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Abstract

In this paper we examine the determinants of China's equilibrium real effective exchange rate and investigate the misalignments in the Renminbi. This paper makes a number of theoretical and empirical contributions. At the theoretical level, we extend the NATREX model to incorporate a large number of economic fundamentals that capture the unique features of the Chinese economy. At the empirical level, this is the first application of the extended NATREX model to China. Another contribution is that we estimate the extended NATREX model for both the pre- and post- reform periods. We have constructed a unique data set of consistent time series for the effective exchange rate and a large number of economic fundamentals for China since the 1950s. A further contribution is the use of total and net factor productivity obtained from an estimated production function. We find strong evidence of persistent undervaluation of the RMB during 1994-2005, accelerating in particularly after 2000. However the misalignment rates are much lower than those reported by previous studies. We also find weak evidence of overvaluation for most of the pre-reform period. For the rest of the sample period, there was no persistent misalignment.

Key Words: Equilibrium real effective exchange rate; Misalignments; Chinese Renminbi; Extended NATREX model; Pre- and post-reform periods

JEL Classification: F31, F32, F41, C51 C52, O53

1. Introduction

China's growing importance in the world economy, its mounting trade surplus and its huge foreign exchange reserves, have caused considerable debate among politicians and academics about the value of its currency, Renminbi (RMB)[1]. We contribute to this debate by examining the determinants of China's equilibrium real effective exchange rate and investigating the misalignments in the RMB. Our research is motivated partly by the important implications for China's exchange rate policy and international competitiveness, and partly by the need to address several limitations of the existing literature.

The equilibrium effective exchange rate for China has been investigated by a number of studies, with the majority showing substantial undervaluation since the middle of the 1990s[2]. However, most of them use either some version of the PPP-Purchasing Power Parity-framework (i.e. Wang, 2004, 2005; Shi, 2006; Dunway *et al*, 2006) or the BEER-Behavioural Equilibrium Exchange Rate- model (i.e. Zhang, 2002; Bénassy-Quéré *et al*, 2004; Funke and Rahn, 2005; Wang *et al*, 2007; Chen, 2007)[3]. In this paper we develop and apply an Extended NATREX model that has not been previously applied to China. In contrast to PPP and BEER, the NATREX model considers the whole economy and provides more information about the determination of the equilibrium exchange rate. The Chinese economy has a growth path that distinguishes it from other economies. However, the fundamentals that have been employed so far are largely restricted by or identical to the ones in the original models

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[1] Renminbi (RMB) is the name of the Chinese currency. Yuan is the unit of the currency. In the foreign exchange market, the exchange rate is measured as CNY against other currencies (e.g. US dollar). But when Chinese authorities refer to appreciation, depreciation, overvaluation, undervaluation and equilibrium value of the currency, they are referring to the RMB.

[2] For an extensive review of the empirical literature on China's equilibrium exchange rate, using alternative models, see You (2008).

[3] An exception to this are Jeong and Mazier 2003), Wang (2004) and Coudert and Couharde (2007) who apply the FEER (fundamental equilibrium exchange rate) model.

which were designed for industrial countries. If the fundamentals that make the distinction between China and other countries are not included, the conclusions drawn on the misalignments are likely to be less convincing. Therefore, this paper incorporates the economic fundamentals that reflect the uniqueness of the Chinese economy as determinants of the equilibrium exchange rate.

Another limitation of the existing literature is that all studies of China's effective exchange rate are restricted to the post-reform period (i.e. last twenty years) or the period after 2000, as data for the effective exchange rate of the RMB is not available for the pre-reform period. By restricting their time spans, previous studies miss the opportunity to provide a comparative analysis of the misalignments not only between the centrally-planned pre-reform period and the market-oriented post-reform period (after 1978), but also amongst different periods of nominal exchange rate adjustments[4]. Therefore, to be able to carry out such a comparative analysis and provide policy implications accordingly, this paper covers both pre- and post-reform periods. We construct the real effective exchange rate against China's fourteen main trade partners that goes back to 1960, based on yearly revolving competitive weights. Trade with these partners accounts for over 80% of China's foreign trade. We further construct effective fundamentals for the same period.

An important contribution of our paper is the construction of a unique data base of consistent time series for a wide range of economic fundamentals for China since 1952 that are crucial in determining the NATREX but have not been analysed by previous studies.

Another contribution is that we estimate the production function for China and derive total factor productivity for both pre- and post-reform periods. This contrasts with

[4] For a summary of China's exchange rate regimes since the 1950s, see Table 1.

previous studies that approximate productivity by the GDP growth rate. This is the first time that total factor productivity is estimated when rural transformation is taken into account, and enables us to distinguish between total and net factor productivity that is due to pure technical progress.

The paper is organised as follows. Section 2 outlines and analyses the extended NATREX model used for the study of the equilibrium real effective exchange rate. Section 3 describes the construction of the effective exchange rate and of the other effective variables. Section 4 discusses the estimates of the NATREX model and analyses the determinants of the equilibrium real effective exchange rate. Section 5 analyses the misalignments of the RMB. Section 6 summarises the main findings and considers their policy implications.

2. The Extended NATREX Model[5]

The NATREX model, introduced by Stein (1995), is the "natural real exchange rate" that would prevail if speculative and cyclical factors could be removed whilst unemployment is at its natural rate. The medium run equilibrium conditions that determine the NATREX are the basic balance of payments and the portfolio balance between the holdings of assets denominated in the home and in the foreign currency. In the long run, the fundamentals are defined as disturbances to productivity and social time preferences. They affect the evolution of capital and foreign debt via the investment function and the current account. When capital and foreign debt converge to their steady state, the NATREX becomes a function of economic fundamentals.

Stein's model was developed for studying the equilibrium US dollar and was therefore designed to capture the features of advanced industrial countries[6]. This

[5] For a detailed description of the model, and an analysis of the dynamics and equilibrium properties of the model, see You and Sarantis (2008a).

paper is the first attempt to extend Stein’s (1995) NATREX model to China. We incorporate fundamentals, which have rarely been studied by the existing literature, into the framework of the NATREX model to capture the unique characteristics of the Chinese economy. More precisely, we extend Stein’s (1995) original NATREX model in a number of crucial ways that allow us to shed light on the determinants of the Chinese equilibrium real exchange rate[7]:

First, the two state variables in Stein’s model are capital per effective labour and foreign debt per effective labour. As China is a net creditor, the two state variables for China are capital per effective labour and net foreign assets per effective labour.

Second, instead of using approximations for productivity, we consider a production function to derive total factor productivity. Furthermore, rural transformation is incorporated into the production function to reflect the effect of China’s rural-urban migration and rural industrialization on factor productivity. This enables us to distinguish between total and net factor productivity.

Third, time preference is regarded as exogenous in Stein’s model. Following Modigliani and Cao (2004), we treat time preference as an endogenous variable that is determined by fundamentals such as demographic factors and liquidity constraints.

Fourth, aggregate investment is decomposed into domestic private investment, government investment and foreign direct investment (FDI). This enables us to analyse, for the first time, the effects on the real exchange rate of such fundamentals as relative unit labour cost, relative rate of return to capital, taxation and country risk, all of which play an important role in the emerging market economies.

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[6] Other country applications of the original NATREX model include Lim and Stein (1995) for Australia; Stein and Paladino (1999) for Germany, France and Italy; Connolly and Devereux (1995) for Latin America; Rajan and Siregar (2002) for Singapore and Hong Kong.

[7] This extended NATREX model is relevant to all emerging markets which have some of the characteristics of China’s economy.

Fifth, following Lim and Stein (1995), we regard the terms of trade for China as an exogenous fundamental, which is a more realistic assumption for emerging market economies. Based on the exogenous terms of trade, the goods market clearing condition is equivalent to non-tradable goods market equilibrium.

Sixth, as the uncovered interest parity (UIP) does not seem to hold for China, the country risk premium is introduced in the portfolio balance equation to explain the divergence from UIP.

2.1. The Structure of the Model

Savings

Savings are equal to domestic output[8], *y*, which is a function of capital (*k*), net factor productivity (*NFP*) and rural transformation (*RT*), plus income from abroad (*r'F*), less consumption, *C.* Consumption is a function of wealth (capital, *k,* plus foreign assets, *F*) and social time preference. The latter is modelled as an endogenous variable dependent on demographic factors (measured by the dependency ratio *DEP*)[9] and financial liberalisation, measured by the ratio of domestic credit to gross domestic product (*CREP*)[10]:

$$s = y(k; NFP, RT) + r'F - C(k, F; CREP, DEP) = S(\underset{+}{k}, \underset{-}{F}; \underset{+}{NFP}, \underset{+}{RT}, \underset{+}{r'}, \underset{-}{CREP}, \underset{-}{DEP}) \tag{1}$$

[8] Note that, as in Stein's (1995) original model, output, capital, foreign assets and other quantity variables are measured per effective labour.

[9] Empirical support for the importance of demographic factors to consumer behaviour in China is provided by Modigliani and Cao (2004). In their study of Chinese savings, the authors find that the One-Child policy has led to a gradual reduction in the ratio of minors (under 15) to employment and thereby has reduced the consumption-to-income ratio.

[10] Under an imperfect financial market, the effectiveness of financial liberalisation in relaxing the liquidity constraints is an important determinant of consumption in China. See, for example, Yang and Li (1997), Zhang (1997), and Zhang and Wan (2002).

Terms of Trade and the Real Exchange Rate

Following Lim and Stein (1995), we assume that the economy produces an exportable good 1 and a non-tradable good n. The foreign country does likewise where the export good is good 2. R_n denotes the relative price of non-traded good n (p_n) to the exported good (p_1). The terms of trade (T) is the relative price of exported good 1 (p_1) to imported good 2 (p_2') measured in a common currency:

$$T = N \frac{p_1}{p_2'}, \tag{2}$$

where N is the nominal exchange rate defined as foreign currency per Chinese Yuan, CNY.

The real exchange rate of China, R, is a function of terms of trade T and the relative price of non-tradables R_n :

$$R = T(R_n)^a \tag{3}$$

where a denotes the weight given to the non-tradable sector in the GDP deflator.

Given that the influence of China on the world trade is still limited despite the relative increase of its importance (see Kamin *et al,* 2006), the terms of trade are regarded as exogenous in this study.

Investment

Aggregate investment (*I*) is equal to domestic private investment, which is a function of output (*y*) and the user cost of capital (*c*)[11], plus government investment (*GI*) which is treated as exogenous in China (see Zhu and Liang (1999) and Shen (1999, 2000) for a similar treatment), plus foreign direct investment (*FDI*), which is a function of

[11] See Song *et al* (2001) and He and Qin (2004) for as similar modelling of business sector investment in China. As the authors argue, given the small scale of financial markets in China, financial market imperfections and the restrictions imposed by the government on transactions in financial markets , Tobin's q ratio is not applicable to China.

relative unit labour cost (*RULC*), relative return to capital (*RRC*) and country risk (proxied by net foreign assets, *F*)[12].

