

# Analysis of RMB's Real Effective Exchange Rate after the "Exchange Rate Reform"

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**Abstract.** Based on behavioral equilibrium exchange rate model, this paper analyzes the relationship between RMB real effective exchange rate and the underlying economic variables in July 2005-December 2011. The results show that (1) co-integration relationship exists between the real effective exchange rate of RMB and the selected explanatory variables. (2) Since the exchange rate reform in 2005, the RMB real effective exchange rate and the equilibrium exchange rate showed a fluctuation rise trend. (3) The RMB real effective exchange rate is always in the alternative overestimated and underestimated state. If the width of the target zone is 1%, the RMB real effective exchange rate is basically in disorders. When the width of the target area expands to 2%, the real effective exchange rate misalignment occurred mainly in the early stage of exchange rate reform to late 2005, February 2007 to January 2008, October 2008 to December 2009, before and after the restart reform. Misalignment reaches maximum during the financial crisis and decreases after the crisis.

## Introduction

On July 21, 2005, the People's Bank of China announced that China began to implement a managed floating exchange rate system based on market supply and demand, with reference to a basket of currencies. During the outbreak of the financial crisis, China kept the exchange rate relative to the dollar. After the crisis, the central bank announced on June 19, 2010 to restart the exchange reform to further promote the reform of the RMB exchange rate formation mechanism and enhance the flexibility of the RMB exchange rate. Therefore, the trend of RMB exchange rate has been the focus of attention of all parties, which led to researches into the real exchange rate of RMB exchange rate misalignment.

In recent years, domestic scholars have done a lot of research on the exchange rate of RMB real effective exchange rate. According to the behavioral equilibrium exchange rate theory, Qian Zhiquan (2011) uses the vector error correction technique to calculate the equilibrium exchange rate in China. It is found that the RMB exchange rate is undervalued and overvalued in the period of 1999-2007<sup>[1]</sup>. Li Yongning, Guo Yuqing and Zhao Jun (2011) construct the nominal effective exchange rate index and the real effective exchange rate index of 46 trading partners. They found that in addition to the RMB in the Asian financial crisis during the overestimation, the rest of the period is undervalued, the smaller the degree of dislocation of the RMB<sup>[2]</sup>. Li Zeguang (2012) uses the error current account gap method, the basic method of behavioral equilibrium correction model and ML-ARCH model to measure the equilibrium interval of the RMB exchange rate of RMB, that underestimated the degree in the 10%-15% range, far lower than the foreign scholars on the RMB exchange rate undervalued level measure<sup>[3]</sup>. Tang Yahui, Chen Shoudong (2012) based on the BEER model, 1983-2009 estimates the annual RMB equilibrium exchange rate and misalignment of RMB exchange rate overvalued, found in 1983-1985, 1997-2003, 2008-2009 in three stages, the highest rate reached 24.64% overvalued<sup>[4]</sup>.

On the whole, most domestic scholars adopt data before 2010 in their studies, but there are relatively few researches into the exchange rate reform since 2010 to restart the RMB exchange rate misalignment of the real effective exchange rate. Moreover, these studies use annual data or quarterly data, which cannot accurately reflect the degree of misalignment of the real effective exchange rate. Therefore, in order to better reflect the recent RMB real exchange rate misalignment degree, this paper attempts to use the data from July 2005 to –December 2011 in their studies.

## Research Models and Methods

Since the data of RMB real effective exchange rate can be obtained by IMF, BIS and other international institutions, it is necessary to calculate the exchange rate of RMB real effective exchange rate and calculate the equilibrium exchange rate.

**Equilibrium Exchange Rate Model Construction.** At present, there are four types of equilibrium exchange rate models: equilibrium real exchange rate model (ERER), natural equilibrium exchange rate model (NATREX), basic factor equilibrium exchange rate model (FEER) and behavioral equilibrium exchange rate model (BEER).

