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**Equilibrium and Misalignment: An  
Assessment of the RMB Exchange Rate  
from 1978 to 1999**

by

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# **Equilibrium and Misalignment: An Assessment of the RMB Exchange Rate from 1978 to 1999<sup>1</sup>**

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## **Abstract**

Exchange rate misalignment tends to disrupt the economic growth of developing countries, and persistent overvaluation may even lead to currency crises. Since the Asian financial crises in 1998, economists and policy makers have been concerned with whether or not the China currency, renminbi yuan (RMB) is overvalued. Based on new developments in the equilibrium exchange rate theory, this paper develops equilibrium real exchange rate (ERER) and behavioral equilibrium exchange rate (BEER) models for RMB by using cointegration analysis, the Hodrick-Prescott (H-P) filter and other econometrics techniques. The estimation results show that the exchange rate of RMB is close to the equilibrium level in 1999. Towards the end, this paper analyzes the trajectory of RMB exchange rate misalignment since 1978, and makes an assessment of RMB exchange rates. The author suggests gradual reforms in exchange rate policies.

JEL classification: F31, F32

Keywords: RMB exchange rate; Equilibrium exchange rate; Cointegration

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## 1. Introduction

Expectations of the devaluation of the Chinese currency, renminbi yuan (RMB), have been prevalent in the world financial markets since the Asia financial crises. Previous discussions on whether or not RMB exchange rates are overvalued are based on analyzing several economic indicators, such as the trade balance, foreign investment, and foreign exchange reserves, & etc. These analyses are not convincing because the same data can be used to support different arguments.

This article attempts to give a comprehensive assessment of the RMB exchange rates based on the equilibrium exchange rate theories. There have been many studies on equilibrium exchange rates, the most widely cited of which include Williamson (1994), Hinkle (1999), MacDonald (1997,1998), and MacDonald and Stein (1999). Zhang (2001) investigates the misalignment of the RMB.

In this paper, the equilibrium real exchange rate is defined as the rate that is consistent with the simultaneous achievement of internal and external equilibrium (Williamson, 1994). This paper differs from the earlier research in three respects. First, this paper is based on multilateral exchange rates instead of bilateral exchange rates. Second, all economic fundamentals are smoothed by Hodrick-Prescott (H-P) filters. Third, two different models are developed in order to derive credible conclusions based on both annual and quarterly data.

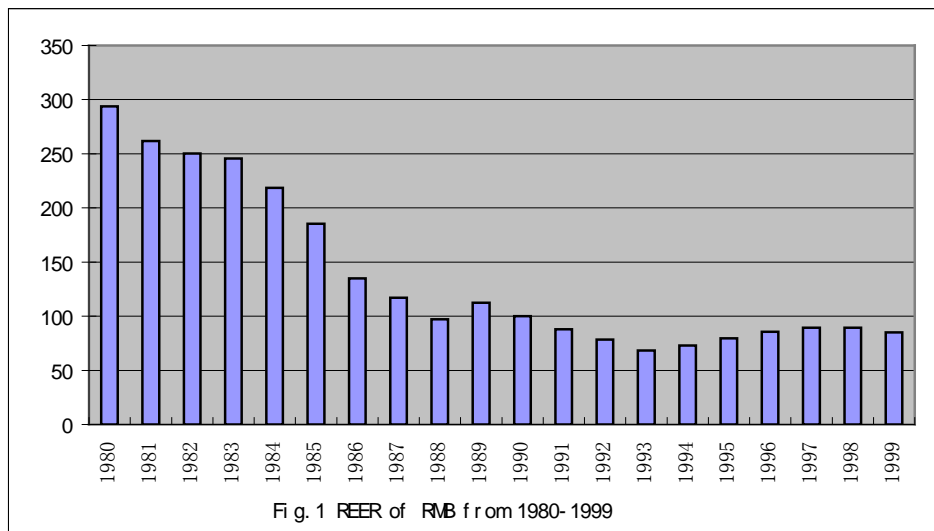
The paper is organized as follows. In Section 2, the trajectory of RMB nominal and real exchange rates from 1978 to 1999 is analyzed. Some important reforms are reviewed. In Section 3, different versions of purchasing power parity tests are performed on RMB exchange rates. In Section 4, using cointegration analysis and H-P filters, the author estimates the equilibrium exchange rate of RMB based on Elbadawi's developing country model on equilibrium real exchange rate (ERER), and analyzes the misalignment of RMB empirically. In addition, Section 4 points out some shortcomings in the empirical analysis of the Edwards (1989) model. In Section 5, another RMB equilibrium exchange rate model, behavioral equilibrium exchange rate (BEER), is developed. Section 6 compares the ERER and BEER models. Section 7 analyzes the shortcomings of China's existing RMB exchange rate determination mechanisms. The future direction of reform is discussed. Section 8 offers some conclusions.

## 2. Developments in the Nominal and Real Exchange Rates of RMB

The RMB exchange rates have gone through several devaluations since 1978 in order to maintain China's international competitiveness. Nominal RMB exchange rates against the US dollar (USD) have declined from 1.6836 RMB/USD in 1978 to 8.2783 in 1999, a devaluation of about 79.7%.

Theoretical and empirical research has shown that the fluctuations in the real exchange rates, instead of the nominal exchange rates, influence the competitiveness of a country's exports and the macro-economy. Therefore, we will focus on China's real effective exchange rates (REER) as calculated by the IMF, and take into account the exchange rates of sixteen countries and regions. The countries (regions) and their respective weights are: Hong Kong Special Administration Region (0.230322), Japan (0.196801), USA (0.152570), Germany (0.084016), Taiwan (0.047109), France (0.076697), Italy (0.042933), British (0.036844), Canada (0.027657), Korea (0.026481), Netherlands (0.022859), Belgium (0.019968), Singapore (0.019258), Australia (0.017827), Swiss (0.015870) and Spain (0.012788). Note that when we refer in this article to the real exchange rate of RMB, we generally mean REER.

REER was 293.87 in 1980, 89.35 in 1998 and 85.11 in 1999 (1990 is the base year with REER=100, and the rise in REER indicates home currency appreciation). The fluctuations in REER in China can be divided into three phases (Figure 1).



During the first period, from 1980 to 1988, RMB experienced its most dramatic devaluation, when it

declined from 293.87 to 97.29. The nominal exchange rates of RMB fell from 1.4984 in 1980 to 3.7221 in 1987. In 1988, REER declined further from 117.1 to 97.29 while nominal rates remained unchanged. In March 1988, the regulation of foreign exchange swap centers was relaxed in order to stimulate exports and control import of luxury goods. The increase in retention quotas was coupled with an increase in the number of swap centers, and all enterprises with retention quotas became eligible to access the swap centers at a more depreciated market-determined rate (previously, access to swap centers had been limited to foreign-funded enterprises). As a result, the volume of foreign exchange transactions through the swap centers increased much more dramatically than transactions through at the official rates. Since the swap rates were much higher than the official rates, the effective exchange rate (nominal and real) devaluated rapidly in 1988.

The second phase is from 1988 to 1993. The average nominal exchange rate of 1989 was down by 1% (devaluation took place on December 15, 1989, therefore it had little influence on average exchange rate), while the swap rates and the nominal effective exchange rate (NEER) remained stable. However, inflation in 1989 reached 17.8%, so real effective exchange rates appreciated from 97.29 in 1988 to 112.39 in 1993. This was the first round of RMB real appreciation since 1980. Afterwards, RMB depreciated during 1989-1993, and REER of RMB reached as low as 68.44 in 1993.