Capital is used to produce non-tradable good *n* and exportable good 1, while capital good consists of both non-tradable good *n* and imported good 2. Relative price of non-tradables to imported goods, TR_n , affects shares of I_n and I_2 within the aggregate investment I . For instance, a higher relative price of non-tradables discourages investment using non-tradables, I_n , and encourages investment using imported goods, I_2. You and Sarantis (2008a) show that the investment using non-tradables and imported goods can be expressed as:

$$
\begin{aligned}
I = I_2 + I_n &= I_2\big(y(k, NFP, RT), c(R_n, T, r, \tau), GI, FDI(RULC, RRC, F), R_n, T\big)\\
&\qquad\quad \text{+ + + +/− + − − + − + + + +}\\
&\quad + I_n\big(y(k, NFP, RT), c(R_n, T, r, \tau), GI, R_n, T\big)\\
&\qquad\quad \text{+ + + +/− + − − + − −}\\
&\quad = I(R_n, k, F; NFP, RT, r, \tau, GI, RULC, RRC, T)^{13}\\
&\qquad\quad \text{+/- + + + + − − + − + +}
\end{aligned}
$$

Goods Market Equilibrium

Based on the exogenous terms of trade, the equilibrium condition for the good market is the market clearing condition for the non-traded good (see Lim and Stein, 1995):

$$(I - S) + CA = 0$$

$$C_n\left(R_n, k, F; DEP, CREP, T\right) + I_n\left(R_n, k; NFP, RT, r, \tau, GI, T\right) - y_n\left(R_n, k; NFP, RT\right) = 0 \tag{5}$$

[12] Foreign direct investment is an important component of aggregate investment in China (see You, 2008), and a number of studies have investigated its determinants. Among them, wages and country risk have been found to be the most significant determinants of FDI. See Ho (2004) for a review of the literature on FDI in China.

[13] On one hand, higher terms of trade implies a higher relative price of non-tradables to imported goods, which discourages I_n and encourages I_2 , so its total effect on aggregate investment I becomes ambiguous. One the other hand, higher terms of trade implies a lower user cost of capital, which stimulates both segments of investment (I_n and I_2) and hence aggregate investment I . Compared to its positive effect on aggregate investment, the effect of terms of trade on allocating demand of investment using non-tradables and imports is negligible, so we are assuming that the sign of the terms of trade is positive. Note that r is the domestic interest rate and τ is the tax rate.

The market clearing equation (5) implies that the demand for the non-traded good, which consists of consumption C_n and investment using non-tradables I_n, equals the supply of the non-traded good y_n.

Current Account

The current account is the trade balance plus the interest rate income on foreign assets, $r'F$. The trade balance is the value of exported good 1 (y_1) less the value of imported good 2, which consists of consumption and investment that uses imported goods (C_2 and I_2).

$$\begin{aligned} CA = y_1(R_n, k; NFP, RT) - I_2\left(R_n, k, F; NFP, RT, r, \tau, GI, RULC, RRC, T\right) \\ - C_2(R_n, k, F; DEP, CREP, T) + r'F \end{aligned} \tag{6}$$

Portfolio Balance

Ma *et al* (2004) and Liu and Otani (2005) found that China's capital controls are still effective and that deviations from the uncovered interest rate parity exhibit strong non-stationarity and persistency. Therefore, for a typical developing country like China, UIP is unlikely to hold due to the existence of the country risk premium. Therefore, the portfolio balance is expressed as:

$$r = r' + h(F) = (\underset{+}{r'}, \underset{-}{F}) \tag{7}$$

where foreign assets F is used to approximate the country risk premium of China[14].

Accumulation of Capital

Capital accumulation is given by

$$dk / dt = I - nk \tag{8}$$

[14] For a similar approach, see Lim and Stein (1995), Lane and Milesi-Ferretti (2001), Selaive and Tuesta (2003) and Benczúr *et al* (2006).

where n is the population growth rate.

Accumulation of Foreign Assets

Rate of change of foreign assets is savings less investment and minus nF:

$$\frac{dF}{dt} = S - I - nF = CA - nF \tag{9}$$

where n is the growth rate of effective labour.

2.2. Medium-Run Equilibrium

The medium-run is defined as the period in which the capital intensity and foreign assets are taken as predetermined variables. The terms of trade are exogenous for China, which implies that the equilibrium condition for the goods market is equivalent to the market clearing for non-tradables, given by equation (5). The first two items on the left-hand side are consumption and investment of non-traded goods, the sum of which is the demand for non-traded goods (D_n). The third term gives the supply of non-traded goods (S_n).

The relative price of non-tradables, R_n, equilibrates the market of non-traded goods. Solving explicitly for R_n in equation (5) yields:

$$R_n(t) = R_n\big(k(t), F(t); Z(t)\big), \tag{10}$$

$$Z = \big[DEP, CREP, NFP, RT, r', \tau, GI, T\big] \tag{10a}$$

where Z denotes the fundamentals that determine the relative price of non-tradables.

Based on equations (3) and (10), the medium-run equilibrium real exchange rate is given by:

$$R(t) = T\big[R_n\big(k(t), F(t); Z(t)\big)\big]^a = R\big(k(t), F(t); Z\big) \tag{11}$$

In the medium-run, k and F are exogenous. Therefore, any disturbance to the exogenous variables will shift the demand and/or supply curve of non-tradables and generate a new R_n to maintain the goods market equilibrium. The effects of changes in exogenous variables on R_n in the medium-run are listed in Appendix A.

2.3. Dynamic Adjustment

The long-run dynamics involve endogenous movements of the capital and foreign assets. Combining the change of capital equation (8), investment equation (4) and portfolio balance (7) yields the equation for the evolution of capital:

$$dk/dt = J(k, F; Z),\ J_k < 0,\ J_F > 0 \quad (12)$$

[15]

Based on portfolio balance equation (7) and savings equation (1), we obtain:

$$s = S(k, F; Z),\ S_k > 0,\ S_F < 0 \quad (13)$$

From equations (12), (13) and (9) we obtain the equation for the evolution of foreign assets:

$$dF/dt = S - J = L(k, F; Z),\ L_k > 0,\ L_F < 0 \quad (14)$$

Equations (12) and (14) describe the dynamic system for the evolution of capital and foreign assets. You and Sarantis (2008a) show that the stability condition ($G = J_k L_F - L_k J_F > 0$) holds as long as (a) the impact of capital stock on investment is greater than the impact of net foreign assets on investment ($-J_k > J_F$) along $J = 0$ and (b) the impact of net foreign assets on current account is greater than the impact of capital on current account ($-L_F > L_k$) along $L = 0$. The trajectories of

[15] Following Stein (1995) and Lim and Stein (1995), we assume the population growth n is zero for mathematical convenience.

capital and foreign assets to their steady state are illustrated in the phase diagram shown in Figure 1.

2.4. The Steady-State

The long-run steady state is reached when capital and foreign assets converge to sustainable constants k^* and F^*:

$$J(k^*, F^*; Z) = 0 \tag{15}$$

$$L(k^*, F^*; Z) = S(k^*, F^*; Z) - J(k^*, F^*; Z) = 0 \tag{16}$$

Solving equations (15) and (16) we can obtain the steady states:

$$k^* = k(Z) \tag{17}$$

$$F^* = F(Z) \tag{18}$$

Changes in k^* and F^* will affect the equilibrium condition in the goods market which is equivalent to the non-tradables equilibrium. Hence the relative price of non-tradables will adjust to its steady state R_n^* to equilibrate the non-tradables market while capital and foreign assets are at their steady states. Therefore, the non-tradables market equilibrium under steady state can be described as:

$$C_n\left(R_n^*, k^*, F^*; DEP, CREP, T\right) + I_n\left(R_n^*, k^*, F^*; NFP, RT, r', \tau, GI, T\right) = y_n\left(R_n^*, k^*; NFP, RT\right) \tag{19}$$

Solving equation (19) we can get the expression for the steady state relative price of non-tradables (equation (20)) and derive $\frac{dR_n{}^*}{dZ}$ (equation (21)):

$$R_n^* = R_n\left(k(Z), F(Z); Z\right) = R_n^*(Z) \tag{20}$$

$$\frac{dR_n^*}{dZ} = \left(\frac{\partial R_n}{\partial k}\right)\frac{dk^*}{dZ} + \left(\frac{\partial R_n}{\partial F}\right)\frac{dF^*}{dZ} + \frac{\partial R_n}{\partial Z} \tag{21}$$

$$R^* = T(R_n^*)^a = R^*(Z) \tag{22}$$

The first two items on the right hand side of equation (21) capture the indirect effect of disturbances in fundamentals on R_n through changes in k^* and F^* in the long-run. The last item captures the direct effect of disturbances in fundamentals on R_n in the medium-run. All signs are shown in Appendix A[16].

According to equation (22), the fundamentals which affect the relative price of-non-tradables, R_n^*, affect the long-run real exchange rate, R^*, in a similar way. The only exception is the terms of trade. As equation (3) indicates, changes in the terms of trade affect the real exchange rate directly and indirectly via changes in R_n. The direct effect is always positive, while the indirect effect is ambiguous. The terms of trade reduce the relative price of non-tradables in the medium term but increase it in the long term. However, this indirect effect is rather small compared with the direct effect, so we expect higher terms of trade to cause appreciation of the real exchange rate both in medium-run and long-run equilibrium.

Therefore, the long-run equilibrium equation for the real exchange rate is given by:

$$R^* = R^*(\underset{+}{T}, \underset{+}{NFP}, \underset{+}{RT}, \underset{-}{DEP}, \underset{-}{CREP}, \underset{-}{RULC}, \underset{+}{RRC}, \underset{-}{GI}, \underset{+/-}{r'}, \underset{-}{\tau}) \tag{23}$$

3. Measurement of the Effective Variables

3.1. The Real Effective Exchange Rate (REER)

REER for China is estimated based on the methodology of Zanello and Desruelle (ZD) (1997) that is used by IMF but different from it in four perspectives. We introduce the methodology of ZD (1997) and then discuss our methods.

ZD (1997) compute unit labour cost (ULC)-based REER indicators for a group of 21 industrialised countries and two sets of consumer price index (CPI)-based nominal

[16] For a detailed mathematical derivation of the medium-run and long-run effects of the fundamentals on the real exchange rate, see You and Sarantis (2008a), Appendices A-C.

and real effective exchange rates indicators for a majority of IMF members and for a limited set of recent IMF members. China belongs to the group that uses the first set of CPI-based REER and therefore we will introduce this method in detail.

Generally speaking, the methodology of ZD (1997) computes effective exchange rates as a geometric mean that is based on trade weights and takes the third market effect into account. The REER is computed as

$$REER = \prod_{j \neq i} \left[\frac{P_i R_i}{P_j R_j} \right]^{W_{ij}} \tag{24}$$

where j is an index that runs over country i 's trade partners, W_{ij} is the competitiveness weight put by country i on country j and is normalised with the sum equal to unity, P_i and P_j are CPI of countries i and j , R_i and R_j are the nominal exchange rates of countries i and j 's currencies in USD[17].

