London Metropolitan University

The Equilibrium Exchange Rate of the Chinese Renminbi: Determinants and Misalignments

Ke Fei You

Department of Economics, Finance and International Business

Calcutta House Library
Old Castle Street
London E1 7NT
LONDON metropolitan university

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Abstract

The aim of this thesis is to investigate the equilibrium exchange rate of the Chinese currency, Renminbi (RMB). We extend the NATREX and FABEER models and modify the FEER model to make them applicable to China. Empirical estimations are carried out to obtain the equilibrium exchange rate for the real bilateral CNY/USD, nominal bilateral CNY/USD, and the real effective exchange rates. The sample period is 1952-2005.

This thesis incorporates into the theoretical models 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. In addition, 11 of China's main trade partners are included in the extended multi-country FABEER model. Many of these trade partners have never been included in any previous studies.

This thesis constructs a large data set of consistent time series that includes economic fundamentals, trade-related variables, Euro variables and real effective exchange rate for the period 1952-2005. It carries out for first time an econometric estimation of total factor productivity when rural transformation is taken into account. The effective exchange rate was for the first time constructed backwards to 1960, including trade partners that account for over 80% of China's foreign trade.

At the empirical level, the thesis provides the first comprehensive application and comparison of the NATREX, FEER and FABEER models to China. It is also the first time the equilibrium exchange rates for the nominal bilateral CNY/USD and the real effective exchange rates are estimated for both pre- and post-reform periods. In addition, it is the first study that presents a comparative investigation of different measures of the exchange rate.

The empirical results support the equilibrium relationships between the economic fundamentals and the exchange rates in a manner that is consistent with the predictions of the theoretical models. The empirical evidence generally suggests overvaluation in the pre-reform period and undervaluation for the post-reform period. However, the misalignment rates, especially for the recent years, have not been as large as suggested by most previous studies.

Chapter 1
Introduction

China is by far the largest developing economy that still chooses to maintain a currency peg. With the ongoing global current account imbalances, the value of its currency, Renminbi (RMB)[1], has been a central concern amongst politicians and academics. China's growing importance in the world economy and its mounting trade surplus with the US, as well as its huge foreign exchange reserves, have confronted researchers with the following two questions: is the RMB undervalued? If yes, by how much?

To answer these questions, the equilibrium exchange rate of the RMB has been investigated by a number of studies, especially after the visit of the US Treasury Secretary John Snow to China at the end of 2003. Amongst them, alternative models have been employed and different conclusions were drawn. One strand of the literature finds severe undervaluation of the RMB and the other strand suggests the RMB is close to its equilibrium value.

1.1. Motivation

This thesis investigates the equilibrium exchange rate of the RMB. The thesis is motivated partly by the need to address several limitations of the existing literature, and partly by the important implications for China's exchange rate policy. Alternative models have been employed by previous studies. However, it is often the case that the

[1] Renminbi (RMB) is the name of the Chinese currency. Yuan is the unit of the currency. In Chinese people's daily life, goods and services are priced in Yuan. RMB is used by the Chinese authorities in their statements such as "The People's Bank of China (Central Bank of China) will issue new RMB notes with face value of 200 Yuan". CNY, which stands for Chinese Yuan, is the three-letter currency code used by the International Organization of Standardization. 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.

original models were developed for industrial countries and then applied directly to China without considering their limitations and applicability to China. Furthermore, some models have been employed extensively (i.e. PPP, BEER) whilst others (i.e. NATREX, FEER, FABEER) have rarely been implemented. Therefore, based on a review of the literature, this thesis identifies and adopts models that have not yet been employed extensively by researchers, and then carries out theoretical extensions or modifications of the chosen models to address their limitations and to make them applicable to China.

Another limitation of the existing literature arises from the fact that almost all studies focus on the recent post-reform period (i.e. last twenty years) or the period after 2000. The "reform and opening-up" policy was implemented by Deng Xiaoping in 1978. Since then, China has been transforming from a centrally-planned economy to a market-oriented economy. Furthermore, the nominal exchange rate of the Chinese Yuan (CNY) (currency unit of RMB) has been fixed against the US Dollar (USD) since 1994 and was also fixed before 1971; whilst during 1972-1993, there had been several adjustments in the nominal rates. 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, but also amongst different periods of nominal rate adjustments. Therefore, to be able to carry out such a comparative analysis and provide policy implications accordingly, this thesis covers both pre- and post-reform periods.

The Chinese economy has a growth path that distinguishes it from any other economies. Such a growth path is shaped by the evolution of economic fundamentals that reflect the unique features of the Chinese economy. However, the fundamentals that have been employed so far are largely restricted by or identical to the ones in the original models which were often 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 thesis incorporates the determinants that reflect the uniqueness of the economy as determinants of the equilibrium exchange rate of the RMB. Such incorporation is achieved via extensions or modifications of existing models at the theoretical level and via the construction of consistent time series for a wide range of fundamentals since 1952.

Previous studies often examine only one measure of the foreign exchange rate (often the real bilateral CNY/USD exchange rate). There have hardly been any studies that investigate the nominal equilibrium exchange rate. Though previous studies suggest the magnitudes of undervaluation or overvaluation in the real bilateral exchange rate, they provide little information for the policy makers as it is the nominal exchange rate, rather than the real exchange rate, that the Chinese policy makers actually adjust. This thesis provides a comprehensive analysis by investigating not only real bilateral and real effective exchange rates, but also the nominal bilateral CNY/USD exchange rate.

1.2. Structure of the Thesis

The thesis is organised as follows. Chapter 2 reviews the literature on alternative methods of the equilibrium exchange rate and their empirical applications to China. This helps to highlight the rational behind the motivation of this thesis, and identifies specifically the areas that warrant further research. Having identified the limitations of existing literature, the NATREX (Natural Real Exchange Rate), FEER (Fundamental Equilibrium Exchange Rate) and FABEER (Five Area Bilateral Equilibrium Exchange Rate) models are selected as the basis of further theoretical and empirical research in the following chapters. These three models are chosen for two reasons. First, their applications to China have been limited (especially the NATREX and FABEER models). Second, in contrast to PPP and BEER, the NATREX, FEER and FABEER models consider the whole economy and provide more information about the determination of the equilibrium exchange rate. This enables us to extend these models in order to analyse the importance of fundamentals that are crucial to China.

Chapter 3 looks into the Chinese economy and discusses the foreign exchange policy in both pre- and post-reform periods. This chapter begins with a description of the overall growth of the Chinese economy. It is followed by a detailed analysis of developments in the balance of payments, including a discussion of relevant trade policies and reforms. It then analyses foreign exchange policies that have been implemented since 1950s and corresponding developments in the foreign exchange market. Chapter 3 provides background information which is essential to understanding and interpreting the misalignments obtained in the following chapters.

Chapter 4 provides the first attempt to extend Stein's (1994) NATREX model to China. The original NATREX model that was applied to the US is extended in several perspectives to achieve its applicability to China. The terms of trade are regarded as an exogenous fundamental, which is more realistic for China. Time preference, which is regarded as exogenous in Stein (1994), is endogenised as a function of fundamentals such as demographic factors and liquidity constraints. Aggregate investment is divided into domestic private investment, government investment and foreign direct investment. Each investment component is modelled individually, thus enabling us to incorporate fundamentals such as relative unit labour cost and relative rate of return to capital. To derive total factor productivity, we consider a production function that incorporates the rural transformation. These extensions allow us to incorporate a variety of fundamentals as determinants of the equilibrium exchange rate for the RMB. These fundamentals capture the unique characteristics of the Chinese economy and no previous study covers and analyses such a wide range of fundamentals. Furthermore, based on dynamic stability analysis, we derive the medium-run and long-run real equilibrium exchange rates that are driven by these dynamic fundamentals.

Chapter 5 carries out the first empirical application of the extended NATREX model to China. It examines the NATREX for both the real bilateral USD/CNY exchange rate and the real effective exchange rate of the RMB. A data set of consistent time series for a large number of fundamentals is constructed for both pre- and post-reform periods. In particular, we estimate total and net factor productivity based on the production function in Chapter 4. It is the first econometric estimation of China's total factor productivity that takes into account the contribution of rural transformation. In addition, the real effective exchange rate of RMB is constructed backwards to 1960 (as official data from the IMF only starts from the 1980s) based on methods used by IMF but covering a much larger number of China's trade partners (trade with them accounts for over 80% of China's foreign trade). It is the first time the equilibrium real effective exchange rate of the RMB is estimated for both pre- and post-reform periods. Johansen cointegration methods are employed to test for the long-run equilibrium relationship among the variables. Before carrying out the cointegration tests, the stationarity of the variables is tested using ADF unit root tests. The Hodrick-Prescott filter is applied to fundamentals to remove the transitory components. Based on cointegrating vectors and smoothed fundamentals, we obtain the NATREX for both the real CNY/USD and the real effective exchange rates and calculate the misalignments.

Chapter 6 applies the modified FEER model to the real bilateral CNY/USD exchange rate in a two-country model. In order to estimate the trend current account, we construct time series of trade-related variables, including prices, volumes, competitiveness, commodity prices for export and import respectively, which enable us to estimate export/import prices and volumes equations separately for both pre- and post-reform periods. In previous FEER applications for China, the sustainable current account is either assumed to be a certain percentage of output, or estimated based on fundamentals that are designed for industrial countries (i.e. Debelle and Faruqee, 1998) or for a panel of developing countries that does not even include China (i.e. Chinn and Prasad, 2000). Therefore, Chapter 6 modifies the FEER model by incorporating into the sustainable current account fundamentals that embody the distinctive characteristic of the Chinese economy but have not been employed by previous studies. Next, this chapter presents the empirical analysis of the modified FEER model for both pre- and post-reform periods, while the few existing studies focus only on the post-reform period or the period after 2000. Based on the cointegrating vectors and smoothed fundamentals, FEER is derived and misalignments are calculated accordingly.

Chapter 7 estimates the FEER for the nominal bilateral CNY/ USD exchange rate in a multi-country model. For this purpose we use the multi-country FABEER (Five Area Bilateral Equilibrium Exchange Rate) model of Wren-Lewis (2003, 2004a), but with several extensions. Wren-Lewis (2003) develops the FABEER model for the major four economic blocs (US, Euro area, UK, and Japan) and Wren-Lewis (2004a) includes China into the FABEER model for a single year of 2002 based on assumptions about the sustainable current account of China. in this thesis we extend the model to 12 countries. In addition to China, we include 11 of its main trade partners (including the 4 above), whose trade with China accounts for over 80% of China's foreign trade. Furthermore, in Wren-Lewis (2004a), there is no breakdown of trade values into volumes and prices in the trade equations and all coefficients are calibrated. We separate trade values into volumes and prices. We construct consistent time series for trade-related variables and all equations for export/import volumes and prices are estimated. Moreover, Wren-Lewis (2004a) assumes the sustainable current account to be a certain percentage of GDP. Similar to Chapter 6, we model the sustainable current account on the saving and investment functions developed in Chapter 4 in order to incorporate a variety of fundamentals that embody the unique features of the Chinese economy. The sustainable current account is then estimated using cointegrating methods. Furthermore, the data span is expanded from a single year of 2002 to the whole of pre- and post-reform periods. Based on cointegrating vectors and smoothed fundamentals, the FEER and corresponding misalignments are computed.

Chapter 8 summarises the main findings of the thesis, outlines policy implications, and suggests areas for future research.

Chapter 2

Literature Review

2.1. Introduction

A number of alternative concepts have been used to define the equilibrium exchange rate. Based on these different concepts, an array of approaches has been developed to assess the equilibrium exchange rate. This chapter presents a review of the different approaches employed by existing studies as well as the corresponding conceptual frameworks that underpin these approaches. Alternative approaches reviewed in this chapter include the Purchasing Power Parity (PPP), Fundamental Equilibrium Exchange Rate (FEER), Behavioural Equilibrium Exchange Rate (BEER), and Natural Real Exchange Rate (NATREX). For each approach under review, we provide a selection of empirical applications of these approaches, focusing not only on studies on industrial economics, but also on developing and transition economics. Since the reform and opening up policy was implemented in 1978, the economic growth of China has gained considerable attention. The equilibrium values of the Renminbi (RMB) have been examined by many researches. In this chapter, we review in a separate section the existing empirical studies on China's equilibrium exchange rate using alternative approaches.

This chapter is organised as follows. Section 2.2 reviews the alternative concepts of the equilibrium exchange rate as well as corresponding approaches and empirical studies. Section 2.3 focuses on China. It provides an extensive review of existing literature that applies these alternative approaches to investigate the equilibrium exchange rate of China. Section 2.4 provides a summary of the limitations of existing studies on China.

2.2. Alternative Approaches to the Equilibrium Exchange Rate[1]

2.2.1. Purchasing Power Parity (PPP)

Purchasing Power Parity (PPP) states that the price level for a fixed basket of goods in any two countries should be identical after converting the prices into the same currency. The foundation of a strong version of PPP theory is the "law of one price" (LOP). It states that abstracting from complicating factors, such as the transportation costs, taxes and tariffs, any traded good in the world market will have the same price when it is calculated with a common currency. Applying this idea to the price of a market basket at time t, we have $P_t = S_t P_t^*$, where S_t, P_t and P_t^* denote nominal exchange rate (measured as domestic currency per unit of foreign currency), domestic and foreign price level of the basket respectively. Using logarithms yields

$$s_t = p_t - p_t^* \tag{2.1}$$

where lower case denote natural logarithm. Equation (2.1) is the absolute PPP. Relative PPP requires changes in relative price to be offset by changes in nominal exchange rate

$$\Delta s_t = \Delta p_t - \Delta p_t^* \tag{2.2}$$

If PPP holds, in statistical term, the real exchange rate (q_t) would be stationary

$$q_t = s_t - p_t + p_t^* \tag{2.3}$$

Literature in 1980s fails to reject the null of a unit root, with the exception of studies

[1] In existing literature, the exchange rate is measured as either domestic currency per unit of foreign currency or as foreign currency per unit of domestic currency. In this section we review the theoretical framework of the PPP hypothesis, FEER, BEER and NATREX models. The exchange rate in each model is defined according to the original theoretical framework. Therefore, the exchange rates in the PPP hypothesis and the FEER model are measured as domestic currency per unit of foreign currency, while in the BEER and the NATREX models the exchange rates are measured as foreign currency per unit of domestic currency. Hence an increase in the exchange rate indicates depreciation in the first pair of models and appreciation in the second pair of models. In our theoretical modelling and empirical estimations in the following chapters, we keep the same measures of exchange rates as defined in this section.

for hyper-inflation economies, employ long data span (i.e. 100 years), or not use the US dollar as a *numeraire*[2].

Some recent papers tend to use panel unit root tests and cointegration techniques. Amongst them, studies employ panel unit toot tests overall tend to find evidence supporting long-run PPP (e.g. Frankel and Rose, 1996; Oh, 1996; Wu, 1996; Coakley and Fuertes, 1997; Wu and Wu, 2001) with some exceptions (e.g. Papell, 1997; O'Connell, 1998; Cerrato and Sarantis, 2007a, b). Most recent studies employ nonlinear unit root techniques (e.g. Taylor *et al*, 2001; Chortareas *et al*, 2002; Chortareas and Kapetanios, 2003; Sarno *el al.*, 2004) and unit roots tests that allow for structural breaks (e.g. Narayan, 2006, 2008) find greater evidence for PPP compared with previous studies.

Another strand of literature employs time series cointegration (e.g. Taylor, 1988; Mark, 1990; Sarantis and Stewart, 1993; Cheung and Lai, 1993; Edison *et al* 1997; Ender and Falk, 1998; Coakley and Fuertes, 2000) and more recent panel cointegration techniques (e.g. Pedroni, 1997, 2000, 2004; Canzoneri *et al*, 1999; Banerjee, 1999; Baltagi and Kao, 2000; Imbs, 2002; Cerrato and Sarantis, 2008) to test PPP. Both provide mixed results.

For developing countries, there have been a limited number of studies using time series unit root tests (e.g. Cheung and Lai, 2000; Narayan, 2006), panel unit root tests (e.g. Phylaktis and Kassimatis, 1994; Wu and Chen, 1999; Luintel, 2000, Cerrato and Sarantis, 2007b), time series cointegration techniques (e.g. Doganlar, 1999; Salehizadeh and Taylor, 1999), and panel cointegration techniques (Nagayasu, 1998; Boyd and Smith, 1999; Basher and Mohsin, 2004; Cerrato and Sarantis, 2007b). Overall they tend to find mixed results[3].

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[2] See MacDonald (1995) and Breuer (1994) for surveys of earlier studies of PPP.

[3] For a recent survey of studies on PPP, please refer to Taylor (2006). PPP is not employed in the empirical studies of this thesis and hence relative studies are not discussed in great detail here.

2.2.2 Fundamental Equilibrium Exchange Rate (FEER)

2.2.2.1. Conceptual Framework

Since the Fundamental Equilibrium Exchange Rate (FEER) approach was first popularised by Williamson (1983), it has become an increasingly important approach to study the equilibrium exchange rate. FEER is the real exchange rate that maintains the external and internal balance in the medium-run. The internal balance is defined as the level of output that is consistent with both full employment and a low and sustainable rate of inflation. The external balance is characterised as the sustainable desired net flow of resources between countries when they are in internal balance. Because this approach focuses on economic fundamentals that persist over a medium-run, the short-run cyclical conditions and temporary factors are abstracted. In this sense, Williamson (1994) has characterised the FEER as the equilibrium exchange rate that would be consistent with the "ideal economic conditions".

The core of the macroeconomic balance approach is to equate the current account (CA) to the capital account with a negative sign ($-KA$)

$$CA = -KA \qquad (2.4)$$

The current account is explained as a function of home and foreign aggregate output or demand, y_d and y_f respectively, and the real effective exchange rate q (measured as domestic currency per unit of foreign currency)

$$CA = b_0 + b_1 q + b_2 \bar{y}_d + b_3 \bar{y}_f \qquad (2.5)$$

where the bars represent "sustainable", "normal", or "underlying" values (Clark and Macdonald, 1998); b_1, b_2 and b_3 are parameters. The signs of b_1, b_2 and b_3 are expected to be "+", "-", and "+". In equation (2.5), it is clear that the effective real exchange rate q, is the exchange rate that is consistent with the internal balance and remain unchanged. However, in the medium-run, q must adjust to FEER to match the sustainable capital account which equals to $-\overline{KA}$. Therefore, FEER is value of the exchange rate that consistent with both internal and external balances in the medium-run. Based on equations (2.2) and (2.3), we can solve for FEER as

$$FEER = (-\overline{KA} - b_0 - b_2\bar{y}_d - b_3\bar{y}_f)/b_1 \tag{2.6}$$

Equation (2.6) shows that the FEER is a method to calculate the real exchange rate which is consistent with the medium-run macroeconomic equilibrium. The projected current account is compared with the exogenous capital account, whilst the FEER is the real exchange rate that brings the current account at full employment to equal the capital account. Therefore, FEER gives policymakers an assessment to evaluate the exchange rate regarding the sustainable current account position. It is assumed that a divergence of q from FEER will generate forces that will eventually eliminate this divergence. However, the nature of the adjustment forces is left unspecified. The implication of the FEER approach is to compare the real exchange rate with the FEER exchange rate. This estimates whether the current exchange rate is undervalued ($q > FEER$) or overvalued ($q < FEER$).

The FEER analysis is extended by Isard and Faruqee (1998), who separate the current account into the desired aggregate savings and investment at full employment. Thus, the equation (2.6) can be rewritten as

$$FEER = \left[(\bar{S} - \bar{I}) - b_0 - b_2\bar{y}_d - b_3\bar{y}_f)\right]/b_1 \tag{2.7}$$

where $\bar{S}$ and $\bar{I}$ represent the desired level of savings and investment separately. The advantage of this extension is that it generates plausible methods for estimating the equilibrium current account which depends much less on judgement than other implementations of the FEER approach.

The recursive characteristic of the FEER, discussed by Wren-Lewis (1992), implies that the current account determines that capital account without any feedback from the latter to the former. In particular, a shift in asset preference that changes the exchange rate will not affect the current account in the medium-run because neither savings nor investment is a function of the exchange rate. However, if the changes in the capital account persist for a long-run, the real exchange rate and current account will be affected.

2.2.2.2. Empirical Studies on FEER

There are two alternative ways to estimate FEER in existing literature. The first approach uses a complete macroeconomic model and the second approach uses the partial equilibrium model (Driver and Westaway, 2004).

The complete macroeconomic model approach, developed by Williamson (1983, 1994), includes the real exchange rate as one variable within a complete system of equations. This gives predicted values for each variable including the exchange rate. When the model is specified for a medium-run the solution will be the equilibrium exchange rate. To identify the equilibrium effective exchange rate that simultaneously achieve external and internal balance, researches have employed alternative multi-country macroeconometric models, which include EAG (External Adjustment with Growth model), NIGEM (National Institute Global Econometric Model), Interlink model of the OECD, Intermod model (developed as a variant of IMF's Multimod model), Mimosa (Multinational Integrated Model for Simulation and Analysis), MSG (Mckibbin-Sachs Global Model)[4].

[4] For detailed description of these models, please refer to Williamson (1994). These models are not discussed in detail here as they are not employed in this thesis. In recent years, there have not been many studies apply compete macroeconomic approach in the context of FEER model. Some examples are Bayoumi et al (1994), Church (1999), Borowski and Couharde (2003).

The second approach, partial equilibrium approach, has been widely employed to more recent simulations of the FEER. The partial equilibrium approach attempts to estimate part of this complete macroeconomic system, but to treat the rest as an exogenous input based on judgement. This approach computes the "off-model" estimates of potential output and medium-run current account and uses them in the econometrically estimated static trade equation to produce a path for the FEER. The motivation is mainly simplicity and clarity, and the validity of such conditioning depends on how realistic it is to assume there is no feedback from the estimated exchange rate to these exogenous variables. However, if there is feedback from the real exchange rate to trend output or savings and investment decision there may be inconsistencies between the off-model assumptions and the solution for the real exchange rate.

There are three steps in estimating the FEER using the partial equilibrium approach (Driver and Wren-Lewis, 1998). The first step is to estimate the trend current account that is consistent with the internal balance. The second step is to calculate the sustainable (medium-run equilibrium) current account—the current account that corresponds to external balance. The trend current account in the first step is estimated by treating the real exchange rate as exogenous. However, the real exchange rate must move to clear the balance of payments and simultaneously drive the trend current account to match the sustainable current account. The third step is to calculate the real exchange rate that delivers this match.

Some recent empirical studies using the partial equilibrium approach[5] include Driver and Wren-Lweis (1998), Isard *el al* (2001), Hristov (2002), Jeong and Mazier (2003), Coudert and Couharde (2003, 2007) and Wren-Lewis (2003, 2004a, 2004b), Barisone,

[5] For earlier studies, please refer to Driver and Westaway (2004).

et al (2006). Though all adopt the partial equilibrium approach, they differ in specific measurements of the trend current account (current account under internal balance) and the sustainable current account (current account consistent with the external balance). For instance, for the trend current account, in some studies it is measured based on multi-country model (e.g. Isard *et al*, 2001, Jeong and Mazier, 2003; Coudert and Couharde, 2003, 2007; Wren-Lewis, 2003, 2004a, 2004b), while in some others it is modelled for each individual country based on traditional demand curve approach (e.g. Driver and Wren-Lweis, 1998; Barisone *et al*, 2006). In terms of the sustainable current account, in some studies it is modelled as savings minus investment (e.g. Isard *et al*, 2001, Jeong and Mazier, 2003, Coudert and Couharde, 2003, 2007, Barisone *et al*, 2006), an approach developed by the IMF (Debelle and Faruqee, 1998 and Masson, 1998), in some other studies it is obtained by off-model projections (e.g. Driver and Wren-Lewis, 1998, Wren-Lewis 2003, 2004a, 2004b).

Most of these studies focus on industrial countries except a few which focus on or include developing and transitions countries (i.e. Coudert and Couharde, 2003, 2007; Isard *et al*, 2001; Wren-Lewis, 2004a).

We further discuss Barisone *et al* (2006) and Wren-Lewis (2003) in detail as they are closely related to the following chapters. Barisone *et al* (2006) estimate FEERs for the 6 main industrial countries (the US, Japan, German, UK, French and Canada), for the period 1973 Q1-1997 Q4. To obtain the trend current account, they first estimate trade equations (export/import prices and volumes) for each country to strip out short-run shocks and then impose the internal balance condition (zero output gap) to obtain the trend net trade. The other two components of the trend current account, IPD (interest, profit and dividend) flows and net transfers, are regarded as exogenous, except they allow for exchange rate revaluations and smooth both series using the Hodrick-

Prescott filter (HP-filter). The sustainable current account, following Debelle and Faruqee (1998), is estimated based on savings-minus-investment norm. The FEERs are estimated as the equilibrium exchange rate in the medium-run that bring trend current account to match the sustainable value.

Typical partial equilibrium models estimate effective exchange rates for each country modelled and then these rates are transformed to recover bilateral exchange rates, such as Driver and Wren-Lewis (1998) and Barisone *et al* (2006). Wren-Lewis (2003) works with nominal bilateral exchange rate directly in his estimates of the equilibrium exchange rate of Sterling against the Euro for the period 1990-2002. Wren-Lewis (2003) estimates the trend current account in a multi-country FABEER (Five Area Bilateral Equilibrium Exchange Rate) model. The five areas are the US, Euro area, Japan, UK, and the rest of the world. Interaction between blocs occurs through import volumes and export prices, with the former determining other countries' export volumes and the latter influencing both the competitiveness of other countries' exports and domestic output as well as import prices. This is combined with exogenous assumptions about the medium-run sustainable current account to obtain the equilibrium exchange rates[6].

According to Akram *et al* (2003), there are some points of uncertainty in the existing literature of applying FFER to examine the equilibrium exchange rate. The first point concerns the magnitude of income and the price elasticities for imports and exports. Most empirical studies assume an income elasticity greater than unity and a price elasticity less than unity. Theoretically, the import share in the budget can increase over time and exceed unity in a long time period. However, if imports do not respond

[6] Wren-Lewis (2004a) and Wren-Lewis (2004b) extend the "Five Area Bilateral Equilibrium Exchange Rate" (FABEER) model of Wren-Lewis (2003) to include China, New Zealand and Australian, where there is no feedback from China, New Zealand and Australian to the five area/currencies the US, Euro area, Japan, UK and the Rest of the World.

much to the change in the exchange rate, changes in FEER level may be unreasonably large when there is a partial change in the income level.

Another uncertainty comes from the specification of internal balance. In the FEER model, the equilibrium level of GDP is generally assumed to be identical to the potential GDP level. However, different methods are used to derive this level. In the large macroeconomic models, GDP is modelled as a function of production factors. Potential GDP is explained as part of the GDP. In the partial equilibrium approach, to assess the potential GDP, the trend component form the time series for GDP is extracted by filter techniques. However, by estimating the equilibrium level for GDP outside the FEER model, the possible feedback effects from the real exchange rate level to the GDP may be neglected. It is also fairly common to estimate the potential GDP with the help of time trends. However, this approach may also neglect the fact that the (potential) GDP does not grow with a constant rate.

A third uncertainty concerns the specification on the external balance. It is simple to set the current balance to zero by assuming that there is no sustainable income from abroad. However, this is not realistic because there might be a deficit or surplus that lasts for several years. Therefore, the external balance can be defined as the average current account balance over a business cycle, or it can be defined as the deficit or surplus on the current account balance which constitutes a constant share of GDP.

2.2.3. Behavioural Equilibrium Exchange Rate (BEER)

The Behavioural Equilibrium Exchange Rate (BEER) was put forward by Macdonald and Clark (1998). They employ a reduced form equation (2.8) that explains the behaviour of the real effective exchange rate (q_t) over the sample period

$$q_t = \beta_1' Z_{1t} + \beta_2' Z_{2t} + \tau' T_t + \varepsilon_t \qquad (2.8)$$

where Z_{1t} is a vector of economic fundamentals that are expected to have a persistent effect over the long-run, Z_{2t} is a vector of economic fundamentals that affect the real exchange rate over the medium-run, T_t is a vector of transitory factors affecting the real exchange rate in the short-run, β_1', β_2' and τ'_t are vectors of reduced-form coefficients, ε_t is the random disturbance term, q_t is the actual real exchange rate. Therefore, the value of the actual real exchange rate is determined by the long-run fundamentals, medium-run fundamentals and short-run variables. Whilst the current value of equilibrium exchange rate (q_t') is determined by two sets of economic fundamentals

$$q_t' = \beta_1' Z_{1t} + \beta_2' Z_{2t} \tag{2.9}$$

Macdonald and Clark (1998) define the current misalignment, denoted by cm_t, as the difference between the actual real exchange rate and the real exchange rate given by the current value of all the economic fundamentals

$$cm_t \equiv q_t - q_t' = q_t - \beta_1' Z_{1t} - \beta_2' Z_{2t} = \tau' T_t + \varepsilon_t \tag{2.10}$$

The total misalignment is defined as the difference between the actual real rate and the real rate given by the sustainable or long-run values of the economic fundamentals, represented by $\overline{Z}_{1t}$ and $\overline{Z}_{2t}$

$$tm_t = q_t - \beta_1' \overline{Z}_{1t} - \beta_2' \overline{Z}_{2t} \tag{2.11}$$

By adding and subtracting q_t' from the right hand side of equation (2.11) we get

$$tm_t = \tau' T_t + \varepsilon_t + \left[\beta_1'(Z_{1t} - \overline{Z}_{1t}) + \beta_2'(Z_{2t} - \overline{Z}_{2t})\right] \tag{2.12}$$

Therefore, in the BEER approach, the total misalignment consists of the transitory factors, random disturbances, and the magnitude to which the economic fundamentals are away from their sustainable values. The economic fundamentals included in

Macdonald and Clark (1998) are the interest rate differential between the domestic and the foreign countries, ratio of domestic to foreign government debt, terms of trade, relative price of non-tradables and net foreign assets.

The total misalignment in the BEER approach can be decomposed into transitory factors, random disturbances and the magnitude to which the economic fundamentals are away from their sustainable values. It captures movements in real exchange rates over time rather that just in the medium or long-run. It is in this sense Driver and Westaway (2004) regard the BEER as a short-run equilibrium concept. On the other hand, FEER is an approach designed to calculate the real effective value of a currency over the medium-run. It abstracts from the short-run cyclical conditions and temporary factors and focuses on "economic fundamentals" which are likely to persist over the medium-run. Hence FEER is a medium-run equilibrium concept.

The BEER model has been applied to industrial countries (e.g. Alberola *et al*, 1999; Hansen and Roeger, 2000; Clostermann and Schnatz, 2000; Lorenzen and Thygesen, 2000; Maeso-Fernández *et al*, 2001; Schnatz *et al*, 2003). Other fundamentals such as real price of oil and relative productivity are introduced apart from fundamentals employed in Macdonald and Clark (1998). The BEER model has also been employed to investigate the equilibrium exchange rate for transition countries (Filipozzi, 2000; Kim and Korhonen, 2002; Égert, 2002; Rahn, 2003; Maeso-Fernández *et al*, 2004) and more recently developing countries (Dufrenot and Yehoue, 2005; Marial, 2005; Iimi, 2006; Iossifiv and Loukoianova, 2007). Fundamentals such as productivity, openness and investment share of GDP are incorporated as determinants of BEER for these non-industrial countries.

2.2.4. Natural Real Exchange Rate (NATREX)

2.2.4.1. Conceptual Framework

The concept of NATREX, introduced by Stein (1994), is the "natural real exchange rate" that would prevail if speculative and cyclical factors could be removed whilst unemployment is at its natural rate. In the NATREX model, the medium-run equilibrium conditions determining the NATREX are the basic balance of payments which is in equilibrium and the portfolio balance between the holdings of assets denominated in the home and in the foreign currency. The level of capital stock and net foreign debt are pre-determined. In the long-run, changes in fundamentals, such as disturbances to productivity and social thrift at home and abroad, affect the evolution of the capital stock and net foreign debt via the investment function and the current account. As capital stock and net foreign debt change, the medium-run equilibrium values of the real exchange rate and the real interest rate change. When the capital stock and net foreign debt converge to their steady states the NATREX achieves its steady-state value and is a function of the disturbances. The distinction between the medium and long-run is an essential feature of the NATREX model. The NATREX is a moving equilibrium real exchange rate responding to continuous changes in exogenous and endogenous real fundamentals. The real exchange rate can be determined at three different stages of adjustment

$$R(t) = R(k(t), F(t); Z(t), T(t)) \quad \text{actual real exchange rate} \tag{2.13}$$

$$R = R(k(t), F(t); Z(t)) \quad \text{NATREX} \tag{2.14}$$

$$R^{*} = R^{*}(Z(t)) \quad \text{steady-state rate} \tag{2.15}$$

where Z denotes real exogenous disturbances, k and F denote capital stock and net foreign debt, T denotes short-run speculative and cyclical factors. The actual real exchange rate $R(t)$ differs from the NATREX due to T and the differences converge to zero. Therefore, in the NATREX model, the actual real exchange rate converges to the NATREX, while the NATREX itself is moving towards the steady-state rate R^*. The trajectory of NATREX can be explained by the real fundamentals Z in a manner consistent with the predictions of the NATREX model.

Compared with PPP theory, the NATREX does not focus upon whether or not the real exchange rate is stationary over an arbitrary period, but whether or not it reflects the fundamentals. The interaction between the medium-run and the long-run enables the NATREX to be a dynamic equilibrium rate. In the FEER model, the FEER is the rate that brings the current account in line with the "desirable capital account" which is not distorted by the public policies. In contrast the NATREX is affected by changes in fiscal policies and it will predict the equilibrium exchange rate that reflects the policy changes. Therefore, the NATREX is a moving equilibrium that does not consider the desirability of the disturbance or the outcome.

2.2.4.2. Empirical Studies on NATREX

Existing studies on NATRAX mainly focus on industrial countries: USA (Stein, 1994, 1995a, 2001), Germany (Stein, 1995b; Stein and Sauernheimer, 1996; Stein and Paladino, 1999), France (Crouhy-Veyrac and Marc, 1995; Stein and Paladino, 1999), Italy (Stein and Paladino, 1999; Gandolfo and Felettigh, 1998; Federici and Gandolfo, 2002), Belgium (Verrue and Colpaert, 1998), Australia (Lim and Stein, 1995), Euro Zone (Stein, 2001, 2002; Duval 2002; Detken *et al*, 2002). On the other hand, applications of the NATREX model to developing countries have been limited: Latin America (Connolly and Devereux, 1995), Singapore (Siregar and Har, 2001; Rajan and Siregar, 2002), Hong Kong (Rajan and Siregar, 2002), ASEAN4 countries (Indonesia, Malaysia, Philippines, Thailand) plus Korea (Stein and Lim, 2004), Marocco (Bouoiyour and Rey, 2005), Czech Republic (Frait and Komárek, 2001), and China (Holger *et al* 2001). We discuss Stein (1994) and Lim and Stein (1995) in detail as they are closely related to the following chapters[7].

Stein (1994) estimates the NATREX for the US from 1976 to 1988. It is the first time the NATREX model is specified and applied. The real exchange rate is defined as the nominal exchange rate adjusted by domestic and foreign GDP price deflators. The two fundamentals that affect the real exchange rate are time preference and productivity. The endogenous variables are the real exchange rate and the ratio of current account balance over the Gross National Product (GNP). Twelve-quarter moving averages of the growth of real GDP in the US and the G-10 countries are employed to measure the productivity of capital at home and abroad. The ratio of consumption and government purchases to the GNP is employed as a proxy of the US time preference. The NATREX is derived using the estimated coefficients and actual values of fundamentals. The results suggest that, though with some significant short-period deviations (which are interpreted as the effect of speculative factors), the real exchange rate converges to the NATREX.

Lim and Stein (1995) apply the NATREX model to Australia. In general, they follow the study of Stein (1994) with the same two fundamentals (productivity and social time preference). However, compared with the US, Australia is regarded as an open but small economy. Therefore there are four adjustment of the original NATREX model. First, the goods market is divided into tradables and non-tradables and therefore goods market clearing condition is equivalent to tradables market balance. Hence the real exchange rate is a function of the relative price of non-tradables and terms of trade. Second, the terms of trade of Australia are regarded as exogenous.

[7] The above mentioned studies on developing countries using NATREX model overall adopt same modelling and fundamentals as Stein (1994) and Lim and Stein (1995). The only application for China,

Third, as the uncovered interest parity was rejected between Australia and US long-run real interest rate, a risk premium (measured by net foreign assets relative to GDP) is incorporated into the portfolio balance equation. Fourth, the social consumption is divided into household consumption and government expenditure.

2.3. Empirical Studies on China's Equilibrium Exchange Rate

In this section we review the recent literature that investigate China's equilibrium exchange rate and misalignments using PPP, FEER, BEER and NATREX approaches. Table 2.1 further summarises.

2.3.1. Purchasing Power Parity (PPP)

Existing studies that examine PPP in China use both time series (Zhang, 2002; Wang, 2004, 2005; Shi, 2006; Dunaway *et al*, 2006) and panel data (Frankel, 2005; Dunaway *et al*, 2006; Coudert and Coharde, 2007).

In the category of PPP estimations for a single-country (China), based on standard Dicky-Fuller (ADF) and Phillips-Perron unit root tests, Zhang (2002) and Shi (2006) find the real bilateral exchange rate[8] and real effective exchange rate respectively are not stationary for the period 1980-1999 and 1991-2005 respectively. Wang (2005) applies the ADF unit root test to the real effective exchange rate for the period 1980-2003 and can not reject the null hypothesis of unit root. Zhang (2002) and Wang (2005) further estimate the cointegration relationship between their measurement of exchange rates and relative prices, with the former finds one cointegration relationship but wrongly signed and the latter finds no evidence of cointegration.

Holger *et al* (2001) is discussed in detail in Section 2.3.4.

[8] The real (nominal) bilateral exchange rate in this section, if not otherwise stated, refers to the real (nominal) bilateral exchange rate of CNY against the USD.

Their results suggest the PPP does not hold for China. Wang (2004) and Dunaway *et al* (2006) apply the extended PPP approach[9] to the real effective exchange rate for the periods 1980-2003 and 1980-2002 respectively. Wang's (2004) findings suggest small undervaluation (around 5%) in 2003 and Dunaway *et al* (2006) find a much larger undervaluation of around 30% in 2005 based on an out-of-sample forecast.

Based on panel data, Frankel (2005) estimates the extended PPP for a large group of countries (118 including China) containing both industrial and developing countries for two years of 1990 and 2000. In both cases China is an outlier and the real bilateral exchange rate is undervalued between 34%-42% in 1990 and between 36%-45% in 2000. Dunaway *et al* (2006) estimate extended PPP for a smaller group of 11 Asia-Pacific economies including China for the period 1980-2002. Their findings suggest the real effective exchange rate could be undervalued by up to 50% in 2005 based on an out-of-sample forecast. Coudert and Coharde (2007) estimate the extended PPP for a panel of 132 countries including China for the period 2000-2004. The economic fundamentals chosen are the relative productivity differentials approximated by GDP per capita relative to the US. The panel regression shows a correctly signed and statically significant coefficient. However, China is outside the confidence intervals. Based on the estimated coefficients, they find that the real exchange rate is undervalued by 44% to 64% in 2000-2004. Coudert and Coharde (2007) also estimate the PPP directly using a panel of 23 emerging countries from 1980 Q1 to 2005 Q2. The real exchange rate and relative price level are non-stationary and they are cointegrated. However, when they estimate PPP for each individual country, the relative price level is wrongly signed for China. Based on coefficient obtained from

[9] The extended PPP approach is based on the assumption that purchasing power parity holds in the long-run, but factors may act to prevent the actual exchange rate from converging to its PPP-determined level in the short to medium-run (Dunaway *et al*, 2006).

the panel cointegration, they calculated the real exchange rate is undervalued by 16%-29% in 2005 Q2.

Some researchers attempt to address the Balassa-Samuelson (BS) effect for China, though results are mixed. Chinn (2000) finds there is no BS effect in China, using both time series and a panel of 9 Asian countries including China. Coudert and Coharde (2007) find evidence for the existence for BS effect for a panel of 23 emerging countries including China. But when using time series data China is an outlier amongst the 23 countries, and hence no evidence of BS effect is found for China.

2.3.2. Fundamental Equilibrium Exchange Rate (FEER)

To our knowledge, all existing studies that apply FEER to China use the partial equilibrium model (i.e. Jeong and Mazier, 2003; Wang, 2004; Wren-Lewis, 2004a; Coudert and Coharde, 2007).

Amongst them, Wang (2004) evaluates the equilibrium exchange rate for a single country China based on a simplified FEER model for the year 2000-2002. The trend current account is measured by the average for 2000-2002 (2.1%). Two alternative sustainable current accounts are provided, one based on coefficients obtained from Chinn and Prasad (2000) (3.10%) and the other derived by estimating the current account balance that would stabilize the net foreign assets to GDP ratio at the 2001 level (0.98%). The real effective exchange rate is moderately overvalued and undervalued based on the first and second sustainable current account respectively[10].

Jeong and Mazier (2003) estimate trend and sustainable current account for China, Japan and South Korea for the period 1981-2000. The trend current account is

[10] Wang (2004) does not provide detailed numbers of undervaluation or overvaluation.

obtained based on a multi-country model for China, Japan, South Korea, US and the Euro Area[11] though parameters of the trade equations for each country are taken from existing studies. In terms of the sustainable current account, it is estimated following Debelle and Faruqee (1998) and Chinn and Prasad (2000) as savings minus investment. Panel data for 19 industrial countries are used in the estimation to give sustainable current account for the Japan and South Korea, while another panel data for 18 emerging countries are used to give the value for China. Based on their estimations, the nominal bilateral (against USD) and real effective exchange rates of China is largely overvalued in the mid-1980s (20% in nominal terms and 30% in real effective terms), close to its equilibrium parity from the late 1980s to early 1990s, and strikingly undervalued since 1997 (60% in nominal terms and 33% in real effective terms).

Coudert and Coharde (2007) work with both real bilateral exchange rate and real effective exchange rate for China for two years: 2002 and 2003. The trend current account is estimated based on the NIGEM model and the two alternative sustainable values of -2.8% and -1.5% are extracted from Williamson and Mahar (1998) and Jeong and Mazier (2003). Based on these values, in 2002, the bilateral real exchange rate is undervalued by 59% and 49% respectively and the real effective exchange rate is undervalued by 33% and 27% respectively; in 2003, the bilateral real exchange rate is undervalued by 54% and 44% respectively and the real effective exchange rate is undervalued by 30% and 23% respectively.

Wren-Lewis (2004a) includes China into the framework of FABEER model of Wren-Lewis (2003), assuming there is no feedback from China to the four major countries in the FABEER model. The FABEER model works with the nominal exchange rate

[11] The multi-country model in Jeong and Mazier (2003) follows Couharde and Mazier (2000) and Borowski and Couharde (2000) with some extensions.

directly and in Wren-Lewis (2004a) the nominal exchange rate of CNY/USD is considered. Due to data limitation, for the only year of 2002, the trend current account is obtained based on calibrated parameters in trade equations and the trade equations do not split between trade prices and volumes. The sustainable current account is based on off-model projections of 1% and 0% (as a percentage of GDP) for 2002 and the misalignment of the nominal bilateral exchange rate is around 20% and 28% respectively.

2.3.3. Behavioral Equilibrium Exchange Rate (BEER)

Most existing literature that use the BEER model to examine the equilibrium exchange rate for China employ time series data (i.e. Zhang, 2001; Zhang, 2002; Funke and Rhan, 2005; Wang *et al*, 2007; Chen, 2007). Few studies have estimated BEER for China in a panel environment. The only study, to our knowledge, is Bénassy-Quéré *et al* (2004).

Zhang (2001) employs the BEER approach to estimate the misalignment of the real bilateral exchange rate from 1952 to 1997. The economic fundamentals that determine the BEER include investment represented by the index of gross fixed capital formation (which is also viewed as a proxy for technological progress), the index of government consumption (which captures the effect of fiscal policy), growth rate of China's exports and degree of openness[12]. Using the cointegrating vector, the BEER is derived and misalignments are calculated accordingly. Their results suggest overvaluation during much of the pre-reform period 1957-1977 and undervaluation in 12 out of 20 years during the post-reform period 1978-1997.

[12] Dummy variables are incorporated to reflect the impact of the great famine in 1961 and 1962 and the introduction of the secondary exchange rate in 1981.

Zhang (2002) applies the BEER model to the real effective exchange rate for China for the post-reform period 1984 Q1-1999 Q4. The determinants of the BEER include terms of trade, productivity (approximated by GDP), money supply and net foreign assets (all seasonal adjusted). The fundamentals are smoothed using the HP-filter. Based on cointegrating vector obtained from cointegration techniques and smoothed fundamentals, the BEER is calculated for the real effective exchange rate. The results suggest that the real effective exchange rate has been overvalued during 1984-1986 and 1989-1990 at around 20% and 14% respectively; undervalued during 1986-1989 and 1991-1995 at 15% and 22% respectively. Interestingly, for the period 1995-1999, the equilibrium exchange rate keeps on depreciating form 87 in 1995 to 73 in 1999, suggesting that the real effective exchange rate has been overvalued by more than 10%.

Funke and Rahn (2005) apply the BEER model to the real effective and nominal bilateral exchange rates of China. The two economic fundamentals they chose are productivity differential between the home country and abroad and the net foreign asset position. The cointegration tests are implemented for data from 1994 Q1 to 2002 Q4. Based on the cointegrating vector obtained from cointegration tests and actual fundamentals they obtain BEER for both real effective exchange rate and nominal bilateral exchange rate. The real effective exchange rate is generally in line with BEER for the whole sample period with the peaks of misalignment occurring at end of 1999 at -8% (minus imply undervaluation) and the misalignment at end of sample period is -3%. The nominal bilateral exchange rate has been undervalued since 1997 but the misalignment has not been substantial, with the peaks around -17%, and the misalignment at end of sample period is -11%. Therefore, Funke and Rahn (2005) argue that substantial undervaluation of the RMB argued by many existing studies is often exaggerated.

Wang *et al* (2007) and Chen (2007) apply BEER model to real effective exchange rate of China for the periods 1980-2004 and 1994 Q1-2006Q2 respectively. The fundamentals are terms of trade, relative price of non-tradables to tradables, interest rate differential, foreign exchange reserve and money supply in the former period and terms of trade, net foreign assets, and openness in the latter period. The procedures of their estimations are very similar to Zhang (2002). Though Wang *et al* (2007) and Chen (2007) find the real effective exchange rate is undervalued and overvalued respectively at the end of sample period, though the absolute misalignments are less than 3% in both cases. The misalignment for the both sample periods has been varying within narrow bands of ±5% in Wang *et al* (2007) and ±6% in Chen (2007).

Bénassy-Quéré *et al* (2004) estimate BEER for both real effective exchange rate and real bilateral exchange rate against the USD for a panel of 15 industrial and developing countries including China for the period 1981-2000. The economic fundamentals are the same as in equation (2.24). Their results suggest that China's real effective exchange rate is undervalued by 16.2% in 2001 and the real bilateral exchange rate against USD is undervalued by 44% and 47.3% in 2001 and 2003 respectively.

2.3.4. Natural Real Exchange Rate (NATREX)

Studies that apply the NATREX model to China have been rare. The only study that applies NATREX to China is Holger *et al* (2001), who evaluate the equilibrium value of the real bilateral exchange rate against the USD for the period 1988 Q4-1998 Q4. The real exchange rate is defined as nominal exchange rate of CNY per USD times the producer price index of the US and divided by retails price index of China. The economic fundamentals incorporated in the model are the same ones as in Stein (1994), which are productivity and time preference, plus the world real interest rate. Productivity at home and abroad is approximated by growth rate of domestic and foreign real GDP[13] and the time preference for China is measured as (public and private) consumption/GDP ratio. The time preference for foreign countries is dropped due to data limitation. Based on cointegrating vectors obtained from cointegration tests and actual value of fundamentals, they obtain the NATREX value of real exchange rate. Their findings suggest that, though the real exchange rate converges to its NATREX value for the whole period, the real exchange rate of China is overvalued for the period 1994-1996 and undervalued for the periods 1992-early 1994 and late 1997-1998. The exact magnitude of misalignment is unknown as it in not reported in Holger *et al* (2001).

2.4. Conclusions

In the first part of this chapter we reviewed alternative approaches developed to estimate the equilibrium exchange rate. We explained the conceptual frameworks of the Purchasing Power Parity (PPP) hypothesis, Behavioural Equilibrium Exchange Rate (BEER) model, Fundamentals Equilibrium Exchange Rate (FEER) model and the Natural Real Exchange Rate (NATREX) model. Under each equilibrium concept reviewed, we presented a selection of empirical studies for industrial countries as well for developing and transition countries. In the second part of this chapter we turned our focus to China. We presented an extensive review of empirical studies that evaluate the equilibrium exchange rate for China employing alternative methods.

[13] The foreign real GDP is measured as the sum of real GDP of China's main trade partners: US, UK,

Our review of the existing literature for China suggests the follows. First, the NATREX model has not been applied extensively to China. Second, studies testing PPP for China could not reject the null of a unit root — PPP does not seem to hold in China; no evidence of Balassa-Samuelson effect has been found in China. Third, most studies tend to find undervaluation of the Chinese RMB in the post-reform period; though the band of undervaluation is relatively wide, between 0% and 60%, the majority of these studies find evidence at the top of the band, especially for the period after the millennium. Fourth, terms of trade, productivity and net foreign assets are the economic fundamentals mostly employed and they are often statistically significant.

The major limitations of existing studies for China can be summarised as follows. First, the only study of NATREX for China is Holger *et al* (2001), who have adopted identical modelling and estimation procedures as Stein (1994) who developed the NATREX model and applied it to the US. Given that there are fundamental differences between the economies of China and the US, an extension of Stein's (1994) NATREX model which makes it applicable to China would be necessary. Second, there is no application of the FABEER model for China, except for a single year of 2002 by Wren-Lewis (2004a). Third, the time span of all studies has been restricted to post-reform period; the only exception is Zhang (2001) who employs the BEER model. Fourth, except Jeong and Mazier (2003), Wren-Lewis (2004a) and Funke and Rahn (2005) who evaluate the equilibrium nominal bilateral exchange rate of the CNY against the USD, all other studies investigate the equilibrium real bilateral and real effective exchange rates. Fifth, though a number of economic fundamentals have been employed, there is still a large scope for introducing fundamentals that capture the unique characteristics of the Chinese economy.

Japan, Hong Kong and Australia.

Table 2.1. Empirical Studies on China's Equilibrium Exchange Rate

a) Empirical Studies for the Chinese Exchange Rate—PPP				
Authors	Measures of Exchange Rate	Data Span	Model Specification	Findings
Zhang (2002)	RER	1980-1999 Time series	PPP	RER is non-stationary. RER and relative prices are cointegrated but the cointegrating vector is wrongly signed. No evidence for PPP.
Wang (2005)	REER	1980-2003 Time series	PPP	REER is non-stationary. REER and relative prices are not cointegrated at all. No evidence for PPP.
Shi (2006)	REER	1991-2005 Time series	PPP	REER is non-stationary. No evidence for PPP
Wang (2004)	REER	1980-2003 Times series	Extended PPP Economic fundamentals: relative productivity gains, net foreign assets and openness.	REER: small undervaluation (around 5%) in 2003
Dunaway *et al* (2006)	REER	1980-2002 Time series	Extended PPP Economic fundamentals: productivity at home relative to the world and net foreign assets	REER: undervaluation of around 30% in 2005 based on an out-of-sample forecast.
Frankel (2005)	RER	1990 and 2000 Panel data	Extended PPP Economic fundamentals: real GDP per capita	RER: undervalued between 34%-42% in 1990 and between 36%-45% in 2000. In both years China is an outlier (amongst 118 sample courtiers).
Coudert and Couharde (2007)	RER	2000-2004 Panel data	Extended PPP Economic fundamentals: GDP per capital relative to the US	RER: undervalued by 44%-64% in 2000-2004 (estimated based on a panel of 132 countries)
Coudert and Couharde (2007)	RER	1998 Q1-2002 Q4 Panel data	PPP	RER: undervalued by 16%-29% in 2005 Q2 (estimated based on a panel of 23 emerging countries)
Dunaway *et al* (2006)	REER	1980-2005 Panel Data	Extended PPP Economic fundamentals: productivity at home relative to the world, net foreign assets, terms of trade and openness	REER: undervalued by up to 50% in 2005 based on an out-of-sample forecast (estimated based on 11 Asia-Pacific economies).

b) Empirical Studies for the Chinese Exchange Rate—FEER

Authors	Measures of Exchange Rate	Data Span	Trend Current Account (as a percentage of GDP)	Sustainable Current Account (as a percentage of GDP)	Findings
Jeong and Mazier (2003)	REER and NER	1981-2000 Panel data	Based on a multi-country model for China, Japan, South Korea, US and the Euro Area but parameters of the trade equations for each country are taken from existing studies.	It estimated following Debelle and Faruqee (1998) and Chinn and Prasad (2000). Fundamentals include: governmental budget balance, dependency ratio, income per capita relative to the US, net foreign direct investment, net foreign assets, degree of openness and output gap. Panel data for 18 emerging countries are used to give the value for China.	NER and REER: largely overvalued in middle 1980s (20% in NER and 30% in REER); close to its equilibrium parity from the late 1980s to early 1990s, and strikingly undervalued since 1997 (60% NER 33% REER).
Wang (2004)	REER	2000-2002 Time series	Approximated by the average for 2000-2002 (2.1%).	Two alternative sustainable current account calculated based on existing study or certain assumptions 1). 3.10%; 2). 0.98%.	The real effective exchange rate is moderately overvalued based on the first sustainable current account and is moderately undervalued based on the second one.
Wren-Lewis (2004a)	NER	2002 Time series	It includes China into the framework of FABEER model of Wren-Lewis (2003). The trade equations do not split between prices and volumes and the coefficients in the trade equation are calibrated.	Off-model assumption of 1) 0% 2) 1%	2002: NER is undervalued at 20% and 28% based on 1% and 0% of sustainable current account respectively.
Coudert and Couharde (2007)	REER and RER	2002-2003 Time series	Estimated based on the NIGEM model	Two alternative sustainable current accounts are extracted from two existing studies: 1) -2.8% from Williamson (1998) 2) -1.5% from Jeong and Mazier (2003)	Based on -2.8% and -1.5%, in 2002, the RER is undervalued by 59% and 49% respectively and the REER is undervalued by 33% and 27% respectively; in 2003, the RER is undervalued by 54% and 44% respectively and the REER is undervalued by 30% and 23% respectively.

c) Empirical Studies for the Chinese Exchange Rate—BEER

Authors	Measures of Exchange Rate	Data Span	Determinants (Economic Fundamentals)	Findings
Zhang Zhi Chao (2001)	RER	1952-1997 Time series	Investment, government consumption, growth rate of China's exports, degree of openness	Chronic overvaluation occurred before 1978. Undervaluation occurred in 12 of 20 years from 1978 to 1997. There is a substantial real depreciation of the Chinese currency since 1981. After 1978, the reversion of the real exchange rate to equilibrium is faster. The magnitude of overvaluation smaller.
Zhang Xiao Pu (2002)	REER	1984 Q1-1999 Q4 Time series	Terms of trade, productivity of China, money supply, net foreign assets	1984-1986 and 1989-1990: overvalued at around 20% and 14% respectively; 1986-1989 and 1991-1995: undervalued at 15% and 22% respectively; 1995-1999: overvalued by more than 10%. The REER has moved closer to the equilibrium level since 1999. Currently, REER is not seriously overvalued.
Funke and Rahn (2005)	REER and NER	1994 Q1-2002 Q4 Time series	productivity differential between home country and abroad, net foreign asset position	REER is generally inline with BEER for the whole sample period with the peaks of misalignment occur for both series at end of 1999 at -8% and the misalignments at end of 2002 are -3% NER: overvalued before 1997 and undervalued since 1997 but the misalignments are not substantial, with the peaks around -17% and the misalignments at end of 2002 are around -11%
Wang *et al* (2007)	REER	1980-2004	terms of trade, relative price of non-tradables to tradables, interest rate differential, foreign exchange reserve and money supply	REER is undervalued in 2004 by 3%. The misalignment for the whole sample periods has been varying within narrow band of ±5%.
Chen (2007)	REER	1994 Q1-2006Q2 Time series	terms of trade, net foreign assets, and openness	REER is undervalued from 2005 to 2006 Q2 by about 1%. The misalignment for the whole sample periods has been varying within narrow band of ±6%.
Bénassy-Quéré *et al* (2004)	REER and RER	1981-2000 Panel Data	productivity differential between home country and abroad, net foreign asset position	REER: undervalued by 16.2% in 2001 RER: undervalued by 44% and 47.3% in 2001 and 2003 respectively (estimated in a panel of 15 countries)

d) Empirical Studies for the Chinese Exchange Rate—NATREX

Authors	Measurement of Exchange Rate	Data Span	Determinants (Economic Fundamentals)	Findings
Holger *et al* (2001)	RER	1988 Q4-1999 Q4 Time series	Productivity at home and aboard, time preference at home, interest rate differential	Late 1988-late 1991: RER is inline with NATREX, though with moderate over and undervaluation. 1992-early 1994: undervalued middle 1994-1996: overvalued late 1997-1998: undervalued

Chapter 3
The Chinese Economy and Foreign Exchange Policy

3.1. Introduction

Before 1978, a centrally-planned economy was implemented throughout China. The economic development was interrupted several times by political campaigns (i.e. the Great Leap Forward during 1958-1962, the Cultural Revolution during 1966-1976). In 1978, under the leadership of Deng Xiaoping, the Chinese government put forward the national policy of "reform and opening-up". Since then, the national priority has been shifted from political campaigns to economic development. The centrally-planned economy was gradually replaced by a market-oriented economy.

This chapter presents an review of the Chinese economy, focusing on the post-reform period (1978-2005). Section 3.2 analyses China's GDP growth. Section 3.3 offers an overview of the balance of payments and discussion of relevant policies and reforms. Furthermore, a series of new foreign exchange policies have been implemented since 1978. Hence this chapter also reviews the history of China's foreign exchange policy (Section 3.4) and discusses recent development in China's foreign exchange market (Section 3.5).

3.2. GDP Growth

Table 3.1 lists the annual GDP growth rates over the period 1978-2005. The growth of the real GDP has been persistent, though there were moderate differences in these annual growth rates. The average annual growth rates for the 1980s and 1990s were 9.8% and 10% respectively. Since the new millennium (2000-2005), the average annual growth rate has been remained as high as 9.4%. Notably, in 1990 and 1999, the annual growth rates fell to 3.8 and 7.1 respectively. This may reflect the impact of the Tiananmen Turmoil in 1989 and the Asian Financial Crisis at the end of 1990s on the Chinese economy. According to the World Bank[1], in 2005 China's GDP was the fourth largest in the world. The sectoral contribution to GDP (1978-2005) is listed in Table 3.2[2]. The share of industry remains stable around 50%. However, the shares of agriculture and service in 2005 have decreased and increased by 15% respectively compared with 1978.

3.3. Balance of Payments

During the past three decades China's balance of payments has gone through dramatic changes. China's macro policy has played an essential role in leading, supporting, and adjusting the development of the balance of payments since the implementation of the national policy of reform and opening-up. The most influential macroeconomic policies on the economy include reducing tariff and non-tariff barriers, establishing special economic zones and open costal cities, state-owned enterprises reforms, and financial market reforms. Consequently, compared with the pre-reform period, the balance of payments in the post-reform period shows a major expansion in foreign trade and capital flows[3].

3.3.1. Overview of the Balance of Payments

3.3.1.1. Current Account

The current account (1982-2005) is illustrated in Table 3.4. Before 1994 (the unification of the Dual Foreign Exchange Rates System) there were current account

[1] http://siteresources.worldbank.org/DATASTATISTICS/Resources/GDP.pdf
[2] Table 3.3 lists the difference in definition between the World Bank and China Statistical Yearbook.

deficits over several years and this was due to the unstable exchange rate. After 1994 the current account increased until 1997 and started to decrease as a result of the Asian Financial Crisis. After China's entry into the WTO (in December 2001), the current account has increased substantially. In 2005 the current account accounts for 7.2% of the GDP.

Exports, imports and the foreign trade balance have a similar trend with the current account. Before 1994 exports and imports seemed to increase at a slower rate. Occasionally, imports exceeded exports with small and unstable differences between them. Since 1994 exports have overtaken imports. During 1994-2005, the average growth rates are as high as 21.8% and 18.6% for exports and imports respectively.

Moreover, the structure of exports and imports has also been optimised (Table 3.5). The primary goods exports used to account for half of the total exports (i.e. 50.3% in 1980). By 2005 the ratio had been reduced to 6.4%. Manufactured goods exports accounted for less then 50% of the total exports in 1980. Whilst by 2005 the ratio increased to 93.5%. Furthermore Table 3.6 shows that the inner structure of manufactured goods exports has been optimised. For instance, the ratio of machinery and transport equipment (which requires relatively higher level of technology) to manufactured goods has increased from 9.4% in 1980 to 49.4% in 2005.

The main export destinations have also altered their positions (Table 3.7). In the early 1980s China's top 4 export destinations were Hong Kong, Japan, European Union (EU) and the US (the US had the smallest share). However, the ratio of the US kept on increasing throughout 1990s. Since 1999, the US has become China's most important export destination. Furthermore, exports to EU have increased substantially. Since 2003, EU has become the second largest export destination of China, only after

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[3] Please refer to Wu and Mao (1993) for detailed descriptions of China's balance of payment before

the US. In contrast, exports to Japan have kept on reducing. Hong Kong used to be the biggest export destination of China. However, the ratio of China's exports to Hong Kong has been declining since 1993 and Hong Kong became China's third largest export destination since 2003. On the other hand, the ranking of origin countries/areas of Chinese imports remains unchanged: Japan, EU, US and Hong Kong. However, one interesting change is that Chinese imports from these four countries/areas account for less than 35% of total import of China in 2006, comparing with around 70% in early 1980s. It indicates an increasing importance of other Asian (e.g. South Korea, Thailand) and third world countries in China's imports.

3.3.1.2. Capital Account

Foreign Direct Investment (FDI) to China has increased dramatically in the past three decades. The nominal growth rate of FDI to China is unstable during the past three decades (Table 3.8). In 1998, 1999 and 2003 FDI growth rates were negative. This may be due to the Asian Financial Crises at the end of 1990s and the break out of Severe Acute Respiratory Syndrome (SARS) in China in 2003. Before 1992 the share of FDI to GDP was less than 1.0% (except in 1991). Deng Xiaoping's South Tour in 1992 established the direction of "setting up a socialist market economy in China". This guideline stimulated FDI to China by helping to create a better investment environment for Foreign Invested Enterprises (FIEs). As a result FDI to China increased dramatically during 1992 to 1994. Since 1995 the share of FDI to GDP has started to decline. The Asian Financial Crisis at the end of 1990s is one of the reasons. Another interpretation focuses on the tight foreign investment policy implemented by the government in the late 1990s, which was still quite strict for FIEs and this

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1978.

discouraged FDI inflows. As illustrated by Rosen (1999), FIEs in China faced non-commercial burdens ranging from the partnering pressure of corruption to residual restrictions upon the range of operations. After China's entry into WTO in 2001, more favourable policies to FIEs were implemented[4]. Therefore, FDI in China rebounded again (despite the negative effect of the SARs in 2003). In 2005, China attracted nearly 80 billion US Dollars (USD) FDI and became the third largest FDI recipient in the world[5]. FDI plays an important role in China's economic growth. According to Tong (2003), FDI contributes significantly to China's industrial output, export volume, foreign exchange reserves, taxation and employment[6].

Before 1992 the ratio of the capital account to GDP was relative unstable (it went negative occasionally). After Deng Xiaoping's South Tour in 1992 the capital account/GDP ratio started to increase. This trend was interrupted by the Asian Financial Crisis and was affected by the tight investment policies for FIEs. After China's entry into WTO, with more FDI inflow, the importance of the capital account kept on increasing (though slightly affected by SARs in 2003). By the end of 2004, the ratio of the capital account to the GDP was 6.7%. However, it reduced to 2.8% in 2005, mainly due to much larger outflows of FDI, portfolio and other investment[7].

3.3.1.3. Foreign Exchange Reserves

China's foreign exchange reserves (FERs) have increased significantly in the recent thirty years. Before 1990 the FERs fluctuated below 10 billion USD (Table 3.9). The main reason for the low level of FERs was the large amount of purchase in equipment

[4] 390484 FIEs had been approved by the Chinese government in 2001 (Jiang and Li, 2002).
[5] FDI to China came mainly from 5 countries (areas): Hong Kong, the USA, Japan, Taiwan, and the British Virgin Islands (Long, 2004).
[6] Please refer to Graham and Wada (2001) for detailed discussion on the effects of FDI on China's economic performance and growth.

and primary materials urgently needed for the reconstruction of China's market-oriented economy. The fluctuation was due to the unstable value of the Renminbi (RMB) (Table 3.13). In 1990, China's FERs broke through the benchmark of 10 billion USD. After this breakthrough, especially after the termination of the Dual Foreign Exchange System in 1994, China's FERs increased dramatically. It was this considerable amount of FERs that backed up China's economy during the Asian financial crisis at the end of 1990s. After China's entry into the WTO in 2001 the growth rate was even faster. The FERs soared to 819 billion USD by the end of 2005 (accounting for 36.5% of the GDP). China was the second largest foreign exchange reserve country in 2005 in the world (only next to Japan)[8].

