency stable. However, as we can see in equation (12), increasing foreign reserves causes the long run equilibrium level of the real effective exchange rate to rise, and hence make RMB even more undervalued (a vicious circle).

There are both internal and external reasons for this misalignment to occur. For external reason, we should notice that the continuing weakening US dollar has contributed to this undervaluation. Also, since US dollar and Euro dollar have been dominating the foreign exchange market for a long time, other countries whose domestic currencies can not be used as major currencies in international trade have to have multiple currencies appeared in their balance sheets. This could cause the misalignment of these dominated currencies. For internal reasons, inefficient capital market and fixed exchange rate system have worsened the misalignment, which in turn, would cause the fear of floating their currencies (again, a vicious circle).

As mentioned at the beginning of this paper, what are the possible consequences of this misalignment, though not as severe as many other studies have concluded, of Chinese currency? In Preeg (2003), the direct result is the $100 billion more US trade

deficit which would not have incurred without the undervaluation of Japan and China's currencies. This trade deficit then leaded to 1.5 million job losses and slowing down of productivity and output growth.

Theoretically, a higher savings rate generally corresponds with a trade surplus. Correspondingly, the United States with its negative savings rate consistently has high trade deficits, whereas China is likely to have large trade surplus for its positive savings rate. The fact is that the United States has posted a trade deficit since the 1970s. In Morris' testimony, he admitted that even if China did revalue the RMB by 20 per cent, and other Asian countries including Japan allowed their currencies to appreciate by 10 per cent, the trade weighted value of the dollar would only decline by 5 percent. This in turn may improve the U.S. current account by only $50 billion dollars.

For those who advocate the revaluation of Chinese currency, their main reasons are prolonging Chinese trade surplus and worsening of the domestic resource distribution. According to the statistical data provided by Chinese custom, in 2003, the trade surpluses with the US and Euro countries amounted to 58.6 and 19.1 billion US$. On the other hand, however, China's trade deficits with other Asian countries were 78.1 billion US$. In 2004, both the trade surpluses and deficits have increased. Hence, this situation is not as simple as past Japan case, where Japan had trade surplus towards all other countries. And of course, this more complicated problem can not be solved only by revaluation of the Chinese currency.

In 2005, Robert Mundell stressed 18 harmful consequences of the revaluation of Chinese currency in one of his speeches. Some important consequences include postponing the process of China's switching to floating exchange rate regime; decreasing the foreign direct investment; slowing down the economic growth, worsening

employment and bad debt of commercial banks, and leading to inflation pressure. In addition, the revaluation of RMB will also increase the loan repayment burden of other neighbor countries and give higher gains to speculative activities.

2.1 About Foreign Reserves

Moreover, huge Chinese foreign reserves are treated as a threat to the balance of the world economy, especially to the US. However, since China is adopting this managed floating exchange rate regime, enough foreign reserves are necessary to guarantee that this system goes on its wheels.

To illustrate the idea more clearly, let′s first look at the mechanism that central banks use to stabilize the value of domestic currency. To maintain the same exchange rate if there is increased demand in domestic currency, the central bank can sell more of them and purchase the foreign currency in return, which will increase the sum of foreign exchange reserves. In this case, the value of domestic currency is being held down, and vice versa. Thus, the accumulation of the foreign exchange reserves is the evidence that Chinese RMB has been facing upward pressure.

Moreover, since the amount of foreign reserves available to defend a weak currency is limited, a foreign exchange crisis or devaluation could be the end result (Asian financial Crisis). For a currency in very high and rising demand, foreign exchange reserves can theoretically be continuously accumulated, although eventually the increased domestic money supply will result in inflation and reduce the demand for the domestic currency. In practice, some central banks, through open market operations aimed at preventing their currency from appreciating, can at the same time build

substantial reserves. By the end of March 2008, China had accumulated 1682.2 Billion US$ foreign exchange reserves[18].

However, with the appreciation of RMB and the depreciation of US dollar, this $1682 billion can easily shrink. For example, if China's exchange rate continues appreciating to 6 Yuan per dollar, the foreign exchange reserves will be decreased by 27 per cent. Also, the inflows of "Hot Money" have been rising rapidly since 2005, China's exchange rate regime reform. From 2005 to 2007, it amounted to over $800 billion, which is half of the foreign exchange reserve in 2007. It implies that move than half of the foreign exchange reserves can be easily withdrew, resulting in high inflation pressure and dramatic devaluation of the RMB. If this happens, the huge foreign exchange reserves China has accumulated might not be enough to against the downward pressure of the devaluation.

Taking all the above information into consideration, the amount of the China's foreign exchange reserve has been exaggerated.

To sum up, the misalignment of Chinese currency is not the main reason for the trade deficit of the U.S. Also, the foreign exchange reserves that China holds are not such a severe threat to the world economy, and there are many factors have resulted in this. However, this is not to say that China should not appreciate its currency; on the contrary, in order to decrease the further inflows of "Hot Money", and hence foreign reserves, China should appreciate its currency gradually. At the same time, China needs to improve its financial system so as to hasten the space of relaxing the capital account convertibility. Finally, stimulating domestic consumption and imports is another way to boost economy and expend the foreign exchange reserves.

[18] The People's Bank of China monthly report.