The weights scheme for China is based on trade in manufactures and primary commodities. For the manufactures, the competitiveness weights for each pair of countries (i and j) are calculated as:

$$W(m)_{ij} = \beta_i^M MW_{ij} + \beta_i^X XW_{ij} \tag{25}$$

where

$W(m)_{ij}$: competitiveness weights based on trade in manufactures.

$\beta_i^M = \dfrac{\sum_{l \neq i} X_l^i}{\sum_{l \neq i} X_l^i + \sum_{n \neq i} X_i^n}$: share of manufacture imports in country i 's total trade of manufactures.

[17] This implies that an increase (decrease) in REER represents an appreciation (depreciation) of the Chinese Renminbi.

$\beta_i^X = \dfrac{\sum_{n \neq i} X_i^n}{\sum_{l \neq i} X_l^i + \sum_{n \neq i} X_i^n}$: share of manufacture exports in country i's total trade of manufactures.

$MW_{ij} = s_j^i = \dfrac{X_j^i}{\sum_{l \neq i} X_l^i}$: share of country i's manufactures imports form country j.

XW_{ij}: overall export weight that is the combination of BXW_{ij} and TXW_{ij} with equal importance.

$$XW_{ij} = \frac{1}{2} BXW_{ij} + \frac{1}{2} TXW_{ij}$$

$$= \frac{1}{2} w_i^j + \frac{1}{2} \frac{\sum_{k \neq i,j} w_i^k s_j^k}{\sum_{k \neq i} w_i^k (1 - s_i^k)}$$

$BXW_{ij} = w_i^j = \dfrac{X_i^j}{\sum_{n \neq i} X_i^n}$: bilateral export weight that is the share of country i's manufactures exports to country j.

TXW_{ij}: third-market weight that is equal to a weighted average over all third-country markets of country j's import share divided by a weighted average combined import shares of all of country i's competitors, with the weights being the share of country i's exports to the various markets.

$s_j^k = \dfrac{X_j^k}{\sum_{l \neq k} X_l^k}$: share of country j's manufactures exports to market k.

$w_i^k = \dfrac{X_i^k}{\sum_{n \neq i} X_i^n}$: share of country i's manufactures exports to market k.

X_l^k: country l's manufactures exports to market k; X_l^i: country l's manufactures exports to country i; X_i^n: country i's manufactures exports to country n; X_j^k: country j's manufactures exports to market k.

The construction of REER in our study is different from the IMF CPI-based REER in four perspectives. Firstly, to avoid complexity in calculation and presumption about primary commodity, weights are calculated using aggregate trade rather than trade in manufactures and primary commodity separately as suggested by ZD (1997). In other words, we adopt equation (25) for our calculation of competitiveness weights but instead of using data of manufactures exports and imports we use data for total exports and imports. Second, we calculated REER for China that goes back to 1960 compared with IMF data that starts from 1980. Thirdly, IMF chooses competitiveness weights of certain years and uses them as approximations for all other years[18]. We calculated weights for each individual year for the period 1960-2005 to allow for time variation in weights[19]. Since our data span is comparatively long, we collected China's trade data for the period 1960-2005 and chose countries that have trade with China that exceeds 1% of China's total trade. China's main trade partners are listed in Table 2. For the period 1960-2005, trade with the 14 main trade partners accounts for 81% of China's total trade (Table 2). Therefore, i refers to China and j refers to China's 14 main trade partners.

Trade data of China and these 14 countries is collected from Direction of Trade Statistics (DOTS) for the period 1960-2005. There are always discrepancies between bilateral trade data of two countries. Therefore, we use the average of trade data from

[18] Currently the IMF uses trade data for 1989-1991 to construct the REER for China. However, China is a dynamically evolving economy and its trade with other countries has changed quite significantly over the last 45 years. Hence fixed weights could fail to reflect the changes in the relative importance of various countries in China's foreign trade and result in an inaccurate assessment of the effective exchange rate.

[19] Note that some studies use not only fixed weights, but also a restricted number of trade partners. For example Funke and Rahn (2005) use the trade data between China and US, Japan and the Euroland in 1996 to calculate the trade weights. These weights are then used to construct REER for China for the period 1985Q1 to 2002Q4.

two countries[20]. This is also suggested by ZD (1997). Unfortunately, China's trade for the period 1960-1977 is not available from DOTS and therefore we use other countries' records of their trade with China as China's trade data fort this period.

Thus we obtain CPI-based REER for the RMB using yearly revolving weights from 1960 to 2005 and we compare our data with IMF CPI-based REER for the period 1980-2005 (Figure 2). The graph shows our CPI-based REER is highly correlated with the IMF' index and both have same turning points. In particular, for the period 1994-2005 these two data sets are almost identical. This shows our method is valid.

To remain consistent with the definition of the real exchange rate required by the NATREX model, we need to construct the GDP deflator-based REER. Recall the equation for REER (24), now P_i and P_j are GDP price deflators of countries i and j instead of CPI. GDP-deflator based REER is what we use in the econometric estimations.

3.2. Effective Terms of Trade (ETOT)[21]

The effective terms of trade (ETOT) are calculated as the geometric mean of the terms of trade of China to its main trade partners, with the weights equal to W_{ij}

$$ETOT = \prod_{j \neq i} \left[\frac{TOT_i}{TOT_j} \right]^{W_{ij}} \tag{26}$$

[20] For example, China's export to the US will be the average of China's (report country) export to US and US (report country) import from China.

[21] Since we model the effective exchange rate, we need to use effective fundamentals as well (i.e. relative variables between China and its trade partners). We do this for the terms of trade, unit labour cost and the foreign interest rate. Unfortunately we have been unable to obtain consistent time series on the other fundamentals for most of China's trade partners, so for these fundamentals we will only use the Chinese variables.

where i denotes China, j represents China's 14 main trade partners, TOT denotes terms of trade and W_{ij} denotes the competitiveness weights. Terms of trade (TOT) are calculated as export prices divided by import prices.

3.3. Effective Unit Labour Cost (ERULC)

ERULC for the period 1960-2005 is constructed as the geometric mean of unit labour cost of China to its main trade partners with the weights equal W_{ij}

$$ERULC = \prod_{i \neq j} \left[\frac{ULC_i \times R_i}{ULC_j \times R_j} \right]^{W_{ij}} \tag{27}$$

where ULC denotes unit labour cost, i denotes China, j represent China's 14 main trade partners; R_i , R_j and W_{ij} denote nominal exchange rate of the USDagainst CNY, nominal exchange rate of the USD against currency of country j and normalised competitiveness trade share, respectively.

3.4. Foreign Interest Rate (FR)

The foreign interest rate is constructed as the arithmetic mean of China's main trade partners' long-term interest rate with the weights equal the competitiveness trade weights

$$FR = \sum_{j=1}^{n} W_{ij} r'_j \tag{28}$$

where i denotes China, j represents China's 14 main trade partners; r'_j, W_{ij} and n denote real long term interest rate of country j, normalised competitiveness trade shares and number of countries respectively.

4. Empirical Results

Equation (23) is a long-run equilibrium relationship and is estimated with the Johansen (1988, 1991) cointegration method. The sample period is 1960-2005. The construction of variables and data sources are described in Appendices B and C.

4.1 Unit Root Tests

The first step in the application of cointegration methods is to test the order of integration of the individual variables. To test for unit roots, we used the augmented Dickey-Fuller test (ADF) and the results are shown in Table 3. The number of lags in the ADF test is chosen using the general to specific procedure suggested by Campbell and Perron (1991). We set a maximum lag length of 3 and then we tested down using a 10% level of significance. As discussed by Campbell and Perron (1991) and Ng and Perron (1995), this method has better size and power properties compared with alternative methods, such as selecting the lag length based on the Akaike Info Criterion (AIC).

The ADF test cannot reject the null of unit root for all variables at 5% except CHRC1, CHRC2 and RRC2. Therefore we regard all variables as nonstationary except CHRC1, CHRC2 and RRC2. ADF tests for the first difference of the nonstationary variables show all of them are $I(1)$ processes so they can enter into a cointegration relationship. We also report ADF test with lags chosen by the AIC criterion for comparison. These statistics confirm the results obtained by the Campbell and Perron method.

4.2. Johansen Cointegration Tests

Regarding the lag length of VAR, we started with maximum lag of 3 and tested downward using the AIC criterion. In terms of choosing the number of cointegration vectors (CVs), we refer to both max-eigenvalue and trace statistics. When the results based on these two statistics differ, we chose the ones based on the max-eigenvalue statistic as Banerjee *et al* (1986, 1993) suggest that the max-eigenvalue statistic is more reliable in small samples.

Given the large number of fundamentals and the relatively small size of the sample, we cannot introduce all fundamentals in a single VAR. The strategy we adopted was to experiment with different combinations of fundamentals while keeping the core variables (productivity, terms of trade and social time preference) in all equations and dropping others that are insignificant. For each combination of fundamentals, we used all four measures of productivity (i.e., TFP1, TFP2, NFP1, NFP2) and social preference (DEP and CREP). For all experiments, VAR(1,1) was chosen.

The results of Johansen cointegration tests are shown in Table 4[22]. The max-eigenvalue statistic suggests one CV at 1% significance level for each equation while the trace statistic suggests more than one for equations A and C. We adopt the results based on max-eigenvalue statistic for the reasons explained above. For equations A and C, the adjustment coefficients are negative and statistically significant at 10% and 5% respectively. The adjustment coefficient is insignificant for equation B. For equation C, the core variable, terms of trade, is insignificant. Looking at equation A, all core variables are significant. For other non-core variables, only rural transformation (RT) is insignificant. Most of the variables have expected signs. In conclusion we choose equation A as the most satisfactory one and this is the equation we are going to use to calculate the NATREX.

[22] Results with TFP1 and NFP1 were unsatisfactory and failed to produce significant cointegrating vectors. Therefore they are not reported here.

4.3. Interpretation of the Long-run Equilibrium Relationship

The long-run equilibrium equation for the real effective exchange rate is:

$$\underset{}{REER}=\underset{(0.3885)}{0.8216ETOT}+\underset{(0.4301)}{2.4747NFP2}+\underset{(0.6318)}{0.9754RT}+\underset{(0.2130)}{1.1165ERULC}-\underset{(0.4075)}{2.6153CREP}$$

$$+\underset{(0.3162)}{1.4002TAX1}-4.3414 \qquad (29)$$

All fundamentals in equation (29) are statistically significant except RT. The results can be divided into two categories. The first category includes the fundamentals that have the signs as predicted by the extended NATREX model. Higher effective terms of trade (ETOT) and productivity (NFP2) significantly raise the long-run value of REER, while higher degree of financial liberalisation (CREP) significantly reduces the long-run value of REER. A higher rural transformation (RT) does appreciate the REER but the effect has not been significant.

The second category includes variables that have opposite signs to those predicted by the model, which are the effective unit labour cost (ERULC) and the tax rate (TAX1). The data show that REER and ERULC are highly correlated and that the decline of REER is closely matched by a similar decline in ERULC. A possible explanation for the positive relationship between REER and ERULC can be found in Grafe and Wyplosz (1999). Using a theoretical model, the authors show that in transition economies with large inefficient state sectors and new efficient private sectors (which also describes China), the real exchange rate and the real wage are positively correlated. Due to the existence of China's enormous labour surplus, the real wage has been increasing at a rate slower than the growth rate of productivity. As a result, the relative unit labour cost of China (in comparison to all its main trade partners) has been declining, and this is reflected in a similar decline in the real exchange rate for most of the sample period.