There are several reasons to explain the fast accumulation of FERs. First, the thriving exports accumulated large amount of FERs. Second, the relaxation on capital account restrictions encouraged more FDI in China. Third, a stable and sound investment environment improved foreign investors' confidence in China. Fourth, the revaluation pressure on China's RMB during this period attracted large amounts of international idle funds, attempting to make profit from the appreciation of the RMB[9]. Net foreign assets (Table 3.9) have a very similar trend as the FERs.

3.3.2. Policies and Reforms Relevant to the Balance of Payments

In this section, we discuss the most influential policies and reforms that affected the balance of payments since 1978, which include the reductions in tariff and non-tariff

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[7] Both net portfolio investment and net other investment turned from positive in 2004 to negative in 2005.

[8] In 2006, China surpassed Japan and become the world largest holder of foreign exchange reserves.

[9] For instance, according to the statistics of SAFE, the error and missing item was 27 billion USD on the balance of payments for 2004, nearly 50% higher than 2003. International analysts believe that the main part of the error and missing item is the speculative capital. These speculators aim at the possibility that Chinese government might revalue the RMB.

barriers, establishment of the five special economic zones and open costal cities, state-owned enterprises reforms, and the financial market reforms.

3.3.2.1. Trade Policy—Reduction in Tariff and Non-Tariff Barriers

To protect the domestic industry the Chinese government used to impose heavy tariffs on imports from foreign countries. Until 1992 China's overall tariff rate was as high as 43.2% (Fan and Zheng, 1999), and there were a variety of Non-Tariff Barriers (NTBs) (i.e. quotas, licensing).

From 1992 to 1998, the government reduced its overall tariff rate six times from 43.2% to 17.0%. In order to enter the WTO China signed the Sino-US deal in November 1999. The agreement announced that China's tariff reduction plan for industrial goods, agriculture, and service. Just before China's accession into WTO, the overall tariff rate was 15.3% (Table 3.10). To fulfil its commitment in terms of the overall tariff rate, in 2005 China's overall tariff rate has declined form to 9.9%, a reduction of 35.1% compared with 2001.

China's commitment for the WTO of removing NTBs involves phasing out restrictions in a broad range of services, removing subsidies on loss-making state-owned enterprises, stopping interference in trade flows by favouring particular suppliers, stopping restrictions on the quantities that are imported or exported, and no subsidizing exports or fixing prices (Yu, 2004). From 1992 to 1998, over 1000 quotas and licenses on a wide range of goods have been removed. After entering into the WTO in 2001 China has been required to speed up the elimination of the NTBs. For instance, throughout the first two years of China's WTO membership China maintained the import tariff-rate quotes (TRQs) system on agriculture products as a NTB for agriculture goods imports. In response to the requirements of the WTO membership, since 2003, import TRQs were lifted for various imported agricultural products. Furthermore, China has already begun to open up its service sectors that include telecommunication, insurance, banking services, professional services including law firms, consultancy, accountancy and so on[10].

The tariff reduction and the remove of NTBs increase the trade values rapidly, especially the imports. Chinese people benefit from the price reduction of the imports. Meanwhile, China's national industries are facing powerful competitors from all over the world. For instance, in 2005 the import tax for automobile was reduced from 34.2% (engines lower than three litres) and 37.6% (engines higher than three litres) to 30%. The decreased cost of imported cars put pressure on China's domestic automobile industry, which used to be well-protected by Chinese government.

3.3.2.2. Special Economic Zones and Open Coastal Cities

The Special Economic Zones (SEZs) were established during the early implementation stage of the reform and opening-up policy following the idea of Deng Xiaoping. In the initial stage of reform and opening-up, China was lacking of experience in foreign trade and legislation systems. Therefore, only five comparatively more developed and open east coastal cities (provinces) were selected to be the SEZs during 1980 to 1988[11] to attract foreign investment and expand foreign trade. By combining local advantages and favourable economic policies given by the

[10] However, there are still special NTBs for imports to China. For example, China does not recognise any test or certification that occurs outside of China, which increases the cost of foreign exporters because they have to retake the test on their goods again in China. Regulatory framework is imposed to foreign invested testing and certification organisations if they conduct conformity assessment services for China's domestic market. Therefore, more reforms are needed to eliminate the NTBs in China.

[11] They are Shenzhen, Zhuhai, Shantou in Guangdong Province, Xiamen in east China's Fujian Province, and southern China's Hainan Province. Shenzhen, Zhuhai, Shantou and Xiamen were set up in 1980 while Hainan Special Economic Zone was established in 1988.

central government, the SEZs' economic growth has experienced a much faster speed than the other cities and provinces.

The favourable policies for the SPEs can be summarised into the following three points: special tax incentives for foreign investments in the SEZs; greater independence on international trade activities; and special economic characteristics[12]. SEZs are listed separately in the national planning (including financial planning) and have province-level authority on economic administration. SEZs local congress and government have legislation authority. Therefore, in a word, the central government allows SEZs to utilize a special economic management system.

Besides SEZs, in 1984, China further opened 14 coastal cities[13] for overseas investment. In 1990, Pudong New Zone in Shanghai was established, and more cities in the Yangtze River valley were opened. Furthermore, a number of broader cities, all the capital cities of inland provinces and autonomous regions have been opened since 1992. 15 free trade zones, 32 state-level economic and technological development zones, and 53 new- and high-tech industrial development zones have been established in large- and medium-sized cities by the end of 2000. Different favorable polices are given to these open areas. Thus SEZs, open coastal areas and some inland areas have formed the "windows" for developing foreign-oriented trade and attracting foreign capital.

The implementation of the open China to the world is one of the most successful measures among the whole reform and opening-up campaign. Foreign exchange is

[12] The special economic characteristics can be further interpreted as follows, First of all, the constructions primarily rely on attracting and utilizing foreign capitals. Secondly, primary economic forms are sino-foreign joint venture and partnerships as well as wholly foreign-owned enterprises. Thirdly, products are primarily export-oriented. Last but not least, economic activities are primarily driven by the market.

[13] The 14 coastal cities are Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Fuzhou, Guangzhou, Zhanjiang and Beihai. In 1985 the open costal areas were further expanded by extending towards the Yangtze River Delta, Pearl River Delta, Xiamen-

accumulated by exports from these areas, and advanced technologies are imported via these areas to develop not only the costal but also the inland areas. Under the preferential policies, more and more foreign capitals have chosen these areas as their destinations. Table 3.11 lists the gross regional products (GRP) of and the foreign capital actually utilized by the SEZs and 14 coastal cities. Though they only occupy 1.5% of China's total land SEZs and 14 coastal cities contributed 18.0%, 22.8% and 24.9% to China's GDP in 1995, 2000, and 2003 respectively. In terms of foreign investment, SEZs and 14 other coastal cities are the destinations of almost half of FDI to China. In 2003 the percentage even went higher to 61.0%. However, it is worth noticing that in 2005, the GRP/GDP and foreign capital utilized/FDI ratios declined to 22.9% and 42.1% respectively, which reflect faster economic development in China's inner cities.

3.3.2.3. State-Owned Enterprises Reforms

Before 1978, the State-Owned Enterprises (SOEs) dominated the whole of the Chinese economy. Under the centrally-planned economy, SOEs were fully administrated by the Chinese government. They received production quotas from the government and sold their products to the government. The government would then reallocate the profits to SOEs according to the central plan. Since the launch of the national policy of reform and opening up in 1978, SOEs have experienced dramatic reforms through restructuring and privatisation.

At the early stage of the reforms, the non-state-owned enterprises (township and village enterprises, private sectors, and joint enterprises) were encouraged and they developed dramatically. According to the "Market-Oriented Reforms of China's

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Zhangzhou-Quanzhou Triangle in south Fujian, Shandong Peninsula, Liaodong Peninsula, Hebei

Enterprises in Retrospect (2003)" in 1991, 43.8% of the total industrial output of China's economy was due to the non state-owned enterprises.

Further SOEs reforms involved privatising and restructuring the SOEs' property right. In 1997, the Fifteenth National Congress established the policy of "grasping the large SOEs and letting go of the small ones", which implies that while China's government would continuously own the big-sized SOEs, the small- and medium-sized SOEs would be sold, contracted, or closed. In 1999, the 4th Plenum of the Fifteenth Party Congress Central Committee clarified that Shareholding System Reforms would be implemented for the SOEs. These SOEs would be restructured into legally listed companies, joint ventures, and multiple-shareholding entities. In 2002, the Sixteenth National Congress of the CPC made a further statement that except the SOEs that must be controlled by Chinese government, Shareholding System was encouraged for all other SOEs. Therefore, large number of SOEs was privatised by selling SOEs' property right to collective groups, individuals and foreign investors. The Chinese government is not the only owner of the SOEs any more. For instance, in 1992, listed companies were 100% pure SOEs. Whilst in 2001, 31.67% of the listed companies were pure SOEs.

In March 2003, the stated-owned Assets Supervision and Administration Commission of the State Council (SASAC) was established, which indicated a new round of privatisation of China's SOEs. New forms of shareholding also emerged, like the Management Buy-out (MBO), which refers to the purchase of SOEs' share carried out by the companies' managers. Through MBO, the efficiency of the company is improved by the unification of the owners and the managers. SOEs reforms also provided investment opportunities for the foreign investors. In April 2003, the legal

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Province and Guangxi Province into the open coastal belt.

barriers for foreign investors were removed by the "*Provisional Rules on Mergers and Acquisitions of Domestic Enterprises by Foreign Investors*".

In 1995, 65% of urban employees worked in SOEs and SOEs occupied 60% of total national assets. In 2006, SOEs and state-holding industrial enterprises employed only 6% of urban employees while they occupied 46% of total national assets. In 1995, the number of SOEs was 17% of the total number of industrial enterprise. While in 2006, the number SOEs and state-holding industrial enterprises was only 8% of the total number of industrial enterprise. However, these SOEs and state-holding industrial enterprises contribute to 31% of the gross industrial output in 2006, not much different from 34% in 1995. This indicates that the current SOEs and state-holding industrial enterprises are industrial giants and by increasing their efficiency, despite they fact that they employ fewer employees, they still make a significant contribution to China's economy.

3.3.2.4. Financial Market Reforms—Banking System and Capital Market

Banking System Reforms

Before 1978, China's banking system was under the direct control of the Chinese government. Under the centrally-planned economy, the banking system was merely the book keeper of the central planner providing financial tools for the allocation of physical resources. Market forces were introduced into the banking system in the 1980s when the banking sector expanded significantly. Problems were also formed during this fast expansion because of both internal and external reasons. Externally, a huge number of Non-Performing Loans (NPLs) flowed to the low efficiency state-owned enterprises under the centrally-planned system and government protection. After the commencement of China's SOEs reforms, bankruptcy and privatisation procedures left additional amounts of NPLs to the banking system. Internally, the loan officers had not incentive to filter bad loans from good ones due to the fact that the loans were issued to co-operate with the whole reform rather than seeking profits[14].

Before the banking system reform commenced in 1998, China's banking system includes: the Central Bank — People's Bank of China (PBC), State-owned Commercial Banks (SOCBs), Policy Banks, Commercial Banks under Shareholding System, City Commercial Banks, Rural Credit Cooperation, Foreign Invested Banks and others. There are four SOCBs: Bank of China (BoC), China Construction Bank (CCB), Industry and Commercial Bank of China (ICBC), and the Agriculture Bank of China (ABC)[15].

The process of banking system reform can be described into three stages. First, the disposition of NPLs. According to China Banking Regulatory Commission (CBRC), by the end of 2003, there were 233.4 billion USD NPLs in China's four SOCBs (accounting for 20.4% of all loans they issued and 16.4% of GDP)[16]. In 1998, the State Council injected 270 billion Chinese Yuan (CNY) (33 billion USD) to China's four SOCBs as capital supplement. It marked the commencement of China's banking system reform. In 1999 four designated Asset Management Companies (AMCs)[17] were established to purchase, manage and finally dispose NPLs from SOCBs. Since then, large amount of NPLs have been transferred from four SOCBs to AMCs, and AMCs sold these NPLs gradually in auctions[18]. In addition, the government has

[14] As Lo (2001) points out, during the early reforms after 1978, loans were issued to co-operate with the whole reform rather than seeking profits. Therefore, the default risk of loan offers was almost equal to zero. Furthermore, under state-ownership, loan officers were offered employment contracts regardless of how well they performance in make profits for the banks. Additionally, lack of credit risk analysing skills and absence of monitor system deteriorated the status of the banks.

[15] SOCBs dominate the whole banking system. According to China Banking Regulatory Commission (CBRC), even in 2007, state-owned banks accounted for around 50% of total banking capital.

[16] We would like to collect data of NPLs in 1990s. However, CBRC only reports data from 2003.

[17] The four designated AMCs are the Huarong, Orient, Cinda and the Great Wall.

[18] For instance, in 2002, Huarong (the China Huarong Asset Management Corporation) conducted the country's first-ever NPL portfolio sale to foreign investors. With the help of Earnest and Young, one of

carried out many capital injections in large sum into the four SOCBs. According to CBRC, the ratio of NPLs to all loans reduced to 8.6% in 2005 and 6.2% in 2007.

The second stage of the banking system reform focuses on the implementation of shareholding system, which implies that the forms of SOCBs' property rights could be joint ventures and listed companies rather than 100% state-owned banks. Bank of China Ltd. and China Construction Bank Ltd. were established On 26th August and 21st September 2004 respectively. In 2005, Industrial and Commercial Bank of China Ltd. was founded. It indicated that three out of four SOCBs have been transferred to commercial banks under shareholding system[19]. A modern financial enterprises system was implemented in these banks with the establishment of shareholders meeting, board meeting, supervisors meeting. As a result, China's banking system became more open to foreign investors. In Shanghai, one of the first cities opened to foreign banks, the capital of foreign banks covered 12.2% of the overall capital in the banking system by the end of March 2005. By the end of 2007, 24 foreign banks have opened 119 branches in China and 82.3 billion USD foreign investment flowed into China's banking system. According to CBRC, foreign banks' capital accounted for 1.5% in China's banking system by the end of 2003, and this ratio increased to 2.4% in 2007.

The third stage of the banking system reform is to transform the SOCBs into listed companies. CCB went public in Hong Kong in October 2005, followed by BoC in June 2006. ICBC went public simultaneously at Hong Kong and Shanghai Stock Exchange in October 2006.

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the major accounting and consulting firms, Huarong sold one tranche of NPLs to a consortium which was led by Morgan Stanley and included Lehman Brothers, Salomon Smith Barney and others.

[19] The fourth SOCB, the Agriculture bank of China is expected to implement shareholding system by 2008.

Nearly a decade has passed since Chinese government's first injection of capital into SOCBs in 1998. Through the banking system reforms, the overall competitive of the banks has been improved. Amongst the top 1000 world banks ranking by *TheBanker*, in 2007, 31 Chinese banks are in the list. Among them, ICBC and BoC are the 7th and 9th biggest banks in the world respectively.

Capital Market Reforms

China's capital market has a short development history of less than 20 years. The establishment of Shanghai Security Exchanges in December 1990 and Shenzhen Security Exchanges in July 1991 marked the formation of China's security market. The China Securities Regulatory Commission (CSRC) was established in 1992 to assist and guide China's capital market to develop. China's capital market has grown up dramatically since then. According to CSRC, the total market capitalisation by September 2002 was 4.4 trillion CNY, accounting for more than a third of China's GDP. This further increased to 8.9 trillion CNY in 2006, accounting for almost half of China's GDP. The number of listed companies increased dramatically from 10 in 1990 to 1434 in 2006. During the 12 years from 1991 to 2002 the funds raised by Chinese companies through public offering reached 854 billion CNY. Furthermore, 559 billion CNY was raised in 2006 alone. According to CSRC, by the end of 2006, China is the third largest capital market in Asia (only after Tokyo and Hong Kong).

While the economic growth has been the biggest driver behind the development in the capital market, the capital market reforms also contributed to its development. The main forms of capital market reforms include the reduction of large amount of state-owned shares and encouraging foreign investment in China's capital market.

In 1990 the government occupied 65% of the shares in the Shanghai Security Exchange. Furthermore, state-owned shares were not allowed to circulate on the stock exchange market in China. This meant that more than half of the shares in China's stock market did not have liquidity. Therefore, government policies had significant effects upon China's stock market in contrast to the market force.

The first form of capital market reform is therefore to reduce the ratio of state-owned shares. In 1994, Zhuhai Hen Tong Group purchased 35.5% of Lingguang Industry Ltd.'s shares. It was China's first case of selling the state-owned shares. On 12th June 2001, the State Council released the "*Temporary Measures in Reducing State-Owned Share to Fund Social Welfare System*"[20]. However, since then, how to reduce the state-owned shares and achieve free circulation are topics under debate.

The second form of capital market reform is to allow foreign investment into the capital market. In 2002, CSRC and PBC introduced the Qualified Foreign Institution Investor (QFII) program as a provision for foreign capital entering China's capital market. By the end of 2006, there are 52 institutions that have qualified as QFIIs. The sum of foreign investment quotas for these 52 institutions has reached 9 billion USD. Consequently Chinese domestic companies have begun to face competition from foreign enterprises.

3.4. Foreign Exchange Policy

Before the decision of reform and opening-up was made in 1978, China had a rigid control on foreign exchange due to the lack of foreign currency resources. All foreign

[20] However, China's stock market subsequently switched to bear market after the new measures. The Shanghai Securities Index has dropped from 2245 to 1515 on 22nd October 2001. Sever capital outflows caused large losses to securities brokers and institutional investors. To stabilise the stock market and save the benefits for securities brokers and investors, the government suspended the temporary measures on 23rd October 2001.

exchange should be surrendered to BoC at the official exchange rate[21]. The nominal CNY/USD exchange rate was fixed at 2.5 since 1956 except the government artificially appreciated the RMB from 2.5 CNY per USD in 1971 to 1.7 in 1978 (Table 3.13) After 1978, China has gradually transferred itself from a centrally-planned economy to a market-oriented economy. The foreign exchange system has also experienced several adjustments.

According to the historical events, focusing on the last three decades (Table 3.12), China's foreign exchange system can be divided roughly into three periods, which are 1979-1993, 1994-2005, and after 2005.

3.4.1. Foreign Exchange System during 1979-1993

In 1979, a "Foreign Exchange Rate Retention System" was introduced. Under the retention system, a moderate proportion of foreign exchange was allowed to be kept by appointed enterprises. These enterprises could then sell the foreign exchange retention beyond their usage to other enterprises via the foreign exchange adjustment market. With the development of the foreign exchange retention system, the BoC started to take foreign exchange adjustment as one of its services from October 1980. The sources of foreign exchange in the adjustment market were expanded from state-owned and collective enterprises to enterprises funded by foreign investors, foreign donation and foreign currency held by domestic residences.

In order to stimulate export performance, China instituted the "Internal Rate of Trade Settlement" in 1981. The "Internal Rate" was calculated from the average cost of earning a unit of foreign exchange through exports plus 10% of the profits. The internal rate (applied to foreign tradables transaction) was set at 2.8 CNY per USD

[21]Foreign exchange needed for imports must be purchased from the BoC with allocation limitation

while the official exchange rate (applied in non-tradables transactions) was 1.5 CNY per USD. The dual exchange rate system stimulated exports. However, problems occurred due to the ambiguous distinction between tradables and non-tradables transactions. Moreover, with the appreciation of the USD against other major currencies during this period, the government depreciated the RMB by raising the exchange rate from 1.5 CNY per USD to 2.3 in 1984. By the end of 1984, the official exchange rate has already been very close to the internal rate of trade settlement. Therefore, the dual exchange was abolished on the 1st January 1985 and the two exchange rates were unified at 2.8 CNY per USD. This is the first unification between the internal rate and official rate in China's foreign exchange policy history.

To assist the development of foreign exchange adjustment markets, the restrictions on the exchange rate on the adjustment market were relaxed in March of 1988. The official exchange rate was substituted by the swap rates agreed by two parties. The swap rates were determined by market supply and demand. In March 1988, local Foreign Exchange Adjustment Centres (FEACs) were established consecutively. With the increasing volume of swap transactions via the FEACs, the swap rate and official rate became parallel, which formed the Dual Exchange Rate System[22]. Under the Dual Exchange Rate System, in-plan and above-plan trades were essentially conducted at two different exchange rates, which were defined as the administered official exchange rate and the market-determined swap rate respectively.

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decided by the central plan.

[22] The introduction of the Dual Exchange Rate was a consequence of China's reform and opening-up policy. It gave internal convertibility to the RMB by allowing transactions at the swap rate between importers who could not get foreign exchange at the official rate and sellers who had extra foreign exchange. The importers' willingness to pay the swap rate (which was higher than the official rate), especially with a freer transaction environment after March 1988, gave the export enterprises strong incentives to export goods to the international market and to convert foreign exchange into the domestic currency. This incentive contributed to the increasing export volume during this period.

From the 9th April 1991, the adjustment of the official exchange rate was transferred from a large scale one-time adjustment to a moderate frequent adjustment. At the end of 1993, the official exchange rate was 5.27 CNY per USD, indicating a 9% devaluation of RMB (compared with that on 17th November 1990). The devaluation of RMB drove the exchange rate to a more realistic level. The premium between swap rate and official rate became volatile after removing the restrictions in 1988. In 1989, the premium fell sharply in response to the devaluation of the official exchange rate and a rapid increase of foreign exchange supply in the adjustment centres. After reaching the lowest point of about 8%, the premium raised again to about 45% by early 1993. With the intervention of the government, the swap rate rose to 8.72 CNY per USD at the end of 1993.

However, the Dual Exchange Rate also had its pitfalls. Firstly, it discouraged the foreign investment because it was simply unfair for the foreign investors to convert foreign exchange to RMB at the official rate and to convert RMB back to foreign exchange with the swap rate. Secondly, there were 18 foreign exchange adjustment markets and 90 FEACs before 1994. Therefore, the swap rate varied from area to area. Due to the different development levels, the supply and demand were unbalanced in one area and the black market prevailed which pushed the swap rate higher. Thirdly, enterprises with licences were the principal transaction participants, whilst the financial institutions played a role equivalent to no more than dealers because they were not allowed to participate in any transactions. The absence of the financial institutions as the primary leaders in the exchange rate adjustment centres provided windfall profits for the license holders by selling foreign exchange to importers. These importers were short of foreign exchange due to the bureaucratic allocation of the government. Without the financial institutions' leadership in the adjustment market, it was practically less effective for the BoC to intervene when the adjustment centres were overheating. These disadvantages led to the termination of the Dual Exchange Rate System in 1994, which is the *second* unification in China's foreign exchange policy history.

Before 1979, the BoC monopolistically operated foreign exchange. After the implementation of the reform and opening-up policy, special banks, commercial banks and some non-banking financial institutions were authorised to participate in the foreign exchange operation. On the 1st April 1980, convertible notes were introduced to foreigners and overseas Chinese to consume in approved stores and airports. Domestic residents were allowed to hold a certain ratio of their foreign exchange (though with restrictions on purchasing foreign exchange and limitations upon foreign exchange used for going abroad). From 1985, domestic residents were permitted to hold all the foreign remittance. From December 1991, all domestic residents were allowed to sell their foreign exchange at the swap centres. Certain amounts of foreign exchange were approved to be carried abroad for studying abroad, immigration, visiting family abroad and supporting relatives abroad. These reforms were a prelude for the unification of the Dual Exchange Rate in 1994.

3.4.2. Foreign Exchange Rate System after the Unification in 1994

On the 1st January 1994, the SAFE announced the termination the Dual Exchange Rate System of official rate and swap rate and substituted it with a unified and managed floating exchange rate system[23]. This was the second unification of the swap

[23] Currently, China's foreign exchange regime is a "managed floating exchange rate system" according to the announcement of PBC. However, some economists argue that China's foreign exchange regime is de facto a fixed system pegged to USD. According to Jiang et al. (2004), there are three reasons supporting this argument. Firstly, since 1994 and before the revaluation of RMB in July 2005 RMB has truly fixed pegging USD in the range of 8.27-8.75 (though USD exchange rate to major industrialized countries has gone through dramatic changes). Secondly, the "floating" band is extremely narrow —

and office rates. The foreign exchange retention system and the allocation of quotas were also abolished. The exchange rate was settled at 8.7 CNY per USD, with a floating margin of ±0.3% around the central parity.

The unification of the Dual Foreign Exchange System contributed significantly to the further development of China's economic reform. Firstly, the swap rate prior to the unification was replaced by the identical inter-bank foreign exchange rate across the country, eliminating the difference between FEACs. Thus, the speculative and uneven transactions were controlled. Secondly, the banks (especially the PBC) became the primary operators of foreign exchange. On the 1st April 1994, the inter-bank exchange rate market China's Foreign Exchange Trading Centre was established in Shanghai, connecting all of the branches across the country. The PBC determined the benchmark rate which reflected market conditions. Thirdly, the exchange rate of RMB during the current account reform devalued from 5.8 CNY per USD in 1993 to 8.7 in 1994. The foreign exchange reserves were enhanced from 21.2 billion USD at the end of 1993 to 145 billion Dollars at the end of 1997. The Chinese government appreciated the RMB from 8.7 CNY per USD in 1994 to 8.3 in 1995 and remained it stable until 2005. Fourthly, the stable and depreciated official exchange rate created a sound investment environment for the foreign investors. As a confirmation for China's successful reform, China was accepted by the WTO in November 2001.

3.4.2.1. Convertibility under Current Account

During April 1994 and June 1996, there was conditional convertibility under the current account. Foreign exchange transactions under current account used to be

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±0.3%. Thirdly, based on the weighted average rate formed by the bank's foreign currency market from the previous day, the PBC announces the basic standard exchange rate between RMB and the US Dollar, HK Dollar and the Japanese yen. Then according to the basic standard exchange rate with the operated in FEACs before April 1994. All foreign exchange transactions under the current account for domestic enterprises were operated by designated banks under the new exchange rate system operated. Convertible notes were ceased from issuing. The purchasing and selling of foreign exchange privately became forbidden. However, the foreign invested enterprises still had to purchase and sell the foreign exchange in the FEACs.

Since July 1996, foreign invested enterprises were included into the inter-bank foreign exchange market. All FEACs were closed after the 1st December 1998. From 1st July 1996 the foreign exchange purchasing limitation for the domestic residents was raised significantly. By December 1996, all remaining restrictions on foreign exchange under the current account were removed. The full convertibility of RMB was accomplished. China announced meeting the requirements of Article VIII of the Agreement of International Monetary Fund (IMF).

3.4.2.2. Convertibility under Capital Account

To gradually realise the convertibility of RMB under capital account, the government has made efforts to improve the capital account management. However, China remained strict control of the capital account by adhering to the three principles. Firstly, with the exception of the state departments, all foreign exchange income under the capital account in foreign countries must be moved back to China. Secondly, domestic enterprises and institutions (including foreign invested enterprises) must open foreign exchange capital account in banks. Capital deriving from foreign investment could be operated directly in designated banks with appropriate documentation, whilst foreign exchange income under the capital account

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US Dollar and referring to the exchange rate in international market, the PBC could exchange RMB from other recourses would be sold to the designated banks with the approval from the foreign exchange administrations. Thirdly, the purchase and payment of foreign exchange under the capital account should be operated at designated banks with the approval from foreign exchange administrations.

These principles indicate the strict control of the capital account from the government. However, the government relaxed capital account control (though gradually and in modest steps) after the achievement of the unconditional convertibility on current account and entry into the WTO in 2001. On 19th September 2001, the PBC and the SAFE announced the elimination of purchasing limitation to repay the overdue foreign loan and the relaxation of the purchasing limitation to repay the foreign loan and to invest abroad. On 3rd April 2003 the SAFE announced that the examination and approval procedures on the qualification of domestic enterprises' and their overseas branches' exchange financing would cease. On 17th May 2004, the SAFE announced that foreign exchange enterprises were exempt from providing appropriate documentation to purchase foreign exchange under a quota of 200,000 USD. In August 2005, the SAFE allowed devolution of its approving authority to local foreign exchange branch if the repurchasing of certain foreign listed shares by foreign listed overseas companies is less than 25 million USD.

The relaxation on capital account management established a sound environment for foreign investment and provided more freedom for domestic investment abroad. However, the Asian financial crisis warned the China's government against jeopardising the economy by lifting the restrictions on the capital account shortly without the achievement of a strong financial system. Therefore, there is still a long way to the full convertibility of foreign exchange under the capital account.

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into other foreign currencies other than the three currencies mentioned above.

3.4.3. Foreign Exchange System after 2005

3.4.3.1 Announcement of the People's Bank of China

On 21st July 2005, The PBC announced that the exchange rate is adjusted to 8.11 CNY per USD from 21st July 2005, a revaluation of 2%[24]. The floating band of CNY against the USD remains ±0.3% around the central parity, whilst the floating bands of CNY against other currencies will be announced by the PBC. RMB will be pegged to a basket of currencies rather than the USD. Also the RMB exchange rate regime will be improved with greater flexibility[25].

On the 10th August 2005, the governor of Chinese central bank, Zhou Xiaochuan, revealed the currencies in the basket. Dominant among a raft of currencies are the USD, Euro, Japanese Yen and South Korea's won. The Singapore Dollar, Pound Sterling, Malaysian Ringgit, Russian Rouble, Australian Dollar, Thai Baht and the Canadian Dollar are also considered in the calculation. Zhou explained that the currencies were chosen according to their shares in China's foreign trade, foreign debt and foreign direct investment. Currently the US, EU, Japan and South Korea are China's biggest trading partners. Their currencies are naturally the main ones in the basket. However, the details of how individual currencies are weighted in the basket remain unrevealed.

3.4.3.2. Background and Consequences of the Announcement

The US government believes the undervalued RMB assists the large deficit (Table 3.14) and claims large and efficient revaluation of Chinese RMB. While Chinese government believes that the reform on Chinese exchange rate system should be

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[24] The full text is available on the central bank's website www.pbc.gov.cn

[25] In May 2007, the Chinese central bank increased the floating band of CNY against the USD from ±0.3% to ±0.5% around the central parity.

implemented considering the development status of China and under the instruction of WTO rather than obey the trade protectionism advocated by some other countries. Chinese government agrees that China's RMB reform is unavoidable and necessary. However, China is currently experiencing high GDP growth and has large trade surplus, which are the similar situation as Japan before the Plaza Agreement[26]. To avoid the same disastrous road as Japan, Chinese government must adjust the RMB with cautions. Furthermore, the revaluation of the RMB is not justified as the solution for the US trade deficit. Products from other developing countries will flow into the US instead of Chinese goods even though China appreciates the RMB. Last but not least, the US trade deficit with China is equivalent to only 2% of the US GDP in 2007. Therefore, moderate revaluation of China's RMB will have little impact on US trade deficit[27].

Since the announcement in July 2005, the CNY has been appreciating against the USD. On 10th of April 2008, for the first time the CNY/USD exchange rate went below 7, which implies the RMB had appreciated by 14% since July 2005.

3.5. Development of Foreign Exchange Market

The development of China's foreign exchange market (Table 3.15) is affected and reflects foreign exchange policy. Before the unification in 1994, swap exchange rate played an essential role in the economy. After the termination of the Dual Exchange

[26] On 22nd September1985, finance ministers from the world's five biggest economies (the US, Japan, West Germany, France and the UK) announced the Plaza Accord at the eponymous New York hotel. Japan promised a looser monetary policy and a range of financial-sector reforms. All countries agreed to intervene in currency markets as necessary to get the Dollar down. The Dollar fell from around 240 yen to below 200 in three months within three months after the agreement, and continued to decline throughout 1986 till it reached 160 yen per US Dollar. The Japanese economy was greatly depressed by the sudden, sharp appreciation of the currency despite of a series of economic policy packages aimed at stimulating the economy. Details of the Plaza Agreement can be found in Kuroda (2004).

[27] According to the simulation of Park's (2005), a projected 10% revaluation of the RMB would only improve the US trade balance by 3.6 billion USD, a mere 0.02% change in the current account as a

Rate in 1994, the inter-bank foreign exchange functioned formally on the 4th April 1994. The level of foreign exchange transactions in 1994 was not as high as might be expected (40 billion USD). Two reasons account for this. First, the transaction range of the inter-bank foreign exchange market, at that time, was limited within the USD and Hong Kong Dollar. Second, the operational technology and regulation corresponding to these transactions were still underdeveloped. In 1995, the Japanese Yen was added into China's inter-bank foreign transaction market. With the widening service range and the improvement in both relative technology and regulation, foreign exchange transactions raised to 70 billion USD in 1997. Asian Financial Crises affected the overall Chinese economy, including the overall turnover in China's foreign exchange market in 1998 and 1999. After 2000, China's economy recovered gradually from the impacts of Asian Financial Crisis. Foreign trade and foreign investment were more active than before the crisis. In April 2002, Euro was added into China's foreign exchange market. In 2003, China's foreign exchange transaction reached 151 billion USD and the figure soared to 209 billion USD in 2004. By the end of June 2005 there have been 366 banks and financial institutions in China's official foreign exchange market.

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percent of GDP. Even when the expected revaluation is enlarged to 20%, the results change little, contributing only to a 0.05% reduction in the US current account deficit.

Table 3.1. China's GDP Growth

Year	China's Nominal GDP (100 Million CNY)	China's Real GDP (100 Million CNY)	Chin"s Real GDP Growth Rate (%)	Implied GDP Price Deflator (2000=100)
1978	3645.2	12896.7		28.3
1979	4062.6	13876.9	7.6	29.3
1980	4545.6	14959.3	7.8	30.4
1981	4889.5	15737.2	5.2	31.1
1982	5330.5	17169.2	9.1	31.0
1983	5985.6	19040.7	10.9	31.4
1984	7234.8	21934.9	15.2	33.0
1985	9040.7	24896.1	13.5	36.3
1986	10274.4	27086.9	8.8	37.9
1987	12050.6	30229.0	11.6	39.9
1988	15036.8	33644.9	11.3	44.7
1989	17000.9	35024.3	4.1	48.5
1990	18718.3	36355.3	3.8	51.5
1991	21826.2	39700.0	9.2	55.0
1992	26937.3	45337.3	14.2	59.4
1993	35260.0	51684.6	14.0	68.2
1994	48108.5	58455.3	13.1	82.3
1995	59810.5	64826.9	10.9	92.3
1996	70142.5	71309.6	10.0	98.4
1997	77653.1	77941.4	9.3	99.6
1998	83024.3	84020.8	7.8	98.8
1999	88189.0	90406.4	7.6	97.5
2000	98000.5	98000.5	8.4	100.0
2001	108068.2	106134.5	8.3	101.8
2002	119095.7	115792.8	9.1	102.9
2003	135174.0	127372.1	10.0	106.1
2004	159586.7	140236.6	10.1	113.8
2005	183956.1	154540.8	10.2	119.0
1980-1989			9.8	
1990-1999			10.0	
2000-2005			9.4	

Note: China's nominal GDP is colleted from *China Statistical Yearbook 2006* (*CSY 2006*). GDP price deflator is calculated based on data collected from *CSY 2006*. Others are author's calculation.

Table 3.2. Contributions to China's GDP by Economic Sector

Year	Gross Domestic Products	Primary Industry (Agriculture)	Secondary Industry (Industry)	Tertiary Industry (Services)
1978	100	27.9	47.9	24.2
1979	100	31.0	47.1	21.9
1980	100	29.9	48.2	21.9
1981	100	31.6	46.1	22.3
1982	100	33.1	44.8	22.1
1983	100	32.9	44.4	22.7
1984	100	31.8	43.1	25.1
1985	100	28.2	42.9	28.9
1986	100	26.9	43.7	29.4
1987	100	26.6	43.5	29.9
1988	100	25.5	43.8	30.7
1989	100	24.9	42.9	32.2
1990	100	26.9	41.3	31.8
1991	100	24.3	41.8	33.9
1992	100	21.5	43.5	35.0
1993	100	19.5	46.6	33.9
1994	100	19.6	46.6	33.8
1995	100	19.8	47.2	33.0
1996	100	19.5	47.5	33.0
1997	100	18.1	47.5	34.4
1998	100	17.3	46.2	36.5
1999	100	16.2	45.8	38.0
2000	100	14.8	45.9	39.3
2001	100	14.1	45.2	40.7
2002	100	13.5	44.8	41.7
2003	100	12.6	46.0	41.4
2004	100	13.1	46.2	40.7
2005	100	12.6	47.5	39.9
Average	100	22.6	45.3	32.1

Note: Data is collected from *CSY 2006*

Table 3.3. Comparison between World Bank and China's Definitions

<table>
<tr><td rowspan="5">World Bank GDP</td><td colspan="3">Agriculture</td></tr>
<tr><td rowspan="3">Industry</td><td colspan="2">Manufacturing</td></tr>
<tr><td colspan="2">Mining, electricity, water, and gas</td></tr>
<tr><td colspan="2">Construction</td></tr>
<tr><td colspan="3">Services</td></tr>
<tr><td rowspan="5">China's GDP</td><td colspan="3">Primary Industry (Agriculture)</td></tr>
<tr><td rowspan="3">Secondary Industry (Industry)</td><td rowspan="2">Industry*</td><td>Manufacturing</td></tr>
<tr><td>Quarrying, mining, electricity, water, and gas</td></tr>
<tr><td colspan="2">Construction</td></tr>
<tr><td colspan="3">Tertiary Industry (Services)</td></tr>
</table>

Note: The definition of China's Industry is narrower than the World Bank's. A "*" is used to distinguish.

Table 3.4. Foreign Trade Balance and Current Account (Millions of USD)

Year	Export Value	Export Growth Rate (%)	Import Value	Import Growth Rate (%)	Foreign Trade Balance	Foreign Trade Balance/ GDP (%)	Current Account	Current Account/ GDP (%)
1982	21125		16876		4249	2.0	5674	2.0
1983	20707	-2.0	18717	10.9	1990	0.9	4240	1.4
1984	23905	15.4	23891	27.6	14	0.0	2030	0.6
1985	25108	5.0	38231	60.0	-13123	-4.4	-11417	-3.7
1986	25756	2.6	34896	-8.7	-9140	-2.8	-7034	-2.4
1987	34734	34.9	36395	4.3	-1661	-0.5	300	0.1
1988	41054	18.2	46369	27.4	-5315	-1.3	-3802	-0.9
1989	43220	5.3	48840	5.3	-5620	-1.3	-4317	-1.0
1990	51519	19.2	42354	-13.3	9165	2.1	11997	3.1
1991	58919	14.4	50176	18.5	8743	1.8	13272	3.2
1992	69568	18.1	64385	28.3	5183	0.9	6401	1.3
1993	75659	8.8	86313	34.1	-10654	-1.7	-11609	-1.9
1994	102561	35.6	95271	10.4	7290	1.0	6908	1.2
1995	128110	24.9	110060	15.5	18050.1	2.3	1618.39	0.2
1996	151077	17.9	131542	19.5	19535	2.3	7243	0.9
1997	182670	20.9	136448	3.7	46222	4.9	36963	3.9
1998	183529	0.5	136915	0.3	46614	4.6	31472	3.1
1999	194716	6.1	158734	15.9	35982	3.3	21115	2.0
2000	249131	27.9	214657	35.2	34473.7	2.9	20518.4	1.7
2001	266075	6.8	232058	8.1	34017	2.7	17401	1.3
2002	325651	22.4	281484	21.3	44166.6	3.2	35422	2.5
2003	438270	34.6	393618	39.8	44651.6	2.9	45874.8	2.8
2004	593393	35.4	534410	35.8	58982.3	3.5	68659.2	3.6
2005	762484	28.5	628295	17.6	134189	7.2	160818	7.2

Note: Data is collected from *International Financial Statistics* (*IFS*)

Table 3.5. Compositions of China's Exports and Imports (Million USD)

Year	Export of Primary Goods			Export of Manufactured Goods			Import of Primary Goods			Import of Manufactured Goods		
		% of Total Exports	% of GDP		% of Total Exports	% of GDP		% of Total Imports	% of GDP		% of Total Imports	% of GDP
1980	9114	50.3	3	9005	49.7	3	6959	34.8	2.3	13058	65.2	4.3
1985	13828	50.6	4.5	13522	49.4	4.4	5289	12.5	1.7	36963	87.5	12.1
1989	15078	28.7	3.4	37460	71.3	8.3	11754	19.9	2.6	47386	80.1	10.6
1990	15886	25.6	4.1	46205	74.4	11.9	9853	18.5	2.5	43492	81.5	11.2
1991	16145	22.5	4	55698	77.5	13.7	10834	17	2.7	52957	83	13
1992	17004	20	3.5	67936	80	14.1	13255	16.4	2.7	67330	83.5	13.9
1993	16666	18.2	2.8	75078	81.8	12.5	14210	13.7	2.4	89749	86.3	14.9
1994	19708	16.3	3.6	101298	83.7	18.7	16486	14.3	3	99128	85.7	18.3
1995	21485	14.4	3.1	127295	85.6	18.2	24417	18.5	3.5	107667	81.5	15.4
1996	21925	14.5	2.7	129123	85.5	15.8	25441	18.3	3.1	113392	81.7	13.9
1997	23953	13.1	2.7	158839	86.9	17.7	28620	20.1	3.2	113750	79.9	12.7
1998	20489	11.2	2.2	163220	88.8	17.2	22949	16.4	2.4	117288	83.6	12.4
1999	19941	10.2	2	174990	89.8	17.7	26846	16.2	2.7	138853	83.8	14
2000	25460	10.2	2.4	223743	89.8	20.7	46739	20.8	4.3	178355	79.2	16.5
2001	26338	9.9	2.2	239760	90.1	20.4	45743	18.8	3.9	197810	81.2	16.8
2002	28540	8.8	2.2	297056	91.2	23.4	49271	16.7	3.9	245899	83.3	19.4
2003	34812	7.9	2.5	403416	92.1	28.5	72763	17.6	5.1	339996	82.4	24
2004	40549	6.8	2.4	552777	93.2	32.6	117267	16.9	5.3	443962	83.1	26.2
2005	49037	6.4	2.6	712916	93.5	38.2	147714	18.5	6.2	512239	81.5	27.4

Note: Data is collected from *CSY 2006*.

Table 3.6. Compositions of China's Manufactured Goods Exports

Year	Ratio of Chemicals and Related Products to Manufactured Goods (%)	Ratio of Light and Textile Industrial Products, Rubber Products, and Minerals to Metallurgical Products Manufactured Goods (%)	Ratio of Machinery and Transport Equipment to Manufactured Goods (%)	Ratio of Miscellaneous Products to Manufactured Goods (%)	Ratio of Products not Otherwise Classified to Manufactured Goods (%)
1980	12.4	44.4	9.4	31.5	2.3
1985	10	33.2	5.7	25.8	25.2
1989	8.5	29.1	10.3	28.7	23.3
1990	8.1	27.2	12.1	27.5	25.2
1991	6.9	26	12.8	29.8	24.5
1992	6.4	23.8	19.5	50.4	N/A
1993	6.2	21.8	20.4	51.7	N/A
1994	6.2	22.9	21.6	49.3	0
1995	7.1	25.3	24.7	42.9	0
1996	6.9	22.1	27.3	43.7	0
1997	6.4	21.7	27.5	44.4	0
1998	6.3	19.9	30.8	43	0
1999	5.9	19	33.6	41.4	0
2000	5.4	19	36.9	38.6	0.1
2001	4.6	15.1	32.8	30.1	0.2
2002	5.2	17.8	42.7	34.1	0.2
2003	4.9	17.1	46.5	31.3	0.2
2004	4.8	18.2	48.5	28.3	0.2
2005	5.0	18.1	49.4	27.2	0.2

Note: Data is collected from *CSY 2006*.

Table 3.7. China's Main Export Destinations and Origin of Imports

Year	Export Destination					Shares %					Origin of Imports					Shares %				
	Total Export	US	EU	Japan	HK	US	EU	Japan	HK	Sum	Total Import	US	EU	Japan	HK	US	EU	Japan	HK	Sum
1980	18.1	1.0	3.2	4.0	4.4	5.4	17.8	22.2	24.0	69.5	19.5	3.8	3.9	5.2	0.6	19.6	20.0	26.5	2.9	69.1
1981	21.5	1.5	3.2	4.7	5.3	7.0	15.0	22.1	24.5	68.6	21.6	4.7	3.8	6.2	1.2	21.6	17.3	28.6	5.7	73.3
1982	21.9	1.8	2.8	4.8	5.2	8.1	12.8	22.0	23.7	66.5	18.9	4.3	2.9	3.9	1.3	22.8	15.4	20.6	6.9	65.8
1983	22.1	1.7	3.1	4.5	5.8	7.8	14.1	20.4	26.2	68.5	21.3	2.8	4.2	5.5	1.7	12.9	19.9	25.8	8.0	66.6
1984	24.8	2.3	2.8	5.2	6.6	9.3	11.3	20.8	26.5	67.9	26.0	3.8	4.4	8.1	2.8	14.8	16.9	31.0	10.9	73.6
1985	27.3	2.3	3.0	6.1	7.1	8.5	11.1	22.3	26.2	68.1	42.5	5.2	7.7	15.2	4.8	12.2	18.1	35.7	11.2	77.3
1986	31.4	2.6	5.0	5.1	9.8	8.4	16.1	16.2	31.2	71.8	43.3	4.7	9.9	12.5	5.6	10.9	22.8	28.8	12.9	75.4
1987	39.5	3.0	5.2	6.4	13.8	7.7	13.1	16.2	34.9	71.9	43.2	4.8	9.2	10.1	8.4	11.2	21.2	23.3	19.5	75.2
1988	47.7	3.4	5.9	8.0	18.2	7.1	12.4	16.9	38.3	74.7	55.4	6.6	10.1	11.1	12.0	12.0	18.2	20.0	21.7	71.9
1989	52.9	4.4	6.0	8.4	21.9	8.3	11.3	15.9	41.4	76.9	59.1	7.9	10.9	10.5	12.5	13.3	18.4	17.8	21.2	70.7
1990	62.8	5.3	6.6	9.2	27.2	8.5	10.6	14.7	43.3	77.0	53.8	6.6	9.8	7.7	14.6	12.2	18.3	14.2	27.1	71.8
1991	72.0	6.2	7.4	10.3	32.1	8.6	10.3	14.2	44.7	77.8	63.9	8.0	9.7	10.0	17.5	12.5	15.2	15.7	27.5	70.9
1992	85.6	8.6	8.3	11.7	37.5	10.0	9.7	13.7	43.8	77.2	81.9	8.9	11.3	13.7	20.5	10.9	13.7	16.7	25.1	66.4
1993	91.7	17.0	12.9	15.8	22.1	18.5	14.1	17.2	24.1	73.8	103.6	10.6	16.6	23.3	10.5	10.3	16.0	22.5	10.1	58.9
1994	120.9	21.4	16.4	21.5	32.4	17.7	13.6	17.8	26.8	75.9	115.7	14.0	19.3	26.3	9.5	12.1	16.7	22.7	8.2	59.7
1995	149.0	24.7	20.5	28.5	36.0	16.6	13.8	19.1	24.2	73.7	132.2	16.1	21.8	29.0	8.6	12.2	16.5	21.9	6.5	57.1
1996	151.2	26.7	21.1	30.9	32.9	17.7	14.0	20.4	21.8	73.9	138.9	16.2	20.2	29.2	7.8	11.6	14.6	21.0	5.6	52.9
1997	182.9	32.7	25.5	31.8	43.8	17.9	13.9	17.4	23.9	73.2	142.2	16.3	19.4	29.0	7.0	11.5	13.6	20.4	4.9	50.4
1998	183.7	38.0	30.1	29.7	38.8	20.7	16.4	16.2	21.1	74.3	140.4	17.0	20.9	28.3	6.7	12.1	14.9	20.2	4.7	51.9
1999	194.9	42.0	32.3	32.4	36.9	21.5	16.5	16.6	18.9	73.6	165.7	19.5	25.9	33.8	6.9	11.8	15.6	20.4	4.2	51.9
2000	249.2	52.2	41.1	41.7	44.5	20.9	16.5	16.7	17.9	72.0	225.2	22.4	30.8	41.5	9.4	9.9	13.7	18.4	4.2	46.3
2001	266.7	54.4	44.6	45.1	46.5	20.4	16.7	16.9	17.4	71.5	243.6	26.2	36.5	42.8	9.4	10.8	15.0	17.6	3.9	47.2
2002	325.7	70.1	52.9	48.5	58.5	21.5	16.3	14.9	18.0	70.6	295.4	27.3	39.9	53.5	10.8	9.2	13.5	18.1	3.7	44.5
2003	438.4	92.6	79.1	59.4	76.3	21.1	18.1	13.6	17.4	70.1	412.8	33.9	55.0	74.2	11.1	8.2	13.3	18.0	2.7	42.2
2004	593.4	125.2	108.7	73.5	100.9	21.1	18.3	12.4	17.0	68.8	561.4	44.8	70.5	94.4	11.8	8.0	12.6	16.8	2.1	39.4
2005	762.3	163.3	145.7	84.1	124.5	21.4	19.1	11.0	16.3	67.9	660.2	49.0	73.9	100.5	12.2	7.4	11.2	15.2	1.9	35.7
2006	969.3	203.9	189.9	91.8	155.4	21.0	19.6	9.5	16.0	66.1	791.8	59.3	90.7	115.8	10.8	7.5	11.5	14.6	1.4	34.9

Note: Data is collected from *Direction of Trade Statistics Yearbook* (*DOTs*). According to *DOTs*, EU includes Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, and the United Kingdom.

Table 3.8. Foreign Direct Investment (FDI) and Capital Account (Million USD)

Year	FDI to China	China's Direct Investment Abroad	Net Direct Investment	Nominal Growth Rate of FDI to China (%)	FDI to China/GDP (%)	Capital Account	Capital Account/ GDP (%)
1982	430	-44	386	N/A	0.2	338	0.1
1983	636	-93	543	47.9	0.2	-226	-0.1
1984	1258	-134	1124	97.8	0.4	-1003	-0.3
1985	1659	-629	1030	31.9	0.5	8972	2.9
1986	1875	-450	1425	13.0	0.6	5944	2.0
1987	2314	-645	1669	23.4	0.7	6002	1.9
1988	3194	-850	2344	38.0	0.8	7132	1.8
1989	3393	-780	2613	6.2	0.8	3724	0.8
1990	3487	-830	2657	2.8	0.9	3255	0.8
1991	4366	-913	3453	25.2	1.1	8032	2.0
1992	11156	-4000	7156	155.5	2.3	-251	-0.1
1993	27515	-4400	23115	146.6	4.6	23474	3.9
1994	33787	-2000	31787	22.8	6.2	32644	6.0
1995	35849.2	-2000	33849.2	6.1	5.1	38675	5.5
1996	40180	-2114	38066	12.1	4.9	39967	4.9
1997	44237	-2563	41674	10.1	4.9	21015	2.3
1998	43751	-2634	41117	-1.1	4.6	6321	0.7
1999	38753	-1775	36978	-11.4	3.9	5179	0.5
2000	38399.3	-916	37483.3	-0.9	3.6	1922	0.2
2001	44241	-6884	37357	15.2	3.8	34775	3.0
2002	49308	-2518.41	46789.59	11.5	3.9	32291	2.5
2003	47076.7	152.275	47228.975	-4.5	3.3	52726	3.7
2004	54936	-1805	53131	16.7	3.3	110660	6.7
2005	79126	-11305	67821	44.0	3.5	62964	2.8

Note: Data is collected from China's *State Administration of Foreign Exchange* (*SAFE*). Minus signs represent investment from China to abroad.

Table 3.9. Foreign Exchange Reserves and Net Foreign Assets (Billion USD)

Year	Reserves	Net Foreign Assets	Reserves/GDP (%)	Net Foreign Assets/GDP (%)
1978	0.2	0.3	0.1	0.1
1979	0.8	-1.1	0.3	-0.4
1980	-1.3	-1.9	-0.4	-0.6
1981	2.7	1.6	0.9	0.5
1982	7.0	8.5	2.5	3
1983	8.9	12.1	3.0	4
1984	8.2	11.7	2.7	3.8
1985	2.6	7.5	0.9	2.4
1986	2.1	3.1	0.7	1
1987	2.9	7.8	0.9	2.4
1988	3.4	9.1	0.8	2.3
1989	5.6	10.7	1.2	2.4
1990	11.1	21.7	2.9	5.6
1991	21.7	27.3	5.3	6.7
1992	19.4	30.6	4.0	6.3
1993	21.2	38.6	3.5	6.4
1994	51.6	58.8	9.5	10.8
1995	73.6	76.5	10.5	10.9
1996	105.1	110.7	12.9	13.6
1997	139.9	164.8	15.6	18.3
1998	145.0	181.7	15.3	19.2
1999	154.7	205.7	15.6	20.7
2000	165.6	243.1	15.3	22.5
2001	212.2	319.3	18.0	27.2
2002	286.4	383.6	22.5	30.2
2003	403.3	455.9	28.5	32.2
2004	609.9	668.7	37.0	40.5
2005	818.9	923.9	36.5	41.1

Note: Foreign exchange reserves and net foreign assets are collected from *SAFE* and *IFS* respectively.

Table 3.10. China's Overall Tariff Rate (2001-2005)

Year	Overall Tariff Rate (%)
2001	15.3
2002	12.0
2003	11.0
2004	10.4
2005	9.9

Note: Data is collected from *SAFE*.

Table 3.11. Gross Regional Product (GRP) and FDI Inflows of Special Economic Zones (SEZs) and Open Coastal Cities

Year	GRP of SEZs (100 Million CNY)	GRP of Coastal Cities (100 Million CNY)	Total GRP of SEZs and Coastal Cities/GDP (%)	Foreign Capital actually utilised SEZs (100 million USD)	Foreign Capital actually utilised by Coastal Cities (100 million USD)	Total Foreign Capital actually utilised by the SEZs and Coastal Cities/FDI to China
1995	1507	9044	18	50	150	55.8
2000	2974	17110	22.8	40	140	46.9
2003	4655	24521	24.9	60	227	61.0
2005	7244	34817	22.9	45	288	42.1

Note: Data is collected from *CSY 2006.*

Table 3.12. Historical Events 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% of revaluation of CNY against USD. The RMB is pegged to a basket of currencies rather just the USD.

Table 3.13. Nominal Exchange Rate of CNY against USD (Period Average)

Year	CNY per USD	Year	CNY per USD	Year	CNY per USD
1956	2.46	1973	1.98	1990	4.78
1957	2.46	1974	1.96	1991	5.32
1958	2.46	1975	1.86	1992	5.51
1959	2.46	1976	1.94	1993	5.76
1960	2.46	1977	1.86	1994	8.62
1961	2.46	1978	1.68	1995	8.35
1962	2.46	1979	1.55	1996	8.31
1963	2.46	1980	1.50	1997	8.29
1964	2.46	1981	1.70	1998	8.28
1965	2.46	1982	1.89	1999	8.28
1966	2.46	1983	1.98	2000	8.28
1967	2.46	1984	2.29	2001	8.28
1968	2.46	1985	2.93	2002	8.28
1969	2.46	1986	3.43	2003	8.28
1970	2.46	1987	3.72	2004	8.28
1971	2.46	1988	3.72	2005	8.19
1972	2.24	1989	3.76	2006	7.97

Note: Data is collected from *IFS*

Table 3.14. US Exports from, Imports to and Trade Balance with China (Billion USD)

Year	Exports	% of Total	Imports	% of Total	Balance	% of Total
1994	9.3	1.8	38.8	5.8	-29.5	17.8
1995	11.8	2.0	45.5	6.1	-33.8	19.4
1996	12.0	2.0	51.5	6.4	-39.5	20.7
1997	12.9	1.9	62.6	7.1	-49.7	25.0
1998	14.2	2.1	71.2	7.7	-56.9	22.9
1999	13.1	1.9	81.8	7.9	-68.7	19.7
2000	16.2	2.1	100.0	8.2	-83.8	18.4
2001	19.2	2.7	102.3	8.9	-83.1	19.3
2002	22.1	3.2	125.2	10.7	-103.1	21.3
2003	28.4	4.0	152.4	12.1	-124.1	22.5
2004	34.7	4.2	196.7	13.4	-162.0	24.2
2005	41.8	4.6	243.5	14.6	-201.7	25.6
2006	55.2	5.3	287.8	15.5	-232.6	27.7
2007	65.2	5.6	321.5	16.5	-256.3	31.4

Note: Data is collected from the *Foreign Trade Statistics, US Census Bureau*

Table 3.15. Statistics of China's Foreign Exchange Transactions

Year	Overall Turnover (100 Million USD)	USD		HKD		JPY		EURO	
		Trading Volume (100 Million USD)	Weighted Average Exchange Rate (RMB/USD)	Trading Volume (100 Million HKD)	Weighted Average Exchange Rate (RMB/HKD)	Trading Volume (100 Million JPY)	Weighted Average Exchange Rate (RMB/100JPY)	Trading Volume (100 Million Euro)	Weighted Average Exchange Rate (RMB/EURO)
1994	408.0								
1997	700.0								
1998	519.6								
2000	421.8								
2001	750.32	741.33		30.62		613.93			
2002	971.90	951.09	8.2769	108.81	1.0608	730.79	6.6203	1.07	8.0044
2003	1511.32	1478.17	8.2770	186.32	1.0626	761.57	7.1594	2.97	9.3830
2004	2090.41	2044.10	8.2768	244.94	1.0623	1349.63	7.6729	1.86	10.2982
2005 (January-June)	1461.46	1429.29	8.2765	174.15	1.0617	781.97	7.8087	1.92	10.6415

Note: Data is collected from People's Bank of China. Transaction in Euro started in March 2002.

Chapter 4

An Extended NATREX Model for China

4.1. Introduction

This chapter is the first attempt to extend Stein's (1994) NATREX model to China. We incorporate fundamentals that have not been studied by the previous literature into the framework of the NATREX model to capture the unique characteristics of the Chinese economy. Based on dynamic stability analysis, we derive the medium-run and long-run real equilibrium exchange rates that are delivered by these dynamic fundamentals. The extended NATREX model developed in this chapter provides the theoretical foundation for the empirical investigation in Chapter 5.

4.2. Differences between Stein's Model and the Extended Model for China

The differences between the original NATREX model of Stein (1994) and our extended model can be summarised from the following six perspectives.

1. The two state variables (endogenous fundamentals) in Stein's model are capital per effective labour and net 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.

2. The growth rate of GDP is used as an approximation of productivity in Stein's model. However, in our study we estimate the production function for China to derive total factor productivity. Furthermore, following Woo (1998), rural transformation is incorporated into the production function to reflect the effect of China's rural-urban migration and rural industrialisation on the real exchange rate.

3. Time preference is regarded as exogenous in Stein's model. Modigliani and Cao (2004) model savings in China using the life cycle model and find it is endogenously determined by other fundamentals. Following Modigliani and Cao (2004), time preference in our study is considered as an endogenous variable that is determined by fundamentals such as demographic factors and liquidity constraints.

4. The aggregate investment is a function of Tobin's q in Stein's model. In this study, the investment is divided into domestic private investment, government investment and foreign direct investment (FDI). The domestic private investment function is constructed based on Jorgensen's (1963) neoclassical model. China's market-oriented economy is still in transition, given that elements of planned economy remain in government investment. Therefore, government investment is separated from gross investment and regarded as exogenous to capture the effect of government behaviour on the real exchange rate. China is one of the biggest FDI destinations in the world. Therefore, fundamentals that affect FDI flows to China, such as relative unit labour cost, relative rate of return to capital and country risk premium, are incorporated in the investment function to estimate their influence on the real exchange rate.

5. As the uncovered interest parity does not seem to hold for China, country risk premium is introduced in the portfolio balance equation to explain the divergence.

6. Terms of trade are regarded as endogenous for the US in Stein's (1994) model and are exogenous for Australia in Lim and Stein (1995). We regard the terms of trade for China as an exogenous fundamental. Based on the exogenous terms of trade, the goods market clearing condition is equivalent to non-tradable goods market equilibrium.

The rest of this chapter is organised as follows. Section 4.3 outlines the structure of the model and the specification of its individual components. Section 4.4 examines the dynamic stability of the model and analyses the medium-run and steady state equilibrium. Section 4.5 analyses in detail the effects of the economic fundamentals on the relative price of non-tradables and on the real exchange rate in the medium-run and the long-run. The final section draws conclusions.

4.3. The Structure of the Model

4.3.1. Consumption

In Stein (1994), consumption, C, is proportional at rate g to the current wealth, W: $C(t) = gW(t)$. g is referred to as the social time preference. Wealth is a function of capital per effective labour, $k(t)$, and net foreign debt per effective labour, $F(t)$: $W(t) = k(t) - F(t)$. Therefore, the consumption function can be written as $C = C(k, F; g)$ with $\partial C/\partial g > 0$. For China, there are two modifications for the consumption function. First, as China is a net creditor, wealth is capital $k(t)$ plus foreign assets $F(t)$ [1]: $W(t) = k(t) + F(t)$. Second, following Modigliani and Cao (2004), the social time preference g is modelled as an endogenous rather than exogenous variable. The determinants of g are demographic factors and financial liberalisation.

4.3.1.1. Demographic Factors

Since the "One-Child" policy was implemented in the late 1970s, the ratio of minors (age under 15) to employment has gradually diminished. In China the pre-working population is raised and educated while their parents pay most of the expenditure

[1] Capital per effective labour, $k(t)$, net foreign assets per effective labour, $F(t)$, and other quantity variables are all measured per unit of effective labour in the entire economy. We refer to capital and foreign assets as capital stock per effective labour and net foreign assets per effective labour for simplicity.

before they are eligible to work. Therefore, the ratio of minor population has a positive effect on consumption ratio. Using cross-section data, Modigliani (1970) shows that both the ratio of retired population (age 65 and over) and the ratio of pre-working population to the working-age population (age between 20 and 65) have a strong and high significant negative effect on the savings ratio. However, as argued by Modigliani and Cao (2004), for China the relation between the number of minors and employed population is the crucial demographic variable. In their study of Chinese savings, Modigliani and Cao (2004) find that One-Child policy has led to a gradual reduction in the ratio of minors to employment and thereby has reduced the consumption-to-income ratio. Therefore, the dependency ratio (DEP), the ratio of minors to the employed population, will be incorporated into the consumption function to indicate the demographic effects.

4.3.1.2. Liquidity Constraints

Existing literature studying consumption in China shows the insignificance of interest rate effect and the importance of liquidity constraints on consumption (e.g., Li, 1999; Research Bureau of the PBC, 1999; Wang *et al*, 2000; Yang and Li, 1997; Zhang, 1997; Zhang and Wan, 2002). The behaviour of consumers in developing countries could be dominated by liquidity constraints that affect the ability to substitute consumption intertemporally (Rossi, 1988). On the other hand, as argued by Prasad (2004), China's transformation into a dynamic private-sector-led economy and its integration into the global economy have been among the most dramatic economic developments of the recent decades. Therefore, under an imperfect financial market, the effectiveness of financial liberalisation in relaxing the liquidity constraints is an important determinant of consumption in China. Following Kose, Prasad and

Terrones (2006), we incorporate the level of financial market development, measured by the ratio of total credit to the private sector to GDP ($CREP$), into the consumption function.

In terms of the real interest rate, according to Krugman (1998), a reduction in real interest rates caused by the expectations of inflation would stimulate personal consumption. However, according to Zhang and Wan (2002), the substitution effect of the real interest rate is weak in China. In addition, they argue that the interest rate in China is still administered. Therefore, the interest rate is not included in the consumption function as its effect on consumption is insignificant and it is not yet market determined.

Therefore, the consumption function for China could be expressed as

$$C = C(\underset{+}{k}, \underset{+}{F}; g) = C(k, F; \underset{+}{DEP}, \underset{+}{CREP}) \qquad (4.1)^2$$

where DEP and $CREP$ are demographics factors and financial liberalisation respectively.

4.3.2. Production Function

4.3.2.1. Total Factor Productivity

In Stein's (1994) NATREX framework, output per effective labour, y, is a function of capital per effective labour, k, and productivity, $u : y = y(k;u)$. The productivity is approximated using twelve-quarter moving average of the growth rate of the real GDP in the US and the G-10 countries in Stein (1994). Other approximations of productivity have been used in the existing NATREX studies. Lim and Stein (1995) use the average product of labour in their study of NATREX for Australia. Connolly and Devereux (1995) employ relative income per capita in terms of the US to analyse the NATREX for France and Germany. Crouhy-Veyrac and Marc (1995) use the ratio of business capital to employment in their study of Latin America. Stein (1995b) employs the q-ratio as an approximation of productivity, where q=industrial share prices (GR62)/prices of industrial products (GR63) in his study of NATREX for Germany. For China, instead of using approximations, we will derive total factor productivity (TFP) from estimations of the production function[3] ($y = y(k;TFP)$) and incorporate it as a key fundamental into the extended NATREX model.