During the third phase, from 1993 to 1999, RMB exchange rates showed a distinct trend of appreciation, from 68.44 in 1993 to 85.11 in 1999. The movement of REER, however, is somewhat confusing when the multiple exchange rates of RMB were unified to 8.7 RMB/USD in 1994, from the official rate at 5.7. This represents a significant devaluation of the RMB exchange rate. Conversely, the real effective exchange rate appreciated to 72.83 in 1994. This contradiction was due to the exchange rate changes in the swap market, and the calculation of REER includes the swap rates. By 1993, the swap market had developed such that it handled nearly 80% of foreign exchange transactions. In the same year, the USD price in the foreign exchange swap market rocketed from 7.7 RMB/USD at the beginning of the year to 9 RMB/USD in February, and, to 10.8 RMB/USD at the end of June. The average swap rate was 8.64 RMB/USD in 1994, indicating an appreciation of 32%. RMB real effective exchange rate in 1994 appreciated because the sharp devaluation of REER in 1993. In addition, the inflation rate in 1994 rose to

21.7%.

### 3.RMB Exchange Rates and Purchasing Power Parity (PPP)

In order to test whether PPP holds for the RMB exchange rates, we will consider all three versions of PPP (Breuer, 1994). Our sample is from 1979 to 1999, and all data are monthly, including RMB nominal exchange rates, China's consumer price index,<sup>2</sup> and America's consumer price index.

#### 3.1 Univariate PPP

This test determines whether the real exchange rate behaves as a unit root process. The logarithm of real exchange rate  $q_t$  is generally defined as:

$$q_t = s_t - p_t + p_t^* \quad (1)$$

where  $s_t$  is the logarithm of the nominal exchange rate (domestic price of foreign currency), and  $p_t$  and  $p_t^*$  are the logarithms of the domestic and foreign price indexes.

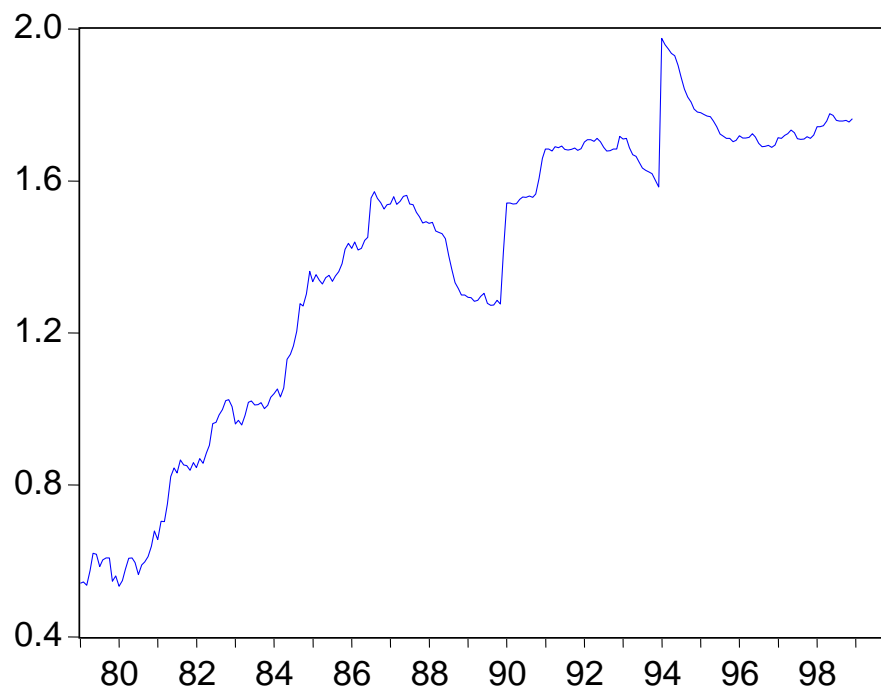


Fig. 2. Real exchange rate: q

<sup>2</sup> Although some study show wholesale price index may be a better guide to the long run purchasing power exchange rate (Breuer, 1994), wholesale price index is not available in China in 1980s.

Using this equation, we can compute the real exchange rate (Figure 2). Both this figure and the augmented Dickey-Fuller (ADF) or Phillips-Perron unit root tests show that  $q_t$  is not a stationary series.<sup>3</sup>

### 3.2 Bivariate PPP

The bivariate version tests the cointegration relationship between exchange rates and domestic- foreign prices:

$$s_t = \alpha + \beta (p_t - p_t^*) + u_t \quad (2)$$

The bivariate specification only imposes symmetry, and it is the relaxed version of univariate specification. The results show that the null hypothesis of zero cointegrating equation cannot be rejected.

### 3.3 Trivariate PPP

The trivariate specification tests whether the exchange rate, the domestic price series, and the foreign price series are cointegrated. The trivariate version is the most general and relaxed, and it imposes neither symmetry nor proportionality.

$$s_t = \alpha + \beta_1 p_t - \beta_2 p_t^* + u_t \quad (3)$$

The ADF tests are performed on  $s_t, p_t, p_t^*$  respectively. They are all I(1) series. The cointegration relationship is found by using the Johansen maximum likelihood method.

$$s = -40.965 - 3.288p + 12.628p^* \quad (4)$$

However, we find the signs of  $p, p^*$  in (4) are opposite to the signs in (3). According to the basic principles of PPP, the RMB exchange rate should depreciate (namely,  $s$  should go up) when China's price index goes up; and it should appreciate (namely,  $s$  should go down) when the US prices go up. So in (4), the sign of  $p$  should be positive rather than negative; and the sign of  $p^*$  should be negative rather than positive. We can conclude that a reasonable cointegration relationship does not exist among  $s_t, p_t, p_t^*$ . Actually, as pointed out by Breuer (1994), even if we were to find a reasonable cointegration relationship, it

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<sup>3</sup> The econometric results are omitted here to limit the length of this paper.

would be hard to interpret the significance of the results. This kind of exchange rate is not the relevant equilibrium exchange rate, and it does not provide policy makers with the basis for nominal exchange rate adjustments.

#### 4. An ERER Model for Equilibrium Exchange Rate of RMB

##### 4.1 Equilibrium exchange rate for developing countries

Edwards (1989) advances a widely accepted equilibrium exchange rate model for developing countries. The model captures the most salient macroeconomic features of developing economies, including the existence of exchange controls and trade barriers. However, the model has a drawback when we apply it to estimate the equilibrium exchange rates of RMB. The kernel of Edward's model is the following dynamic equation:

$$\begin{aligned} \Delta \log e_t = & \theta \{ \log e_t^* - \log e_{t-1} \} - \lambda \{ Z_t - Z_t^* \} \\ & + \phi \{ \log E_t - \log E_{t-1} \} - \phi [ PMPR_t - PMPR_{t-1} ] \end{aligned} \quad (5)$$

where  $e$  is the real exchange rate,  $e^*$  is the equilibrium exchange rate,  $Z$  is a vector of macroeconomic indexes,  $Z^*$  is the corresponding vector of sustainable macroeconomic indexes,  $E$  is the nominal exchange rate, and  $PMPR$  is the parallel market premium.