A higher tax rate discourages investment and hence reduces the long-run equilibrium effective exchange rate. On the other hand, a higher tax rate results in higher government revenue, which implies the government could spend more on infrastructure and innovations. As the non-tradables sector is labour intensive and the tradables sector is capital intensive, higher spending on infrastructure and innovations encourages production of tradables. This will stimulate the production of output and generate current account surplus in the long-run and hence higher foreign assets. Higher foreign assets raise the effective exchange rate. It seems that the latter effect dominates in determining the equilibrium effective exchange rate in the long-run.

5. NATREX and Misalignments

Based on equation (29) and using actual and HP (Hodrick-Prescott)-filtered values of fundamentals, we calculated NATREX, HPNATREX and misalignment rates (Figures 3-6) [23]. Table 5 summarises our empirical findings on misalignment rates.

The REER followed the NATREX closely for the period 1972-1994 when there were large adjustments for the nominal exchange rate. For years before 1972 and after 1994, when the nominal exchange rate was fixed, the differences between NATREX and REER were relatively bigger. For the period 1960-1964, the NATREX was quite volatile due to the effects of the Great Leap Forward (1958-1962) while REER was comparatively stable due to the fixed nominal exchange rate. The overvaluation of the RMB suggested by the comparison between NATREX and REER was as high as 36.6% in 1961 and 19.0% on average for this period. For the period 1965-1971 the NATREX was still unstable but less volatile compared with early 1960s and the discrepancies between NATREX and REER were reduced.

[23] The HP filter allows us to remove the cyclical components of the fundamentals and concentrate instead on their trend values. Note that the ADF tests show that the misalignment rates in Figures (3-6) are both stationary at 5%.

Over the period 1972-1994, the misalignment rates of REER to NATREX were reduced to a narrow band of $\pm 8\%$ except an undervaluation of 10.4% in 1985 and overvaluation of 9.5% in 1991. Both NATREX and REER declined during this period. The decline in REER was mainly due to large decrease in the nominal exchange rate from 0.67 USD/CNY in 1981 to 0.12 in 1994. The decline of NATREX was mainly due to decrease in ERULC.

Since 1994, the nominal exchange rate has been fixed at 0.12 USD/CNY. NATREX and REER both rose during 1995-2005. The rise in NATREX was mainly due to higher ERULC, ETOT, and TFP2 during this period. The fundamentals have been changing faster than changes of the relative prices, which led to a higher NATREX compared with REER and generated undervaluation of the RMB for the entire period 1994-2005. The average misalignment rate for this period was 8.3% with the highest rate of 15.7% in 2005. There was an overall increasing tendency in the misalignment rates for the period 1994-2005.

Misalignment rates of REER based on HPNATREX are more informative because the equilibrium real exchange rate is based on the trend values of the fundamentals. As expected, these misalignments are smoother. It is noticeable that, for the period 1994-2005 when the nominal exchange rate of USD/CNY was fixed at 0.12, there were 12 years of consecutive undervaluation of the RMB with an average misalignment rate of 7.8%. There has been a particular acceleration in the rate of undervaluation since 2000, reaching 15% in 2005. Although we did find evidence of persistent undervaluation since 1994, the undervaluation has not been as large as suggested by some other studies of China's real effective exchange rate (i.e. 33% during 1997-2000 in Jeong and Mazier (2003); 16.1% in 2001 in Bénassy-Quéré *et al* (2004); 30-50% in 2005 in

Dunaway *et al* (2006); 23%-33% during 2002-2003 in Coudert and Couharde (2007))[24].

For the period 1960-1993, misalignment rates varied within a narrow band $\pm$ 8% with highest overvaluation of 7.6% in 1964 and highest undervaluation of 3.2% in 1987. In particular, from 1960-1971 the RMB had been overvalued for 12 consecutive years with an average misalignment rate of 4.0%. There was another 7 years of consecutive years of overvaluation for the period 1979 to 1985 with an average misalignment rate of 1.8%. From 1972 to 1978 there was 7 years of consecutive undervaluation but with an average misalignment rate of less than 1%. For the rest of the years the REER has been very close to HPNATREX.

6. Conclusions and Policy Implications

This paper makes a number of theoretical and empirical contributions to the literature on China's equilibrium exchange rate. At the theoretical level, we extend the NATREX model to incorporate a large number of economic fundamentals that capture the unique features of the Chinese economy. No previous study covers and analyses such a wide range of fundamentals. At the empirical level, this is the first application of the extended NATREX model to China. Another contribution is that we estimated the extended NATREX model for the real effective exchange rate for both the pre- and post- reform periods, while all previous studies focus only on the post-reform period. We have constructed a unique data set of consistent time series of economic fundamentals for China since the 1950s that are crucial for determining the NATREX but have not been employed by other studies. In addition we constructed the RMB's real effective exchange rate against all China's trade partners since 1960,

[24] Note that none of these studies applied the NATREX model, or used many of the fundamentals considered in our paper. Consequently we believe that our empirical results are more reliable.

as well as effective fundamentals, such as effective terms trade and effective unit labour cost. A further contribution is the use of total and net factor productivity obtained from an estimated production function.

The main empirical findings of our study are summarised as follows. First, we have found one significant cointegrating vector, thus providing support for the theoretical NATREX model. Second, the significant determinants of the equilibrium real effective exchange rate are the effective terms of trade, net factor productivity, effective unit labour cost, financial liberalisation and the tax rate. Third, we found strong evidence of undervaluation of the RMB for the period 1994-2005. The average misalignment rate was 7.8%, with the undervaluation rate accelerating in particularly since 2001, reaching 15% in 2005. However the misalignment rates are much lower than those reported by previous studies. We also found weak evidence of overvaluation from 1960s to early 1970s with moderate misalignment rates. For the rest of the period, there was no persistent undervaluation or overvaluation and the misalignment rates were within ±4%.

A number of policy implications follow from the empirical findings of this paper. Across the whole pre- and post-reform period, the misalignments tend to be relatively larger when the nominal exchange rate is fixed and relatively smaller when there are adjustments in the nominal exchange rate. This implies that, to reduce the misalignments in the value of RMB, the Chinese government must introduce greater flexibility into the nominal exchange rate.

On the 21st June 2005, the Chinese Central Bank mandated more flexibility in the exchange rate regime by switching its peg to a basket of currencies. Though the central bank does not reveal it, studies (e.g. Eichengreen, 2006; Frankel and Wei, 2007) suggest that the implicit weight of the USD in the basket is strikingly high: over

90% . Given that the share of China's trade with Europe and other Asian countries has been rising while that with the USA has been declining over the recent years[25], greater exchange rate flexibility will be achieved by increasing gradually the weights of other currencies in the basket. Otherwise, even if the misalignments in the bilateral CNY/USD are reduced, substantial misalignments in the real effective exchange rate of the RMB may remain[26]. Greater flexibility will also require the adoption of broader floating bands not only for the CNY/USD rate, but also for the exchange rate of the CNY against other currencies (e.g. Euro, Yen, Korea Won, etc) to reflect the relative changes in the structure of China's foreign trade.

Another crucial issue concerns the sustainability of the current peg. The rising trend in the undervaluation of the RMB against a basket of currencies since the beginning of the 21st century implies an unfair and persistent competitiveness advantage for China that could lead to its trade partners imposing import restrictions. To avoid such a risk, significant appreciation of the RMB against a basket of main currencies (reflecting the relative important of the respective countries in China's trade) will be required.

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[25] For example, the share of China's trade with the USA declined from 20% in 2000 to 17% in 2007. On the other hand, its the trade share with the European Union increased from 14.2% in 2000 to 17.4% in 2007. During the same period, China's trade share with some Asian Countries (Korea, Malaysia, Singapore and Thailand) went up from 9.2% to 11.9%.

[26] According to Frankel and Wei (2007), though the exchange rate of CNY/USD had decreased by 6% (i.e. the RMB has appreciated by 6%) between June 2005 and the end of 2006, the effective exchange rate had hardly changed during the same period.

Appendix A. Equilibrium Effects

	Medium-run			Long-run					Trajectories
Z	J_Z	$L_Z=(S-J)_Z$	$\partial R_n/\partial Z$	dk^*/dZ	dF^*/dZ	$(\partial R_n/\partial k)\,dk^*/dZ$	$(\partial R_n/\partial F)dF^*/dZ$	dR_n^*/dZ	
T	+	+	−	+	+	+	+	+	$E3-E$
	+	−	−	+	+	+	+	+	$E2-N-E$
NFP_t	+	+	+	+	+	+	+	+	$E3-E$
	+	−	+	+	+	+	+	+	$E2-N-E$
NFP_n	+	−	−	+	+	−	+	−	$E2-N-E$
RT_t	+	+	+	+	+	+	+	+	$E3-E$
	+	−	+	+	+	+	+	+	$E2-N-E$
RT_n	+	−	−	+	+	−	+	−	$E2-N-E$
$RULC$	−	+	0	−	−	0	−	−	$E4-M-E$
RRC	+	−	0	+	+	0	+	+	$E2-N-E$
DEP	0	−	+	−	−	−	−	−	$E1-E$
$CREP$	0	−	+	−	−	−	−	−	$E1-E$
GI	+	−	+	+	+	+	+	+	$E2-N-E$
r' (net creditor)	−	+	−	−	−	−	−	−	$E4-M-E$
	−	+	−	−	+	−	+	+/−	$E4'-E$
	−	+	−	+	+	+	+	+	$E5-X-E$
τ	−	+	−	−	−	−	−	−	$E4-M-E$

Note: the fundamentals affect the relative price of non-tradables (R_n) and the real exchange rate (R) in a similar way, both in the medium run and long run, and hence are not repeated here. Terms of trade are the only exception of this rule. Based on equation (4.10), the terms of trade (T) affect the real exchange rate directly and indirectly through their effect on R_n . As analysed in Section 4.5.6, the direct and indirect effect are both positive, though the latter is relatively smaller than the former. This implies that in the medium run and long run dR^*/dT is always positive, meaning that higher terms of trade increase the real exchange rate (i.e. an appreciation of RMB).

Appendix B

Variable Construction and Data Sources for China[27]

The main data sources of this study include the *50 Years of New China* (*50YNC*), *China Statistical Yearbook* (*CSY 2006)* of China National Statistical Bureau (NBS), the *World Development Indicators* (*WDI*) of World Bank, the *International Financial Statistics* (*IFS*) of International Monetary Fund (IMF), the *National Income and Product Account* (*NIPA*) of the US Bureau of Economic Analysis (BEA) and the *China State Administration of Foreign Exchange* (*SAFE*). The Data span is 1952-2005. *CSY 2006* reports most of the data from 1978. For the years before 1978, most of the data is collected from *50YNC* (published in 2000), which covers data from 1952 to 1999. Therefore, we collect data for the period 1978-2005 from *CSY 2006,* and for the period 1952-1977 from *50YNC.* To obtain the consistency between these two data series (*50YNC* and *CSY 2006*) we adjust the original data of *50YNC* for the period 1952-1977 as follows.