4.3.2.2. Net Factor Productivity and Rural Transformation

Since the "reform and opening-up" policy was implemented in 1978, two forms of rural transformation have taken place: rural-urban migration and rural industrialisation. Rural-urban migration has been reducing China's rural population through migration from countryside to cities. Rural industrialisation has shifted farmers from working in their fields to working in labour-intensive rural enterprises (i.e. Town and Village Enterprises). Rural transformation is particularly relevant for China as China's economic growth benefits greatly from its unlimited labour supply which is generated from rural transformation. In contrast to transition countries, China's transformation from centrally-planned to market-oriented economy is characterised by the shifting of labour from the lower productive primary sector to more productive secondary and tertiary sectors[4].

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[2] Signs are explained in detail in Appendix 4.B.

[3] We use *TFP* because productivity approximated by output per labour or the growth rate of output may lead to measurement errors. For instance, conventionally output per labour is a function of capital per labour and total factor productivity. Using output per labour as an approximation of total factor productivity implies capital per labour must expand at the same speed of output per labour and total factor productivity. Otherwise, total factor productivity will be over valued or under valued by using output per labour as an approximation.

[4] Chow (1993) finds that the marginal value product of labour in 1978 to be 63 Yuan in agriculture, 1027 Yuan in industry, 452 Yuan in construction, 739 Yuan in transportation and 1809 Yuan in commerce.

The link between China's rural transformation and economic growth has been analysed by Woo (1998). He separates the TFP between net TFP and reallocation of labour. The determinants he incorporates in the economic growth model are capital accumulation, labour force growth, reallocation of labour from agriculture and net TFP growth. The official economic growth rates are 9.3% and 9.7% for China during the periods 1979-1993 and 1985-1993 respectively. Labour reallocation accounts for 1.1% and 1.3% of the economic growth for the two periods separately. In this study, we divide TFP into net factor productivity (NFP) and rural transformation (RT). Therefore, the production function for China takes the form of

$$\underset{}{y} = y(\underset{+}{k};\underset{+}{NFP},\underset{+}{RT}) \tag{4.2}$$

4.3.3. Savings Function

Savings can be expressed as Gross National Income less consumption

$$s = y(k;NFP,RT) + r'F - C(k,F;CREP,DEP) = S(\underset{+}{k},\underset{-}{F};\underset{+}{NFP},\underset{+}{RT},\underset{+}{r'},\underset{-}{CREP},\underset{-}{DEP}) \tag{4.3}$$

where r' denotes the world's real interest rate.

4.3.4. Investment Function

Stein (1994) derives the investment function from the q ratio developed by Tobin (1969). The q ratio stands for the ratio of market value of business capital assets to the replacement value of those assets. However, as proposed by Song *et al* (2001), Tobin's q ratio does not seem to be applicable to China. In the first place, firms' capital assets are valued in the financial markets in Tobin's model. China's financial markets have a development history of less than twenty years[5]. Not only is the scale of financial markets relatively small but also there are restrictions on the transactions in the financial markets imposed by the government. Furthermore, the assumption of a perfect competitive market, a crucial assumption of Tobin's model, does not hold for China.

Besides Tobin's q, alternative investment models include the accelerator model, cash-flow model, and the neoclassical model. Recent studies have tried to explain China's aggregate investment using different models (e.g. Sun, 1998; Zhu and Liang, 1999; Shen, 1999, 2000; Song *et al*, 2001; Qin and Song, 2003; He and Qin, 2004). Various variables have been used to interpret the path of aggregate investment[6]. Among these studies, Song *et al* (2001) and He and Qin (2004) employ the neoclassical investment model. In Song *et al* (2001), the model for aggregate investment is based on the assumption that firms' investment decisions are made by assessing the market demand (measured by output) and the cost of capital

$$\frac{dK}{dt} = I(Y,c)$$

where K, c and Y are capital, user cost of capital and output. The cost of capital is calculated as: $c = \alpha\frac{Y}{K}$, where α is elasticity of output with respect to capital. α is estimated from the production function: $Q_t = AK_t^{\alpha} L_t^{\beta} H_t^{\gamma} R_t^{\eta}$, where Q_t, K_t, L_t, H_t and R_t are, respectively, the quantity of final products, capital , labour inputs, input of human capital and R&D expenditure on technological innovation. He and Qin (2004) apply the neoclassical investment model to the business sector investment. The business sector investment is modelled as a function of the cost of capital, output

[5]Shenzhen and Shanghai Stock Exchange Market, the first two Chinese stock markets were established in 1992.

and government investment. In He and Qin (2004), the user cost of capital is estimated using the definition of Romer (2001)

$$c = \frac{p_k(r+\delta)}{p(1-\tau)} \tag{4.4}$$

where c, p_k, p, r, δ and τ are, respectively, the user cost of capital, price of capital good

s, output price, real interest rate, rate of economic depreciation and the composite tax rate.

Following Song *et al* (2001) and He and Qin (2004), we model domestic private investment using the neoclassical model[7]. However, compared with Song *et al* (2001) who apply the neoclassical model to China's aggregate investment, we first divide the aggregate investment into domestic investment and FDI, with the former further divided into domestic private investment and government investment. Then we model each investment with an individual function with the domestic private investment modelled using the neoclassical model. Such a division of aggregate investment into three components is necessary not only because all these investment are important components of China's aggregate investment, but also because each investment has its own properties and determinants. A similar division has been implemented by He and Qin (2004) where they separate domestic aggregate investment into business sector investment and government investment and each investment is modelled individually. Now we are going explain the modelling of the three components of China's aggregate investment (domestic private investment, government investment and FDI) in detail.

[6] For an review of these papers, please refer to He and Qin (2004).

4.3.4.1. Domestic Private Investment—Neoclassical Investment Model

Following He and Qin (2004), the domestic private investment per effective labour for China (I_{DPI}) can be modelled as

$$I_{DPI} = f(y, c)$$

It can be further written as

$$I_{DPI} = f(y, c) = f\big(y(k; NFP, RT), c\big) = f(\underset{+}{k}; \underset{+}{NFP}, \underset{+}{RT}, \underset{-}{c}) \qquad (4.5)$$

4.3.4.2. Government Investment

Before the launch of the national policy of "reform and opening-up" in 1978, state-owned enterprises (SOEs) were fully administrated by Chinese government under the centrally-planned economy. Restructuring and privatisation have reduced the number of SOEs. However, according to data from Chinese Statistical Yearbook, a considerable proportion of investment still flows to SOEs. For instance, 35.5% of total investment of fixed assets flowed to SOEs in 2004. Investment to SOEs is clearly affected by government investment policies. According to Xiang (1999), one of the major roles of government investment is to finance state-prioritised investment projects. Zhu and Liang (1999), Shen (1999) and Shen (2000) include government investment as an explanatory variable of aggregate investment and find it significant. Therefore, the ratio of government investment to total fixed assets investment (GI) is incorporated into the investment function as an exogenous variable to capture the effects of government behaviour.

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[7] For reasons of why neoclassical model is more applicable to model China's investment, refer to Song *et al.* (2001).

4.3.4.3. Foreign Direct Investment

FDI is an important component of aggregate investment in China[8]. The reduction of barriers to FDI and the implementation of policies to improve the investment environment have played a key role in attracting FDI in China. Special Economic Zones, open coastal cities and FDI favourable policies are among the most successful measures of China's economic reform since 1978. There are extensive studies analysing the determinants of FDI to China[9]. Amongst them, wage levels have been widely employed as a crucial determinant of FDI to China (i.e. Dees, 1998; Coughlin and Segev, 2002; Fung *et al*, 2002; Shan, 2002; Sun *et al*, 2002; Zhang, 2000, 2001; Ho, 2004). As the US is regarded as the foreign country in this study, the relative unit labour cost of China to the US will be employed rather than Chinese wage levels. A considerable amount of literature shows that country risk has a significant impact on foreign investment decisions. Some recent studies include Nordal (2001), Bevan and Estrin (2004) and Janicki and Wunnava (2004). Some studies on the determinants of FDI in China try to incorporate country risk related variables as determinants due to data limitation on country risk. For instance, Ng and Tuan (2003) incorporate trade constraints and both Zhang (2000) and Zhang (2001) incorporate trade barriers and political stability as determinants of FDI to China. In our study, we use foreign assets F as an approximate of country risk (as in Lim and Stein, 1995) and incorporate it into the FDI function. Furthermore, we introduce the relative return to capital of China as an important determinant of FDI. Therefore, FDI is a function of

$$FDI = f(RULC, RRC, F) \tag{4.6}$$

where $RULC$ and RRC are relative unit labour cost of China to the US and relative return to capital of China to the US respectively.

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[8] See Chapter 3.

Therefore, the aggregate investment function can be expressed as

$$I = I(I_{DPI}, GI, FDI) = I(\underset{+}{k}, \underset{+}{F}; \underset{+}{NFP}, \underset{+}{RT}, \underset{-}{c}, \underset{+}{GI}, \underset{-}{RULC}, \underset{+}{RRC}) \tag{4.7}$$

4.3.5. Goods Market and Current Account

In their study of NATREX for Australia, Lim and Stein (1995) assume that the economy produces exports 1 and non-tradables n. The foreign country does likewise where the exports are goods 2. R_n denotes the relative price of non-tradables n (p_n) to the exports (p_1)

$$R_n = \frac{p_n}{p_1}. \tag{4.8}$$

The terms of trade (T) are the relative price of exports 1 (p_1) to imports 2 (p_2') measured in a common currency

$$T = N\frac{p_1}{p_2'}, \tag{4.9}$$

where N is the nominal exchange rate defined as US dollar per Australia dollar. The terms of trade T and prices of the US are exogenous for the small open economy Australia.

Following Stein and Lim (1995), the real exchange rate of China, R, is a function of terms of trade T and the relative price of non-tradables R_n (Appendix 4.A)

$$R = T(R_n)^a \tag{4.10}$$

where a denotes the weight given to the non-tradables sector in the GDP price deflator. The relationship between nominal and real exchange rate is defined as

$$N = R\frac{p'}{p}, \tag{4.11}$$

[9] For a literature review of recent studies of determinants of FDI in China, please refer to Ho (2004).

where N, p and p' denote the nominal exchange rate (defined as US dollar, USD, per Chinese Yuan, CNY), the Chinese GDP price deflator and the US GDP price deflator respectively.

We regard China's terms of trade as exogenous. China's export share in the world has increased considerably from 0.75% of total world exports in 1978 to 7.3% in 2005 (Chinatoday, 2006[10]). However, Kamin *et al* (2006) evaluate the question of whether China's buoyant export growth has led to significant changes in the import prices. They find that the impact of Chinese exports on global import prices has been, while non-negligible, fairly modest. In terms of the China-US trade relationship, they identify a statistically significant effect of US imports from China on US import prices, but given the size of this effect and the relatively low share of imports in US GDP, the ultimate impact on US consumer prices has likely been quite small. Furthermore, using multi-country database of trade transaction, they find that, since 1993, Chinese exports reduce annual import inflation in a large set of economies by 0.25% or less on average. Therefore, the terms of trade are regarded as exogenous in this study given that the influence of China in the world trade is still limited despite the relative increase in its importance.

Aggregate consumption can be divided into consumption of non-tradables n (C_n) and consumption of imports 2 (C_2). The relative price of non-tradables n (p_n) to the imports 2 (p'_2) can be expressed as

$$N\frac{p_n}{p'_2} = \left(\frac{Np_1}{p'_2}\right)\left(\frac{p_n}{p_1}\right) = TR_n \qquad (4.12)$$

[10] http://www.chinatoday.com/trade/a.htm

This relative price affects shares of C_n and C_2 within the aggregate consumption C. For instance, an increase in the relative price of non-tradables n (p_n) to the imports 2 (p_2') will decrease demand for non-tradables and increase demand for imports. Therefore, consumption of non-tradables n (C_n) and consumption of imports 2 (C_2) can be expressed as

$$C_n = C_n(\underset{-}{R_n}, \underset{+}{k}, \underset{+}{F}; \underset{+}{DEP}, \underset{+}{CREP}, \underset{-}{T}) \tag{4.1a}$$

$$C_2 = C_2(\underset{+}{R_n}, \underset{+}{k}, \underset{+}{F}; \underset{+}{DEP}, \underset{+}{CREP}, \underset{+}{T}) \tag{4.1b}$$

Production can be divided into production of non-tradables n (y_n) and exports (y_1). The relative price of non-tradables n (p_n) to the exports 1 (p_1), $R_n = p_n / p_1$, affects allocation of supply of y_n and y_1. For instance, an increase in R_n will increase the supply of non-tradables, y_n, and decrease the supply of exports, y_1. Therefore, y_n and y_1 can be expressed as:

$$y_n = y_n(\underset{+}{R_n}, \underset{+}{k}; \underset{+}{NFP}, \underset{+}{RT}) \tag{4.2a}$$

$$y_1 = y_1(\underset{-}{R_n}, \underset{+}{k}; \underset{+}{NFP}, \underset{+}{RT}) \tag{4.2b}$$

Capital is used to produce non-tradables n and exports 1, while capital good consists of both non-tradables n and imports 2. Relative price of non-tradables to imports, TR_n, affects shares of investment using non-tradables (I_n) and investment using imports (I_2) within the aggregate investment I. For instance, a higher relative price of non-tradables discourages I_n, and encourages I_2.

If the investment good consists of fraction m of imports 2 and fraction $(1-m)$ of non-tradables n, then $I = I_2^m I_n^{(1-m)}$. Hence the price of capital is

$p_k = (p_2'/N)^m (p_n)^{(1-m)}$. If capital is used to produce fraction a of exports 1 and fraction $(1-a)$ of non-tradables n, then the output price is $p = (p_1)^a (p_n)^{(1-a)}$. Hence the relative price $\frac{p_k}{p}$ in equation (4.4) can be rewritten as

$$\frac{p_k}{p} = \frac{(p_2'/N)^m (p_n)^{(1-m)}}{(p_1)^a (p_n)^{(1-a)}} = T^{-m} R_n^{\ a-m} \tag{4.13}$$

The user cost of capital can be rewritten as

$$c = \frac{p_k(r+\delta)}{p(1-\tau)} = T^{-m} R_n^{\ a-m} d \text{ or } c = c(T, R_n, d) \tag{4.14}$$

where $d = \frac{r+\delta}{1-\tau}$. As we assume the depreciation rate, δ, is a constant, d is a function of r and τ: $d = d(r,\tau)$. Therefore equation (4.14) can be rewritten as

$$c = c(T, R_n, r, \tau) \tag{4.15}$$

An increase in terms of trade T decreases the user cost of capital and increases investment. Higher r and τ raise user cost of capital and discourage investment. The effect of relative price of non-tradables R_n is ambiguous, depending on the sign of $(a-m)$. Compared with its main effect of allocating investment using non-tradables and imports within aggregate investment, the ambiguous effect of R_n on user cost of capital is negligible. As mentioned above, an increase in R_n will discourage demand for investment using non-tradables, I_n and encourage demand for investment using imports, I_2.

Hence the investment using non-tradables and imports can be expressed as

$$\begin{aligned} I_2 &= I_2\big(\underset{+}{R_n}, \underset{+}{k}, \underset{+}{F}; \underset{+}{NFP}, \underset{+}{RT}, c(\underset{+/-}{R_n}, \underset{+}{T}, \underset{-}{r}, \underset{-}{\tau}), \underset{+}{GI}, \underset{-}{RULC}, \underset{+}{RRC}, \underset{+}{T}\big) \\ &= I_2\big(\underset{+}{R_n}, \underset{+}{k}, \underset{+}{F}; \underset{+}{NFP}, \underset{+}{RT}, \underset{-}{r}, \underset{-}{\tau}, \underset{+}{GI}, \underset{-}{RULC}, \underset{+}{RRC}, \underset{+}{T}\big) \end{aligned} \tag{4.7a}$$

$$I_n = I_n\left(R_n, k; NFP, RT, c(R_n, T, r, \tau), GI, T\right)$$

− + + + +/− + − − + −

$$= I_n\left(R_n, k; NFP, RT, r, \tau, GI, T\right) \quad (4.7b)$$

− + + + − − + +/−

$$I = I_2 + I_n = I(R_n, k, F; NFP, RT, r, \tau, GI, RULC, RRC, T)^{11} \quad (4.7c)$$

+/- + + + + − − + − + +

Based on the exogenous terms of trade, the equilibrium condition for the good market is the market clearing condition for the non-tradables

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

$$C_n\left(R_n, k, F; DEP, CREP, T\right) + I_n\left(R_n, k; NFP, RT, r, \tau, GI, T\right) - y_n\left(R_n, k; NFP, RT\right) = 0 \quad (4.16)$$

The market clearing equation (4.16) implies that the demand for the non-tradables, which consists of consumption C_n and investment using non-tradables I_n, equals the supply of the non-tradables y_n.

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

$$\begin{aligned} CA = {} & y_1(R_n, k; NFP, RT) - I_2\left(R_n, k, F; NFP, RT, r, \tau, GI, RULC, RRC, T\right) \\ & - C_2(R_n, k, F; DEP, CREP, T) + r'F \end{aligned} \quad (4.17)$$

4.3.6. Rate of Change of Foreign Assets

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

[11] On the one hand, higher T implies a lower user cost of capital, which stimulates both segments of investment (I_n and I_2) and hence aggregate investment I. One the other hand, higher terms of trade (T) implies a higher relative price of non-tradables to imported goods, which discourages I_n and encourages I_2. So its total effect of T on aggregate investment I becomes ambiguous. However, compared to its positive effect on aggregate investment, the effect of T on allocating demand of investment between using non-tradables and using imports is negligible. Hence eventually T has a positive effect on aggregate investment I.

$$\frac{dF}{dt} = S - I - nF = CA - nF \tag{4.18}$$

where n is the growth rate of effective labour.

4.3.7. Portfolio Balance

In his study of NATREX of the US dollar, Stein (1994) finds that the real long-term bond yields of US and the G-10 countries converge. This implies acceptance of the uncovered interest parity (UIP) hypothesis. In their study for the small open economy Australia, Lim and Stein (1995) find that there are some significant deviations from UIP. The interest rate parity theory was used in a seminal paper Frenkel and Levich (1977). Such a theory was further analysed and studied by many others (e.g. Dooley and Isard, 1980; Otani and Tiwari, 198; Frankel, 1984, 1991). According to these studies, deviations from both covered and uncovered interest rate parity conditions capture transaction costs, including political risks, exchange rate risk (market pressure), and transaction costs—which Frankel (1991) calls "the country premium". In term of China, Ma *et al* (2004) find that though onshore and offshore interest rate differentials have been shrinking over time, China's capital controls are still effective as these interest rate differentials still remain large. Liu and Otani (2005) show that deviations from the UIP condition for China 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 premium. Lane and Milesi-Ferretti (2001) suggest that a country's steady state risk premium (in their case measured as the real interest rates differential) is inversely and linearly related to net foreign asset position in their study of long term capital movement for a group of industrial and developing counties including China. Other studies which relate the deviations from UIP to net foreign assets include Selaive and Tuesta (2003a) and Cavallo and Ghironi (2002).

Selaive and Tuesta (2003a, b) find that net foreign assets play a crucial role in breaking the link between the real exchange rate and the ratio of marginal utilities, and hence become a time-varying risk-premium in the UIP condition. In Benczúr *et al* (2006), the country risk premium is dependent on the ratio of net foreign assets (debt) to GDP for Hungary. Therefore, following Lim and Stein (1995), the portfolio balance is expressed as

$$r = r' + h(F) = (\underset{+}{r'}, \underset{-}{F}) \tag{4.19}$$

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

4.3.8. Summary of the Extended NATREX Model

Goods market clearing = balance in non-tradables:

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

$$C_n(R_n, k, F; DEP, CREP, T) + I_n(R_n, k, F; NFP, RT, r', \tau, GI, T) - y_n(R_n, k; NFP, RT) = 0 \tag{4.16}$$ [12]

Current account:

$$\begin{aligned} CA = {} & y_1(R_n, k; NFP, RT) - I_2(R_n, k, F; NFP, RT, r', \tau, GI, RULC, RRC, T) \\ & - C_2(R_n, k, F; DEP, CREP, T) + r'F \end{aligned} \tag{4.17}$$

Real exchange rates:

$$R = T(R_n)^a \tag{4.10}$$

Investment equation:

$$dk/dt = I - nk \tag{4.20}$$

$$I = I(R_n, k, F; NFP, RT, r', \tau, GI, RULC, RRC, T) \tag{4.7c}$$

[12] Based on the portfolio balance $r = r(r', F)$, user cost of capital in equation (4.15) can be rewritten $c = c(T, R_n, F, r', \tau)$.

Capital inflow:

$$dF/dt = S - I - nF = CA - nF \tag{4.18}$$

Savings equation:

$$s = y(k; NFP, RT) + r'F - C(k, F; CREP, DEP) = S(k, F; NFP, RT, r', CREP, DEP) \tag{4.3}$$

Portfolio balance:

$$r = r(r', F) \tag{4.19}$$

Note: all quantity variables are measured per unit of effective labour in the entire economy. k=capital stock per effective labour; F=net foreign assets per effective labour; I=investment per effective labour; S=savings per effective labour; CA=current account per effective labour; y=output per effective labour; $R_n=p_n/p_I$=relative price of non-tradables to exports; T=terms of trade; R=real exchange rate; n=growth rate of effective labour; NFP=net factor productivity; RT=rural transformation; r'=real interest rate of the world; τ =tax rate; GI=government investment/aggregate investment ratio; RUCL=relative unit labour cost; RRC=relative return of return to capital; DEP=dependency ratio; CREP=financial liberalisation.

4.4. Analysis of the Model

4.4.1. Medium-Run Equilibrium

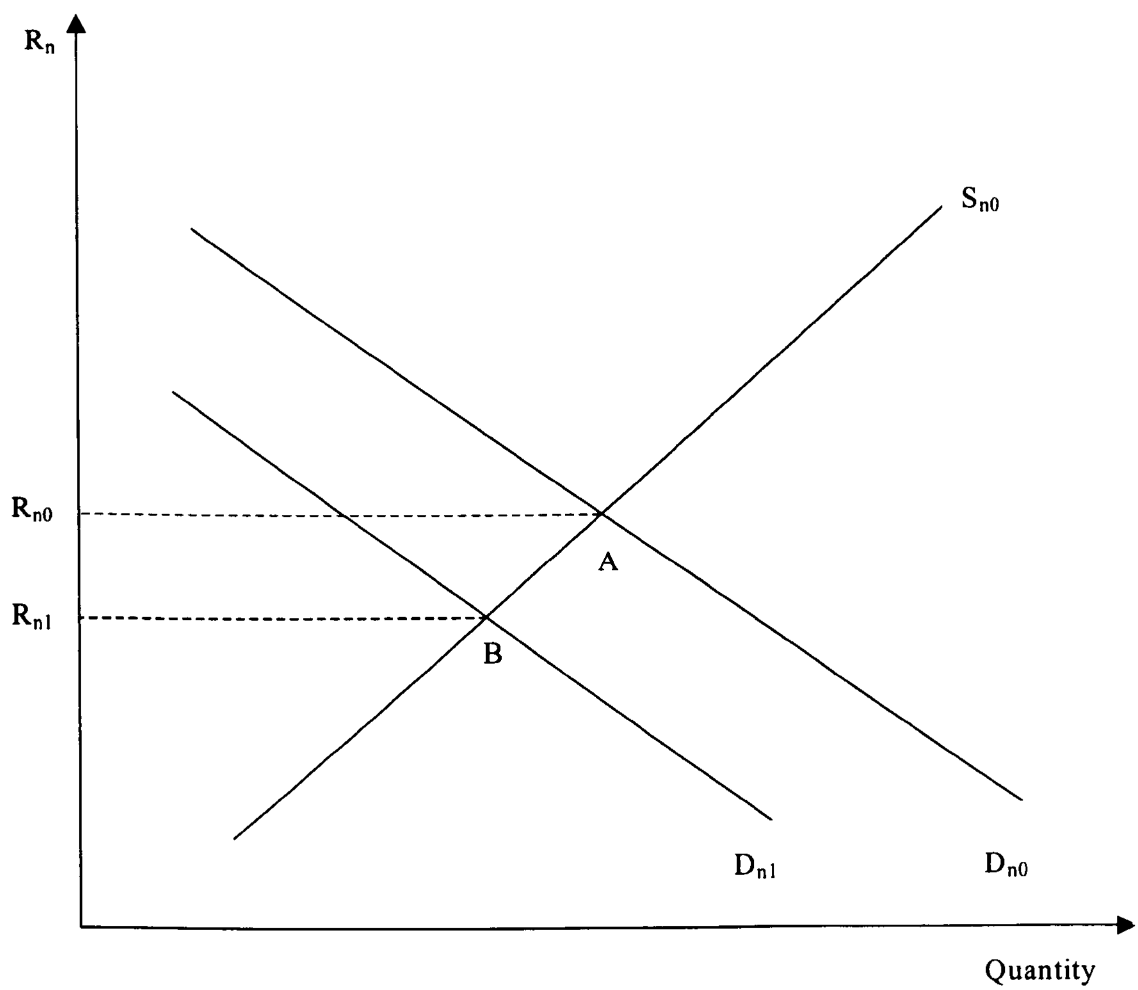
The medium-run is defined as the period in which the capital and foreign assets are taken as predetermined variables. The terms of trade are exogenous for China, which implies that the equilibrium condition for the goods market is equivalent to the market clearing for non-tradables

$$C_n(R_n, k, F; DEP, CREP, T) + I_n(R_n, k, F; NFP, RT, r', \tau, GI, T) = y_n(R_n, k; NFP, RT) \tag{4.16}$$

The first two items on the left hand side are consumption and investment of non-tradables, the sum of which is the demand for non-tradables (D_n). The right hand side of the equation (4.16) gives the supply of non-tradables (S_n). Following Lim and Stein's (1995) study of Australia, the goods market equilibrium (equation 4.16) can be graphed as in Figure 4.1.

The demand curve, D_n, is downward-sloping due to the fact that an increase in the relative price of non-tradables decreases the demand for consumption of non-tradables and investment using non-tradables. The opposite applies to the upward-sloping supply curve of non-tradables, S_n. The medium-run equilibrium of the goods market is at point A ($D_n = S_n$) where the real exchange rate is R_{n0}.

Figure 4.1. The Relative Price of Non-Tradables $R_n = p_n / p_1$



The relative price of non-tradables, R_n, equilibrates the market of non-tradables. Solving explicitly for R_n in equation (4.16) yields

$$R_n(t) = R_n\big(k(t), F(t); Z(t)\big),$$

$$Z = \big[DEP, CREP, NFP, RT, r', \tau, GI, T\big] \qquad (4.21)$$

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

Based on equations (4.10) and (4,21), the medium-run equilibrium real exchange rate is given by

$$R(t) = T[R_n(k(t), F(t); Z(t))]^a = R(k(t), F(t); Z) \tag{4.22}$$

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 obtained from equations (4.16) and (4.21) and listed in Appendix 4.B.

4.4.2. Dynamic Adjustment

The long-run dynamics involve endogenous movements of the capital and foreign assets. Combining the change of capital equation (4.20), investment equation (4.7c) and portfolio balance equation (4.19) yields the equation for the evolution of capital

$$dk/dt = J(k, F; Z),\ J_k < 0,\ J_F > 0\ ^{13} \qquad (4.23)\ ^{14}$$

Based on portfolio balance equation (4.19) and savings equation (4.3), we obtain

$$s = S(k, F; Z),\ S_k > 0,\ S_F < 0 \tag{4.24}$$

From equations (4.23), (4.24) and (4.18) we obtain the equation for the evolution of foreign assets

$$dF/dt = S - J = L(k, F; Z),\ L_k > 0,\ L_F < 0 \tag{4.25}$$

Equations (4.23) and (4.25) describe the dynamic system concerning the evolution of capital and foreign assets. Now we are going to analyse the dynamic stability of capital and foreign assets in a phase diagram.

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[13] See Appendix 4.C for the signs of the derivatives.
[14] Following Stein (1994) and Lim and Stein (1995), we assume the population growth n is zero for mathematical convenience.

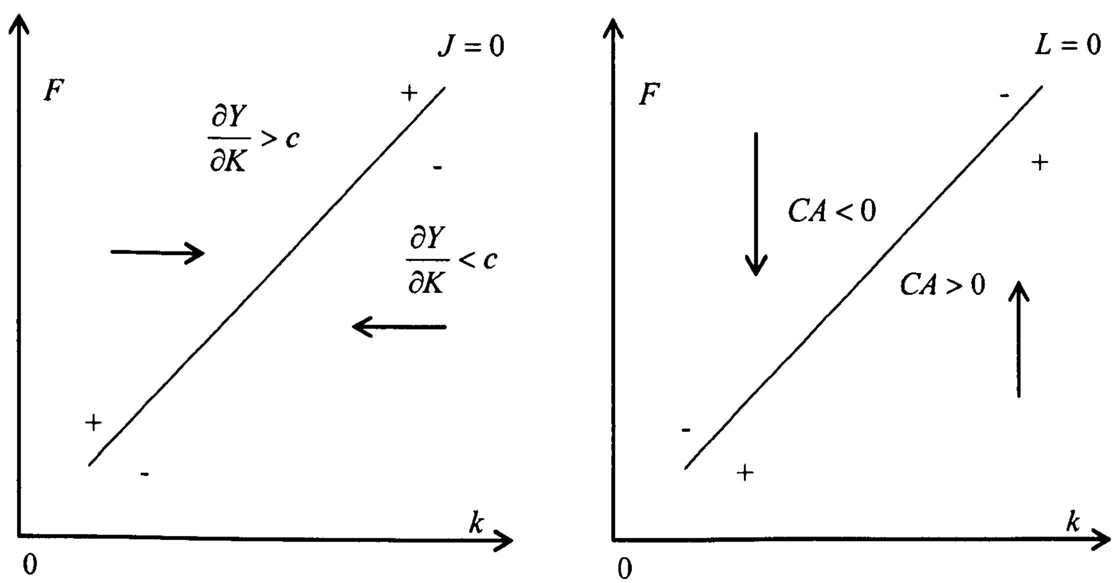
(1) In the left panel of Figure 4.2, $J = 0$ is the locus of points of capital and foreign assets at which the rate of investment is zero. It is positive sloped because of $\left.\frac{dF}{dk}\right|_{J=0} = -\frac{J_k}{J_F} > 0$ given $J_k < 0$ and $J_F > 0$. An increase in the capital decreases marginal productivity of capital and decreases further investment: $J_k < 0$. An increase in the foreign assets reduces country risk and real domestic interest rate, hence generates higher investment: $J_F > 0$. To the left of $J = 0$ where marginal productivity exceeds the user cost of capital ($\frac{\partial Y}{\partial K} > c$) and $k < k^*$, capital rises, whilst to the right of $J = 0$ where marginal productivity is lower than the user cost of capital ($\frac{\partial Y}{\partial K} < c$) and $k > k^*$, capital declines.

(2) In the right panel of Figure 4.2, $L = 0$ is the locus of the points of capital and foreign assets where there are no capital outflows since investment equals savings. On any points of $L = 0$ curve there is zero current account: $CA = 0$. $L = 0$ curve is positive sloped because of $\left.\frac{dF}{dk}\right|_{L=0} = -\frac{L_k}{L_F} > 0$ given $L_k > 0$ and $L_F < 0$. An increase in capital lowers investment ($J_k < 0$) and raises savings ($S_k > 0$) and hence increases savings less investment: $L_k > 0$. Higher foreign assets increase wealth and hence consumption rises. Higher consumption means lower savings ($S_F < 0$) and higher investment ($J_F > 0$) and therefore $(S - J)$ declines: $L_F < 0$. Above $L = 0$ curve where foreign assets exceed their steady state value ($F > F^*$), investment exceeds savings and there is current account deficit ($CA < 0$). Thus foreign assets decline towards their steady state. Below $L = 0$ curve where foreign assets are lower than

their steady state value ($F < F^*$), savings exceed investment and there is current account surplus ($CA > 0$). Thus foreign assets rise towards their steady state.

(3) $S_F < 0$: This is a crucial assumption of NATREX model. Higher foreign assets will generate lower savings and *vice versa*. This stability condition will prevent the foreign assets from increasing infinitely. Higher capital increases output and therefore raises savings: $S_k > 0$;

Figure 4.2. The Slopes of $J = 0$ and $L = 0$ [15]



(4) Given assumptions (1) to (3), we can determine that both $J = 0$ and $L = 0$ are upward-sloping but which one has the bigger slope is unknown. To ensure the stability of the model, the slope of $J = 0$ has to be greater than that of $L = 0$. This is explained in detail as follows.

Given that $\frac{\partial S}{\partial k} > 0$, $\frac{\partial S}{\partial F} < 0$, $\frac{\partial J}{\partial k} < 0$, $\frac{\partial J}{\partial F} > 0$, $\frac{\partial L}{\partial k} > 0$, $\frac{\partial L}{\partial F} < 0$, the sign of

$-\frac{J_k}{J_F} - \left(-\frac{L_k}{L_F}\right)$ is ambiguous. The two possibilities are:

$$-\frac{J_k}{J_F} - \left(-\frac{L_k}{L_F}\right) \Rightarrow G = J_k L_F - L_k J_F > 0 \qquad \text{(case 1)}$$

$$-\frac{J_k}{J_F} - \left(-\frac{L_k}{L_F}\right) \Rightarrow G = J_k L_F - L_k J_F < 0 \qquad \text{(case 2)}$$

Case 1 implies that $J = 0$ has a greater slope than $L = 0$ and is illustrated in Figure 4.3. Based on the directions indicated in Figure 4.3, all streamlines in this phase diagram flow noncyclically towards the equilibrium point E. Some streamlines stay in a single region and others cross from one region to another. When a streamline crosses over, it must have either an infinite slope (crossing $L = 0$) or a zero slope (crossing $J = 0$) as suggested by the dotted line attached to it. This is due to the fact that, along $L = 0$ (or $J = 0$) curve, L (or J) is stationary over time, so the streamline must not have any horizontal (vertical) movement while crossing that curve. The equilibrium point (E) on this diagram is a stable node as all streamlines associated to it lead noncyclically towards it (Chiang, 1987). Such a stable node E under case 1 ensures the stability of the model.

Case 2 implies that the slope of $J = 0$ is smaller than $L = 0$ and is illustrated in Figure 4.4. The equilibrium point (E) on this diagram is a saddle point (Chiang, 1987) –it is stable in some directions but unstable in others. A saddle point has one pair of streamlines, the stable branches of the saddle point that flow directly and consistently toward the equilibrium, and one pair of streamlines, the unstable branches of the saddle point that flow directly and consistently away from it. All the other trajectories head toward the saddle point initially but sooner or later turn away from it. Since stability is observed only on the stable branches, a saddle point is classified as an

[15] Both $J = 0$ and $L = 0$ are upward-sloping but they could be curved. We draw two straight lines for continence and it does not affect the direction towards which capital and foreign assets are heading.

unstable equilibrium (Chiang, 1987). Since the equilibrium point E in case 2 is a saddle point, it can not ensure the stability of the model.

Therefore, the stability condition $G > 0$ must hold to ensure the stability of the model, which is described by Figure 4.3. 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 foreign assets on investment ($-J_k > J_F$) along $J = 0$ and (b) the impact of foreign assets on current account is greater than the impact of capital on current account ($-L_F > L_k$) along $L = 0$.

Figure 4.3. Case 1: $G > 0$

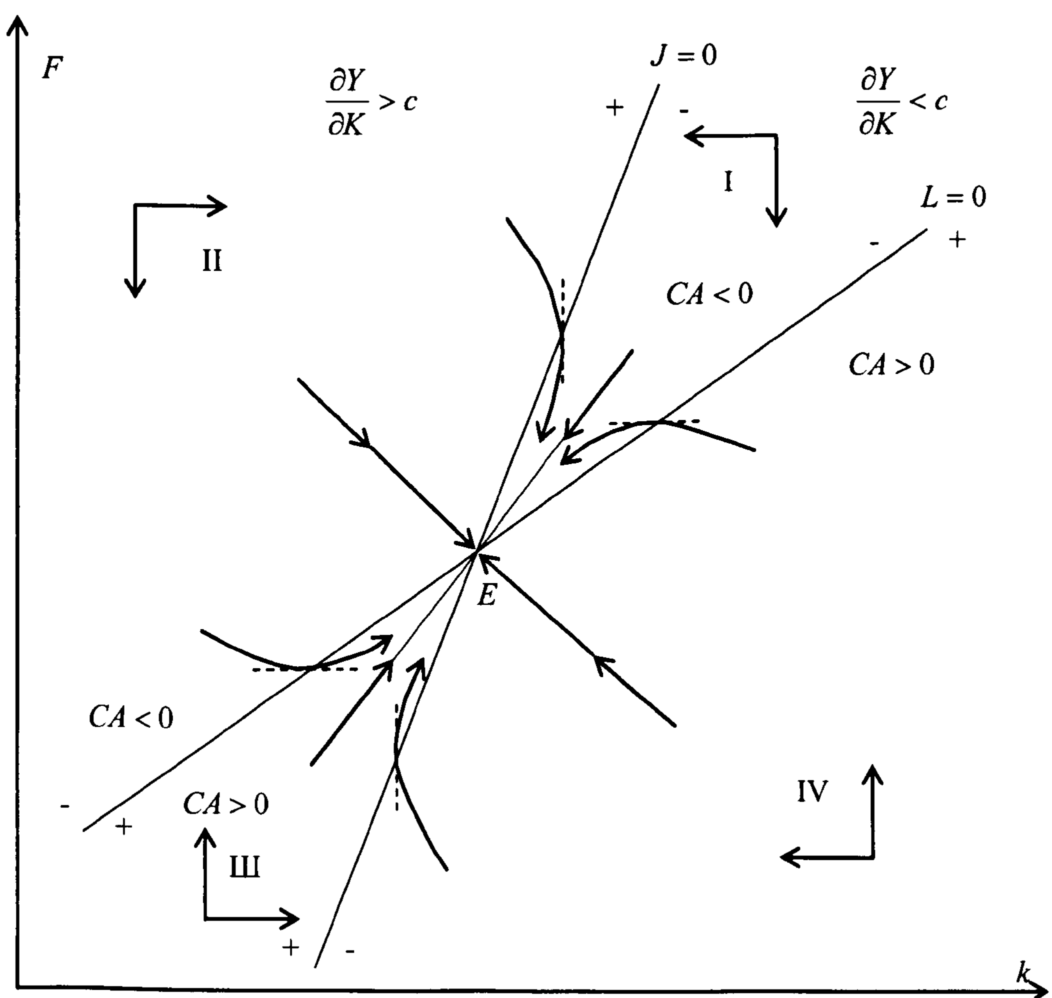
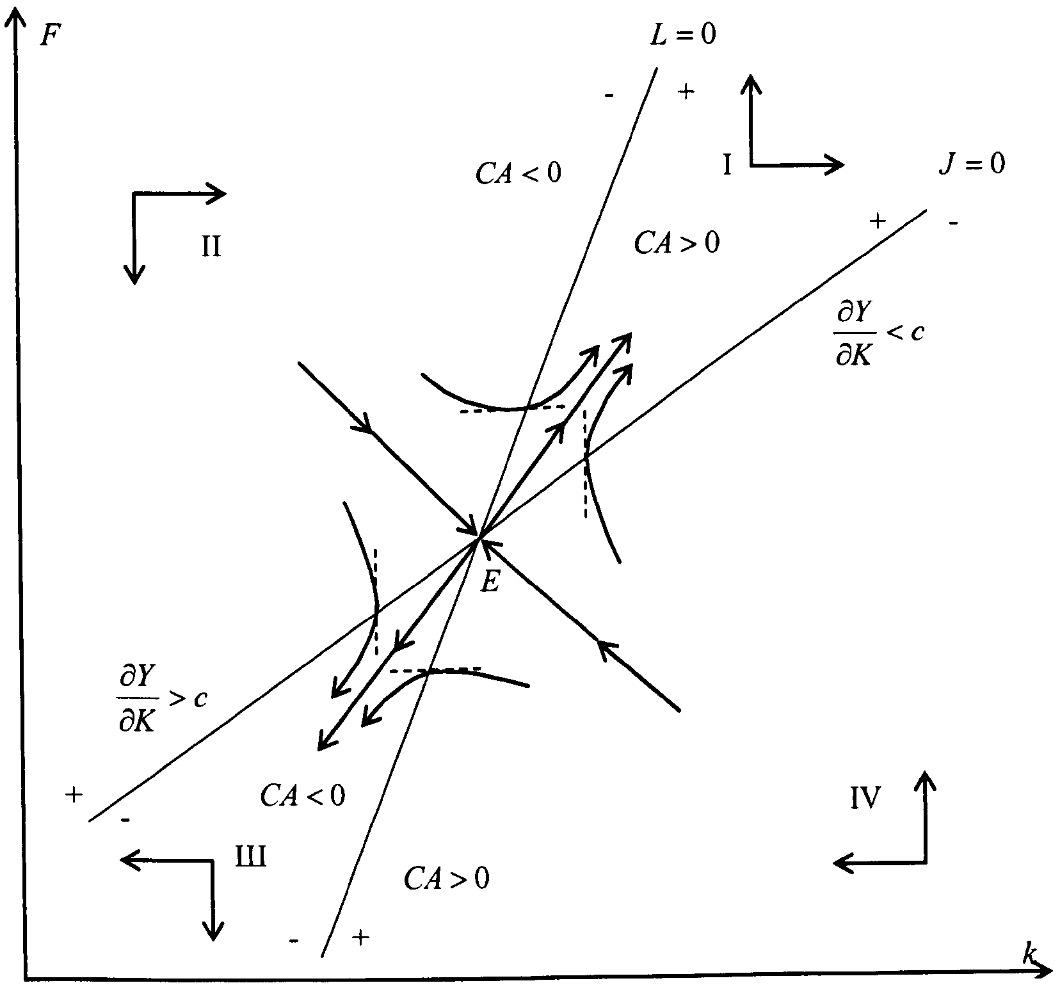
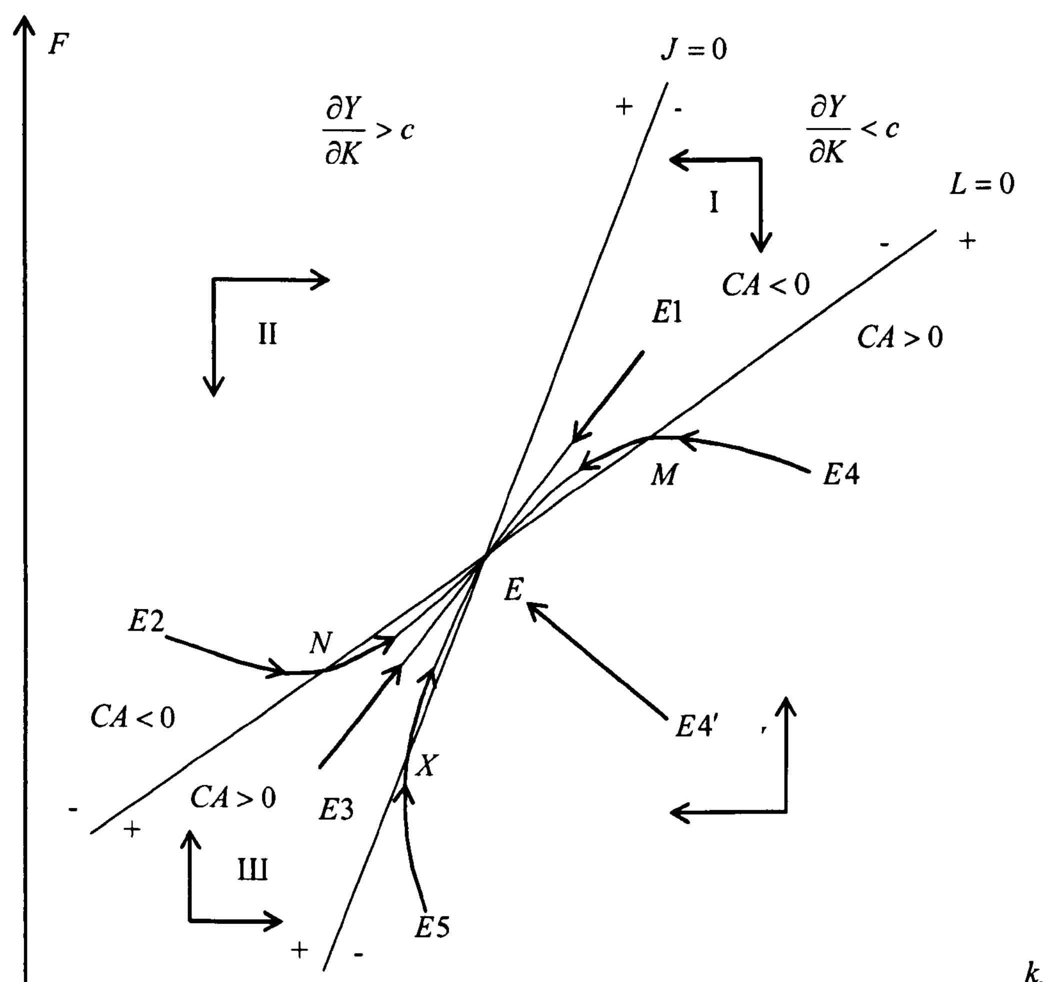


Figure 4.4. Case 2: $G < 0$



Based on Figure 4.3, we developed the phase diagram (Figure 4.5) that indicates possible paths of capital and foreign assets to their steady states when there are changes in the fundamentals. The critical assumptions for stability are: $J_k < 0$, $J_F > 0$, $S_F < 0$, $S_k > 0$ and $G > 0$.

Figure 4.5. Trajectories of Capital and Foreign Assets to Their Steady States



4.4.3. The Steady-State

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

$$J(k^*, F^*; Z) = 0 \tag{4.26}$$

$$L(k^*, F^*; Z) = S(k^*, F^*; Z) - J(k^*, F^*; Z) = 0 \tag{4.27}$$

Solving equations (4.26) and (4.27) we can obtain the steady states

$$k^* = k(Z) \tag{4.28}$$

$$F^* = F(Z) \tag{4.29}$$

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

$$C_n(R_n^*, k^*, F^*; DEP, CREP, T) + I_n(R_n^*, k^*, F^*; NFP, RT, r', \tau, GI, T) = y_n(R_n^*, k^*; NFP, RT) \tag{4.30}$$

Solving equation (4.30) we can get the expression for the steady state relative price of non-tradables (equation (4.31a)) and derive dR_n^*/dZ (equation (4.31b))

$$R_n^* = R_n(k(Z), F(Z); Z) = R_n^*(Z) \tag{4.31a}$$

$$\frac{dR_n^*}{dZ} = \left(\frac{\partial R_n}{\partial k}\right)\frac{dk^*}{dZ} + \left(\frac{\partial R_n}{\partial F}\right)\frac{dF^*}{dZ} + \frac{\partial R_n}{\partial Z} \tag{4.31b}$$

$$R^* = T(R_n^*)^a = R^*(Z) \tag{4.32}$$

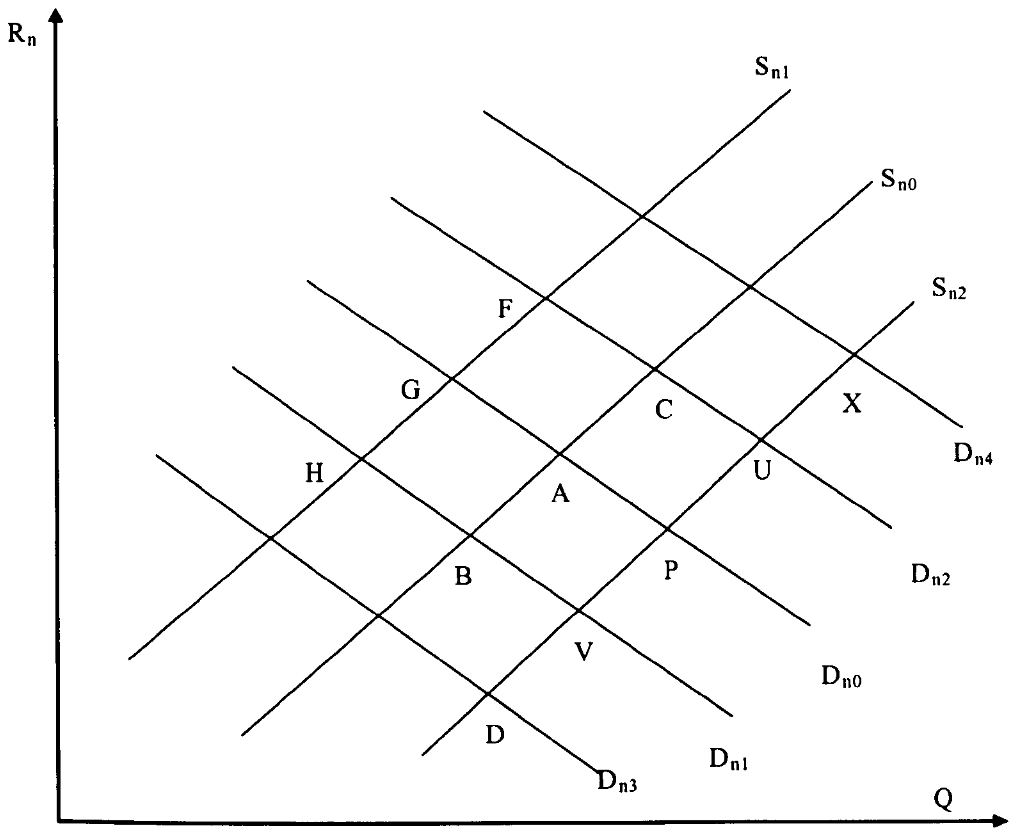
The last item on the right hand side of equation (4.31b) measures the direct effect of the disturbance in fundamentals on R_n in the medium-run. The signs of this item are derived and explained in Appendix 4.B. The first two items indicate the indirect effect of disturbance in fundamentals on R_n through changes in k^* and F^* in the long-run. Details of the derivation of dk^*/dZ, dF^*/dZ and mathematical computation of their signs are shown in Appendix 4.C. Derivation of dR_n^*/dZ is discussed in Appendix 4.D. All signs are summarised in Appendix E. According to equation (4.32), the fundamentals which affect the relative price of-non-tradables, R_n^*, affect the long-run real exchange rate, R^*, in a similar way. Only the terms of trade are an exception to this rule. As equation (4.10) indicates, changes in the terms of trade affect the real exchange rate directly and indirectly via changes in R_n. These direct and indirect effects of terms of trade will be explained in detail in Section 4.5.6.

4.5. Relative Price of Non-Tradables and the Real Exchange Rate in the Medium-Run and Long-Run

Now we are going to analyse the sign of dR_n^*/dZ combining the phase diagram (Figure 4.5) which indicates the trajectories of steady state capital k^* and foreign assets F^* and Figure 4.6 which describes the goods market equilibrium. The sign of $\partial R_n/\partial Z$ is determined by the effect of changes in fundamentals on R_n in the medium-run. The signs of dk^*/dZ and dF^*/dZ are determined by the effect of changes in fundamentals on steady state capital and foreign assets in the long-run.

It is important to note that according to equation (4.32) a rise in the relative price of non-tradables implies a rise in the real exchange rate (i.e. an appreciation of the RMB), and *vice versa*. This applies to all other fundamentals (Sections 4.5.1-4.5.11), except in the case of the terms of trade (Section 4.5.6.). Hence we will not repeat it in the following sections.

Figure 4.6. (Non-Tradable) Goods Market Equilibrium



4.5.1. Dependency ratio

An increase in the dependency ratio raises consumption of non-tradables, which in turn shifts the demand curve from D_{n0} to D_{n2} and raises the relative price of non-tradables from A to C. Therefore, the direct effect of a higher dependency ratio on the price of non-tradables is positive: $\partial R_n / \partial DEP > 0$.

In the long-run, a rise in the dependency ratio reduces foreign assets and capital. High consumption increases borrowing from foreign countries and leads to net long-term capital inflows. The capital decreases due to the higher risk premium generated by lower foreign assets. Therefore, a rise in the dependency ratio leads the economy to stabilise at lower foreign assets and lower capital: $dF^* / dDEP < 0, dk^* / dDEP < 0$. The trajectories of capital and foreign assets are described as $E1 - E$.

With lower foreign assets, wealth reduces unambiguously. Consumption gradually decline to D_{n0}, which reduces the relative price of non-tradables: $(\partial R_n/\partial F)dF^*/dDEP < 0$. The non-tradable sector in China is regarded as labour intensive. Thus a decline in capital increases supply of non-tradables[16] from S_{n0} to S_{n2} and reduces the relative price of non-tradables to point P : $(\partial R_n/\partial k)dk^*/dDEP < 0$. The relative price of non-tradables is lower than initial point A. This is due to the fact that desired capital inflows[17] decline and interest income from foreign countries reduces or there will be interest payment to foreign countries if the economy changes from net creditor to net debtor. To produce the trade surplus needed to offset lower interest income from (or higher interest payments to) foreign countries, the relative price of non-tradables must decline to below its initial level.

$$\frac{dR_n^*}{dDEP} = \underset{-}{\left(\frac{\partial R_n}{\partial k}\right)}\frac{dk^*}{dDEP} + \underset{-}{\left(\frac{\partial R_n}{\partial F}\right)}\frac{dF^*}{dDEP} + \underset{+}{\frac{\partial R_n}{\partial DEP}} < 0 \qquad (4.33)$$

Therefore, an increase in dependency ratio DEP first raises the relative price of non-tradables and then reduces it in long-run equilibrium.

4.5.2. Financial Liberalisation

A higher degree of financial liberalisation relaxes liquidity constraints on consumption and enables current consumption to be repaid by future income. A higher consumption, financed by borrowing, shifts the demand for non-tradables from D_{n0} to D_{n2} and raises the relative price of non-tradables: $\partial R_n/\partial CREP > 0$.

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[16] Higher capital stock will draw resources away from the non-tradables sector to the tradables sector as non-tradables sector is labour intensive. Therefore, there is a negative relationship between capital and supply of non-tradables.

[17] Changes in desired capital inflows are the dominant force in explaining changes in the NATREX. The NATREX adjusts to produce whatever current account balances that are needed to match changing long-term capital flows.

In the long-run, a rise in the degree of financial liberalisation reduces foreign assets and capital. An increase in consumption financed by borrowing generates capital inflows and drives the interest rate higher. Capital decreases not only because of higher user cost of capital generated by the higher domestic interest rate but also because of the higher risk premium generated by lower foreign assets. Therefore, a higher degree of financial liberalisation leads the economy to stabilise at lower foreign assets and lower capital: $dF^{*}/dCREP < 0, dk^{*}/dCREP < 0$. The trajectories of capital and foreign assets are described as $E1 - E$.

Lower foreign assets reduce consumption as wealth declines. Demand for non-tradables reduces, say, from D_{n2} to D_{n0}, and relative price of non-tradables declines: $(\partial R_n/\partial F) dF^{*}/dCREP < 0$. Lower capital increases supply of non-tradables from S_{n0} to S_{n2} and reduces the relative price of non-tradables to point P : $(\partial R_n/\partial k) dk^{*}/dCREP < 0$. The relative price of non-tradables is lower than initial point A.

$$\frac{dR_n^{*}}{dCREP} = \underset{-}{\left(\frac{\partial R_n}{\partial k}\right)} \frac{dk^{*}}{dCREP} + \underset{-}{\left(\frac{\partial R_n}{\partial F}\right)} \frac{dF^{*}}{dCREP} + \underset{+}{\frac{\partial R_n}{\partial CREP}} < 0 \qquad (4.34)$$

An increase in the degree of financial liberalisation has similar effects on the relative price of non-tradables as an increase in the dependency ratio: raises R_n in the medium-run and reduces it in the steady state.

4.5.3. Social Time Preference

A rise in social time preference has same direct and indirect effects on the relative price of non-tradables as a rise in dependency ratio and a higher degree of financial liberalisation. Therefore

$$\frac{dR_n^*}{dg} = \underset{-}{\left(\frac{\partial R_n}{\partial k}\right)}\frac{dk^*}{dg} + \underset{-}{\left(\frac{\partial R_n}{\partial F}\right)}\frac{dF^*}{dg} + \underset{+}{\frac{\partial R_n}{\partial g}} < 0 \tag{4.35}$$

with $dF^*/dg < 0, dk^*/dg < 0$ and their trajectories are described by $E1 - E$.

4.5.4. Net Factor Productivity

When a country produces both tradables and non-tradables, the sectoral location of the productivity increase determines the trajectory of the relative price of non-tradables. The effect of a rise in net factor productivity on R_n, hence on the real exchange rate allows us to estimate the Balassa-Samuelson effect (Balassa, 1964).

4.5.4.1. Net Factor Productivity in Tradables Sector

A productivity increase in tradables sector increases investment and hence increases demand for investment using non-tradables from D_{n0} to D_{n2}: $\partial I_n/\partial NFP_t > 0$, where NFP_t denotes net factor productivity in the tradables sector. A higher productivity in the tradables sector shifts resources from the non-tradables to the tradables sector and hence decreases supply of non-tradables from S_{n0} to S_{n1} : $\partial y_n/\partial NFP_t < 0$. R_n increases from point A to F: $\partial R_n/\partial NFP_t > 0$. On the one hand, capital formation leads to current account deficit. On the other hand, higher output of tradables given higher productivity in tradables sector generates current account surplus. Hence there is current account deficit or surplus and capital formation in the medium-run, which is described by $E2$ or $E3$.

In the long-run, an increase of productivity in the tradables sector raises foreign assets and capital. A higher NFP_t generates current account surplus due to a higher supply of tradables. Investment in tradables sector further increases output of tradables and current account surplus. Therefore: $dk^*/dNFP_t > 0$ and $dF^*/dNFP_t > 0$. If the starting point is $E2$, at point N current account deficit turns into surplus. Current account surplus raises foreign assets, which reduces savings and raises consumption. The current account converges to balance while foreign assets are increasing towards their steady state. The trajectories of steady state capital and foreign assets are described as: $E2 - N - E$. If the starting point is $E3$, the trajectory is $E3 - E$.

An increase in output due to a higher NFP_t raises income and consumption, creating an excess demand for non-tradables and raising relative price of non-tradables: $(\partial R_n/\partial F)dF^*/dNFP_t > 0$[18]. Capital formation in tradables sector decreases supply of non-tradables and raises R_n : $(\partial R_n/\partial k)dk^*/dNFP_t > 0$. Hence there is a further increase of R_n in the long-run.

$$\frac{dR_n^*}{dNFP_t} = \underset{+}{\left(\frac{\partial R_n}{\partial k}\right)}\frac{dk^*}{dNFP_t} + \underset{+}{\left(\frac{\partial R_n}{\partial F}\right)}\frac{dF^*}{dNFP_t} + \underset{+}{\frac{\partial R_n}{\partial NFP_t}} > 0 \qquad (4.36a)$$

Therefore, an increase in productivity in the tradables sector, given exogenous terms of trade, generates a steady increase in the relative price of non-tradables in long-run equilibrium.

As a developing country, we expect the productivity increase in China occurs in the tradables sector, which is the situation described by equation (4.36a). By estimating the effect of productivity increase on the real exchange rate, we will be able to test the existence of the Balassa-Samuelson effect.

[18] If the real wage in tradables sector is bid up due to higher productivity, prices in non-tradables will also be forced up. Due to China's great labour surplus, we ignore the effect of higher productivity of tradables sector on real wage.

4.5.4.2. Net Factor Productivity in Non-Tradables Sector

If the productivity increase occurs in the non-tradables sector, investment increases and so does demand for investment using non-tradables: $\partial I_n/\partial NFP_n > 0$, where NFP_n denotes net factor productivity in non-tradables sector. A higher productivity in non-tradables increases supply of non-tradables: $\partial y_n/\partial NFP_n > 0$. The former increases demand for non-tradables from D_{n0} to D_{n2} and the latter increases supply of non-tradables from S_{n0} to S_{n2}, which shifts R_n from A to U. The total effect on R_n is negative as we assume the supply effect dominates the investment effect: $\partial R_n/\partial NFP_n < 0$.

In the long-run, an increase in productivity in non-tradables sector raises capital and foreign assets. A shift of resources from tradables sector to non-tradables sector due to higher NFP_n decreases the supply of tradables and capital accumulation generates current account deficit. This is captured by point $E2$. As capital accumulates output rises gradually and savings rise relative to investment. At point N savings equals investment; after that savings exceed investment and there is current account surplus. Along trajectory $E2 - N - E$, capital and foreign assets increase: $dk^*/dNFP_n > 0$ and $dF^*/dNFP_n > 0$

A rise in wealth increases demand for non-tradables and raises the relative price of non-tradables: $(\partial R_n/\partial F)dF^*/dNFP_n > 0$. Higher capital in non-tradable sector increases supply of non-tradables, which reduces the relative price of non-tradables: $(\partial R_n/\partial k)dk^*/dNFP_n < 0$. Due to the fact that there is not only a rise in NFP_n but also capital accumulation in the non-tradables sector, the rise in the supply of non-tradables should be much higher than that of the demand for non-tradables. Therefore, an increase in NFP_n has a total effect of reducing the relative price of non-tradables.

$$\frac{dR_n^*}{dNFP_n} = \underset{-}{\left(\frac{\partial R_n}{\partial k}\right)} \frac{dk^*}{dNFP_n} + \underset{+}{\left(\frac{\partial R_n}{\partial F}\right)} \frac{dF^*}{dNFP_n} + \underset{-}{\frac{\partial R_n}{\partial NFP_n}} < 0 \qquad (4.36b)$$

An increase in NFP_n reduces the relative price of non-tradables in the long-run.

4.5.5. Rural Transformation

Rural transformation takes the forms of rural-urban migration and rural urbanisation. Both forms shift labour force from lower productivity agriculture sector to other sectors that have higher productivity. Rural transformation shifts resources from agriculture to other sectors, but it does not alter the net factor productivity (technological progress) in each individual sector. It increases the total factor productivity by increasing the weights of higher productivity sectors and reducing the weight of lower productivity sector (agriculture).

The direction in which the labour shifts affects the trajectory of the relative price of non-tradables. If more labour is allocated to tradables sectors (RT_t), which implies the tradables sector is more productive, the trajectories of foreign assets and capital are the same as when there is an increase in net factor productivity in the tradables sector: $E3-E$ or $E2-N-E$. If more labour is allocated to non-tradable sectors (RT_n), which implies the non-tradables sector is more productive, the trajectories of foreign assets and capital are the same as when there is an increase in net factor productivity in the non-tradables sector: $E2-N-E$. Hence an increase in rural transformation which allocates more labour to non-tradables/tradables has similar direct and indirect effect with an increase in productivity in non-tradables/tradables sector

$$\frac{dR_n^*}{dRT_t} = \left(\frac{\partial R_n}{\partial k}\right)\frac{dk^*}{dRT_t} + \left(\frac{\partial R_n}{\partial F}\right)\frac{dF^*}{dRT_t} + \frac{\partial R_n}{\partial RT_t} > 0 \qquad (4.37a)$$

$$\qquad + \qquad\qquad + \qquad\qquad +$$

$$\frac{dR_n^*}{dRT_n} = \left(\frac{\partial R_n}{\partial k}\right)\frac{dk^*}{dRT_n} + \left(\frac{\partial R_n}{\partial F}\right)\frac{dF^*}{dRT_n} + \frac{\partial R_n}{\partial RT_n} < 0 \qquad (4.37b)$$

$$\qquad - \qquad\qquad + \qquad\qquad -$$

For China, we expect rural transformation to occur with labour shifting from non-tradables to tradables sector, which is the situation described by equation (4.37a).

4.5.6. Terms of Trade

For China the terms of trade are exogenous. According to equation (4.32), the terms of trade influence the real exchange rate directly and through its effects on R_n. The direct effect is always positive. Now, we are going to analyse the indirect effect.

In the medium-run, an increase in terms of trade implies an increase in the relative price of non-tradables to imports, $TR_n = Np_n/p_2^{'}$. The non-tradables become relatively expensive compared with imports. The consumption demand for non-tradables and investment demand using non-tradables decreases. On the other hand, an increase in the terms of trade will decrease the user cost of capital and, hence, stimulate investment demand in the non-tradables component. The total direct effect of higher terms of trade on the demand for non-tradables is ambiguous. As we assume the consumption effect dominates the investment effect, the total demand for non-tradables will decrease and the demand curve will shift from D_{n0} to D_{n1}. The relative price of non-tradables will decrease to point B : $\partial R_n/\partial T < 0$. However, this indirect effect is rather small when compared with the direct effect of the terms of trade on the real exchange rate (see equation (4.10)). Therefore, we expect the higher terms of trade to cause a rise in the real exchange rate (i.e. an appreciation of the RMB) in medium-run equilibrium.

In the long-run, increase in the terms of trade will increase capital and foreign assets. Improvements in the terms of trade create the current account surplus due to the price effect: domestic exports are sold to the world market at a relatively higher price and goods are imported from the world market at a relatively lower price. Lower user cost of capital stimulates capital formation. The higher investment may exceed the savings and generate current account deficit. Therefore, under the capital formation, there might be current account surplus ($E3$) or deficit ($E2$). In the first case, the trajectory is $E3-E$, whilst in the second case the trajectory is $E2-N-E$. In both cases, capital formation generates higher capital and higher foreign assets: $dk^*/dT>0$ and $dF^*/dT>0$.