Since the equilibrium real exchange rate  $e^*$  is in turn a function of the fundamentals, such as the terms of trade, the level and composition of government consumption, import tariffs, and capital flows, instrumenting  $e^*$  with these fundamentals, Edwards obtains an equation that could be estimated by Ordinary Least Square or Instrument Variable methods. However, in empirical analysis, there are many independent variables (generally more than seven), and some of them—for instance capital flows, productivity, domestic credit, and government consumption—are closely related. So naturally some variables will be not be significant in the equation. But according to Edwards' model, almost all these variables should be included in the equation; otherwise, the estimated equilibrium exchange rate does not coincide with his model. It is therefore unclear when one applies Edwards' model in empirical analysis.

On the basis of Edwards' model, Elbadawi (1994) advances a forward-looking ERER model:



$$\log \tilde{e}_t = \sum_{j=0}^{\infty} \lambda^j \delta_t' \tilde{F}_{t+j} \quad (6)$$

where  $\tilde{e}_t$  is the equilibrium real exchange rate, and  $\tilde{F}$  is the sustainable value of vector of fundamentals F:

$$F = \left[ 1, \log(TOT), \log(OPEN), \frac{NKI}{GDP}, \log\left(\frac{G \cdot EXP}{GDP}\right), \log\left(\frac{CURR \cdot G \cdot EXP}{G \cdot EXP}\right) \right]'$$

where  $TOT$  is the terms of trade,  $OPEN$  is openness,  $NKI$  is net capital inflow,  $GEXP$  is government expenditure, and  $CURR G EXP$  is current government expenditure.

When Elbadawi's model is used in empirical study, the cointegration technique was generally needed, and its results are more reasonable.

#### 4.2 Estimation results

I choose to include terms of trade, productivity, investment ratio, foreign capital inflow, tariffs, domestic credit, government consumption, openness, and others as the fundamental variables that may be related to China's equilibrium exchange rate. Cointegration analysis is performed on the above annual data from 1980 to 1999. Insignificant variables are removed from the equation, and finally the three variables that are cointegrated with RMB real effective exchange rate are found: terms of trade, openness, and government consumption. The terms of trade was defined as the ratio of export price index to import price index, and the data are obtained from World Bank. The openness is defined as the ratio of import to GDP, and government consumption is defined as the ratio of government expenditures to GDP. Both are calculated based on data from IFS and China's Statistical Yearbook. The logarithms of the three variables are denoted as  $LTOT$ ,  $LOPEN$ , and  $LGOVEXP$  respectively, and  $LREER$  is the logarithm of REER (Figure 3).

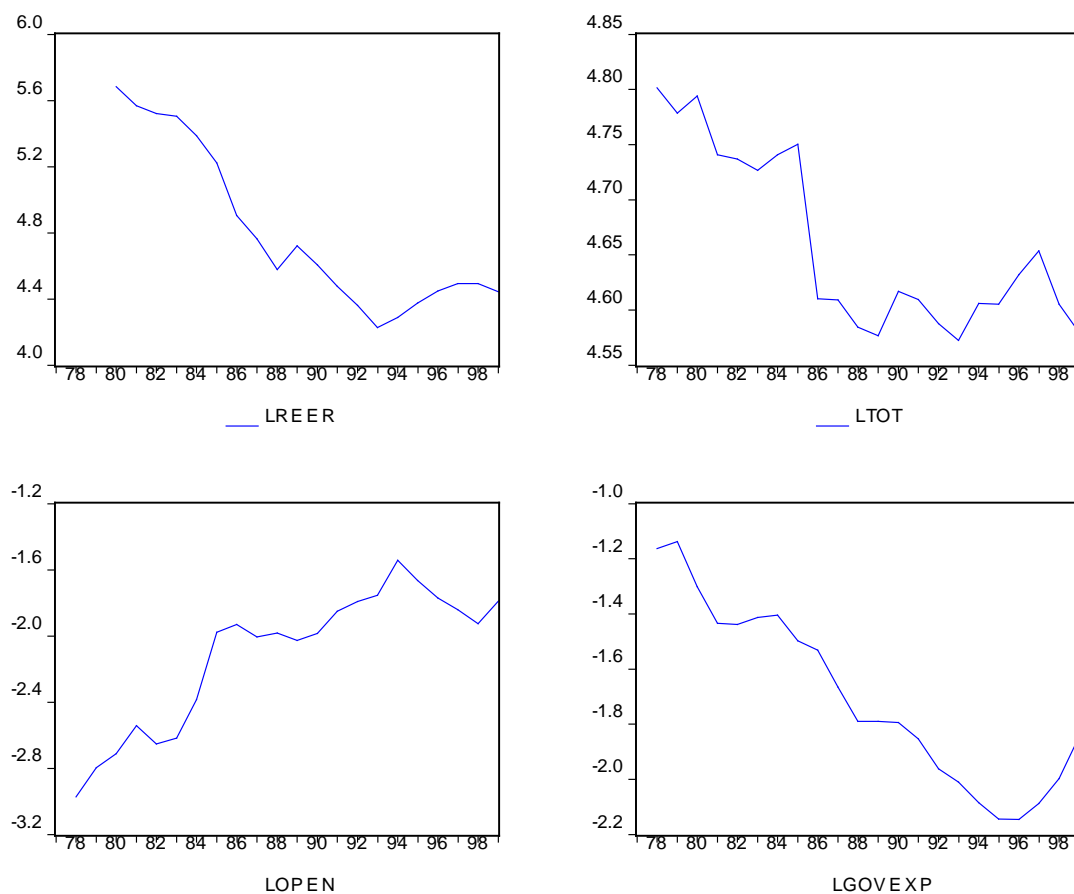


Fig. 3. REER and economic fundamentals

The ADF unit root tests for *LTOT*, *LOPEN*, *LGOVEXP*, and *LREER* show that they are all I(1) processes (Table 1). The Engle-Granger two-step test is applied to explore the relationships among them.

Table 1. Unit root test (ERER model)

Variables	Test Specifications	ADF Statistic	Critical Value
LREER	(C, 0, 1)	-1.702	-3.857
$\Delta$ PEEPA	(C, t, 2)	-4.11	-3.735
LTOT	(C, 0, 1)	-1.528	-3.807
$\Delta$ TOTA	(C, 0, 1)	-3.202	-3.029
LOPEN	(C, 0, 1)	-1.747	-3.807
$\Delta$ NEPIOA	(C, 0, 1)	-3.197	-3.029
LGOVEXP	(C, 0, 1)	-2.373	-3.807
$\Delta$ LGOVEXP	(0, 0, 1)	-2.155	-1.96

Note: C and t denote the constant and trend in ADF test. The critical values are obtained at least the 5% significance level.

The static regression result shows that all the independent variables are highly significant (Table 2), and that the residual is a stationary series (its ADF statistic is 2.08, the critical value at 5% significance level is -1.98). There is, therefore, a cointegration relationship between *LREER* and *LTOT*, *LOPEN*, and *LGOVEXP* :

$$LREER = 6.29 + 2.45LTOT - 0.43LOPEN + 0.68LGOVEXP \quad (7)$$

Table 2 Cointegration Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.287374	1.854557	-3.390229	0.0037
LTOT	2.453971	0.404568	6.065657	0.0000
LOPEN	-0.432108	0.109061	-3.962078	0.0011
LGOVEXP	0.677992	0.121465	5.581788	0.0000
R-squared	0.982009	Mean dependent var		4.803369
Adjusted R-squared	0.978636	S.D. dependent var		0.487718
S.E. of regression	0.071287	Akaike info criterion		-2.267338
Sum squared resid	0.081310	Schwarz criterion		-2.068191
Log likelihood	26.67338	F-statistic		291.1113
Durbin-Watson stat	1.839989	Prob(F-statistic)		0.000000

Dependent Variable: LREER

In theory, improving terms of trade calls for equilibrium exchange rate appreciation; a more liberalized and open economy requires a more depreciated ERER. Since governments tend to devote more of their expenditures to non-tradables than the private sector, government expenditures to GDP ratio has a positive effect on real exchange rate. So, all the coefficients in (7) are of the expected sign. The long run elasticity of REER with respect to terms of trade is 2.45, while that with respect to openness is - 0.43, and 0.68 with respect to government consumption.