Appendix

1. Trade volumes used to calculate the trade weights W_is are the sum of two annual exports and imports volumes in 2004 and 2005. These data are taken from China Data Online (CDO).
2. E_i^N represents the bilateral nominal Exchange Rate (1985Q1 to 2007Q4), which shows how much Chinese Yuan a foreign currency is worth.
3. The CPI, consumer price index (1985Q1 to 2007Q4), is seasonal adjusted data from International Monetary Fund (IMF). According to IMF and CDO, PPI and WPI are the same in China. However, we can find only annual China's PPI (1985 to 2007) from CDO. The quarterly data are derived using Eviews according to Bertesekas (1976). Funke and Rahn (2005) used the same method to compact high frequency data. For other countries, quarterly seasonal adjusted data (1985Q1 to 2007Q4) are taken from IMF.
4. The ACA is the cumulative current account. The annual seasonal adjusted data set of ACA (1982 to 2007) in China is taken from IMF. Quarterly data are derived by Eviews using the same method above. Note that ACA data are added up from 1982 Q1.
5. The GDP, gross domestic product (1985Q1 to 2007Q4), of all countries are seasonal adjusted data from IMF. Unit of this variable is billion US dollar.
6. China's Export and Import price index (1985Q1 to 2007Q4) are using seasonal adjusted data set from DataStream. For other countries, their Export and Import price index are taken from IMF, quarterly seasonal adjusted.

7. China's Export and Import Volumes (1985Q1 to 2007Q4) are quarterly seasonal adjusted data from IMF.
8. The annual foreign reserves (1985 to 2007) of China is taken from World Development Indicators (WDI), quarterly data (1985Q1 to 2007Q4) are derived using Eviews.

References

Bayoumi, T., P. Clack, S. Symansky, and M. Taylor (1994), "The Robustness of Equilibrium Exchange Rate Calculatino to Alternative Assumptions and Methodologies," J. Williamson (eds.), ***Estimating Equilibrium Exchange Rates*** (Washington: Institute for International Economics).

Bouveret, A., S. Mestiri, and H. Sterdyniak (2006), "The Renminbi Equilibrium Exchange Rate: an Agnostic View," IMF working paper.

Canzoneri, M. R., R. Cumby, and B. Diba (1999), "Relative Labor Productivity and the Real Exchange Rate in the Long Run: Evidence from a Panel of OECD Countries," ***Journal of International Economics*** 47(2), 245-66.

Chang, G., and Q. Shao (2004), "How much is the Chinese Currency Undervalued? A Quantitative Estimation," ***China Economic Review*** 15, 366-71.

Chou, W. L., and Y. Shih (1998), "The Equilibrium Exchange Rate of the Chinese Renminbi," ***Journal of Comparative Economics*** 26, 165-74.

Clark, P., and R. Macdonald (1998), "Exchange Rates and Economic Fundamentals: A Methodological Comparison of BEERs and FEERs," IMF working paper.

Coudert, V. and C. Couharde (2005), "Real Equilibrium Exchange Rate in China: Is the Renminbi Undervalued?" IMF working paper.

Edwards, S. (1994), "Real and Monetary Determinanants of Real Exchange Rate Behavior: Theory and Evidence from Developing Countries," in J. Williamson (eds.), ***Estimating Equilibrium Exchange Rates*** (Washington: Institute for International Economics).

Faruqee, H. (1994), "Long-Run Determinants of the Real Exchange Rate: A Stock-Flow Equilibrium Approach," IMF 42, 80-107.

Elbadawi, Ibrahim, 1994, "Estimating Long-Run Equilibrium Real Exchange," ***Estimating Equilibrium Exchange Rates***, ed. by John Williamson (Washington: Institute for International Economics).

Francisco M., Chiara O. Bernd S. (2001), "Determinants of the Euro Real Effective Exchange Rate: A BEER/PEER Approach," Working paper, European Central Bank, No. 85.

Funke, M., and J. Rahn (2005), "Just How Undervalued is the Chinese Renminbi?" ***World Economy*** 28, 465-89.

Goldfajn, Ilan, and Rodrigo Valdes, 1999, "The Aftermath of Appreciations," ***Quarterly Journal of Economics***, Vol. 114 (February), pp. 229-62.

John B. Taylor (2003), "china's Exchange Rate Regime and its effects on the U.S. Economy."

Kakkar, V., and M. Ogaki (1999), "Real Exchange Rates and Nontradables: A Relative Price Approach," Journal of Empirical Finance 6 (3), 193-215.

Kwan, C. H. (2006), "Reform of China's Foreign Exchange Rate System – How the Newly Adopted Managed Floating System Actually Works," ***Nomura Capital Market Review*** 8 (4), 38-42.

Li Xiangming, 2003, "Trade Liberalization and Real exchange Rate Movement," distributed by Emmanuel Zervoudakis, IMF working paper, WP/03/104.

Limi, A. (2006), "Exchange Rate Misalignment: An Application of the Behavioral Equilibrium Exchange Rate (BEER) to Botswana," IMF working paper.

MacDonald, R. (1997), "What Determines Real Exchange Rate: the Long and Short of It," ***Journal of International Financial Markets*** 8 (2), 117-53.

Maeso-Fernandez, F., C. Osbat, and B. Schnatz (2002), "Determinants of the Euro Real Effective Exchange Rate: A BEER/PEER Approach," ***Journal of Comparative Economics*** 26, 165-74.