Since the non-tradable sector is labour intensive, an increase in capital reduces supply of non-tradables from S_{n0} to S_{n1} and increases the relative price of non-tradables: $(\partial R_n/\partial k)dk^*/dT>0$. Furthermore, the increase in wealth due to higher foreign assets raises demand for non-tradables, say, from D_{n1} to D_{n0} and therefore raises the relative price of non-tradables: $(\partial R_n/\partial F)dF^*/dT>0$. Eventually, the relative price of non-tradables will rise from point A to point G.

$$\frac{dR_n^*}{dT}=\underset{+}{\left(\frac{\partial R_n}{\partial k}\right)}\frac{dk^*}{dT}+\underset{+}{\left(\frac{\partial R_n}{\partial F}\right)}\frac{dF^*}{dT}+\underset{-}{\frac{\partial R_n}{\partial T}}>0 \qquad (4.38)$$

According to equation (4.10), higher terms of trade have a practically one-to-one positive direct effect on the real exchange rate[19]. On the other hand, higher terms of trade first reduce the relative price of non-tradables in the medium-run and raise it in the steady state. R_n^* increases from point A to G, which further raises the real

[19] In their study of NATREX for Australia, Lim and Stein (1995) find the coefficient of terms of trade is 0.84 (with a standard error of 0.17), which is not significantly different from unity.

exchange rate, R_n^*,—this is the indirect effect of terms of trade on the real exchange rate via R_n^*, which reinforces the positive direct effect. Therefore, higher terms of trade will lead to a rise in the real exchange rate (i.e. an appreciation of the RMB), both in the medium-run and the long-run.

4.5.7. World's Real Interest Rate

An increase in the world's real interest rate r' raises the user cost of capital and in turn reduces demand for investment. Since some of the investment uses non-tradables, the demand for non-tradables declines, which shifts the demand curve of non-tradables from D_{n0} to D_{n1}. The relative price of non-tradables declines from A to B: $\partial R_n / \partial r' < 0$.

As the domestic economy is a net creditor, an increase in r' increases interest income from foreign countries and produces current account surplus. A lower demand for investment also helps to generate the current account surplus. In the long-run, output declines gradually due to lower capital. If the extra interest income is insufficient to compensate the decline in output, the current account will turn from surplus to deficit in the long-run. There will be a decline in both capital and foreign assets. Such a trajectory can be described by $E4 - M - E$, where current account turns to deficit at point M. If the extra interest income is greater than the decline in output, there will be a continuous current account surplus and thus higher foreign assets, even though capital is lower. Higher foreign assets reduce country risk and encourage FDI. If FDI inflows are insufficient, there will be a lower capital eventually. Such a trajectory can be described by $E4' - E$. If FDI inflows are sufficient to offset the decline of capital due to higher interest rate, there will be a higher capital. The trajectory is described by $E5 - X - E$, where FDI inflows offset the decline of capital at point X.

Along $E4 - M - E$, a lower capital raises supply of non-tradables and reduces its relative price: $(\partial R_n / \partial k) dk^* / dr' < 0$. Lower foreign assets reduce wealth and therefore reduce demand for non-tradables: $(\partial R_n / \partial F) dF^* / dr' < 0$. The total effect is to reduce the relative price of non-tradables.

Along $E4' - E$, the decline in capital increases the supply of non-tradables and reduces the relative price of non-tradables: $(\partial R_n / \partial k) dk^* / dr' < 0$. Demand for non-tradables increases due to a higher wealth, which raises the relative price of non-tradables: $(\partial R_n / \partial F) dF^* / dr' > 0$. The total effect is ambiguous.

Along $E5 - X - E$, since the non-tradable sector is labour intensive a higher capital reduces the supply of non-tradables from S_{n0} to S_{n1} and raises its relative price: $(\partial R_n / \partial k) dk^* / dr' > 0$. Higher net foreign assets raise the relative price of non-tradables: $(\partial R_n / \partial F) dF^* / dr' > 0$. The total effect is to increase the relative price of non-tradables.

$$\frac{dR_n^*}{dr'} = \underset{-}{\left(\frac{\partial R_n}{\partial k}\right)} \frac{dk^*}{dr'} + \underset{-}{\left(\frac{\partial R_n}{\partial F}\right)} \frac{dF^*}{dr'} + \underset{-}{\frac{\partial R_n}{\partial r'}} < 0 \tag{4.39a}$$

$$\frac{dR_n^*}{dr'} = \underset{-}{\left(\frac{\partial R_n}{\partial k}\right)} \frac{dk^*}{dr'} + \underset{+}{\left(\frac{\partial R_n}{\partial F}\right)} \frac{dF^*}{dr'} + \underset{-}{\frac{\partial R_n}{\partial r'}} >< 0 \tag{4.39b}$$

$$\frac{dR_n^*}{dr'} = \underset{+}{\left(\frac{\partial R_n}{\partial k}\right)} \frac{dk^*}{dr'} + \underset{+}{\left(\frac{\partial R_n}{\partial F}\right)} \frac{dF^*}{dr'} + \underset{-}{\frac{\partial R_n}{\partial r'}} < 0 \tag{4.39c}$$

4.5.8. Relative Unit Labour Cost of China

Most of FDI into China flows into the tradable sector due to the government's policy of encouraging export oriented industry and relative cheap labour supported by the enormous labour supply. Since the terms of trade are exogenous for China, an increase in the unit labour cost of China relative to its competitors ($RULC$) makes it less profitable to sell tradables at the exogenous world prices and attracts less FDI. The relative price of non-tradables is left unaffected. Therefore, there is no direct effect of a higher relative unit labour cost on the relative price of non-tradables in the medium-run: $\partial R_n / \partial RULC = 0$

In the long-run, a higher $RULC$ decreases capital and foreign assets. Initially, investment falls below savings and generates current account surplus. Hence there is capital reduction and current account surplus ($E4$). The output gradually declines and so do the savings. At point M savings are equivalent to investment. Along trajectory $M - E$, as output continues to decline, savings fall below investment and there is current account deficit. Hence the economy is stabilised at point E with lower capital and foreign assets: $dk^* / dRULC < 0$ and $dF^* / dRULC < 0$.

Lower output of tradables reduces foreign assets and wealth, which reduces demand for non-tradables from D_{n0} to D_{n1}: $(\partial R_n / \partial F) dF^* / dRULC < 0$. Since the capital in non-tradable sector remains unchanged as the destination of FDI is the tradables sector, the supply of non-tradables is not altered: $(\partial R_n / \partial k) dk^* / dRULC = 0$. Therefore a higher $RULC$ reduces the relative price on non-tradables in long-run equilibrium.

$$\frac{dR_n^*}{dRULC} = \left(\frac{\partial R_n}{\partial k}\right) \underset{0}{\frac{dk^*}{dRULC}} + \left(\frac{\partial R_n}{\partial F}\right) \underset{-}{\frac{dF^*}{dRULC}} + \underset{0}{\frac{\partial R_n}{\partial RULC}} < 0 \qquad (4.40)$$

4.5.9. Relative Rate of Return to Capital of China

An increase in the relative rate of return to capital in China makes China's market more attractive to FDI and generates capital inflows. As we assume the destination of FDI is the tradables sector, capital inflows occur in the tradables sector. Since FDI is imported investment, the demand for non-tradables investment is not affected, nor does the supply of non-tradables. Therefore, an increase in RRC does not have direct effects on the relative price of non-tradables in the medium-run: $\partial R_n/\partial RRC = 0$.

In the long-run, a higher RRC increases capital and foreign assets. Originally, capital inflows in tradables sector raise investment relative to savings and generate current account deficit, as described by point $E2$. However, in the long-run, the output of tradables increases gradually due to higher capital in tradables sector, and so do savings. At point N, savings equal investment. Along $N-E$ savings exceed investment and there is current account surplus. Thus, the economy stabilises with higher capital and foreign assets: $dk^*/dRRC > 0$ and $dF^*/dRRC > 0$.

A higher capital in tradables does not affect the supply of non-tradables sector. Thus it does not affect relative price of non-tradables: $(\partial R_n/\partial k)dk^*/dRRC = 0$. As foreign assets increase, wealth increases. Consequently consumption of non-tradables increases from D_{n0} to D_{n2}, which raises relative price of non-tradables: $(\partial R_n/\partial F)dF^*/dRRC > 0$. Therefore, a higher relative rate of return to capital raises the relative price of tradables in long-run equilibrium.

$$\frac{dR_n^*}{dRRC} = \underset{0}{\left(\frac{\partial R_n}{\partial k}\right)\frac{dk^*}{dRRC}} + \underset{+}{\left(\frac{\partial R_n}{\partial F}\right)\frac{dF^*}{dRRC}} + \underset{0}{\frac{\partial R_n}{\partial RRC}} > 0 \qquad (4.41)$$

4.5.10. Government Investment

A higher government investment (GI) raises demand for investment using non-tradables and increases the relative price of non-tradables: $\partial R_n/\partial GI > 0$. The demand curve shifts from D_{n0} to D_{n2}. There are capital formation and current account deficit, as described by point $E2$.

In the long-run, a higher GI increases capital and foreign assets. After the government investment is put into place, output starts to increase and so do savings. At point N savings are equivalent to investment; after point N savings exceed investment and there is current account surplus. Therefore, there are higher capital and foreign assets: $\partial k/\partial GI > 0$ and $\partial F/\partial GI > 0$. The trajectory is described by $E2 - N - E$.

Along the trajectory $E2 - N - E$, higher capital tends to reduce supply of non-tradables and raises the price of it: $(\partial R_n/\partial k)dk^*/dGI > 0$. The supply curve shifts from S_{n0} to S_{n1}. Higher foreign assets raise wealth and increase consumption of non-tradables: $(\partial R_n/\partial F)dF^*/dGI > 0$. The demand curve shifts from D_{n2} to D_{n4} and there is a long-run steady increase in the relative price of non-tradables.

$$\frac{dR_n^*}{dGI} = \underset{+}{\left(\frac{\partial R_n}{\partial k}\right)}\frac{dk^*}{dGI} + \underset{+}{\left(\frac{\partial R_n}{\partial F}\right)}\frac{dF^*}{dGI} + \underset{+}{\frac{\partial R_n}{\partial GI}} > 0 \tag{4.42}$$

However, if GI crowds out domestic private investment, and given the GI has lower efficiency (as the purpose of GI is not profit seeking but to sustain SOEs and public services), the output of GI may not be sufficient to turn current account from deficit to surplus. Thus there will be a decline in foreign assets in the long-run. Lower foreign assets imply higher country risk premium and higher user cost of capital, both discourage investment. Therefore, capital declines in the long-run. Under such a scenario, a higher GI will reduce the relative price of non-tradables in the long-run. We expect this will be the case for China.

4.5.11. Taxation

A higher taxation (τ) increases user cost of capital and discourages investment. A lower demand for investment decreases investment using non-tradables and shifts demand curve from D_{n0} to D_{n1}. The direct effect of an increase in τ is to reduce the relative price of non-tradables: $dR_n/d\tau < 0$.

In the long-run, a higher τ reduces capital and foreign assets: $dk^*/d\tau < 0$, $dF^*/d\tau < 0$. Originally, a lower investment generates current account surplus, as described by point $E4$. However, output and savings gradually decline. At point M, savings equal investment and current account is in balance. Along $M-E$, savings are lower than investment and there is current account deficit.

A lower capital raises output of non-tradables and reduces relative price of non-tradables: $(\partial R_n/\partial k)dk^*/d\tau < 0$. The supply curve shifts from S_{n0} to S_{n2}. Lower foreign assets reduce wealth and consumption declines. The demand curve shifts from D_{n1} to D_{n3} and reduces relative price of non-tradables: $(\partial R_n/\partial F)dF^*/\tau < 0$.

$$\frac{dR_n^*}{d\tau} = \underset{-}{\left(\frac{\partial R_n}{\partial k}\right)}\frac{dk^*}{d\tau} + \underset{-}{\left(\frac{\partial R_n}{\partial F}\right)}\frac{dF^*}{d\tau} + \underset{-}{\frac{\partial R_n}{\partial \tau}} < 0 \qquad (4.43)$$

Therefore, an increase in τ generates a steady reduction in the relative price of non-tradables.

4.6. Conclusions

In this chapter we extend Stein's (1994) NATREX model to China. This is a dynamic model which investigates the determinants of the real exchange rate in the medium-run and the long-run, when short-run shocks are removed. The two state variables are capital and foreign assets. In the medium-run, these two state variables are predetermined. Changes in fundamentals and levels of capital and foreign assets determine the medium-run equilibrium real exchange rate and relative price of non-tradables. In the long-run, capital and foreign assets converge to the new steady states delivered by changes in the fundamentals. Hence the long-run equilibrium real exchange rate and relative price of non-tradables are entirely determined by the fundamentals. The dynamic stability of the model requires (a) the impact of capital on investment to be greater than the impact of foreign assets on investment when investment is zero and (b) the impact of foreign assets on current account to be greater than the impact of capital on current account when current account is in balance.

The fundamentals that affect the long-run equilibrium value of the real exchange rate include terms of trade, total and net factor productivity, rural transformation, dependency ratio, financial liberalisation, relative unit labour cost, relative rate of return to capital, government investment, tax rate and the world's real interest rate. According to the model, higher terms of trade, total and net factor productivity (in the tradables sector), rural transformation, relative rate of return to capital and government investment raise the equilibrium real exchange rate (i.e. appreciate in the RMB) in the long-run. On the other hand, higher relative unit labour cost, dependency ratio, financial liberalisation and tax rate reduce the long-run equilibrium real exchange rate (i.e. depreciate in the RMB).

We make a number of contributions to the literature. Instead of using foreign debt (Stein, 1995), we use foreign assets as one of the state variables since we regard China as a net creditor. We incorporate into the NATREX framework fundamentals that reflect the unique characteristics of the Chinese economy but have not been studied by existing literature, i.e. relative unit labour cost, relative return to capital, rural transformation, demographic factors and liquidity constraints. Instead of using GDP growth rate and other approximations of productivity as in most of the NATREX applications, we employ total and net factor productivity as an important determinant of the long-run equilibrium real exchange rate. In particular, we introduce rural transformation in the production function, which has rarely been implemented in existing studies of China's production function. Time preference, an exogenous variable in Stein's (1994) original NATREX model, is endogenised as a function of dependency ratio and financial liberalisation to reflect the unique consumption pattern in China. Aggregate investment is divided into three components, private domestic investment, government investment and foreign direct investment, and each component is modelled individually. The private domestic investment is modelled based on neoclassical model and the government investment is regarded as exogenous. In particular, foreign direct investment is determined by fundamentals such as relative unit labour cost and relative rate of return to capital. Finally, we provide detailed mathematical and economic analysis of the predictions of the model in both the medium-run and the long-run.

Appendix 4.A. The Real Exchange Rate

This section discusses the derivation of the real exchange rate in Stein and Lim (1995) in their study of NATREX for Australia. The relationship between nominal and real exchange rate is defined in equation (4.11)

$$N = R\frac{p'}{p}, \tag{4.11}$$

where N, R, p and p' denote the nominal exchange rate of USD per Australian Dollar, real exchange rate, Australian GDP price deflator and the US GDP price deflator respectively. The economy produces exports 1 and non-tradables n, consumes imports 2 and non-tradables n. The domestic price and foreign price are defined as:

$$p = p_n^a p_1^{1-a} \tag{4.44a}$$

$$p' = (p_n')^b (p_2')^{1-b} \tag{4.44b}$$

where p_n and p_n' are domestic and foreign price of non-tradables n; p_1 denotes the price of exports (from Australia to the US); p_2' denotes the price of imports from foreign country (from the US to Australia); a and b denote the weights given to the non-tradables sector in the GDP price deflator. p_n' and p_2' are exogenous for domestic country (Australia). R_n denotes the relative price of non-tradables n (p_n) to the exports (p_1):

$$R_n = \frac{p_n}{p_1}. \tag{4.8}$$

The terms of trade (T) are the relative price of exports 1 (p_1) to imports 2 (p_2') measured in a common currency:

$$T = N\frac{p_1}{p_2'}. \tag{4.9}$$

The real exchange rate R can be rewritten arithmetically as:

$$R = T(R_n)^a (p'_2 / p'_n)^b = T(R_n)^a c \sim T(R)^a \qquad (4.45)$$

$$\log R = \log T + a \log R_n + e$$

where c is the exogenous relative price and $c = (p'_2 / p'_n)^b$. Therefore, the real exchange rate R is a function of terms of trade T and relative price of non-tradables R_n:

$$R = T(R_n)^a \qquad (4.10)$$

Appendix 4.B. Medium-Run Equilibrium

In the medium-run, capital and foreign assets are predetermined. In other words, k and F do not alter in the medium-run. The equilibrium of the goods market is described by equation (4.16):

$$C_n(R_n,k,F;DEP,CREP,T)+I_n(R_n,k,F;NFP,RT,r',\tau,GI,T)-y_n(R_n,k;NFP,RT)=0 \tag{4.16}$$

where $\frac{\partial C_n}{\partial R_n}<0$, $\frac{\partial C_n}{\partial DEP}>0$, $\frac{\partial C_n}{\partial CREP}>0$ ($\frac{\partial C_n}{\partial g}>0$), $\frac{\partial C_n}{\partial T}<0$, $\frac{\partial I_n}{\partial R_n}<0$, $\frac{\partial I_n}{\partial NFP}>0$ ($\frac{\partial I_n}{\partial NFP_n}>0$, $\frac{\partial I_n}{\partial NFP_t}>0$), $\frac{\partial I_n}{\partial RT}>0$ ($\frac{\partial I_n}{\partial RT_n}>0$, $\frac{\partial I_n}{\partial RT_t}>0$), $\frac{\partial I_n}{\partial r'}<0$, $\frac{\partial I_n}{\partial \tau}<0$, $\frac{\partial I_n}{\partial GI}>0$, $\frac{\partial I_n}{\partial T}><0$, $\frac{\partial y_n}{\partial R_n}>0$, $\frac{\partial y_n}{\partial NFP_n}>0$, $\frac{\partial y_n}{\partial NFP_t}<0$, $\frac{\partial y_n}{\partial RT_n}>0$ and $\frac{\partial y_n}{\partial RT_t}<0$.

Total differentiate C_n, I_n and y_n separately:

$$dC_n=\frac{\partial C_n}{\partial R_n}dR_n+\frac{\partial C_n}{\partial DEP}dDEP+\frac{\partial C_n}{\partial CREP}dCREP+\frac{\partial C_n}{\partial T}dT=\frac{\partial C_n}{\partial R_n}dR_n+\frac{\partial C_n}{\partial Z}dZ \tag{4.46}$$

$$dI_n=\frac{\partial I_n}{\partial R_n}dR_n+\frac{\partial I_n}{\partial NFP}dNFP+\frac{\partial I_n}{\partial RT}dRT+\frac{\partial I_n}{\partial r'}dr'+\frac{\partial I_n}{\partial \tau}d\tau+\frac{\partial I_n}{\partial GI}dGI+\frac{\partial I_n}{\partial T}dT=\frac{\partial I_n}{\partial R_n}dR_n+\frac{\partial I_n}{\partial Z}dZ \tag{4.47}$$

$$dy_n=\frac{\partial y_n}{\partial R_n}dR_n+\frac{\partial y_n}{\partial NFP_n}dNFP_n+\frac{\partial y_n}{\partial NFP_t}dNFP_t+\frac{\partial I_n}{\partial RT_n}dRT_n+\frac{\partial I_n}{\partial RT_t}dRT_t=\frac{\partial y_n}{\partial R_n}dR_n+\frac{\partial y_n}{\partial Z}dZ \tag{4.48}$$

where $Z=[DEP,CREP,NFP,RT,r',\tau,GI,T]$

Therefore, total differentiation of equation (4.16) can be rewritten as:

$$dC_n+dI_n-dy_n=0$$
$$\Rightarrow\left(\frac{\partial C_n}{\partial R_n}dR_n+\frac{\partial C_n}{\partial Z}dZ\right)+\left(\frac{\partial I_n}{\partial R_n}dR_n+\frac{\partial I_n}{\partial Z}dZ\right)-\left(\frac{\partial y_n}{\partial R_n}dR_n+\frac{\partial y_n}{\partial Z}dZ\right)=0 \tag{4.49}$$

$$\Rightarrow dR_n=\frac{\frac{\partial C_n}{\partial Z}dZ+\frac{\partial I_n}{\partial Z}dZ-\frac{\partial I_n}{\partial Z}dZ}{M}\text{ where } M=-\left(\frac{\partial C_n}{\partial R_n}+\frac{\partial I_n}{\partial R_n}-\frac{\partial y_n}{\partial R_n}\right)>0 \tag{4.50}$$

Now we are going to analyse the sign of dR_n/dZ when there is a change in Z:

$$\frac{dR_n}{dDEP}=\frac{\left(\frac{\partial C_n}{\partial DEP}\right)}{M}>0;\ \frac{dR_n}{dCREP}=\frac{\left(\frac{\partial C_n}{\partial CREP}\right)}{M}>0\ (\frac{dR_n}{dg}=\frac{\left(\frac{\partial C_n}{\partial g}\right)}{M}>0);$$

$$\frac{dR_n}{dNFP_n}=\frac{\left(\frac{\partial I_n}{\partial NFP_n}-\frac{\partial y_n}{\partial NFP_n}\right)}{M}<0;\ \frac{dR_n}{dNFP_t}=\frac{\left(\frac{\partial I_n}{\partial NFP_t}-\frac{\partial y_n}{\partial NFP_t}\right)}{M}>0;$$

$$\frac{dR_n}{dRT_n}=\frac{\left(\frac{\partial I_n}{\partial RT_n}-\frac{\partial y_n}{\partial RT_n}\right)}{M}<0;\ \frac{dR_n}{dRT_t}=\frac{\left(\frac{\partial I_n}{\partial RT_t}-\frac{\partial y_n}{\partial RT_t}\right)}{M}>0;\ \frac{dR_n}{dr'}=\frac{\left(\frac{\partial I_n}{\partial r'}\right)}{M}<0;$$

$$\frac{dR_n}{d\tau}=\frac{\left(\frac{\partial I_n}{\partial \tau}\right)}{M}<0;\ \frac{dR_n}{dGI}=\frac{\left(\frac{\partial I_n}{\partial GI}\right)}{M}>0;\ \frac{dR_n}{dT}=\frac{\left(\frac{\partial C_n}{\partial T}+\frac{\partial I_n}{\partial T}\right)}{M}<0.$$

$\frac{\partial C_n}{\partial R_n}<0$: an increase in relative price of non-tradables reduces demand for non-tradables consumptions.

$\frac{\partial C_n}{\partial DEP}>0$: a higher dependency ratio means more non-tradables are demanded as there are relatively more minors needed to be raised and educated.

$\frac{\partial C_n}{\partial CREP}>0$: in a more financial liberalised economy, people are able to borrow more to consume now and repay later. More consumption means more demand for non-tradables.

$\frac{\partial C_n}{\partial g}>0$: a higher time preference, as a result of higher DEP or $CREP$, raises consumption for non-tradables.

$\frac{\partial C_n}{\partial T}<0$: the relative price of non-tradables to imported goods can be expressed as TR_n (equation (4.12)). Therefore a higher T implies a higher relative price of non-tradables and leads to a lower consumption of non-tradables.

$\frac{\partial I_n}{\partial R_n} < 0$: an increase in R_n has an ambiguous effect on user cost of capital. However, this effect is negligible compared with the negative effect of a higher R_n on investment using non-tradables.

$\frac{\partial I_n}{\partial NFP} > 0$ ($\frac{\partial I_n}{\partial NFP_n} > 0$, $\frac{\partial I_n}{\partial NFP_t} > 0$), $\frac{\partial I_n}{\partial RT} > 0$ ($\frac{\partial I_n}{\partial RT_n} > 0$, $\frac{\partial I_n}{\partial RT_t} > 0$): investment using non-tradables depends positively on the demand of the market—the output of the market y. y is a function of k, NFP (NFP_t, NFP_n) and RT (RT_t, RT_n). Higher k, NFP (NFP_t, NFP_n) and RT (RT_t, RT_n) mean a higher output and therefore higher demand for investment. Consequently investment using non-tradables I_n is also higher.

$\frac{\partial I_n}{\partial r'} < 0$: a higher world's real interest rate raises real domestic interest rate. This leads to a higher user cost of capital and lower investment. Investment using non-tradables also declines.

$\frac{\partial I_n}{\partial \tau} < 0$: a higher tax rate leads to a higher user cost of capital and reduces I_n.

$\frac{\partial I_n}{\partial GI} > 0$: government investment is part of aggregate investment if there is no crowding out effect. A higher GI means higher aggregate investment and therefore demand for investment using non-tradables is also higher.

$\frac{\partial I_n}{\partial T} >< 0$: an increase in T decreases the user cost of capital and therefore stimulates investment. Investment using non-tradables I_n also increases. On the other hand, higher terms of trade mean a higher relative price of non-tradables to importable and discourages investment using non-tradables.

$\frac{\partial y_n}{\partial R_n} > 0$: a higher R_n generates higher supply of non-tradables.

$\frac{\partial y_n}{\partial NFP_n} > 0$, $\frac{\partial y_n}{\partial RT_n} > 0$: higher productivity in non-tradables sector or more labour shifting from tradables sector to non-tradables sector increases the supply of non-tradables.

$\frac{\partial y_n}{\partial NFP_t} < 0$, $\frac{\partial y_n}{\partial RT_t} < 0$: higher productivity in tradables sector or more labour shifting from non-tradables sector to tradables sector shifts resources from non-tradables sector to tradables sector and reduces the output of non-tradables.

$\frac{dR_n}{dT} = \frac{\left(\frac{\partial C_n}{\partial T} + \frac{\partial I_n}{\partial T}\right)}{M} < 0$: based on $\frac{\partial C_n}{\partial T} < 0$ and $\frac{\partial I_n}{\partial T} >< 0$, the effect of an increase in terms of trade on relative price of non-tradables is ambiguous. However, we assume the effect of terms of trade on consumption ($\frac{\partial C_n}{\partial T} < 0$) dominates its effect on investment using non-tradables .

$\frac{dR_n}{dNFP_n} = \frac{\left(\frac{\partial I_n}{\partial NFP_n} - \frac{\partial y_n}{\partial NFP_n}\right)}{M} < 0$: based on $\frac{\partial I_n}{\partial NFP_n} > 0$ and $\frac{\partial y_n}{\partial NFP_n} > 0$, the sign of $\frac{dR_n}{dNFP_n}$ is ambiguous. However, we assume that the supply effect ($\frac{\partial y_n}{\partial NFP_n} > 0$) dominates.

$\frac{dR_n}{dRT_n} = \frac{\left(\frac{\partial I_n}{\partial RT_n} - \frac{\partial y_n}{\partial RT_n}\right)}{M} < 0$: based on $\frac{\partial I_n}{\partial RT_n} > 0$ and $\frac{\partial y_n}{\partial RT_n} > 0$, the sign of $\frac{dR_n}{dRT_n}$ is ambiguous. However, we assume that the supply effect $\frac{\partial y_n}{\partial RT_n} > 0$ dominates.

Appendix 4.C. Long-Run Equilibrium

In the long-run, the dynamic system concerns the evolution of the capital and foreign assets, which is described by equations (4.23) and (4.25)

$$\frac{dk}{dt} = J(k, F; Z) \tag{4.23}$$

$$\frac{dF}{dt} = S(k, F; Z) - J(k, F; Z) = L(k, F; Z) \tag{4.25}$$

The steady state is described by equations (4.26) and (4.27)

$$J(k^*, F^*; Z) = 0 \tag{4.26}$$

$$L(k^*, F^*; Z) = S(k^*, F^*; Z) - J(k^*, F^*; Z) = 0 \tag{4.27}$$

Now we are going to solve the steady state equation. Total differentiate equations (4.26) and (4.27) and solve for $\frac{dk^*}{dZ}$ and $\frac{dF^*}{dZ}$

$$dJ = \frac{\partial J}{\partial k} dk^* + \frac{\partial J}{\partial F} dF^* + \frac{\partial J}{\partial Z} dZ = 0 \tag{4.51}$$

$$dL = \left(\frac{\partial S}{\partial k} - \frac{\partial J}{\partial k}\right) dk^* + \left(\frac{\partial S}{\partial F} - \frac{\partial J}{\partial F}\right) dF^* + \left(\frac{\partial S}{\partial Z} - \frac{\partial J}{\partial Z}\right) dZ = 0 \tag{4.52}$$

$$\begin{bmatrix} \frac{\partial J}{\partial k} & \frac{\partial J}{\partial F} \\ \frac{\partial S}{\partial k} - \frac{\partial J}{\partial k} & \frac{\partial S}{\partial F} - \frac{\partial J}{\partial F} \end{bmatrix} \begin{bmatrix} dk^* \\ dF^* \end{bmatrix} = \begin{bmatrix} -\frac{\partial J}{\partial Z} \\ -\left(\frac{\partial S}{\partial Z} - \frac{\partial J}{\partial Z}\right) \end{bmatrix} dZ$$

$$\Rightarrow \begin{bmatrix} dk^* \\ dF^* \end{bmatrix} = \frac{1}{G} \begin{bmatrix} \frac{\partial S}{\partial F} - \frac{\partial J}{\partial F} & -\frac{\partial J}{\partial F} \\ -\left(\frac{\partial S}{\partial k} - \frac{\partial J}{\partial k}\right) & \frac{\partial J}{\partial k} \end{bmatrix} \begin{bmatrix} -\frac{\partial J}{\partial Z} \\ -\left(\frac{\partial S}{\partial Z} - \frac{\partial J}{\partial Z}\right) \end{bmatrix} dZ \tag{4.53}$$

$$\Rightarrow \frac{dk^*}{dZ} = \frac{\left(\frac{\partial S}{\partial F} - \frac{\partial J}{\partial F}\right)\left(-\frac{\partial J}{\partial Z}\right) + \left(-\frac{\partial J}{\partial F}\right)\left(-\left(\frac{\partial S}{\partial Z} - \frac{\partial J}{\partial Z}\right)\right)}{G} = \frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial Z} - \frac{\partial S}{\partial F}\frac{\partial J}{\partial Z}}{G} \tag{4.54}$$

and $$\frac{dF^*}{dZ} = \frac{-\left(\frac{\partial S}{\partial k} - \frac{\partial J}{\partial k}\right)\left(-\frac{\partial J}{\partial Z}\right) + \frac{\partial J}{\partial k}\left(-\left(\frac{\partial S}{\partial Z} - \frac{\partial J}{\partial Z}\right)\right)}{G} = \frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial Z} - \frac{\partial J}{\partial k}\frac{\partial S}{\partial Z}}{G} \tag{4.55}$$

where

$$G = \begin{vmatrix} \dfrac{\partial J}{\partial k} & \dfrac{\partial J}{\partial F} \\ \dfrac{\partial S}{\partial k} - \dfrac{\partial J}{\partial k} & \dfrac{\partial S}{\partial F} - \dfrac{\partial J}{\partial F} \end{vmatrix} = \frac{\partial J}{\partial k}\left(\frac{\partial S}{\partial F} - \frac{\partial J}{\partial F}\right) - \frac{\partial J}{\partial F}\left(\frac{\partial S}{\partial k} - \frac{\partial J}{\partial k}\right) = \frac{\partial J}{\partial k}\frac{\partial L}{\partial F} - \frac{\partial L}{\partial k}\frac{\partial J}{\partial F} > 0 \tag{4.56}$$

Equations (4.54) and (4.55) represent the effect of changes in the fundamentals on capital and foreign assets in the steady state. Now we are going to analyse the signs of equations (4.54) and (4.55) given $\frac{\partial S}{\partial k} > 0$, $\frac{\partial S}{\partial F} < 0$, $\frac{\partial J}{\partial k} < 0$, $\frac{\partial J}{\partial F} > 0$, $\frac{\partial L}{\partial k} > 0$, $\frac{\partial L}{\partial F} < 0$ and $G > 0$.

$\frac{\partial S}{\partial k} > 0$: a higher capital increases output and therefore raises savings.

$\frac{\partial S}{\partial F} < 0$: this is a crucial assumption of NATREX model. Higher foreign assets generate lower savings and *vice versa*. This condition prevents foreign assets from increasing infinitely.

$\frac{\partial J}{\partial k} < 0$: given a diminishing marginal productivity of capital, a higher capital implies a lower marginal productivity of capital and therefore the accumulation of capital slows down.

$\frac{\partial J}{\partial F} > 0$: higher foreign assets imply lower country risk, which generates higher capital.

$\frac{\partial L}{\partial k} > 0$: a higher capital raises output gradually and generates current account surplus.

$\frac{\partial L}{\partial F} < 0$: higher foreign assets reduce savings ($\frac{\partial S}{\partial F} < 0$) and stimulate capital inflows due to lower country risk, which generates current account deficit.

$G > 0$: this is the stability condition and has been explained in the main text.

We need to derive the signs for $\frac{\partial S}{\partial Z}$ and $\frac{\partial k}{\partial Z}$. Based on savings equations (4.3) and (4.24) and investment equations (4.7c) and (4.23), we obtain

$$S(k, F; Z) = S(k, F; NFP, RT, r', CREP, DEP) \quad (4.57)$$

$$\frac{dk}{dt} = J(k, F; Z) = I(R_n, k, F; NFP, RT, r', \tau, GI, RULC, RRC, T) \quad (4.58)$$

where $\frac{\partial S}{\partial NFP} > 0$ ($\frac{\partial S}{\partial NFP_n} > 0$, $\frac{\partial S}{\partial NFP_t} > 0$), $\frac{\partial S}{\partial RT} > 0$ ($\frac{\partial S}{\partial RT_n} > 0$, $\frac{\partial S}{\partial RT_t} > 0$), $\frac{\partial S}{\partial r'} > 0$, $\frac{\partial S}{\partial CREP} < 0$, $\frac{\partial S}{\partial DEP} < 0$ ($\frac{\partial S}{\partial g} < 0$); $\frac{\partial J}{\partial NFP} > 0$ ($\frac{\partial J}{\partial NFP_n} > 0$, $\frac{\partial J}{\partial NFP_t} > 0$), $\frac{\partial J}{\partial RT} > 0$ ($\frac{\partial J}{\partial RT_n} > 0$, $\frac{\partial J}{\partial RT_t} > 0$), $\frac{\partial J}{\partial RULC} < 0$, $\frac{\partial J}{\partial RRC} > 0$, $\frac{\partial J}{\partial T} > 0$, $\frac{\partial J}{\partial GI} > 0$, $\frac{\partial J}{\partial r'} < 0$ and $\frac{\partial J}{\partial \tau} < 0$.

Therefore, the signs of $\frac{dk^*}{dZ}$ and $\frac{dF^*}{dZ}$ are analysed as

$$\frac{dk^*}{dNFP} = \frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial NFP} - \frac{\partial S}{\partial F}\frac{\partial J}{\partial NFP}}{G} > 0, \quad \frac{dF^*}{dNFP} = \frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial NFP} - \frac{\partial J}{\partial k}\frac{\partial S}{\partial NFP}}{G} > 0,$$

$$\frac{dk^*}{dNFP_n} = \frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial NFP_n} - \frac{\partial S}{\partial F}\frac{\partial J}{\partial NFP_n}}{G} > 0, \quad \frac{dF^*}{dNFP_n} = \frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial NFP_n} - \frac{\partial J}{\partial k}\frac{\partial S}{\partial NFP_n}}{G} > 0,$$

$$\frac{dk^*}{dNFP_t} = \frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial NFP_t} - \frac{\partial S}{\partial F}\frac{\partial J}{\partial NFP_t}}{G} > 0, \quad \frac{dF^*}{dNFP_t} = \frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial NFP_t} - \frac{\partial J}{\partial k}\frac{\partial S}{\partial NFP_t}}{G} > 0,$$

$$\frac{dk^*}{dRT}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial RT}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial RT}}{G}>0,\ \frac{dF^*}{dRT}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial RT}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial RT}}{G}>0,$$

$$\frac{dk^*}{dRT_n}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial RT_n}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial RT_n}}{G}>0,\ \frac{dF^*}{dRT_n}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial RT_n}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial RT_n}}{G}>0,$$

$$\frac{dk^*}{dRT_t}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial RT_t}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial RT_t}}{G}>0,\ \frac{dF^*}{dRT_t}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial RT_t}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial RT_t}}{G}>0,$$

$$\frac{dk^*}{dCREP}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial CREP}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial CREP}}{G}<0,\ \frac{dF^*}{dCREP}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial CREP}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial CREP}}{G}<0,$$

$$\frac{dk^*}{dDEP}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial DEP}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial DEP}}{G}<0,\ \frac{dF^*}{dDEP}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial DEP}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial DEP}}{G}<0,$$

$$\left(\frac{dk^*}{dg}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial g}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial g}}{G}<0,\frac{dF^*}{dg}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial g}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial g}}{G}<0\right),$$

$$\frac{dk^*}{dRULC}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial RULC}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial RULC}}{G}<0,\frac{dF^*}{dRULC}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial RULC}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial RULC}}{G}<0,$$

$$\frac{dk^*}{dRRC}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial RRC}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial RRC}}{G}>0,\ \frac{dF^*}{dRRC}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial RRC}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial RRC}}{G}>0,$$

$$\frac{dk^*}{dT}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial T}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial T}}{G}>0,\ \frac{dF^*}{dT}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial T}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial T}}{G}>0,$$

$$\frac{dk^*}{dGI}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial GI}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial GI}}{G}>0,\ \frac{dF^*}{dGI}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial GI}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial GI}}{G}>0,$$

$$\frac{dk^*}{dr'}=\frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial r'}-\frac{\partial S}{\partial F}\frac{\partial J}{\partial r'}}{G}><0,\ \frac{dF^*}{dr'}=\frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial r'}-\frac{\partial J}{\partial k}\frac{\partial S}{\partial r'}}{G}><0,$$

$$\frac{dk^*}{d\tau} = \frac{\frac{\partial J}{\partial F}\frac{\partial S}{\partial \tau} - \frac{\partial S}{\partial F}\frac{\partial J}{\partial \tau}}{G} < 0, \quad \frac{dF^*}{d\tau} = \frac{\frac{\partial S}{\partial k}\frac{\partial J}{\partial \tau} - \frac{\partial J}{\partial k}\frac{\partial S}{\partial \tau}}{G} < 0.$$

$\frac{\partial S}{\partial NFP} > 0$ ($\frac{\partial S}{\partial NFP_n} > 0, \frac{\partial S}{\partial NFP_t} > 0$): higher net factor productivity, no matter in the non-tradables or tradables sector, generates higher output and income. Higher income implies higher savings.

$\frac{\partial S}{\partial RT} > 0$ ($\frac{\partial S}{\partial RT_n} > 0$, $\frac{\partial S}{\partial RT_t} > 0$): rural transformation which shifts labour from the tradables sector to the non-tradabes sector (or from non-tradables sector to the tradabes sector) implies more labour has been allocated to more productive sector. Hence output raises and so do savings.

$\frac{\partial S}{\partial r'} > 0$: for a net creditor country, a higher world's real interest rate means more interest rate income from its foreign assets and in turn higher savings.

$\frac{\partial S}{\partial DEP} < 0$: the dependency ratio has a positive effect on consumption ($\frac{\partial C_n}{\partial DEP} > 0$) therefore has a negative effect on savings

$\frac{\partial S}{\partial CREP} < 0$: the financial liberalisation has a positive effect on consumption ($\frac{\partial C_n}{\partial CREP} > 0$) therefore is has a negative effect on savings.

$\frac{\partial S}{\partial g} < 0$: a higher time preference means higher consumption ($\frac{\partial C_n}{\partial g} > 0$) hence means lower savings.

$\frac{\partial J}{\partial NFP} > 0$ ($\frac{\partial J}{\partial NFP_n} > 0$, $\frac{\partial J}{\partial NFP_t} > 0$): higher net factor productivity, no matter in the non-tradables or tradables sector, implies higher marginal productivity of capital, which leads to a higher investment.

$\frac{\partial J}{\partial RT} > 0$ ($\frac{\partial J}{\partial RT_n} > 0$, $\frac{\partial J}{\partial RT_t} > 0$): rural transformation which shifts labour from the tradables sector to the non-tradabes sector (or from non-tradables sector to the tradabes sector) implies higher total factor productivity as more labour has been allocated to more productive sector. That leads to higher marginal productivity and stimulates investment.

$\frac{\partial J}{\partial RULC} < 0$: a higher relative unit labour cost of China makes China less attractive to FDI and thus reduces FDI inflows.

$\frac{\partial J}{\partial RRC} > 0$: a higher relative rate of return to capital of China relative to the US make China more attractive to FDI and thus increases FDI inflows.

$\frac{\partial J}{\partial T} > 0$: higher terms of trade reduce the user cost of capital and stimulate investment.

$\frac{\partial J}{\partial GI} > 0$: the government investment is a component of the aggregate investment. Hence a higher government investment increases aggregate investment if there is no crowding out effect.

$\frac{\partial J}{\partial r'} < 0$: a higher real world's real interest rate raises user cost of capital and discourages investment.

$\frac{\partial J}{\partial \tau} < 0$: a higher tax rate raises user cost of capital and discourages investment.

Appendix 4.D. The Long-Run Equilibrium Exchange Rate and Relative Price of Non-Tradables

In Appendix 4.B we derived the direct effect of fundamentals Z on R_n in the medium-run when k and F are predetermined. In this section we will derive the total effect of of fundamentals Z on R_n in the long-run, when k and F converge to their steady states. Recall the non-tradables market equilibrium (equation 4.16)

$$C_n(R_n,k,F;DEP,CREP,T)+I_n(R_n,k,F;NFP,RT,r',\tau,GI,T)-y_n(R_n,k;NFP,RT)=0 \tag{4.16}$$

Total differentiate equation (4.16) we obtain

$$\left(\frac{\partial C_n}{\partial R_n}dR_n^*+\frac{\partial C_n}{\partial k}dk^*+\frac{\partial C_n}{\partial F}dF^*+\frac{\partial C_n}{\partial Z}dZ\right)+\left(\frac{\partial I_n}{\partial R_n}dR_n^*+\frac{\partial I_n}{\partial k}dk^*+\frac{\partial I_n}{\partial F}dF^*+\frac{\partial I_n}{\partial Z}dZ\right) -\left(\frac{\partial y_n}{\partial R_n}dR_n^*+\frac{\partial y_n}{\partial k}dk^*+\frac{\partial y_n}{\partial Z}dZ\right)=0 \tag{4.59}$$

$$\Rightarrow dR_n^*=\frac{\left(\frac{\partial C_n}{\partial k}+\frac{\partial I_n}{\partial k}-\frac{\partial y_n}{\partial k}\right)dk^*+\left(\frac{\partial C_n}{\partial F}+\frac{\partial I_n}{\partial F}\right)dF^*+\left(\frac{\partial C_n}{\partial Z}+\frac{\partial I_n}{\partial Z}-\frac{\partial y_n}{\partial Z}\right)dZ}{M} \tag{4.60}$$

$$\Rightarrow \frac{dR_n^*}{dZ}=\frac{\left(\frac{\partial C_n}{\partial k}+\frac{\partial I_n}{\partial k}-\frac{\partial y_n}{\partial k}\right)\frac{dk^*}{dZ}+\left(\frac{\partial C_n}{\partial F}+\frac{\partial I_n}{\partial F}\right)\frac{dF^*}{dZ}+\left(\frac{\partial C_n}{\partial Z}+\frac{\partial I_n}{\partial Z}-\frac{\partial y_n}{\partial Z}\right)}{M} \tag{4.61}$$

$$\Rightarrow \frac{dR_n^*}{dZ}=\left(\frac{\partial R_n}{\partial k}\right)\frac{dk^*}{dZ}+\left(\frac{\partial R_n}{\partial F}\right)\frac{dF^*}{dZ}+\frac{\partial R_n}{\partial Z} \tag{4.31b}$$

Equation (4.31b) describes the total effect of fundamentals Z on R_n in long-run equilibrium. The last item is the direct effect of fundamentals Z on R_n in the medium-run. The signs of this item have been analysed in Appendix 4.B. The first two items in equation (4.31b) measure the indirect effect of fundamentals Z on R_n in the long-run when k and F reach new steady states. The signs of $\frac{dk^*}{dZ}$ and $\frac{dF^*}{dZ}$ have been analysed in Appendix 4.C. The signs of the first two items are explained in the main text. Based on equation (4.10), the long run equilibrium exchange rate can be written as

$$R^* = T(R_n^*)^a = R^*(Z) \tag{4.32}$$

According to equation (4.32), the fundamentals which affect the relative price of non-tradables, R_n^*, affect the real exchange rate, R^*, in a similar way. One exception are the terms of trade which have a direct and indirect (via R_n^*) effect on the real exchange rate (these are analysed in Section 4.5.6).

Appendix 4.E. 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	−	+	−	−	−	−	−	$E1-E$
g	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).

Chapter 5
Estimation of the Extended NATREX Model

5.1. Introduction

This chapter provides the first empirical application of the extended NATREX model to China[1]. The NATREX is estimated for both the real bilateral US Dollar/Chinese Yuan exchange rate and the real effective exchange rate for the time span of both pre- and post-reform periods. We construct a unique data base of consistent time series including economic fundamentals since 1952 that are crucial in determining the NATREX but have not been analysed by previous studies. To avoid approximation of productivity, we estimate the production function for China and derive total factor productivity for both pre- and post-reform periods. This is the first time that total factor productivity is estimated when rural transformation is taken into account. All existing studies of China's effective exchange rate are restricted to the post-reform period as data for the effective exchange rate of the RMB is not available for the pre-reform period. 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. The econometric methodologies we use are the ADF unit root tests based on Campbell and Perron's (1991) general to specific methods and the Johansen cointegration method. The long-run equilibrium estimates together with the Hodrick-Prescott filtered fundamentals are used to construct the NATREX for the real bilateral and real effective exchange rates. Misalignments are calculated accordingly.

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[1] Holger *et al* (2001) is the only paper so far has applied NATREX model to China. However, their study has applied identical modelling and estimation procedures as Stein (1994). Hence the limitations of Stein's (1994) NATREX model discussed in Chapter 4 also apply to Holger *et al* (2001).

This chapter is organised as follows. The next section explains data sources and variable measurement. Section 5.3 specifies the productivity function and estimates of total and net factor productivity for China. Section 5.4 explains the unit root and Johansen cointegration tests employed. Section 5.5 presents empirical estimates of the NATREX for the real bilateral USD/CNY exchange rate and analyses the misalignments. Section 5.6 explains data sources and variable measurement for the real effective exchange rate and other effective variables. This is followed by estimation of the NATREX for the real effective exchange rate of the RMB and investigation of the misalignments. Section 5.7 concludes.

5.2. Data Sources and Variable Measurement

The main data sources of this study include the *50 Years of New China* (*50YNC*), various issues of the *China Statistical Yearbook* (*CSY*) (mainly *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*). They are summarised in Appendix 5.A. The Data span is 1952-2005[2].

The Chinese government conducted the first National Economic Census in 2004 and updated data after the census is reported in *CSY 2006*. However, *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 1952-1977 from *50YNC* and data for the period 1978-

[2] However, due to data limitation, the data span is 1953-2005 for some variables including the dependency ratio (DEP), government investment (GI), US real long-term interest rate (USR), rate of return to capital of China using capital series 2 (CHRC2) and the rate of return of China using capital series 2 (RRC2).

2005 from *CSY 2006*. However, as mentioned above, data from 1978 is updated due to the census in 2004. 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. Then the original data of *50YNC* from 1952 to 1977 is multiplied by the adjustment factor and we name it "adjusted data" from 1952 to 1977.

5.2.1. Nominal GDP

Table A-03 "*Gross Domestic Product of China*", *50YNC* provides nominal GDP from 1952 to 1999. Table 3-1 "*Gross Domestic Product*", *CSY 2006* provides nominal GDP from 1978 to 2005. Nominal GDP from 1952 to1977 is collected from adjusted data of *50YNC* and nominal GDP from 1978 to 2005 is collected from *CSY 2006*[3]

5.2.2. GDP Price Deflator

The GDP price deflator is calculated using the same methodology as Jun (2003). Table A-05 "*Indices of Gross Domestic Product of China*", *50YNC* provides GDP at constant prices (preceding year =100) from 1952 to 1999. Table 3-3 "*Indices of Gross*

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

Domestic Product", *CSY 2006* provides GDP at constant prices (preceding year =100) from 1978 to 2005. GDP at constant prices (preceding year=100) from 1952 to 1977 is collected from original data of *50YNC*[4] and data from 1978-2005 is collected from *CSY 2006*. Nominal GDP data from 1952 to 2005 is constructed in Section 5.2.1. 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 multiplying 100, we get the implicit GDP price deflator (preceding year=100). By choosing 1978, 1990 and 2000 as base years, we convert GDP price deflator into 1978 prices (1978=100), 2000 prices (2000=100) and 1990 prices (1990=100)[5] and we call them GDP price deflator 1, 2 and 3 respectively. *WDI 2006* provides GDP price deflator with the base year of 1990=100 between 1960 and 2005 and we call it GDP price deflator 4. GDP price deflator 4 and GDP price deflator 3 are consistent with each other. After this confirmation, we use GDP deflators 1 (1978=100) and 2 (2000=100) in our study.

5.2.3. Real GDP of China

Real GDP in 1978 prices and 2000 prices are constructed by dividing nominal GDP by GDP deflators (1978=100 and 2000=100) and multiplying by 100.

5.2.4. Real Exchange Rate (RER)

The real exchange rate is calculated as

$$RER = Np / p' \qquad (5.1)$$

[4] Data of GDP at constant prices (preceding year=100) *50YNC* and data from *CSY 2006* are identical for period 1978-1992.

[5] We construct implied GDP price deflator with base year of 1978 due to the capital stock is constructed using base year 1978 (see Section 5.2.16); with the base year 2000 due to most data from *IFS* choose 2000 as base year; with base year of 1990 as GDP price deflator provided by *WDI* is with the base year 1990=100.

where RER, N, p and p' are the real exchange rate, nominal exchange rate (US dollar per Chinese Yuan, USD/CNY), GDP price deflator of China and GDP price deflator of the US respectively. An increase in the real exchange rate implies an appreciation of RMB and *vice versa*. Data for the nominal exchange rate is collected from *IFS* (line rh.zf) for the period 1952-2005. The US GDP price deflator from 1952 to 2005 (2000=100) is collected from *IFS* (line 99bir). The GDP price deflator from 1952 to 2005 for China (2000=100) is described in Section 5.2.2. After obtaining the real exchange rate, we convert it into an index with the year 2000 being equal to 100.

5.2.5. Total Number of Employed Persons (L)

The total number of employed persons from 1952 to 1977 is collected from table A-02 "*Employment, Staff and Workers of China*", original data from *50YNC*. From 1978 to 2005, data is collected from table 5-2 "*Number of Employed Persons at the Year-end by Three Industries*", *CSY 2006*.

5.2.6. Rural Transformation (RT) (%)

Rural transformation is defined as unity minus the ratio of employed persons by primary industry to total number of employed persons. It is expressed as a percentage. 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 is collected from A-02 "*Employment, Staff and Workers of China*", original data from *50YNC* and data from 1978 to 2005 is collected from table 5-2 "*Number of Employed Persons at the Year-end by Three Industries*", *CSY 2006*.

5.2.7. Nominal Consumption

The final consumption expenditure includes household consumption and government consumption. Final consumption expenditure from 1952 to 1977 is collected from Table A-06 *"Gross Domestic Product by Expenditure Approach of China"*, adjusted data from *50YNC* and data from 1978 to 2005 is collected from Table 3-11 *"Gross Domestic Product by Expenditure Approach"*, *CSY 2006.*

5.2.8. Consumer Price Index

Table A-21 *"Overall Price Indices of China"*, *50YNC* provides consumer price index (CPI) from 1950 to 1998 (preceding year=100). Table 9-1 *"Fixed-base Price Indices"*, *CSY 2006* provides CPI of 1978, 1980, 1985 and 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 1978 (1978=100) and 2000 (2000=100) and we name them CPI1 and CPI2 respectively[6].

5.2.9. Real Consumption of China

Data for real consumption in 1978 prices and 2000 prices is constructed by dividing nominal consumption by consumer price indices (1978=100 and 2000=100) and multiplying by 100.

5.2.10. Real Social Time Preference (g) (%)

Real social time preference in 2000 prices is the ratio of real final consumption to real GDP, both in 2000 prices. It is expressed as a percentage .

[6] We construct CPI1 (1978=100) for the calculation of real capital stock (see Section 5.2.16). We construct CPI2 (2000=100) since data from *IFS* is often with base year 2000=100.

5.2.11. 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. Modigliani and Cao (2004) provide dependency ratio for the period 1953 to 2000. We use the three overlapping years (1960, 1961, and 1962) average of *WDI* data divided by the same three overlapping years average of Modigliani and Cao's (2005) data as the adjustment factor. Data from Modigliani and Cao's (2005) for the period 1953 to 1959 is multiplied by the adjustment factor. Therefore, for the period 1953-1959 the dependency ratio is collected from adjusted data of Modigliani and Cao (2004), and for the period 1960-2005 it is calculated using data from *WDI 2006*, *50YNC* and *CSY 2006.*

5.2.12. Financial Liberalisation (CREP) (%)

Following Kose, Prasad, and Terrone (2006), financial liberalisation is measured as the ratio of domestic credit to private sector to Nominal GDP. It is expressed as a percentage. Nominal GDP data is described in Section 5.2.1. The construction of domestic credit to private sector needs explanation.

The *IFS* provides data of domestic credit to private sector for China (line 32d[7]) covering 1977 to 2005. According to the explanatory notes of the *IFS*[8], the domestic

[7] *IFS* defines domestic credit (line 32) as the sum of claims on central government (net)(32an), claims on state and local governments (32b), claims on non-financial public enterprises (32c), claims on private sector (32d), claims on other banking institutions (32f) and claims on non-bank financial institutions (32g).

credit to private sector (line 32d) = (monetary authority's claim on private sector (line 12d) + banking institutions' claim on private sector) (line 22d). Table A-59 *Credit Funds Balance Sheet of State Bank Uses of Funds, 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. It is understandable that before the reform and opening up policy in 1978, monetary authority hardly issued credit to private sector. Even after 1978, the amount of monetary authority's claim on private sector represents only a small portion of domestic credit to private sector (1% on average during 1985-2005). 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.

5.2.13. 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. Table 6-4 *Total Investment in Fixed Assets in the Whole Country by Sources of Funds and Use of Funds, CSY 2006* provides the ratio of state budgetary appropriation to the total investment in fixed assets covering 1981-2005. For the year of 1952-1980, official data of ratio of government appropriation to total investment in fixed assets is not available. Therefore we can only express this in an approximation.

According to the explanatory notes of *CSY 2002*, by channel of management total investment in fixed assets can be divided into capital construction, technical update

[8] Online explanatory notes of *IFS* are available from http://docs.lib.duke.edu/data/guides/*IFS*ENG.html of Pekins Library, Duke University.

and transformation (innovation), real estate development and others. Table 5-3 *Investment in Capital Construction and Technical Updates and Transformation, CSY 1996* provides state budgetary appropriation in capital construction from 1953 to 1995 and Table 6-6 *Investment in Capital Construction and Innovation CSY 2002* provides same data from 1957-2001[9]. For the overlapping years of 1957-1995, data from *CSY 1996* and *CSY 2002* is identical. Combining *CSY 1996* and *CSY 2002*, the original data for state appropriation in capital construction is collected for the period 1953-1980. Total fixed assets investment from 1953-1980 is collected from Bai, Hsieh and Qian (2006)[10].

The main channel through which government investment is injected is the state appropriation in capital construction[11]. Therefore we use

$$\frac{\text{state budgetary appropriation in capital construction}}{\text{total fixed assets investment}} * \text{adjustment factor}$$

as an approximation of

$$\frac{\text{state budgetary appropriation}}{\text{total fixed assets investment}}$$

for the period 1953-1980. We choose 1980, 1981 and 1982 as overlapping years. The 3-year average ratio of state appropriation in capital construction (original data from *CSY 1996* and *CSY 2002*) to total fixed assets investment is called ratio A. The 3-year average ratio of total state appropriation (data from *CSY 2006*) to total fixed assets investment is called ratio B. B divided by A is the adjustment factor.

[9] From CSY 2003 on, NBS does not report detailed national investment in fixed assets according to channel of management.

[10] Bai, Hsieh and Qian (2006) provide fixed assets investment from 1953 to 2005 as the sum of construction and installation, equipment and instruments, and others. In their study, data from 1953 to 1977 is collected from Hsueh and Li (1999) and data from 1978 to 2005 is collected from *CSY 2006*.

[11] For instance, for the year 1980, 1981 and 1982, the sum of state appropriation in capital construction accounts for 82.5%, 83.5% and 87.1% of total state budgetary appropriation that goes to fixed assets investment.

5.2.14. 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[12]. We convert the terms of trade for the period 1980-2005 into base year 1980=100[13].

For years before 1980, neither terms of trade, nor export or import prices for China is available. Therefore, they can only be expressed in approximate terms for the period 1952-1979.

5.2.14.1. Export Prices 1952-1982

Before the reform and opening up policy in 1978, the government attempted to use primary goods to exchange equipment and machines from foreign countries. Therefore the main exported item is primary goods. Even shortly after 1978, primary goods still account 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 are 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 1952-1979.

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[12] *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) for the period 1980-2004. 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*. For the year 2005, data is not available from *WDI 2006* nor from *UNCTAD*. Therefore we use data of 2004 as data of 2005.

[13] The reason why we choose 1980 as our base year will be explained later.

The price index for China's primary goods is computed using the same methodology that we used in calculating the GDP price deflator. Primary goods at constant prices (preceding year=100) from 1952-1977 is collected from Table A-05 "*Indices of Gross Domestic Product of China*", original data from *50YNC* and from 1978-2005 is collected from Table 3-3 "*Indices of Gross Domestic Product*", *CSY 2006*. Data for primary goods at current price from 1952 to 1977 is collected from Table A-03 "*Gross Domestic Product of China*", original data from *50YNC* and data for the period 1978-2005 is collected from Table 3-1 "*Gross Domestic Product*", *CSY 2006.* We construct primary goods at current prices (previous year=100) by dividing nominal primary goods of current year by nominal primary goods of previous year. By dividing primary goods at current prices by primary goods at constant prices and multiplying by 100, we get the implicit primary goods price index (preceding year=100). By choosing 1980 as base year, we convert primary goods price index into 1980 prices (1980=100) for the whole period 1952-1982. Then the index is then converted into USD using nominal exchange rate index of USD/CNY (1980=100).

5.2.14.2. Import Prices 1952-1982

We use the world export prices to approximate China's import prices[14]. The world export is available from *IFS* (line 00174) for the whole period 1952-2005 with base year 2000=100. Therefore we convert it into 1980=100[15]. 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). It is with the base year of 1980.

[14] We did not use US export price due to the historical "embargo" decision of Chinese government towards trade with the US. Only after the reform and opening up policy in 1978 the trade between US and China started to thrive.

[15] It is converted into 1980=100 because the export prices index (primary goods price index) for the period uses 1980 as a base year.

5.2.14.3. Terms of Trade 1952-2005

To combine the terms of trade for the two periods, 1952-1982 (1980=100) and 1980-2005 (1980=100), 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.

Now we explain the reasons for choosing 1980 as our base year. We use 1980 rather than other years for three reasons. First, the earliest terms of trade data for China are available from 1980. Second, from 1980-1985, the ratio of primary goods export to total export are 50.3%, 46.6%, 45.0%, 43.3%, 45.7% and 50.6%. Since 1986 the ratio has dropped dramatically from 36.4% to 6.4% in 2005. Therefore, only before 1985 it is reliable to use primary good price index as an approximation of export prices. Thirdly, to combine terms of trade 1952-1982 with 1980-2005, we need to adjust terms of trade 1952-1980 using the adjustment factor. The adjustment factor is only reliable if it is calculated using overlapping years that are before 1985, in our case we choose 1980, 1981 and 1982.

We have terms of trade for the period 1952-2005 (1980=100). Since other variables in our studies are expressed in 2000 prices, we convert the terms of trade into 2000=100.

5.2.15. Nominal Net Exports

Net exports of goods and service from 1952 to 1977 is collected from Table A-06 *"Gross Domestic Product by Expenditure Approach of China"*, adjusted data from *50YNC*. Data from 1978 to 2005 is collected from Table 3-11 "*Gross Domestic Product by Expenditure Approach*", *CSY 2006*.

5.2.16. Real Capital Stock

Lack of investment price is a major issue for estimating real capital stock for China as the official Chinese statistics did not report price index for fixed asset investment until 1991[16]. In this section, we present three series (capital stock 1, 2, and 3), the construction of which represents the main stream of calculating capital stock for China. Capital stock 1, 2, and 3 in our study use different investment price indices as well as different initial capital stocks and depreciation rates. The reason we construct three capital stock series is because the capital share obtained from the estimation of the production function could be sensitive to the choice of capital series. Therefore we compare the capital shares generated from these three capital stocks to evaluate the degree of sensitivity of capital shares to different choices of capital stock series.

5.2.16.1. Real Capital Stock (K1) — An Extension of Chow and Li (2002)

K1 is calculated following the methodology of Chow and Li (2002) but using updated data after the National Economics Consensus in 2004. We extend the data span from 1952-1998 in Chow and Li (2002) to 1952-2005.

Chow and Li (2002)

Chow and Li (2002) calculate the real capital formation for 1952-1998 as follows

$$\text{Real Capital Formation} = (\text{Real GDP-Real Consumption-Real Net Exports}) \quad (5.2)$$

Real GDP (1978=100) and real consumption (1978=100) are described in Sections 5.2.3 and 5.2.9 respectively. Nominal net export are adjusted by GDP price deflator 1 (1978=100) to get real net exports. Therefore the real capital formation from 1952 to 2005 is the residual and is in 1978 prices.

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[16] The earliest official data of price index of investment in fixed assets is reported in "Investment in Fixed Assets Price Index" *CSY 2002*, starting from 1991.

For the period 1952-1978, it is shown that there is no significant change in the price of capital[17]. Therefore, nominal capital formation is regarded as equivalent to the real capital formation. The initial capital stock was chosen as 2213 (100 million CNY) in 1952 prices[18]. The depreciation rate is 0 for 1952-1978.

From 1979-1992, the capital formation is calculated as

$$K_t = RI + K_{t-1}*(1-0.054)$$

where K_t and K_{t-1} denotes capital stock at time t and t-1, RI denotes the real investment and 0.054 is the depreciation rate.

From 1993 to 1998, Chow and Li (2002) calculate the capital stock as follows

$$K_t = K_{t-1} + RNI$$

$$RNI = RGI*[(GI - TOTAL\ DEPRECIATION)/GI]$$

where RNI denotes the real net investment, RGI denotes real capital formation that is calculated as in equation (5.2) and GI denotes the gross capital formation at current prices. Total depreciation is the sum of provincial depreciation data at current prices.

Our Estimation

We employ the methodology of Chow and Li (2002) but use updated data after National Economics Consensus in 2004. We use the initial capital stock of 2213 (100 million CNY) in 1952 prices. For the period 1952-1978, we use the original data of capital stock from Chow and Li (2002)[19]. For the period 1979-2005, data needed for

[17] Chow (1993) finds that from 1952-1978, price of investment remained almost constant, which is consistent with Jefferson *et al* (1992).

[18] Chow and Li (2002) regard the price of capital as 100 for the whole period 1952-1978 with 1978 as the base year. Therefore, the initial capital stock that is in 1952 prices is equivalent to the same amount of initial capital stock in 1978 prices.

[19] We use data from Chow and Li (2002) rather than collecting updated data of nominal capital formation for the period 1952-1978 for two reasons. First, we collected original data of nominal capital formation of 1952-1978 from Table A-6 *Gross Domestic Product by Expenditure Approach of China, 50YNC* and data after 1978 is collected from Table 3-12 *"Components of Gross Domestic Product by Expenditure Approach"*, *CSY 2006*. We compare the overlapping year of 1978, 1979 and 1980 and calculated the adjustment factor which is very close to unity: 1.003. Second, Chow (1993) analyses that for the period 1952-1978 there is no significant change in the price of capital and hence nominal capital

the computation of real capital formation, i.e. real GDP, real consumption, nominal net exports, and GDP price deflator, is introduced in previous sections. The depreciation rate is 0 from 1952 to 1978 and 0.054 from 1979 to 1992. For the period 1993-1998, sum of provincial depreciation from Chow and Li (2002) is used as it is not affected by National Economics Consensus in 2004 [20]. Provincial data of depreciation of 1999, 2000, 2001, 2003, and 2005 is collected from Table 3-10 "*Structure of Gross Domestic Product by Region", CSY 2000, 2001, 2002, 2004 and 2006.* While data for 2002 and 2004 is not available we use the average of 2001 and 2003 to approximate 2002 and average of 2003 and 2005 to approximate 2004. The sum of the provincial depreciation is used as the total depreciation.

Investment Price Index

Investment price index is calculated here for comparison and for future use. P_{K1} is 100 for the period 1952-1978[21]. For the period 1979-2005, the implied investment price index is calculated as the ratio of nominal capital formation to real capital formation at 1978 prices. Nominal capital formation data from 1978 to 2005 is collected from Table 3-11 "*Gross Domestic Product by Expenditure Approach*", *CSY 2006.* The real capital formation from 1979 to 2005 is calculated using equation (5.2) as mentioned above. By combining the two periods of 1952-1978 and 1979-2005 we get price of capital series 1, P_{K1}, with 1978 as the base year.

formation is regarded as equivalent to the real capital formation. Therefore, to avoid confusion and complication, we decide to use data of capital stock from Chow and Li (2002) for the period 1953-1978.