In 1989, Adwards proposed a balanced real exchange rate model to construct a functional equation between the real exchange rate and the terms of trade, the ratio of government consumption to nonvolatile goods to GDP, technological progress, tariff levels, and the ratio of investment to GDP. Analyze the equilibrium exchange rate of developing countries<sup>[5]</sup>. In 1994, Stein proposed a natural equilibrium exchange rate model, that the equilibrium exchange rate is not considered speculative capital flows, cyclical factors and international reserve changes in the case, determined by the economic fundamentals, to achieve balance of payments level of exchange rate, the model describes the dynamic relationship between medium-term equilibrium and long-term equilibrium<sup>[6]</sup>. But the model of the medium-term equilibrium is artificially designed, in reality is unlikely to achieve. Fundamental element equilibrium exchange rate model proposed by Williamson, the core idea of the model can be expressed by the following formula:  $CA = KA$ , that is, the current project matches with capital projects<sup>[7]</sup>. However, the model has a large number of parameter estimation in the calculation process, which requires a lot of data support and does not apply to the developing countries with incomplete data, but also subjective in the parameter estimation process, which will affect the actual results.

At present, the commonly used method in domestic and foreign research is the behavioral equilibrium exchange rate model proposed by Clark and MacDonald<sup>[8]</sup>. The model constructs the simple equation according to the behavioral relationship between the real effective exchange rate and the basic economic factors, and uses the cointegration method to estimate the model parameters and the equilibrium value of the real exchange rate. The core idea can be expressed by the following formula:

$$q_t = \beta_1 Z_{1t} + \beta_2 Z_{2t} + \tau T_t + \varepsilon_t \quad (1)$$

$q_t$  refers to real effective exchange rate;  $Z_{1t}$ ,  $Z_{2t}$  and  $T_t$  refer to the long-term factor, intermediate-term factor and short-term or temporary factors affecting the real effective exchange rate;  $\varepsilon_t$  refers to random interference item,  $\beta_1$ ,  $\beta_2$  and  $\tau$  refer to coefficient vectors. When the real effective exchange rate is completely explained by long-term and intermediate-term factors, it is deemed that the balanced exchange rate level is achieved, i.e.:

$$\eta_t^* = \beta_1 Z_{1t} + \beta_2 Z_{2t} \quad (2)$$

As a country controlled by capital projects, China should choose according to national conditions. According to the research results of scholars at home and abroad and considering the availability of data, this paper chooses the terms of trade, labor productivity, foreign net assets and broad money supply  $M_2$  as the factors to calculate the equilibrium exchange rate and construct the following model:

$$BEER = f(tot(+), prod(+), m2(-), nfa(+)) \quad (3)$$

Tot represents the terms of trade, prod represents labor productivity,  $m_2$  is the broad money supply,  $nfa$  is the foreign net assets, and the positive and negative signs in parentheses indicate the direction of the different economic variables on the equilibrium exchange rate. It is generally accepted that the ratio of terms of trade increases, on behalf of the improvement of the terms of trade, the current account will also be improved, then need to balance the exchange rate appreciation in order to maintain the long-term balance of the current account. Labor productivity increases generally occur in the tradable sector, with fewer changes in labor productivity in the non-tradable sector, improved productivity in the country's trade, improved current items, and equal appreciation of exchange rates to maintain external balance. The increase in the domestic broad money supply will lead to an increase in the domestic inflation rate, causing the real exchange rate to rise, thereby reducing the competitiveness of their exports, so long-term need to balance the exchange rate depreciation to maintain balance. Foreign net assets are the difference between foreign assets and foreign liabilities, mainly composed of foreign exchange reserves, gold reserves, if the foreign net assets of the economy increased, on behalf of the country's foreign income increased, the current project to improve, in order to maintain long-term external balance, it is necessary to appreciate a balanced exchange rate.