Montiel, O. J., (1999a) "The Long-Run Equilibrium Real Exchange Rate: Conceptual Issues and Empirical Research," in L. Hinkle and P. J. Montiel (eds.), ***Exchange Rate Misalignment: Concepts and Measurement for Developing Countries*** (Oxford: Oxford University Press), 219-63.

Nikolaos G., and Athanasios P. (2007) "Estimating the Equilibrium Effective Exchange Rate for Potential EMU members," University of Crete.

Philip R. Lane, Gian M. M., (2001) "The External Wealth of Nations: Measures of Foreign Assets and Liabilities for Industrial and Developing Countries," ***Journal of International Economics*** 55, 263-294.

Preeg, E. H. (2003), "Exchange Rate Manipulation to Gain an Unfair Competitive Advantage: the Case Against Japan and China," in C. F. Bergsten and J. Williamson (eds.), ***Dollar Overvaluation and the World Economy*** (Washington, DC: Institute for International Economics), 267-84.

Shi, J., and H. Yu (2005), "Renminbi Equilibrium Exchange Rate and China's Exchange Rate Misalignment: 1991-2004," working paper, China Center for Economic Research.

"The Accumulation of Foreign Reserves," International Relations Committee Task Force, 2006, Occasional Paper Series No. 43.

Verbeek, M. (2004), ***A Guide to Modern Econometric***, (John Wiley and Sons, Ltd) 2nd Ed.

Wang, Y., X. Zhao, and J. Han (2005), "Empirical Research on RMB Equilibrium Exchange Rate – Analysis and Forecast Based on the Multivariate VAR Model," working paper.

Williamson, J. (ed.) (1994), ***Estimating Equilibrium Exchange Rates*** (Washington: Institute of International Economics), 177-244.

Xiang M. L. (2003), "Trade Liberalization and Real Exchange Rate Movement," IMF working paper.

Yang, J., and I. Bajeux_Besnainou (2006), "Is the Chinese Currency Undervalued?" ***International Research Journal of Finance and Economics*** 2006 (2), 107-30.

Yi, G., and M. Fan (1997), "The Determinants of Exchange Rate of RMB and Tendency Analysis," ***Economic Research*** 10.
Zhang, X. (2002), "Equilibrium and Misalignment: and Assessment of the RMB Exchange Rate from 1978 to 1999," working paper, Stanford University.

Yin-Wong C., Menzie D. C, Eiji F. (2007), "The Overvaluation of Renminbi Undervaluation," ***Journal of International Money and Finance*** 26, 762-785.

Zhang, Z. (2001), "Real Exchange Rate Misalignment in China: An Empirical Investigation," ***Journal of Comparative Economic*** 29, 80-94.

Figures and Tables

Figure 1. PPP to Nominal Exchange Rate Ratio (1980 – 2006)