[20] Each year *CSY* report provisional depreciation of the previous year only. Therefore, the consensus in 2004 does not affect provisional of 1993 to 1998 or it is not possible to check if data of 1993 to 1998 have changed. Therefore we keep data from Chow and Li (2002) for the period 1993-1998.

[21] Recall that there is no obvious change in the price of investment in China for the period 1952-1978 according to Chow (1993).

5.2.16.2. Real Capital Stock 2 (K2) — Bai et al (2006)

K2 from 1952-2005 is obtained from Bai *et al* (2006)[22].

Data of Investment

In Bai *et al* (2006), data of "gross fixed capital formation" from 1952 to 1977 is collected from Heush and Li (1999) and data from 1978 to 2005 is collected from *CSY 2006*[23]. Some researchers use investment in fixed assets to estimate the capital stock (e.g. Huang, Ren, and Liu, 2002; Wand and Wu, 2003). According to Bai, Hsieh and Qian (2006), they use gross fixed capital formation as a more accurate measure of the change in China's reproducible capital stock instead of using fixed assets investment for two reasons. In the first place, China National Statistical Bureau counts the value of purchased land and expenditure on used machinery and pre-existing structures as part of investment in fixed assets while neither of these should be regarded as an increase in China's reproducible capital stock. The second reason is that the fixed assets investment is based on survey data for large investment projects only, which will obvious understate aggregate investment.

However, the gross fixed capital formation is not divided into different types of investment while the series of total investment in fixed assets is separated into two types of investment in fixed assets: investment in structures and building, investment in machinery and equipment[24]. To get around this problem, Bai, Hsieh and Qian (2006) assume that the shares of these two types of capital in fixed capital formation are the same as those for total investment in fixed assets. They collect data for investment in fixed assets, investment in structures and building, investment in

[22] I am very grateful for the generous help of Bai, C-E and Qian, Z, who sent me the data of real capital stock (1952-2005) used in their study of Bai, Hsieh and Qian (2006).

[23] Bai, *et al* (2006) do not adjust data from 1952 to 1977 by any adjustment factor. However, to respect the originality of their estimation, we use the real capital stock data in their study.

[24] There is another type of total investment in fixed assets: Others. However, it is omitted in the calculation due to its small share.

machinery and equipment for the period 1952-1977 from Hsueh and Li (1999) and data for the period 1978-2004 from *CSY 2006*.

Investment Price Index

Between 1953 and 1977, Bai *et al* (2006) uses the investment price index from Heush and Li (1999) to deflate the nominal gross fixed capital formation. Between 1978 and 1990, they use the deflator of value added in the construction industry to measure the price of structures and building. Price of machinery and equipment during the same period is measured by the output price deflator of the domestic machinery and equipment industry. Then the investment price index for the period 1978-1990 is calculated as:

Price index of structures and building * ratio of fixed capital formation in structures and building to the total fixed capital formation + Price index of equipment * ratio of fixed capital formation in equipment to the total fixed capital formation.

After 1991 the NBS reports separately price indices for investment in structures and buildings and for investment in machinery and equipment.

All price indices are measured in 1978 prices. Therefore, the price index of investment in 1978 prices is obtained by combining these three periods 1952-1977, 1978-1990 and 1991-2005[25].

Initial Capital Stock and Depreciation Ratio

The capital stock in 1952 is initialised as the ratio of investment in 1953 to the sum of the average growth rate of investment in 1953-1958. The depreciation rate is assumed to be 8% for structures and buildings and 24% for machinery and equipment.

[25] In terms of investment price index of capital series 2, data of price indices of fixed capital formation in construction and equipment and the ratio of these two fixed investment to the total fixed assets investment starts from 1953. Therefore, 1953 investment price index of capital series 2 is used as that of 1952.

5.2.16.3. Real Capital stock 3 (K3) — An Extension of Hsueh and Li (1999)

We calculate K3 based on Hsueh and Li (1999) but using updated data from *CSY 2006*. Hsueh and Li (1999) provides complete data of the implicit investment price index from 1952 to 1995 that has been referred to by many studies[26].

Investment Price Index

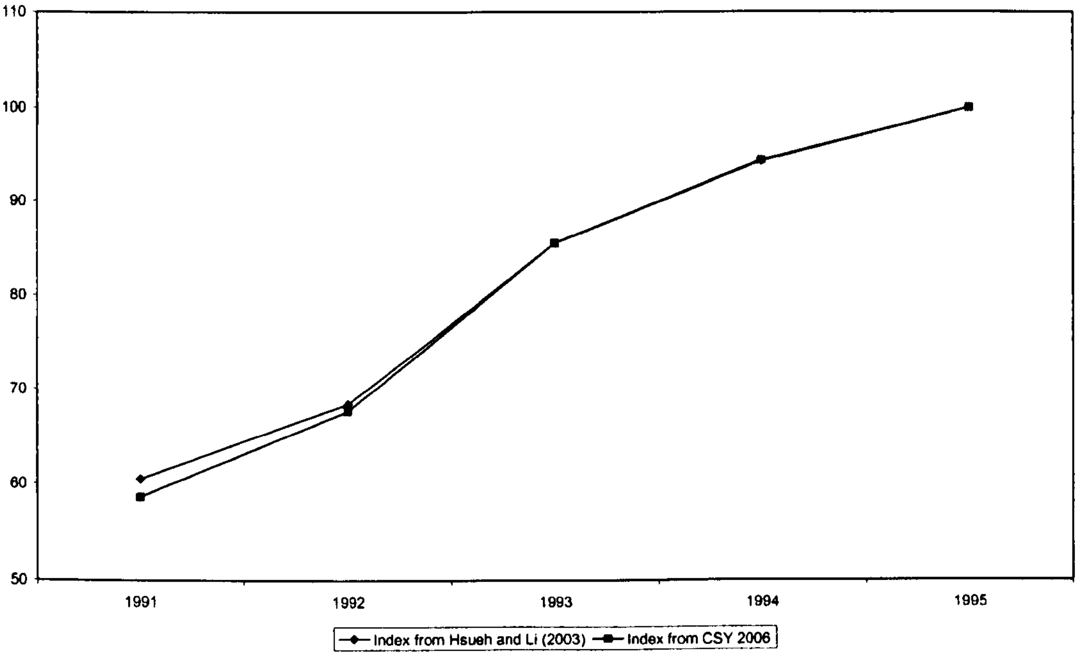
Hsueh and Li (1999) provide the implicit investment price index for the period 1952-1995 based on data from the *Annual Report of Statistics on Investment in Fixed Assets* by taking the weighted average of prices of machinery and equipment and prices of construction and installation. The first official data of "Investment in Fixed Assets Price Index" available is from *CSY 2005* starting from 1991. Table 9-2 "*Fixed-base Price Indices*", *CSY 2006* provides investment in fixed assets price index for 1991 to 2005. We combine Hsueh and Li's (1999) data and *CSY 2006* data by converting both of them into the base year 1995[27]. As shown in Figure 5.1, the two investment price indices follow each other closely for the overlapping year of 1991 to 1995. Therefore, Hsueh and Li's (1999) data is a reliable approximation for the prices of investment in fixed assets. After this confirmation, we combine Hsueh and Li's (1999) data from the period 1952-1990 and *CSY 2006* data for the period 1991-2005.

Data of Investment

For the same reason as Bai *et al* (2006), we use gross fixed capital formation as a more accurate measure of the change in China's reproducible capital stock rather than using investment in fixed assets. Following Hsueh and Li (1999), we collect data of nominal gross fixed capital formation for the period 1952-1977 from Table A-6 *Gross Domestic Product by Expenditure Approach of China,* adjusted data of *50YNC* and for

[26] Recent examples include Wang and Yao (2003) and Lang and Teng (2005).
[27] The reason we convert them into 1995 is to compare the overlapping year of 1991 and 1995 for the two data series and evaluate if the two data series are consistent with each other (See Figure 5.1)

Figure 5.1. Comparison of Investment in Fixed Assets Price Index (1995=100)



the period 1978-2005 from Table 3-12 *"Components of Gross Domestic Product by Expenditure Approach", CSY 2006*[28].

Initial Capital stock and Depreciation Ratio

The initial capital stock is defined as 221.3 billion CNY following Chow and Li (2002) in 1952 prices. For simplicity, the annual depreciation is defined as 5%, which is consistent with Perkins (1988) and Chow and Li (2002). Then the real capital stock is constructed as follows

$$K_t = K_{t-1}(1-5\%) + I_t$$

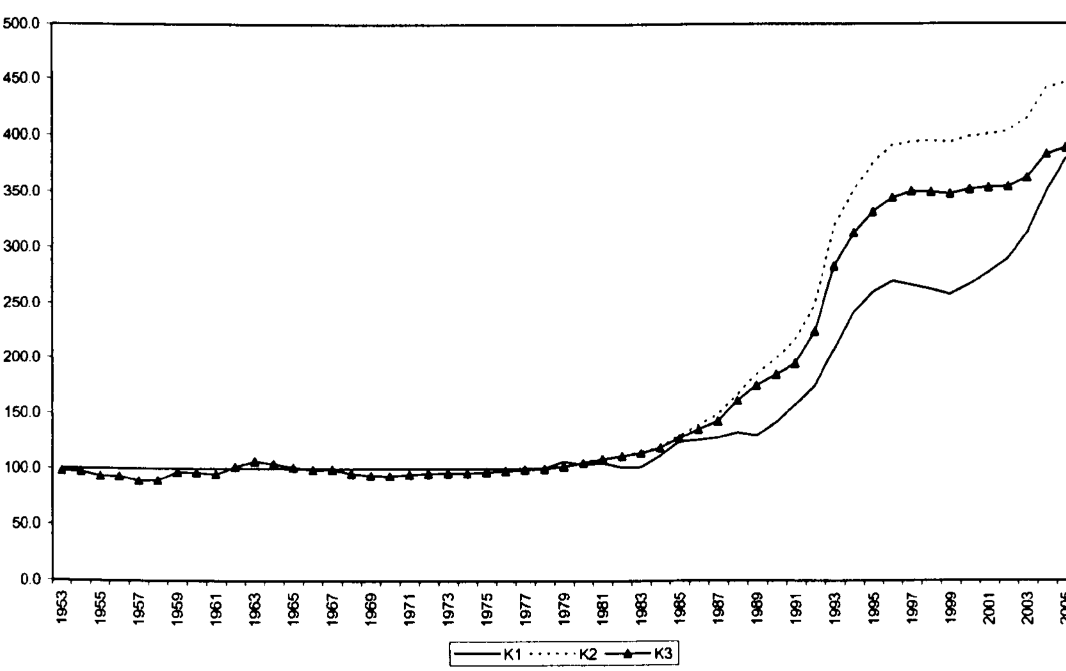
where K_t and K_{t-1} are the real capital stocks at time t and t-1 respectively, I_t is the real investment in fixed assets, which is the nominal investment in fixed assets deflated by the price of investment in fixed assets, and 5% is the annual depreciation rate.

[28] The aggregate investment is regarded as the gross fixed capital formation in Hsueh and Li (1999). Their data of nominal gross fixed assets from 1952 to 1995 is consistent with "gross fixed capital formation" Table A-6 *"Gross Domestic Product by Expenditure Approach of China"*, original data of *50YNC*.

5.2.16.4. Capital Stock Series 1, 2, and 3

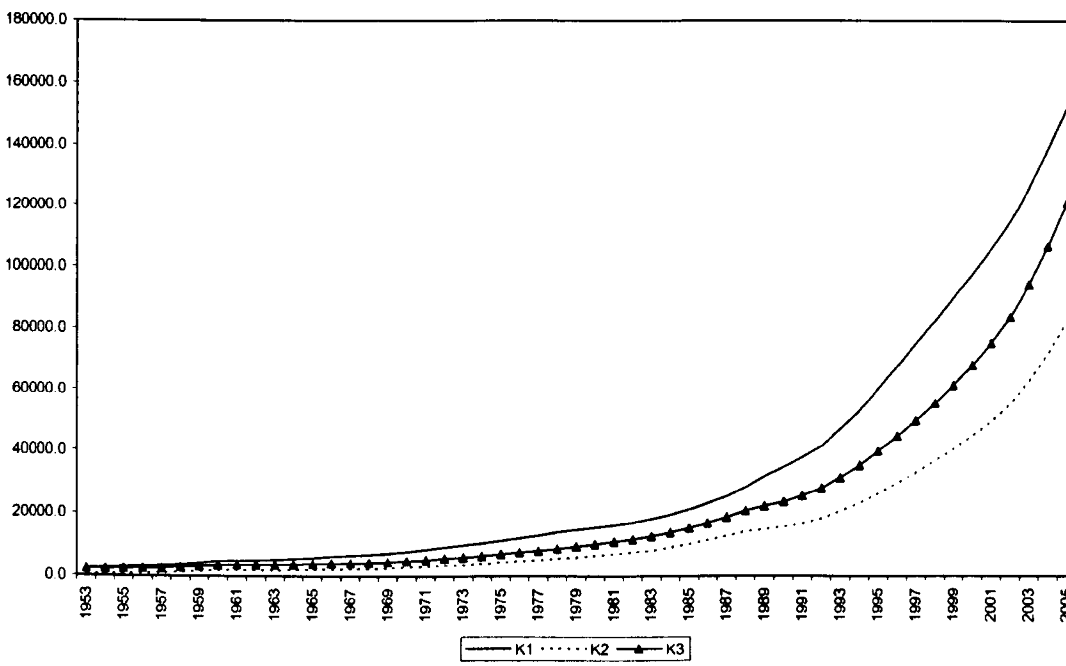
The investment price indices and real capital stocks in 1978 prices are illustrated in Figures 5.2 and 5.3[29]. All three capital stock series and investment price indices have the same trend. Before 1978, these three series and their price indices are fairly close to each other. K1 is the highest and K2 is the lowest. This could be due to the highest investment price index of K2 after 1978 and the lowest initial capital stock of K2 in 1952. K3 is generally lower than K1 even though they have the same initial capital stock (221.3 billion CNY in 1952 prices). This is firstly due to the higher investment price index of K3 compared with K1 and secondly due to change in inventories is not included in gross fixed capital formation for K3 but is included in gross capital formation for K1.

Figure 5.2. Investment Price Indices (1978=100)



[29] The investment price indices and real capital stocks in 1978 prices for capital stock series 1,2, and 3 are constructed from 1952 to 2005. However, the series start from 1953 in Figures 5.2 and 5.3 to be consistent as some variables are only available from 1953 (i.e. dependency ratio (DEP), government investment (GI), US real long-term interest rate (USR), rate of return to capital of China using capital series 2 (CHRC2) and the rate of return of China using capital series 2 (RRC2)). In the estimation of the production function (Section 5.3), we start our estimation from 1952.

Figure 5.3. Real Capital Stock in 1978 Prices (100 Million CNY)



5.2.17. Relative Unit Labour Cost (RULC)

5.2.17.1. Definition of RULC

According to the Bureau of Labour Statistics, U.S. Department of Labour, unit labour costs are 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[30].

Therefore, the relative unit labour cost is calculated as the ratio the unit labour cost of China to the unit labour cost of the US in the same currency

$$RULC^{ChinaUS} = \frac{ULC^{China}}{ULC^{US}} \times N \tag{5.3}$$

$$RULC^{ChinaUS} = \frac{LC^{China} / (Y^{China} p^{China})}{LC^{US} / (Y^{US} p^{US})} \times N \tag{5.4}$$

where $RULC^{ChinaUS}$, ULC^{China}, ULC^{US}, N, LC^{China}, $(Y^{China} p^{China})$, LC^{US} and $(Y^{US} p^{US})$ denote, respectively, the relative unit labour cost of China to the US, unit labour cost of China, unit labour cost of the US, nominal exchange rate of the

[30] http://www.bls.gov/news.release/prod4.tn.htm

USD/CNY, labour compensation of China, real output of China, labour compensation of the US, and real output of the US. Y^{China}, Y^{US}, p^{China} and p^{US} are nominal output of China, nominal output of the US, GDP price deflators of China and GDP price deflator of the US respectively.

5.2.17.2. Data Sources

Data sources for the nominal exchange rate of USD against CNY (N), GDP price deflator of China (p^{China}) and GDP price deflator of the US (p^{US}) have been discussed in previous sections. US nominal output (Y^{US}) and labour compensation of the US (LC^{US}) for the period 1952-2005 is collected from Table 1.1.5 *Gross Domestic Product* and Table 1.12 *National Income by Type of Income, Bureau of Economic Analysis, U.S. Department of Commerce.* The Chinese nominal output (Y^{China}) has been described in section 5.2.1. Data of labour compensation of China (LC^{China}) needs explanation.

Labour compensation is constructed 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[31].

$\left(LC^{China}/Y^{China}\right)$ is actually the labour share of China. Therefore we use labour share of Bai *et al* (2006) for the period 1978-2005. Data of labour compensation before 1978 is 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 0f 50%- 54% during 1978-

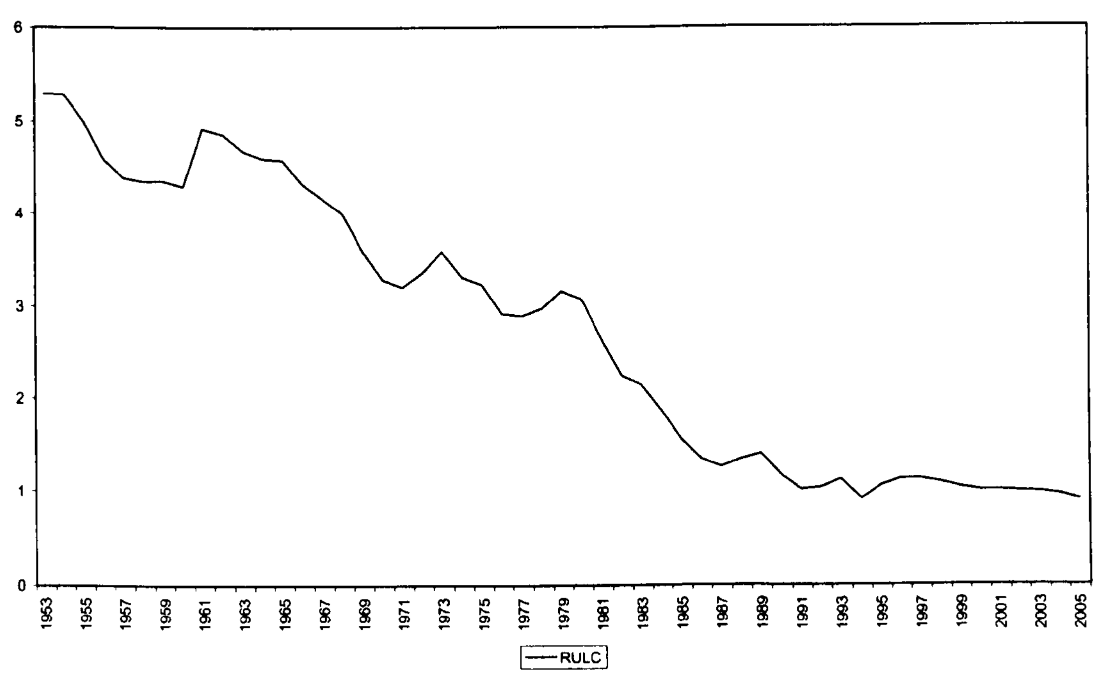
[31] According to notes made by on Bai, Hsieh and Qian (2006), data for 1978-1995 is collected from Hsueh and Li (1999), data for 1996-2002 is collected from NBS (2003), data for 2003 are from *CSY* 2004 and data for 2005 are from *CSY* 2006. The share of capital in total income for 2004 is missing from the official data and is therefore taken to be the average of those for 2003 and 2005.

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[32]. By adjusting the labour share (LC^{China}/Y^{China}) by the GDP price deflator, we obtain the unit labour cost of China: $LC^{China}/(Y^{China}p^{China})$.

5.2.17.3. China-US Relative Unit Labour Cost (RULC)

After obtaining ULC^{China} and ULC^{US}, we convert both series into indices by choosing 2000 as the base year (2000=100). We denote China-US relative unit labour cost RULC. As shown in Figure 5.4, there is a downward trend for RULC. Before the reform, RULC is more volatile. There is a sharp decrease shortly after the reform in 1978 and since late 1980s the series has become comparatively stable.

Figure 5.4. China-US Relative Unit Labour Cost



[32] 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.

5.2.18. Relative Rate of Return to Capital (RRC)

5.2.18.1. Rate of Return to Capital in China (CHRC)

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

$$RC = \frac{\alpha}{P_K K / P_Y Y} + \left(\hat{P}_K - \hat{P}_Y\right) - \delta \qquad (5.5)$$

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.

Labour share (LC^{China}/Y^{China}) is calculated in Section 5.2.17. The capital share α is one minus labour share. Real capital series 1, 2, 3 ($K1$, $K2$, $K3$) (1978=100) and real GDP (1978=100) are constructed as above. Hence we have three series of capital-output ratio ($P_K K / P_Y Y$) from capital stock series 1, 2 and 3 and we call them capital-output ratios 1, 2 and 3 respectively. Price of output (P_Y) is explained in Section 5.2.2. We have three series of capital prices corresponding to three real capital stock series and we call them P_{K1} P_{K2} and P_{K3} respectively. All three investment price indices are in 1978 prices as described in Section 5.2.16.

The depreciation rate of capital series 1 and 3 is mention above. However, for simplicity, here we regard depreciation rate of both capital series 1 and 3 as 5%. In terms of capital series 2, according to Bai *et al* (2006) the depreciation rate is assumed to be 8% for structures and buildings (construction) and 24% for machinery and equipment. We calculate the depreciation rate for capital series 2 as follows:

$$\frac{(8\%\text{* Investment in fixed capital formation in construction} + 24\%\text{ * investment in fixed capital formation in equipment})}{\text{Investment in fixed capital formation in (construction + equipment)}}$$

Now we can calculate the rate of return to capital for China according to equation (5.5). We obtain three series based on capital series 1, 2 and 3. We denote them by CHRC1, CHRC2 and CHRC3 respectively.

5.2.18.2. Rate of Return to Capital in the US (USRC)

Following Gomme *et al* (2006), the US rate of return to capital is measured as the real after-tax capital income divided by real market capital. The after-tax capital income is the sum of all income generated by market capital minus the relevant taxes. The stock of market capital includes private non-residential structures, private non-residential equipment and software, and private inventories. Therefore, the real after-tax capital income is defined as

$$
\begin{aligned}
Y_{AT} = {} & \text{Net Operating Surplus} - \text{Housing Net operating Surplus} \\
& - \alpha\,(\text{Proprietor's Income} - \text{Housing Proprietor's Income}) \\
& - t_h\,(\text{Net Interest} - \text{Housing Net Interest}) \\
& - (1-\alpha)\,t_h\,(\text{Proprietor's Income} - \text{Housing Proprietor's Income}) \\
& - t_h\,(\text{Rental Income} - \text{Housing Rental Income}) - \text{Business Property Taxes} \\
& - \text{Taxes on Corporate Income} - \text{State and Local Other Taxes}
\end{aligned}
$$

where Y_{AT} denotes after-tax capital income, α denotes labour share, t_h denotes household income tax rate which is calculated as the ratio of personal current taxes to the sum of net interest, proprietor's income, rental income and wage and salaries. The income flows and tax rates have been modified to subtract out the income generated from the housing sector. Annual data are collected from *National Income and Product Account (NIPA) from US Bureau of Economic Analysis (BEA).* Nominal after-tax capital income is converted into real variable by dividing by price index of personal consumption expenditures. Real market capital stock is measured as:

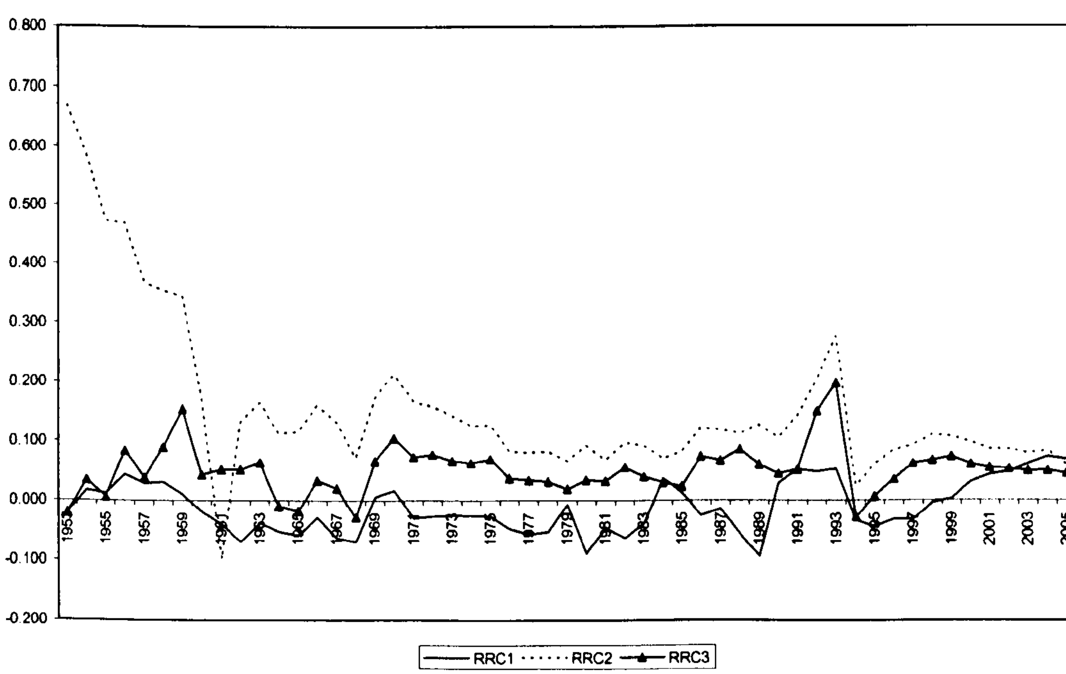
$$
\begin{aligned}
\text{Real Market Capital stock }(t+1) = {} & [\text{Initial Real Non-residential Capital stock }(t) \\
& + \text{Initial Real Stock of Real Private Inventories }(t)] * (1-\delta) \\
& + \text{Real Non-residential Fixed Investment }(t+1) \\
& + \text{Real Change in Private Inventories }(t+1)
\end{aligned}
$$

where δ is the depreciation rate that is set to equal the long-run annual depreciation of 6.9113% from Gomme *et al* (2006). Capital stock and investment data are deflated by the price of non-residential investment and price of private inventories. All data are collected from *BEA*. Then the US rate of return to capital is calculated as the ratio of real after-tax capital income to real market capital stock.

5.2.18.3. China-US Relative Rate of Return to Capital (RRC)

The relative rate of return to capital is then computed as: RRC = CHRC-USRC. Due to there are three series of rate of return to capital for China (CHRC1, 2 and 3), we obtain three series of relative rate of return to capital: RRC1, RRC2 and RRC3. They are shown in Figure 5.5. RRC2 is the highest and RRC1 is the lowest. The three series have overall similar tendency except in 1950s.

Figure 5.5. China-US Relative Rate of Return to Capital



5.2.19. 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[33]) to nominal GDP.

Table 8-4 *Government Tax Revenue, CSY 2001* provides data of government tax revenue form 1950 to 2000. Table 8-3 *Taxes, CSY 2006* provides same data for 1978, 1980, 1985, 1989-2005. For all the overlapping years, data of tax from *CSY 2001* and *CSY 2006* are identical. Therefore, for the period 1952-1988, original data is collected from *CSY 2001* and data from 1989 to 2005 is collected from *CSY 2006*. Both *CSYs* state explicitly the tariff and agriculture and related tax.

5.2.20. World's Real Interest Rate (USR) (%)

The world real interest rate is measured as the real US 10 years government bond yield. Nominal US 10 years government bond yield for the period 1954-2005[34] is collected from *IFS* (line 61). US CPI data from 1951 to 2005 is collected from *IFS* (line 64) and inflation from 1953 to 2005 is calculated from it. Nominal US 10 years government bond yield minus inflation rate gives the US real interest rate and it is in percentage form.

---

[33] We exclude agriculture and related tax is due to that 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.

[34] 10 years bond yield for 1953 are not available and therefore we use 3 years government bond yield in 1953 replace.

5.2.21. Net Foreign Assets

According to Lane and Milesi-Ferretti (2001), the net external position of a country, the net foreign assets, is given by the sum of the foreign exchange reserves, net debt position, the net equity stock position and the net FDI stock position:

$$F_t = FDIA_t + EQA_t + DEBTA_t + FX_t - FDIL_t - EQL_t - DEBTL_t$$

where F_t and FX_t denotes net foreign assets and foreign exchange reserves (FX reserves), FDI_t, EQ_t, and $DEBT_t$ are stock of foreign direct investment, portfolio equity and debt respectively, A and L denote assets and liabilities respectively.

IFS provides data for net foreign assets (line 31n, stock variable) covering 1977 to 2005 in CNY. But data before 1977 is not available. *China State Administration of Foreign Exchange* (*SAFE*) provides stock of FX reserves from 1950 to 2005 in USD[35] [36]. We convert FX reserves into CNY using nominal exchange rate of USD/CNY. The problem is that stock of net debt, net equity and net FDI is not available[37]. However, before the reform and opening up policy was implemented in 1978, China was a closed centrally-planned economy. Hence we assume that before 1978 the importance of foreign direct investment, portfolio equity and debt on China's balance of payment were negligible. Therefore, for the period 1952-1976, net foreign assets are approximated using FX reserves. Combining these two periods, 1952-1976 and 1977-2005, we obtain net foreign assets for the period 1952-2005[38].

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[35] http://www.safe.gov.cn/model_safe_en/tjsj_en/tjsj_detail_en.jsp?ID=30303000000000000,14&id=3

[36] *CSY 2006* provides same data from 1978-2005. For the overlapping years these two data source provide identical data of FX reserves stock.

[37] *IFS* provides information of China's current account from 1982. Net debt, net equity and net FDI are also available from 1982. However, they are all flow variables. Given the starting date of available data (1982) and data span in our study (1952-2005), it is impossible to use any cumulated net debt, net equity and net FDI as stocks of those variables.

[38] Strictly speaking, we should construct adjustment factor for the year of 1977, 1978 and 1979 and adjust F of 1952-1976 by the adjustment factor. However, we do not think this is necessary in this case because the shares of FX reserves to nominal GDP vary between 0.1% and 0.6% for the period 1952-1976. During 1977-1979, the shares of FX reserves to nominal GDP vary between 0.1% and 0.5%

5.3. The Production Function and Productivity

Chow (1993), Borensztein and Ostry (1996), Hu and Khan (1997) and Maddison (1998) study China's economic growth for both pre- and post-reform periods[39]. They find a significant contribution of total factor productivity (TFP) to the economic growth in the post-reform period while in the pre-reform period economic growth is mainly attributed to capital accumulation. On the other hand, Sachs and Woo (1997) and Woo (1998) study the post-reform period and find that the high economic growth after reform is mainly attributed to capital accumulation whilst technological progress has little contribution to the growth..

Though it seems hard to define whether there is significant technological progress for the entire pre- and post-reform periods, it seems fair to say that there is little evidence of TFP growth for the pre-reform period according to the results of existing empirical studies. In particular, Chow (1993) employs extensive data of capital formation and labour and estimates the Cobb-Douglas production functions for China's aggregate economy and five sub-sectors respectively from 1952 to 1988. He finds that there is no technological change in China from 1952 to 1980[40]. Chow and Li (2002) further extend Chow (1993) and re-estimate the Cobb-Douglas production for the period 1952-1998 by setting the time trend t, which captures the technological change, to zero for the period 1952-1977, to one in 1978 and increasing by one each year thereafter. We adopt the same methodology as Chow and Li (2002) in our study.

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while the share of net foreign assets to nominal GDP varies between -0.4% and 0.7%. Given the small shares, the adjustment factor will not affect the results and therefore it is better to use the original data.

[39] For earlier studies please refer to the surveys of Wu (1993) and Wu and Yang (1995).

[40] Chow (1993) further justifies this "zero technological change" by the implementation of the first Five-Year Plan in 1953 which tried to increase outputs in five sectors through capital formation in these sectors. The estimations of both sectoral and aggregate production functions show there was no technological change. After 1960, the centrally-planned did not give any incentive to private enterprises to innovate and therefore there was no technological progress. Chow (1993) argues that Solow's (1956) growth model is an important phenomenon to explain for a market economy like the US; one cannot presume its existence in a country like China during a period when private initiatives for innovations and adopting new technology from abroad appeared to be absent.

To our knowledge, rural transformation has not been studied extensively in the existing literature of China's production function. Few studies that incorporate rural transformation are Borensztein and Ostry (1996), World Bank (1996) and Woo (1998) for the post-reform period, and all show significant contribution of labour reallocation to the GDP growth. Therefore, we incorporate rural transformation into the production function for China for both pre- and post-reform periods.

5.3.1. The Production Function

Following Chow and Li (2002), the Cobb-Douglas production function can be written as

$$Y = AK^{\alpha}L^{1-\alpha} \qquad (5.6)$$

where Y, K, L, A and α are real output, real capital stock, labour, level of technology and capital share of income respectively. Dividing both sides by L we obtain the form

$$y = Ak^{\alpha} = e^{\beta t}k^{\alpha} \qquad (5.7)$$

where β measures the effect of technological progress. y and k denote real output per labour and real capital stock per labour respectively. Conventionally, A is also referred as TFP. In our study, we separate TFP into net factor productivity (NFP) and rural transformation (RT). NFP captures the pure technology progress and RT captures the effect of inter-sectoral labour flows. Unlike other emerging economies, China's transformation from centrally-planned to market-oriented economy is characterised by "rural transformation". It refers to both rural-urban migration and rural industrialisation. The former refers to the internal labour migration from countryside to cities. The latter refers to the establishment of rural enterprises (i.e. Town and Village Enterprises) which have been shifting farmers from working in the field to working in these labour intensive rural enterprises. Both result in shifts of labour from relatively low productivity primary sector to relatively more productive secondary and tertiary sectors[41]. Therefore, even if the levels of technology in different sectors remain unchanged (hence NFP is unchanged), labour flows from sectors with lower marginal productivity of labour to sectors with higher marginal productivity of labour will increase the TFP. In other words, for a country like China with enormous labour surplus, it is not only the total number of effective labour that matters for output growth; the distribution of effective labour also matters.

Therefore, the production function for China takes the form

$$y = TFPk^{\alpha} = (NFP)(RT^{\gamma})k^{\alpha} \tag{5.8}$$

where γ measures the effect of changes in RT on TFP. Put it in a numerical way, it measures how many units of increment in the level of TFP there will be if RT increases by one unit. We expect it to be within the range of zero and unity ($0 < \gamma < 1$). Hence equation (5.7) can be rewritten as:

$$y = (e^{\beta t})(RT^{\gamma})k^{\alpha}. \tag{5.9}$$

5.3.2. Data

Two real capital stock series are employed for the period 1952-2005[42]. The first capital series, $K1$, is the extended series of Chow and Li (2002). The second capital series, $K2$, is collected from Bai *et al* (2006). The other series include real GDP, labour and rural transformation, which are described in detail in Section 5.2.16. $K1$, $K2$ and real GDP are divided by labour (number of employed persons). As

[41] Chow (1993) finds the marginal value product of labour in 1978 to be 63 Yuan in agriculture, 1027 Yuan in industry, 452 Yuan in construction, 739 Yuan in transportation and 1809 Yuan in commerce.

[42] We also estimate the production function using $K3$. However, capital shares estimated using $K3$ are 0.81 and 0.92 for the cases with and without RT respectively, which is unrealistic and out of line with the results of existing literature. Furthermore, constants and time trends are not significant in the estimation of production function using $K3$. Therefore we do not report the results of $K3$ here.

mentioned above, following Chow (1993) and Chow and Li (2002), we set time trend, which indicates the pure technological change, to zero for the period 1952-1977, to one in 1978 and increasing by one each year thereafter and denote it as t.

5.3.3. Empirical Results and Interpretation

We estimate the production function using Ordinary Least Squares (OLS). However, if the error term is autocorrelated, then OLS estimators are unbiased but inefficient. Therefore, in our study we use the heteroskedasticity-and autocorrelation-consistent variance estimator (HAC) (Newey and West, 1987), which derives the correct formula for the standard errors of the OLS estimates with autocorrelated errors.

Taking natural logarithm of equations (5.7) and (5.9) yields equations (5.10) and (5.11) respectively. Therefore, in our study we use both time trend to capture NFP, the pure technological change, and RT to capture the effect of changes in RT on TFP. The level of TFP is the sum of levels of NFP and RT.

We estimated two production functions (equations (5.10) and (5.11)) for the period 1952-2005 using $\ln k1$ and $\ln k2$. The first one does not incorporate RT and second one does. The results are reported in Table 5.1.

$$\ln y_t = c + \alpha \ln k_t + \beta t + u_t \tag{5.10}$$

$$\ln y_t = c + \alpha \ln k_t + \beta t + \gamma \ln(RT)_t + u_t \tag{5.11}$$

All coefficients are correctly signed and statistically significant before and after RT is incorporated into the production function. However, there are four noticeable changes after the rural transformation is incorporated. First, capital shares are reduced from 0.648 to 0.573 for $k1$ and from 0.408 to 0.362 for $k2$. That implies that the inclusion of RT in the production function reduces capital shares since RT captures the originally ignored part of change in TFP if only time trend is included. Second, the

Table 5.1. Estimation of Production Function (1952-2005)

Variables	Regressions			
	1	2	3	4
Constant	1.4639	3.7334	1.0591	3.3873
	(0.4327)	(0.2705)	(0.4382)	(0.3378)
$\ln k1$	0.6484		0.5731	
	(0.0548)		(0.0480)	
$\ln k2$		0.4076		0.3617
		(0.0404)		(0.0465)
t	0.0288	0.0421	0.0231	0.0388
	(0.0040)	(0.0042)	(0.0042)	(0.0044)
$\ln RT$			0.3144	0.2079
			(0.0684)	(0.0901)
$\overline{R}^2$	0.9840	0.9849	0.9902	0.9881
Log likelihood	48.9599	50.4434	62.6204	55.2177

Note: $\overline{R}^2$ denotes adjusted R-squared. Standard errors are in parentheses. All regressions use heteroskedasticity-and autocorrelation-consistent standard errors (HAC) (Newey and West, 1987).

intercepts and coefficients of t in the second set (regressions 3 and 4) are slightly lower than these in the first set (regressions 1 and 2) after controlling for RT. It implies that the missing of RT from the production function magnifies not only the original level of NFP, which is represented by the intercept, but also the growth rate of NFP, which is captured by the coefficient of t. In other words, if RT is not controlled for, the contribution of NFP to TFP is over valued. Third, RT is positive and significant for both cases using $k1$ and $k2$ and the coefficients are within the range of zero and unity. Fourth, both adjusted- R squared and log likelihood are higher in the second set, implying a better fit of the model after the integration of RT.

We compare capital shares estimated in our study with previous studies (Table 5.2). Capital share estimated using $k1$ (0.573) is lower than those reported by Chow (1993) and Chow and Li (2002), which reflects the effect of incorporating RT into the production function. However, the differences have been relatively small as capital shares in our study, Chow (1993) and Chow and Li (2002) are fairly close to 0.6. Capital share estimated using $k2$ is lower than Hu and Khan (1997) and higher than Maddison (1998). Nevertheless, the discrepancies are small as capital share of $k2$ in

Table 5.2. Comparison between Our Study and Previous Studies

Sources	Periods	Capital Share %		Average Productivity Growth Rate %			
		Pre-reform	Post-reform	Pre-reform (%)		Post-reform (%)	
This Study	1952-2005	K1: 0.573055		GTFP1: 0.60	GNFP1: 0.05	GTFP1: 3.23	GNFP1: 2.36
					GCRT1: 0.55		GCRT1: 0.87
		K2: 0.361657		GTFP2: 0.40	GNFP2: 0.04	GTFP2: 4.18	GNFP2: 3.60
					GCRT2: 0.36		GCRT2: 0.57
Chow (1993)	1952-1988	0.6317		0		na	
Chow and Li (2002)	1952-1998	0.6284		0		3	
Hu and Khan (1997)	1953-1994	0.386	0.453	1.1		3.9	
Maddison (1998)	1952-1995	0.3		-0.78		2.23	
Borensztein and Ostry (1996)	1953-1994	n.a.		-0.7		3.8	
Woo (1998)	1979-1993	n.a.	0.4, 0,5 and 0.6	n.a.		GNFP: 1.1 to 1.3	
						GRT: 1.1	

our study, Hu and Khan (1997) and Maddison (1998) vary around 0.4.

Table 5.3 shows the levels of total factor productivity (TFP), net factor productivity (NFP) and productivity due to rural transformation (CRT). The corresponding growth rates of TFP, NFP and CRT are shown in Table 5.4. The levels of TFP, NFP and CRT (in natural logarithm) are calculated using coefficients in regressions 3 and 4 in Table 5.1 and actual values of variables (in natural logarithm)[43]. We denote the levels as TFP1, NFP1, CRT1, TFP2, NFP2 and CRT2, and the growth rates as GTFP1, GNFP1, GCRT1, GTFP2, GNFP2 and GCRT2, with 1 and 2 indicating they are calculated using $\ln k1$ and $\ln k2$. These series are exhibited in Figures 5.6-5.9. In Figure 5.6, NFP and TFP have overall similar shapes. NFP1 and TFP1 are lower in levels compared with NFP2 and TFP2. This is due to series $K1$ being larger than $K2$ and therefore capital shares of $K1$ are greater than those with $K2$ (Table 5.1). With higher capital shares of $K1$, the levels of NFP1 and TFP1 are in general lower than the levels of NFP2 and TFP2. Figure 5.6 shows that rural transformation accounts for

[43] The levels of NFP and TFP are calculated as $NFP1_t = \ln y_t - 0.573\ln k1_t - 0.314\ln(RT)_t$, $NFP2_t = \ln y_t - 0.362\ln k2_t - 0.208\ln(RT)_t$, $TFP1_t = \ln y_t - 0.573\ln k1_t$, and $TFP2_t = \ln y_t - 0.362\ln k2_t$ respectively.

a considerable proportion of the level of total factor productivity, although the results are sensitive to the capital stock employed. As we can see from Figures 5.7 and 5.8, GNFP1 and GNFP2 follow each other quite closely, as do GTFP1 and GTFP2. The four series all present local minimal (most negative) growth rates in 1961, 1967, 1976 and 1990. For the year 1958, GNFP1 and GNFP2 are not consistent with (much lower than) GTFP1 and GTFP2 due to the high growth rate of RT in that year (Figure 5.9). We also plotted the growth rates of GDP per labour (GYL) against the growth rates of TFP in Figure (5.8). As expected, the growth rate of GDP is above the growth rates of both TFP series in all years apart from during 1962-1963 (the end of the Great Leap Forward period) and 1990 (shortly after the Tiananmen Square incident in 1989). Though the cyclical movements of the growth rates of GDP and TFP are almost identical throughout the sample period, the gap between these two sets of growth rates has been considerably large. Therefore, using the growth rate of GDP per labour to approximate that of TFP (as in most applications of NATREX model) is inaccurate.

In Tables 5.3 and 5.4 we also calculate the averages of NFP, TFP, GNFP1 and GNFP2 for each decade, pre- and post-reform periods and periods divided according to historical events. During the pre-reform period 1952-1977, the growth rates of NFP and TFP were volatile due to the Great Leap Forward (1958-1962) and the Cultural Revolution (1967-1976)[44] (Figures 5.7 and 5.8), especially for the period 1958-1970. If this period (1958-1970) is excluded, the volatility is reduced and NFP and TFP are nearly horizontal lines (Figure 5.6). The average growth rate of NFP during this period is near zero[45], which suggest lack of technological progress during the post-reform period as suggest by Chow (1993). However, when rural transformation is

[44] The period Cultural Revolution is conventionally defined as 1966-1976. However, due to the fact that it started in October 1966, we define the ten years Cultural Revolution as from 1967 to 1976.
[45] GNFP1 and GNFP2 were as low as 0.05% and 0.04% for the pre-reform period.

introduced, the growth rates of total factor productivity, GTFP1 and GTFP2, increase to 0.60% and 0.40% respectively[46].

For the post-reform period 1978-2005, NFP1, NFP2, TFP1 and TFP 2 have all exhibited similarly increasing trends except a drop in 1989 (the period of the political troubles in Tiananmen Square). The volatility of their growth rates have all significantly reduced compared with the pre-reform period, especially during the last decade. The average growth rates of total factor productivity in this period are 3.2% and 4.2% for GTFP1 and GTFP2 respectively.

We compare the growth rate of productivity with previous studies and show the results in Table 5.2. For the pre-reform period, some studies show zero productivity growth (i.e. Chow, 1993; Chow and Li, 2002), some show negative growth (i.e. Maddison, 1998; Borensztein and Ostry, 1996) and some show positive growth (i.e. Hu and Khan, 1997). Out study find near zero growth rates of NFP for both cases of $\ln k1$ and $\ln k2$, which is consistent with Chow (1993) and Chow and Li (2002), and positive but trivial growth rates of TFP which are mainly attributed to positive growth rate of RT. For the post-reform period, the average growth rates of NFP and TFP are 2.36% and 3.23% respectively based on $k1$ and 3.60% and 4.18% respectively based on $k2$. Such growth rates are higher than those reported by Woo (1998) but are overall in line with most of other studies in Table 5.2.

[46] When 1961, the biggest outlier, is excluded, both growth rates of NFP1 and NFP2 increase by about one percentage point (to around 1%), while the growth rates of TFP1 and TFP2 increase by about 1.4 percentage point (becoming 2.03% and 1.73% respectively).

Table 5.3. Levels of NFP, TFP and Contribution of RT to the Levels of TFP

Year	K1			K2		
	NFP1	TFP1	CRT1	NFP2	TFP2	CRT2
1952	1.04	1.93	0.88	3.44	4.03	0.58
1953	1.13	2.02	0.89	3.50	4.09	0.59
1954	1.11	2.00	0.89	3.46	4.05	0.59
1955	1.13	2.02	0.89	3.46	4.04	0.59
1956	1.17	2.10	0.93	3.46	4.08	0.62
1957	1.17	2.09	0.92	3.45	4.06	0.61
1958	1.00	2.18	1.17	3.32	4.10	0.78
1959	1.04	2.18	1.14	3.35	4.11	0.76
1960	1.01	2.12	1.11	3.31	4.05	0.73
1961	0.80	1.78	0.98	3.08	3.73	0.65
1962	0.80	1.71	0.91	3.08	3.68	0.60
1963	0.87	1.77	0.90	3.16	3.76	0.60
1964	0.99	1.90	0.90	3.29	3.88	0.60
1965	1.09	2.00	0.92	3.39	3.99	0.61
1966	1.12	2.04	0.92	3.43	4.04	0.61
1967	1.03	1.94	0.91	3.34	3.95	0.60
1968	0.94	1.86	0.91	3.27	3.87	0.60
1969	1.05	1.97	0.92	3.37	3.98	0.61
1970	1.15	2.08	0.93	3.48	4.09	0.61
1971	1.14	2.09	0.95	3.47	4.10	0.63
1972	1.12	2.08	0.96	3.46	4.10	0.63
1973	1.14	2.10	0.96	3.49	4.13	0.64
1974	1.11	2.07	0.97	3.47	4.11	0.64
1975	1.12	2.11	0.98	3.49	4.14	0.65
1976	1.04	2.05	1.00	3.43	4.09	0.66
1977	1.06	2.08	1.02	3.45	4.13	0.67
1978	1.07	2.13	1.06	3.49	4.19	0.70
1979	1.10	2.17	1.07	3.52	4.22	0.71
1980	1.12	2.20	1.08	3.53	4.25	0.72
1981	1.13	2.22	1.09	3.53	4.25	0.72
1982	1.17	2.26	1.09	3.57	4.29	0.72
1983	1.22	2.32	1.10	3.62	4.35	0.73
1984	1.28	2.40	1.13	3.68	4.43	0.74
1985	1.32	2.46	1.14	3.74	4.49	0.75
1986	1.33	2.49	1.15	3.76	4.52	0.76
1987	1.37	2.53	1.16	3.81	4.57	0.77
1988	1.40	2.56	1.16	3.85	4.62	0.77
1989	1.37	2.53	1.16	3.87	4.63	0.77
1990	1.29	2.45	1.16	3.79	4.55	0.77
1991	1.32	2.48	1.16	3.84	4.61	0.77
1992	1.39	2.56	1.17	3.93	4.70	0.77
1993	1.42	2.61	1.19	4.00	4.79	0.78
1994	1.46	2.66	1.20	4.06	4.86	0.79
1995	1.47	2.69	1.22	4.11	4.91	0.80
1996	1.48	2.71	1.23	4.14	4.96	0.81
1997	1.51	2.74	1.23	4.18	5.00	0.81
1998	1.52	2.75	1.23	4.21	5.03	0.81
1999	1.54	2.77	1.23	4.24	5.06	0.81
2000	1.57	2.80	1.23	4.28	5.09	0.81
2001	1.60	2.83	1.23	4.32	5.13	0.81
2002	1.64	2.86	1.23	4.36	5.17	0.81

2003	1.67	2.90	1.24	4.40	5.21	0.82
2004	1.69	2.94	1.25	4.43	5.26	0.83
2005	1.72	2.98	1.26	4.46	5.30	0.83
Mean rates in selected periods						
1952-1955	1.10	1.99	0.89	3.46	4.05	0.59
1956-1965	0.99	1.98	0.99	3.29	3.94	0.65
1966-1975	1.09	2.03	0.94	3.43	4.05	0.62
1976-1985	1.15	2.23	1.08	3.56	4.27	0.71
1986-1995	1.38	2.56	1.17	3.90	4.68	0.78
1996-2005	1.59	2.83	1.24	4.30	5.12	0.82
1952-1977	1.05	2.01	0.96	3.38	4.01	0.63
1978-2005	1.40	2.57	1.17	3.95	4.73	0.78
Mean rates in selected periods according to historical events						
1952-1957	1.13	2.03	0.90	3.46	4.06	0.59
1958-1962	0.93	1.99	1.06	3.23	3.93	0.70
1963-1966	1.02	1.93	0.91	3.32	3.92	0.60
1967-1976	1.09	2.03	0.95	3.43	4.06	0.63
1977-1981	1.10	2.16	1.06	3.51	4.21	0.70
1982-1985	1.25	2.36	1.11	3.65	4.39	0.74
1986-1990	1.35	2.51	1.16	3.82	4.58	0.77
1991-1995	1.41	2.60	1.19	3.99	4.77	0.79
1996-2005	1.59	2.83	1.24	4.30	5.12	0.82

Note: NFP1= net factor productivity (natural log) estimated using capital series 1
NFP2= net factor productivity (natural log) estimated using capital series 2
TFP1=total factor productivity (natural log) estimated using capital series 1
TFP2=total factor productivity (natural log) estimated using capital series 2
CRT1=contribution of level of rural transformation to the level of TFP1
CRT2=contribution of level of rural transformation to the level of TFP2

Figure 5.6. Levels of NFP, TFP and Contribution of RT to the Levels of TFP

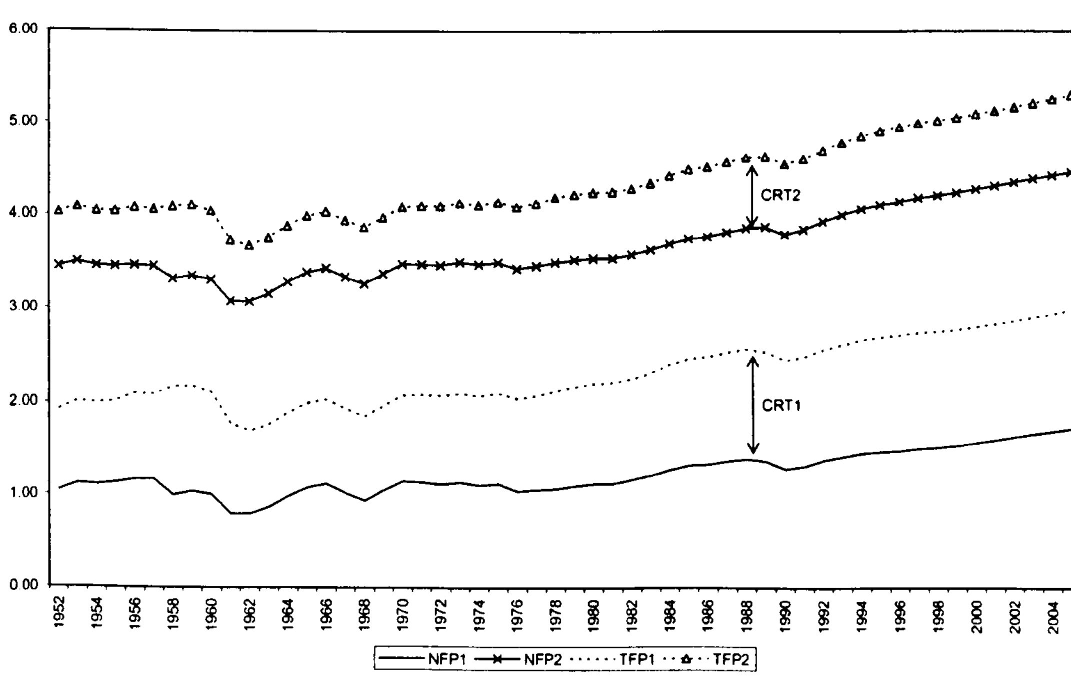


Table 5.4. Growth Rates of NFP, TFP and Contribution of Growth Rate of RT to the Growth Rate of TFP (%)

Year	K1			K2		
	GNFP1	GTFP1	GCRT1	GNFP2	GTFP2	GCRT2
1953	8.13	9.02	0.89	5.36	5.95	0.59
1954	-1.19	-1.32	-0.13	-3.96	-4.04	-0.09
1955	1.89	1.65	-0.24	-0.36	-0.51	-0.16
1956	3.63	8.34	4.71	0.95	4.06	3.11
1957	0.38	-0.72	-1.10	-1.10	-1.82	-0.73
1958	-17.03	8.12	25.14	-13.45	3.18	16.63
1959	3.96	0.85	-3.11	3.38	1.33	-2.06
1960	-3.23	-6.35	-3.13	-4.14	-6.21	-2.07
1961	-21.01	-33.76	-12.75	-23.02	-31.45	-8.43
1962	0.23	-7.45	-7.68	-0.47	-5.54	-5.08
1963	7.05	6.44	-0.60	8.49	8.09	-0.40
1964	11.78	12.22	0.44	12.44	12.73	0.29
1965	9.48	10.53	1.05	10.28	10.98	0.69
1966	3.86	4.01	0.14	4.35	4.45	0.10
1967	-9.77	-10.02	-0.25	-9.09	-9.25	-0.17
1968	-8.25	-8.24	0.01	-7.35	-7.35	0.00
1969	10.89	10.98	0.08	10.37	10.42	0.05
1970	10.06	11.48	1.41	10.38	11.32	0.93
1971	-1.17	0.50	1.67	-0.37	0.74	1.10
1972	-2.04	-0.77	1.27	-0.73	0.11	0.84
1973	1.97	2.19	0.22	3.02	3.17	0.15
1974	-3.11	-2.70	0.41	-2.47	-2.20	0.27
1975	1.31	3.12	1.82	2.14	3.34	1.20
1976	-7.79	-5.98	1.82	-6.66	-5.46	1.20
1977	1.29	2.95	1.65	2.86	3.95	1.09
1978	1.07	5.64	4.56	3.68	6.70	3.02
1979	3.16	3.93	0.77	2.56	3.07	0.51
1980	2.24	3.32	1.08	1.69	2.40	0.71
1981	0.50	1.14	0.64	0.13	0.56	0.43
1982	4.17	4.14	-0.03	3.71	3.69	-0.02
1983	4.73	5.74	1.01	5.05	5.72	0.67
1984	5.91	8.68	2.78	6.17	8.01	1.84
1985	4.91	6.30	1.39	5.64	6.56	0.92
1986	0.88	2.09	1.21	2.06	2.86	0.80
1987	3.70	4.46	0.76	4.69	5.19	0.50
1988	2.72	3.22	0.49	4.71	5.03	0.33
1989	-2.61	-3.15	-0.54	1.30	0.94	-0.36
1990	-8.21	-8.25	-0.04	-8.06	-8.09	-0.03
1991	3.07	3.38	0.31	5.45	5.65	0.21
1992	6.56	7.48	0.92	8.68	9.29	0.61
1993	3.83	5.38	1.55	7.30	8.33	1.03
1994	3.38	4.86	1.48	6.23	7.20	0.98
1995	1.42	2.83	1.41	4.42	5.36	0.93
1996	1.25	2.34	1.10	3.69	4.42	0.73
1997	2.10	2.48	0.38	3.84	4.09	0.25
1998	1.59	1.65	0.06	2.87	2.92	0.04
1999	1.97	1.78	-0.19	3.16	3.03	-0.12
2000	3.05	3.11	0.06	3.82	3.86	0.04
2001	2.76	2.76	0.00	3.47	3.47	0.00
2002	3.58	3.58	0.00	4.12	4.12	0.00

2003	3.34	3.90	0.56	3.95	4.32	0.37
2004	2.37	3.70	1.33	3.29	4.17	0.88
2005	2.76	3.98	1.22	3.31	4.11	0.81
Mean rates in selected periods						
1952-1955	2.94	3.11	0.17	0.35	0.46	0.11
1956-1965	-0.48	-0.18	0.30	-0.66	-0.47	0.20
1966-1975	0.38	1.05	0.68	1.03	1.47	0.45
1976-1985	2.02	3.59	1.57	2.48	3.52	1.04
1986-1995	1.47	2.23	0.76	3.68	4.18	0.50
1996-2005	2.48	2.93	0.45	3.55	3.85	0.30
1952-1977	0.05	0.60	0.55	0.04	0.40	0.36
1978-2005	2.36	3.23	0.87	3.60	4.18	0.57
Mean rates in selected periods according to historical events						
1952-1957	2.57	3.39	0.83	0.18	0.73	0.55
1958-1962	-7.42	-7.72	-0.30	-7.54	-7.74	-0.20
1963-1966	8.04	8.30	0.26	8.89	9.06	0.17
1967-1976	-0.79	0.06	0.85	-0.07	0.48	0.56
1977-1981	1.65	3.40	1.74	2.19	3.34	1.15
1982-1985	4.93	6.22	1.29	5.14	5.99	0.85
1986-1990	-0.70	-0.33	0.38	0.94	1.19	0.25
1991-1995	3.65	4.79	1.14	6.42	7.17	0.75
1996-2005	2.48	2.93	0.45	3.55	3.85	0.30

Note: GNFP1=growth rate of rural transformation (=$NFP1_t - NFP1_{t-1}$) (%)
GNFP2=growth rate of rural transformation (=$NFP2_t - NFP2_{t-1}$) (%)
GTFP1=growth rate of rural transformation (=$TFP1_t - TFP1_{t-1}$) (%)
GTFP2=growth rate of rural transformation (=$TFP2_t - TFP2_{t-1}$) (%)
GCRT1=growth of the contribution of rural transformation to the growth of TFP1 (%)
GCRT2=growth of the contribution of rural transformation to the growth of TFP2 (%)

Figure 5.7. Growth Rates of NFP

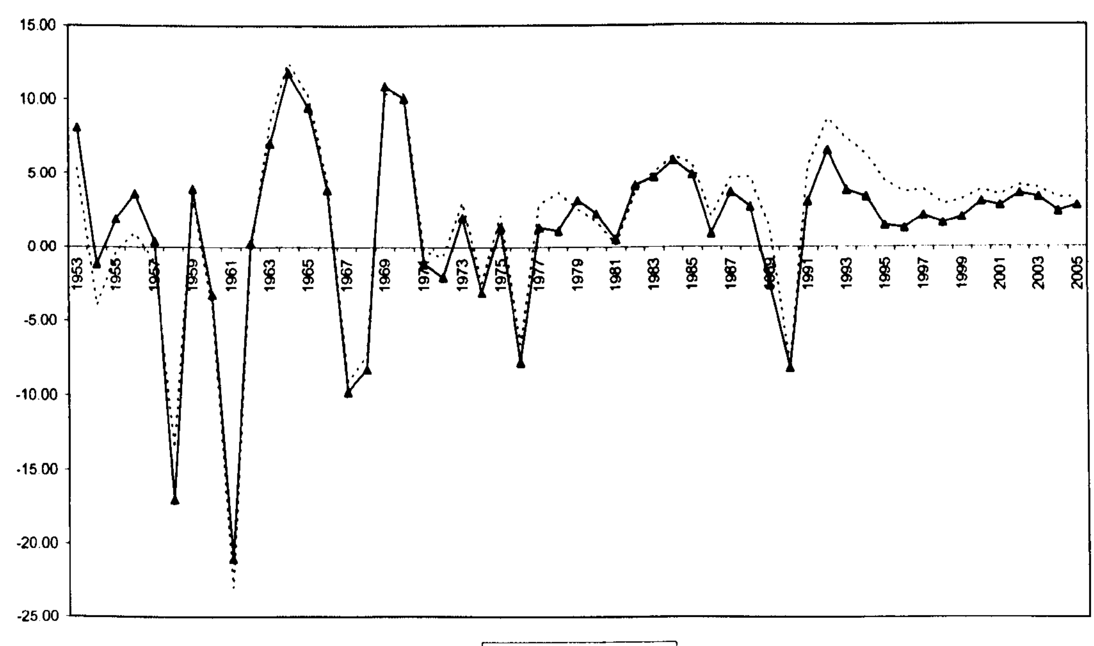


Figure 5.8. Growth Rates of TFP and Output per Labour

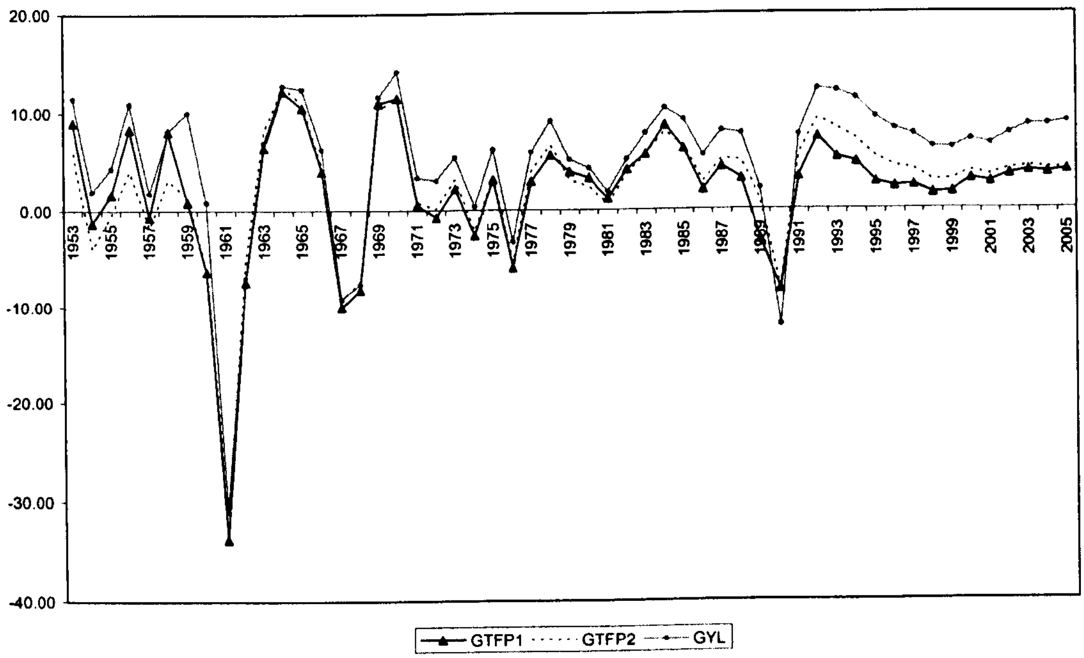
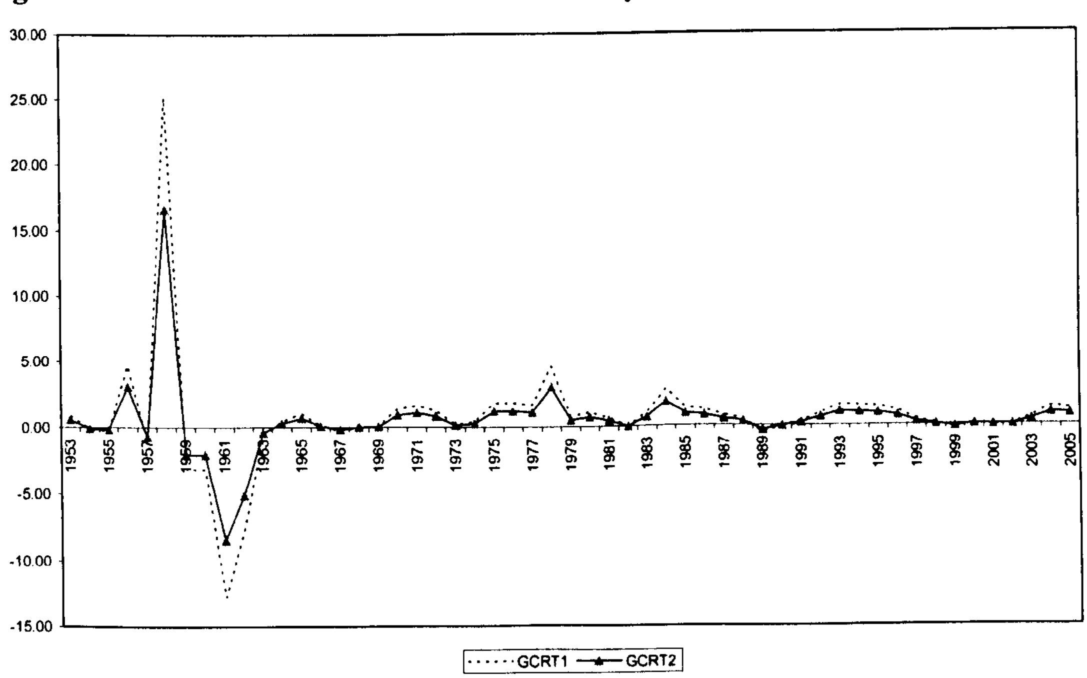


Figure 5.9. Growth of Total Factor Productivity due to RT



5.4. Econometric Methods

5.4.1. Unit Root Tests

Consider a simple AR(1) process

$$y_t = \rho y_{t-1} + x_t'\delta + \varepsilon_t \tag{5.12}$$

where y_t is a time series, x_t dentoes optional exogenous repressors which may consist of a constant, or a constant and a linear time trend, or neither; ρ and δ are parameters; ε_t is assumed to be white noise. The unit root tests generally test the null and alternative hypotheses

$$H_0 : \rho = 1$$

$$H_1 : \rho < 1$$

If the null hypothesis $H_0 : \rho = 1$ is rejected ($|\rho| < 1$), y_t is a stationary or trend stationary series ($I(0)$ process) and variance of y_t does not increase with time[47]. If the null hypothesis $H_0 : \rho = 1$ cannot be rejected, there is a unit root and y_t is nonstationary ($I(1)$ process) as the variance of y_t increases with time.