### 4.3 The short-run error correction estimation

Since there is a cointegration relationship between RMB exchange rate and economic fundamentals, according to Granger representation theorem, there must be a short-run error correction model. The estimation results (Table 3) strongly support the following error correction model:

$$\Delta \log REER = 0.75[\log REERF(-1) - \log REER(-1)] + 1.61\Delta \log TOT - 0.46\Delta \log OPEN + 0.77\Delta \log GOVEXP - 0.37\Delta \log DC + 0.008NOMDEV + 0.01NOMDEV(-1) \quad \square 8 \square$$

where *REERF* is the fitted value of *REER* derived from equation (7), *GOVEXP* is government expenditures, *DC* is domestic credit, and *NOMDEV* is nominal devaluation.

Table 3. Error Correction Regressions

Variable	Coefficient	Std. Error	t-Statistic	Prob.
U	0.751129	0.357839	2.099068	0.0597
DLTOT	1.606916	0.545027	2.948325	0.0132
DLOPEN	-0.455410	0.172148	-2.645465	0.0228
DLGOVEXP	0.767288	0.312971	2.451623	0.0322
DCREDIT	-0.370785	0.349023	-1.062350	0.3108
NOMDEV	0.007810	0.027990	0.279009	0.7854
NOMDEV(-1)	0.014323	0.025662	0.558144	0.5879
R-squared	0.760057	Mean dependent var		-0.066143
Adjusted R-squared	0.629179	S.D. dependent var		0.117354
S.E. of regression	0.071463	Akaike info criterion		-2.153985
Sum squared resid	0.056176	Schwarz criterion		-1.807729
Log likelihood	26.38586	F-statistic		5.807373
Durbin-Watson stat	1.779914	Prob(F-statistic)		0.006041

Dependent Variable: DLREER

The elasticity of  $[\log REERF(-1) - \log REER(-1)]$ , the error correction term, is 0.75. This coefficient reflects the dynamic self-correcting mechanism of the error correction model, and its value is very close to

the results obtained by Elbadawi (1994). In his research, the coefficients for Chile, Ghana, and India are 0.78, 0.71, and 0.67 respectively. If there is an overvaluation in the previous period (  $[\log REERF(-1) - \log REER(-1)] < 0$  ), since the coefficient is positive, the REER will depreciate in the following period (  $\Delta \log REER < 0$  ), and larger values signify faster rates of adjustment. The short-run effects of expansionary macroeconomic policy and devaluations of the official exchange rates were insignificant. In the short-run, the real exchange rate is also influenced by the transitory movements of the fundamentals, including terms of trade, openness, and government consumption, and their significance level are as high as 1.3%, 2.3%, and 3.2% respectively. So in both the long and the short run, worsening terms of trade, more openness, and reduced government consumption are associated with depreciation.

#### 4.4 Derivation of the equilibrium real exchange rate

In order to obtain the “sustainable” or “permanent” values of the fundamentals, two kinds of methods are available. One is time series techniques such as Beveridge-Nelson (B-N) decomposition and H-P filter; the other is to construct the counterfactual. This article uses the H-P filter, a method first used by Hodrick and Prescott (1997) and now widely used among macroeconomists to obtain a smooth estimate of the long-term trend component of a series. Technically, it is a two-sided linear filter that computes the smoothed series  $s$  of  $y$  by minimizing the variance of  $y$  around  $s$ , subject to a penalty that constrains the second difference of  $s$ . That is, the H-P filter chooses to minimize:

$$\sum_{t=1}^T (y_t - s_t)^2 + \lambda \sum_{t=2}^{T-1} [(s_{t+1} - s_t) - (s_t - s_{t-1})]^2$$

The penalty parameter  $\lambda$  controls the smoothness of the series  $s_t$ . The larger the  $\lambda$ , the smoother are the  $s_t$ . As  $\lambda \rightarrow \infty$ ,  $s_t$  approaches a linear trend. After the economic fundamentals are smoothed for terms of trade, openness, and government consumption (Figure 4), the equilibrium exchange rate, REERHPF, is derived (Figure 5) and the misalignment is also calculated (Figure 6).

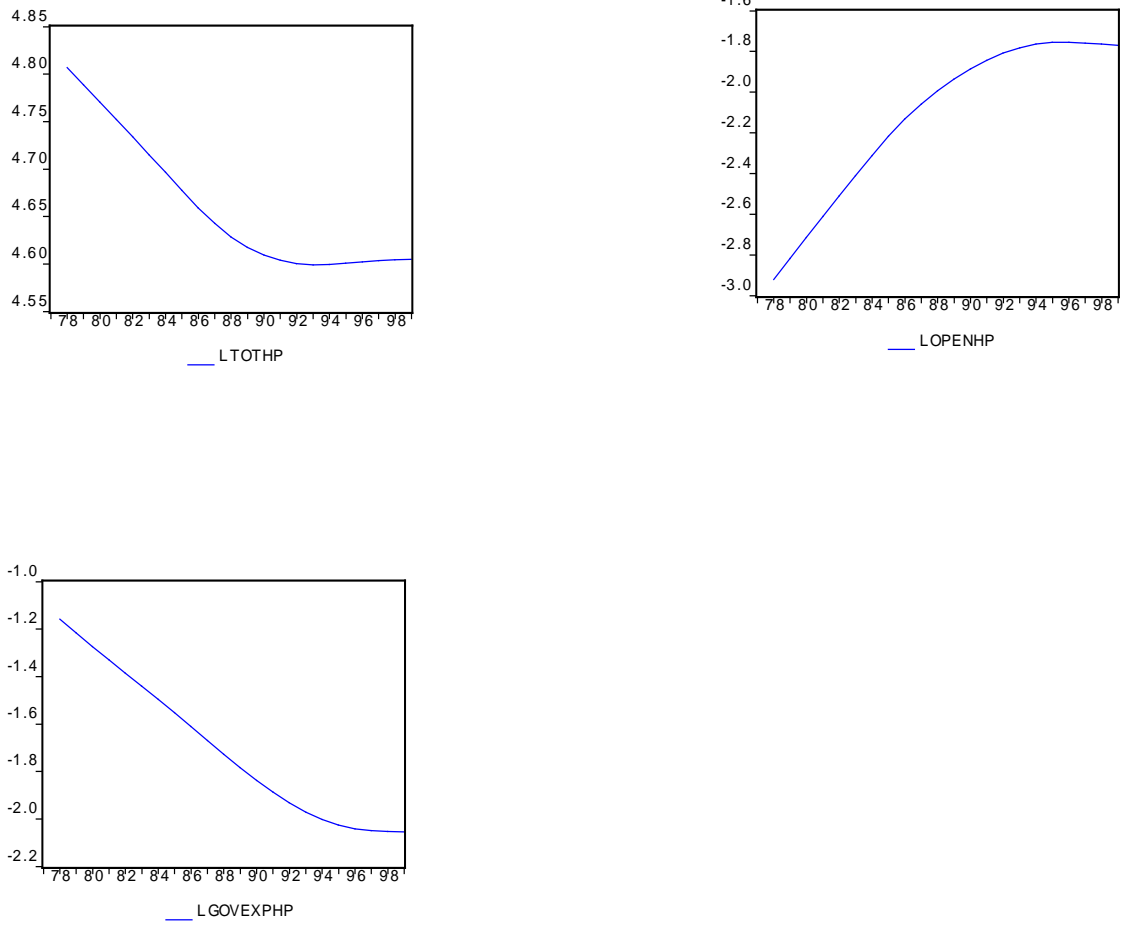


Fig. 4. Economic fundamental smoothed by H-P filter (ERER model)

