A Twelve-Area Model for the Equilibrium Nominal Chinese Yuan/US Dollar Exchange Rate

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Abstract

This paper investigates the determinants of the equilibrium nominal CNY/USD exchange rate and misalignments of the Renminbi during 1976-2008. We extend the five-area FABEER model of Wren-Lewis (2003) to a twelve-area model. All parameters are estimated with allowance for endogenous structural breaks. We employ the Gregory and Hansen (1996) method which can test for cointegration relationships in the presence of a level shift, level shift with trend and a regime shift. In addition, our investigation of the sustainable current account highlights macroeconomic factors that determine savings and investment in the longer-term. We find that all trade equations and the sustainable current account are subject to structural breaks in the cointegration relationships. The break dates echo events such as the establishment of special economic zones in 1980 and China's WTO accession in 2001.The equilibrium nominal rates suggest that the Renminbi was overvalued in most years from early 1990s until 2003, and it has been strongly undervalued for five consecutive years during 2004-2008. The recent undervaluation is quite large, though it stays in the lower spectrum of misalignment rates compared with previous studies. Misalignment rates simulated using a three percent sustainable current account suggest that targets of sustainable current account based on assumptions rather than on estimation may lead to results biased towards larger undervaluation.

Key Words: Fundamental equilibrium exchange rate; TABEER model; Nominal CNY/USD; Structural breaks; China

JEL Classification: F31, F32, C51 C52, O53

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1. Introduction

China's mounting trade surplus with the USA has led many politicians and academics in the USA to claim that China enjoys an unfair competitiveness advantage due to a deliberate policy of keeping its currency, Renminbi (RMB), undervalued. A number of studies have addressed this subject by investigating the equilibrium real exchange rate between the Chinese Yuan (CNY) and the US Dollar (USD), with the majority showing substantial undervaluation in the real RMB since the middle of the 1990s[1]. In contrast, studies analysing the equilibrium bilateral nominal CNY/USD exchange rates are very limited, and there is a much lower degree of consensus amongst them[2]. Compared with the bilateral real exchange rate, the bilateral nominal rate is a much more informative indicator for government and to be used as a policy instrument. This paper investigates the equilibrium nominal CNY/USD exchange rate and analyses the misalignments in the RMB. Our research is partly motivated by the important implications for China's exchange rate policy and international competitiveness, and partly by the need to address some issues in existing literature.

We model the equilibrium nominal CNY/USD exchange rate along the lines of the Five Area Bilateral Equilibrium Exchange Rate (FABEER) model of Wren-Lewis (2003). The FABEER model falls into the Fundamental Equilibrium Exchange Rate (FEER) framework popularised by Williamson (1983). It estimates a model for aggregates trade flows but uses off model projections of sustainable current account. Whilst a typical FEER model estimates equilibrium real exchange rates, an important innovation of the FABEER model is that it works with equilibrium bilateral nominal exchange rates directly.

[1] For a recent review of the empirical literature on China's equilibrium exchange rate using alternative models, see Cline and Williamson (2007).

[2] To our knowledge, only three papers examine the equilibrium nominal CNY/USD exchange rate; i.e. Jeong and Mazier (2003), Funke and Rahn (2004) and Wren-Lewis (2004b). They find that the nominal rate is undervalued by 60% during 1997-2000, 12-14% in 2004 and 19-22% in 2003 respectively.

We make three important contributions to the existing literature. First, we extend the FABEER model from a five-area (US, Euro area, Japan, UK and the rest of the world) model to a twelve-area model. We include China and its eleven main trade partners; i.e. Australia, Canada, Euro area, Hong Kong, Japan, Korea, Malaysia, Singapore, Thailand, United States and the United Kingdom. The criterion is that any economic bloc that has aggregate trade with China that accounts for more than 1% of China's total trade during the sample period is included. These eleven areas account for over 82% of China's total foreign trade[3]. We refer to our model as a TABEER (Twelve Area Bilateral Equilibrium Exchange Rate) model.

Second, the Chinese economy has experienced major political and economic changes in recent decades. Potential structural breaks are an important factor to be considered when estimating the equilibrium rate of the RMB, yet it is an issue that has been ignored by all previous FEER studies for China. In addition, parameters in trade equations are obtained either on the basis of very limited years of observations, or by simplified calibration[4]. In our study, we estimate all the parameters in the trade equations. We employ a sample period covering the recent three decades (1976-2008) and allow for the presence of structural breaks in cointegration equations using the Gregory and Hansen (1996) method.

Third, previous FEER studies for China often use a fixed "target" current account towards which the current account should move in the long term. The target is chosen based on the level needed to achieve US current account rebalancing (e.g. 2.5% of GDP in Cline, 2005) or on a simplified assumption of a normal current account (e.g. 0% and 1% of GDP in Wren-Lewis, 2004). Assuming the sustainable current account to

[3] Data are collected from *Direction of Trade Statistics*. We use the sum of the eleven trade partners' imports from and export to China divided by China's total imports and exports during 1976-2008.

[4] For instance, FEER estimates of Coudert and Couharde (2007) and Wang (2004) are for 2002-2003 and 2000-2002 respectively; Wren-Lewis (2004) uses calibrated parameters in trade equations.

be a certain fixed target may be plausible for a single year, but it could be misleading for the whole sample period as the sustainable current account evolves over time, reflecting the evolution of the fundamentals. Our investigation of the sustainable current account utilises an approach that highlights macroeconomic fundamentals that determine savings and investment in the long term. Specifically, following Chinn and Prasad (2003) and You and Sarantis (2008), a unique set of economic fundamentals is constructed for China, with some of them relative to China's eleven trade partners.

The paper is organised as follows. Section 2 sets out the extended FABEER model for China. Section 3 discusses the structural break test. Section 4 presents empirical estimates of the trend and sustainable current accounts. Section 5 investigates the misalignments in the nominal RMB. Section 6 compares our studies with previous studies. Section 7 discusses some their policy implications. Section 8 concludes.

2. A TABEER Model for China

As we mentioned earlier, the FABEER model of Wren-Lewis (2003) belongs to the category of FEER model but it works with bilateral nominal exchange rates directly. The five areas are the US, Euro area, UK, Japan and the rest of the world. For each bloc, the model contains trade (exports and imports) volume equations and trade prices equations. Together with an equation for net interests, profits and dividends (IPD) flows, this provides a complete model of the trend current account for each bloc, conditional on an exogenous exchange rate. The trend current account is consistent with internal balance and is free from any short term deviations. The sustainable current account matches the medium term structural capital flows. The model is then solved for the equilibrium exchange rates by finding the set of bilateral nominal exchange rates that matches trend current accounts with the exogenous assumptions

about the sustainable current accounts. Interactions amongst blocs occur through two routes in the model. The first is through import volumes, which determine other countries' export volumes. The second is through export prices, which influence both the competitiveness of other countries' export and domestic output as well as import prices.

Wren-Lewis (2004) includes China into his FABEER model only for the single year of 2002. So far this is the only study that employs the FABEER model to study China's equilibrium nominal exchange rate. In addition to the three major extensions we outlined in Section 1, it is worth mentioning that we also provide a more complete treatment of trade equations compared with Wren-Lewis (2004) by splitting the trade values into volumes and prices and estimating directly all trade elasticities.

2.1. Trend Current Account

The trend current account consists of full trend trade balance, trend interest profits and dividends (IPD) flows and the trend net transfers. The difference between trend trade balance and full trend trade balance is that the latter also takes into account the trend effect of China's main trade partners on China.

Following Wren-Lewis (2003), the export (X) and import (M) volumes, and the export (XP) and import (MP) prices of country i are expressed as

$$X_i = (WM, XCOM_i) \Rightarrow X_i = \left(\sum_{i \neq j} M_j, \frac{\sum_{j \neq i} h_{ij} XP_j}{XP_i}\right) \quad \text{export volume equation (1)}$$

$$\begin{array}{cccc} + & + & + & + \end{array}$$

$$XP_i = (WXPh, DP) = \left(\sum_{j \neq i} h_{ij} XP_j\right)^{\gamma} (P_i / N_i)^{1-\gamma} \quad \text{export price equation (2)}$$

$$\begin{array}{cccc} + & + & + & + \end{array}$$

$$M_i = (Y_i, MCOM) \Rightarrow M_i = (Y_i, \frac{MP_i}{P_i / N_i})_i \qquad \text{import volume equation (3)}$$

$$\begin{array}{cccc} + & - & + & - \end{array}$$

$$MP_i = (WXPv, DP) = \left(\sum_{j \neq i} v_{ij} XP_j \right)^{\phi} (P_i / N_i)^{1-\phi} \qquad \text{import price equation (4)}$$

$$\begin{array}{cccc} + & + & + & + \end{array}$$

$$NT_i = X_i * XP_i - M_i * MP_i \qquad \text{net trade equation (5)}$$

where $XCOM$, $MCOM$, Y , DP , P and N are export competitiveness, import competitiveness, real domestic output, domestic output price in US dollar, domestic output price and nominal exchange rate (domestic currency per US dollar). An increase (decrease) in N indicates a depreciation (appreciation) of the domestic currency. γ and ϕ are parameters. i denotes individual country and j denotes all the other countries except country i. In our study i denotes China and j denotes China's 11 main trade partners. $WM = \sum_{i \neq j} M_j$ denotes total demand for imports by other trade blocs. $WXPh = \sum_{j \neq i} h_{ij} XP_j$ and $WXPv = \sum_{j \neq i} v_{ij} XP_j$ are world prices in the export and import price equations for China. These are measured as the weighted export prices of China's trade partners. Specifically, in the export price equation, the weights h_{ij} reflect the relative importance of China's trade partners in the world market; in the import price equation, the weights v_{ij} reflect the relative importance of each trade partner for China's imports. WM and Y capture the impact of world and domestic activity on China's export and import volumes respectively. $XCOM$ is measured as the ratio of weighted export prices of China's trade partners' to China's exports price. An increase in $XCOM$ stimulates China's exports. $MCOM$ is measured as the ratio of China's import price to domestic price level. An increase in $MCOM$ reduces imports to China.