The standard Dickey-Fuller (DF) test (Dickey and Fuller, 1979) estimates the following equation

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \varepsilon_t \tag{5.13}$$

where $\Delta y_t = y_t - y_{t-1}$ and α is the parameter to be estimated. Therefore, equation (5.13) is derived by subtracting y_{t-1} from both sides of equation (5.12). Consequently the null and alternative hypotheses should be rewritten as[48]:

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[47] If y_t is stationary both mean and variance of series y_t do not increase with time. If y_t is trend stationary the variance does not increase with time, but the mean of y_t will increase as time increases.

[48] Under the null hypothesis of a unit root, the ADF statistic does not follow the conventional Student t distribution. Therefore, Dickey and Fuller (1979) derive asymptotic results ands simulate critical values for various test and sample sizes.

$$H_0 : \alpha = 0$$

$$H_1 : \alpha < 0 \tag{5.14}$$

If we can not reject the H_0 hypothesis, it implies that y has a unit root. The standard DF unit root test is valid if and only if the series is an AR(1) process. If there is series correlation at higher orders, the assumption that ε_t is white noise is violated. The Augmented Dickey-Fuller (ADF) test (Said and Dickey, 1984) constructs a parametric correction for higher-order correlation by assuming that y_t follows an AR(p) process as follows

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \tag{5.15}$$

where p lagged difference are added into equation (5.13)[49]. The ADF test estimates the hypotheses stated by equation (5.14). If the null hypothesis is rejected there is no unit root in the series y_t and y_t is stationary[50].

5.4.2. Johansen Cointegration Test

Now suppose y_t is a $(k \times 1)$ vector. If the k variables in vector y_t are all $I(1)$ processes, and the linear combination of them is stationary, the k variables are said to be cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship among the variables.

To test for such linear combinations, in a series of influential papers, Johansen (1988, 1991) and Johansen and Juselius (1990) propose the full maximum likelihood estimation and testing approach based on the vector error correction model (VECM).

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[49] The lag length can be estimated using the Akaike Info Criterion (AIC) or Bayes Information Criterion (BIC).

[50] The asymptotic distribution of the t-ratio for α is independent of the number of lagged first differences included in the ADF test.

The first step is to estimate a vector autoregression (VAR) model for the k-variate unit root process y_t

$$y_t = B_0 + B_1 y_{t-1} + B_2 y_{t-2} + \ldots + B_p y_{t-p} + e_t \tag{5.16}$$

where B_0 is a $(k \times 1)$ vector of constants; B_1 to B_p are p $(k \times k)$ matrices of coefficients; e_t is a $(k \times 1)$ vector of error terms. The lag length p could be chosen by both AIC and SIC criteria. If we subtract y_{t-1} on both side of equation (5.16) and rearrange it we can get the VECM form

$$\Delta y_t = B_0 + \Pi y_{t-1} + \sum_{i=1}^{p-1} M_i \Delta y_{t-i} + e_t \tag{5.17}$$

where $\Pi = -\left[I_k - \left(\sum_{i=1}^{p} B_i \right) \right]$ and $M_i = -\left(\sum_{i=h+1}^{p} B_i \right)$ for $h = 1, 2, \ldots (p-1)$.

The second step is to determine the rank of $(k \times k)$ matrix Π. The rank of Π is the number of linearly independent rows (columns) in the matrix. If the rank of Π is r there are r linearly independent combinations of variables in vector y_t that are stationary. The rank of Π equals the number of its characteristic roots that are differ from zero. If there is a scalar λ satisfies equation (5.18)

$$\Pi z = \lambda z$$

$$(\Pi - \lambda I) z = 0 \tag{5.18}$$

where Π is a $(k \times k)$ matrix and z is a $(k \times 1)$ vector (not identically equal to zero), λ is called the a characteristic root of Π. λ is generated by solving the characteristic equation of matrix Π

$$|\Pi - \lambda I| = 0 \tag{5.19}$$

There will be k (some of them might be repeated) characteristic roots (λ_1, λ_2,..., λ_k) that satisfy equation (5.19) [51]. There are three possible results:

(1) If $r(\Pi) = 0$ the rank of Π is zero. Each element of Π is zero and $\lambda_1 = \lambda_2 = ... = \lambda_k = 0$. There is no cointegration relationship for variables (i.e. $\{y_{1t}\}$, $\{y_{2t}\}$,..., $\{y_{kt}\}$).

(2) If $r(\Pi) = k$ there are k different non-zero characteristic roots and the matrix Π is called full rank matrix. Thus there are k independent cointegration vectors for all k variables.

(3) If $r(\Pi) = r$ ($0 < r < k$), there are r different non-zero characteristic roots and hence there are r independent cointegrating vectors.

The number of roots that are statistically different from zero is determined using trace statistic and maximum eigenvalue statistic. The trace statistic estimates the null hypothesis that the number of independent cointegrating vectors is less than or equal to r against a general alternative of no cointegrating vectors by testing equation (5.20)

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{k}\ln(1-\hat{\lambda}_i) \qquad (5.20)$$

where $\hat{\lambda}_i$ denotes the estimated values of the characteristic roots or eigenvalues obtained from the estimated matrix Π and T is the number of usable observations. Since $\ln(1) = 0$, $\ln(1-\hat{\lambda}_i) = 0$ if $\hat{\lambda}_i$ are zero or if the rank of Π is zero ($r(\Pi) = 0$). On the contrary, if Π is a full rank matrix ($r(\Pi) = k$), then $\ln(1-\hat{\lambda}_1) \neq \ln(1-\hat{\lambda}_2) \neq ... \neq \ln(1-\hat{\lambda}_k) \neq 0$. If the rank of Π is between zero and k ($r(\Pi) = r$, $0 < r < k$) , then $\ln(1-\hat{\lambda}_1) \neq \ln(1-\hat{\lambda}_2) \neq ... \neq \ln(1-\hat{\lambda}_r) \neq 0$ and

[51] For more details about the rank and characteristic root of a $(k \times k)$ matrix, please refer to Chiang (1987).

$\ln(1-\hat{\lambda}_{r+1}) = \ln(1-\hat{\lambda}_{r+2}) = ... = \ln(1-\hat{\lambda}_k) = 0$. The further the characteristic roots are from zero, the more negative is $\ln(1-\hat{\lambda}_i)$ and the larger is the value of $\lambda_{trace}(r)$, *vice versa*. The maximum eigenvalue statistic tests the null hypothesis that the number of cointegrating vectors is r against the alternative that there are $(r+1)$ cointegrating vectors by estimating equation (5.21)

$$\lambda_{\max}(r, r+1) = -T\ln(1-\hat{\lambda}_{r+1}) \tag{5.21}$$

Similarly, the closer $\hat{\lambda}_{r+1}$ is to zero, the smaller is $\lambda_{\max}$, *vice versa*.

Furthermore, Johansen cointegration methodology allows us to place restrictions on cointegrating vectors and adjustment coefficients. Suppose the rank of Π is r ($r(\Pi) = r$) and $0 < r < k$, Π is actually equivalent to $\alpha\beta'$ where β is a $k \times r$ cointegration vectors and α is a $k \times r$ matrix of weights with which each cointegrating vector enters the r equations of the VAR. Therefore, we can rewrite equation (5.17) as follows

$$\Delta y_t = B_0 + \alpha\beta' y_{t-1} + \sum_{i=1}^{p-1} M_i \Delta y_{t-i} + e_t$$

$$\Pi = \alpha\beta' \tag{5.22}$$

Therefore, by separating Π into α and β , the method enable us to impose restrictions on the cointegrating vectors β and/or the speed of adjustment α .

Johansen cointegration is the methodology we will use to test for the long-run relationship between the exchange rates and economic fundamentals[52].

[52] Other cointegration tests include Engle-Granger methodology (Engle and Granger, 1987) and the dynamic OLS methodology (Stock and Watson, 1993). Engle-Granger methodology does not provide separate estimation for each cointegrating vectors. Moreover, the vector of speed of adjustment in the vector error correction model (VECM) is generated using the residuals that are generated from the regression equations and the results of the VECM might be violated if there are any errors in the regression estimations. The Johansen (1988) and dynamic OLS methodologies circumvent the defects of the Engle-Granger procedure by relying on the relationship between the rank of a matrix and its characteristic roots. In our study we carried out cointegration tests employing both the dynamic OLS

5.5. Empirical Results for the Real USD/CNY Exchange Rate

5.5.1. Unit Root Tests

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 results of unit root tests are shown in Table 5.5. The ADF test cannot reject the null of a unit root for all variables except RRC2, CHRC1 and CHRC2. For RRC1 and USR the null of a unit root cannot be rejected at 1% and for all other variables at 5%. Therefore we regard all variables as nonstationary except RRC2, CHRC1 and CHRC2. 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 statistics with lags chosen by AIC for comparison. These statistics confirm the results obtained by the Campbell and Perron method.

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and Johansen cointegration methods. However, the results using dynamic OLS are not satisfying. Therefore we use Johansen cointegration methods in our estimation and results are shown and discussed in Section 5.5.

Table 5.5. Unit Root Tests (ADF)

	General to Specific Method					AIC				
Sample Period: 1952-2005		Level		1st Difference			Level		1st Difference	
Variables	Lag Length	ADF	p-value	ADF.	p-value	Lag Length	ADF	p-value	ADF	p-value
RER	0	-0.53	0.8761	-5.75	0.0000	1	-0.74	0.8265	-4.94	0.0002
TOT	0	-0.73	0.8298	-6.24	0.0000	0	-0.73	0.8298	-6.24	0.0000
G	2	-1.05	0.7302	-5.81	0.0000	3	-1.11	0.7047	-5.51	0.0000
DEP	0	2.03	0.9999	-5.58	0.0000	0	2.03	0.9999	-5.58	0.0000
CREP	2	-1.59	0.4821	-4.13	0.0021	2	-1.59	0.4821	-4.13	0.0021
RULC	0	-0.14	0.9391	-5.89	0.0000	0	-0.14	0.9391	-5.89	0.0000
RRC1	1	-3.47	0.0135	-6.58	0.0000	1	-3.47	0.0135	-6.58	0.000C
RRC2[53]	2	-3.80	0.0053			2	-3.80	0.0053		
CHRC1	0	-4.64	0.0004			0	-4.64	0.0004		
CHRC2	2	-3.58	0.0096			2	-3.58	0.0096		
USRC	0	-1.01	0.7441	-7.43	0.0000	0	-1.01	0.7441	-7.43	0.0000
TFP1	2	0.20	0.9697	-5.37	0.0000	3	0.65	0.9898	-4.35	0.0011
TFP2	2	1.05	0.9966	-4.75	0.0003	2	1.05	0.9966	-4.75	0.0003
NFP1	2	0.31	0.9766	-4.14	0.0020	2	0.31	0.9766	-4.14	0.0020
NFP2	2	1.13	0.9972	-3.81	0.0052	2	1.13	0.9972	-3.81	0.0052
RT	3	-1.12	0.6997	-5.07	0.0001	3	-1.12	0.6997	-5.07	0.0001
GI	3	-0.64	0.8530	-2.88	0.0549	3	-0.64	0.8530	-2.88	0.0549
USR	1	-3.30	0.0199	-6.39	0.0000	2	-2.32	0.1704	-4.81	0.0003
TAX1	0	-2.42	0.1410	-6.90	0.0000	0	-2.42	0.1410	-6.90	0.0000
TAX2	0	-2.26	0.1888	-6.85	0.0000	0	-2.26	0.1888	-6.85	0.0000

Note: Critical values for 1%, 5% and 10% are -3.57, -2.92 and -2.60 respectively.

RER= USD/CNY real exchange rate; TOT=terms of trade; G=social time preference; DEP=dependency ratio; CREP=financial liberalisation; RULC=relative unit labour cost; RRC1=relative rate of return to capital 1; RRC2=relative rate of return to capital 2; CHRC1=China's relative rate of return to capital 1; CHRC2=China's relative rate of return to capital 2; USRC=US' rate of return to capital; 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; USR=US real interest rate; TAX1=tax rate 1 (exclude tariff); TAX2= tax rate 2 (exclude tariff and tax on agriculture).

All variables are measured in natural logarithm except RRC1, RRC2, CHRC1, CHRC2, USRC and USR as they are rates of returns.

[53] We did not include RRC3, relative rate of return to capital based on capital series 3. The reason is that, in the estimation of productivity (Section 5.3), K3 is excluded as it gives abnormally higher capital shares. To be consistent with section of productivity, we excluded RRC3 in this section. Correspondingly, CHRC3 is also excluded.

5.5.2. Johansen Cointegration Tests

First, we estimate the original NATREX model by choosing the fundamentals used in Lim and Stein (1995) for Australia: terms of trade (TOT), productivity (TFP1, TFP2, NFP1 and NFP2), time preference (G) and US real interest rate (USR).

Regarding the lag length of VAR, we started with maximum lag of 3 and tested downward using the AIC. For all experiments, VAR(1,1) was chosen. 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. According to Cheung and Lai (1993), Johansen cointegration tests tend to overestimate the number of CVs when there are large numbers of variables and small samples sizes. Therefore we use 1% significance level instead of 5% to determine the number of CVs. These methods of choosing lag length of VAR and number of CVs are applied to all econometric estimations in this chapter.

The results are shown in Table 5.6. Both trace and max-eigenvalue statistics indicate one significant CV at both 5% and 1% in all four cases except in equation A trace statistic suggests one CV at 5%. However, the adjustment coefficients of RER are positive and insignificant in all cases, implying the long-run CVs are not valid. Productivity (TFP1, TFP2, NFP1 and NFP2) is wrongly signed in all four cases. In three out of four cases (except equation A) the terms of trade are with the right sign but they are all insignificant. In general, without taking into account other fundamentals that capture the unique characteristics of the Chinese economy, the original NATREX model does not seem to be applicable to China.

Table 5.6. Johansen Cointegration Results for the Lim and Stein (1995) Model

	Hypothesized No. of CE(s)	Trace Statistic	5% Critical Value	1% Critical Value	p-value	Max-Eigen Statistic	5 % Critical Value	1% Critical Value	p-value
Equation A	None	75.92	69.82	77.82	0.0150	40.54*	33.88	39.37	0.0069
	At most 1	35.38	47.86	54.68	0.4280	21.99	27.58	32.72	0.2207
Equation B	None	78.81 *	69.82	77.82	0.0080	41.24*	33.88	39.37	0.0055
	At most 1	37.58	47.86	54.68	0.3209	21.36	27.58	32.72	0.2548
Equation C	None	83.72 *	69.82	77.82	0.0026	42.75*	33.88	39.37	0.0034
	At most 1	40.97	47.86	54.68	0.1897	21.38	27.58	32.72	0.2539
Equation D	None	82.78*	69.82	77.82	0.0033	42.73*	33.88	39.37	0.0034
	At most 1	40.05	47.86	54.68	0.2208	21.10	27.58	32.72	0.2703

Normalized Cointegrating Coefficients (standard error in parentheses)						
Equation A	RER	TOT	TFP1	G	USR	C
	1.0000	0.0377	0.0090	-3.4202	0.0911	9.0559
		(0.1942)	(0.2815)	(0.4723)	(0.0153)	
	Adjustment coefficient (standard error in parentheses)					
	D(RER)	0.0525				
		(0.0600)				
Equation B	RER	TOT	TFP2	G	USR	C
	1.0000	-0.0172	0.0782	-3.1258	0.0805	7.7443
		(0.1694)	(0.1715)	(0.4184)	(0.0137)	
	Adjustment coefficient (standard error parentheses)					
	D(RER)	0.0577				
		(0.0654)				
Equation C	RER	TOT	NFP1	G	USR	C
	1.0000	-0.0458	0.1930	-3.1410	0.0722	8.0766
		(0.1633)	(0.2549)	(0.3320)	(0.0134)	
	Adjustment coefficient (standard error in parentheses)					
	D(RER)	0.0577				
		(0.0654)				
Equation D	RER	TOT	NFP2	G	USR	C
	1.0000	-0.0947	0.1413	-2.9408	0.0706	7.1628
		(0.1552)	(0.1592)	(0.3488)	(0.0128)	
	Adjustment coefficient (standard error in parentheses)					
	D(RER)	0.0577				
		(0.0654)				

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

Next, we apply the Johansen cointegration method to the extended NATREX model developed in Chapter 4. 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[54]) 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)[55]. For all experiments, VAR(1,1) was chosen.

The cointegration results are shown in Table 5.7. For equations E and G, both trace and max-eigenvalue statistics suggest one CV at 1% significance level. For equations F and H, there is no significant CV. Looking at equation G, the adjustment coefficient is insignificant, which raises doubts about the validity of the CV as a long-run relationship. In addition, TOT is wrongly signed and insignificant in equation G. For equation E, the adjustment coefficient is negative and significant at 10%. All variables are statistically significant at 5% and most have expected signs. When using productivity that is derived from capital series 2 (TFP2 and NFP2), there is no significant CV. In conclusion we choose equation E as the most satisfactory one and this is the equation we are going to use to calculate the NATREX.

[54] The social time preference (G) is our study is a function of dependency ratio (DEP) and financial liberalisation (CREP). Therefore, in the estimation, we use DEP and CREP instead of G.

[55] In the estimation, TFP1and NFP1 must be in the same cointegration equation with RRC1 or CHRC1 since NFP1 is estimated using capital series 1 and so are RRC1 and CHRC1. For the same reason, TFP2 and NFP2 must be in the same cointegration equation with RRC2 or CHRC2. However, RRC2 and CHRC2 are stationary and therefore they are replaced by USRC and CHRC1 is also stationary and therefore is replaced by RRC1.

Table 5.7. Johansen Cointegration Results — the Extended NATREX Model

	Hypothesized No. of CE(s)	Trace Statistic	5 % Critical Value	1% Critical Value	p-value	Max-Eigen Statistic	5% Critical Value	1% Critical Value	p-value
Equation E	None	193.76 *	159.53	171.09	0.0002	66.99 *	52.36	58.67	0.0009
	At most 1	126.76	125.62	135.97	0.0425	50.77	46.23	52.31	0.0153
Equation F	None	171.00	159.53	171.09	0.0101	45.39	52.36	58.67	0.2165
	At most 1	125.61	125.62	135.97	0.0501	40.18	46.23	52.31	0.1926
Equation G	None	199.59 *	159.53	171.09	0.0001	75.18 *	52.36	58.67	0.0001
	At most 1	124.41	125.62	135.97	0.0591	43.93	46.23	52.31	0.0866
Equation H	None	207.16	197.37	210.05	0.0149	56.01	58.43	65.00	0.0852
	At most 1	151.15	159.53	171.09	0.1304	44.47	52.36	58.67	0.2545

Normalized cointegrating coefficients (std.err. in parentheses)

Equation E	RER	TOT	TFP1	DEP	CREP	RULC	RRC	GI	C	
	RER	-0.3816	-1.7799	-4.3335	-0.3735	-1.0920	-0.0650	0.5792	19.6213	
	1.0000	(0.1486)	(0.2868)	(0.5333)	(0.1006)	(0.1768)	(0.0081)	(0.0936)		
	Adjustment coefficient (std.err. in parentheses)									
	D(RER)	-0.1167								
		(0.0658)								
Equation F	RER	TOT	TFP2	DEP	CREP	RULC	USRC	GI	C	
	1.0000	-0.6539	-0.6111	-4.0406	-0.0740	-1.0651	0.1416	0.7720	14.7976	
		(0.1829)	(0.2549)	(0.7082)	(0.1060)	(0.2273)	(0.0351)	(0.1170)		
	Adjustment coefficient (std.err. in parentheses)									
	D(RER)	0.0705								
		0.0783								
Equation G	RER	TOT	NFP1	DEP	CREP	RULC	RRC	GI	C	
	1.0000	0.0117	-1.5346	-3.3284	-0.5583	-1.3383	-0.0513	0.5278	12.3349	
		(0.1047)	(0.2381)	(0.3839)	(0.0853)	(0.1349)	(0.0055)	(0.0707)		
	Adjustment coefficient (std.err. in parentheses)									
	D(RER)	-0.1069								
		(0.0811)								
Equation H	RER	TOT	NFP2	RT	CREP	RULC	USRC	GI	TAX1	C
	1.0000	-0.2695	-0.0992	-0.3766	0.1877	-0.5686	-0.0300	-0.2055	0.2074	-2.2843
		(0.0716)	(0.0571)	(0.0709)	(0.0493)	(0.0671)	(0.0083)	(0.0221)	(0.0537)	
	Adjustment coefficient (std.err. in parentheses)									
	D(RER)	-0.4823								
		(0.2613)								

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

5.5.3. Interpretation of the Long-Run Equilibrium Relationships

Equation E

$$RER=\underset{(0.1486)}{0.3816}TOT+\underset{(0.2868)}{1.7799}TFP1+\underset{(0.5333)}{4.3335}DEP+\underset{(0.1006)}{0.3735}CREP+\underset{(0.1768)}{1.0920}RULC$$
$$+\underset{(0.0081)}{0.0650}RRC1-\underset{(0.0936)}{0.5792}GI-19.6213$$

All variables in equation E are statistically significant[56]. The results can be divided into two categories. The first category is the fundamentals that have expected signs as in Appendix 4.E. Higher terms of trade (TOT), productivity (TFP1) and relative return to capital (RRC) significantly raise the long-run value of RER (i.e. appreciate the RMB)[57]. The positive effect of productivity on RER confirms the existence of the Balassa-Samuelson effect. On the other hand, higher government investment (GI) has a significant negative effect on the long-run value of RER (i.e. depreciate the RMB), implying there is crowding out effect and intention of government investment is mainly to maintain state-owned enterprises or to provide public service rather than profit seeking[58].

The second category includes the dependency ratio (DEP), financial liberalisation (CREP), and the relative unit labour cost (RULC), which have opposite signs compared to what the model predicts.

[56] One may argue that China's accession to World Trade Organisation (WTO) in 2001 could have some effect on China's current account and the exchange rate. To test for this effect, we added a dummy variable for 2001 in the cointegrating equation E. The estimated coefficient for the WTO dummy was 0.2045 (0.3279)—number in parenthesis is the standard error. The standard error indicates that the WTO dummy is statistically insignificant. We added the same WTO dummy to a few more cointegrating relationships; i.e. the NATREX for the real effective exchange rate, trend current account (Chapter 6) and sustainable current account (Chapter 7). But the WTO dummy was statistically insignificant in all cases. It might be that any effect of the WTO on the current account involves long time lags. In such case it would be too soon for the effect to be evident in the econometric estimations given that our sample ends in 2005.

[57] It is import to note that the real exchange rate is defined as USD/CNY. Hence an increase (decrease) in real exchange rate (RER) implies an appreciation (depreciation) of the RMB

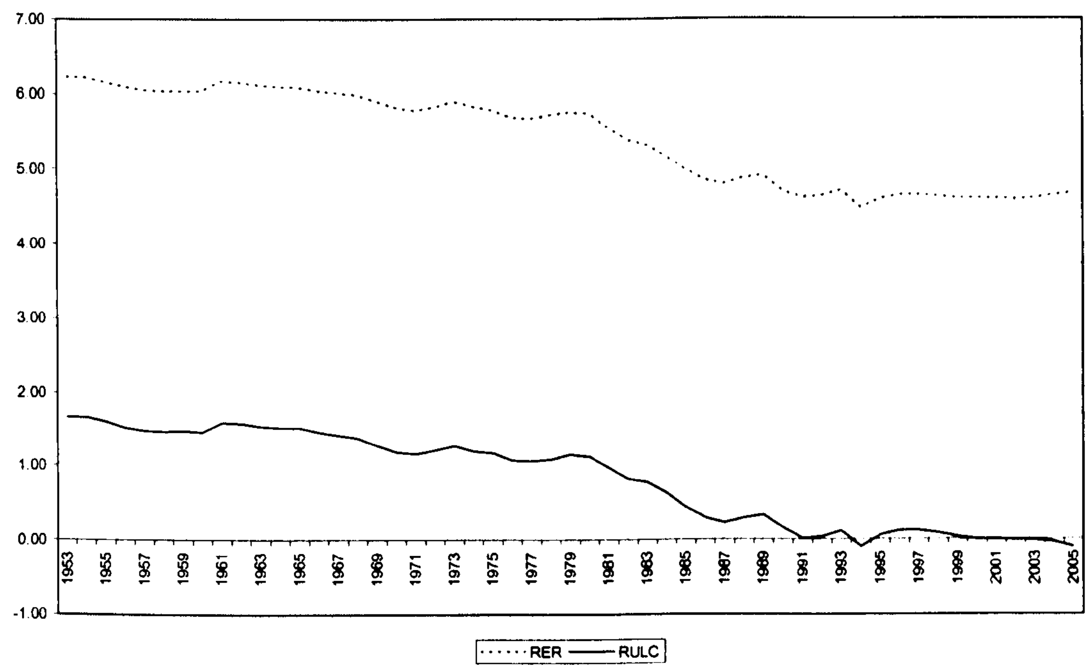
[58] See Section 4.5.10 for detailed explanations for why in China more government investment reduces the real exchange rate (i.e. depreciates the RMB) in the long-run.

DEP: Modigliani and Cao (2004) find a lower dependency ratio has reduced the consumption-to-income ratio and therefore has increased savings ratio in China for the period 1952-2000. The neoclassical growth model asserts that higher savings generate faster capital accumulation and hence raises the real exchange rate in the long-run. However, on the demand side, a lower consumption reduces demand for non-tradables and reduces the real exchange rate in the long-run. It seems that in China, the latter force dominates. Aggregate consumption in China has been low and even declining despite of the high growth rates of output. According to IMF and the World Bank, the average consumption proportion in the world is 78.6%. It is 83.7% in the US and 78% in India for the period 1991-1995. However, consumption in China during 1952-1988 was 68% and it fell to 59.5% in the following decade. For the year of 1998, 1999 and 2000, it was only 58.1%, 60.2% and 60.8% (He and Xu, 2003). The reasons behind the higher savings ratio are mainly lack of pension system, strong bequest motive to descendents and extremely cautious nature. Therefore, in contrast to the neoclassical theory, a lower dependency ratio in China, which led to insufficient domestic consumption, has reduced the real exchange rate.

CREP: In our extended NATREX model, financial liberalisation increases consumption by relaxing the budget constraint and depreciates the real exchange rate in the long-run. On the other hand, a higher degree of financial liberalisation implies a better investment environment and a more developed capital market. This attracts more foreign investment to China and hence raises the real exchange rate in the long-run. If the latter force dominates, CREP will have an overall positive effect on the real exchange rate. It seems that this is the case for China since financial liberalisation might have insignificant effect on relaxing the budget constraint and increasing consumption (given strong incentives for savings).

RULC: The extended NATREX model predicts a negative relationship between RULC and RER. We found a positive relationship instead. Looking at the data (Figure 5.10), RULC and RER are highly correlated: a correlation coefficient of 99.8% for the period 1952-2005. The decline of RER is very closely matched by a similar decline in RULC. There are two possible explanations discussed below.

Figure 5.10. Real USD/CNY Exchange Rate (RER) and China-US Relative Unit Labour Cost (RULC) (1953-2005) (in Natural Logs)



i) An increase in unit labour cost in China increases the price level and therefore raises the relative price of China to the US. In a floating system, the nominal exchange rate declines to offset the higher relative price. In China the nominal exchange rate has been fixed. Therefore, an increase in RULC raises the relative price, which generates a higher real exchange rate.

ii) Our second explanation is drawn from Grafe and Wyplosz (1999). In their model of real exchange rate in transition economies, they define the real exchange rate as the other side of the coin of the real wage. We now explain how Grafe and Wyplosz (1999) justify such a statement in detail. They assume that there are two sectors in the economy: large inefficient state sector and the new efficient sectors. The state sector produces tradables. The new efficient sectors are the production of economic transformation and include new tradables sector and new non-tradables sector. The non-tradables sector is less capital intensive than the tradables sector. The economic transformation is driven by the demand side. Labour cost and real exchange rate need to be initially low to allow the new tradables sector to generate high enough profit margins to be expanded. Such assumptions are applicable to China. To meet higher demand for its output, the under-developed non-tradables sector must raise wages to attract workers from the state sector. As the non-tradables sector is labour intensive and needs little capital, the operation commences immediately when the transformation starts. Higher demand and higher wages raise the relative price of non-tradables and hence raises the real exchange rate. The new tradables sector takes longer time to commence the operation as it requires much more capital accumulation. By the time it is ready to operate, the real exchange rate has already started to appreciate due to the higher real wage in non-tradables sector. But the absolute level of the real exchange rate is still low enough to allow the new tradables sector to start its operation, possibly with some help of external financing (i.e. FDI attracted by the relative lower wage). In other words, the real wage is still low enough for the new tradables sector to afford and to generate high enough profit margins to be expanded. In the beginning, entire profit is invested in productive capital. After certain stage of expansion, the new tradables sector can pay higher wage to keep up with the wage increase in the non-tradables sector using part of its profit[59] and to attract more required labour from the state sector. For the new tradables sector, it is the higher real wage in new non-tradables sector, hence the real exchange rate raises, allows the real

[59] As the capital reaching its steady state in the new tradables sector, the absolute amount of capital that needs to be accumulated gradually declines. Consequently, retained earnings progressively decline and this allows the real wage to rise.

wage to increase. Labour market equilibrium requires that wages also grow in the state sector. For this reason, productivity must also rise in the state sector and this implies closing down the least efficient production lines first. Therefore, real exchange rate and the real wage are two sides of the same coin.

Such a positive relationship between real wages (relative unit labour cost in our case) and real exchange rate exists not only in China. Grafe and Wyplosz (1999) find a correlation coefficient of 95% between dollar wages and the non-tradables/tradables price ratio across transition countries in Central and Eastern Europe.

Having explained the positive relationship between relative unit labour cost of China to the US and bilateral real USD/CNY exchange rate, now we need to explain why both series are downward sloping (Figure 5.10), contrasting to upward trends predicted by Grafe and Wyplosz (1999) under transformation. A higher unit labour cost of China raises the real exchange rate, as Grafe and Wyplosz (1999) expect, if the unit labour cost of the US does not alter. However, due to the existence of China's enormous labour surplus, real wage has been increasing but at a rate that is slower than the growth rate of productivity. Furthermore, the reforms in state-owned enterprises are characterised by laying off a great number of workers and these workers have to find new jobs by themselves. It has generated even more labour supply. Compared with China, the real wage has been increasing at more or less the same rate as the growth rate of productivity in the US. Under such situations, even productivity growth is faster in China than the US, the relative unit labour cost of China to the US is declining (as the real wage grows much slower in China). And therefore the real exchange rate of USD/CNY declines.

5.5.4. NATREX and Misalignments

We use the long-run coefficients from equation E (Table 5.6) and actual values of fundamentals to calculate the NATREX and plot it against the real exchange rate (Figure 5.11). Following Siregar and Har (2001), the misalignment rates are calculated as the actual real exchange rate minus NATREX and then divided by NATREX. The misalignment rates are illustrated in Figure 5.12. One problem with the NATREX approach is that the variables that enter the cointegration equation are not themselves at their equilibrium values. To remove the transitory components from the fundamentals we use the Hodrick-Prescott filter (HP-filter), firstly applied by Hodrick and Prescott (1997), to obtain the equilibrium value of the fundamentals and calculate the HPNATREX (Figure 5.13) as well as the misalignment rates (Figure 5.14)[60]. Table 5.8 summaries the findings on misalignment rates[61].

Table 5.8. Summary of Findings — RER

Actual fundamentals	Pre-reform Period (1953-1977)	Post-reform Period (1978-2005)
RER and NATREX	In 9 out of 25 years the MRs indicate overvaluation with an AMR of 5.2%. For the rest 16 years the MRs indicate undervaluation with an AMR of 4.7%. The MRs were relatively smaller after 1966 than the years before.	The reversion of the real exchange rate to NATREX was faster. In 10 out of 28 years the MRs indicate undervaluation with an AMR of 2.6%. For the rest of the 18 years the MRs indicate overvaluation with an AMR of 5.0%.
HP-filtered fundamentals	Pre-reform Period (1953-1977)	Post-reform Period (1978-2005)
RER And HPNATREX	8 out of 25 years the MRs indicate overvaluation with an AMR of 0.4%. For the rest 17 years the MRs indicate undervaluation with an AMR of 2.3%.	3 out of 28 years the MRs indicate undervaluation with an AMR of 1.0%. The rest of 25 years the MRs indicate overvaluation with an AMR of 2.5%.

Note: MR and AMR refer to misalignment rate and average misalignment rate.

[60] An alternative way is to decompose time series into permanent and transitory components (i.e. Alberola *et al*, 1999; Maeso-Fernandez *et al*, 2001; Clark and MacDonald, 2004). The HP-filter has been more commonly used in existing literature and we adopt it in our study as well.

[61] ADF tests show that the misalignment rates in Figures 5.12 and 5.14 are both stationary at 5%.

Figure 5.11. NATREX and the Real Exchange Rate (RER)

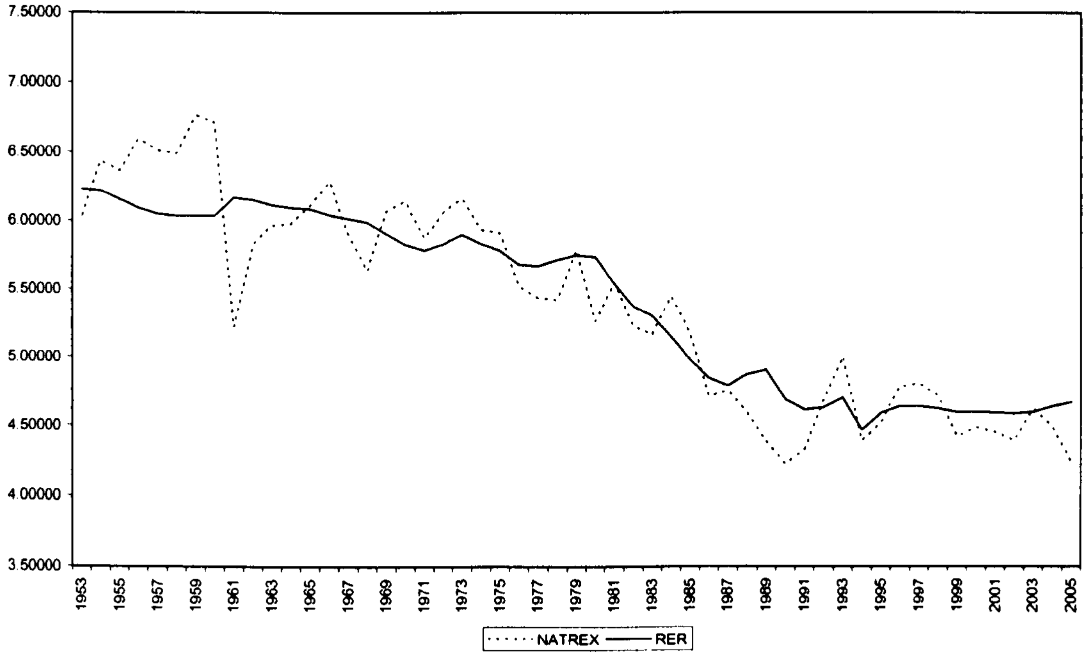
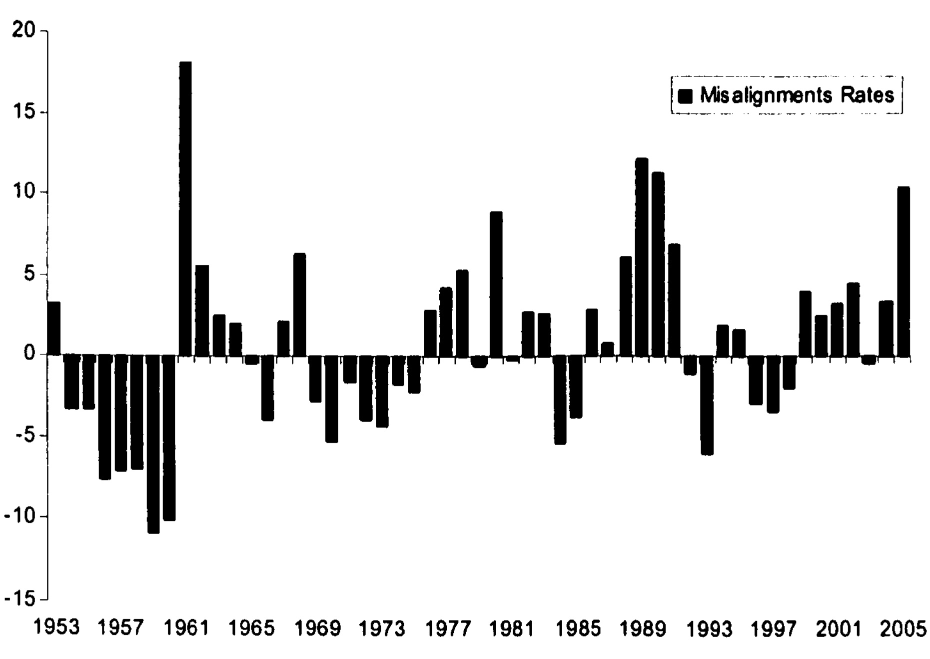


Figure 5.12. Misalignment Rates (%) between the Real Exchange Rate (RER) and NATREX



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

Figure 5.13. HPNATREX and the Real Exchange Rate (RER)

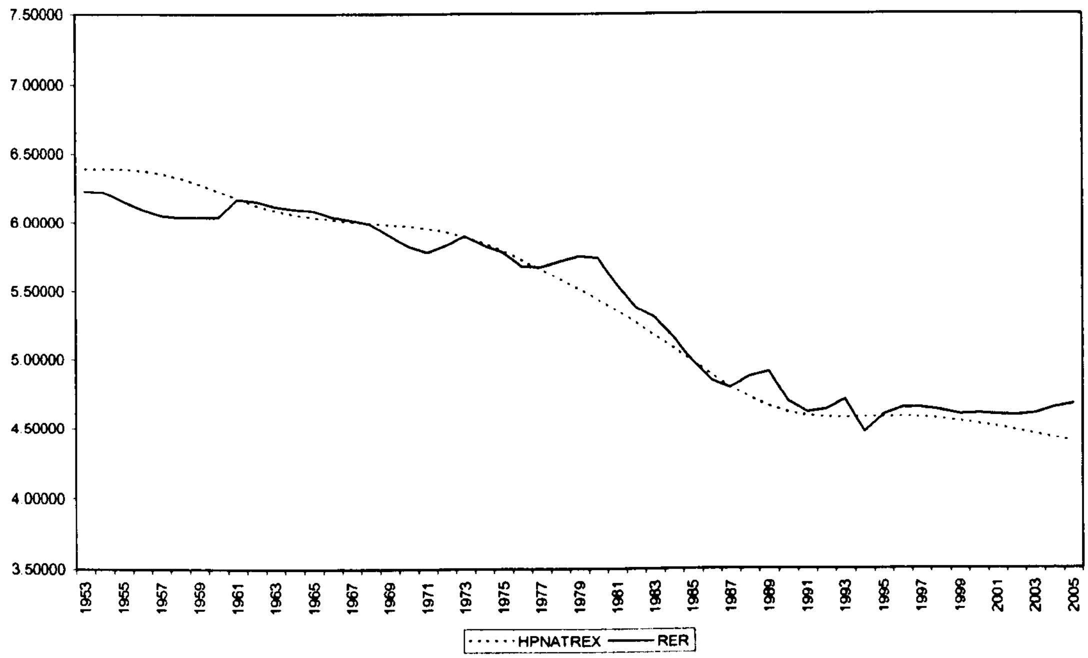
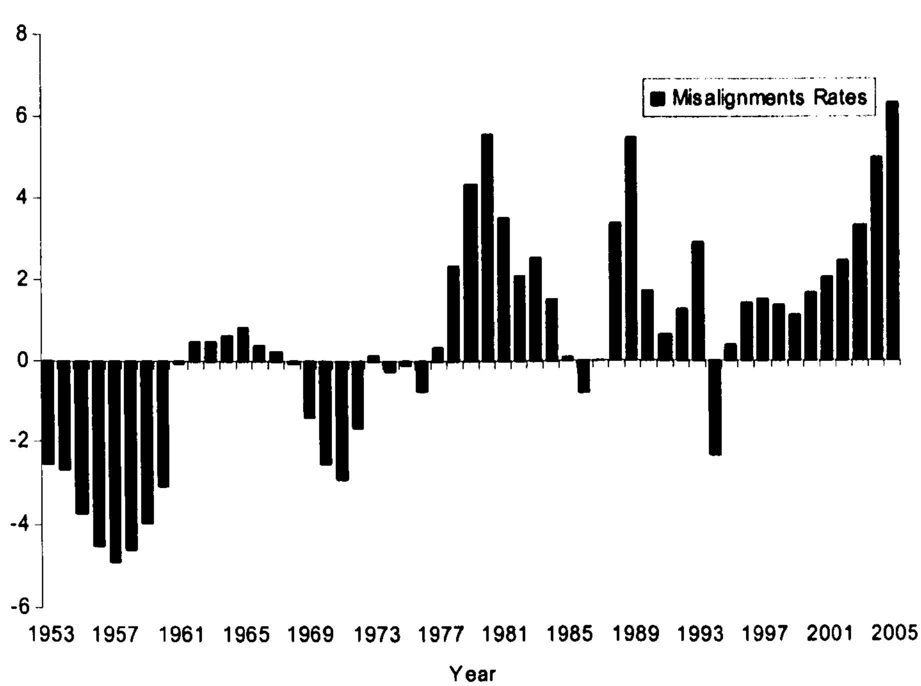


Figure 5.14. Misalignment Rates (%) between RER and HPNATREX



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

Existing literature often argues that the RMB is undervalued with some suggesting substantial undervaluation and others suggesting slight misalignments[62]. This study incorporates fundamentals that have not been employed in the estimation of equilibrium exchange rates, such as relative unit labour cost, relative return to capital, dependency ratio and financial liberalisation. These fundamentals together with productivity and terms of trade are crucial determinants of the equilibrium exchange rate of the RMB as they embody the unique economic characteristics of China. Our estimated NATREX has two features. First, the real exchange rate converges to NATREX for the whole period and the its reversion to the NATREX is faster in the post-reform period. Secondly, we found that, though with modest magnitude, overvaluation happened for most of the years since the late 1970s, which is contrary to conventional argument of the undervaluation RMB.

Looking at Figure 5.11, the NATREX was relatively volatile for the period 1953-1965 due to historical events such as the Great Leap Forward. Meanwhile, the real exchange rate was relatively stable due to the fixed nominal exchange rate of 0.41 USD/CNY until 1971. The misalignment rates calculated based on NATREX and real exchange rate suggest that the RMB was undervalued by up to 10.8% before 1960 and overvalued by up to 18.1% during 1961-1965. During the Cultural Revolution (1966-1976), the NATREX was less volatile and discrepancies between NATREX and real exchange rate had been reduced. The misalignment rates were within a narrower band of ±6% during this period. During the post-reform period 1978-2005, in 8 out of 28 years the RMB was overvalued. There had been 6 consecutive years of overvaluation during 1986-1991 mainly due to large decline in the NATREX in the late 1980s led by the political turmoil in Tiananmen Square at that time. Though the nominal

[62] For details of some recent papers that suggest different magnitude of undervaluation of the RMB refer to Table 2.1

USD/CNY exchange rate was reduced from 0.29 to 0.19 in 1991, it was not enough to match the decline in the NATREX. Hence the RMB was on average overvalued by 7% during 1986-1991 with the highest overvaluation of 12% occurred in 1989. During the most recent period 1994-2005 when the real USD/CNY rate was relatively stable (mainly due to the fixed nominal exchange rate), interestingly we found that overvaluation occurred in 8 out of the 12 years. However, the overvaluation of RMB during this period had not been persistent nor large. The average overvaluation was less than 4% in these 8 years. It is worth noticing that in 2005, despite the growth of total factor productivity, decline in terms of trade, relative unit labour cost and dependency ratio led to a large decline in NATREX. This in turn led to an overvaluation of 10.4% of the RMB in 2005. Nevertheless, overall the RMB had been relatively close to the equilibrium value in the post-reform period as the average undervaluation and overvaluation were only 2.6% and 5.0 % respectively.

The misalignment rates of HPNATREX, based on HP-filtered fundamentals, are overall less significant (Figure 5.14). Before the reform and opening up policy was implemented in 1978, the RMB was overall undervalued, though the misalignment rates were less than 5%, except for the period 1962-1967 when there were minor overvaluation (of 0.5% on average)[63]. The undervaluation were relatively smaller during 1973-1977 than that during 1952-1961. Since 1978, the RMB has been overvalued except in 1994[64] due to a large depreciation in 1994[65]. However, the misalignment rates since 1978 have been below 6%. Overall, the misalignment rates varied within a narrow band of ±6% for the whole period 1952-2005. This implies

[63] There was overvaluation in 1973 and 1977 as well while the misalignment rates were as trivial as 0.1% and 0.3% respectively.

[64] There was undervaluation in 1986 and 1987 as well while the misalignment rates were as trivial as 0.8% and 0.04%.

[65] In 1994, the Chinese government adjust the exchange rate from 5.8 to 8.6 CNY/ USD (0.12 to 0.17 USD/CNY).

that though there have been misalignments in the real exchange rate of the RMB, the magnitude of such misalignments had been modest.

In contrast to Zhang (2001) who suggests chronic overvaluation for the pre-reform period, we find no such evidence. In contrast to most existing studies, for the post-reform period we found overvaluation in most years, albeit of modest magnitude. Our study shows that the conventional impression of the RMB undervaluation is often exaggerated[66]. After finding no evidence of currency manipulation of the RMB, The US Government Accountability Office (2005) stresses the importance of broad macroeconomic and structural factor behind global trade imbalances when assessing whether the RMB is undervalued. According to the current account budget surplus in recent years the RMB may appear substantially undervalued, but when the relevant dynamic economic fundamentals (such as relative unit labour cost, productivity, relative rate of return to capital and financial liberalisation) are taken into account, the undervaluation may be relatively moderate, or even that the RMB is overvalued, albeit of modest magnitude[67]. And this is exactly what we find in this study.

5.6. The Real Effective Exchange Rate

Different models and economic fundamentals have been employed to investigate the real effective exchange rate (REER) of the RMB. Amongst existing studies, some find undervaluation of up to 30% (i.e. Jeong and Mazier, 2003; Dunaway *et al*, 2006; Coudert and Couharde, 2007) and some find slight overvaluation (i.e. Zhang, 2002; Wang, 2004; Wang *et al*, 2007, Chen, 2007)[68]. However, the time spans in all previous studies are restricted to the post-reform period. This may due to the fact the

[66] Funke and Rahn (2005) reach the same conclusion.
[67] Cheung *et al* (2005) argue the same.
[68] For details of some recent papers studying the real effective exchange rate of the Chinese RMB please refer to Table 2.1.

data of REER for China is only available for the post-reform period. In this section we analyse how the evolvement of the economic fundamentals affect China's REER within the extended NATREX framework. Our study intends to extend previous studies from the following perspectives. First, it is the first application of NATREX model to China's REER. Second, we constructed data of REER for China for the period 1960-2005 [69] using competitiveness weights that evolve every year simultaneously with the trade shares between China and its main trade partners. Trade with these countries accounts for over 80% of China's foreign trade. Third, we employ economic fundamentals introduced in Chapter 4 as the determinants of the equilibrium exchange rate. These fundamentals capture the unique features of the Chinese economy but have not be used by previous studies. In addition, to be consistent with the concept of REER, we constructed the effective terms of trade (ETOT), effective relative unit labour cost (ERULC) and the real foreign interest rate (FR)[70].

5.6.1. Variable Measurement and Data Sources

5.6.1.1. 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.

CPI-based REER Indicators— Zanello and Desruelle (ZD) (1997)

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

[69] Some data that is needed to construct relative fundamentals is not available for the years prior to 1960. Therefore, the data span starts from 1960 in this section.

[70] We could not construct data of effective relative return to capital due to data limitation for most of China's main trade partners. Therefore, RRC1 is used in the following estimations.

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

$$REER = \prod_{j \neq i} \left[\frac{P_i R_i}{P_j R_j} \right]^{W_{ij}} \tag{5.23}$$

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.

The weights scheme for China is based on trade in manufactures and primary commodities[71]. For the manufactures, the competitiveness weights for each pair of countries (i and j) are calculated as:

$$W(m)_{ij} = \beta_i^M MW_{ij} + \beta_i^X XW_{ij} \tag{5.24}$$

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.

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

[71] For a set of 46 other countries and regions, trade weights scheme is also based on tourism services.

$MW_{ij} = s_j^i = \frac{X_j^i}{\sum_{l \neq i} X_l^i}$: 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.

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

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

$BXW_{ij} = w_i^j = \frac{X_i^j}{\sum_{n \neq i} X_i^n}$: 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.

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

$w_i^k = \frac{X_i^k}{\sum_{n \neq i} X_i^n}$: 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.

For the weights based on primary commodities, ZD (1997) use a very different method to compute. The method is based on the assumption that primary commodities are homogenous goods and therefore, for each primary commodity there is only one world market and one world price. In other words, for each primary commodity, the weight attached to country j by any country should reflect the importance of country j as either a seller or a buyer in the world market[72].

CPI-based and GDP deflator-based REER Indicators for China

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 (5.24) 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. We calculated weights for each individual year for the period 1952-2005 to allow for time variation in weights. Last but not least, conventional studies choose trade partners using certain years' trade data[73]. 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 the table below. For the period 1960-2005, trade with the 14 main trade partners accounts for 81% of China's total trade (Table 5.9). Therefore, i refers to China and j refers to China's 14 main trade partners.

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[72] For equation of calculating weights based on primary commodity, please refer to Zanello and Desruelle (1997). It is not used in our study therefore it is not necessary to discuss it here.

[73] For instance, Funke and Rahn (2005) use the trade data between China and US, Japan and the Euroland in 1996 to calculate the trade weights. This trade weights of the single year (1996) is then used to construct REER for China for the period 1985Q1 to 2002Q4.

Table 5.9. 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

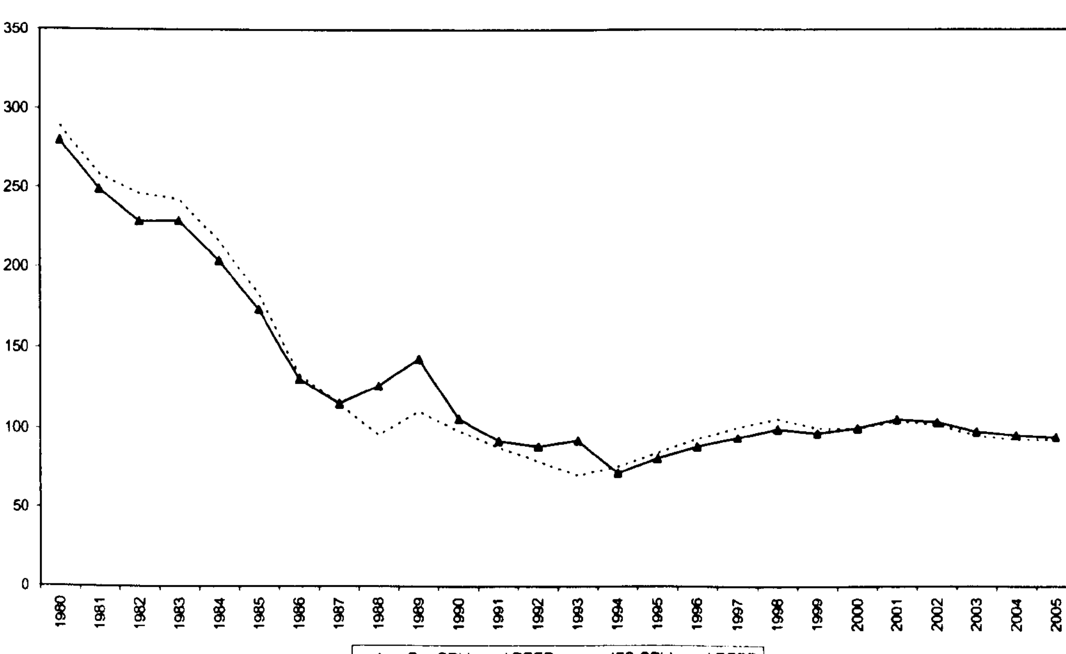
Trade data of China and these 14 countries is collected from Direction of Trade Statistics (DOTS) for the period 1960-2005. There are always discrepancies between bilateral trade data of two countries. Therefore, we use the average of trade data from two countries[74]. This is also suggested by ZD (1997). 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[75]. Nominal exchange rates (USD per national currency) are collected from *IFS* (line rh) for China and its 10 main trade partners (exclude Germany, France, Italy and Netherlands). In terms 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 form with 2000=100 and are expressed as

[74] For instance, 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.
[75] For instance, for the year of 1965, China's export to US will be the US (report country) import from China.

USD per national currency. CPI index are 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. CPI for China is discussed in Section 5.2.8. All CPI are in 2000 prices.

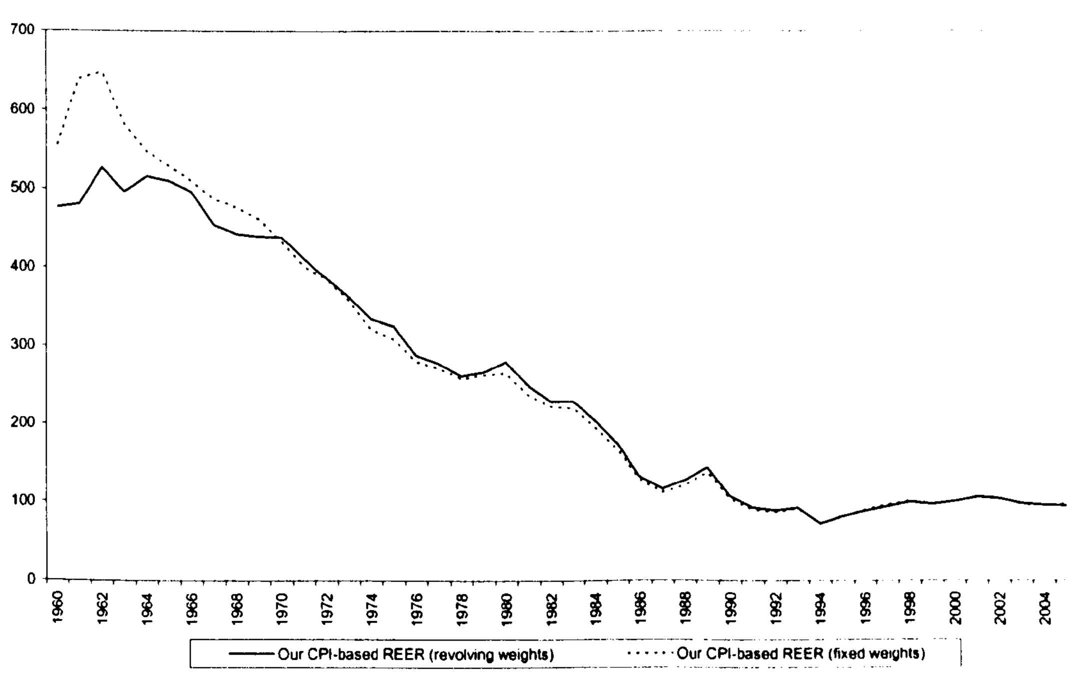
Thus we obtain CPI-based REER for the RMB using yearly revolving weights from 1960 to 2005 and we compare our data with IMF CPI-based REER for the period 1980-2005 (Figure 5.15). The graph shows our CPI-based REER is highly correlated with *IFS*' and both have same turning points. In particular, for the period 1994-2005 these two data sets are almost identical. This shows our method is valid.

Figure 5.15. Our CPI-based REER and IMF CPI-based REER Indices (2000=100)



We also constructed another series of CPI-based REER for the RMB using fixed weights and plotted it against the one using yearly revolving weights in Figure 5.16. The fixed weights are obtained as the average of the yearly revolving weights from 1960 to 2006. The two series are fairly close after the mid-1990s. However, the gap is widening as we go backwards, especially in the early 1980s and mid-1970s. In particular, the gap has been very large during 1960-1970. The widening gap implies there are considerable amount of errors in the fixed weights before 1994. This is natural as trade weights attached to China's trade partners may change slowly in the short-run but may alter considerably in the long-run. Therefore, we believe it is more accurate to use yearly revolving weights instead of fixed weights, especially in our study that covers 1960-2005.

Figure 5.16. Our CPI-based REER (revolving weights and fixed weights) Indices (2000=100)

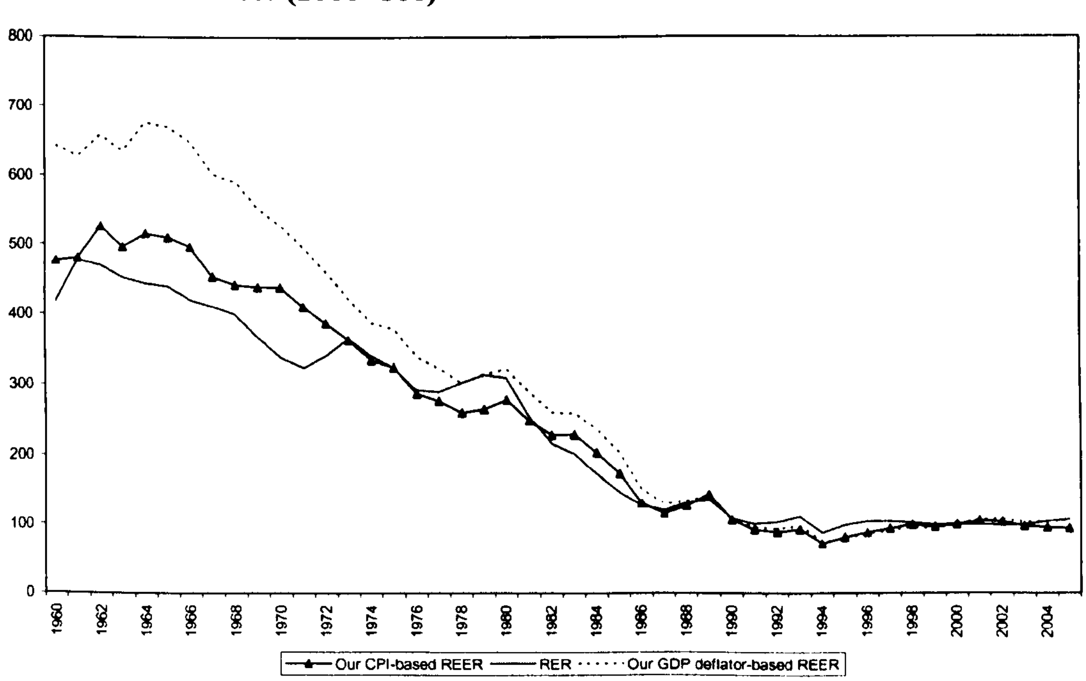


To keep the consistency between REER and the GDP-deflator adjusted real exchange rate that is required by the NATREX model, we need to construct GDP deflator-based REER. Recall the equation for REER (5.23), now P_i and P_j are GDP price deflators of countries i and j instead of CPI. GDP-deflator based REER is what we use in the following econometric estimations.

GDP price deflators 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. GDP price deflator for China has been described in Section 5.2.2. All GDP price deflators are in 2000 prices.

We calculated GDP-based REER for the period 1960-2005 and compare it with our CPI-based REER (Figure 5.17) and real USD/CNY exchange rate (RER). GDP-based REER is higher than CPI-based REER and RER from 1960 to late1970s and the rest of period they follow each other quite closely.

Figure 5.17. Our GDP Deflator-Based REER, CPI-Based REER and RER Indices (2000=100)



5.6.1.2. Effective Terms of Trade (ETOT)

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}

$$ETOT = \prod_{j \neq i} \left[\frac{TOT_i}{TOT_j} \right]^{W_{ij}} \tag{5.25}$$

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. The calculation of China's TOT is described in Section 5.2.14. 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)[76]. We depict the ETOT and TOT for the period 1960-2005 in Figure 5.18. Before early 1970s, ETOT is slightly higher than TOT while for the rest of the period these two series move closely to each other.

5.6.1.3. Effective Relative Unit Labour Cost (ERULC)

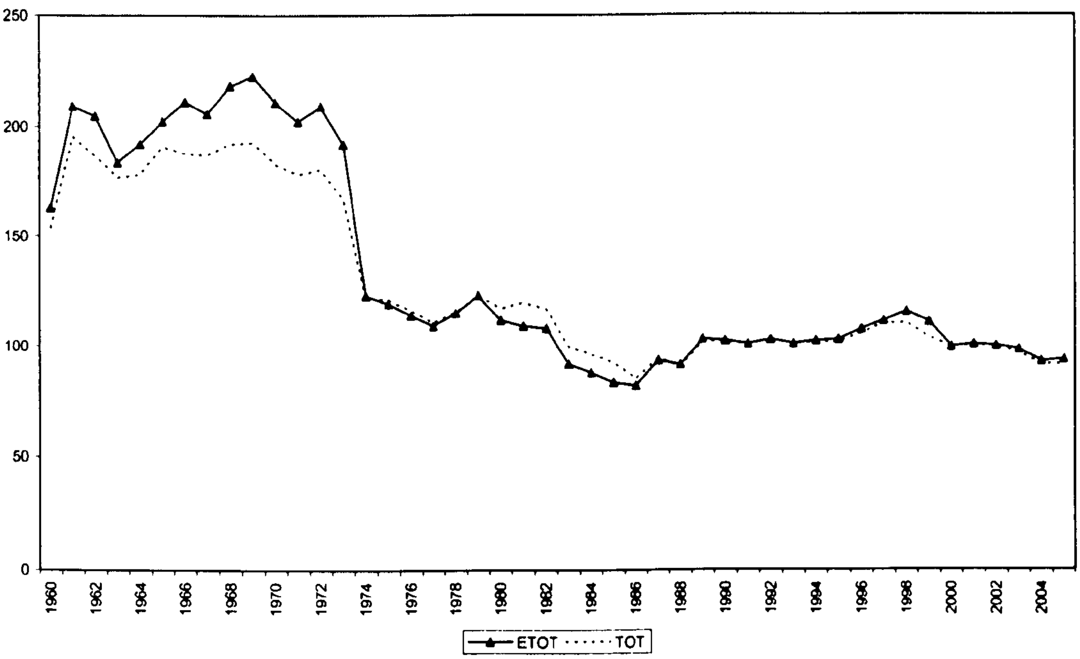
ERULC for the period 1960-2005 is constructed as the geometric mean of unit labour cost of China to its main trade partners with the weights equal W_{ij}

$$ERULC = \prod_{i \neq j} \left[\frac{ULC_i \times R_i}{ULC_j \times R_j} \right]^{W_{ij}} \tag{5.26}$$

where ULC denotes unit labour cost, where i denotes China, j represent China's 14 main trade partners; R_i, R_j and W_{ij} denote nominal exchange rate of the USD

[76] 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.