1. For the years of 1978-1980, data from *50YNC* is compared with *CSY 2006*;

2a. If the two data series are identical, we leave data of 1952-1977 from *50YNC* unchanged and call it "original data" from 1952 to 1977;

2b. If the two data series are different, we adjust data of 1952-1977 from *50YNC* using an adjustment factor. The adjustment factor is calculated as the ratio of the three overlapping years' average of data from *CSY 2006* to the same three years' average of data from *50YNC*. The three overlapping years are 1978, 1979 and 1980 unless other years are stated. We name it "adjusted data" from 1952 to 1977.

Nominal GDP: Nominal GDP from 1952 to1977 is collected from adjusted data of *50YNC*, and nominal GDP from 1978 to 2005 is collected from *CSY 2006*[28] .

[27] For a detailed explanation of the construction of the Chinese variables, see You (2008).

GDP Price Deflator (P): The GDP deflator is calculated using the same methodology as Jun (2003). GDP at constant prices (preceding year=100) from 1952 to 1977 is collected from original data of *50YNC* and data from 1978-2005 is collected from *CSY 2006*. We construct GDP at current prices (previous year=100) by dividing nominal GDP of current year by nominal GDP of previous year. By dividing GDP at current prices by GDP at constant prices and times 100, we get the implicit GDP deflator (preceding year=100). By choosing 1990 and 2000 as base years, we convert GDP deflators into 1990 prices (1990=100) and 2000 prices (2000=100) and we call them GDP deflators 1 and 2 respectively. *WDI 2006* provides GDP deflator with the base year of 1990=100 between 1960 and 2005. GDP deflator 1 and the WDI GDP deflator are consistent with each other. After this confirmation, we use GDP 2 (2000=100) in our study.

Real GDP (Y): The series for real GDP in 2000 prices is constructed by dividing nominal GDP by the GDP deflator (2000=100) and multiplying by 100.

Total Number of Employed Persons (L): The total number of employed persons from 1952 to 1977 is collected from original data from *50YNC*. From 1978 to 2005, data are collected from *CSY 2006*.

Rural Transformation (RT): Rural transformation is defined as one minus the ratio of employed persons by primary industry to total number of employed persons. It is in percentage form. According to the definition of *CSY 2005*, primary industry is equivalent to agriculture. Data of the employed persons by primary industry from 1952 to 1977 are collected from original data from *50YNC,* and data from 1978 to 2005 are collected from *CSY 2006*.

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[28] *WDI 2006* provides GDP (current Local Currency Unit) from 1960 to 2005, which is consistent with the combined data of *50YNC* and *CSY 2006.*

Consumer Price Index (CPI): 50YNC provides consumer price index (CPI) from 1950 to 1998 (preceding year=100). *CSY 2006* provides CPI data for 1989-2005 (preceding year=100). CPI series from these two data sources are identical for all overlapping years. Therefore, CPI for the period 1952-1988 is collected from original data of *50YNC*. From 1989 to 2005 we use data from *CSY* 2006. Then the whole series is converted into base year 2000 (2000=100).

Dependency Ratio (DEP): The dependency ratio is defined as the ratio of minor to the total employed persons. Minor is defined as the population age between 0 and 14, or under 15. It is expressed as a percentage. The *WDI 2006* provides statistics for the total population and the ratio of China's population age under 15 to total population from 1960 to 2005. The multiplication of these two series gives the population age under 15. We divide the population age under 15 by total employed persons (L) to obtain the dependency ratio from 1960 to 2005. For the period 1953-1959, the dependency ratio is collected from Modigliani and Cao (2004), modified by an adjustment factor based on the overlapping years 1961-1962.

Financial Liberalisation (CREP): Following Kose *et al* (2006), financial liberalisation is measured as the ratio of domestic credit to private sector to nominal GDP. It is expressed as a percentage. The *IFS* provides data of domestic credit to private sector for China (line 32d) covering 1977 to 2005. According to the explanatory notes of the *IFS*, the domestic credit to private sector (line 32d) is equal to monetary authority's claim on private sector (line 12d) + banking institutions' claim on private sector (line 22d). *50YNC* provides data of banking institutions' claim on private sector as "all loans" from 1952 to 1999. We find that for the years from 1977 to 1980, banking institutions' claim on private sector from *50YNC* is identical to domestic credit to private sector (line 32d) of *IFS*. It implies that before 1980, monetary authority's claim on private sector (line 12d) is negligible. Therefore, for the period 1952-1976, banking institutions' claim on private sector from *50YNC* is a very close approximate of domestic credit to private sector and we use it in our study.

Government Investment (GI): Government investment is measured as the ratio of government investment to the total investment in fixed assets. It is expressed as a percentage. *CSY 2006* provides the ratio of state budgetary appropriation to the total investment in fixed assets covering 1981-2005. For the years 1952-1980, official data are not available. *CSY 1996 and CSY 2002* include data on state appropriation in capital construction for the period 1953-2001. These data, combined with data on total fixed assets investment from from Bai *et al* (2006)[29], are used to obtain observations on GI for 1952-1980.

Nominal Exchange Rate, (R_i)*,* (USD per Chinese Yuan): data are collected from *IFS* (line rh). The exchange rate is converted into index with 2000=100.

Terms of Trade (TOT): The terms of trade are defined conventionally as the ratio of export prices to the import prices in a common currency. Terms of trade for China are, as far as we know, only available from the special studies section of *UNCTAD Handbook of Statistics* and *WDI.* Both provide data after 1980 and with base year 2000=100. Export and import prices provided by these two data sources are consistent with each other and we will use *WDI* data from 1980 to 2005[30].

For years before 1980, neither terms of trade, nor export or import prices for China are available. Therefore, they can only be expressed in approximate terms for the period 1952-1979. Before the reform and opening up policy in 1978, the government

[29] Bai *et al* (2006) provide fixed assets investment from 1953 to 2005 as the sum of construction and installation, equipment and instruments, and others.

[30] *WDI 2006* provide data of export quantity index (2000 = 100), export value index (2000 = 100), import quantity index (2000 = 100) and import value index (2000 = 100) since 1980. Terms of trade are calculated as (export value index /export quantity index)/(import value index/ import quantity index). Terms of trade calculated from *WDI* data are identical to data provided by *UNCTAD*.

attempted to use primary goods to exchange equipment and machines from foreign countries. Therefore the main exported item was primary goods. Even shortly after 1978, primary goods still accounted for more than half of China's exports. For instance, according to Table 18-5 *Export Value by Category of Commodities (Customs Statistics), CSY2006*, 50.3% of total exports were primary goods for the year 1980. Hence, the price index of primary goods is used as an approximate of export prices index for the period 1952-1982. The price index for China's primary goods is computed using the same methodology that we used in calculating the GDP price deflator. Data on primary goods at constant prices and current prices were collected from *50YNC* and *CSY 2006*. The constructed price index is then converted into USD using the nominal exchange rate index of USD/CNY.

We use the world export prices to approximate China's import prices. The world export prices are available from *IFS* (line 00174) for the whole period 1952-2005.

The terms of trade for the period 1952-1982 are calculated as the ratio of export prices index (primary goods price index) to the import prices index (world export prices index). To combine the terms of trade for the two periods, 1952-1982 and 1980-2005, we calculate the adjustment factor by choosing 1980, 1981 and 1982 as overlapping years and then adjust the terms of trade for the period 1952-1979 by the adjustment factor.

Total (TFP) and Net (NFP) Factor Productivity: These are calculated in You and Sarantis (2008b) from the estimation of a production function (over the period 1952-2005) that includes for the first time rural transformation. NFP measures factor productivity due to technical progress, while TFP measures factor productivity due to both technical progress and efficiency gains resulting from rural-urban migration and rural industrialisation. Note that TFP1(NFP1) and TFP2(NFP2) are based on two alternative measures of capital stock: K1 that is calculated by employing the methodology of Chow and Li (2002), but using updated data from CSY 2006 and extended from 1998 to 2005; and K2 obtained from Bai *et al* (2006).

Unit Labour Cost (ULC): According to the Bureau of Labour Statistics, U.S. Department of Labour, unit labour cost is defined as the cost of labour input required to produce one unit of output. They are computed as compensation in nominal terms divided by real output.

Labour compensation is based on Bai *et al* (2006). In their paper studying the return to capital in China, they collect labour share for each province and estimate the aggregate labour share as the average of provincial labour shares weighted by the share of each province's output in GDP for the period 1978-2005. Therefore we use labour share of Bai *et al* (2006) for the period 1978-2005. Data of labour compensation before 1978 are not available. However, we notice that the labour shares for the years of 1978-2005 in Bai *et al* (2006) fluctuate within a narrow band of 50%- 54% during 1978-2003 and only decrease considerably in 2004 and 2005. In other words, the labour shares have been actually quite stable apart from 2004 and 2005. Therefore we use the 3 years average (1978-1980) labour share as that for the years of 1952-1977[31]. Given the labour share, real GDP and the GDP deflator, we calculate the unit labour cost of China for the sample period, converted into index form (2000=100).

Rate of Return to Capital (CHRC): Following Bai *et al* (2006), the rate of return to capital for China is measured as

$$RC = \frac{\alpha}{P_K K / P_Y Y} + \left(\hat{P}_K - \hat{P}_Y\right) - \delta \tag{30}$$

[31] In his study for China's total factor productivity, Holz (2006) also uses three years average (1978-1980) as an approximation of the period 1952-1977.

where RC denotes real return to capital, α denotes capital share in income, $P_K K / P_Y Y$ denotes the real capital-output ratio (P_K , K , P_Y and Y denote price of capital, quantity of capital, price of output and quantity of output respectively), $\hat{P}_K$ and $\hat{P}_Y$ denote percentage rates of change of prices of capital and output, and δ denotes the depreciation rate. Since we used two capital stock series in the construction of total factor productivity, we also constructed two series for China's rate of return to capital: CHRC1 and CHRC2.

Tax Rate (TAX): According to *CSY 2006*, government tax revenue consists of the value added tax, business tax, consumer tax, agriculture and related tax, company income tax and the tariff. We construct the composite tax rates 1 and 2 and denote them by TAX1 and TAX2 respectively, both in percentage forms. Following He and Qin (2004), TAX1 is the ratio of the sum of value added tax, business tax, consumer tax, agriculture and related tax and company income tax (tariff is excluded) to nominal GDP. TAX2 is the ratio of the sum of value added tax, business tax, consumer tax and company income tax (tariff and agriculture and related tax are excluded[32]) to nominal GDP. Data on government tax revenue are collected from *CSY 2001* for 1952-1988, and from *CSY 2006* for 1989-2005.

[32] We exclude agriculture and related tax because agriculture tax is not used as a fiscal policy in China. The government may lower the agriculture tax as a form of subsidising the farmers to support and encourage the development of agriculture.