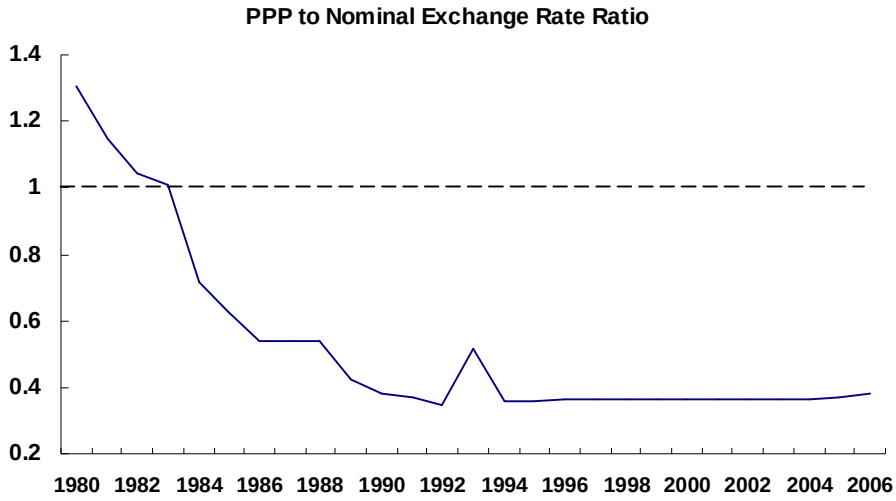

Figure 2. Real Exchange Rate

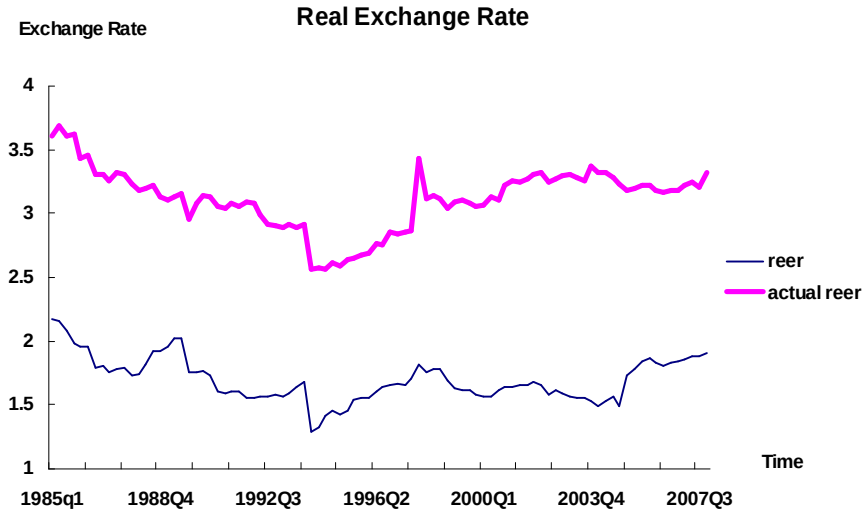

Figure 3. Movements of Fundamental Variables

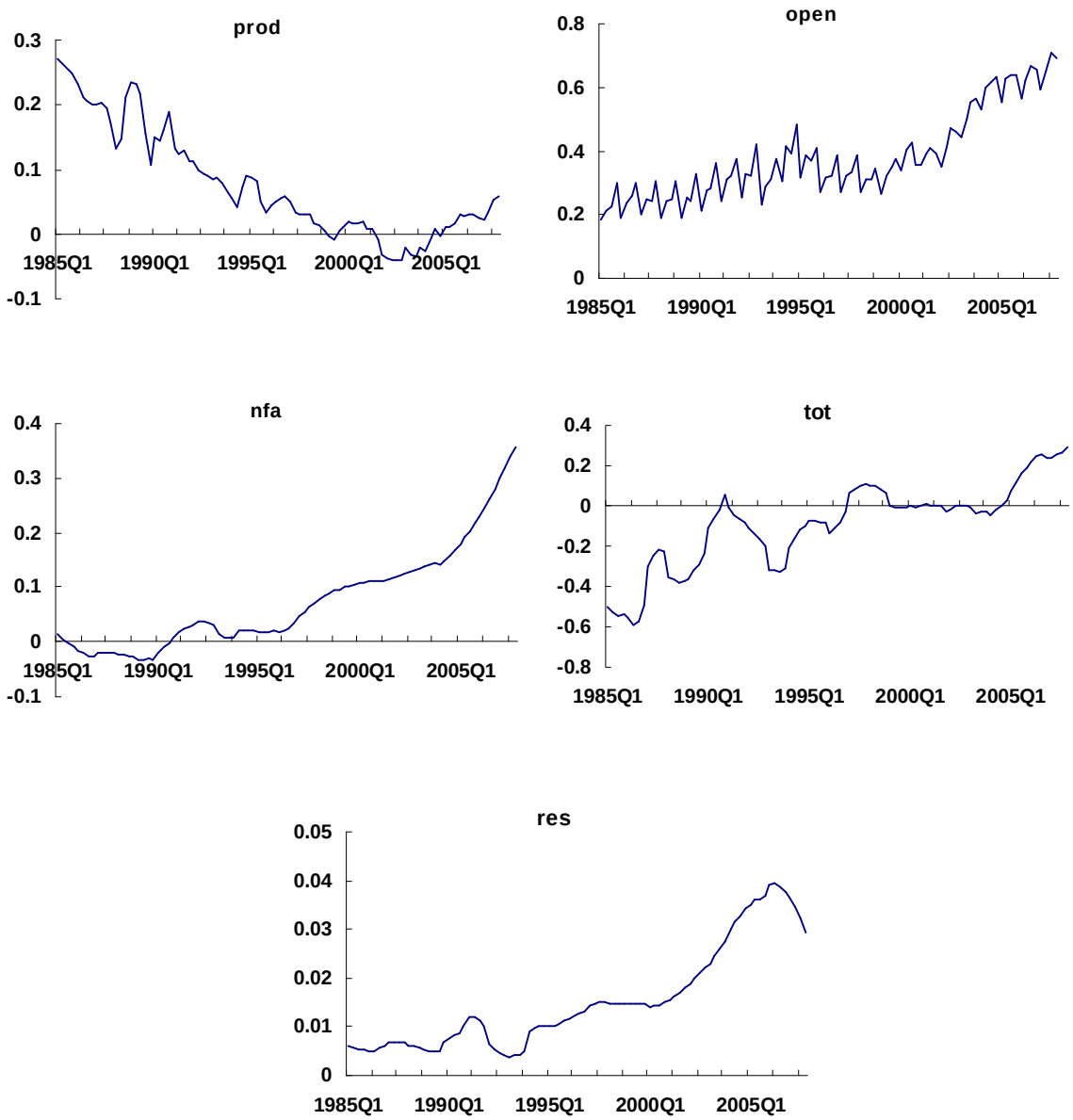

Figure 4. Deviation of Real Exchange Rate from Equilibrium

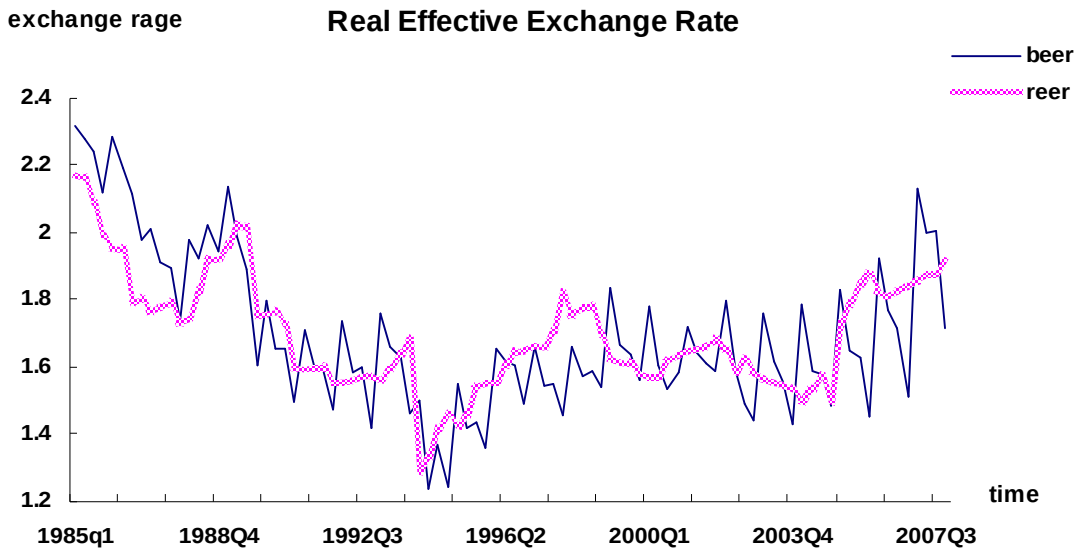

Figure 5. Percentage Deviation From Equilibrium

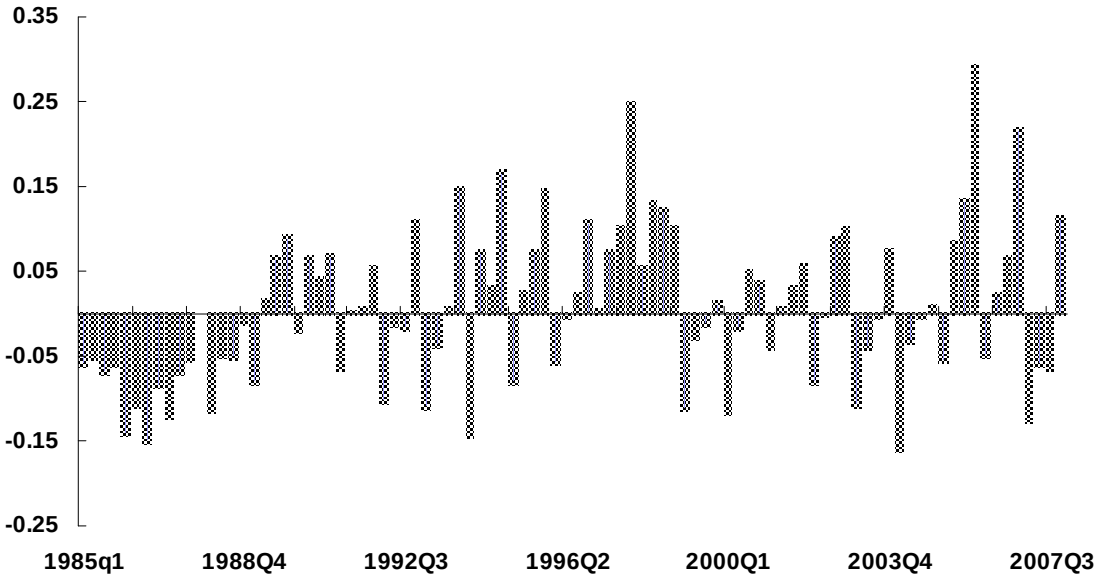

Figure 6. Permanent Deviation from Equilibrium

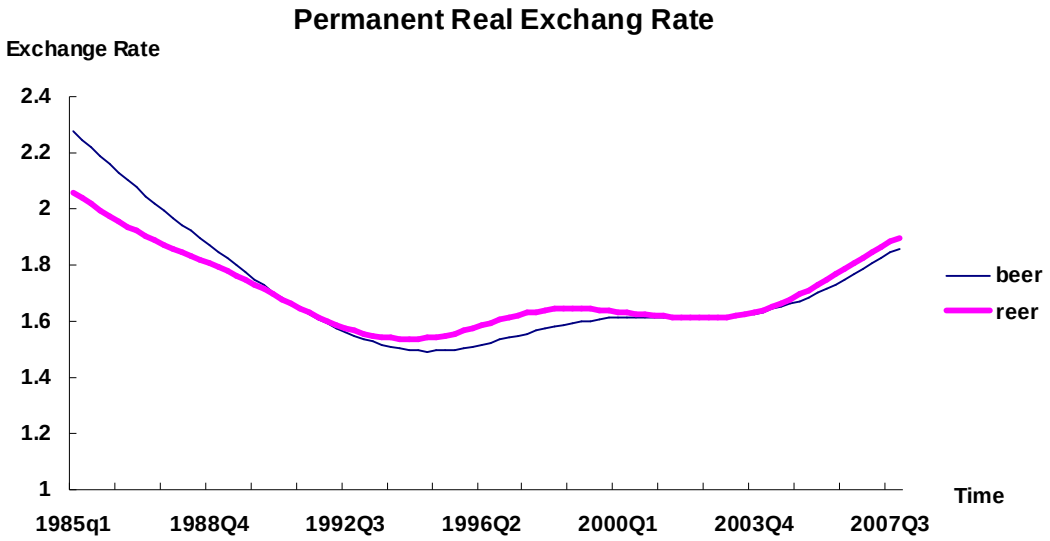

Figure 7. Percentage Deviation from Equilibrium