Figure 5.18. Effective Terms of Trade (ETOT) and Terms of Trade (TOT) Indices (2000=100)



against CNY, nominal exchange rate of the USD against currency of country j and normalised competitiveness trade share. Unit labour cost of China is measured as $ULC_i = \frac{LC_i}{Y_i/p_i}$ where LC_i and Y_i/p_i denote labour compensation of China and real GDP of China adjusted by GDP price deflator. Details of these two data series have been described in section 5.2.17. 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 wage rates and earnings index[77] and GDP volume index of country j.

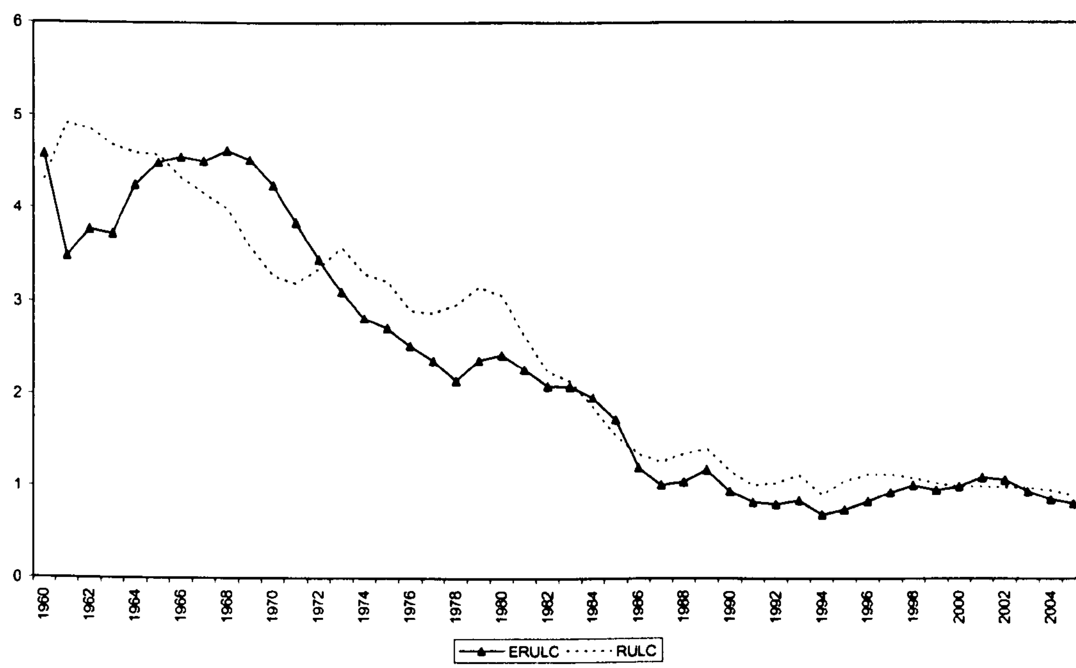
Indices of wage rates and earnings (2000=100) are collected from *IFS* (line 65). However, data is available only for 10 out of 14 countries for the period 1960-2005, which are Korea, Australia, Canada, France, Germany, Italy, Japan, Netherlands, UK

[77] Wage rates and earnings index are measured in USD.

and the US[78]. Trade with these 10 countries accounts for 51.8% of China's total trade with the world for the period 1960-2005 (Table 5.9). 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[79].

ERULC is depicted against RULC in Figure 5.19. ERULC is overall slightly lower than RULC except from middle 1960s to the beginning of 1970s. Both series are more volatile in the pre-reform period that the post-reform period and have followed each other quite closely since early 1980s.

Figure 5.19. Effective Relative Unit Labour Cost (ERULC) and Relative Unit Labour Cost (RULC)



[78] For Italy and Germany, indices of wage rates and earnings from *IFS* start from 1962. For the year 1960 and 1961, we use three year average o f 1962, 1963 and 1964 to replace.

[79] 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).

5.6.1.4. 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

$$FR = \sum_{j=1}^{n} W_{ij} r_j' \tag{5.27}$$

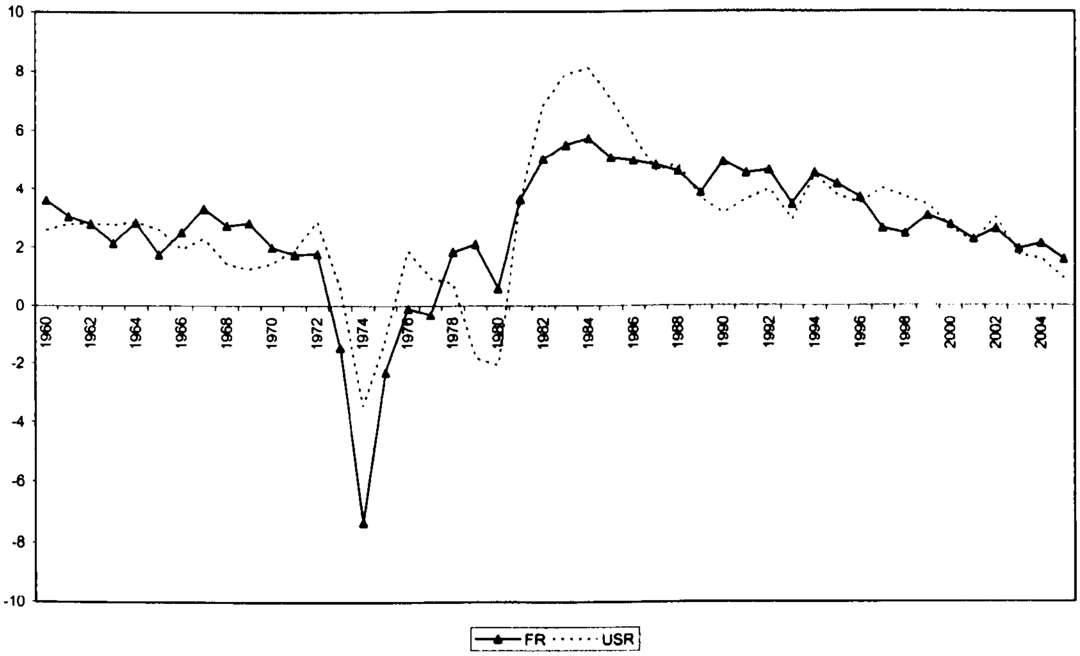
where i denotes China, j represents China's 14 main trade partners; r_j', W_{ij} and n denote real long term interest rate of country j, normalised competitiveness trade shares and number of countries respectively.

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, UK and the US[80]. Trade with these 9 countries accounts for 47.1% of China's total trade with the world for the period 1960-2005 (Table 5.9). Therefore, j represents these 9 countries and W_{ij} is the competitiveness weights that are normalised among these 9 countries with $n = 9$. Data for CPI have been explained in Section 5.6.1.1. and inflation is calculated from CPI. The real long-term interest rate (r_j') is calculated by subtracting the inflation rate from the nominal long-term government bond yield. FR is expressed as a percentage.

We depict FR against the US real long-term interest rate (USR) for the period 1960-2005 in Figure 5.20. These two series follow each other quietly closely sharing the same turning points, which implies financial integration.

[80] 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, which is the ratio of 3 overlapping years' average of the nominal T-bond yield long-term interest rate to the same 3 years' average of nominal lending rate. The 3 overlapping years are 1966, 1967 and 1968.

Figure 5.20. Real Foreign Interest Rate (FR) and US Real Interest Rate (USR) (%)



5.6.2. Empirical Results for the Real Effective Exchange Rate

5.6.2.1. Unit Root Tests

The results of the unit root tests are shown in Table 5.10. The number of lags in the ADF test is chosen using the same methodology as in Section 5.5. 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 AIC for comparison. These statistics confirm the results obtained by the Campbell and Perron method.

Table 5.10. 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
REER2	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
RRC1	0	-2.73	0.0774	-7.58	0.0000	0	-2.73	0.0774	-7.58	0.0000
RRC2	0	-5.71	0.0000			0	-5.71	0.0000		
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.
All variables are in natural logarithm except CHRC1, CHRC2 and FR as they are rate of returns.

5.6.2.2. Johansen Cointegration Tests

The method and criteria of choosing lag length of VAR and number of cointegrating vectors (CVs) are the same as in Section 5.5. Given the large number of fundamentals and size of the sample, again we kept the core variables (effective terms of trade, productivity and social time preference) and dropped other insignificant ones. For all experiments, VAR(1,1) was chosen by the AIC.

The results of Johansen cointegration tests are shown in Table 5.11[81]. The max-eigenvalue statistic suggests one CV at 1% significance level for each equation while trace statistic suggests more than one for equations I and K. We adopt the results based on max-eigenvalue statistic for the reasons explained in Section 5.5. For equations I and K, the adjustment coefficients are negative and statistically significant at 10% and 5% respectively. The adjustment coefficient is insignificant for equation J. For equation K, the core variable, terms of trade, is insignificant. Looking at equations I, 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 I as the most satisfactory one and this is the equation we are going to use to calculate the NATREX.

5.6.2.3. Interpretation of the Long-run Equilibrium Relationships

Equation I

$$
\begin{aligned}
REER = {} & \underset{(0.3885)}{0.8216}ETOT + \underset{(0.4301)}{2.4747}NFP2 + \underset{(0.6318)}{0.9754}RT + \underset{(0.2130)}{1.1165}ERULC - \underset{(0.4075)}{2.6153}CREP \\
& + \underset{(0.3162)}{1.4002}TAX1 - 4.3414
\end{aligned}
$$

All fundamentals in equation I are statistically significant except RT. The results can be divided into two categories. The first category includes the fundamentals that have

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

Table 5.11. Johansen Cointegration Results — the Extended NATREX Model

	Hypothesized No. of CE(s)	Trace Statistic	5% Critical Value	1% Critical Value	p-value	Max-Eigen Statistic	5% Critical Value	1% Critical Value	p-value
Equation I	None	179.51 *	125.62	135.97	0.0000	65.05 *	46.23	52.31	0.0002
	At most 1	114.45 *	95.75	104.96	0.0014	45.46	40.08	45.87	0.0113
	At most 2	68.99	69.82	77.82	0.0581	32.69	33.88	39.37	0.0688
	At most 3	36.30	47.86	54.68	0.3812	17.99	27.58	32.72	0.4957
Equation J	None	163.30 *	125.62	135.97	0.0000	67.94 *	46.23	52.31	0.0001
	At most 1	95.37	95.75	104.96	0.0531	42.22	40.08	45.87	0.0283
	At most 2	53.15	69.82	77.82	0.4986	20.42	33.88	39.37	0.7271
	At most 3	32.73	47.86	54.68	0.5716	17.50	27.58	32.72	0.5372
Equation K	None	129.68 *	95.75	104.96	0.0000	51.71 *	40.08	45.87	0.0016
	At most 1	77.97 *	69.82	77.82	0.0097	35.23	33.88	39.37	0.0343
	At most 2	42.74	47.86	54.68	0.1390	22.56	27.58	32.72	0.1933
	At most 3	20.18	29.80	35.46	0.4105	10.08	21.13	25.86	0.7367

Normalized cointegrating coefficients (std.err. in parentheses)

Equation I	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 J	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 K	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)						

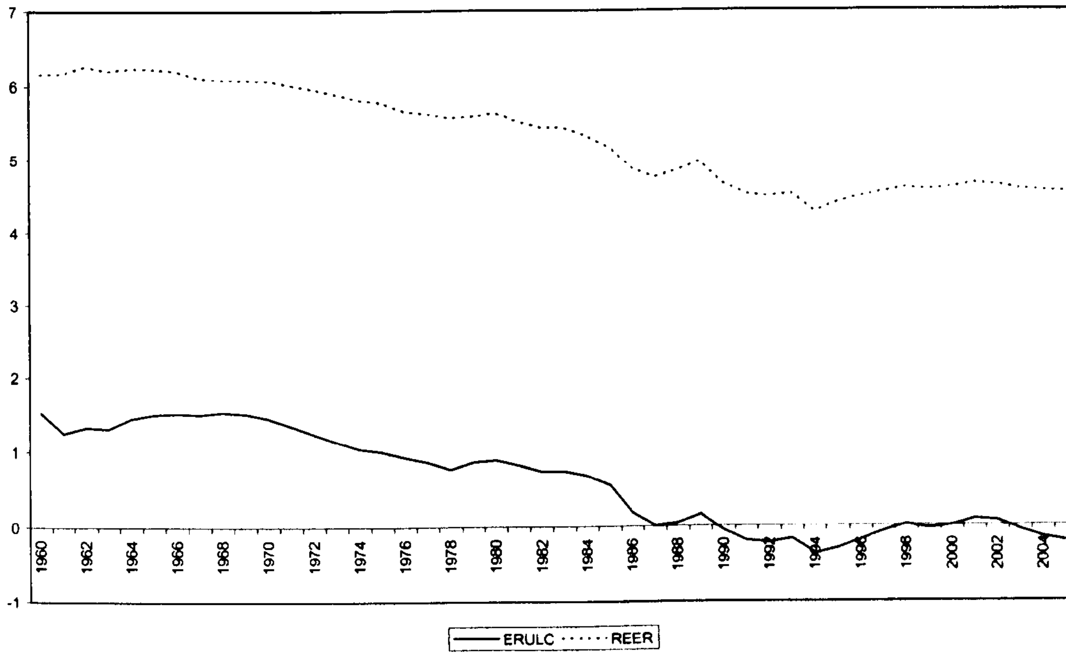
Note: "*" denotes rejection of the hypothesis at the 1% level. Critical values are taken from MacKinnon *et al* (1999).

the signs as predicted by the extended NATREX model. Higher effective terms of trade (ETOT) and productivity (NFP2) significantly raises the long-run value of REER, while higher degree of financial liberalisation (CREP) significantly reduces the long-run value of REER[82]. 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 relative unit labour cost (ERULC) and the tax rate (TAX1). We found a positive and highly significant relationship between ERULC and REER, the same as the relationship we found between the China-US relative unit labour cost (RULC) and the real USD/CNY exchange rate (RER) in Section 5.5. The correlation coefficient between ERULC and REER is 99.1% (Figure 5.21). The rational of such a positive relationship was explained in Section 5.5. In terms of the tax ratio, on the one hand, a higher tax ratio discourages investment and hence reduces the long-run equilibrium effective exchange rate. On the other hand, a higher tax ratio implies 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 from the government encourage production of tradables. This will stimulate the production of output and generate current account surplus in the long-run and hence increases foreign assets. Higher foreign assets raise the effective exchange rate. It seems that the upward force dominates in determining equilibrium effective exchange rate in the long-run.

[82] A higher level of CREP reduces the real exchange rate (RER) in section 5.5 and raises the real effective exchange rate (REER) in this section. As discussed in section 5.5.3, a higher level of CREP has both upward and downward effects on investment. In the case of REER, the downward effect of CREP dominates in determining the REER in the long-run and therefore a higher CREP raises the equilibrium REER.

Figure 5.21. Real Effective Exchange Rate (REER) and Effective Relative Unit Labour Cost (ERULC) (1960-2005) (in Natural Logs)



5.6.3. NATREX and Misalignments

Based on equation I and using actual and HP-filtered values of fundamentals, we calculated NATREX, HPNATREX and misalignment rates (Figures 5.22 to 5.25). Table 5.12 summarises findings on misalignment rates[83].

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 historical event such as 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 FEER 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

[83] ADF tests show that the misalignment rates in Figures 5.23 and 5.25 are both stationary at 5%.

Table 5.12. 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 was 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 was 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 was 12 years consecutive undervaluation with an AMR of 7.8%.

Note: AMR refers to average misalignment rate.

early 1960s and the discrepancies between NATREX and REER were reduced. Over the period 1972-1994, the misalignment rates of REER to NATREX were reduced to a narrow band of ± 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.

Figure 5.22. NATREX and Real Effective Exchange Rate (REER)

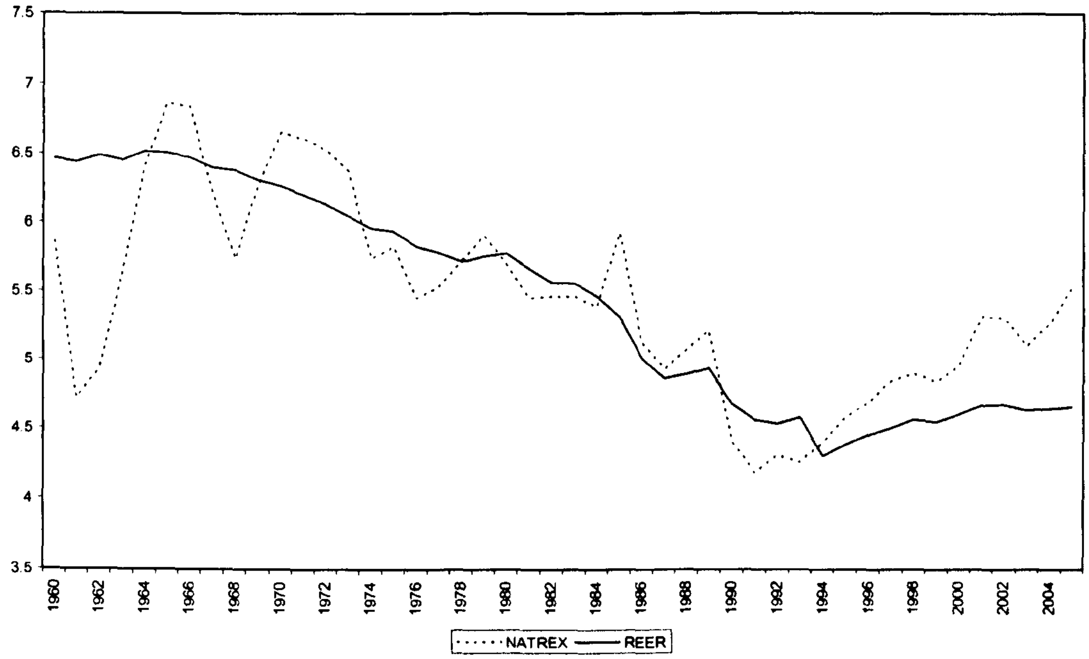
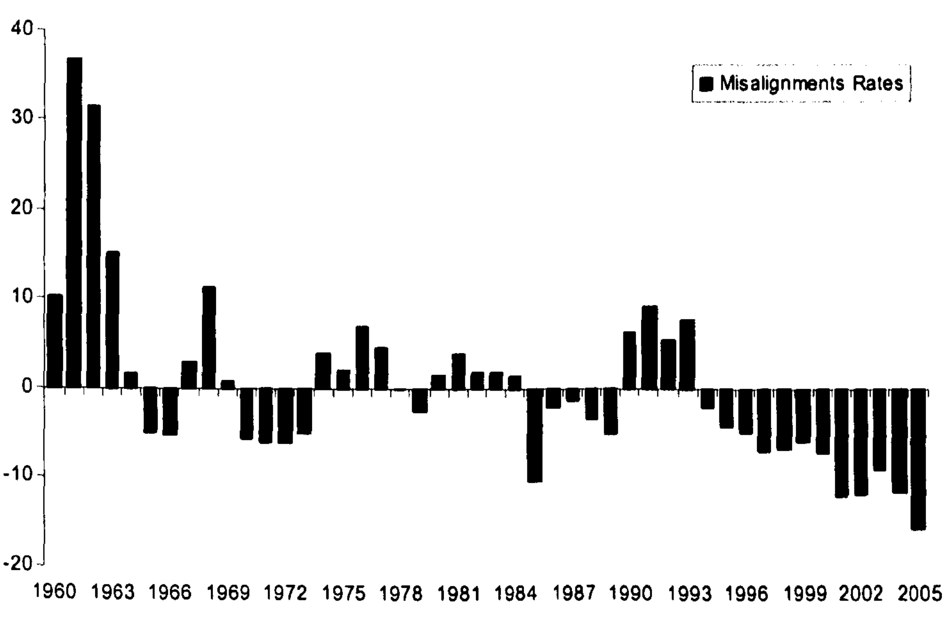


Figure 5.23. Misalignment Rates (%) between REER and NATREX



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 5.24. HPNATREX and Real Effective Exchange Rate (REER)

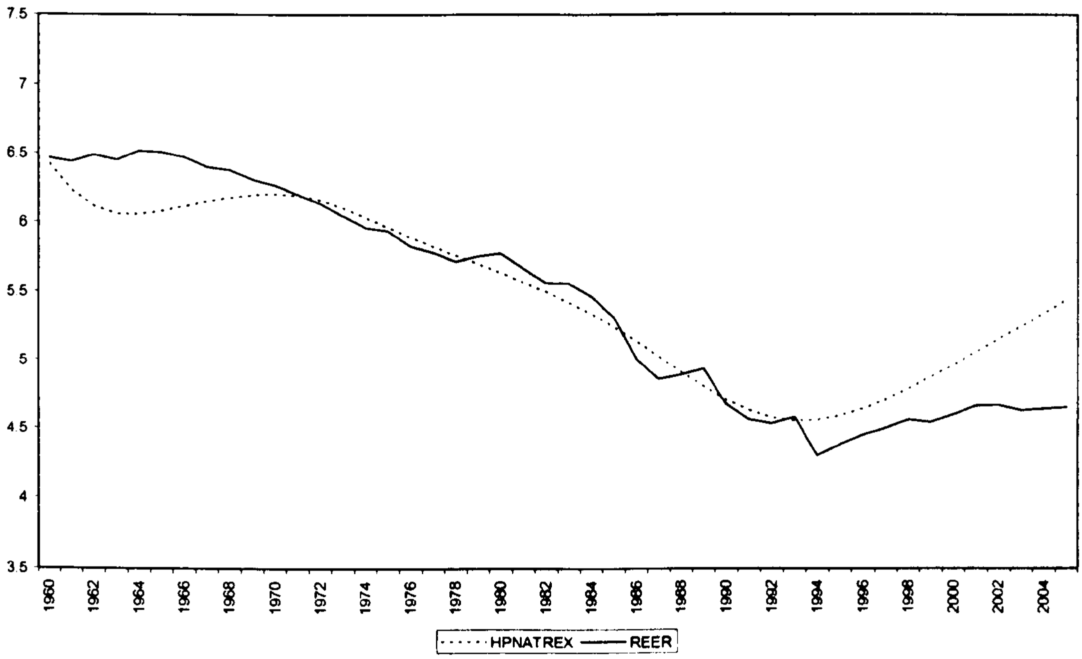
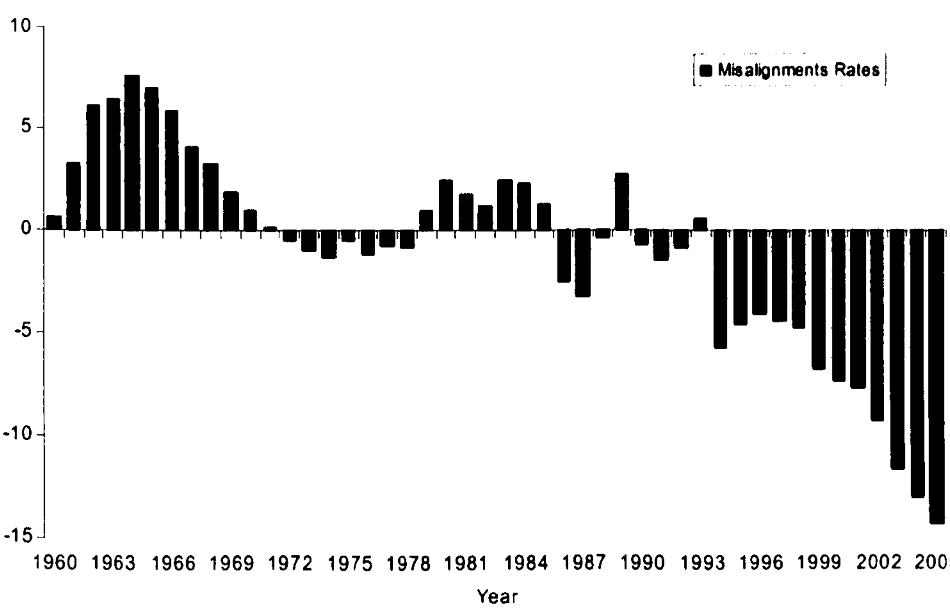


Figure 5.25. Misalignment Rates (%) between REER and HPNATREX



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.

Misalignment rates of REER from HPNATREX move within a much narrower band and 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 7.81%. We did find evidence of persistent undervaluation after 1994. However, the undervaluation has not been as large as suggested by some other studies about China's real effective exchange rate (i.e. 33% since 1997 in Jeong and Mazier (2003), 30-50% in 2005 in Dunaway *et al* (2006)). For the period 1960-1993, misalignment rates varied within a narrow band ± 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. To our knowledge, all other studies of real effective exchange rate for China cover only the post-reform period. Our study is overall consistent with Zhang (2001), one of the few studies of real bilateral USD/CNY exchange rate for both pre- and post-reform periods. For the time span of 1954-1997, Zhang (2001) finds there was overvaluation for the whole 1960s to 1970, undervaluation in 7 out of 11 years for the period 1971-1981 and actual real exchange rate is in line generally with the equilibrium exchange rates from 1982 to 1997.

Compared with the results of the real bilateral USD/CNY exchange rate, the misalignments of REER based on both NATREX and HPNATREX are rather similar during 1960-1993. For the period 1994-2005, results based on REER suggest persistent and increasing undervaluation of the RMB and results based on RER suggest overvaluation. The real bilateral USD/CNY exchange rate is not undervalued but the China-US bilateral trade only accounts for less than one fifth (18.2%) of China's total trade (Table 5.2). The real effective exchange rate is constructed by including all China's main trade partners, which accounts for more than four fifth (81.00%) of China's total trade. The persistent undervaluation of the RMB based on REER implies that the competitiveness of China against all its main trade partners has been higher than it should be since 1994.

5.7. Conclusions

This chapter is the first empirical application of the extended NATREX model to China. Another important contribution of this chapter is the construction of a unique data base of consistent time series of economic fundamentals since 1952 that are crucial for determining the NATREX but have not been employed by other studies. In addition we have also constructed the RMB's real effective exchange rate against all China's trade partners since 1960, as well as effective fundamentals, such as effective terms trade, effective relative unit labour cost. We estimated the extended NATREX model for both the real bilateral USD/CNY exchange rate for the period 1952-2005 and the real effective exchange rate for the period 1960-2005. We used cointegration methods to obtain the long-run equilibrium relationships and hence derive the long-run equilibrium exchange rate. We applied the Hodrick-Prescott filter to remove the short-run random components of the fundamentals and obtain the smoothed long-run equilibrium real exchange rate. We calculated the misalignment rates for the long-run equilibrium exchange rate as well as the smoothed long-run equilibrium exchange rate.

The results of the estimations were interpreted based on the understanding of the unique characteristics of the Chinese economy.

The main findings of our study are summarised as follows. We have found one cointegrating vector both for the real bilateral and the real effective exchange rates. In the case of the real bilateral USD/CNY exchange rate, the significant determinants of the long-run equilibrium exchange rate are terms of trade, total factor productivity, dependency ratio, financial liberalisation, relative unit labour cost, relative rate of return to capital and government investment. In the case of the real effective exchange rate, the significant determinants are effective terms of trade, net factor productivity, effective relative unit labour cost, financial liberalisation and tax rate. With regards to the real bilateral USD/CNY exchange rate, we found no evidence of overvaluation of the RMB for the pre-reform period and, contrary to most studies, our results show that the real exchange rate was overvalued for most of the years in the post-reform period, albeit of moderate misalignment rates. In the case of the real effective exchange rate, we found strong evidence of undervaluation of the RMB for the period 1994-2005 though the misalignment rates have not been as large as 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%.

Appendix 5.A. Summary of Data Sources

GDP (China)	GDP Price Deflator (China)	GDP Price Deflator (US)	Nominal Exchange Rate USD/CNY	Total Number of Employees (China)	Rural Transformation (China)	Nominal Consumption (China)	CPI (China)
1952-1977 Adjusted data from *50YNC*	1952-1977 Original data from *50YNC*	1952-2005 *IFS*	1952-2005 *IFS*	1952-1977 Original data from *50YNC*	1952-1977 Original data from *50YNC*	1952-1977 Adjusted data from *50YNC*	1952-1988 original data from *50YNC*
1978-2005 *CSY 2006*	1978-2005 *CSY 2006*			1978-2005 *CSY 2006*	1978-2005 *CSY 2006*	1978-2005 *CSY 2006*	1989-2005 *CSY 2006*
Nominal Net Exports (China)	**Dependency Ratio (China)**	**Financial Liberalisation (China)**	**Government Investment (China)**	**Government Tax Revenue (China)**	**US Interest Rate**	**Labour Compensation (China)**	**Net Foreign Assets (China)**
1952-1977 Adjusted data from *50YNC*	1953-1959 Adjusted data from Modigliani and Cao (2004)	1952-1976 Original data from *50YNC*	1952-1980 Adjusted data from *CSY 1996* *CSY 2002*	1952-1988 original data from *CSY 2001*	1952-2005 *IFS*	1952-1977 3-year average (1978-1980) labour share of Bai, Hsieh and Qian (2006)	1952-1976 Adjusted data from SAFE
1978-2005 *CSY 2006*	1960-2005 *WDI 2006*	1977-2005 *IFS*	1981-2005 *CSY 2006*	1989-2005 *CSY 2006*		1978-2005 Bai, Hsieh and Qian (2006)	1977-2005 *IFS*

Social Time Preference (China)	Relative Unit Labour Cost of China to the US	Rate of Return to Capital of China	Rate of Return to Capital of the US	Real Capital stock K1 (China)	Real Capital stock K2 (China)	Real Capital stock K3 (China)
Social time preference is calculated using real consumption (CPI adjusted) real GDP (GDP price deflator adjusted)	Author's own calculation based on data listed in this table. For details, please refer to the main context.	Author's own calculation based on the data listed in this table. For details please refer to the main context.	1952-2005 National Income and Product Account (NIPA), BEA	1952-2005 Same methodology as Chow and Li (2002). However, we use adjusted data for 1952-1998 and updated data from *CSY 2006* for 1999-2005 due to the 2004 national economic census	1952-2005 Data is obtained from Bai *et al* (2006)	1952-2005 Same methodology as Hsueh and Li (1999). However, we use adjusted data for 1952-1995 and updated data from *CSY 2006* for 1996-2005 due to the 2004 national economic census.

Terms of Trade (China)	Real Effective Exchange Rate (China)	Total Factor Productivity (China)	Foreign Interest Rate	Effective Terms of Trade	Effective Relative Labour Cost
1952-1979 Adjusted data from *50YNC* and *CSY 2006* 1980-2005 *WDI 2006*	1960-2005 Trade Data is collected from Direction of Trade Statistics (DOTS). Nominal Exchange Rate, CPI and GDP price deflators are collected mainly from *IFS*, and also from *WDI* and OECD.	1952-2005 Author's own calculation based on the estimation of production function	1960-2005 Nominal long-term interest rate is collected from *IFS*. CPI is collected mainly from *IFS*, and also from *WDI* and OECD.	1960-2005 Export and import prices for the 14 trade partners are from *IFS*. Term of trade for China is described above.	1960-2005 Data for China's trade partners: wage rates and earnings index, GDP volume and nominal exchange rate are collected mainly from *IFS*, and also from *WDI*. Data for China is described above.

Chapter 6

A FEER Model for China: The Real CNY/USD Rate in a Two-Country Model

6.1. Introduction

The Fundamental Equilibrium Exchange Rate (FEER), an equilibrium concept developed by Williamson (1994), can be calculated in two alternative ways. The first approach uses a complete macroeconomic model and generates the FEER as a solution. The second approach uses a partial equilibrium model (Driver and Westaway, 2004).

The partial equilibrium approach attempts to estimate part of the complete macroeconomic system and treats the rest as an exogenous input based on judgement. This approach computes the "off-model" estimates of potential output and medium term current account and uses them in the econometrically estimated static trade equation to produce a path for the FEER. The motivation is mainly simplicity and clarity[1]. There are three steps in estimating the FEER using the partial equilibrium approach (Driver and Wren-Lewis, 1998). The first step is to estimate the trend current account that is consistent with the internal balance. The second step is to calculate the sustainable current account—the current account that matches medium term structural capital flows. Both trend and sustainable current accounts are medium term concepts[2]. The trend current account in the first step is estimated keeping the real

[1] The model rules out any feedback from the estimated exchange rate to exogenous variables. If there is feedback from the real exchange rate to trend output or savings and investment decisions, there may be inconsistencies between the off-model assumptions and the solution for the real exchange rate. However, Driver and Wren-Lewis (1999) examine the sensitivity of FEERs to feedback from the real exchange rate to output and conclude that the effects are relatively small.

[2] Different names are used to refer to trend and sustainable current accounts in existing studies of partial equilibrium model (i.e. Hristov, 2002; Wren-Lewis, 2003, 2004a, 2004b; Barisone, Driver and Wren-Lewis, 2006; Coudert and Couharde, 2007). Our study follows the names used by Wren-Lewis (2003).

exchange rate unchanged. However, the real exchange rate must move to clear the balance of payments and simultaneously drive the trend current account to match the sustainable current account. The third step is to calculate the FEER that delivers this match.

Some recent studies that apply the partial equilibrium model to China include Jeong and Mazier (2003), Wang (2004), Wren-Lewis (2004a) and Coudert and Couharde (2007)[3]. This thesis makes two contributions to the existing literature. First, in the existing studies, the sustainable current account is either based on assumptions (i.e. Wren-Lewis, 2004a), or estimated following the savings-minus-investment norm of Debelle and Faruquee (1998) and Chinn and Prasad (2000) (i.e. Jeong and Mazier, 2003; Wang, 2004)[4]. Assuming the sustainable account to be a certain percentage of GDP may seem feasible for a single year (i.e. year 2002 in Wren-Lewis (2004a)), but would not be applicable for a data span of several decades (as in our study) as the sustainable account evolves overtime. Furthermore, the savings-minus-investment norm in Debelle and Faruquee (1998) is developed for industrial countries. It's unlikely that the fundamentals that are significant for the sustainable current account industrial countries are identical to the ones that are significant for China and *vice versa*[5]. Chinn and Prasad (2000) extend Debelle and Faruquee (1998) to a panel of 71 developing countries, which does not include China, by exploring a wider range of fundamentals. Even if China is included, the results of the panel may still not be applicable to China as China is more likely to be an outlier[6]. Therefore, we contribute

[3] Please refer to Chapter 2 for details about these papers.

[4] Coudert and Couharde (2007) use sustainable current account estimated in Jeong and Mazier (2003).

[5] Chinn and Prasad (2000) extend Debelle and Faruquee (1998) to a panel of 71 developing countries as well as 18 industrial countries and the results suggest that fundamentals that are significant for developing countries are different from the ones that are significant for industrial countries.

[6] For instance, Frankel (2005) estimates the extended PPP for a panel of 118 countries including China, for two years of 1990 and 2000. In both cases China is an outlier. Coudert and Coharde (2007) also test the PPP and Balassa-Samuelson effect for a panel of 23 emerging countries including China. They find

to the existing literature by incorporating into the sustainable current account fundamentals that reflect the unique characteristics of the Chinese economy but have not been employed by other studies.

The second contribution relies in the data set that we use. Existing FEER applications to China focus on the post-reform period only. Data span in our study is 1960-2005, covering both pre- and post-reform periods. We have constructed a unique set of consistent time series for a variety of economic fundamentals and trade-related variables, which allows us to carry out econometric estimation of the sustainable and trend current account, and calculate the FEER for both pre- and post-reform periods.

The econometric methodologies we use are the ADF unit root tests based on Campbell and Perron's (1991) general to specific methods and the Johansen cointegration method. Based on the trend and sustainable current accounts we compute the FEER that closes the gap between them and then we calculate the misalignments.

This chapter is organised as follows. Section 6.2 outlines the FEER model for China. Section 6.3 presents the empirical estimation of FEER for the real bilateral CNY/USD exchange rate and analyses the misalignments. Section 6.4 draws conclusions.

6.2. The FEER Model for China

6.2.1. The Real Exchange Rate

Following Barisone, Driver and Wren-Lewis (BDW) (2006), we define the real exchange rate as

$$E = N \times \frac{WXP}{P} \tag{6.1}$$

supportive evidence for PPP and Balassa-Samuelson effect for the panel. But in both cases, no supportive evidence is found for China.

where N, WXP, DP and E denote, respectively, the nominal exchange rate of the Chinese Yuan against the US Dollar (CNY/USD), world export prices (in USD), domestic output price (in CNY) and the real exchange rate. An increase in E implies depreciation of the RMB and *vice versa*.

6.2.2. Trend Current Account

The trend current account is the current account that is consistent with internal balance. In this chapter we estimate the trend current account following the two-country trade model from BDW (2006) where the trend current account has three components: the trend trade balance, trend interest, profits and dividends (IPD) flows and the trend net transfer. The two countries in our study are China and the rest of the world.

6.2.2.1. Trend Trade Balance

The trend trade balance is endogenous and is different from the actual trade balance in two perspectives. First, the actual trade balance contains the effect of temporary shocks while those shocks are stripped out in the trend trade balance. Trade balance is called the predicted trade balance when shocks are removed. Secondly, the trend trade balance is the balance that would have prevailed if output equals potential output (zero output gap). The derivation of trend trade balance involves estimation of trade volume equations and trade prices equations for exports and imports respectively.

Following BDW (2006), the predicted real net trade (RNT) is determined by export volume (X), real export prices (RXP), import volume (M) and real import prices (RMP)[7]

$$X = (WT, XCOM) \Rightarrow X = X(\underset{+}{WT}, \underset{+}{E / RXP}) \qquad \textit{export volume equation} \quad (6.2)$$

$$RXP = RXP(\underset{+}{E}, \underset{+}{RCXP}) \qquad \textit{real export prices equation} \quad (6.3)$$

$$M = (Y, MCOM) \Rightarrow M = M(\underset{+}{Y}, \underset{-}{RMP}) \qquad \textit{import volume equation} \quad (6.4)$$

$$RMP = RMP(\underset{+}{E}, \underset{+}{RCMP}) \qquad \textit{real export prices equation} \quad (6.5)$$

$$RNT = X(\underset{+}{WT}, \underset{+}{E / RXP})RXP(\underset{+}{E}, \underset{+}{RCXP}) - M(\underset{-}{Y}, \underset{+}{RMP})RMP(\underset{-}{E}, \underset{-}{RCMP}) \quad (6.6)$$

where WT, $RCXP$, Y and $RCMP$ denote world export volume, real commodity export prices, real output and real commodity import prices respectively. RXP and RMP are measured as export prices and import prices divided by domestic output price. $RCXP$ and $RCMP$ are measured as commodity export prices and commodity import prices divided by the world export prices[8].

As discussed by BDW(2006), the trade volume equations (6.2) and (6.4) embody the traditional "demand curve" approach (i.e. Goldstein and Kahn, 1985). The real domestic output of China (Y) measures the total demand for imports which captures the impact of the domestic activity on China's imports, while the world export volume (WX) measures the total demand for exports which captures the impact of the world's activity on China's exports. Export and import competitiveness, measured by E / RXP and RMP respectively, act as relative prices of exports and imports. In particular, the import competitiveness, measured by RMP can be further written as

[7] Some studies further divide trade into trade in goods and trade in services (i.e. Hristov, 2002). Due to limited data availability for China, we use data for aggregate exports and imports.

[8] See Appendix 6.A for detailed derivation of equations (6.2)-(6.5).

$E/(WXP/MP)$, where MP denotes China's import prices. Therefore, the import volume equation can be further written as

$$M = M(\underset{+}{Y}, \underset{-}{E/(WXP/MP)}) \qquad \textit{import volume equation} \quad (6.4a)$$

Trade prices (equations (6.3) and (6.5)) depend on commodity prices, domestic prices and world export prices.

Using the coefficients estimated above (equations (6.2)-(6.5)) and the actual values of the variables, we calculate the predicted trend balance (equation (6.6)) that is not affected by the shocks. To obtain trend current account, the internal balance condition (zero output gap) must be satisfied. To achieve such a condition, we apply the HP-filter to the actual value of domestic real output Y. By replacing the actual value of Y by the smoothed values in equation (6.6), we obtain the real trend trade balance $\overline{RNT}$.

6.2.2.2. Trend IPD Flows

Following BDW (2006), we regard IPD flows as exogenous while taking into account the effect of exchange rate revaluation and smoothing the series using the HP-filter. To take into account the effect of currency revaluation, Hristov (2002) models the currency revaluation as the gap between FEER and actual real bilateral exchange rates divided by the actual real exchange rate and incorporate it into the IPD flows

$$IPD = \left(1 + \frac{FEER - E}{E}\right)(IPDC - IPDD) \qquad (6.7)^9$$

where $\frac{FEER - E}{E}$ measures the revaluation effect, $IPDC$ and $IPDD$ denote overseas assets held by domestic residents and domestic assets held by overseas residents respectively. To obtain the smoothed IPD flow, we apply the HP-filter to $(IPDC - IPDD)$

$$\overline{IPD} = \left(1 + \frac{FEER - E}{E}\right)\overline{(IPDC - IPDD)} \tag{6.8}$$

with smoothed series denoted by " ¯ ".

6.2.2.3. Trend Current Account

Net transfer is regarded as exogenous and it is smoothed by the HP-filter to get the trended value. The trend current account is the sum of trend trade balance, trend IPD and trend net transfer. Differences between the actual and trend current account generally reflect either cyclical movements in output, or persistent deviations in actual trade balance (trade volumes or prices) from their predicted levels.

6.2.3. Sustainable Current Account

There are two different approaches for estimating the sustainable current account. One derives measures of sustainable (structure) capital flows, which finance current account imbalances (Williamson and Mahar, 1998). Another approach equates the current account to the savings minus investment in the economy. This methodology was developed by Masson (1998) and applied by Debelle and Faruqee (1998) to industrial countries and by Chinn and Prasad (2000) to developing countries[10]. We model the sustainable current account for China as savings minus investment. However, for reasons discussed in section 6.1, in our study the determinants of the

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[9] In Hristov (2002), the net IPD flow is measured as $IPD = \left(1 + \rho \frac{FEER - E}{E}\right)(IPDC - IPDD)$, with ρ measured the proportion of the revaluation effect and is it assumed that $\rho = 1$. For simplicity, in our study we also assume the proportion of the revaluation effect equals unity.

[10] BDW (2006) also estimate the sustainable current account following Masson (1998) and Debelle and Faruqee (1998).

sustainable current account include fundamentals that matter for China and have not been employed by existing studies. The sustainable current account/GDP ratio (CAY) is determined by

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

$$\text{where } Z = (\underset{+}{TFP}, \underset{-}{CREP}, \underset{-}{DEP}, \underset{+}{RULC}, \underset{-}{RRC}, \underset{+}{r'}, \underset{+}{B}, \underset{+}{\tau}, \underset{-}{GI},) \tag{6.9}$$

where TFP, $CREP$, DEP, $RULC$, RRC, r', B, τ and GI denote, respectively, total factor productivity, financial liberalisation, dependency ratio, relative unit labour cost, relative rate of return to capital, US real interest rate (as an approximation of world real interest rate), relative real price of capital, taxation rate and government investment. The signs under fundamentals indicate their effects on the sustainable current account[11].

6.3. Empirical Results

This section reports the estimations of the model and computes the FEER for the real CNY/USD exchange rate. As argued by BDW (2006), the FEER describes a medium term equilibrium, hence the concern is not the short run dynamics of trend and sustainable current account equations, but their longer term properties. Therefore, we employ the Johansen cointegration methods to test for the long-run properties of the equations. We also look at the adjustment factor in the error-correction model to evaluate the stability of the equations. The sample period is 1960-2005. A detailed description of the data is given in Appendix 6.C.

Before we carry out the cointegration tests we test for the stationarity of the variables using unit root tests. The number of lags in the ADF test is chosen using the general to specific procedure suggested by Campbell and Perron (1991). The detailed procedures of the ADF and cointegration tests are the same as in Chapter 5.

The ADF test (Table 6.1) cannot reject the null of a unit root for all variables except RRC2. For the USR the null of a unit root cannot be rejected at 1% and for all other variables at 5%. Therefore, we regard all variables as nonstationary except RRC2. ADF tests for the first difference of the non-stationary variables show all of them are $I(1)$ processes so they can enter into a cointegration relationship. We also report ADF statistics with lags chosen by the AIC for comparison. These statistics confirm the results obtained by the Campbell and Perron method.

6.3.1. Trend Current Account

A time trend (T) and a constant are incorporated in equations (6.2)-(6.5)[12]. The trade volume equations are freely estimated for the whole sample period (1960-2005). In terms of the trade price equations, freely estimated parameters of the real commodity prices for the whole sample period are implausibly high. According to BDW (2006), the commodity composition of trade share could have been used to impose the coefficient on prices, although it is unclear which year to choose. Therefore we fix the coefficients on the commodity prices to the average commodity composition of trade between 1980-2005, which are 0.24 and 0.20 in real export and import prices equations respectively. We choose the average of 1980-2005 rather than average of the whole sample as in the pre-reform period the composition of commodity could be distorted by the centrally-planned trade pattern of exporting food and textile and

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[11] The specification of the savings and investment functions is discussed in Chapter 4. The derivation of equation (6.9) and signs of each fundamental are discussed in Appendix 6.B.

[12] When no trends are incorporated, the variables in the trade equations are correctly signed but they are either implausible or statistically insignificant. When trends are incorporated variables remain correctly signed and turn to be statistically significant and plausible. Wren-Lewis (2004a, b) also incorporate trends in the trade equations.

Table 6.1. Unit Root Tests (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
E	0	-1.01	0.7424	-6.15	0.0000	0	-1.01	0.7424	-6.15	0.0000
X	0	3.12	1.0000	-6.71	0.0000	0	3.12	1.0000	-6.71	0.0000
WT	0	-0.02	0.9517	-6.26	0.0000	0	-0.02	0.9517	-6.26	0.0000
XCOM	0	-0.59	0.8625	-7.09	0.0000	0	-0.59	0.8625	-7.09	0.0000
M	2	1.87	0.9997	-4.98	0.0002	3	2.34	0.9999	-4.23	0.0018
Y	2	1.17	0.9975	-6.14	0.0000	2	1.17	0.9975	-6.14	0.0000
MCOM	0	-1.06	0.7226	-6.01	0.0000	0	-1.06	0.7226	-6.01	0.0000
RXP	0	-1.58	0.4837	-6.91	0.0000	0	-1.58	0.4837	-6.91	0.0000
RCXP	2	-1.30	0.6216	-4.56	0.0007	2	-1.30	0.6216	-4.56	0.0007
RMP	0	-1.06	0.7226	-6.01	0.0000	0	-1.06	0.7226	-6.01	0.0000
RCMP	2	-1.16	0.6837	-4.23	0.0018	2	-1.16	0.6837	-4.23	0.0018
CAY	0	-2.26	0.1877	-6.44	0.0000	0	-2.26	0.1877	-6.44	0.0000
DEP	1	0.82	0.9932	-3.09	0.0351	1	0.82	0.9932	-3.09	0.0351
CREP	1	-0.74	0.8262	-4.32	0.0013	1	-0.74	0.8262	-4.32	0.0013
RULC	0	-0.29	0.9183	-5.79	0.0000	0	-0.29	0.9183	-5.79	0.0000
RRC1	0	-2.73	0.0774	-7.58	0.0000	0	-2.73	0.0774	-7.58	0.0000
RRC2	0	-5.71	0.0000			0	-5.71	0.0000		
USRC	0	-0.98	0.7536	-6.89	0.0000	0	-0.98	0.7536	-6.89	0.0000
B1	1	-1.32	0.6105	-4.07	0.0027	1	-1.32	0.6105	-4.07	0.0027
B2	2	-1.64	0.4563	-4.82	0.0003	2	-1.64	0.4563	-4.82	0.0003
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
GI	1	-0.61	0.8587	-4.24	0.0016	3	-0.59	0.8628	-2.78	0.0691
USR	1	-3.01	0.0415	-5.71	0.0000	1	-3.01	0.0415	-5.71	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

E=CNY/USD real exchange rate; X=export volume; WT=world trade volume; XCOM=E/RXP=export competitiveness; M=import volume; Y=real output; MCOM=RMP=E/(WXP/MP)=import competitiveness; RXP=real export prices; RCXP=real commodity export prices; RMP=real import prices; RCMP=real commodity import prices; DEP=dependency ratio; CREP=financial liberalisation; RULC=relative unit labour cost; RRC1=relative return to capital 1; RRC2=relative return to capital 2; USRC=US rate of return to capital; B1=relative price of capital to output 1; B2=relative price of capital to output 2; TFP1=total factor productivity 1; TFP2=total factor productivity 2; GI=government investment; USR=US real interest rate; TAX1=tax rate 1 (exclude tariff); TAX2= tax rate 2 (exclude tariff and tax on agriculture).

All variables are measured in natural logarithm except RRC1, RRC2, USRC and USR as they are rates of returns. Also CAY is not measured in natural logarithm as it contains negative values. In terms of CHRC1 and CHRC2 (China's rate of return to capital 1 and 2), the ADF test cannot reject the null of a unit root at 5% for both variables and hence the results are not listed here. B3 is not included here as TFP3 is not available (See Section 5.3 in Chapter 5).

import machinery. We also had to fix the coefficient on the trend in export prices equation as the freely estimated coefficient was implausible[13]. For the import prices equation, there is no significant cointegrating vector when we estimate the whole sample period. Therefore, we had to exclude the pre-reform period and estimate only the sub-period 1980-2005, when there is one significant cointegrating vector, and apply the estimated coefficients to the whole sample period.

In terms of the lag length of VAR, we started with maximum lag of 3 and tested downward using the AIC. For all trade equations, VAR (1, 2) was chosen. In the estimation, Johansen cointegration estimations often suggest one CV at 5% based on both trace and max-eigenvalue statistics. Therefore, 5% is the significance level we use to identify significant CVs in the estimation of trade equations[14].

The results of Johansen cointegration are shown in Table 6.2. Max-eigenvalue statistic suggests only one CV at 5% significance level for all four trade equations Trace statistic suggests only one CV at 5% for all equations except two CVs for export prices equation. We chose the results based on the max-eigenvalue statistic as Banerjee et al. (1986, 1993) suggest that the max-eigenvalue statistic is more reliable in small samples. Therefore, there is one significant cointegrating vector for all four trade equations. The adjustment factors for these trade equations are all negative and significant at 1% (except at 10% for import prices equation), ensuring the stability of all trade equations in the long-run. All estimated coefficients are correctly signed and statistically significant at 5% (except coefficient of import competitiveness is significant at 10%). The coefficients are further summarised in Table 6.3.

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[13] Freely estimated coefficient for the trend was around -4% in the real export prices equation, which implies the export prices decline at a rate of 4% per year and it is much higher than normal practice, especially compared with studies of BDW (2006) and Wren-Lewis (2004a).

[14] As argued by BDW (2006), the concern of the partial equilibrium is to test the properties of the FEER estimates. Therefore, as long as the standard Johansen cointegration suggests one significant

Table 6.2. Johansen Cointegration Results of Trade Volumes and Prices Equations

	Hypothesized No. of CE(s)	Trace Statistic	5% Critical Value	1% Critical Value	p-value	Max-Eigen Statistic	5 % Critical Value	1% Critical Value	p-value
Export Volume Equation	None	58.48*	47.86	54.68	0.0037	34.47*	27.58	32.72	0.0056
	At most 1	24.02	29.80	34.46	0.1998	12.04	21.13	25.86	0.5437
Import Volume Equation	None	55.12*	47.86	54.68	0.0090	29.43*	27.58	32.72	0.0286
	At most 1	25.68	29.80	34.46	0.1384	18.59	21.13	25.86	0.1094
Real Export Prices Equation	None	71.88*	47.86	54.68	0.0001	40.86*	27.58	32.72	0.0006
	At most 1	31.02*	29.80	35.46	0.036	17.72	21.13	25.86	0.1406
Real Import Prices Equation	None	57.12*	47.86	54.68	0.0053	30.35*	27.58	32.72	0.0215
	At most 1	26.77	29.80	35.46	0.1074	17.71	21.13	25.86	0.1409

Normalized cointegrating coefficients (std.err. in parentheses)

Export Volume Equation	X	WT	XCOM	T	C
	1.0000	-0.2603	-1.0490	-0.1281	2.0959
		(0.0724)	(0.1278)	(0.0050)	
	Adjustment coefficient (std.err. in parentheses)				
	D(X)	-0.5270			
		(0.1699)			
Import Volume Equation	M	Y	MCOM	T	C
	1.0000	-0.3580	0.2388	-0.0975	-3.0123
		(0.1433)	(0.1256)	(0.0129)	
	Adjustment coefficients (std.err. in parentheses)				
	D(M)	-0.5145			
		(0.1631)			
Real Export Prices Equation	RXP	RCXP	E	T	C
	1.0000	-0.24	-0.7895	0.01	0.0904
		(0.0000)	(0.0758)	(0.0000)	
	Adjustment coefficients (std.err. in parentheses)				
	D(RPX)	-0.3598			
		(0.1057)			
Real Import Prices Equation	RPM	RCMP	E	T	C
	1.0000	-0.20	-0.8538	0.0124	0.1921
		(0.0000)	(0.1183)	(0.0045)	
	Adjustment coefficients (std.err. in parentheses)				
	D(RMP)	-0.3168			
		(0.1746)			

Note: "*" denotes rejection of the hypothesis at the 5% level. Critical values are taken from MacKinnon *et al* (1999).

CV, based on both trace or max-eigenvalue statistic at statistically significant level, we regard that there is one significant CV.

Table 6.3. Trade Volumes and Prices Equations

Export Volume (X)			Import Volume (M)		
World Activity (WT)	Competitiveness (XCOM)	Trend (T)	Domestic Activity (Y)	Competitiveness (MCOM)	Trend (T)
0.26	1.05	0.128	0.36	-0.24	0.098
Real Export Prices (RXP)			**Real Import Prices (RMP)**		
Relative Price (E)	Real Commodity (RCXP)	Trend (T)	Relative Price (E)	Real Commodity (RCMP)	Trend (T)
0.79	0.24^F	-0.010^F	0.85	0.20^F	-0.012

Note: Superscript "F" denotes the parameters are fixed. All equations are estimated for 1960-2005 except import prices equation is estimated for 1980-2005.

Looking at the export volume equation, export competitiveness elasticity and world activity elasticity are 1.05 and 0.26 respectively, which implies that export volume is more responsive to changes in relative prices than changes in foreign demand. In other words, the large expansion in China's exports is mainly due to improvements in its competitiveness. In terms of the import volume, import competitiveness elasticity and domestic activity elasticity are -0.24 and 0.36 respectively. It implies that China's demand for imports is more income elastic than price elastic. The sum of the absolute values of export and import competitiveness is 1.29, which is greater than unity. This suggests that the Marshall-Lerner condition is satisfied in China, mainly due to the high export prices elasticity, and hence currency devaluation can have a positive effect on the trade balance. Both trade volume equations have positive trends of 0.128 and 0.098 respectively[15].

In terms of the trade prices equations, as explained above, we impose the coefficients on real commodity prices to be 0.24 and 0.20 in the real export and import prices

[15] Existing studies that analysing price elasticity of Chinese real trade (or the effect of real exchange rate on China's real exports and imports) reach no consensus. For a literature review, please refer to Chueng, Chinn and Fujii (2007). The results in our study, namely export and import competitiveness

equations respectively. The time trend in export equation is fixed at -0.01[16]. The coefficients on the real exchange rate (relative price of world export to domestic output in same currency) are 0.79 and 0.85 for real export and import prices respectively. It implies that more than three quarters of the real trade prices are determined by the real exchange rate (or the relative price). Interestingly, similar to BDW (2006), we found negative time trends of -0.012 in import prices equation.

One interesting feature of the trade prices estimates is that they suggest the trade prices of China are dependent mainly on the world export prices. Based on equations (6.18) and (6.19) in Appendix 6.A and the coefficients in the real trade prices equations in Table 6.3, we can obtain γ and ϕ in equations (6.16) and (6.17), which are 0.72 and 0.81 respectively. Therefore, 72% and 81% of the export and import prices respectively are determined by the world export prices and only 28% and 19% are determined by the domestic output price. This supports the exogeneity of the terms of trade for China. This is further summarised in Table 6.4.

Table 6. 4. Decomposition of Coefficients in Prices Equations (6.16)-(6.17) in Appendix 6.A.

Export prices (XP)				Import prices (MP)			
World (WXP)	Domestic (P)	Commodity (CXP)	Trend (T)	World (WXP)	Domestic (P)	Commodity (CMP)	Trend (T)
0.72	0.28	0.24^F	-0.010^F	0.81	0.19	0.20^F	-0.012

Note: Superscript "F" denotes the parameters are fixed. Export prices equation is estimated for 1960-2005 and import prices equation is estimated for 1980-2005.

(price) elasticities, activity (world demand and domestic income) elasticities, are overall within the range suggested by the existing studies.

16 As the freely estimated time trend in real import prices equation has a coefficient of -0.01 (though statistically insignificant), we fix the coefficient of the time trend in real export prices equation at -0.01 as well. We also experimented the properties of the coefficient in the real export prices equation with fixed coefficient changing from -0.005 to -0.01 and the results are not sensitive to these changes.

Based on the coefficients in Table 6.2 and actual value of the variables, we are able to compute the predicted trade volumes and prices and therefore obtain the predicted exports and imports, which are illustrated in Figures 6.1 and 6.2. We apply HP-filter to the real output to obtain the potential output[17]. By imposing the condition of internal balance we obtain the trend net trade. The actual, predicted and trend net trade are plotted in Figure 6.3. We also apply HP-filter to net IPD flows and net transfers to obtain the trend net IPD flows and trend net transfers (Figures 6.4 and 6.5). The sum of the tend net trade, trend net IPD flows and trend net transfers yields the trend current account. The latter is plotted against the real current account (as a percentage of real GDP) in Figure 6.6.

Looking at Figures 6.1 and 6.2, for both exports and imports, the predicted values were fairly close to the actual values, except for the 1960s and 1970s when the predicted imports were persistently higher than the actual values. Figure 6.3 shows that there were little gaps between predicted and trend net trade. It is noticeable that both trend and predicted net trade were lower than the actual values before early 1980s and higher than the actual values for most of the years since middle 1980s, especially for the last three years of the sample period, 2003-2005. Looking at Figure 6.6, before 1984 the trend real current account/ GDP ratio was below the actual values while for the period 1999-2005, the trend value had been higher than the actual value. During 1985-1998, the trend values were less volatile than the actual values and the two series were fairly close to each other.

[17] Following BDW (2006), the world trade volume and real commodity prices are also smoothed using

Figure 6.1. Predicted and Actual Exports (Billion CNY) (in Natural Log)[18]

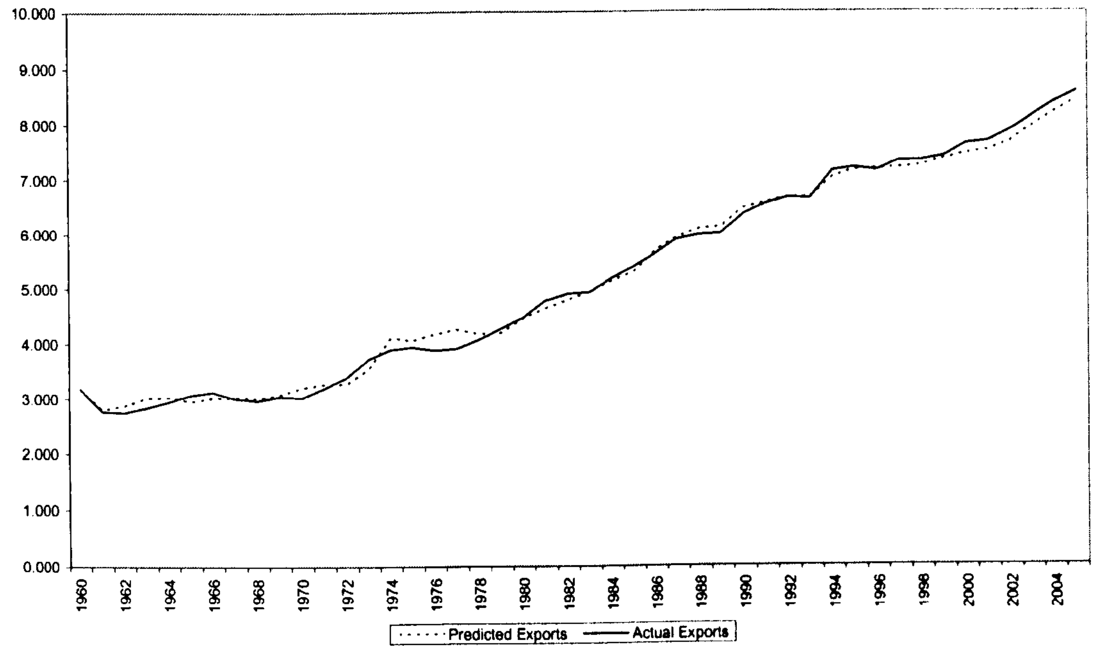
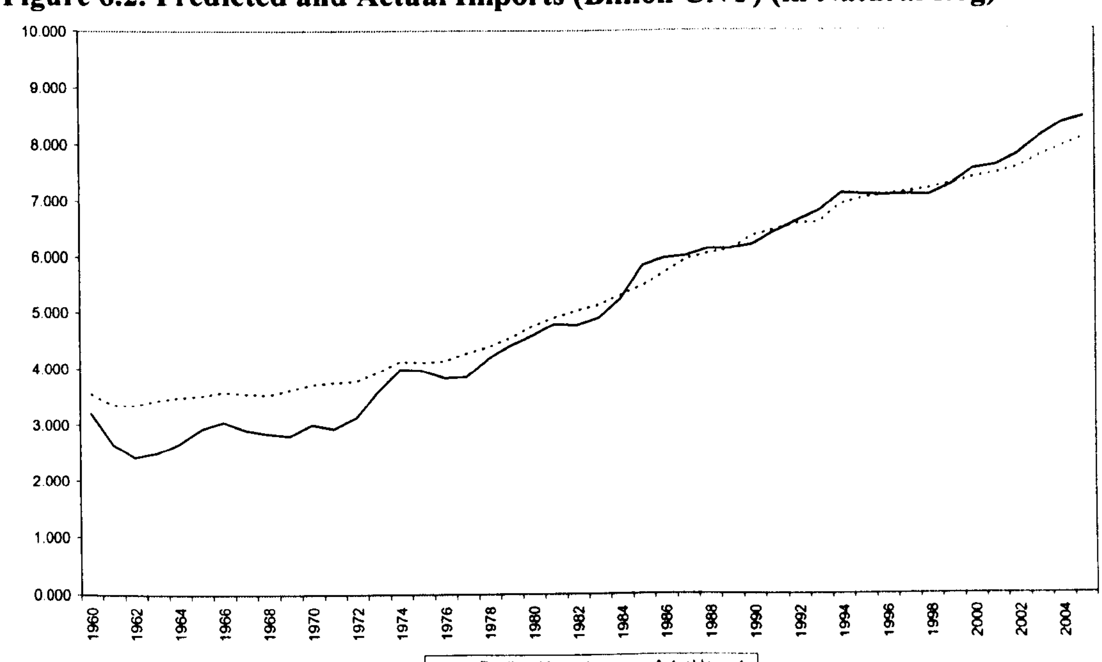


Figure 6.2. Predicted and Actual Imports (Billion CNY) (in Natural Log)



HP-filter. The trend real output, world trade volume and real commodity prices are overall close to the actual values.