Whilst Wren-Lewis (2003) further breaks down total trade into commodity and manufacturing trade in his FABEER model, we use aggregate trade data because trade data on commodity and manufacturing goods are not available not only for China, but also for several other trade partners. Hence the trade volumes and trade prices equations are modelled at an aggregate level as in Barisone *et al* (2006).

Using the estimated coefficients in equations (1)-(4) and actual values of the variables, we can calculate the predicted trade balance that is stripped out of temporary shocks. To obtain the trend trade balance, the internal balance condition (zero output gap) must be satisfied. Hence we replace the actual output by its trend value[5]. The trend trade balance at this stage does not yet allow for the trend effect of China's main trade partners on China. The final stage is to allow for such trend effect. To do so, trend rather than actual import volume and export prices of the eleven areas are used. The trend trade balance at this stage allows for the trend effect, hence becomes the full trend trade balance.

Following Barisone *et al* (2006), we regard IPD flows as exogenous while taking into account the effect of exchange rate revaluation and smoothing the series using the Hodrick-Prescott (HP)-filter. The smoothed IPD flows, $\overline{IPD}$, are given by

$$\overline{IPD} = \left(1 + \frac{EER - N}{N}\right)\overline{(IPDC - IPDD)} \tag{6}$$

where EER denotes the equilibrium bilateral nominal CNY/USD exchange rate; $IPDC$ and $IPDD$ denote, respectively, interest rate for IPD credit and debits. $(EER - N)/N$ is the revaluation effect measured in nominal terms[6]. The last

[5] Trend output is obtained using the Hodrick-Prescott filter.

[6] Wren-Lewis (2003) relates the rate of IPD return of each bloc to a "synthetic world IPD return" and evaluates the value of overseas assets using weights based on the proportion of different currencies in total assets for each individual bloc. For China, we use equation (6) as data on IPD return (or interest

component of trend current account is the trend net transfers, which is also regarded as exogenous as in Barisone *et al* (2006) and is obtained by applying the H-P filter to actual transfers. Therefore, the trend current account for China is the sum of full trend net trade, trend IPD flows and trend net transfers.

2.2. Sustainable Current Account

Although the model has the capacity of generating equilibrium bilateral nominal rates for all currencies included in the model, for the purpose of estimating the equilibrium rate of RMB, we model the sustainable current account for China only. In our study we adopt the methodology developed by Masson (1998) who equate the current account to savings minus investment in the economy. This was applied by Debelle and Farruqee (1998) to industrial countries and Chinn and Prasad (2003) to developing countries. We follow Chinn and Prasad (2003) who identified a comprehensive list of determinants of current account for developing countries based on an extensive review of macroeconomic determinants of long term saving and investment balances. We also draw upon You and Sarantis (2008) who develop an extended Natural Real Exchange Rate (NATREX) model to incorporate a wide range of fundamentals that capture the unique features of the Chinese economy. These macroeconomic and demographic fundamentals are similar those used by Chinn and Prasad (2003) for developing countries.

The group of determinants in Chinn and Prasad (2003) include government budget balance to GDP ratio (GOVBGDP), net foreign assets to GDP ratio (NFAGDP), relative young dependency ratio (RELDEPY), relative old dependence ratio

rate) and composition of different currencies in assets is not available. Similar way of modelling net IPD flows is also used by Hristov (2002).

(RELDEPO), financial deepening (FDEEP), terms of trade (TOT)[7], degree of openness to international trade (OPEN), stage of development factor that is captured by relative per capita income (RELY) and its square (RELYSQ) and average GDP growth (YGR). A large number of developed and developing countries are included in Chinn and Prasad (2003), but China is not one of them. Therefore, we construct this unique group of economic and demographic fundamentals for China and employ them in our estimation of the sustainable current account. Equation (7) presents the list of determinants (and their expected signs)[8] for the current account to GDP ratio (*CAY*):

$$CAY = S - I = CAY(Z),$$

$$Z = (GOVBGDP, NFAGDP, RELDEPY, RELDEPQ, FDEEP, ETOT, OPEN, RELY, RELYSQ, YGR,) \quad (7)$$

$$\begin{array}{cccccccccc} + & + & - & - & + & + & - & + & - & + \end{array}$$

All relative variables in Chinn and Prasad (2003) are constructed compared to the averages of country groups. In our study, they are constructed relative to the weighted averages of China's 11 main trade partners. Note that as terms of trade is an index, we construct effective terms of trade (ETOT) which is a geometric average with weights derived using trade data.

3. Structural Break Tests

There have been major political and economic changes in China in recent decades such as the reform and opening up policy in 1978 and China's accession into WTO in

[7] Chinn and Prasad (2003) explain that they did not use terms of trade in their cross-sectional and panel analysis because terms of trade is an index. In our time series study, we employ term of trade and further construct effective terms of trade as discussed later.

[8] For a detailed discussion of economic theories that rationalise how these determinants affect the current account as well as their expected signs, please refer to Chinn and Prasad (2003) and You and Sarantis (2008).

2001. Conventional cointegration tests cannot accommodate structural changes. Therefore, we employ the Gregory and Hansen (1996) (G-H thereafter) cointegration methodology, where a break is allowed at a single unknown time during the sample period. Specifically, the G-H methods can detect cointegration relationships when there is a level shift (Model C), a level shift with trend (Model C/T) or a regime shift where intercept and slope coefficients change (Model C/S). The specifications of these three models are as follows:

Model C: level shift

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha^{\intercal} y_{2t} + e_t,\ t = 1, \dots, n \tag{8}$$

where y_{1t} is a vector of the dependent variable, y_{2t} is an m-vector of independent variables and is $I(1)$, e_t is the error term and is $I(0)$, μ_1 represents the intercept before the shift, μ_2 denotes the change in the intercept at the time of the shift, α denotes the slope coefficients, n is the number of observations. $\varphi_{t\tau}$ is a dummy variable defined as:

$$\varphi_{t\tau} = \begin{cases} 0 & if \quad t \leq [n\tau], \\ 1 & if \quad t > [n\tau], \end{cases} \tag{9}$$

where the unknown parameter $\tau \in (0,1)$ represents the timing of the change point and [ ] represents the integer part.

Model C/T: level shift with trend

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \beta t + \alpha^{\intercal} y_{2t} + e_t,\ t = 1, \dots, n \tag{10}$$

where β is the coefficient of the time trend t.

Model C/S: regime shift

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha_1^{\intercal} y_{2t} + \alpha_2^{\intercal} y_{2t} \varphi_{t\tau} + e_t,\ t = 1, \dots, n \tag{11}$$

where α_1 denotes the slope coefficients before the break and α_2 denotes change in the slope.

The G-H methods test for the null hypothesis of no cointegration against the alternative of cointegration in the presence of a possible structural change represented in the three models above. Traditional ADF test statistics of unit root are carried out on a series of successive residuals that are corresponding to all possible break points considered over the whole sample period. The location of the minimum value of the statistics indicates the break date. The statistics of G-H methods do not follow standard distribution and hence standard critical values for residual based cointegration tests are not applicable. In our paper we use critical values constructed by Gregory and Hansen (1996) using the response surface.

Another cointegration test that allows for structural break is the Johansen cointegration method (Johansen, Mosconi and Nielsen, 2000), which can allow up to two breaks. However, the break dates are not exogenously tested but treated as known, and the breaks are restricted in the intercept and/or trend only. In contrast, the G-H method searches for break at unknown time and can allow for breaks in the slope coefficients as. Therefore, from these two perspectives, we believe G-H methods could be more accurate as well as more flexible.

4. Empirical Results

Information on the measurement of variables and the data sources is given in the Appendix. The sample period starts in 1976, shortly after the end of the Cultural Revolution, and ends in 2008. Before carrying out the cointegration tests, we first test for stationarity of the variables using ADF (augmented Dickey-Fuller) unit root test. We set a maximum lag length of 4 and the Akaike Information Criterion (AIC) is used to choose the lag length. The unit root test statistics for level and first difference

are reported in Table 2. The ADF test suggests that all variables follow an $I(1)$ process except RELY, RELYSQ and YGR.

4.1. Trade Balance

The G-H test statistics for all trade equations are presented in Table 3, while the corresponding cointegration parameters are reported in Table 4. All three models (C, C/T and C/S) are examined.

4.1.1. Export volume equation

In models C and C/S, where a level shift and a regime shift is allowed respectively, the null of no cointegration is rejected, and hence there is a cointegration relationship in these two models. In model C/S, the break date is 1986. However, the export competitiveness variable is insignificant after the break. In model C, the break date is 2001, when China joined WTO. All coefficients are correctly signed. Interestingly the level shift has a positive sign, which suggests that China's membership into WTO has boosted China's exports to the world. The coefficients of world imports demand (WM) and export competitiveness are 2.2415 and 2.5994 respectively. It shows that both world demand and competitiveness are essential to China's export volume. Compared with a recent survey of China's trade elasticities by Cheung *et al* (2008), we found our world demand elasticity is in the lower end of elasticity reported by previous studies[9]. On the country, our relative export price elasticity is higher than all other studies[10].