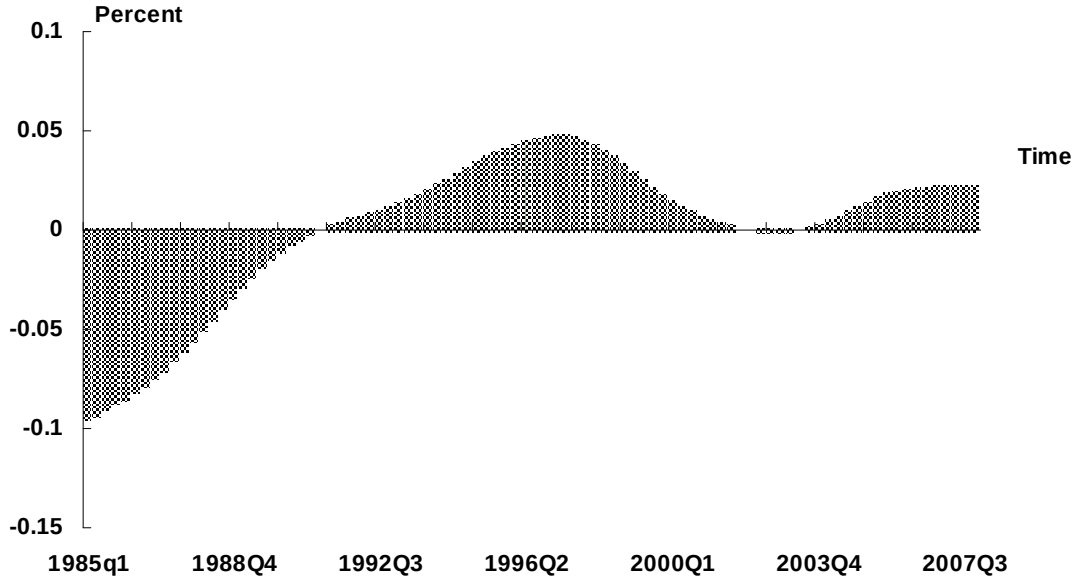

Figure 8. Deviation of Real Exchange Rate from Equilibrium

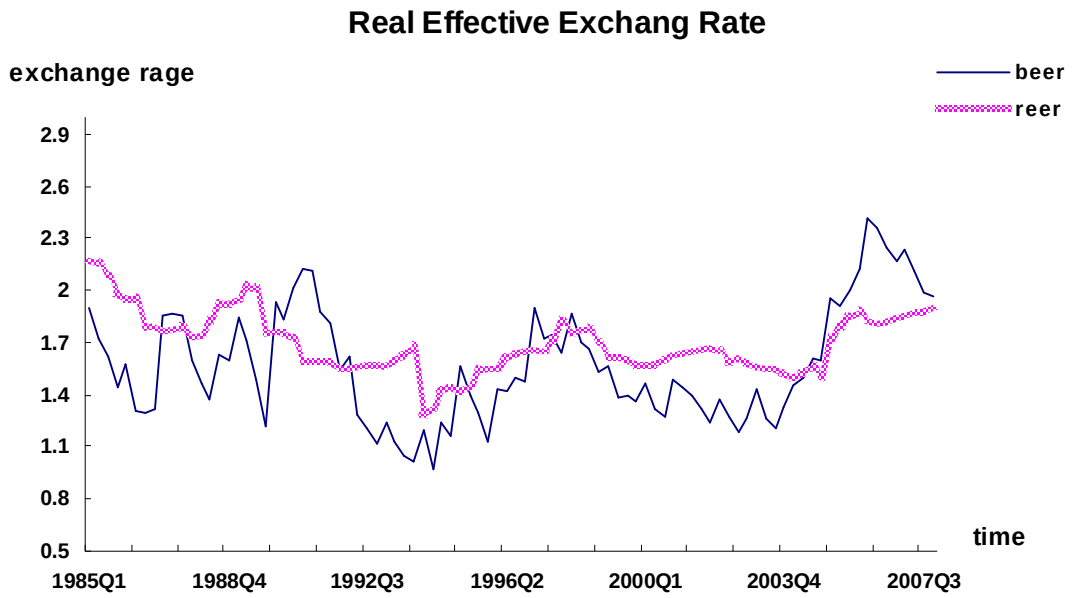

Figure 9. Percentage Deviation from Equilibrium

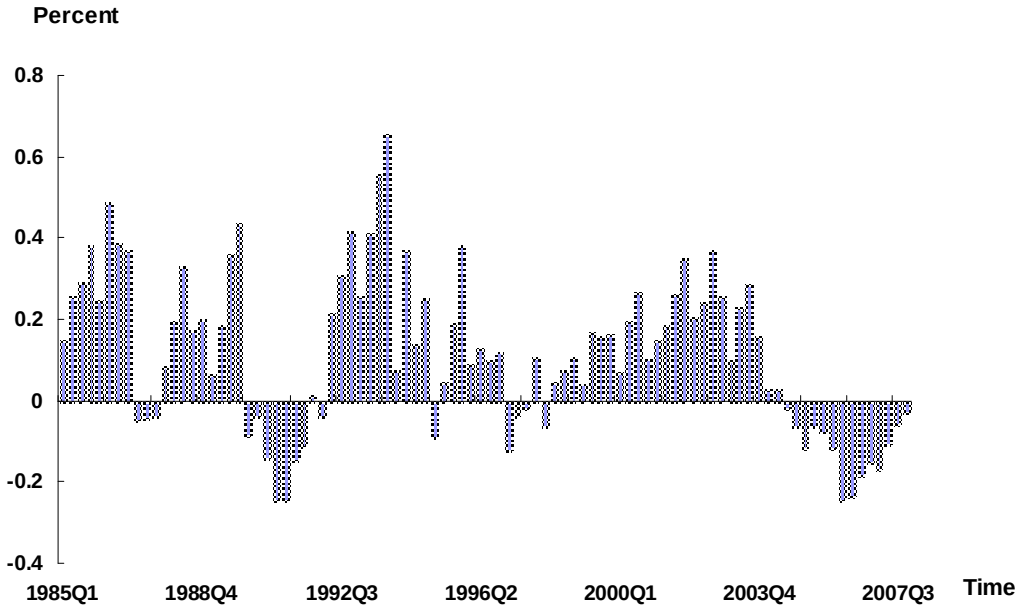

Figure 10. Long Term Movement of Foreign Reserves and Real Exchange Rate

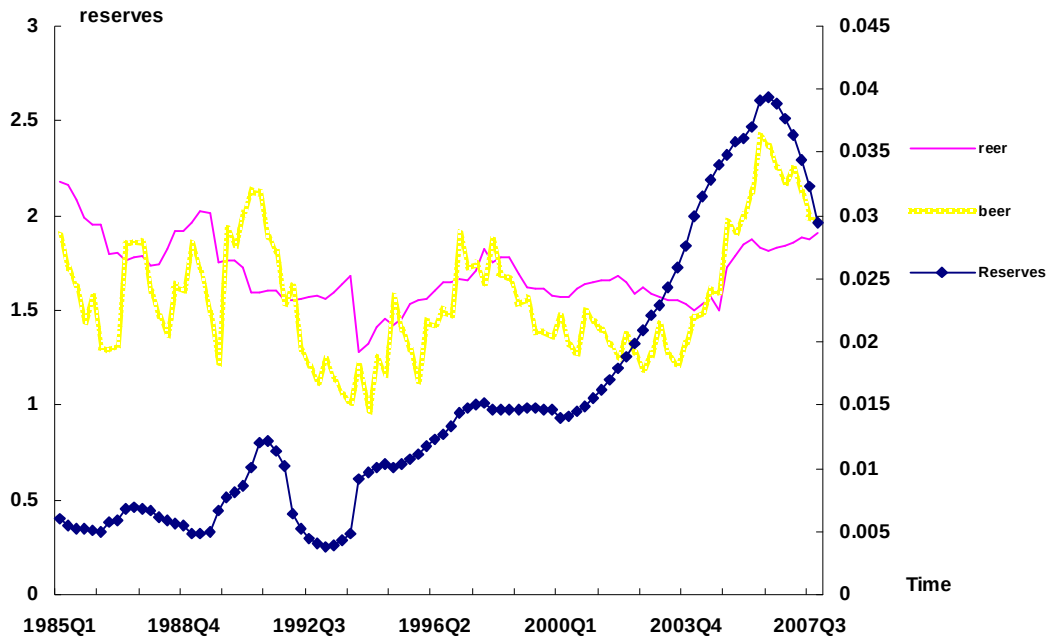

Figure 11. Permanent Deviation from Equilibrium

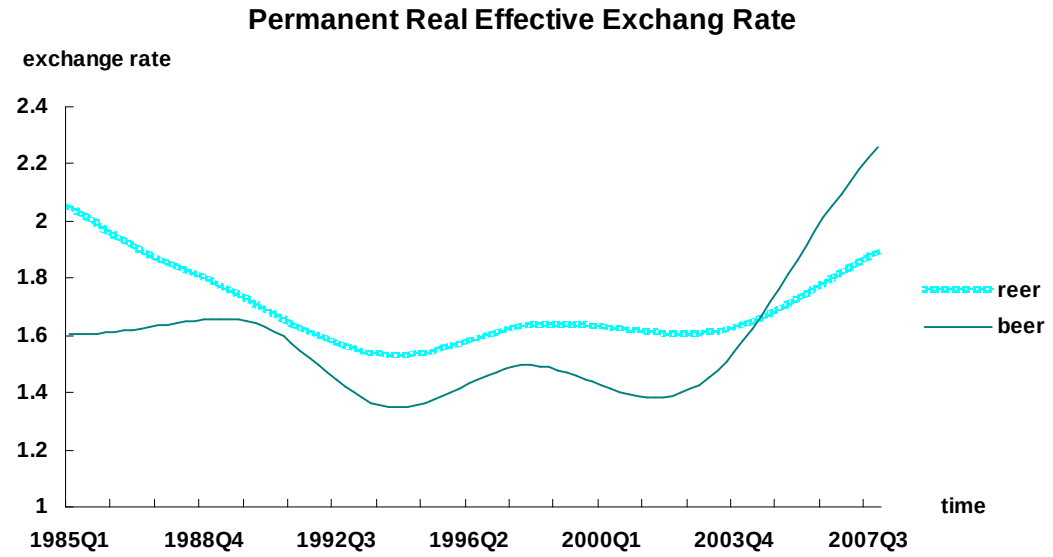

Figure 12. Percentage Deviation from Equilibrium