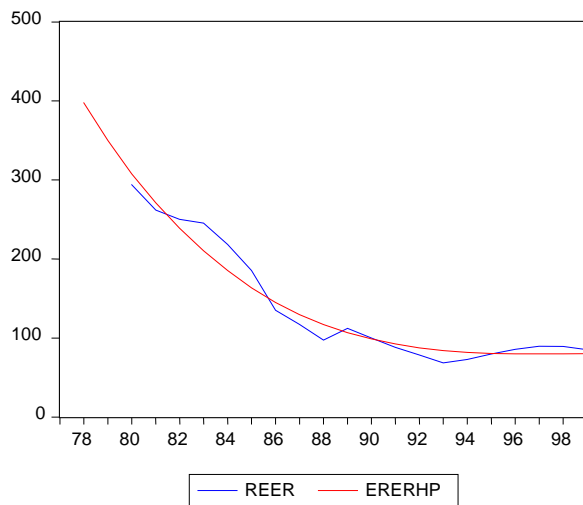


Fig. 5. Actual and equilibrium exchange rate (ERER model)

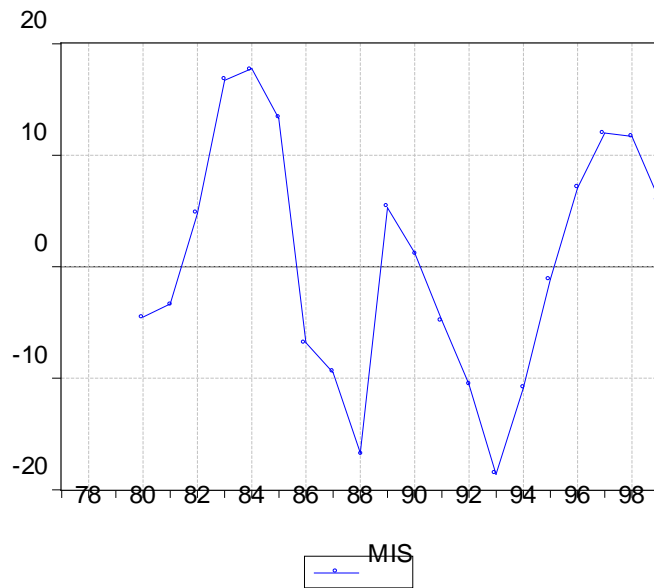


Fig. 6. Exchange rate misalignment (ERER model)

#### 4.5 Assessment on RMB exchange rate

The RMB exchange rate was generally misalignment under two situations: one is that the equilibrium exchange rates changed while real exchange rates failed to follow the change; the other is that equilibrium exchange rates kept stable while real exchange rates fluctuated.

##### 4.5.1 RMB exchange rate in equilibrium

According to the ERER Model, real effective exchange rates of RMB were close to the equilibrium level in 1981, 1990 and 1995. Does this conclusion coincide with the actual behavior of the economy? The answer is affirmative. In 1981, 1990, and 1995, trade surpluses were moderate, and foreign exchange reserves increased; at the same time, inflation and economic growth stayed at reasonable levels (Table 4). In a word, the economy nearly realized both internal and external equilibrium.

Table 4 External and internal equilibrium in 1981,1990, and 1995

	Export (%)	Growth	Trade (US\$ bil)	Balance	Change of Reserve (US\$ bil)	of Forex	GDP Rate (%)	Growth	Inflation Rate (%)
1981	21.5		0		4		4.5		2.4
1990	18.2		8.74		11.56		3.8		2.1
1995	23		16.7		22.47		10.5		14.8

#### 4.5.2 Undervaluation

Since 1980, the RMB has been undervalued twice. The first devaluation took place during the period of 1986 to 1988. The RMB was undervalued by 6.8% in 1986, 9.5% in 1987, and 16.7% in 1988. This was primarily because that RMB official exchange rate was devalued from 3.2 to 3.7 in July 1986, and the foreign exchange swap market was expanded in 1988. These factors led to the rapid depreciation of RMB real exchange rate from 185.4 in 1985 to 97.3 in 1988. Although RMB equilibrium rates declined from 163.6 to 116.8 during the same period, the devaluation was much less pronounced than that of the actual REER. This undervaluation did not change trade balance from deficit to surplus, although it greatly reduced the deficit during that time. For example, in 1987 the trade deficit narrowed from USD 13.5 billion, the average volume of 1985 and 1986, to USD 3.86 billion. Export volumes in 1987 and in 1988 increased over USD 8 billion, by 27% on average. However, the effect of this undervaluation was mitigated because of inefficiencies in the regime of foreign trade and foreign exchange control.

The second undervaluation took place during the period of 1991 to 1995. It was greater and lasted longer than the first. In 1993, the undervaluation reached 18.6%, primarily because the swap rates at that time were much lower than the official rates and accounted for an increasing proportion of the RMB real effective exchange rate. With the undervaluation effect emerging gradually and economic reform proceeding further at the same time, China successfully achieved trade surplus of USD 6 billion in 1994 and then USD 16.7 billion in 1995.

#### 4.5.3 Overvaluation of RMB

The first overvaluation occurred during the period of 1983-1985. The overvaluation lasted for more than 3 years and was significant. The RMB was overvalued by about 16.7%, 17.8% and 13.3% in 1983,



1984, 1985 respectively. This can be attributed primarily to the fact that China's openness was improved from 7% in 1982 to 13.8% in 1985. Consequently, RMB equilibrium exchange rates devalued from 239 to 164, while the actual RMB real exchange rates declined from 250 to 185. The actual devaluation was much less than devaluation of the equilibrium exchange rate. As for the effect of the overvaluation, it caused foreign trade balance to deteriorate. For example, exports fell in 1983 with trade surpluses reduced from USD 3.03 billion of 1982 to USD 0.84 billion. Trade deficit reached USD 1.27 billion in 1984, USD 14.9 billion in 1985, and USD 12 billion in 1986.

In 1989, the RMB experienced some slight overvaluation, as a result of higher inflation. The trade deficit was USD 6.6 billion in that year, while the growth of export slowed from 20% to 10%. The following devaluation at the end of 1989 mitigated the effects of that episode of overvaluation and avoided serious damage to economic development.