[9] Studies reviewed by Cheung *et al* (2008) find world demand elasticity for China's exports ranging from 0.26 to as high as 10. But it must be noted that studies reviewed by Cheung *et al* (2008) that also estimate world demand elasticity for China's exports use bilateral China-US trade data only. Another two recent studies which are not reviewed by Cheung *et al* (2008) are Aziz and Li (2008) and Shu and Yip (2006). Aziz and Li (2008) use China's total trade volume data and Shu and Yip (2006) use data of China's trade with the US, the EU and Japan. They find the elasticity to be 3.8 and 4.27 respectively.

[10] Studies reviewed by Cheung *et al* (2008) find price elasticity for China exports ranging from 0.2 to 1.3. The elasticity find by Aziz and Li (2008) and Shu and Yip (2006) is within this range.

However, it is worth noting that all China's main trade partners are included in this model and we account for one structural break in the cointegration equation.

4.1.2. Import volume equation

In all three models, the null of no cointegration is rejected and the break date is 2001, China's WTO accession year. In models C the income elasticity is well over unity. Given the strong saving propensity in Chinese households, we are inclined to believe that a much lower income elasticity for imports to be more realistic. In model C/S coefficients of MCOM are wrongly signed (negative) and insignificant. We focus on the C/T model where a break in allowed in level with the presence of a time trend. There is a positive trend and all variables are correctly signed and significant. Interestingly, the positive level shift captures an increase in import volume due to China's WTO membership commitment such as reducing tariff and non-tariff-barriers. The income elasticity and competitiveness elasticity are 0.7668 and -0.3131 respectively. This implies that China's demand for imports is more income elastic than price elastic. The income elasticity found in our study is at the lower range of income elasticities reported by previous studies[11]; the relative import price elasticity is lower than in all previous studies[12].

Both export and import volumes experience a structural change in 2001, the year when China joined WTO. The sum of the absolute values of export and import competitiveness is higher than unity (2.9125), mainly due to the high export price elasticity. It suggests that the Marshall-Lerner condition is satisfied in China, and hence currency devaluation can have a positive effect on trade balance.

[11] Studies reviewed by Cheung *et al* (2008) find income elasticity for China's imports ranging from 0.7 to 2.3. The elasticity find by Aziz and Li (2008) and Shu and Yip (2006) is within this range.

[12] Studies reviewed by Cheung *et al* (2008) find price elasticity for China's imports ranging from -0.42 to -2.04. The elasticity find by Aziz and Li (2008) is with the range above and Shu and Yip (2006) find the elasticity to be -2.29.

4.1.3. Export price equation

The null of no cointegration is rejected in models C/T and C/S. A break in year 1989 and 1986 is found respectively. In model C/S, although all coefficients are significant, domestic price (DP) is wrongly signed (negative) after the break, which is rather unfeasible. We adopt model C/T and its G-H test statistics is significant at 1% compared with only 10% in the C/S model and all coefficients are correctly signed and significant. There is a slight negative time trend and a positive level shift. Most importantly, the sum of coefficients of WXPh and DP is very close to unity and they suggest that about 82.3% of the export price is determined by the world export price whilst only around 18.1% is determined by the domestic output price. This implies that export price of China are mainly determined by world export price[13].

4.1.4. Import Price Equation

There is a cointegration relationship in model C/S where a regime shift is allowed, and hence the null of no cointegration is rejected in this model. The break date is 1987. The coefficient for domestic price is only significant after the break, implying that before late 1980s, China's import price was almost entirely determined by the world export price. Since 1988, the importance of domestic price level has increased significantly and it influences about 62.5% of import price. In contrast, world import price, although still playing an important role, determines a much reduced proportion

[13] Most studies of China's trade elasticities use trade value data rather than trade volume and price data separately. Studies that estimate both trade volume and price for China are rare. As far as we know, Dées (1999) estimats China's trade price equation for the period 1984-1995. Compared with our study, Dées (1999) does not take into account structural break, and the sample period is only 12 years. Dées (1999) finds that 72% and 28% of China's export prices are determined by world export prices and domestic price level respectively. Our study finds a stronger impact of world export prices on China's export prices of 82.3%.

(37.6%) of China's import price[14]. We also re-estimated the regression when domestic price is only included for period during 1988-2008, we obtained almost identical weights for these two variables during 1988-2008.

The adjustment factors for all equations are presented in the last row of Table 4. All of them are negative. They are also significant in the import volume and export price equations. Although the adjustment factors of export volume and import price equations are insignificant, they are nevertheless negative, and the stability of import volume and export price will ensure the long-term stability of the net trade.

4.2. Sustainable current account

RELY, RELYSQ and YGR are excluded as they do not follow an $I(1)$ process[15]. We include ETOT, RELDEPY, RELDEPO, OPEN, GOVBGDP, FDEEP and NFAGDP in the cointegration equation. The null of no cointegration is rejected with a break date of 1987. When NFAGDP is included, the estimated sustainable current account is unrealistically high (11.3% in 2008). In all experiments, RELDEPO is wrongly signed and OPEN and FDEEP are insignificant. On the other hand, ETOT, RELDEPY and GOVBGDP remain significant and correctly signed in all cases. Thus we keep these three determinants in our final sustainable current account equation[16].

The G-H statistics are presented in Table 5. The null of no cointegration is rejected in model C. The adjustment factor of the error correction model is negative and

[14] Dées (1999) finds that 87% and 13% of China's import prices are determined by world export prices and domestic price level respectively. Our study finds a much stronger impact of domestic price level on China's import prices of 62%.

[15] We found RELY, RELYSQ and YGR follow I(2), I(3) and I(0) process respectively. First difference of RELY and second difference of RELYSQ follow I(1) process. We experimented with them included in the cointegration. However, both were wrongly signed and insignificant.

[16] It is worth mentioning that in Chinn and Prasad (2003), RELY, YGR and RELDEPO are insignificant in both cross-sectional and penal regression for developing countries. NFAGDP is only significant in panel regression for developing countries. Although Chinn and Prasad (2003) find OPEN and FDEEP to be significant determinants of medium-term current account for developing countries (exclude China), in our study these two variables are insignificant.

significant. The level shift occurs in 1980, shortly after the reform and opening-up policy was implemented in 1978. It divides the whole sample period into 1976-1980 and 1981-2008 with a negative level shift in the second period. In 1980, several costal cities were established as Special Economic Zones (SEZs) by the Chinese government in order to attract foreign investment and expand foreign trade. Many other costal cities were also opened up following the establishment of SEZs in the following years. A negative level shift occurred in 1980 may reflect the large inflow of foreign direct investment attracted by these opening up measures. Although the null of no cointegration is also rejected in model C/S with a break date of 1987, in the cointegration equation all coefficients before the break and the level shift are insignificant. RELDEPY is also wrongly signed. Therefore we use model C as our final equation for sustainable current account.

Estimates of cointegration equation of model C are shown in Table 6. Effective terms of trade have the expected positive sign and are significant. Early studies of Harberger (1950) and Laursen and Metzler (1950) (the HLM effect thereafter) predicts a positive relationship between exogenous changes in the terms of trade and national savings, through consumption smoothing behaviour. For instance, deterioration in terms of trade leads to a fall in a country's current real income that is larger than the decrease in its permanent income. Consumption smoothing ensures that the loss in current real income is smoothed over future periods by lowering aggregate savings, and consequently worsens the current account balance. Some more recent literature examining and supporting the HLM effect includes Ahmed and Park (1994), Mendoza (1995) and Otto (2003).

The relative dependency ratio of the young is negatively signed and significant. A higher relative dependency ratio of the young leads to a higher consumption and lower saving ratio and hence it has a negative influence on the current account.

Government budget balance has a positive relationship with the current account. A variety of models predict such a positive relationship over medium-term. For instance, using the overlapping generation model, Blanchard (1985) rejects Ricardian equivalence and suggests that an increase in government budget balance would lead to higher national savings. This would have further positive impact on the current account. This relationship is expected to be stronger in China where liquidity constraint is relatively tight and propensity to saving is relatively high given its underdeveloped pension and medical care system. Our empirical results confirm this positive relationship between government budget balance and current account.

4.3. Actual, Trend and Sustainable Current Account

Using the estimated parameters in Table 4 and following the steps described in Section 2.1, we have obtained the full trend net trade for China.This is plotted against the actual trend net trade in Figure 1. Trend current account is the sum of the full trend net trade, trend IPD flows and trend net transfers. The sustainable current account is the current account that is consistent with the long term values of its fundamental determinants. Hence, using the estimated coefficients in Table 6 and the HP-filtered macroeconomic determinants, we have obtained the sustainable current account (SCA). It is plotted against the actual (CA) and trend (TCA) current accounts, all measured as a percentage of real GDP, in Figure 2.

Overall, TCA moves in a similar pattern to the actual current account until the middle 1990s. However, it declined more rapidly during the Asian financial crisis in the late

1990s due to the combined effect of flat world demand and a decline in China's export price competitiveness during 1997-1999 as China maintained the value of the RMB throughout the crisis. The TCA also declined during China's WTO early accession period 2001-2002, due to slow down in world trade. The TCA recovered quickly and rose strongly during 2004-2008. This increase was driven mainly by strong world demand and higher export price. The latter was crucial as China was switching to relatively high technology exports.