Figure 13. Impulse Response of REER to Fundamentals Innovations

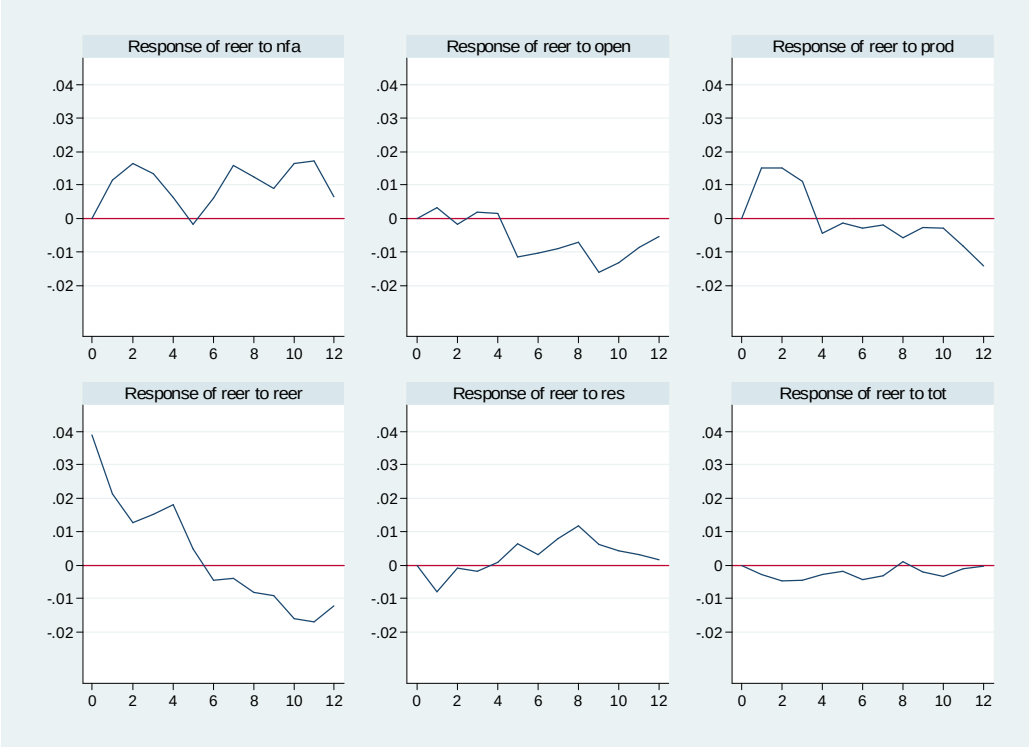

Table 1. ADF Test Results (H_0: variable follows a unit root process)

Variable	Test Statistics	1% Critical	5% Critical	10% Critical
reer	-2.892	-3.523	-2.897	-2.584[19]
Δ*reer*	-9.258*	-3.524	-2.898	-2.584
prod	-2.364	-3.523	-2.897	-2.584
Δ*prod*	-7.754*	-3.524	-2.898	-2.584
open	-2.032	-3.523	-2.897	-2.584
Δ*open*	-17.597*	-3.524	-2.898	-2.584
nfa	-1.000	-3.523	-2.897	-2.584
Δ*nfa*	-9.308*	-3.524	-2.898	-2.584
tot	-1.092	-3.523	-2.897	-2.584