Since 1993, the real effective exchange rate of RMB has been rising persistently, while the equilibrium exchange rate has been stable. Therefore, the RMB was slightly overvalued in 1996 and then more overvalued to 12% in 1997 and 1998. The overvaluation in 1997 was associated with the Asian financial crisis, which resulted in an appreciation of the RMB real exchange rate. Although the Asian financial crisis negatively impacted China's external economy in 1998, the RMB real exchange rate was no more overvalued in 1998 than in 1997. The reason is that RMB real exchange rate did not appreciate because of minor deflation in China in 1998. In 1999, China's consumer price index declined further and the neighboring currencies began to appreciate, so that the actual real effective exchange rate of RMB depreciated, resulting in only 6% overvaluation in 1999. There is a consensus that if a currency is overvalued by less than 10%, the overvaluation can be accommodated through domestic policies without necessarily devaluing the currency.

Because this latest round of overvaluation was not serious, and also because China's foreign trade and foreign exchange regime had been vastly improved, China still maintains a large trade surplus. It may be difficult to understand that the RMB was overvalued in 1997 when China realized a trade surplus as high as USD40.3 billion. However, at least one should notice that the processing trade surplus has grown steadily. From 1995 to 1997, processing trade surplus rose from USD 15.3 billion to USD 29.4 billion and it soared

to USD 37.3 billion in 1999. Processing trade is less vulnerable to fluctuations in the foreign exchange rate because it involves importing raw materials and benefits from exporting processed goods.

## 5. An BEER Model for Equilibrium Exchange Rate of RMB

### 5.1 Theoretical model

In this section, I will try to apply a more general model, BEER, to estimate the equilibrium exchange rate of RMB. Clark and Macdonald (1998) offers the following equation for the BEER model:

$$BEER = f(r - r^*, gdebt / gdebt^*, tot, tnt, nfa) \quad (9)$$

Considering the practice of China and data availability, I specify the model as using the following fundamentals<sup>4</sup>:

$$BEER = f( \quad + \quad + \quad - \quad + \quad ) \quad (10)$$

$$BEER = f( \quad TOT \square PROD \square \quad M2 \square NFA )$$

where TOT is the terms of trade, PROD is the productivity of China, M2 is the money supply, and NFA is net foreign assets. The signs above the right-hand-side variables denote the sign of the partial derivatives. The improvement in the terms of trade and increase in the productivity and net foreign assets will appreciate the equilibrium exchange rate; the expansion of money supply will depreciate it.

### 5.2 Data sources

The sample period is from the first quarter of 1984 to the fourth quarter of 1999. All variables, except the terms of trade, are in logarithms, and all variables are adjusted seasonally (Figure 7). GDP is a proxy for productivity (PROD). The quarterly data of GDP is obtained from both official statistics and estimation based on annual data by some economists. M2 is similarly obtained. NFA data are obtained from IFS. The quarterly data of China's terms of trade are not available. As a proxy, I use trade surplus (export minus import) data, and thus we should be careful when interpreting the coefficient on this variable.

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<sup>4</sup> For example, wholesale or producer price index with long enough time series is not available for China, tnt must be omitted from model.

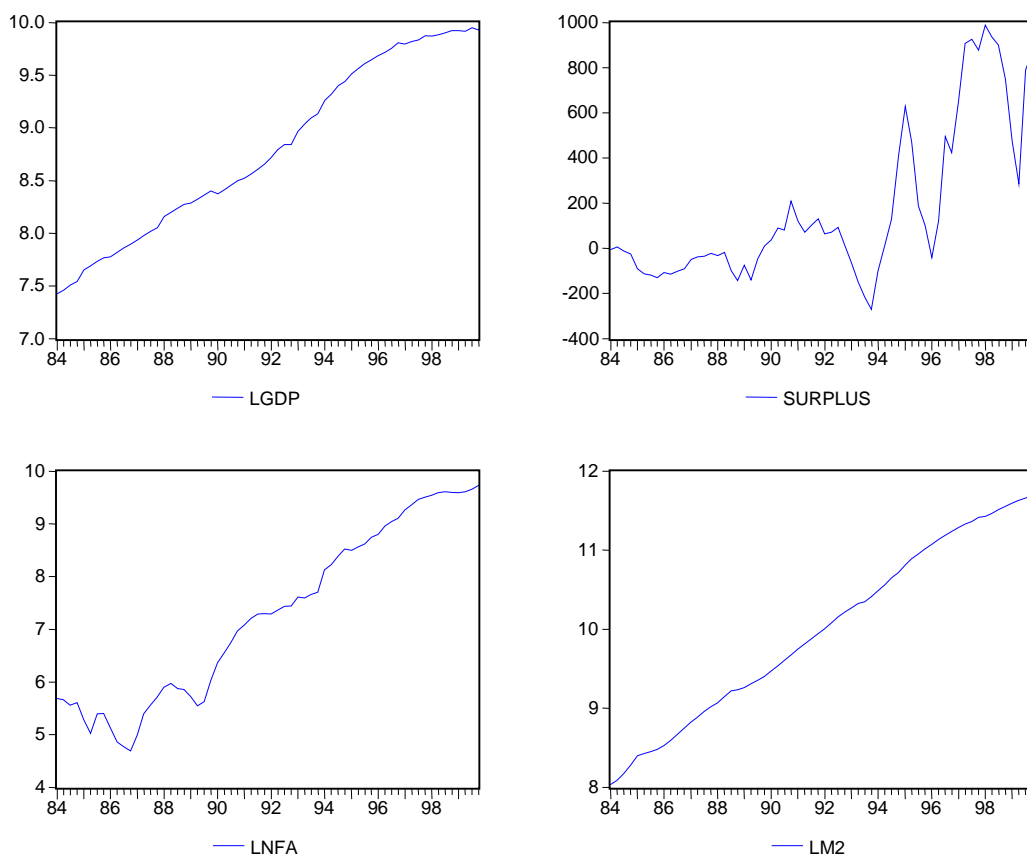


Fig. 7. Economic fundamentals for the BEER model

### 5.3 Estimation results

Since Johansen's maximum likelihood estimation fully captures the long-run relationship among the variables and provides the estimates of all possible cointegration vectors, I use this method to test and estimate the cointegration relationship. The ADF unit root tests show that all variables are I(1) (Table 5), the Johansen technique can thus be performed. The results of the cointegration tests are shown in Table 6. The hypothesis of a non-cointegrated relationship is rejected, and the following equilibrium exchange rate equation is derived:

$$LREER = 8.381 + 1.256LGDP + 0.000272SURPLUS + 0.264LNFA - 1.734LM2 + 0.009TREND \quad (11)$$

Table 5. Unit-root test for REER and economic fundamentals (BEER)

Variables	Test specification	ADF Statistic	Critical Value
LREER	(C, t, 2)	-2.03	-4.11
$\Delta$ LREER	(C, 0, 2)	-3.27	-2.91
SURPLUS	(C, 0, 2)	-1.2	-3.54
$\Delta$ SURPLUS	(C, 0, 2)	-4.09	-3.54
LGDP	(C, 0, 2)	-1.48	-3.54
$\Delta$ LGDP	(C, 0, 1)	-3.48	-2.91
LM2	(C, 0, 2)	-1.15	-3.53
$\Delta$ LM2	(C, 0, 2)	-4.07	-3.53
LNFA	(C, 0, 2)	0.12	-3.53
$\Delta$ LNFA	(C, 0, 2)	-3.74	-3.53

Note: C and t denote the constant and trend in ADF test.

The critical values are obtained at least 5% significance level.

All of the coefficients are correctly signed: the equilibrium exchange rate appreciates in the long run if productivity, trade surplus and net foreign assets increase, or money supply M2 tightens.