There was a level shift in SCA in 1980. As mentioned earlier, it reflects the considerably amount of capital inflow as China implemented several opening up policies such as setting up SEZs. As the economic fundamentals evolve, such as the steady decline in young dependency ratio, the SCA has been increasing gradually since the early 1980s. It varied around a surplus 5% during the last five years. Such level of sustainably current account surplus is matched by consistently sustainable current account deficits of some of China's main trade partners. For instance, the US has been running a current account deficit since 1982[17]. For the 2004-2008, the US ran an average current account deficit of 5.4%.

5. The Nominal Equilibrium Exchange Rate and Misalignments

The trend current account is obtained by treating the nominal exchange rate as exogenous. The nominal exchange rate must adjust to match the trend with the sustainable current account. Given our estimates of trend and sustainable current account, we carry out a simulation to obtain the equilibrium nominal CNY/USD exchange rate, EER, that adjusts the trend current account to the sustainable current account.

[17] Data are from *IFS*. The only exception was 1991 when the current account was +0.05% of the GDP.

Before we analyse the EER and misalignments, we provide a brief review of China's exchange rate policy in recent decades. Table 1 summarises historical events that are related to the exchange rate policy. As we can see, there has been large adjustment in foreign exchange policy and frequent alternation in foreign exchange regimes between1976-1993[18]. In the end of 1993, the swap rate was unified with the official rate at 8.7 CNY per US. In 1994, the RMB was allowed to float within a narrow band of ±3% around the central parity set by the Chinese central bank for interbank transactions. During 1994-2005, as argued by Yi (2008), the floating band was actually less than ±1% around a *de facto* exchange rate of 8.28 CNY per USD. In July 2005, the Chinese central bank announced a 2% revaluation of CNY against USD. The RMB is pegged to a basket of major currencies including USD, Euro, Japanese Yen and Korean Won. The floating band of the CNY against the USD is daily ±0.3%. The RMB appreciated since then from 8.28 to 6.90 CNY per USD in June 2008. However, since July 2008, the RMB was again fixed against the USD at 6.83 for the rest of 2008[19].

As the *de facto* fixed exchange rate regime was adopted since 1994 despite of a short interruption from the middle of 2005 to the middle of 2008, we focus our analysis of the EER and misalignment for the period 1994-2008[20]. Figure 3 plots the nominal

[18] From late 1970s to the unification of the internal settlement rate (ISR) and official exchange rate in 1984, the ISR was used in most trade-related transactions and was allowed to fluctuates within margins that were beyond ±1% around a de facto fixed rate of 2.8 CNY per USD (Yi, 2008). During 1985-1993, a market-determined swap rate was allowed alongside the official rate and large amount of foreign exchange were sold in swap centres, although the quotas were subject to approval by the State Administration of Foreign Exchange. The IMF classifies the RMB as other managed floating regime during 1987-1993 (in their *Annual Report on Exchange Arrangements and Exchange Restrictions*), and Yi (2008) further terms it as managed floating with no predetermined path for the exchange rate.

[19] By the time this paper was written, which was middle of 2010, the RMB was still fixed at 6.83 CNY per USD.

[20] During 1976-1993, the nominal CNY/USD rate had been artificially depreciated many times. In particular, between 1980 and 1993, the nominal rate was depreciated against the USD by nearly 300% from 1.50 to 5.76 whilst the USD appreciated against China's major trade partners (except Japan and Singapore) at the same time. Between 1976 and 1993, the RMB was undervalued for 10 years and overvalued for 8 years.

EER against the actual exchange rate since 1994, while Figure 4 exhibits the misalignment rates.

Since 1994, the nominal RMB has been overvalued against the USD consecutively until 2003, except one year of slipping back to undervaluation in 1995. The largest overvaluation occurred during the 1997 Asian financial crisis. It was mainly due to low trend current account led by stagnate world imports. In addition, China's export competitiveness was also dampened as RMB remained strong whilst other Asian currency depreciated. Another sizeable overvaluation occurred during China's WTO access in 2001. The trend current account was dragged down due to declining world imports demand and fast growing domestic imports. Meanwhile, as the economic fundamentals evolved, the sustainable current account increased gradually from 1.9% in 1994 to 4.2% in 2003. The relationship between the trend and sustainable current account during that period indicates that the RMB needed to depreciate, or in other words, that the RMB was overvalued. Specifically, for the two large overvaluation periods mentioned above, during 1997-2000, the peak of overvaluation was 49.2% in 1998 and the average was 35.1%; during 2001-2003, The RMB was overvalued by 40.8% in 2001 and by 22.9% on average.

It is worth noticing that during 1994-2003, the USD continued to appreciate against China's main trade partners (except UK and Hong Kong). The fact that the nominal CNY/USD rate was largely fixed when the USD gained value against other currencies may have exacerbated the level of overvaluation.

During the last five years of our sample period (2004-2008), we found five consecutive years of undervaluation. Whilst the sustainable current account varies slightly around 5%, the trend current account has risen much faster owning to higher world import demand and rising export price. Additionally, improvement in export

competitiveness and decline in import competitiveness also stimulated the trend current account. These patterns of the sustainable and trend current accounts indicate sizeable undervaluation of the RMB since 2004. The average rate of misalignment rate is 39.9%. The peak was in 2006 with a 51.8% undervaluation. It is interesting to notice that the undervaluation has been decreasing in the last three years and dropped to 33.5% in 2008. The USD has depreciated against major currencies during this period. That the undervaluation of RMB has not become more severe might have be helped by the 12.5% appreciation of the RMB against the USD from 8.0 in 2006 to 7.0 in 2008.

We convert the misalignments to revaluation rates required. The average revaluation needed was 28.2% during 2004-2008. The required revaluation declined from the peak of 34.1% in 2006 to 25.1% in 2008.

6. Comparisons with Previous Studies

Cline and Williamson (2007) review previous estimates of the equilibrium bilateral real CNY/USD exchange rate using PPP (Purchasing Power Parity), BEER (Behavioural Equilibrium Exchange Rate) and FEER (Fundamental Equilibrium Exchange Rate) approaches. They find all previous FEER studies conclude that the RMB is undervalued, with the undervaluation ranging from 15% to 54% during the period 2001-2007. The average appreciation needed in the real bilateral rate is 35%. In contrast to previous studies, we have found the bilateral nominal CNY/USD rate was overvalued during 2001-2003. For the period 2004-2008, we did find substantial undervaluation. However, the average revaluation required is 28.2%, lower than the mean of previous studies and sits in the lower spectrum of required appreciation rates reported by other studies.

As our study investigates the nominal bilateral CNY/USD rate, we further compare our findings with the only two other FEER studies that have also focused on the bilateral nominal exchange rate. The comparison is summarised in Table 9.

Wren-Lewis (2004) includes China in his FABEER model only for a single year; 2002. He uses a simplified approach by assuming trade elasticities for trade value (trade volumes and prices were not separated) and finds a trend current account of 3.4% in 2002. He also assumes a medium-term current account of either 1% or 0% of GDP and obtained undervaluation of 20%-28%. Our economic fundamentals based sustainable current account is 3.9% and our trend current account is just above balance (0.1%) for the same year. Thus we found misalignment of 24.7% in 2002, but on the overvaluation side. Given that we use a twelve area model, including 11 of China's main trade partners, we estimate all parameters in trade volumes, prices and sustainable current account, and allow for structural breaks in all equations, we believe our empirical findings provide a more complete and precise evaluation of the equilibrium rate for the RMB.

Jeong and Mazier (2003) use the FEER model for China during 1980-2000. They find a much lower sustainable current account of between -1.5% and -1.0% for China during 1994-2000. They also find a trend current account between -2% and -4% for the same period. These estimates generate overvaluation in the middle 1990s but undervaluation after 1996. They find a required revaluation of over 60% in 2000. Although our average trend account is similar to Jeong and Mazier (2003) during 1994-2000, our estimated current account is on average 2.6% for the same period. We found the overvaluation persists from mid-1990s until 2003, especially during the Asian financial crisis period and when China entered WTO in 2001. However, the study of Jeong and Mazier (2003) has a number of limitations. First, instead of

estimating their own trade equations covering their sample period, they use the trade elasticities obtained Dées (1999), who estimated trade equations for China using data only for the period 1984-1995. Second, they estimate medium-term current account for a panel of 18 emerging economies and then apply the estimated coefficients to China. Thirdly, no structural breaks are taken into account. Hence our empirical results are deemed to be more reliable[21].

Cline and Williamson (2007) emphasise the importance of the target current account fed into FEER model to the results of how much the RMB is undervalued or overvalued. For instance, various levels of sustainable current account have been used as targets for China, ranging from -2.8% (i.e. Coudert and Couharde (2005)) to 3.1% (e.g. Wang (2004)). To gauge the sensitivity of our estimates of the EER to the choice of sustainable current account, we recalculate the nominal EER (using the same methodology described above) and compute misalignment rates for the period 1994-2008, using a target of 3% for the sustainable current account[22]. The results are plotted in Figures 3 and 4.