**Dislocation Formula of RMB's Real Effective Exchange Rate.** Construct behavioral equilibrium exchange rate and select appropriate variables, calculate China's equilibrium exchange level and determine China's RMB real effective exchange rate's dislocation formula, i.e.,

$$\text{exchange rate} = \frac{\text{real effective exchange rate} - \text{equilibrium exchange rate}}{\text{equilibrium exchange rate}} \quad (4)$$

According to this formula, the degree of dislocation of the real effective exchange rate of the RMB can be measured. This dislocation is manifested as both the low exchange rate and the overvaluation of the exchange rate. Whether the exchange rate is undervalued or overestimated will adversely affect economic efficiency and social welfare. From the theoretical point of view, there should be a balanced exchange rate range, as long as the exchange rate offset value in this range, that the real effective exchange rate of RMB is conducive to the realization of our internal and external balance; once the offset value beyond the range, that the real effective exchange rate of RMB dislocation is relatively serious that appropriate policy adjustments should be made.

### **An Empirical Analysis on the Degree of Dislocation of RMB Real Effective Exchange Rate**

In terms of variable data sources, the real effective exchange rate uses the IMF's real effective exchange rate index; the terms of trade are replaced by the ratio of China's exports and imports; as a result of the comparison of labor productivity between the trade and non-tradable sectors Therefore, this paper uses the per capita GDP of the United States and China's per capita GDP ratio; foreign net assets and broad money supply data are derived from the People's Bank of China, other data according to the China Network, IMF, the US Bureau of Labor Statistics released data.

**Measurement of RMB Equilibrium Exchange Rate.** Before using the cointegration equation to verify the equilibrium relationship between the equilibrium exchange rate and the underlying economic factors, it is necessary to test the stability of each time series. First, we use the X11 season adjustment method to adjust the monthly data from July 2005 to December 2011 to remove seasonal changes. On the seasonally adjusted broad money supply, foreign net assets, the actual effective exchange rate to take its logarithmic form. Because of labor productivity, the terms of trade itself is a ratio form, so do not need to take a logarithm. And then, the unit root test to determine the smoothness of time series is followed and finally the use of cointegration theory for analysis.

**ADF Test Process and Results.** Through the unit root test, it has been found the above indexes of variables are non-stationary time series, but after the first order difference, all time series at the 5% significance level showed stable characteristics, indicating that they are integrated of order one, the test results are shown in Table 1:

Table 1 Results of ADF Test

Variable	ADF Statistic	1% critical value at significant level	5% critical value at significant level	10% critical value at significant level	Whether through the significance test
LNREER	-1.041088	-3.51229	-2.89722	-2.58586	No
D(LNREER)	-6.601293	-3.51229	-2.89722	-2.58586	Yes
LNM2	0.792393	-3.51126	-2.89678	-2.58563	No
D(LNM2)	-8.17014	-3.51229	-2.89722	-2.58586	Yes
LNNFA	-2.32521	-3.51334	-2.89768	-2.5861	No
D(LNNFA)	-3.97073	-3.51229	-2.89722	-2.58586	Yes
PROD	2.478234	-3.51126	-2.89678	-2.58563	No
D(PROD)	-8.76949	-3.51229	-2.89722	-2.58586	Yes
TOT	-2.59962	-3.51229	-2.89722	-2.58586	No
D(TOT)	-15.5004	-3.51229	-2.89722	-2.58586	Yes

### Cointegration Analysis

According to the results of ADF test, it can be seen that there may be cointegration relationship between variables. Then, use the ADF method to test the stability of the residual sequence. The least squares estimate of the variable using Eviews6 is shown in Table 2:

Table 2 Statistical Results of Co Integration Regression

Variable	Coefficient	Standard error	T Statistics	P Value
LNM2	-5.43232	7.044676	-0.77113	0.4429
LNNFA	7.012335	3.092174	2.267768	0.0261
PROD	22.1228	79.51767	2.782132	0.0068
TOT	9.64668	3.475391	2.775711	0.0069

The ADF test for the residual sequence is shown in Table 3:

Table 3 Results of ADF Test for Residual Sequence

Critical value	ADF Statistic	T Value
1% significant level	-3.51229	-8.671428
5% significant level	-2.89722	P value
10% significant level	-2.58586	0.0000

The above test process and the results show that there is a cointegration relationship between the real effective exchange rate of RMB and the corresponding variable from July 2005 to December 2011, and the cointegration equation is:

$$LNREER = 5.522416 - 5.43232LNM_2 + 7.012335LNNFA + 22.1228PROD + 9.64668TOT \quad (5)$$

The significance of the variables in the above equation is shown in Table 2, except for the broad money supply  $M_2$ , the impact of the remaining variables on the real exchange rate is significant. And the coefficient of broad money supply, foreign net assets, labor productivity and terms of trade is consistent with the theoretical analysis, that is, with the increase of foreign net assets, the improvement of labor productivity and the improvement of the terms of trade will lead to the rise of equilibrium exchange rate. The increase in broad money supply leads to a decline in the equilibrium exchange rate. The empirical test shows that the broad money supply  $M_2$  has no significant effect on the formation of our equilibrium exchange rate.

The value of  $LNM_2$ ,  $LNNFA$ ,  $PROD$  and  $TOT$  is substituted into the cointegration equation, which can solve the current equilibrium exchange rate of RMB. Figure 1 shows the RMB real

effective exchange rate and equilibrium exchange rate charts and it has been found that since the exchange reform since 2005, the two exchange rates are in the trend of continuous appreciation and the trend is basically the same.

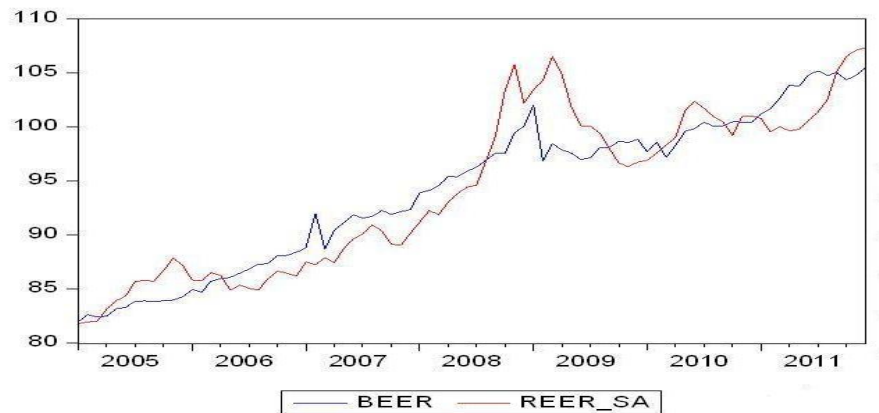


Figure 1. RMB Real Effective Exchange Rate and Equilibrium Exchange Rate

**Realization of RMB Actual Effective Exchange Rate Dislocation Degree.** According to the exchange rate imbalance formula, the actual effective exchange rate disparity of RMB can be calculated, and the actual effective exchange rate index is chosen to select the RMB real effective exchange rate index published by BIS. The index takes into account non-trade factors in weight construction, not only the bilateral export weight, but also the third-party market effect is considered. In the sample country selected to consider the economic and trade relations with China's 61 economies, so you can better measure the level of international competitiveness of the RMB. The results are shown in Fig.