In order to get the “sustainable” or “permanent” values of the fundamentals approximately, we then use the H-P filter to smooth the economic fundamentals (Figure 8). The equilibrium exchange rate, REERHPF, is derived (Figure 9) and the misalignment is also calculated (Figure 10).

Table 6 Cointegration results

	Likelihood	5 Percent	1 Percent	Hypothesized
Eigenvalue	Ratio	Critical Value	Critical Value	No. of CE(s)
0.633823	110.3905	77.74	85.78	None **
0.334008	51.11690	54.64	61.24	At most 1
0.236418	27.13471	34.55	40.49	At most 2
0.141333	11.22036	18.17	23.46	At most 3
0.037096	2.230320	3.74	6.40	At most 4
Unnormalized Cointegrating Coefficients:				
LREER	LGDP <sub>SA</sub>	SURPLUSSA	LNFA <sub>SA</sub>	LM2 <sub>SA</sub>
2.642199	-3.318979	-0.000719	-0.697736	4.580751
0.852757	-0.573987	-0.000691	-0.814510	0.641353
0.516062	-2.462029	0.001053	-0.679354	3.566828
0.295453	2.500983	0.000575	-0.408368	-4.000655

-0.193998      0.049042      -0.000221      0.284911      -3.852071

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Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

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LREER	LGDP	SURPLUSSA	LNFA	LM2SA
1.000000	-1.256143	-0.000272	-0.264074	1.733689
	(0.12878)	(5.5E-05)	(0.03362)	(0.23854)
Log likelihood	146.3725			

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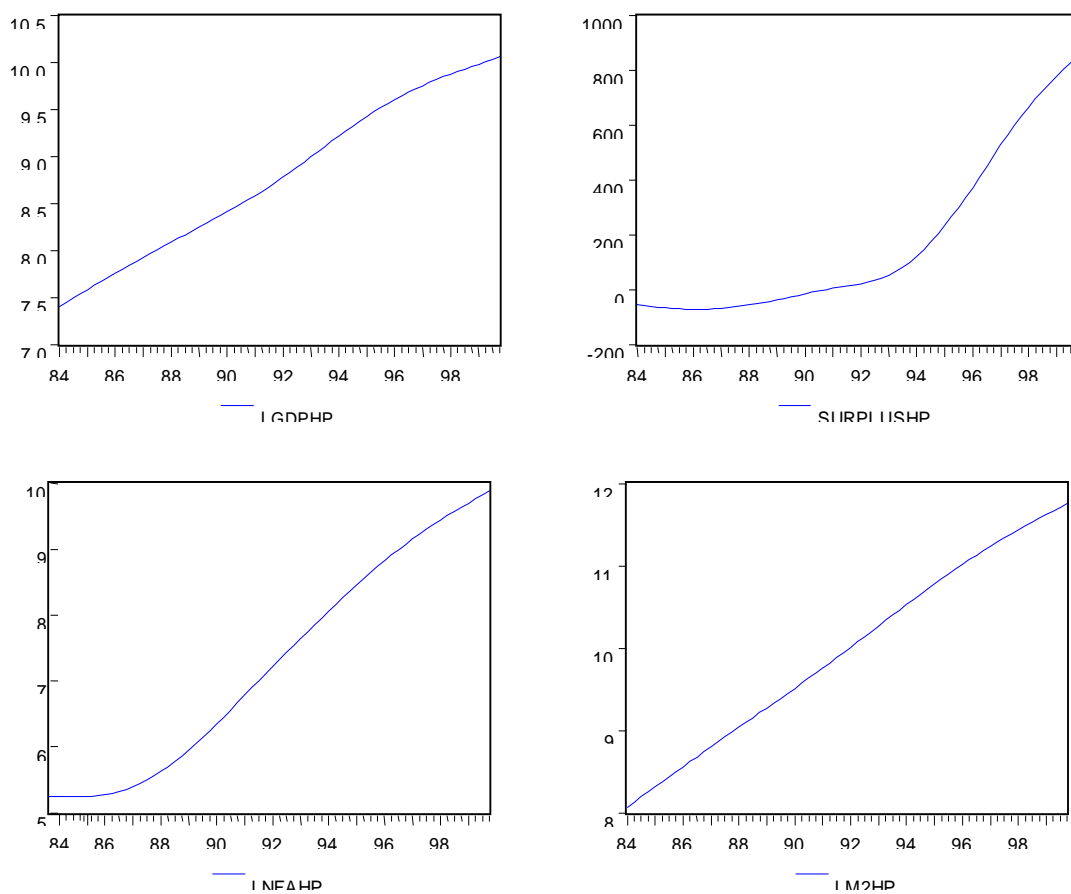


Fig.8. Economic fundamental smoothed by H-P filter (BEER model)

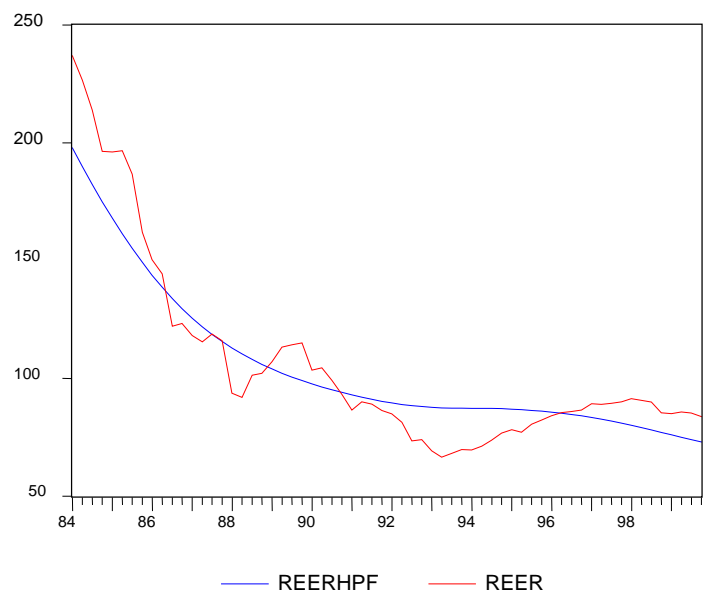


Fig. 9. Actual and equilibrium exchange rate (BEER model)

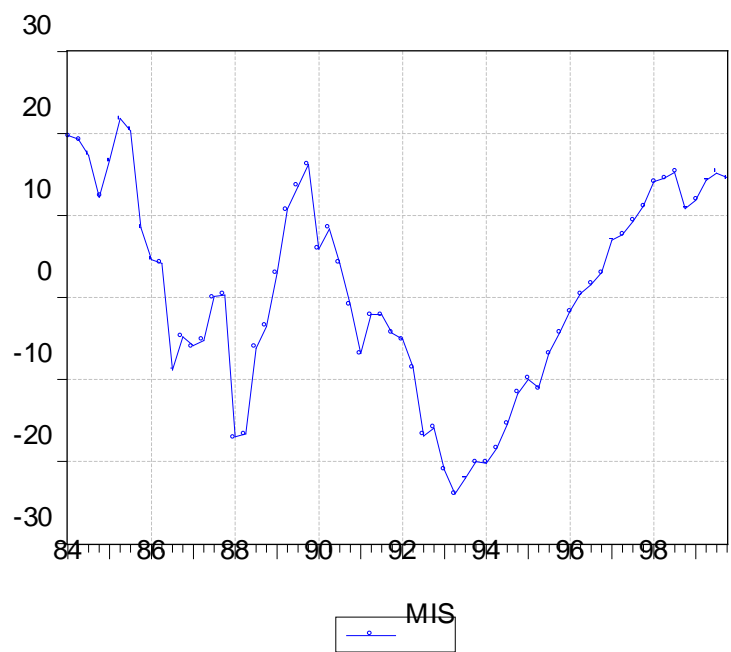


Fig. 10. Exchange rate misalignment (BEER model)

## **6. Comparison between BEER and ERER**

Although the fundamentals included in BEER and ERER model are different, the derived RMB equilibrium exchange rates and misalignment curves are quite similar. This suggests that the results are credible. Some basic conclusions can be drawn from the BEER and ERER models.