We notice three important differences. First, the undervaluation starts one year earlier in 2003. Second, the RMB was less overvalued during 1994-2002. Third, most importantly, undervaluation during 2003-2008 was more severe with an average of 52.5%. The average undervaluation increases to 61.8% for the period 2004-2008. The corresponding required revaluation is 37.8% during 2004-2008, with a peak of 43.9% in 2006. It is evident that assumed targets for sustainable current accounts, which are

[21] Apart from the FEER model, only the BEER model has been used to investigate bilateral nominal CNY/USD exchange rate by Funke and Rahn (2004) for period 1994-2002. They find overvaluation before 1997 and undervaluation of up to 17% thereafter. In contrast to their study, we find persistent overvaluation until 2003.

[22] We choose 3% in our simulation because it is at the high end of target current account used by previous studies. Lower targets such as 1% or 0% will generate higher misalignment rates on the undervaluation side. In other words, using lower targets is equivalent to shifting the EER line and misalignment rates line in Figure 3 and 4 respectively downwards.

not based on macroeconomic fundamentals, generate results that are biased towards larger undervaluation.

7. Policy Implications

Our empirical findings have important implications for China's exchange rate policy. During 2004-2008, we find undervaluation of RMB is not as high as many previous studies have suggested. In 2008, the required revaluation was 25.1%, much lower than the 40% required by the USA Congress. This implies that the immense political pressure from the US demanding sizeable revaluation of the RMB is rather unwarranted. Such an argument is supported by Frankel and Wei (2007), whose econometric estimations suggest that the US Treasury's verdict that "China is guilty of manipulating its currency to gain competitiveness" is largely driven by political variables. If China succumbs to the immense political pressure from the USA and introduces a sudden switch to a floating exchange rate system, it is doubtful that China's underdeveloped financial markets and domestic economy will be able to cope with the enormous international speculation and ensuing appreciation of the RMB. Instead, greater flexibility in the nominal exchange rate combined with gradual adjustment towards a floating system over the medium to long term seems more feasible for China. Our view of a gradual transformation of the exchange rate regime coincides with those of other economists (i.e. McKinnon, 2003; Goldstein, 2004; Frankel, 2006; Cappiello and Ferrucci, 2008). Once some flexibility was allowed for in the exchange rate of the RMB during 2006 and 2008, we did observe reduction in the undervaluation against the USD.

Greater flexibility in the nominal exchange rate should not focus entirely on the rate against the US dollar. In 2005 it was announced that the RMB was to be pegged to a

basket of currencies. However, the USD continues to occupy a strikingly high weight in the basket (e.g. approximately 90% according to Eichengreen (2006) and Frankel and Wei (2007)). Placing heavy weights on the USD on top of a rigid nominal CNY/USD rate could easily create huge swing in RMB misalignments when the value of the USD against other currencies changes. China's trade with its non-US partners (such as the European Union and Korea) has being expanded rapidly since 2000. Therefore, another policy implication of our empirical findings is that weights and floating bands for other currencies included in the basket must be increased to reflect the increasing importance of the respective countries for China's foreign trade.

Our empirical findings also highlight the role of economic fundamentals in correcting misalignments. It is often argued that in order to reduce China's current account surplus and correct the world's large current account imbalance, a certain amount of revaluation of the RMB is needed. But economic fundamentals that determine long term savings and investment ought to play their role in the rebalancing. For instance, other things being equal, nations with persistent high saving ratios and others with persistent low saving ratios may create equally persistent current account surplus and deficit respectively. Therefore, structural changes such as saving and consumption habit are very crucial. For instance, only when pension and medical care systems become more developed, can the saving ratio in China be reduced gradually. Our results imply that currency adjustment should be regarded as part of a broader range of economic policies, rather than the only one.

8. Conclusions

This paper investigates the equilibrium nominal CNY/USD exchange rate and misalignments of the RMB during 1976-2008. First, we extend the five-area FABEER

model to become a twelve-area one (TABEER model) that includes eleven of China's main trade partners which account for over 80% of China's foreign trade. Second, we investigate the sustainable current account utilising an approach that highlights long term determinants of savings and investment. The determinants are identified following Chinn and Prasad (2003) and You and Sarantis (2008) and are constructed for China. Third, we obtain trade elasticities by estimating export and import volumes and prices. Fourth, we employ the Gregory and Hansen (1996) cointegration method to account for structural breaks in all equations.

The following empirical findings warrant special mention: First, after accounting for structural breaks, we found one cointegrating vector for each trade equation and for the sustainable current account equation, which supports the theoretical relationships in the TABEER model.

Second, we found all trade and sustainable current account equations are subject the structural breaks. Both export and import volumes have a break in 2001 when China entered WTO, while export and import prices have a break towards the end of 1980s when further opening-up policies such as opening more coastal cities were implemented. The sustainable current account has a break in 1980, when the government started to establish special economic zones.

Third, both world import demand and price competitiveness are important factors for China's exports. China's demand for imports is more income elastic than price elastic. The Marshall-Lerner condition holds, mainly due to higher export price elasticity. The export price is determined mainly by the world export price, whilst the import price is influenced mainly by the domestic price level after 1987. The trend current account declined during the Asian financial crisis and during China's WTO accession in 2001, followed by a large increase during 2003-2008.

Fourth, effective terms of trade and government budget balance have a significant positive impact on the current account balance, whilst the relative dependency ratio of the young has a negative impact. The sustainable current account has been increasing gradually since 1981 and remained stable around 5% during 2004-2008. Our estimates are generally higher than conventional levels, especially during 2003-2008.

Fifth, our misalignment rates suggest that the bilateral CNY/USD nominal rate was overvalued for most of the years between mid-1990s and 2003, especially during the Asian financial crisis (1997-1999) and when China entered the WTO in 2001. This contrasts to all previous studies. The RMB was undervalued against the USD by an alarming average of 39.9% during 2004-2008. To correct this misalignment, an average revaluation of 28.2% is required. Nevertheless, the magnitude of undervaluation is well below the average suggested by previous studies, and it has been declining since 2006. The required revaluation towards the end of our sample period is well below that demanded by USA politicians and we have argued that greater flexibility in the nominal exchange rate combined with gradual adjustment towards a floating exchange rate system seems more feasible for China.

In addition, we simulated the equilibrium nominal misalignment rates for the period 1994-2008 using a sustainable current account of 3% of GDP. The results show lower overvaluation before 2002 and considerably much higher undervaluation during 2003-2008. This shows that estimates of the equilibrium CNY/USD rate based on assumptions rather than on estimates of the sustainable current account are overall biased towards much higher undervaluation.

Appendix. Data Sources and Variable Measurement

The main data sources of this study include *United Nations Conference on Trade and Development (UNCTAD)*, *International Financial Statistics (IFS)*, *World Development Indicators (WDI)*, *Eurostat*, *Direction of Trade Statistics (DOTS)*, *the 50 Years of New China (50YNC)*, various issues of *China Statistical Yearbook (CSY),* and *Chinese State Administration of Foreign Exchange (SAFE)*. Sample period is 1976-2008. All price indices have 2000 as the base year (2000=100).

1. Variables in Trade Equations

Economic blocs included in the TABEER model are: China, Euro area (which consists of 12 Euro countries), Australia, Canada, Hong Kong (China), Japan, Korea, Malaysia, Singapore, Thailand, United States and the United Kingdom. We refer to them as China, Euro area and the 10 blocs.

Euro variables: As data for the Euro area are not available until late 1990s, synthetic Euro area time series are needed for the earlier years. Following Maeso-Fernandez *et al* (2001), synthetic Euro area time series (X_t^{EURO}) are measured as the geometrically weighted average of the individual Euro area country time series, with the weight y_k for each Euro area country (k) equal to the ratio of manufacturing trade of this Euro area country to the total manufacturing trade of the whole Euro area,

$$X_t^{EURO} = \prod_{k=1}^{12} \left(X_t^k \right)^{y_k}$$

where k = the 12 Euro countries: Austria, Belgium, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain and the weights attached to each countries (y_k) are collected from Maeso-Fernandez *et al* (2001)[23]. We first construct synthetic Euro import and export prices from 1976 to 2008. The earliest year from which data for Euro area import and export prices are available is 1995 from Eurostat. We choose three overlapping years (1995- 1997). We divide the sum of Euro area import and export prices of these three years collected from Eurostat by the sum of our constructed synthetic Euro area import and export prices of the same three years to generate the adjustment factors. The synthetic Euro area import and export prices for the period 1976-1994 are multiplied by the adjustment factors to make them consistent with those for 1995-2008. Other time series of the Euro area include import and export values (in USD) which are calculated as the sum of the 12 Euro countries. Data for import and export values for each individual Euro country are collected from *DOTS*.

Export Values and Import Values: *DOTS* provide each individual country's (including China, the 10 blocs and the 12 Euro countries) trade flow (in USD) with every other country in the model.