Appendix C

Measurement and Data Sources for Foreign Variables

Nominal Exchange Rates, (R_j), (USD per national currency) are collected from *IFS* (line rh) for China's and its 10 main trade partners (excluding Germany, France, Italy and Netherlands). In the case of Germany, France, Italy and Netherlands, OECD uses nominal end of period exchange rate from *IFS* (national currency per USD, line af) for the period 1960-1998 and then converts them into Euro using the irrevocable exchange rates. We adopt the same methodology but instead of using nominal end of period exchange rate (line af) we use average of period exchange rate (line rh). The exchange rates are converted into indices with 2000=100.

Consumer Price Index (CPI): data were collected from *IFS* (line 64 zf) for China's 11 main trade partners (exclude HK, Korea and Germany). CPI data from *IFS* for HK and Korea is not available until 1981 and 1966 respectively. Therefore, for Korea we collect GDP price deflator from *IFS* (line 99bip) for the period to replace CPI for the period 1960-1965. In terms of HK, since *WDI* reports its GDP price deflator from 1960, we collect GDP price deflator from *WDI* (line NY.GDP.DEFL.ZS) to replace CPI for the period 1960-1980. *IFS* provides CPI for Germany from 1991. OECD provides CPI for Germany from 1955 and is consistent with *IFS* from 1991 onwards. Therefore we use OECD data for the period 1960 to 1990 and *IFS* data for the period 1991-2005. All *CPI* indices are based on 2000.

GDP Price Deflator (P): data from 1960-2005 are collected from *IFS* (line 99bipzf for Korea, Singapore and Thailand and line 99birzf for Australia, Canada, France, Germany, Japan, Netherlands, UK and US) for all 14 main trade partners except Hong Kong, Italy, and Malaysia. GDP price deflators for these three countries are not available until 1981, 1970 and 1970 respectively. Therefore, for these three countries, GDP deflators from *WDI* (line NY.GDP.DEFL.ZS) are used for the period 1960-2005. All GDP price deflators are in 2000 prices.

Export and Import Prices for China's main trade partners for the period 1960-2005 are collected from *IFS* (lines 74 dzf and 75 dzf)[33].

Unit Labour Cost (ULC): Labour compensation for China’s 14 main trade partners are not possible to collect due to data limitation. Therefore, the unit labour cost for China’s main trade partners is measured as $ULC_j = \frac{WE_j}{YV_j}$ where WE_j and YV_j denote, respectively, wage rates and earnings index, and GDP volume index of country j. Indices of wage rates and earnings (2000=100) are collected from *IFS* (line 65). However, data is available only for 10 out of 14 countries for the period 1960-2005, which are Korea, Australia, Canada, France, Germany, Italy, Japan, Netherlands, UK and the US. Trade with these 10 countries accounts for 51.8% of China’s total trade with the world for the period 1960-2005 (Table 2). Therefore, j represents these 10 countries and W_{ij} is the competitiveness share that is normalised among these 10 countries. GDP volumes are collected from *IFS* (2000=100) (line 99b) for the 10 main trade partners[34].

Interest Rates(r): IFS provides data of nominal long-term government bond yields (line 61). For the period 1960-2005 only 9 out of 14 China’s main trade partners data is available, which are Australia, Canada, France, Germany, Italy, Japan, Netherlands,

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[33] However, *IFS* data for Hong Kong, Korea, Malaysia, Singapore and France are only available for the periods 1968-2005, 1963-2005, 1960-1987, 1979-2005 and 1990-2005 respectively. For the four Asian countries and regions (Hong Kong, Korea, Malaysia and Singapore), missing data during the period 1960-2005 is filled by the export and import prices of Asia that is available form *IFS* (line 74 dzf and 75 dzf). Germen export and import prices for the period 1960-1989 are used as approximations for these of France.

[34] GDP volume (2000=100) for Italy from *IFS* starts from 1970. WDI provides GDP in constant local currency unit for Italy (line NY.GDP.MKTP.KN) from 1960. Therefore, we convert data from WDI into an index (2000=100).

UK and the US[35]. Trade with these 9 countries accounts for 47.1% of China's total trade with the world for the period 1960-2005 (Table 2). Therefore, j represents these 9 countries and W_{ij} is the competitiveness weights that are normalised among these 9 countries with $n = 9$. The real long-term interest rate (r_j') is calculated by subtracting the inflation rate from the nominal long-term government bond yield.

Trade Data (bilateral trade flows between China and its main trade partners): See Section 3.1.

[35] Nominal long-term government bond yield for Japan from *IFS* starts from 1966 and *IFS* provides lending rate for Japan from 1960. Therefore we construct an adjustment factor for the 3 overlapping years 1966-1968, and use it to adjust the data for the blending rate.

References

Bai, C.-E., Hsieh, C.-T. and Qian, Y., 2006 "The Return to Capital in China", *Brookings Papers on Economic Activity* 2:2006.

Banerjee, A., Dolado, J. J., Galbraith, J. W. and Hendry, D. F., 1986, "Exploring Equilibrium Relationships in Econometrics through Static Models: Some Monte Carlo Evidence, *Oxford Bulletin of Economics and Statistics*, 48, 253-277.

Banerjee, A., Dolado, J. J., Galbraith, J. W. and Hendry, D. F., 1993, *Cointegration, Error Correction and the Econometric Analysis of Nonstationary Data*, Oxford University Press, Oxford.

Bénassy-Quéré, A., Duron-Vigneron, P., Lahrèche-Révil, A., and Mignon, V., 2004, "Burden Sharing and Exchange Rate Misalignments within the Group of Twenty", in Bergsten, C. F. and Williamson, J., Eds., *Dollar Adjustment: How Far? Against What?*, Institute for International Economics, Washington, DC.

Benczúr, P, Simon, A and Várpalotai, V., 2006, "Social Costs of Consumer Impatience in Hungary", *Journal of Policy Modeling* , 28(8), 921–930,

Campbell, J. Y. and Perron, P., 1991, "Pitfalls and Opportunities: What Macroeconomists Should Know about Unit Roots", in Olivier J. Blanchard and Stanley Fischer Eds., *NBER Macroeconomic Annual*, Cambridge, MA: MIT Press, 141-201.

Chen, J., 2007, "Behavior Equilibrium Exchange Rate and Misalignment of Renminbi: A Recent Empirical Study", *DEGIT Conference Papers,*c012_013.

Cheung, Y-W. and Lai, K. S., 1993, "Finite-Sample Sizes of Johansen's Likelihood Ratio Tests for Cointegration", *Oxford Bulletin of Economics and Statistics*, 55(3), 313-328.

Chow, G. and Li, K.-W., 2002, "China's Economic Growth: 1952-2010", *Economic Development and Cultural Change*, 51 October, 247-256.

Connolly, M. and Devereux, J., 1995, "The Equilibrium Real Exchange Rate: Theory and Evidence for Latin America", in Stein, J. L., Allen, P. R. and Associates Eds., *Fundamental Determinants of Exchange Rates*, Oxford University Press, Inc., New York.

Coudert, V. and Couharde C., 2007, "Real Equilibrium Exchange Rate in China: Is the Renminbi Undervalued?", *Journal of Asian Economics*, 18, 568–594.

Dunaway, S., Leign, L., and Li, X., 2006, "How Robust are Estimates of Equilibrium Real Exchange Rates: The Case of China*", IMF Working Paper*, WP/06/220.

Funke, M. and Rahn, J., 2005, "Just How Undervalued Is the Chinese Renminbi", *The World Economy*, 28(4), 465-489.

Grafe, C. and Wyplosz, C., 1999, "The Real Exchange Rate in Transition Economies", in M. Blejer and M. Skreb eds., *Balance of Payments, Exchange Rates, and Competitiveness in Transition Economies*, Kluwer Academic Publishers.

He, X. and Qin, D., 2004, "Aggregate Investment in People's Republic of China: Some Empirical Evidence", *Asian Development Review*, 21(1), 99-117.

Holz, 2006, "Measuring Chinese Productivity Growth, 1952-2005", Hong Kong University of Science and Technology - Division of Social Science, available at http://ihome.ust.hk/~socholz/China-productivity-measures-web-22July06.pdf

Jeong, S-E. and Mazier, J., 2003, "Exchange Rate Regimes and Equilibrium Exchange Rates in East Asia", *Revue Économique*, 54(5), 1161-1182.

Johansen, S., 1988, "Statistical Analysis of Cointegrating Vectors", *Journal of Economic Dynamics and Control*, 12, 231-254.

Johansen, S., 1991, "Estimation and Hypothesis Testing of Cointegrated Vectors in Gaussian Vector Autoregressive Models", *Econometrica* , 59, 1551-1580.

Jun, Z., 2003, "Investment, Investment Efficiency and Economic Growth in China", *Journal of Asia Economics*, 14, 713-734.

Kamin, S. B., Marazzi, M and Schindler, J. W., 2006, "The Impact of Chinese Exports on Global Import Prices", *Review of International Economics*, 14, 179-201.

Kose, M. A., Prasad, E. and Terrone, M. E., 2006, "How Do Trade and Financial Integration Affect the Relationship between Growth and Volatility?", *Journal of International Economics*, 69, 176-202.

Lane, P. R. and Milesi-Ferretti, G., 2001, "Long-Term Capital Movements", *NBER Working Paper*, 8366.

Lim, Guay C. and Stein, J.L., 1995, "The Dynamics of the Real Exchange Rate and Current Account in a Small Open Economy: Australia", in Stein, J. L., Allen, P. R. and Associates Eds., *Fundamental Determinants of Exchange Rates*, Oxford University Press, Inc., New York.

Liu, G.L. and Otani, I., 2005, "Capital Controls and Interest Parity: Evidences from China, 1999-2004," mimeo (March).

Ma, G., Ho, C. and McCauley, R. N., 2004, "The Markets for Non-Deliverable Forwards in Asian Currencies," *BIS Quarterly Review*, 81-94.

Modigliani, F. and Cao, Shi L., 2004, "The Chinese Savings Puzzle and the Life-Cycle Hypothesis", *Journal of Economic Literature*, XLII, 145-170.

Ng, S. and Perron, P., 1995, "Unit root Tests in ARMA Models with Data-Dependent Methods for the Selection of the Truncation Lag", *Journal of American Statistical Association*, 90, 268-81.

Rajan, R. and Siregar, R. Y., 2002, "Choice of Exchange Rate Regime, Currency Board (Hong Kong) or Monitoring Band (Singapore)?", *Australian Economic Paper*, 41(4), 538-556.

Selaive, J. and Tuesta, V, 2003, "Net Foreign assets intensity and Imperfect Financial Integration: An Empirical Approach", *Central Bank of Chile Working Papers*, N° 252, December.

Shen, L., 2000, "China's Macro Econometric Annual Model", in Klein, L. R. and Ichimura, S., Eds., *Econometric Modelling of China*, Singapore: River Edge; New Jersey: World Scientific Publishing Co. Pte. Ltd.

Shen, L., 1999, "China Macroeconomic Annual Model", in Wang, H., Li, B. and Li, S., Eds., *China Available Macroeconomic Models*, Beijing: China Finance and Economics Publishing House.