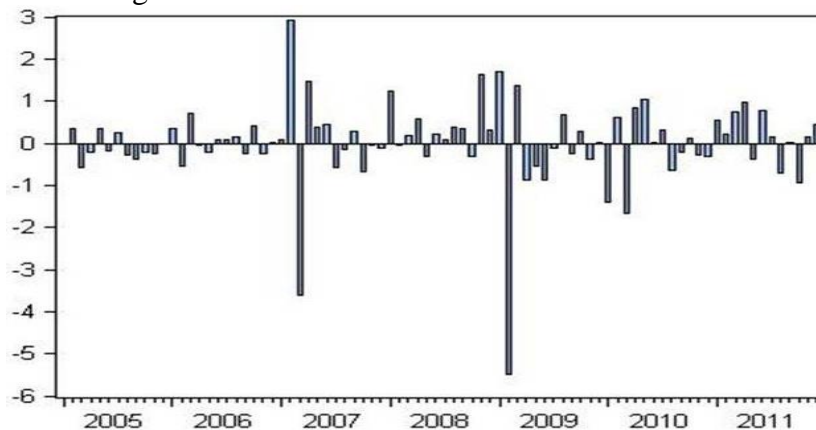


Figure 2. Misalignment of Exchange Rates

It can be seen from Figure 2 that since the real exchange rate of RMB has been in a state of continuous maladjustment, the exchange rate is overvalued and the exchange rate is undervalued. The exchange rate overestimation is divided into four stages: the reform period from May 2006 as the first stage, September 2008 to September 2009 for the second stage, the third stage of the overestimation occurred in March 2010 to January 2011, after October 2011 the exchange rate and overvalued trend. The rest of the period is the low exchange rate stage. It can be seen from the figure that the volatility of the overvalued exchange rate is greater than the exchange rate undervaluation period, the exchange rate overestimation of up to 8.2%, the exchange rate underestimated the maximum up to 5.2%.

## Conclusion

In this paper, based on the influence of behavioral equilibrium exchange rate model (BEER) on the basic economic variables that affect RMB equilibrium exchange rate since the exchange rate reform, quantitative analysis is conducted to measure the deviation degree between RMB real effective exchange rate and the equilibrium exchange rate. The results show that according to the domestic scholars on the study of the exchange rate target zone, in target area, based on the empirical estimates that the exchange rate market in the primary stage, the width of the exchange rate target zone should be the central rate of + 1%, + 2% to maximum expansion. If the width of the target area of 1%, the actual effective exchange rate is basically in a state of imbalance; The target width expanded to 2%, the RMB real effective exchange rate exceeds the time interval of the mainly focus on the exchange rate reform to the end of 2005, early February 2007 to January 2008, October 2008 to December 2009 and restart after the exchange rate reform. From the point of view of the period, the period of exchange rate misalignment appeared in 2008, that is, when the financial crisis appeared and broke out, the main reason is that the exchange rate system was back to the dollar. And after the 2010 exchange rate reform, the exchange rate misalignment significantly reduced. Overall, since the exchange rate reform, the RMB real effective exchange rate and the equilibrium exchange rate is basically in a state of imbalance, indicating that the exchange rate of RMB real effective exchange rate adjustment did not achieve the degree of internal and external equilibrium.

In the process of economic operation, the equilibrium exchange rate is constantly adjusted, and the deviation of the real effective exchange rate and the equilibrium exchange rate of RMB is changed due to different economic conditions. Initial stage of the exchange rate reform, the RMB against the U.S. dollar has maintained a slight appreciation, but due to the same period the dollar against the euro, the yen and other currency devaluation, so that the real effective exchange rate of the RMB oscillation. After the outbreak of the financial crisis, the RMB exchange rate began to re-pegged to the dollar, and passive appreciation of the dollar, resulting in the real effective exchange rate of RMB rose. After the debt crisis in 2010, the dollar and the euro mixed, coupled with the reform of the restart, resulting in a narrow range of real effective exchange rate fluctuations, a slight upward trend. Overall, the real effective exchange rate of RMB in the dislocation phase, has not yet achieved equilibrium.

Misalignment of exchange rate is not only related to the exchange rate formation mechanism, but also influenced by the change of economic fundamentals. To make the RMB real effective exchange rate close to the equilibrium exchange rate, the need to continue to promote the reform of the RMB exchange rate mechanism, the RMB exchange rate formation more affected by the basket of currencies, rather than a single dollar. At the same time, we should deepen reform, adjust the economic structure, and fundamentally promote the real effective exchange rate of RMB to reach or close to the level of equilibrium exchange rate.

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