Export Price and Import Price: export price (XP) and import price (MP) of China (in USD) are collected from *UNCTAD* for the period 1980-2008. For years before 1980, export prices of primary goods and world export prices are used as approximations respectively. Similar to the Euro variables, three overlapping years (1980- 1982) are used to generate the adjustment factors. Data for export and import

[23] The weights are: Austria, 2.89; Belgium-Luxembourg, 7.89; Finland, 3.27; Germany, 34.49, Greece, 0.736; Ireland, 3.76; Italy, 13.99; Netherlands, 9.16; Portugal, 1.07; Spain, 4.90.

prices (in USD) for the 10 blocs and 12 Euro countries are collected from *IFS* (lines 76.ZF and 76.X.ZF). Data for the Euro area are explained above.
Import Volumes: First we add up each individual country's imports from each other country in the model to obtain each country's total import value. For instance, China's total import value equals the sum of China's import from the Euro area and the 10 blocs. Then by adjusting import value (in USD) by the import price index, we obtain the imports volume for China (M), the 10 blocs, and the Euro area.
Export Volume for China (X): By adjusting China's export values (in USD) by the export price index, we obtain export volume for China.
Nominal Exchange Rate (N): it is collected from *IFS* (line 924.RF.ZF) (CNY per USD).
GDP Price Deflator (P) and Real GDP (Y) for China: GDP price deflator for China is collected from *WDI*. It is converted in USD by using the nominal exchange rate (i.e. $DP = P / N$). GDP for China is collected from *WDI* and converted to real GDP using GDP price deflator.
Export Competitiveness of China ($XCOM$): it is defined as the world export prices in export equation ($\sum_{j \neq i} h_{ij} XP_j$) (discussed below), divided by China's export price.
Import Competitiveness of China ($MCOM$): it is defined as domestic import price (in USD) divided by the domestic GDP price deflator (in USD).
World Export Price in Export Price Equation of China ($WXPh = \sum_{j \neq i} h_{ij} XP_j$): it is measured as a weighted average of export prices of countries in the model (except country i), with the weights h_{ij} equal the exports of country j divided by exports of all countries in the model (except country i), where i=China, j =11 trade partners.
World Export Price in Import Price Equation of China ($WMPv = \sum_{j \neq i} v_{ij} XP_j$): it is measured as a weighted average of export prices of all countries in the model (except country i), with the weights v_{ij} equal the ratio of country i's imports from country j to country i's total imports (in our model, i=China).
World Import Volume in Export Volume Equation of China ($WM = \sum_{i \neq j} M_j$): it is measured as the sum of import volumes of China's main trade partners.

2. Variables in Sustainable current account

CAY: current account to GDP ratio of China. Data for China's current account are collected from *IFS* and *SAFE*.
NFAGDP: net foreign assets to GDP ratio of China. Data for net foreign assets for China are collected from *IFS* and *CSY*.
GOVBGDP: government budget balance to GDP ratio of China. Data for China's government budget balance are collected from *50YNC* and *CSY*.
ETOT: effective terms of trade index, measured as the geometric mean of the terms of trade (TOT) of China to its main trade partners with the weights equal to w_{ij}:

$ETOT = \prod_{j \neq i} \left[\frac{TOT_i}{TOT_j} \right]^{w_{ij}}$. i denotes China, j represents China's main trade partners. TOT index is defined as export priced divided by import price. The weights w_{ij} are

derived from trade data. TOT of China is collected from *UNCTAD* and *CSY*. TOT for China's trade partners are collected from *IFS*. Trade data are collected from *DOTS*.
RELDEPY: this is the relative dependency ratio of the young. Dependency ratio of the young is measured as population under 15 divided by total population. Data are collected from *WDI*. Relative means China minus weighted average of China's 11 trade partners. Weights are determined by countries' real GDP. Nominal GDP and GDP price deflators for 11 trade partners are collected from *WDI* to construct real GDP.
RELDEPY: relative dependency ratio of the old. Dependency ratio of the old is measured as population above 65 divided by total population. Data are collected from *WDI*. Relative means China minus weighted average of China's 11 trade partners.
FDEEP: this is the indicator of financial deepening. It is measured as the domestic credit to GDP ratio of China. Data for domestic credit are collected from *50YNC* and *CSY*.
OPEN: this is the indicator of openness. It is measured as the sum of exports and imports to GDP ratio of China. Data for exports and imports are collected from *IFS* and *CSY*.
RELY: relative per capita income, adjusted by PPP exchange rates. PPP adjusted real GDP per capita data are collected from *WDI* for all countries. Relative means China minus weighted average of China's 11 trade partners.
RELYSQ: square of variable RELY.
YGR: real GDP growth of China. Real GDP are discussed above.
Net IPD: net interests, profits and dividends. It is measured as the net interests, profits and dividends credit (IPDC) minus corresponding debt (IPDD). Data are collected from *IFS* and *SAFE*.
NTR: net transfers. It is measured as current transfer credit minus corresponding deficit. Data are collected from *IFS* and *SAFE*.
For a more detailed explanation for measurement and data sources for variables in sustainable current account, please refer to Chinn and Prasad (2003) and You and Sarantis (2008).

References

Aziz, J. and Li, X., 2008, "China's Changing Trade Elasticities", *China and World Economy*, 16(3), 1-21,

Ahmed, S. and Park, J. H., 1994, "Sources of Macroeconomic Fluctuations in Small Open Economies", *Journal of Macroeconomics*, 16(1), 1-36.

Barisone, G., Driver, R. L. and Wren-Lewis, S., 2006, "Are Our FEERs Justified?", *Journal of International Money and Finance*, 25, 741-759.

Blanchard, O.J., 1985, "Debt, Deficits and Finite Horizons", *Journal of Political Economy*, 93, 233-247.

Cappiello, L. and Ferrucci, G., 2008, "The Sustainability of China's Exchange Rate Policy and Capital Account Liberalisation", *Occasional Paper*, 82, European Central Bank.

Cheung, Y-W., Chinn, M. D. and Fujii, E., 2009, "China's Current Account and Exchange Rate", *NBER Working Paper Series*, 14673.

Chinn, M. and Prasad, E. S., 2003, "Medium-Run Determinants of Current Accounts in Industrial and Developing Countries: An Empirical Exploration", *Journal of International Economics,* 59, 47-76.

Cline, W. R., 2005, *The United States as a Debtor Nation*, Institute for International Economics and Center for Global Development, Washington DC.

Cline, W., R. 2007, "Estimating Reference Exchange Rates", Paper presented to a workshop at the Peterson Institute sponsored by Bruegel, KIEP, and the Peterson Institute.

Cline, W. R. and Williamson. J., 2007, "Estimates of the Equilibrium Exchange Rate of the Renminbi: Is There a Consensus and, If Not, Why Not?" Paper presented at the Conference on China's Exchange Rate Policy, Peterson Institute, Washington DC.

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

Debelle, G. and Faruqee, H., 1998, "Savings-Investment Balances in Industrial Countries: An Empirical Investigation", in Isard, P. and Faruqee H. Eds., *Exchange Rate Assessment: Extensions to the Macroeconomic Balance Approach*, *IMF Occasional Paper*, 167.

Dées, S., 1999, "The Role of External Variables in the Chinese Economy; Simulations from a Macroeconomic Model of China", *CEPII Working Paper*, No 9/1999.

Eichengreen, B., 2006, "China's Exchange Rate Regime: The Long and Short of it", Revision of paper for Columbia University's conference on Chinese money and finance held in New York on 2–3 February, 2006.

Frankel, J., 2006, "On the Yuan: The Choice between Adjustment under a Fixed Exchange Rate and Adjustment under a Flexible Rate", *CESifo Economic Studies*, 52(2), 246-275.

Frankel, J. and Wei, S-J. , 2007, "Assessing China's Exchange Rate Regime", *Economic Policy*, 22(51), 575–627.

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

Goldstein, M., 2004, "Adjusting China's Exchange Rate Policies," *Working Paper*, 04-1, Institute for International Economics.

Gregory, A. W and Hansen, B. E., 1996, "Residual-based Tests for Cointegration in Models with Regime Shifts", *Journal of Econometrics*, 70(1), 99-126.

Harberger, A., 1950, "Currency Depreciation, Income and the Balance of Trade", *Journal of Political Economy*, 58, 47-60.

Hristov, K., 2002, "Fundamental Equilibrium Exchange Rates and Currency Boards: Evidence from Argentina and Estonia in the 90's", *Discussion Papers*, 22/2002, Bulgarian National Bank

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., Mosconi, R. and Nielsen, B., 2000, "Cointegration Analysis in the Presence of Structural Breaks in the Deterministic Trend", *Econometrics Journal*, 3(2), 216-249.

Laursen, S. and Metzler,L., 1950, "Flexible Exchange Rates and the Theory of Employment", *Review of Economics and Statistics*, 32, 281-299

MacKinnon, J. G., 2010, "Critical Values for Cointegration Tests", *Working Papers* 1227, Department of Economics, Queen's University,

Maeso-Fernández, F., Osbat, C. and Schnatz, B., 2001, "Determinants of the Euro Real Effective Exchange Rate: A BEER/PEER Approach", *Working Paper,* 85, European Central Bank.

Masson, P., 1998, "A Globally Consistent Conceptual Framework", in Isard, P. and Faruqee H. Eds., *Exchange Rate Assessment: Extensions to the Macroeconomic Balance Approach*, *IMF Occasional Paper*, 167.

Mendoza, E., 1995, "The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations", *International Economic Review*, 36, 101-137.

Otto, G., 2003, "Terms of Trade Shocks and the Balance of Trade: There is a Harberger-Laursen-Metzler Effect", *Journal of International Money and Finance*, 22, 155-184.

Shu , C. and Yip, R., 2006, "Impact of Exchange Rate Movements on the Mainland Economy", *China Economic Issues*, No. 3/06, Hong Kong Monetary Authority, Hong Kong.

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.

Williamson, J., 1983, *The Exchange Rate System*, Institute for International Economics, Washington DC.

Wren-Lewis, S., 2003, "Estimation of Equilibrium Exchange Rates for Sterling Against the Euro", *H. M. Treasury,* UK.