Song, H., Liu, Z and Jiang, P., 2001, "Analysing the Determinants of China's Aggregate Investment in the Reform Period", *China Economic Review*, 12, 227-242.

Stein, J. L., 1995, "The Natural Real Exchange Rate of The US Dollar, and Determinants of Capital Flows", in Stein, J. L., Allen, P. R. and Associates Eds., *Fundamental Determinants of Exchange Rates*, Oxford University Press, Inc., New York.

Stein, J. L. and Paladino, G., 1999, "Exchange Rate Misalignments and Crisis", *CESifo Working Paper*, 205.

Wang, T., 2004, "Exchange Rate Dynamics", in Prasad E., Ed., China's Growth and Integration into the World Economy Prospects and Challenges, *IMF Occasional Paper*, 232, 21-28.

Wang, T., 2005, "Sources of Real Exchange Rate Fluctuations in China", *Journal of Comparative Economics*, 33, 753-771.

Wang, Y., Hui, X. and Soofi, A. S., 2007, "Estimating Renminbi (RMB) Equilibrium Exchange Rate", *Journal of Political Modelling*, 29, 417-429.

You, Ke Fei, 2008, *The Equilibrium Exchange Rate of the Chinese Renminbi: Determinants and Misalignments.* PhD Thesis, London Metropolitan Business School, London Metropolitan University.

You, K. F. and Sarantis, N., 2008a, "An Extended NATREX Model for China", *Discussion Paper No 2008-2*, Centre for International Capital Markets, London Metropolitan Business School, London Metropolitan University.

You, K. F. and Sarantis, N., 2008b, "Rural Transformation and Productivity in China", *Discussion Paper No 2008-6*, Centre for International Capital Markets, London Metropolitan Business School, London Metropolitan University.

Yang, X. D. and Li, Y., 1997, “The Fundamental Consumption Theory and the Evolution of Consumption of Urban Residents in Shanghai: An Empirical Study”, *Jingji Yanjiu (Economic Research Journal)*, 9, 29–36.

Zanello, A. and Desruelle, D., 1997, “A Primer on the IMF’s Information Notice System”, *IMF Working Paper*, 97/71.

Zhang, P., 1997, “Statistical Test, Institutional Explanation and Macro effect Analysis on Consumers’ Behaviour”, *Jingji Yanjiu (Economic Research Journal),* 2, 43–51.

Zhang, X., 2002, “Equilibrium and Misalignment: An Assessment of the RMB Exchange Rate from 1978 to 1999”, *Working Paper*, 127, Stanford University.

Zhang, Y. and Wan, G. H., 2002, “Household Consumption and Monetary Policy in China”, *China Economic Review*, 13, 27-52.

Zhang, Z., 2001, “Real Exchange Rate Misalignment in China: An Empirical Investigation,” *Journal of Comparative Economics*, 29, 80–94.

Zhu, B. and Liang, Y., 1999, “China Macroeconomic Model (Project LINK)”, in H. Wang, B. Li, and S. Li, Eds., *Macroeconomic Models of China in Practice*, Beijing: China Finance and Economics Publishing House.

Table 1. History of China’s Foreign Exchange Policy

Year	Historical Events of China’s Foreign Exchange Policy
1956-1978	The nominal exchange rate of CNY against the USD was fixed until 1971. The government appreciated moderately the RMB during 1972-1978. Apart from this there were almost no adjustments on the foreign exchange policy.
1979	Foreign Exchange Rate Retention System was introduced.
October 1980	Bank of China started to take foreign exchange retention as one of its services.
1981	Internal Rate of Trade Settlement was introduced.
1985	Internal Rate of Trade Settlement was terminated. It was the first unification between the internal and official rates in China’s foreign exchange policy history.
March 1988	Local Foreign Exchange Adjustment Centres were established one after another, where the official exchange rate was substituted by the swap rates agreed by two parties. The Dual Exchange Rate System was formed.
1985-1990	The foreign exchange rate of CNY against the USD was adjusted frequently in large scales.
1991-1993	The foreign exchange rate of CNY against the USD was adjusted gradually and less frequently.
1994	The Dual Exchange Rate System was terminated. It was the second unification between the swap and official rates in China’s foreign exchange policy history. The conditional convertibility under current account was accomplished.
December 1996	The unconditional convertibility under current account was accomplished. China announced meeting the requirements of Article VIII of the Agreement of International Monetary Fund (IMF).
December 1998	All Foreign Exchange Adjustment Centres were closed.
July 2005	Chinese central bank announced a 2% revaluation of CNY against USD. The RMB is pegged to a basket of currencies rather just the USD.

Table 2. China’s Main Trade Partners (1960-2005)

China's Main Trade Partners		(Partner’s Export from China + Partner’s Import to China)/China’s total export and import (%)
US		18.14
Japan		14.07
Europe	France	1.86
	Germany	4.78
	Italy	1.63
	Netherlands	1.48
	UK	1.61
Asia	Hong Kong, China	24.75
	Korea	4.75
	Malaysia	1.19
	Singapore	2.18
	Thailand	1.04
Australia		1.68
Canada		1.86
Total		81.00

Table 3. Unit root test (ADF)

	General to Specific					AIC				
Sample Period: 1960-2005		Level		1st Difference			Level		1st Difference	
Variables	Lag Length	ADF	p-value	ADF	p-value	Lag Length	ADF	p-value	ADF	p-value
REER	0	-0.88	0.7845	-5.27	0.0001	0	-0.88	0.7845	-5.27	0.0001
ETOT	0	-0.94	0.7680	-5.99	0.0000	0	-0.94	0.7680	-5.99	0.0000
DEP	1	0.92	0.9949	-3.16	0.0288	1	0.92	0.9949	-3.16	0.0288
CREP	3	-0.07	0.9469	-7.20	0.0000	3	-0.07	0.9469	-7.20	0.0000
ERULC	1	-0.37	0.9045	-4.30	0.0014	1	-0.37	0.9045	-4.30	0.0014
CHRC1	3	-5.16	0.0001			3	-5.16	0.0001		
CHRC2	1	-6.25	0.0000			1	-6.25	0.0000		
TFP1	2	0.44	0.9827	-5.22	0.0001	3	0.86	0.9941	-3.94	0.0037
TFP2	2	0.99	0.9959	-4.60	0.0005	2	0.99	0.9959	-4.60	0.0005
NFP1	2	0.31	0.9763	-3.86	0.0047	2	0.31	0.9763	-3.86	0.0047
NFP2	2	0.99	0.9958	-3.75	0.0064	2	0.99	0.9958	-3.75	0.0064
RT	3	0.31	0.7152	-4.61	0.0005	3	0.31	0.7152	-4.61	0.0005
GI	1	-0.61	0.8587	-4.24	0.0016	3	-0.59	0.8628	-2.78	0.0691
FR	0	-2.38	0.1518	-6.94	0.0000	0	-2.38	0.1518	-6.94	0.0000
TAX1	0	-2.25	0.1923	-6.40	0.0000	0	-2.25	0.1923	-6.40	0.0000
TAX2	0	-1.99	0.2920	-6.38	0.0000	0	-1.99	0.2920	-6.38	0.0000

Note: Critical values for 1%, 5% and 10% are -3.57, -2.92 and -2.60 respectively.
REER=real effective exchange rate; ETOT=effective terms of trade; ERULC=effective relative unit labour cost; FR=foreign interest rate; DEP=dependency ratio; CREP=financial liberalisation; CHRC1=rate of return to capital 1; CHRC2=rate of return to capital 2; TFP1=total factor productivity 1; TFP2=total factor productivity 2; NFP1= net factor productivity 1; NFP2=net factor productivity 2; RT=rural transformation; GI=government investment/total fixed assets investment; TAX1=tax rate 1 (exclude tariff); TAX2= tax rate 2 (exclude tariff and tax on agriculture).

All variables are in natural logarithm except CHRC1, CHRC2 and FR as they are rates of returns.

Table 4. Johansen Cointegration Results — the Extended NATREX Model

	Hypothesized No. of CE(s)	Trace Statistic	1% Critical Value	p-value	Max-Eigen Statistic	1% Critical Value	p-value
Equation A	None	179.51 *	135.97	0.0000	65.05 *	52.31	0.0002
	At most 1	114.45 *	104.96	0.0014	45.46	45.87	0.0113
	At most 2	68.99	77.82	0.0581	32.69	39.37	0.0688
	At most 3	36.30	54.68	0.3812	17.99	32.72	0.4957
Equation B	None	163.30 *	135.97	0.0000	67.94 *	52.31	0.0001
	At most 1	95.37	104.96	0.0531	42.22	45.87	0.0283
	At most 2	53.15	77.82	0.4986	20.42	39.37	0.7271
	At most 3	32.73	54.68	0.5716	17.50	32.72	0.5372
Equation C	None	129.68 *	104.96	0.0000	51.71 *	45.87	0.0016
	At most 1	77.97 *	77.82	0.0097	35.23	39.37	0.0343
	At most 2	42.74	54.68	0.1390	22.56	32.72	0.1933
	At most 3	20.18	35.46	0.4105	10.08	25.86	0.7367

Normalized cointegrating coefficients (std.err. in parentheses)

Equation A	REER		ETOT	NFP2	RT	ERULC	CREP	TAX1	C
		1.0000	-0.8216	-2.4747	-0.9754	-1.1165	2.6153	-1.4002	4.3414
			(0.3885)	(0.4301)	(0.6318)	(0.2130)	(0.4075)	(0.3162)	
	Adjustment coefficient (standard error in parentheses)								
	D(REER)		-0.0634						
			(0.0372)						
Equation B	REER		ETOT	NFP2	RT	ERULC	FR	GI	C
		1.0000	-1.5996	-2.9075	-4.7113	-2.7007	0.2040	-0.7391	32.6915
			(0.8945)	(0.9967)	(1.5911)	(0.6954)	(0.0580)	(0.3694)	
	Adjustment coefficient (standard error in parentheses)								
	D(REER)		-0.0104						
			(0.0181)						
Equation C	REER		ETOT	TFP2	ERULC	CREP	TAX1	C	
		1.0000	-0.0472	-1.4688	-1.1615	1.5081	-0.5118	-3.0262	
			(0.1792)	(0.2053)	(0.1599)	(0.2723)	(0.2295)		
	Adjustment coefficient (standard error in parentheses)								
	D(REER)		-0.1224						
			(0.0543)						

Note: "*" denotes rejection of the hypothesis at the 1% level. Critical values are taken from MacKinnon *et al* (1999)

Table 5. Summary of Findings — REER

Actual fundamentals	1960-1971 (Fixed nominal exchange rate)	1972-1993 (Large adjustments of nominal exchange rate)	1994-2005 (Fixed nominal exchange rate)
REER and NATREX	There were relatively large misalignments, especially in the overvaluation side. In 8 out of 12 years the RMB was overvalued with an AMR of 8.2% with the highest overvaluation of 36.6% in 1960. For the rest 4 years the RMB was undervalued with an AMR of 5.6%.	REER followed closely the NATREX. There were 9 years of undervaluation and 13 years of overvaluation. The AMR was 1.62%.	There were 12 years consecutive undervaluation with an AMR of 8.3%.
HP-filtered fundamentals	**1960-1971 (Fixed nominal exchange rate)**	**1972-1993 (Large adjustments of nominal exchange rate)**	**1994-2005 (Fixed nominal exchange rate)**
REER and HPNATREX	There were 12 years consecutive overvaluation with an AMR of 4.0%.	REER followed closely the NATREX. There were 13 years of undervaluation and 9 years of overvaluation. The AMR was 0.1%.	There were 12 years consecutive undervaluation with an AMR of 7.8%. Max of 15% in 2005.