Δ*tot*	-5.500*	-3.524	-2.898	-2.584
res	0.063	-3.523	-2.897	-2.584
Δ*res*	-3.725*	-3.524	-2.898	-2.584

Table 2. Cointegration Tests (H_0: rank = r)

Maximum Rank	LL	Eigenvalue	Trace Statistic	5% Critical
r = 0	866.48059		60.1469	47.21
r ≤ 1	886.91359	0.36496	19.2809*	29.68
r ≤ 2	893.4856	0.13588	6.1369	15.41
r ≤ 3	896.33392	0.06133	0.4403	3.76
r ≤ 4	896.55406	0.00488		

Table 3. VECM Results

Variable	Constant	*prod*	*open*	*nfa*	*tot*
b	-1.836726	-1.691076	1.758194	-0.8215722	0.7541114
Z-Statistic		-3.04	4.70	-5.42	1.96

Table 4. Cointegration Tests (H_0: rank = r)

Maximum Rank	LL	Eigenvalue	Trace Statistic	5% Critical
r = 0	1070.3925		49.7916	47.21
r ≤ 1	1082.1559	0.23003	26.2648*	29.68
r ≤ 2	1089.5157	0.15088	11.5451	15.41
r ≤ 3	1093.6059	0.08689	8.3647	3.76
r ≤ 4	1095.2883	0.03670		

[19] Note that the unit root process of variables reer and open is rejected at 10% critical value.

Table 5. VECM Results

Variable	Constant	*prod*	*open*	*res*	*tot*
b	-1.547542	-4.683046	2.260148	-43.03996	-1.546326
Z-Statistic		-5.23	2.68	-4.01	-3.78