Wren-Lewis, S., 2004, "The Needed Changes in Bilateral Exchange Rates", in Bergsten, C. F. and Williamson, J., Eds., *Dollar Adjustment: How Far? Against What?*, Institute for International Economics, Washington, DC.

Yi , J., 2008, "Policy Options for China's Exchange Rate Regime in the Post-Reform Era", *Discussion Paper* No. 26, China Policy Institute and Centre for Global Finance, The University of Nottingham.

You, K. F. and Sarantis, N., 2008, "The Equilibrium Real Effective Exchange Rate of China: A NATREX Approach", *Discussion Paper* No 2008-15, Centre for International Capital Markets, London Metropolitan Business School, London Metropolitan University.

Table 1. History of China's Foreign Exchange Policy

Year	Some 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 the RMB moderately 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 Settlement Rate was introduced.
1984	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 as the swap rate was unified with the official rate. It was the second unification 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. The floating band of the CNY against the USD is daily ±0.3% while that of the CNY against other currencies has remained under the discretion of the central bank.
May 2007	Chinese central bank increased the floating band of the CNY against the USD from daily ±0.3% to ±0.5% while that of the CNY against other currencies has remained under the discretion of the central bank.
July 2008	Chinese central bank reversed to fixing the RMB against the US dollar at 6.83 CNY per USD.

Table 2. ADF unit roots tests

Trade equations variables				
	Level		1st Difference	
Variables	Lag Length	ADF	Lag Length	ADF
X	0	2.7869	0	-4.6824*
WM	1	-0.0903	4	-3.7740*
XCOM	0	-1.7310	3	-4.1449*
M	2	1.0659	1	-5.8318*
Y	2	0.4250	4	-5.1532*
MCOM	0	-2.2491	0	-4.5618*
XP	4	-0.6379	3	-6.1322*
WXPh	1	-2.6504	1	--3.0148*
DP	0	-0.5217	0	-3.9713*
MP	0	-2.0988	0	-3.8732*
WXPv	0	-2.4817	1	-5.3790*
Sustainable current account variables				
	Level		1st Difference	
Variables	Lag Length	ADF	Lag Length	ADF
CA	0	-0.6389	1	-4.8158*
NFAGDP	0	5.0893	0	-2.9985*
GOVBGDP	2	-2.1564	0	-6.4016*
ETOT	4	-2.3306	3	-4.8208*
RELDEPY	4	-1.4378	1	-5.6456*
RELDEPO	4	0.1726	3	-4.3408*
FDEEP	0	-1.1139	0	-4.7135*
OPEN	0	-0.3364	0	-4.3392*
RELY	3	3.3258	3	0.8731
RELYSQ	4	1.3068	4	1.8686
YGR	1	-4.2440*		

Note: Please see Appendix for variable description. All trade variables are measured in natural logarithm. * indicates 5% significance level. Critical value at 5% significance level is -2.9571.

Table 3. Gregory and Hansen tests for cointegration with one structural break at unknown date—trade equations

	Model C		Model C/T		Model C/S	
	G-H test stats	Break date	G-H test stats	Break date	G-H test stats	Break date
Export Volume Equation	-4.8851*	2001	-3.6286	–	-5.4040*	1986
Import Volume Equation	-5.7458***	2001	-5.6495**	2001	-5.9658**	2001
Export Price Equation	-4.1762	–	-5.8001***	1989	-5.4694*	1986
Import Price Equation	-4.6308	–	-4.9070	–	-6.8179***	1987

Note: The critical values for Gregory and Hansen (G-H) test for Model C are -4.69, -4.92 and -5.44 for significance level of 10%, 5% and 1% respectively; for Model C/T are -5.03, -5.29 and -5.80 for significance level of 10%, 5% and 1% respectively; for Model C/S are -5.23, -5.50 and -5.97 for significance level of 10%, 5% and 1% respectively. Critical values are obtained from Gregory and Hansen (1996). *, ** and *** indicate significance level of 10%, 5% and 1% respectively.

Table 4. Cointegration estimates for trade equations

Export Volume Equation		Import Volume Equation[a]		Export Price Equation[a]		Import Price Equation[ab]	
Model C		Model C/T		Model C/T		Model C/S	
WM	2.2415***	Y	0.7668***	WXPh	0.8229***	WXPv	1.1655***
	(0.2207)		(0.1398)		(0.0804)		(0.1562)
XCOM	2.5994***	MCOM	-0.3131**	DP	0.1809**	DP	-0.2160
	(0.4511)		(0.1398)		(0.0787)		(0.1516)
C	-10.0389**	T	-0.0612***	T	-0.0072***	D88-08 × WXPv	-0.7892***
	(3.9408)		(0.0026)		(0.0024)		(0.1907)
D02-08	0.3059*	D02-08	0.2066***	D90-08	0.1653***	D88-08 ×DP	-0.8408***
	(0.1693)		(0.0585)		(0.0522)		(0.1860)
Adjustment Factor in ECM	-0.1030	Adjustment Factor in ECM	-0.8607***	Adjustment Factor in ECM	-0.5871***	Adjustment Factor in ECM	-0.2302
	(0.1244)		(0.2219)		(0.1841)		(0.1683)

Note: Standard errors are in brackets. *, ** and *** indicate significance level of 10%, 5% and 1% respectively. D donates a dummy variable. For instance, D88-08 indicates a dummy that equals to 1 during 1988-2008 and zero during other years of the sample period.
a. the constant is deleted from equation as it is insignificant.
b. we re-estimated import price equation when DP is excluded. We obtain the following coefficients: 0.9405***(0.0131) for WXPv, -0.5643***(0.1079) for D88-08× WXPv, 0.6248***(0.1064) for D88-08×DP, and -0.2699 (0.1990) for adjustment Factor in ECM.

Table 5. Gregory and Hansen tests for cointegration with one structural break at unknown date—sustainable current account

	Model C		Model C/T		Model C/S	
	Test stats	Break date	Test stats	Break date	Test stats	Break date
Sustainable current account Equation	-5.1511*	1980	-5.1213	–	-6.0308**	1987

Note: The critical values for Gregory and Hansen (G-H) test for Model C are -5.02, -5.28 and -5.77 for significance level of 10%, 5% and 1% respectively; for Model C/T are -5.33, -5.57 and -6.05 for significance level of 10%, 5% and 1% respectively; for Model C/S are -5.75, -6.00 and -6.51 for significance level of 10%, 5% and 1% respectively. Critical values are obtained from Gregory and Hansen (1996). *, ** and *** indicate significance level of 10%, 5% and 1% respectively.

Table 6. Cointegration estimates for the sustainable current account

Medium-tern Sustainable Current Account Equation[a]							
Model C							
ETOT	0.11964***	RELDEPY	-0.7270***	GOVBGDP	1.4820**	D81-08	-6.9563***
	(0.0516)		(0.1800)		(0.5766)		(2.3241)
Adjustment Factor in ECM	-0.7475**						
	(0.2709)						

Note: Standard errors are in brackets. *, ** and *** indicate significance level of 10%, 5% and 1% respectively.
a. the constant is deleted from equation as it is insignificant.

Table 7. Current account and misalignment rates (%) in the nominal CNY/USD exchange rate: 2004-2008

Our Findings						
Year	2004	2005	2006	2007	2008	Average
CA	3.6	7.2	9.5	10.9	10.0	
TCA	8.2	10.0	12.2	11.5	8.8	
SCA	4.5	4.8	5.0	5.1	5.1	
Nominal CNY/USD rate	8.3	8.2	8.0	7.6	7.0	
Nominal EERs	6.5	6.0	5.3	5.1	5.2	
Implied Misalignment (%)	-26.7	-37.9	-51.8	-49.8	-33.5	-39.9
Adjustment Required (%)	-21.1	-27.5	-34.1	-33.2	-25.1	-28.2
Simulations using 3% SCA						
Year	2004	2005	2006	2007	2008	Average
Nominal EERs	5.8	5.2	4.5	4.3	4.5	
Implied Misalignment (%)	-58.8	-78.3	-75.8	-53.2	-42.8	-61.8
Adjustment Required (%)	-37.0	-43.9	-43.1	-34.7	-30.0	-37.8

Note: the minus sign of "Implied Misalignment" implies undervaluation. The minus sign of "Adjustment Required" implies revaluation needed. CA, TCA and SCA denote actual current account, trend current account and sustainable current account as a percentage of GDP respectively.