First, both the start and end, as well as the duration and degree of overvaluation or undervaluation, are similar in the two models. There are two overvaluation periods before 1997: one occurs during the 1984-1986, and the other during 1989-1990. The duration and extent of the first overvaluation is more pronounced than the second, the RMB having been overvalued by about 20%. There are two episodes of undervaluation: one during 1986-1989 and the other during 1991-1995. The extent and duration of the second undervaluation is more serious than the first, the RMB having been undervalued by about 20%.

Second, according to the ERER model, the equilibrium exchange rate has been very stable since 1995, and stays at the level of 80. However, according to the BEER model, the equilibrium exchange rate keeps depreciating, changing from 87 in 1995 to 73 in 1999. This suggests that the RMB is still overvalued by more than 10%. The larger growth rate of the money supply is the main reason contributing to the depreciation. Since there are no obvious factors contributing to the rapid devaluation of the equilibrium exchange rate, the ERER model is more a reliable model for RMB exchange rates than the BEER model. If the terms of trade data and relative prices of non-tradable to tradable goods were available for China, the results for the BEER model would probably agree with the ERER model.

## **7. Policy Implications**

### **7.1 Shortcomings of the Existing Mechanisms**

Theoretically, a single, managed floating exchange rate based on market demand and supply of foreign exchange, is almost a perfect RMB exchange rate regime. But this mechanism, such as those based on the kind of “market” and “management”, needs to be further developed. So far there are at least three shortcomings in the RMB exchange rate regime:

First, the determining force of the exchange rate is incommensurate with its important role in the external economy. Under the present management system, most domestic institutions are required to

repatriate their foreign exchange receipts to the designated foreign exchange banks. The central banks implement a proportional control over the foreign exchange working capital held by the banks. If the working capital of a bank exceeds the ceiling of its designated ratio, it must sell through the foreign exchange market. If the working capital drops below the designated ratio, the banks must promptly buy foreign exchange from the foreign exchange market. So China's foreign exchange market, which determines the exchange rates of RMB, is different from those of developed economies.

The total volume of transactions is only around 60 billion USD per year while those of current account and capital and financial account are around 500 billion US dollars. The market is dominated by a few state owned banks and the central bank in recent years. Among the buyers, the central bank covers about 60%; among the sellers, Bank of China, one of the major designated foreign exchange banks, covers more than 60%. This small number of market makers is an obvious problem. Meanwhile, under the present management framework, if selling alone is greater than buying, the exchange rate will face pressure to appreciation. However, since some types of imports, like equipment imported by foreign funded enterprises as investment, don't use foreign exchanges, the exchange rate may still face pressure to appreciation, even if trade balance deficit and other economic fundamentals are likely to worsen. This may mislead policy maker.

Second, the exchange rate lacks flexibility and the reaction to misalignment is very slow. The misalignment analysis above shows that the RMB has frequently been overvalued or undervalued since 1978, and each misalignment tends to last for a long time. However, persistent overvaluation is often a precursor to currency crises, and protracted or recurrent exchange rate misalignment has been associated with lower economic growth over both the medium and long run (Edwards, 1999).

And lastly, the multiplicity of the functions of China's exchange rate policy: maintaining the competitiveness of the export sector, stabilizing prices as a nominal anchor, and maintaining the public confidence in the economic development. The first role requires that the exchange rate be flexible, but the last two roles require that it be stable. Since the Asian financial crisis, the exchange rate becomes essential for macroeconomic stability. Changes in the exchange rate have more immediate impact than fiscal and monetary policies. In order to avoid confusion, the monetary authority should assign a clear objective to



exchange rate policy.

## 7.2 Reform measures

The above analysis suggests that reforming the exchange rate mechanism is necessary and urgent, especially considering China's accession to the WTO. However, the government is debating how to start the reform process (Table 7). None of the available choices can solve the root problem. In order to overcome the difficulties, China need to exit from the fixed exchange rate arrangement like Poland and Israel have, which have successfully increased the flexibility of their exchange rate.

Table 7. The dilemma of exchange rate policy

Choice of Policy	Disadvantage
1.Maintaining Stability	1.Making the regime appear to be a fixed exchange rate; The exchange rate policy could not play as important role as it can. It is disadvantageous to brewing market economy.
2.Devaluation	2. The exchange rate would be faced with appreciation pressure in no time. The trajectory of exchange rate from 1994 to 1997 will emerge again.
3.Appreciation	3. The competitiveness is not enough to support appreciation.

From April 12,2000, the Polish government began a system of fully flexible exchange rates and the transition from a fixed to a flexible exchange rate regime was successfully completed. The case of Poland, as well as other related cases, suggests that the following reform measures may be feasible.

First, the monetary authority should take steps to increase the flexibility of the RMB exchange rate gradually, given that China will maintain the present foreign exchange management framework for the next 3-5 years, especially the compulsory system of repatriating foreign exchange. When the external economy is in good condition, and the public has much confidence in China's economy, the monetary authority should allow the exchange rate to appreciate appropriately. This will give the market a clear signal that the RMB exchange rate will be more flexible in the future. Commercial banks and enterprises will adjust their evaluation of exchange rate risks accordingly. By expanding the forward market, the central bank can

encourage banks and enterprises to cover their risks. The central bank then should shift away from daily intervention to less frequent intervention little by little.

In the early stage, the floating band could be controlled within 5%, and the band could be expanded gradually. The influence of exchange rate policy on the balance of payments will increase, and the passive intervention pressure faced by the central bank will be reduced. Of course, the central bank should still intervene in the foreign exchange market when exchange rate deviates from economic fundamentals.

Second, the roots of the shortcomings in the exchange rate mechanism are the present foreign exchange management system, such as capital control. In the long run, capital account will be liberalized and foreign exchange control will be abolished completely, RMB exchange rate will reflect the supply and demand of foreign exchange. At that time, the central bank needs to intervene only occasionally in the market in order to smooth the fluctuations in the exchange rate.

## **8. Basic Conclusions and Extensions**

The paper analyzes the equilibrium exchange rate of the RMB. Since the opening and reform of China, the real exchange rate of the RMB has been fluctuating around the equilibrium exchange rate and has experienced overvaluation and undervaluation at times. The misalignment of the RMB exchange rate disrupted the development of foreign trade, the foreign reserves of China, and price stability. The RMB exchange rate has moved closer to the equilibrium level since 1999. Currently, the RMB is not seriously overvalued. However, it is necessary to increase the flexibility of the RMB exchange rate in the medium to long run to facilitate capital mobility.

As pointed out by Edwards (1999), the study of equilibrium exchange rate may still have some limitations. For example, the relationship between the equilibrium exchange rate and the current account (capital account) as well as the relationship between the equilibrium exchange rate and internal equilibrium is not explicitly reflected in the model. We believe that these areas require future study.

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