Note: AMR refers to average misalignment rate.

Figure 1. Trajectories of Capital and Foreign Assets to Their Steady States

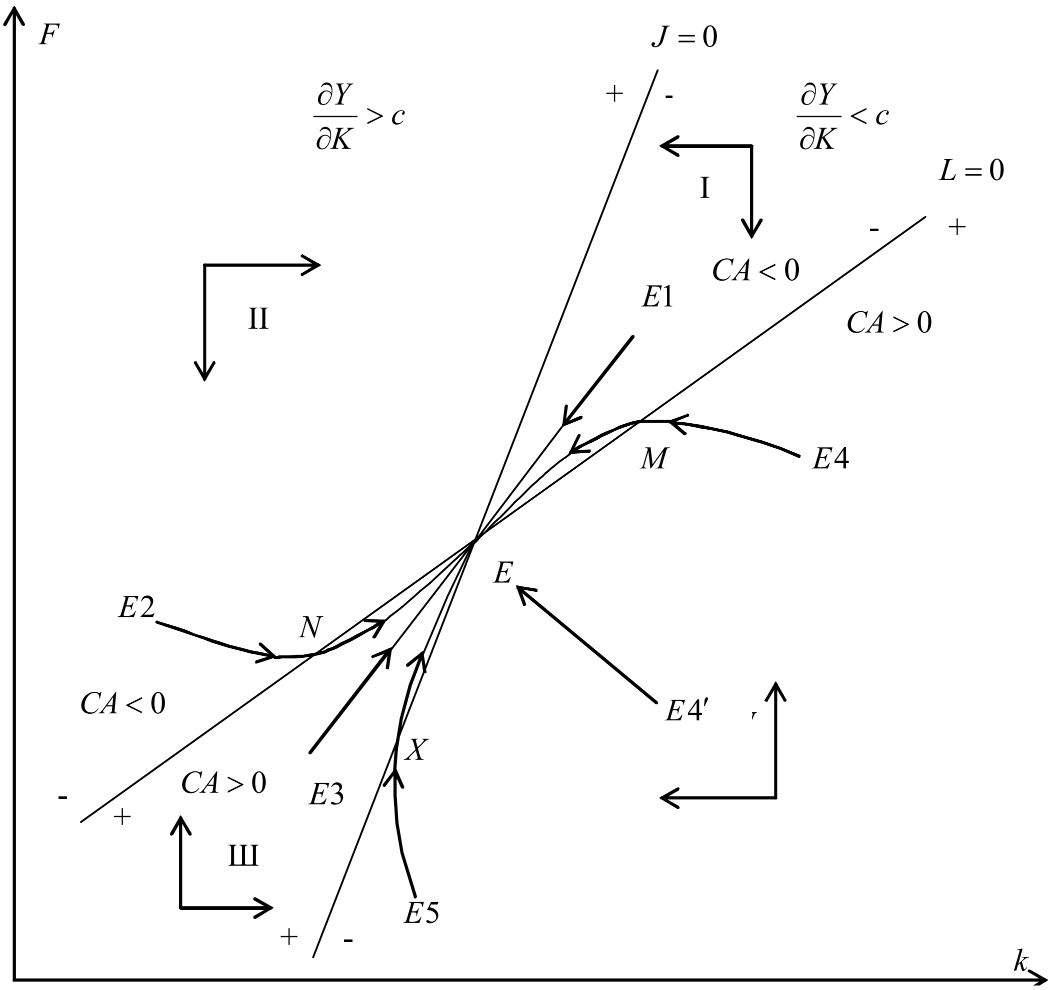


Figure 2. Our CPI-based REER and IMF CPI-based REER Indices (2000=100)

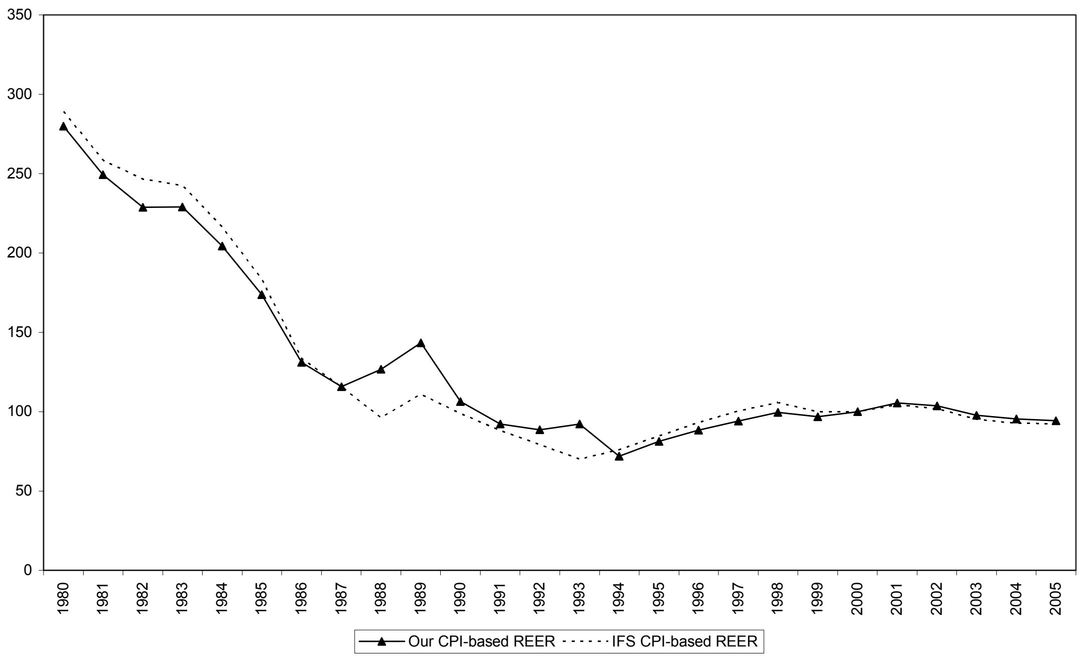
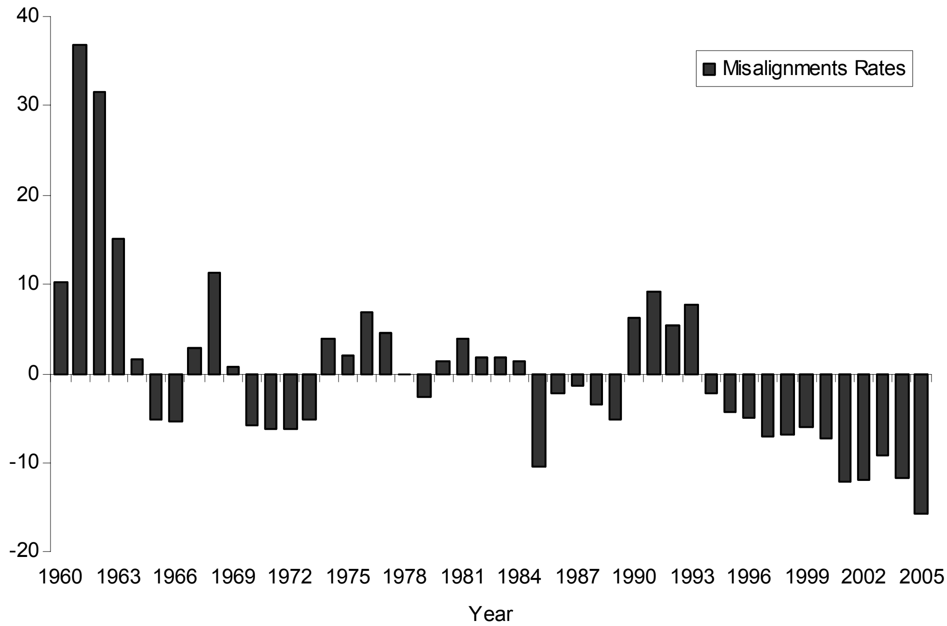


Figure 3. NATREX and Real Effective Exchange Rate (REER)

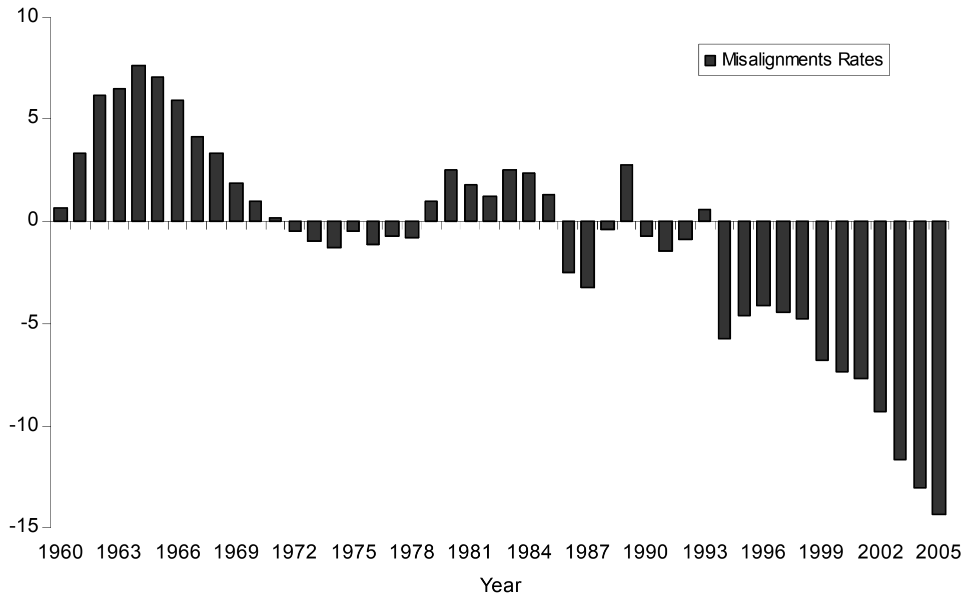
Figure 4. Misalignment Rates (%) between REER and NATREX



Note: Misalignment rate=(REER-NATREX)/NATREX*100%; a positive (negative) misalignment rate implies an overvaluation (undervaluation) of the RMB. REER denotes the real effective exchange rate.

Figure 5. HPNATREX and Real Effective Exchange Rate (REER)

Figure 6. Misalignment Rates (%) between REER and HPNATREX



Note: Misalignment rate=(REER-HPNATREX)/HPNATREX*100%; a positive (negative) misalignment rate implies an overvaluation (undervaluation) of the RMB. REER denotes the real effective exchange rate.