Table 8. Previous studies estimating equilibrium nominal CNY/USD rates

Study	Model	Sample period	TCA	SCA	Results
Wren-Lewis (2004)	Including Chin in FABEER model	2002	3.4%	(1) 1%; (2) 0%	(1) 20% undervalued (2) 28% undervalued
Jeong and Mazier (2003)	FEER	1980-2000	-2-4% in 1994-2000	-1%— -1.5%	60% undervalued
Our Study	Expanding FABEER model to a twelve area model	1976-2008	0.1% in 2002; -0.8% during 1997-2000	3.9% in 2002; 3.0% during 1997-2000	Overvalued by 24.7% in 2002; Overvalued by 35.1% during 1997-2000

Figure 1. Actual trade balance and full trend trade balance (million USD)

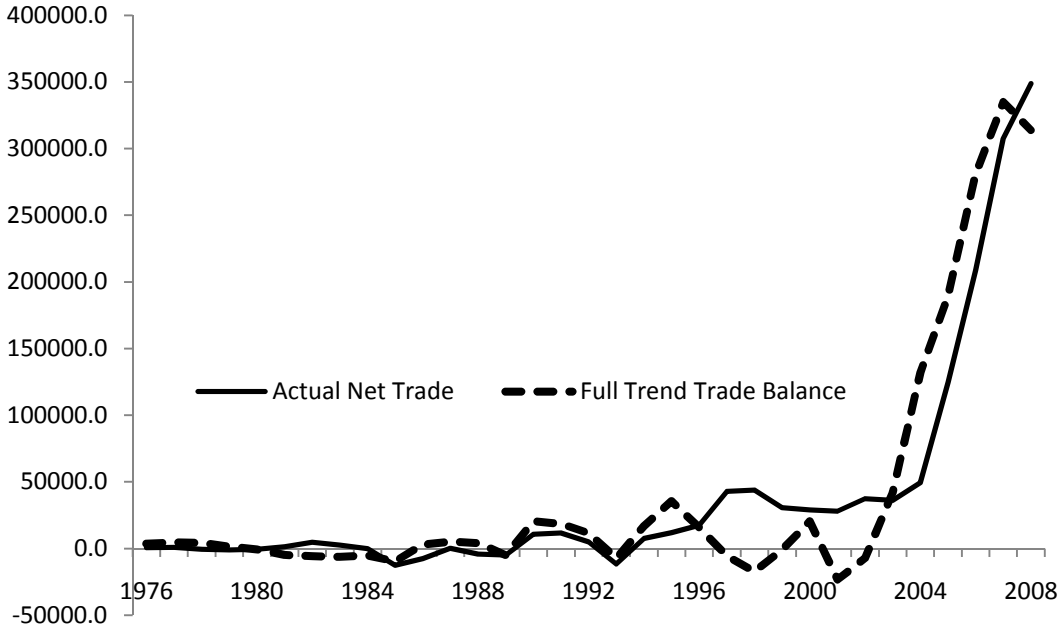


Figure 2. Actual (CA), trend (TCA), and sustainable (SCA) current accounts (% of GDP)

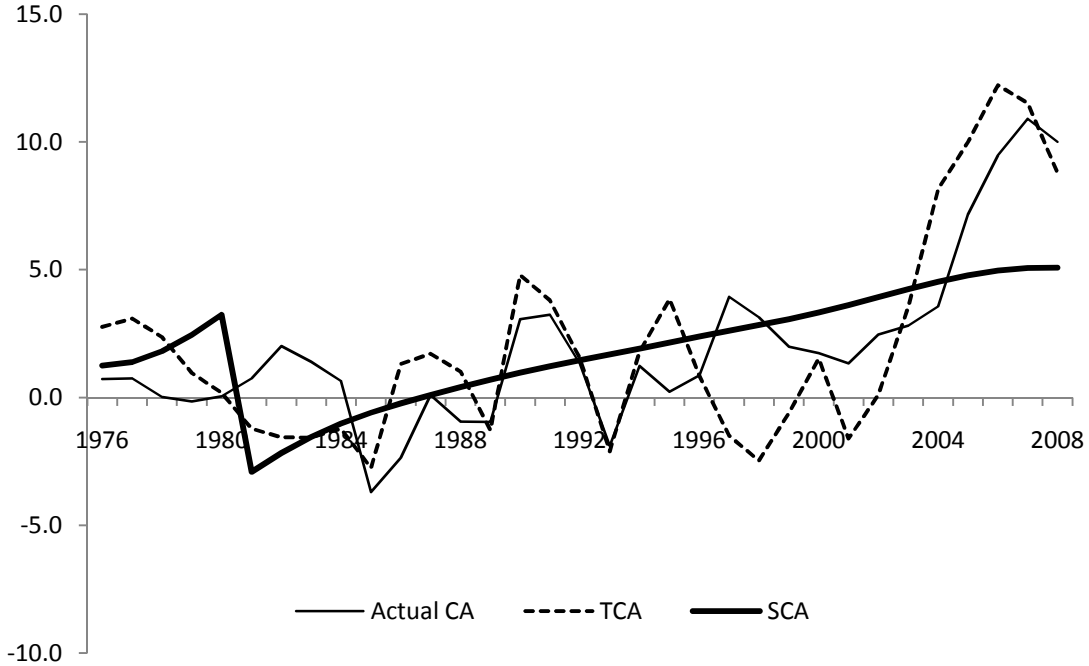


Figure 3. Nominal equilibrium and actual exchange rates (EERs)

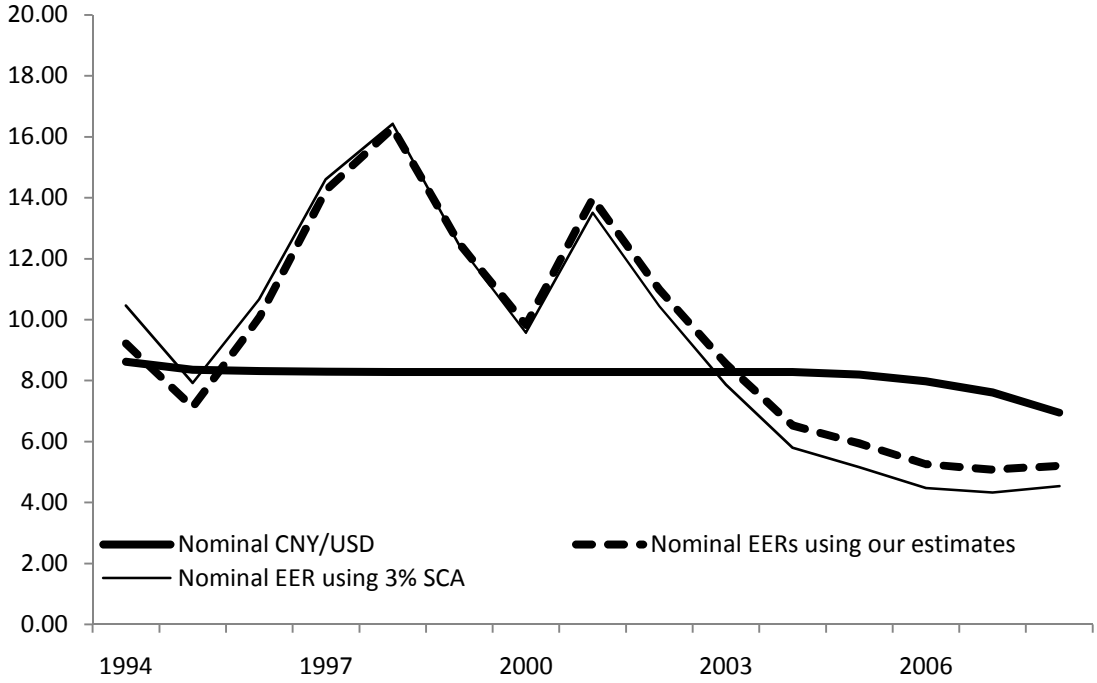
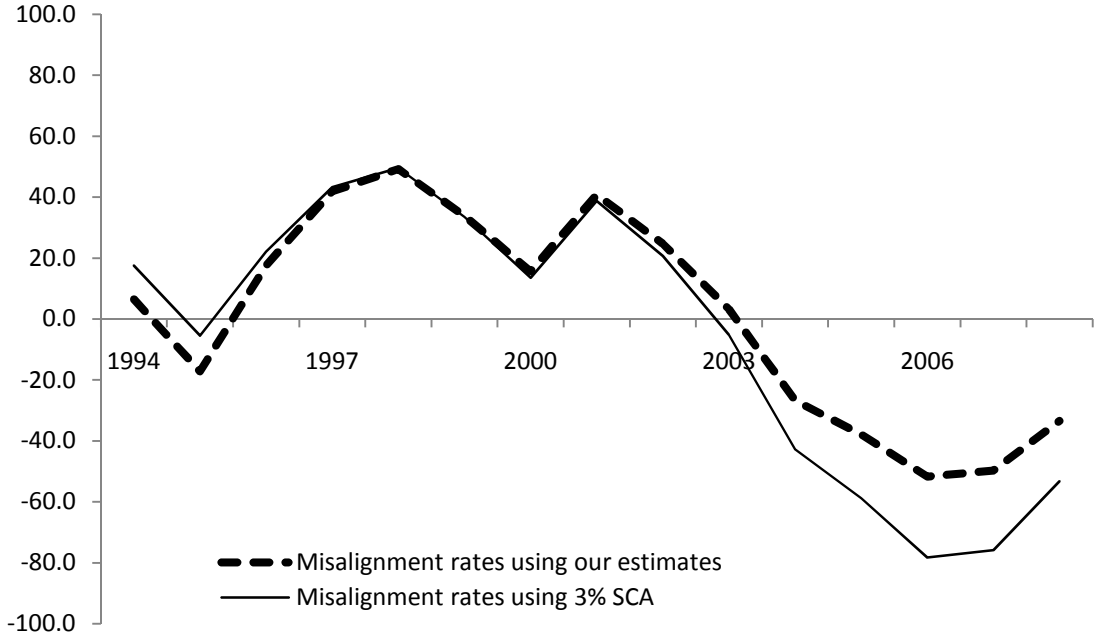


Figure 4. Misalignment rates (%)



Note: Misalignment rate=[(Nominal EERs – N)/Nominal EERs]*100%; N is measured as CNY per USD; a positive (negative) value implies an overvaluation (undervaluation) of the nominal RMB.