Figure 6.3. Predicted, Trend and Actual Net Trade (Billion CNY)[19]

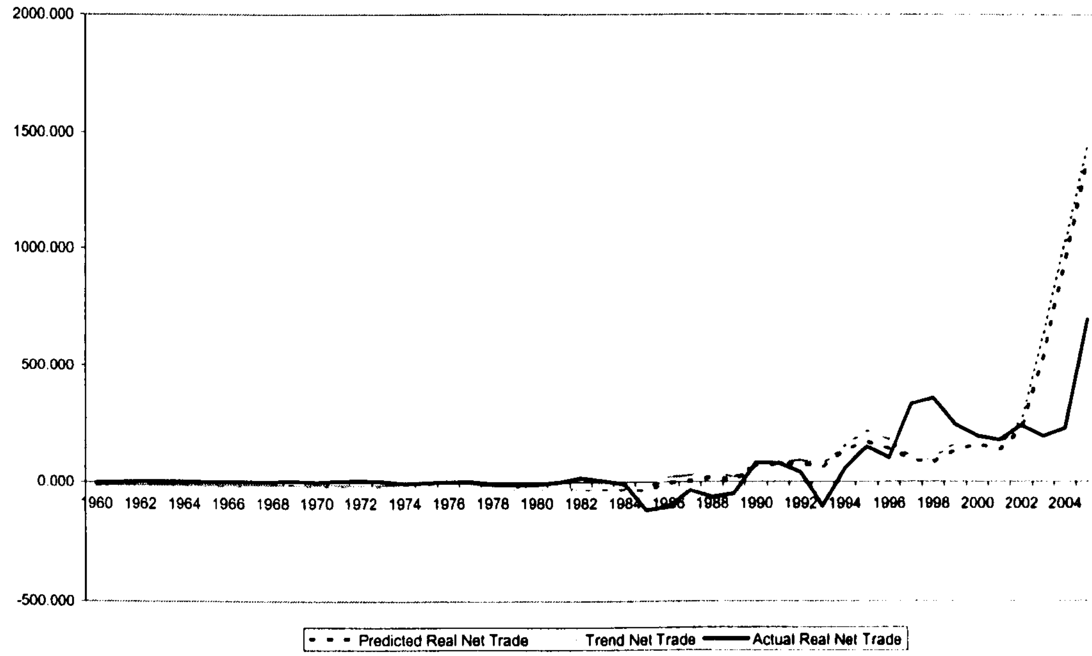
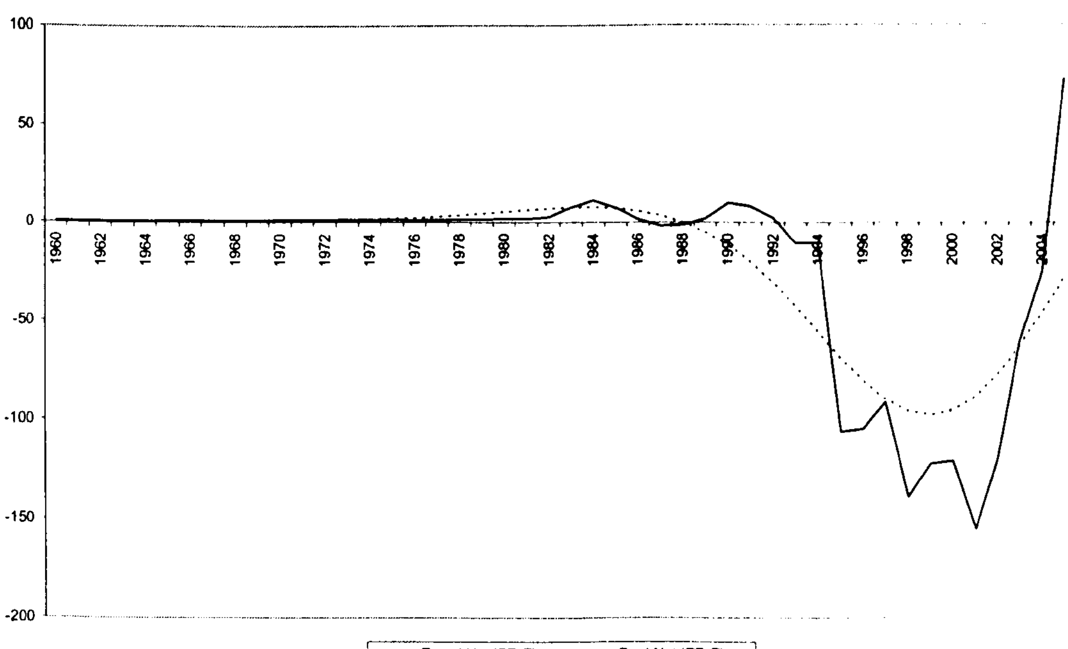


Figure 6.4. Potential and Actual Real Net IPD Flows (Billion CNY)



[18] Predicted Exports in constant prices= (Predicted Export Volume*Predicted Real Export prices)/100; Predicted Imports in constant prices= (Predicted Import Volume*Predicted Real Import Prices)/100.
[19] Net trade, net IPD flows and net transfers are not in natural log as some of the values are negative.

Figure 6.5. Trend and Actual Real Net Transfers (Billion CNY)

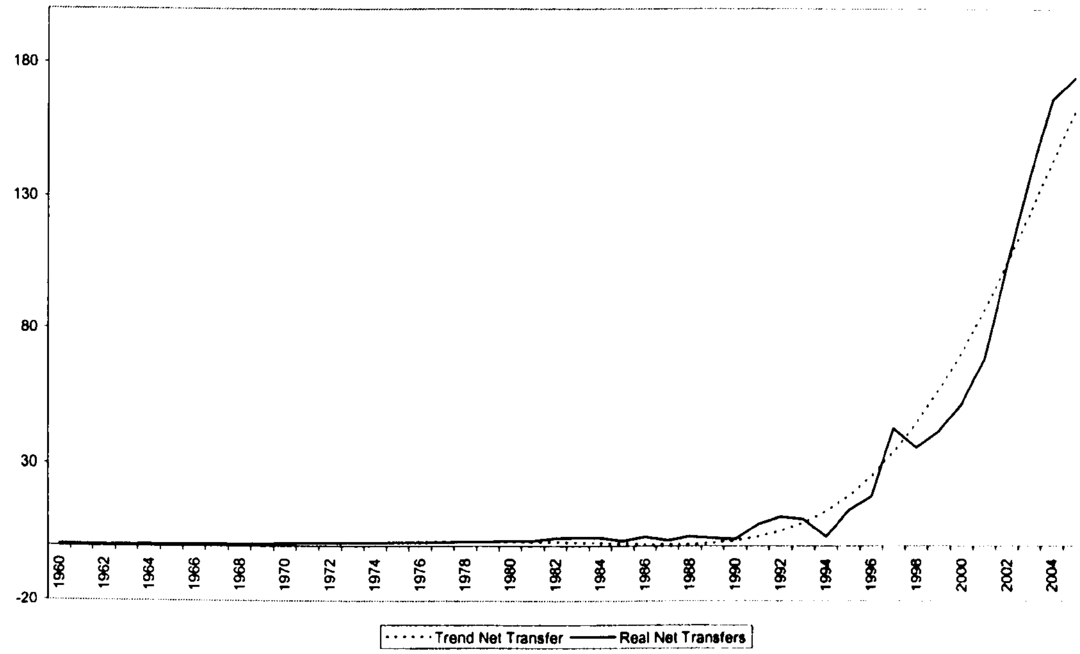
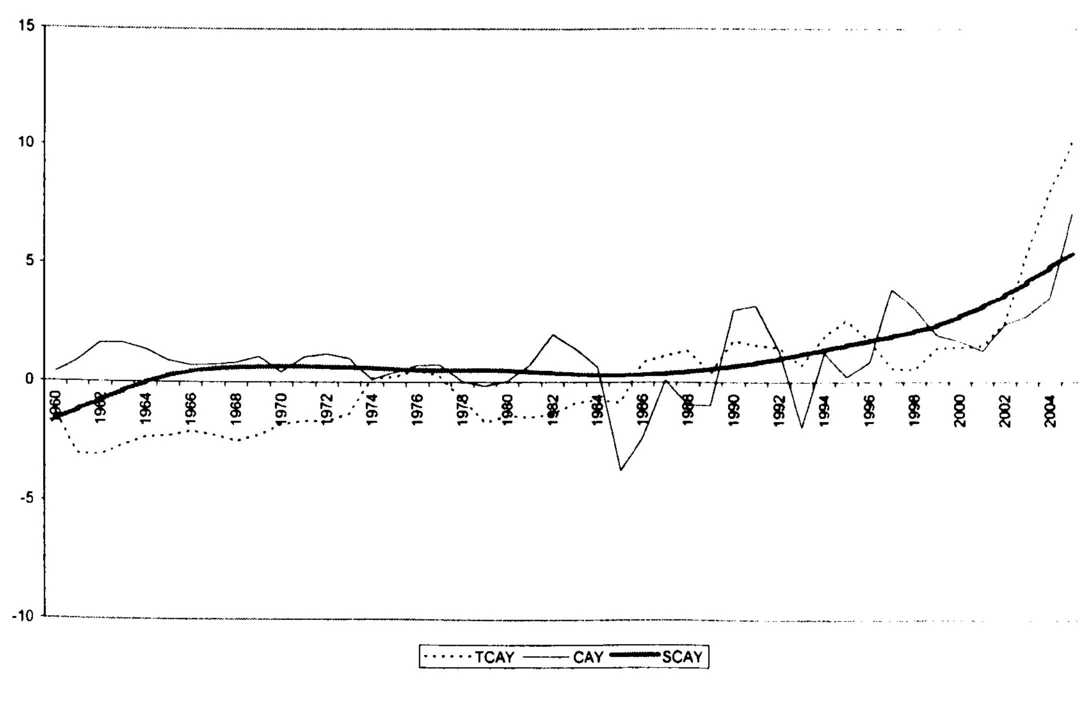


Figure 6.6. Trend (TCAY), Sustainable (SCAY) and Actual (CAY) Current Account (as a percentage of GDP)



6.3.2. Sustainable Current Account

The sustainable current account is estimated based on equation (6.9) using the Johansen cointegration method[20]. Due to the large number of fundamentals, we adopted the same strategy as in Chapter 5, i.e. keeping the core variables (productivity, dependency ratio, financial liberalisation) in all equations and dropping the ones that were not significant. Regarding the lag length of VAR, we started with maximum lag of 3 and tested downward using the AIC. For all experiments, VAR (1, 1) was chosen. In terms of choosing the number of cointegrating vectors (CVs), Johansen cointegration estimations often suggest two CV at 5% and one CV at 1% using the trace statistic and one CV at both 5% and 1% using the max-eiganvalue statistic. We rely on max-eigenvalue statistic as Banerjee et al. (1986, 1993) suggest that the max-eigenvalue statistic is more reliable in small samples. The results of the Johansen cointegration estimations are shown in Table 6.5.

For all three equations in Table 6.5, the max-eigenvalue statistic suggests one CV at both 1% and 5%. The adjustment factors are all negative and significant at 1%, implying the long-run stability of the equations. All coefficients are significant at 5% except RRC1 in equation A which is significant at 10%. In each equation, most of the fundamentals have expected signs. In all three cases, the world real interest rate (USR) is wrongly signed and highly significant. However, sustainable current account computed based on coefficients in equation B and C are abnormally low during the 1960s and high after 2000 compared with the actual values[21]. This may due to the relative large constants in equations B and C. Therefore, we decide to compute sustainable current account based on equation A.

[20] Given that the current account/GDP ratio (CAY) contains negative values, we can not take the logarithms. Hence the sustainable current account equation is estimated in linear form.

[21] For instance, based on equation C, the sustainable current account is -19.4% of GDP in 1960 and 14.0% of GDP in 2005.

Table 6.5. Johansen Cointegration Results for the Sustainable Current Account[22]

	Hypothesized No. of CE(s)	Trace Statistic	5 % Critical Value	1% Critical Value	p-value	Max-Eigen Statistic	5% Critical Value	1% Critical Value	p-value
Equation A	None	158.75*	125.62	135.97	0.0001	60.27*	46.23	52.31	0.0009
	At most 1	98.48*	95.75	104.96	0.0320	30.59	40.08	45.87	0.3861
Equation B	None	252.38*	197.37	210.05	0.0000	86.24*	58.43	65.00	0.0000
	At most 1	166.14*	159.53	171.09	0.0207	47.07	52.36	58.67	0.1575
Equation C	None	123.37*	97.75	104.96	0.0002	55.74*	40.08	45.87	0.0004
	At most 1	67.63	69.82	77.82	0.0738	26.99	33.88	39.37	0.2636

Normalized cointegrating coefficients (std.err. in parentheses)

Equation A	CAY	TFP1	CREP	DEP	RULC	RRC1	USR	C		
	1.0000	-1.1628	0.1680	0.1719	-2.5394	-0.0969	0.3577	-7.57		
		(0.1924)	(0.0287)	(0.0461)	(0.4967)	(0.0590)	(0.0776)			
	Adjustment coefficient (std.err. in parentheses)									
	D(CAY)	-0.5769								
		(0.1449)								
Equation B	CAY	TFP1	CREP	DEP	RULC	B1	USR	GI	TAX1	C
	1.0000	-2.8700	0.4888	0.4096	-2.4482	0.1718	0.4563	-0.1458	-0.5901	-36.3745
		(0.3256)	(0.0469)	(0.1444)	(1.0146)	(0.0675)	(0.1532)	(0.0457)	(0.1469)	
	Adjustment coefficient (std.err. in parentheses)									
	D(CAY)	-0.2226								
		(0.0759)								
Equation C	CAY	TFP1	CREP	DEP	RULC	USR	C			
	1.0000	1.9087	0.2829	0.2617	-3.3964	0.5969	-12.4563			
		(0.3245)	(0.0438)	(0.0782)	(0.8348)	(0.1343)				
	Adjustment coefficient (std.err. in parentheses)									
	D(CAY)	-0.3619								
		(0.0899)								

Note: "*" denotes rejection of the hypothesis at the 5% level. Critical values are taken from MacKinnon *et al* (1999).

[22] When we incorporated TFP2 instead of TFP1, we also found one significant CV for most of the combinations, the adjustment factors were also negative and statistically significant and most of the fundamentals were significant and correctly signed. However, sustainable current account relative to GDP based on coefficients estimated using TFP2 turned to be positive before the mid-1980s and negative after that, which is the opposite of the actual current account. Therefore we only reported cointegrating results based on TFP1.

Equation A

$$CAY=1.1628TFP1 - 0.1680CREP - 0.1719DEP + 2.5394RULC + 0.0969RRC1 -0.3577USR + 7.57$$

In equation A, all coefficients are significant at 5% significance level (except RRC1 at 10%). Though RRC1 and USR are wrongly signed, the core variables, namely TFP1, CREP, DEP and RULC, are all correctly signed and highly significant.

Based on the coefficients in equation A and HP-filtered fundamentals[23] we obtain the sustainable current account (SCAY). This is plotted against the actual (CAY) and trend (TCAY) current accounts, all measured as a percentage of real GDP, in Figure 6.6. Overall, SCAY has been stable though there are some shifts for certain periods. It was negative until 1964 and has been positive since 1965. For the period 1965-1992, the SCAY was very stable within 1% of GDP. Since 1993, it has been increasing, though gradually from 1% to 5.5%. Compared with the CAY, the SCAY is much smoother with the former varying around the latter. However, the volatility of the gap between these two CAYs has been relatively higher during 1986-2005 compared with that during 1960-1985. Compared with the TCAY, the SCAY was higher during the period 1961-1985, and then became smaller for most of the years in the period 1986-2005. Such a relationship between TCAY and SCAY suggests that depreciation and appreciation of the RMB were needed during the periods 1960-1985 and 1986-2005 respectively to match TCAY with the SCAY.

6.3.3. FEER and Misalignments

The trend current account was estimated by treating the real exchange rate as exogenous. However, the real exchange rate must move to clear the balance of payments and simultaneously drive the trend current account to match the sustainable current account. The third step is to calculate the FEER that delivers this match. As TCAY is a function of FEER and SCAY is known, we could solve for the FEER by equating TCAY to SCAY. The relationship between TCAY and SCAY plotted in Figure 6.6 implies that the RMB was overvalued for the period 1960-1985 (except 1961) and undervalued for most of the years during the period 1986-2005. Figure 6.7 plots the FEER that matches the TCAY with the SCAY against the actual real exchange rate and Figure 6.8 exhibits the misalignment rates. Table 6.6 summarises the findings on misalignment rates[24].

Table 6.6. Summary of Findings—FEER for Real Bilateral CNY/USD Rate

1960-1985 (Overvaluation occurred in 24 out of 26 years (except 1960 and 1976) with an AMR of 24%)		1986-2005 (Undervaluation occurred in 12 out of 20 years with an AMR of 5%)		
1960-1973[25] (Fixed nominal exchange rate)	1974-1985 (small adjustments of nominal exchange rate)	1986-1996[26] (large depreciation of nominal exchange rate)	1997-2002 (Fixed nominal exchange rate)	2003-2005 (Fixed nominal exchange rate)
There were relatively large MRs in this period. AMR for this period was 34% with the peak MR at 39% in 1969.	In this early post-reform period MRs were relative smaller. AMR for this period was 12% with peak MR at 26% in 1979.	There were 9 out of 11 years of undervaluation. AMR for this period was 4% with the peak MR at 6% in 1988.	There were 6 years of consecutive overvaluation. AMR for this period was 6% with the peak MR at 7% in 1998.	There were 3 years of consecutive undervaluation. AMR for this period was 10% with the peak MR at 14% in 2005.

Note: AMR and MR refer to average misalignment rate and misalignment rate respectively.

[23] Follow BDW (2006), we apply HP-filter to the all fundamentals that determine the sustainable current account.

[24] ADF tests show that the misalignment rates in Figure 6.8 are stationary at 10%.

[25] The nominal exchange rate has been fixed from 1960-1971. In 1972 and 1973 the nominal rate adjusted slightly. We broadly include 1972 and 1973 into the fixed nominal exchange rate period.

[26] Fixed nominal exchange rate oaf CNY/USD starts from 1994 but here for convenience we regard 1986-1996 as a period of large depreciation of RMB.

Figure 6.7. FEER and Actual Real Bilateral CNY/USD Exchange Rate

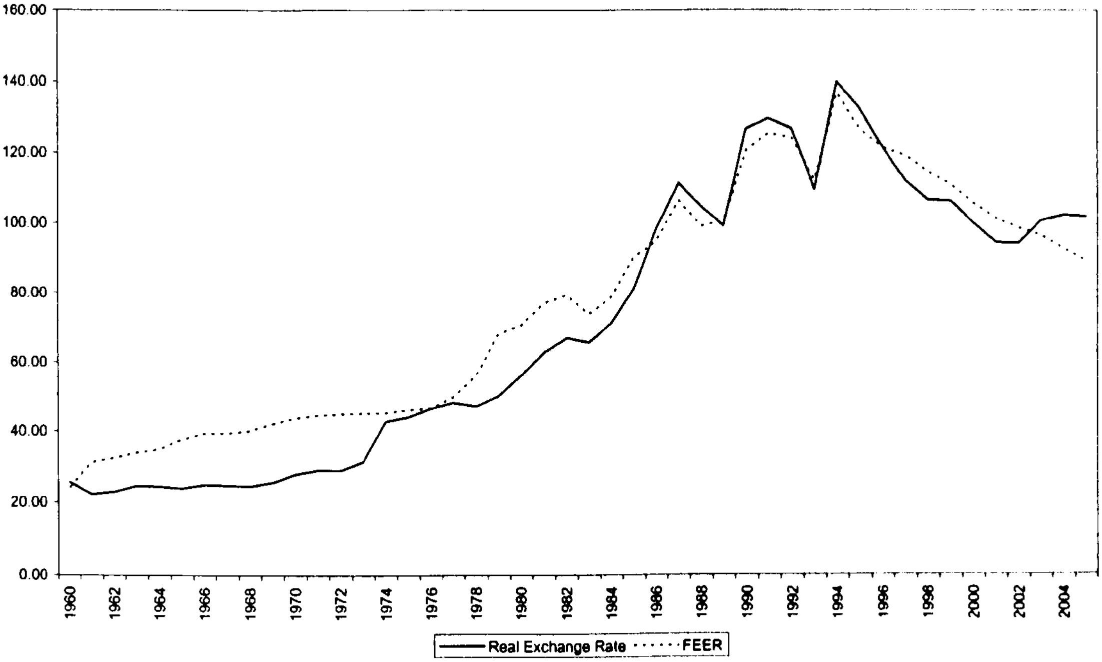
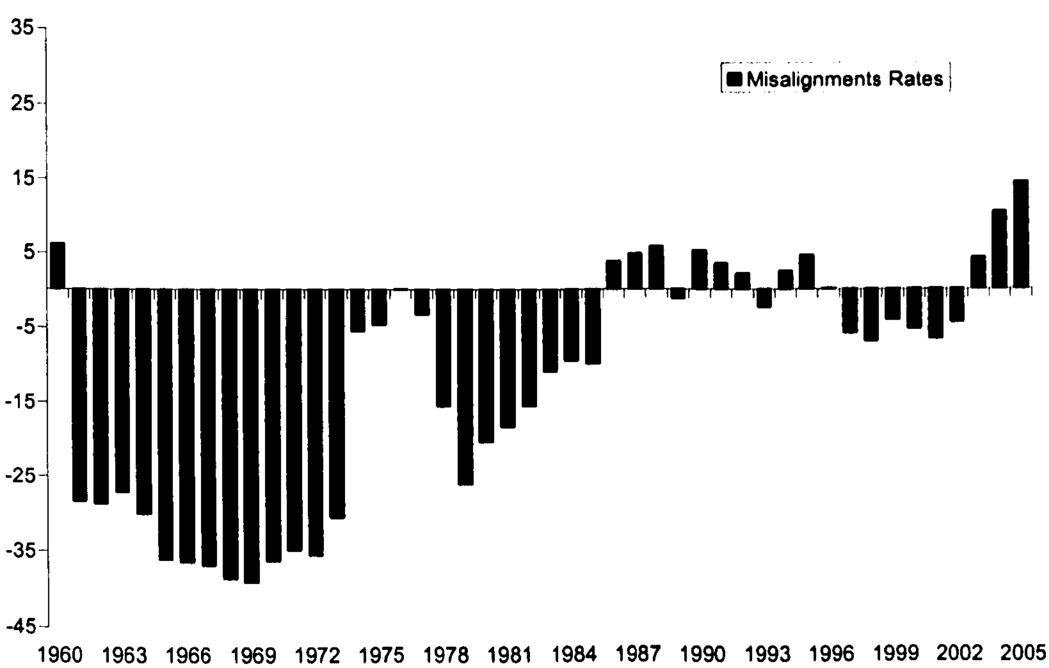


Figure 6.8. Misalignment Rates between Actual Real Bilateral Exchange Rate and FEER (%)



Note: Misalignment rate=(E-FEER)/FEER*100%; a positive (negative) misalignment rate implies an undervaluation (overvaluation) of the RMB. E denotes the real bilateral CNY/USD rate (equation 6.1).

During the pre- and early post-reform period, the comparison between FEER and the actual real bilateral CNY/USD exchange rate suggest that the RMB had been persistently overvalued. From 1960 to 1985, in 24 out of 26 years, the real bilateral CNY/USD exchange rate was lower than the FEER. The misalignment rates show that the RMB was on average overvalued by 24% and with its peak undervaluation of 39% in 1969[27]. However, the overvaluation had been less severe towards the end of pre- and beginning of post-reform period 1974-1985 when there had been some adjustment in the nominal exchange rate of CNY/USD by the Chinese government. The average overvaluation during 1974-1985 was 12% compared with 34% during 1960-1973.

During the post-reform period 1986-2005, in 12 out of 20 years the real exchange rate was above the FEER. The misalignment rates suggest the RMB was undervalued at an average rate of 5%. The other 8 years of overvaluation were with an average rate of 5% as well. Compared with the persistent overvaluation period 1961-1985, misalignment rates in this period were not only spread on both sides of under and overvaluation, but also much more modest. We further divided this period into 3 sub-periods: 1) 1986-1996, undervaluation; 2) 1997-2002, overvaluation; 3) 2003-2005, undervaluation. This general picture is drawn by the relationship between TCAY and SCAY that is determined by fundamentals. It coincides with the development of exchange rate policies in China and the US, which we explain below.

During 1986-1996, the USD had been depreciating against major currencies following the Plaza Agreement in 1985. Meanwhile, the Chinese government depreciated RMB by increasing the nominal exchange rate of CNY against the USD several times. The comparison between FEER and the real bilateral CNY/USD rate suggests that the

[27] Other two years of undervaluation occurred in 1960 and 1976 at 6% and 0.1% respectively.

RMB had been undervalued in 9 out of 11 years at an average rate of 4%. The undervaluation could have been more severe had the difference between the nominal and real exchange rates, i.e., the ratio of world export prices to domestic GDP price deflator (equation 6.1), not been reduced owning to a faster growth in the domestic GDP price deflator.

The overvaluation during the period 1997-2002 was related to the appreciation of the USD and a fixed nominal exchange rate of CNY/USD. There had been 6 years of consecutive overvaluation at an average rate of 6% with its peak rate of 7% in 1998. Meanwhile, the ratio of world export prices to the domestic GDP price deflator kept on falling due to the decline of the former and the rise of the latter, which may has also contributed to the overvaluation.

During 2003-2005, it is interesting to notice that not only RMB had been undervalued, but also that there was an upward trend in this undervaluation. The average undervaluation was 10% with a peak of 14% in 2005. Undervaluation in this period was related to the depreciation of the USD against major currencies and a fixed nominal rate of CNY/USD. At the same time the ratio of world export prices to the domestic GDP price deflator had been relatively stable.

Generally speaking, based on the analysis of FEER and the real bilateral CNY/USD rate, our results suggest that the RMB had been persistently and largely overvalued for the period 1960-1985 and undervalued during 1986-2005 except in 1997-2002. The misalignment rates during 1986-2005 have been generally moderate in relation to findings by previous studies. However, there was an increasing trend of undervaluation in the last three years (2003-2005) of the sample period.

We compare our study with Zhang (2001), one of the few studies of bilateral real exchange rate of China that covered both post- and pre-reform periods (1954-1997).

Based on the BEER model, Zhang (2001) finds relative large overvaluation before 1978 and the real exchange rate is general in line with the BEER after 1978. Our results suggest a similar picture, only the overvaluation in our study is more persistent, from 1961 until 1985. In addition, from 1986 to 1997, the real exchange rate in our study also fluctuates around the FEER within the modest misalignment band of ±6%.

For the period 1998-2005, which was not covered by Zhang (2001), we compare our results with the literature analysing the real bilateral CNY/USD exchange rate for the post-reform period. Most of recent studies suggest undervaluation of the RMB, though with various magnitudes[28]. The average magnitude of undervaluation we found for the period 1986-2005 is much smaller than most of existing studies (i.e. 44-54% in year 2003 by Coudert and Couharde (2007); 36-45% in year 2000 by Frankel (2005); 47% in 2003 by Bénassy-Quéré et al. (2004)).

Now we compare our study with other applications of FEER to China (Table 6.7). We notice that, despite the different measures of the exchange rate used, the trend current account estimates (measured as a percentage of GDP) are quite similar across these studies (within the band of 2-4%); the differences in undervaluation stem from the differences in the sustainable current account estimates (measured as a percentage of GDP) from -2.8% to +3.1%. Basically, the wider the gap between trend and sustainable current account, the larger is the misalignment. The trend current account in our study is similar with existing studies for same years. However, our study suggests a much smaller misalignment than Jeong and Mazier (2003) and Coudert and Couharde (2007), implying a smaller gap between trend and sustainable current account. We believe our estimates of the sustainable current account, which is based

[28]Please refer to Chapter 2 for a review of some of these papers.

on fundamentals that capture the unique features of the Chinese economy that have not been employed by other studies, are more realistic than these of previous papers (see our discussion in Section 6.1).

We also compare our FEER estimates with the NATREX estimates for the real bilateral rate in Chapter 5. For the period 1960-1985, HPNATREX suggests undervaluation occurred in most years, but the misalignment was within 6%. For the same period, the FEER for the real bilateral exchange rate suggests persistent and large overvaluation. During 1986-2005, HPNATREX suggests undervaluation (except in 1994), though within 6%. The FEER suggests overvaluation within 7% during 1997-2002, but for the rest of the period (i.e. 1986-1996 and 2003-2005) the FEER suggests modest undervaluation of less than 15%. The misalignment rates based on

Table 6.7. Misalignments and Choice of Sustainable Current Account—FEER

Study	Exchange Rate	Trend Current Account (as a % of GDP)	Sustainable Current Account (as a % of GDP)	Results
Wang (2004)	REER	2.1 in 2000-2002	(1) 3.10%; (2)0.98%	(1) Modestly overvalued; (2) Modestly undervalued
Wren-Lewis (2004a)	NER	3.4% in 2002	(1) 1%; (2) 0%	(1) 20% undervalued (2) 28% undervalued
Jeong and Mazier (2003)	REER NER	2-4% in 1997-2000[29]	-1%— -1.5%	REER: 33% undervalued NER: 60% undervalued
Coudert and Couharde (2007)	RER	n.a.	(1) -2.8%; (2) -1.5%	(1) 57% undervalued (2) 44% undervalued
Our Study	RER	2.53% in 2002 1.85% in 2000-2002[30]	3.7% in 2002 3.2% in 2000-2002	4% overvalued in 2002 6% overvalued in 2000-2002

Note: NRE, RER, and REER refer to nominal bilateral CNY/USD exchange rate, real bilateral CNY/USD exchange rate and real effective exchange rate.

FEER are more similar to these based on HPNATREX for the real effective exchange rate in Chapter 5 which finds overall overvaluation before 1985 and overall undervaluation afterwards. Both show an increasing trend of undervaluation in the last

[29] The sample period of Jeong and Mazier (2003) is 1982-2000. However, before 1996, the trend current account was relatively volatile, varying between -4%—4% and hence is not included here.
[30] Average of 2000-2002.

years of the sample period, though both with modest magnitude of within 15% which is lower that what suggested by most of the previous studies.

The differences between FEER and NATREX estimates of the real bilateral exchange rate could be due to the different models used and different measurements of the real exchange rate[31]. Furthermore, looking at the cointegrating equations for the NATREX (Table 5.7), the adjustment factors are statistically insignificant in all equations apart from in equation E. But even in equation E it is significant at only 10%. Turning to the cointegrating equations of the FEER (Tables 6.2 and 6.5), all adjustment factors are highly significant even at 1%. Moreover, the constant in equation E in Table 5.7 is relatively large, while these in Tables 6.2 and 6.5 are much smaller. Therefore, the econometric estimates of the NATREX for the real exchange rate are not as good as those of the FEER for the real exchange rate. In addition, we have also constructed the root mean squared error (RMSE) for both FEER and NATREX estimates of the real bilateral exchange rate to evaluate which set of estimates performs better in tracking the actual bilateral exchange rate. For the whole sample period 1960-2005, the RMSE is larger for the FEER (71.63) than that for the NATREX (28.33); however, for the post reform period 1978-2005, the RMSE is smaller for the FEER (15.82) than for the NATREX (24.44). We further computed the RMSE for other post-reform periods (e.g. 1984-2005, 1990-2005, 1994-2005), and again we found much smaller RMSE for the FEER estimates of the real bilateral exchange rate.

In contrast, the overall pattern of the misalignments produced by the FEER model is very similar to that produced by the HPNATREX for the real effective exchange rate and also to that produced by most previous studies. Therefore, we are inclined to

[31] To obtain the real bilateral exchange rate, the relative prices used in the FEER model are world export prices and China's domestic GDP price deflator, whilst the relative prices used in the NATREX model are US domestic GDP price deflator and China's domestic GDP price deflator.

believe that misalignments suggested by FEER are more reliable than those suggested by the NATREX for the real bilateral exchange rate.

6.4. Conclusions

This chapter provides an application of the FEER model, based on the partial equilibrium approach, to the real bilateral exchange rate of the Chinese Yuan against the US Dollar. It is the first FEER application that covers both the pre and post-reform periods. The first contribution of this chapter is that we incorporate into the sustainable current account fundamentals that reflect the unique feature of the Chinese economy but have not been employed by existing studies. The second contribution is the construction of a unique data set of consistent time series. The data set consists of time series of a range of economic fundamentals and trade-related variables, which allow us to carry out econometric investigation of sustainable and trend current accounts for both pre- and post-reform periods. Based on the trend and sustainable current accounts we compute the FEER that closes the gap between them and then we calculate the misalignments.

The main findings of this chapter can be summarised as follows. First, we found one cointegrating vector for each trade equation and for the sustainable current account equation. Second, in the estimation of the trend current account we found: 1) the export volume equation suggests that the increase in China's export volume is due mainly to improvements in its price competitiveness; 2) the import volume equation suggests that China's demand for imports is more income elastic than price elastic; 3) the Marshall-Lerner condition holds in China, meaning currency devaluation (revaluation) can improve (deteriorate) the trade balance; 4) both trade price equations imply China's trade prices are mainly determined by world trade prices, suggesting exogenous terms of trade for China.

Third, in the estimation of the sustainable current account, we found: 1) the significant fundamental determinants in the cointegrating relationship are total factor productivity, dependency ratio, financial liberalisation, relative unit labour cost, relative rate of return to capital and world real interest rate; 2) the estimated sustainable current account (measured as a percentage of GDP) is negative until 1964, positive but very stable within 1% during 1965-1992, positive and increasing gradually from 1% to 5.5% during 1993-2005.

Fourth, comparing FEER and the actual real bilateral exchange rate, we found that the RMB had been persistently overvalued for the period 1961-1985, with the misalignment rates during 1961-1973 significantly larger than that during 1974-1985. During the period 1986-2005, the RMB had been undervalued for 12 out of 20 years. However, the misalignment rates were rather modest (within a band of ±7%), except for the last three years 2003-2005. During 1986-1996, the RMB was undervalued but with an average misalignment rate of only 4%. The most interesting results are those for the last 9 years. During 1997-2002, when there was appreciation of the USD against major currencies and the CNY was fixed against the USD, the RMB had been overvalued, albeit at a modest average misalignment rate of 6%. For the period 2003-2005, when the CNY was still fixed against the USD, we found the RMB has been consistently undervalued, at an average rate of 10%. What is more, there had been an increasing trend of undervaluation in those 3 years, with the severest undervaluation occurring in 2005 at 14%, the highest amongst all years in the post-reform period. Nevertheless, the overall undervaluation, especially in the last 3 years, is not as large as suggested by some previous studies.

Appendix 6.A. The Export/Import Prices and Export/Import Volume Equations

Export Volume and Import Volume Equations

Following the traditional demand curve approach, BDW(2006) model the trade volume as a function of total demand and competitiveness

$$X = (WT, XCOM) \tag{6.10}$$

$$M = (Y, MCOM) \tag{6.11}$$

where X, WT, $XCOM$, M, Y and $MCOM$ denote the domestic export volume, world export volume, export competitiveness, domestic import volume, real domestic output and import competitiveness. As all prices are in USD except the domestic output price of China (P), we convert them into CNY by using the nominal exchange rate index (N). The export competitiveness ($XCOM$) is measured as the world export prices over the domestic export prices and the import competitiveness ($MCOM$) is measured as the domestic import prices over domestic output price. The real export (RXP) and import (RMP) prices are defined, respectively, as domestic export (XP) and import (MP) prices in domestic currency divided by the domestic output price (P)

$$RXP = (N \times XP)/P \tag{6.12}$$

$$RMP = (N \times MP)/P \tag{6.13}$$

the export and import competitiveness can be rewritten as

$$XCOM = WXP \Big/ XP = N \times \frac{WXP}{P} \Big/ N \times \frac{XP}{P} = E / RXP \tag{6.14}$$

$$MCOM = (N \times MP)/P = RMP \tag{6.15}$$

Therefore, equations (6.10) and (6.11) can be rewritten as

$$X = X(WT, E / RXP) \qquad \textit{export volume equation} \quad (6.2)$$

$$M = M(Y, RMP) \qquad \textit{import volume equation} \quad (6.4)$$

Based on the definition of E, import volume equation (6.4) can be further written as

$$M = M(Y, E/(WXP/MP)) \qquad \textit{import volume equation} \quad (6.4a)$$

Export Prices and Import Prices Equations

BDW (2006) model the trade prices as functions of world export prices, domestic output price and commodity price. Wren-Lewis (2003, 2004a) gives detailed construction of the trade prices

$$N \times XP = \left((N \times WXP)^{\gamma} P^{1-\gamma}\right)^{\alpha} (N \times CXP)^{1-\alpha} \qquad (6.16)$$

$$N \times MP = \left((N \times WXP)^{\phi} P^{1-\phi}\right)^{\beta} (N \times CMP)^{1-\beta} \qquad (6.17)$$

where N, XP, MP, WXP, P, CXP and CMP are, relatively, nominal exchange rate (domestic currency per USD), export prices, import prices, world export prices, domestic output price, commodity export prices and commodity import prices. Dividing both sides of equations (6.16) and (6.17) by P

$$N \times \frac{XP}{P} = \frac{(N \times WXP)^{\alpha\gamma+(1-\alpha)}}{P^{\alpha\gamma+(1-\alpha)}} \times \frac{(N \times CXP)^{1-\alpha}}{(N \times WXP)^{1-\alpha}} \qquad (6.18)$$

$$N \times \frac{MP}{P} = \frac{(N \times WXP)^{\beta\phi+(1-\beta)}}{P^{\beta\phi+(1-\beta)}} \times \frac{(N \times CMP)^{1-\beta}}{(N \times WXP)^{1-\beta}} \qquad (6.19)$$

Based on the definition of the real exchange rate ($E = N \times \frac{WXP}{P}$), equations (6.18) and (6.19) can be rewritten as

$$RXP = (E, RCXP) \qquad \textit{real export prices equation} \quad (6.3)$$

$$RMP = (E, RCMP) \qquad \textit{real import prices equation} \quad (6.5)$$

where RXP, RMP, $RCXP$ and $RCMP$ are real export prices, real import prices, real commodity export prices (commodity export prices/world export prices) and real commodity import prices (commodity import prices/world export prices) respectively.

Appendix 6.B. The Sustainable Current Account

Recall the saving and investment functions in Chapter 4

$$s = y(k;TFP) + r'F - C(k,F;CREP,DEP) = S(\underset{+}{k},\underset{-}{F};\underset{+}{TFP},\underset{+}{r'},\underset{-}{CREP},\underset{-}{DEP}) \quad (4.3)^{32}$$

$$I = I(I_{DPI}, GI, FDI) = I(\underset{+}{k},\underset{+}{F};\underset{+}{TFP},\underset{-}{c},\underset{+}{GI},\underset{-}{RULC},\underset{+}{RRC}) \quad (4.7)$$

where k, F, TFP, r', $CREP$, DEP, c, GI, $RULC$ and RRC are, respectively, capital stock per effective labour, net foreign assets per effective labour, total factor productivity, real world's interest rate (approximated by US real interest rate), financial liberalisation, dependency ratio, user cost of capital, government investment/total fixed assets investment, relative unit labour cost and relative rate of return to capital.

Based on equations (4.3), (4.7), (4.4)[33] and (4.19) the current account per effective labour can be written as

$$CA = S - I = CA(k,F;TFP,CREP,DEP,RULC,RRC,r',B,\tau,GI) \quad (6.20)$$

where B denotes relative price of capital (p_k) to price of output (p): $B = p_k/p$.

Therefore, current account/GDP ratio (CAY) can be written as a function of capital stock/GDP ratio (KY), net foreign assets/GDP ratio (FY) and the fundamentals (Z)

$$CAY = CAY(KY,FY;Z)$$

$$\text{where } Z = (TFP,CREP,DEP,RULC,RRC,r',B,\tau,GI,) \quad (6.21)$$

As discussed by Wren-Lewis (2004a), in the framework of FEER, the economy is not in stock equilibrium, but it is in flow equilibrium. Aggregate stock wealth may be changing and hence the medium-term sustainable current account need not be zero.

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[32] Due to large number of fundamentals, we do not further divide total factor productivity (TFP) into net factor productivity (NFP) and rural transformation (RT) as in chapter 5.

[33] The depreciation rate in equation (4.4) δ, is assumed to be a constant. See Chapter 4.

However, the two stock variables themselves are determined by fundamentals (see Chapter 4)

$$kY = (Z) \tag{6.22}$$

$$FY = (Z) \tag{6.23}$$

Equations (6.22) and (6.23) imply that capital and net foreign assets in relation to GDP evolve over time in the directions that are indicated by changes in economic fundaments. Therefore, equation (6.21) can be rewritten as

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

$$\text{where } Z = (\underset{+}{TFP}, \underset{-}{CREP}, \underset{-}{DEP}, \underset{+}{RULC}, \underset{-}{RRC}, \underset{+}{r'}, \underset{+}{B}, \underset{+}{\tau}, \underset{-}{GI},) \tag{6.9}$$

Equation (6.9) implies that the sustainable current account/GDP ratio is purely determined by economic fundamentals. As evolutions in fundamentals take place over time, sustainable current account evolves in a way that is consistent with the effects of changes in fundamentals. Now we are going to discuss the individual effect of each fundamental on the sustainable current account.

Total Factor Productivity

On the one hand, higher total factor productivity stimulates investment; whereas on the other hand, higher total factor productivity increases output and hence savings. As there is not only new investment but also progress in productivity, we assume here that higher total factor productivity will have a larger positive effect on savings than on investment, and, therefore a positive effect on sustainable current account.

Dependency Ratio and Financial Liberalisation

Dependency ratio is defined as the ratio of pre-working (age under 15) population to total employed persons. A higher dependency ratio implies more consumption and less savings which indicates a negative effect on the sustainable current account.

Financial liberalisation is measured by the ratio of total credit to the private sector to GDP. Higher financial liberalisation implies an easier access to credit to finance current consumption with future income. Therefore, higher financial liberalisation leads to lower savings and has a negative effect on sustainable current account.

Relative Unit Labour Cost and Relative Rate of Return to Capital

Higher relative unit labour cost discourages FDI to China. With savings unchanged, the higher relative unit labour cost has a positive effect on the sustainable current account. On the contrary, higher relative rate of return to capital to the US encourage FDI to China and hence has a negative effect on sustainable current account.

Relative Price of Capital to Output and Taxation Rate

Both higher relative price of capital to output and taxation rate lead to higher user cost of capital and consequently discourage domestic investment. Lower investment, with savings unchanged, implies a higher sustainable current account. Therefore, both fundamentals have positive effect on sustainable current account.

Government Investment

Higher government investment leads to higher aggregate investment and hence lower sustainable current account.

World Real Interest Rate

A higher world real interest rate leads to a higher interest income as we regard China as a net creditor. A higher world real interest rate also increases the user cost of capital which discourages investment. Both will have a positive effective on current account.

Appendix 6.C. Data Sources and Variable Measurement

The main data sources for this chapter are the *China Statistical Yearbook* (*CSY*) (mainly *CSY 2006*), the *International Financial Statistics* (*IFS*), and the *United Nations Conference on Trade and Development* (*UNCTAD*). The data span is 1960-2005. All indices are with year 2000 as their base year (2000=100) unless stated. Domestic currency refers to the Chinese Yuan (CNY). Data are collected for China unless stated. Fundamentals (in equation (6.9)) that have been discussed in the data section in Chapter 5 (Section 5.2) are not repeated here.

1. Nominal Exchange Rate (N)

The nominal exchange rate of CNY per USD is collected from *IFS* (line 924.RF.ZF). It is then converted into an index.

2. World Export Price (WXP)

The world export prices index (unit value of world export) (in USD) is collected from *IFS* (line 74. DZF).

3. GDP Price Deflator (P) and Real Output (Y)

See Chapter 5 (Sections 5.2.2 and 5.2.3).

4. The Real Exchange Rate (E)

The real exchange rate is defined in equation (6.1) as the nominal exchange rate times world export prices and divided by the GDP price deflator.

5. Export and Import Values

Data are collected from *IFS* (lines 70.DZF and 71.DZF) (in USD) and then converted into domestic currency using the nominal exchange rate N.

6. Export (XP) and Import (MP) Prices

The construction of export and import prices indices (in USD) is discussed in Chapter 5 (Section 5.2.14). For later usage, we convert the export and import prices indices into domestic currency using the nominal exchange rate index.

7. Export (X) and Import (M) Volumes

By dividing export and import values by export and import prices indices (all in domestic currency) respectively and multiplying by 100, we obtain the export and import values in constant prices.

8. Real Export (RXP) and Import (RMP) Prices

The real export and import prices indices are defined as the export and import prices indices in domestic currency divided by domestic GDP price deflator and multiplied by 100.

9. World Export Volume (WT)

World export volume is derived by dividing world export value by world export prices index and multiplying by 100. World export value (in USD) is collected from *IFS* (line 70.DZF).

11. Commodity Export (CXP) and Import (CMP) Prices

In BDW (2006), the commodity export prices is defined as a weighted average of the following commodity prices: oil prices, world food prices, world beverage prices, world agricultural non food prices, and world metals and minerals prices, with the weights based on the relevant shares of world commodity exports and imports in total trade. *UNCTAD* provides price indices for a) all food (which includes i) beverages ii) vegetable oil seeds and oils iii) agriculture raw materials), b) mineral, ores and metals, c) crude petroleum (average of Dubai/Brent/Texas equally weighted ($/barrel))[34]. *UNCTAD* also provides price of all food which includes the first 3 categories.

Since 1980, *CSY* provides disaggregated trade data. Trade in commodity is disaggregated into a) food and live animals chiefly for food, b) beverages and tobacco, c) animal and vegetable oils, d) fats and waxes non-edible raw materials mineral fuels, e) lubricants and related materials. By dividing trade value of each category by sum of the five categories gives the share of each category. However, data before 1980 is not available.

UNCTAD also provides shares of 4 categories, which are a) all food (includes food, beverages and vegetable oil seeds and oils), b) agricultural raw materials, c) mineral, ores and metals, d) crude petroleum, for some developed countries and developing areas that goes back to 1960. One of the areas covered by *UNCTAD* is the developing countries: other Asia, which include China. For the period 1960-1979, we will use these shares of developing countries: other Asia[35] from *UNCTAD* to approximate the

[34] Another data source for commodity price is *IFS*, which gives world commodity prices for a) food (line 76EXDZF), b) beverages (line 76DWDZF), c) agricultural raw materials (76BXDZF), d) metals (line 76AYDZF), e) average crude petroleum prices (line 76AADZF). In our study we use *UNCTAD* data to obtain consistency as we use shares of each category provided by *UNCTAD* to approximate that of China for years prior to 1980 (see the following sections). We compared prices data from *UNCTAD* and *IFS*, for the same category, prices from these two data sources are very close.

[35] We used shares of developing countries: other Asia to approximate the shares of China for two reasons. First, China is included in the group of developing countries: other Asia. Second, compared with shares of other countries or regions provided by *UNCTAD*, developing countries: other Asia have

shares for China. The matching between shares reported by *CSY* and *UNCTAD* is shown in Table 6.8.

Table 6.8. Detailed Total Trade Disaggregation of *CSY* and *UNCTAD*

Disaggregation of *CSY*			Disaggregation of *UNCTAD*	
Primary Goods	All Food	Food and Live Animals Chiefly for Food	All Food	Primary Goods
		Beverages and Tobacco		
		Animal and Vegetable Oils, Fats and Waxes		
	Non-edible Raw Materials		Minerals, Ores and Metals	
			Agricultural Raw Materials	
	Mineral Fuels, Lubricants and Related Materials		Crude petroleum	
Manufactured Goods			Manufactured Goods	

For years prior to 1980, we apply adjustment factor to shares collected from *UNCTAD*. For each category, the adjustment factor is defined as the 23 years (1980-2002) average[36] of China's shares from *CSY* divided by same 23 years average of shares from *UNCTAD*. Then original shares from *UNCTAD* before 1980 is multiplied by the adjustment factor, hence called the "adjusted shares", to obtain the approximations of shares for China. The adjusted shares are then normalised so that the sum of them of each year is 100%. Therefore, for the years prior to 1980, shares

shares that are closest to shares of China for the period 1980-2005. The only exception is import of fuel. USSA has the closest import shares of fuel compared with China for the years after 1980 and hence we use import shares of fuels of USSA to approximate that of China.

[36] We used 23 years average instead of 3 years average because for some categories, though shares from *UNCTAD* and *CSY* are close and have similar overall tendencies and turning points, data from these two sources for the first three overlapping years (1980-1982) might be more different compared with the overall similarity.

of China are approximated by adjusted shares from *UNCTAD* and for the period 1980-2005, the shares are obtained from data provided by *CSY.*

After obtaining the normalised shares, the commodity export and import prices are calculated as

Commodity Export Price Index = normalised export shares of all food * prices of all food + normalised export shares of mineral, ores and metals * prices of mineral, ores and metals + normalised export shares of agriculture materials * prices of agriculture materials + normalised export shares of crude petroleum * prices of crude petroleum.

(6.24)

Commodity Import Price index = normalised import shares of all food * prices of all food + normalised import shares of mineral, ores and metals * prices of mineral, ores and metals + normalised import shares of agriculture materials * prices of agriculture materials + normalised import shares of crude petroleum * prices of crude petroleum.

(6.25)

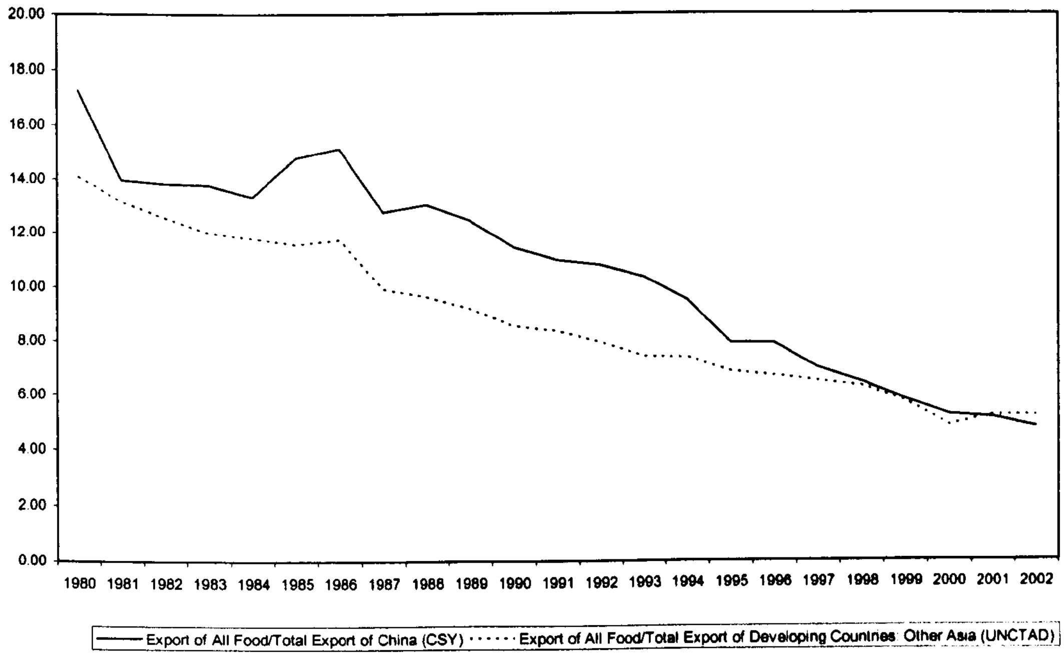
In the following section, we will introduce the detailed procedure of constructing the "adjusted shares" for the period 1960-1979.

11.1. Export Shares

11.1.1. Export Shares of All Food

For the years before 1980, the shares of all food export/total export of China[37] is approximated by the adjusted shares of all food export/total export of developing countries: other Asia from *UNCTAD*. Both shares for the period 1980-2002 are plotted in Figure 6.9. As we can see both series have the same trend and share most turning points. The correlation coefficient between these two series is 0.96.

Figure 6.9. Export Shares of All Food



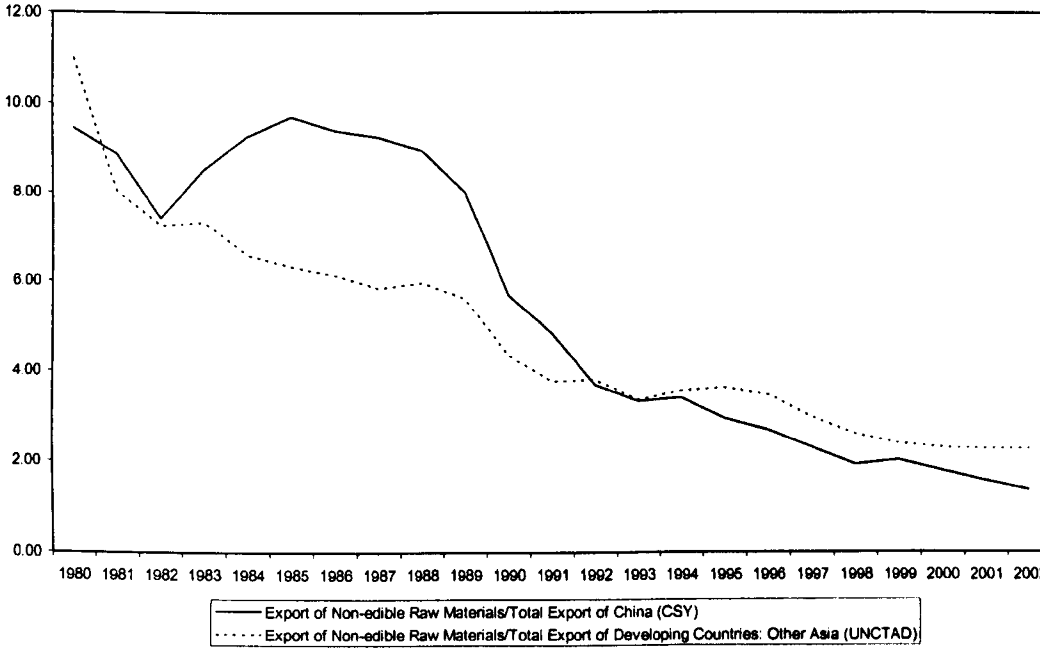
11.1.2. Export Shares of Non-Edible Raw Materials

Export of b) agricultural raw materials and c) mineral, ores and metals together from *UNCTAD* is equivalent to the non-edible raw materials for China. For the years before 1980, the export of non-edible raw materials/total export of China is approximated by the adjusted share of exports of (b+c) /total export of developing countries: other Asia (*UNCTAD*). Both shares for the period 1980-2002 are plotted in Figure 6.10. As we can see both series have the same trend and share turning points. The correlation coefficient between these two series is 0.87.

We need individual export shares of b) agricultural raw materials and c) mineral, ores and metals for the whole period 1960-2005 when we calculate the commodity export prices. Therefore, for the period 1960-1979, individual export shares of b) and c) are approximated by export shares of developing countries: other Asia (*UNCTAD*). For the period 1980-2005, though export shares of non-edible raw materials are obtained

[37] All good is the sum of a) food and live animals chiefly for food, b) beverages and tobacco, c) animal

Figure 6.10. Export Shares of Non-Edible Raw Materials



from *CSY*, the internal shares of b) and c) are approximated by export shares of developing countries: other Asia (*UNCTAD*).

11.1.3. Export Shares of Mineral Fuels, Lubricants and Related Materials

For the years before 1980, the share of mineral fuels, lubricants and related materials export/total export of China is approximated by the share of crude petroleum export/total export of developing countries: other Asia (*UNCTAD*). Both shares for the period 1980-2002 are plotted in Figure 6.11. As we can see both series have the same trend and shares turning points. The correlation coefficient between these two series is 0.97.

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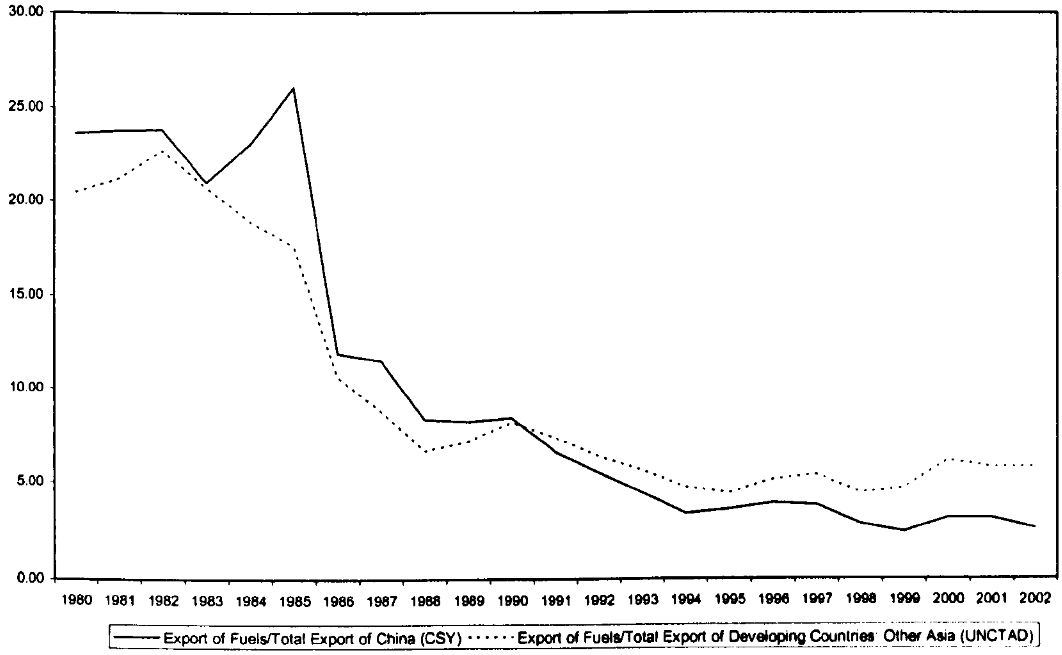
and vegetable oils.

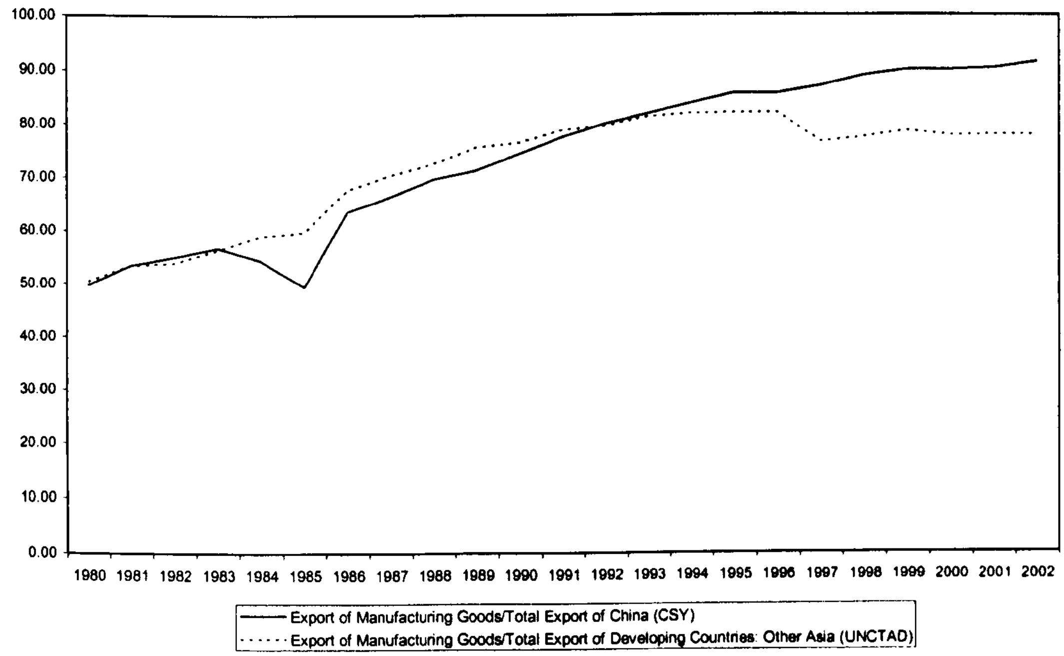
Figure 6.11. Export Shares of Mineral Fuels, Lubricants and Related Materials



11.1.4. Export Shares of Manufacturing Goods

Manufactured goods are not included in the category of commodity goods. Here we construct the export shares of manufacturing goods because we want to construct export shares for all goods for the period 1960-1979 for China and sum them up to see if the sum is close to 100%. If this is so, it is a confirmation of the validity of our approximations. Otherwise it implies problems in the approximation. For the years before 1980, the share of manufacturing goods export/total export of China is approximated by the adjusted share of manufacturing goods export/total export of developing countries: other Asia (*UNCTAD*). Both shares for the period 1980-2002 are plotted in Figure 6.12. As we can see both series have the same trend and shares most turning points. The correlation coefficient between these two series is 0.92.

Figure 6.12. Export Shares of Manufacturing Goods



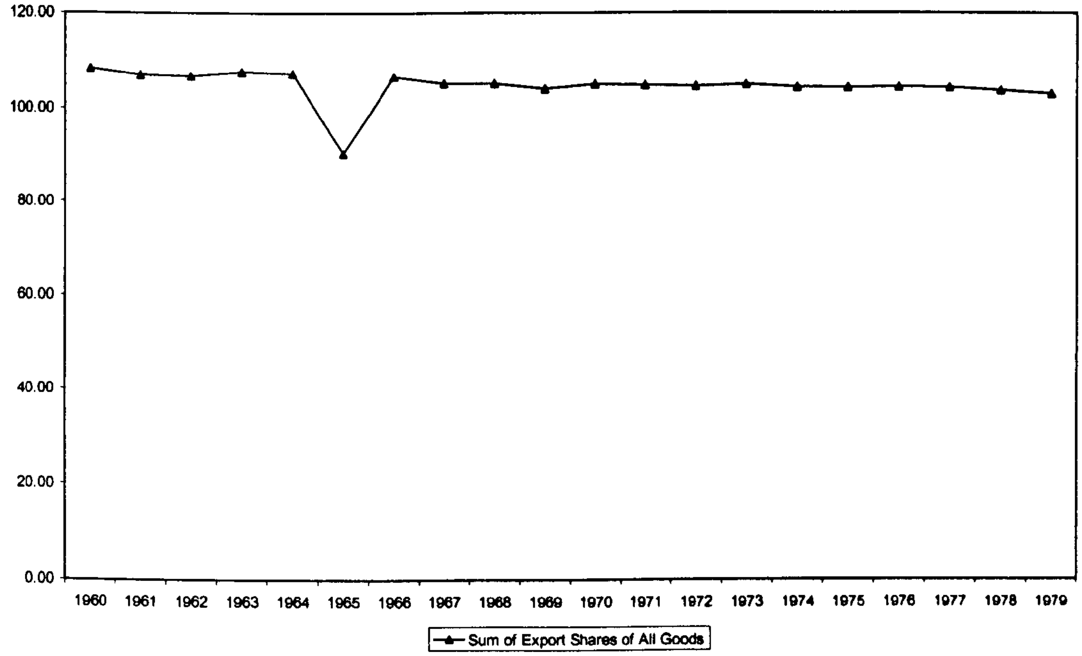
11.1.5. Sum of Export Shares of All Goods

We sum up the export shares of all food, non-edible materials, mineral fuels, lubricants and related materials, and manufactured goods for the period 1960-1979. The sums for all years are slightly higher but very close to 100% (except 1965) (Figure 6.13) with the mean of 104.7%. It confirms the validity of our methods of constructing the export shares for China. After this confirmation, export shares of commodities goods are normalised so that their sum equals 100%.

11.2. Import Shares

For the period 1980-2005, import shares are obtained from *CSY*. For the period 1960-1979, due to data limitation, the import shares are constructed using the same methodology as for the export shares. Hence we do not repeat the detailed procedures here. The correlation coefficients are 0.91 (for the import shares of all food), 0.64 (for import shares of non-edible raw materials), and 0.86 (for imports shares of mineral,

Figure 6.13. Sum of Export Shares of All Goods



fuels, lubricants and related materials). The correlation coefficient is 0.74 for import shares of the manufacturing goods. We sum up the import shares of all food, non-edible materials, mineral fuels, lubricants and related materials, and manufactured goods for the period 1960-1979. The sums for all years are very close to 100% (Figure 6.14) with the mean of 102.3%. This confirms the validity of our methods of constructing the import shares for China. After this confirmation, we then normalise the import shares of the commodities goods so that their sum equals 100%.

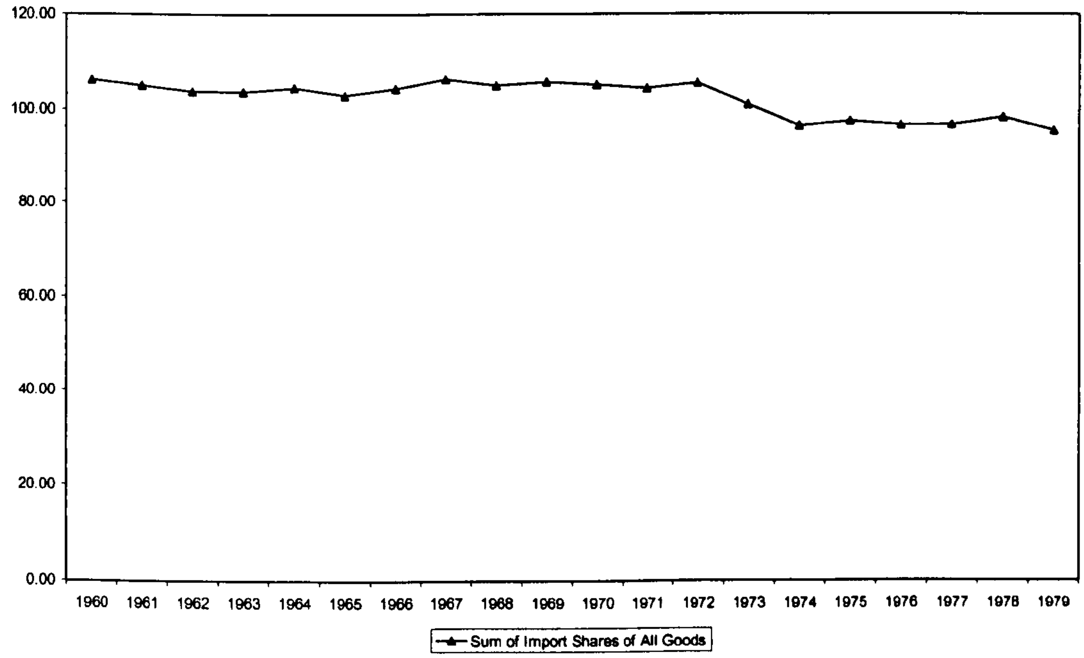
11.3. Commodity Export and Import Prices

Having obtained commodity export and import shares, the commodity export and import prices indices are then calculated using equations (6.24) and (6.25).

12. Real Commodity Export ($RCXP$) and Import Prices ($RCMP$)

They are derived by dividing commodity export and import prices by world export prices index and multiplying by 100.

Figure 6.14. Sum of Import Shares of All Goods



13. World's Real Interest Rate (*USR*)

See Chapter 5 (Section 5.2.20).

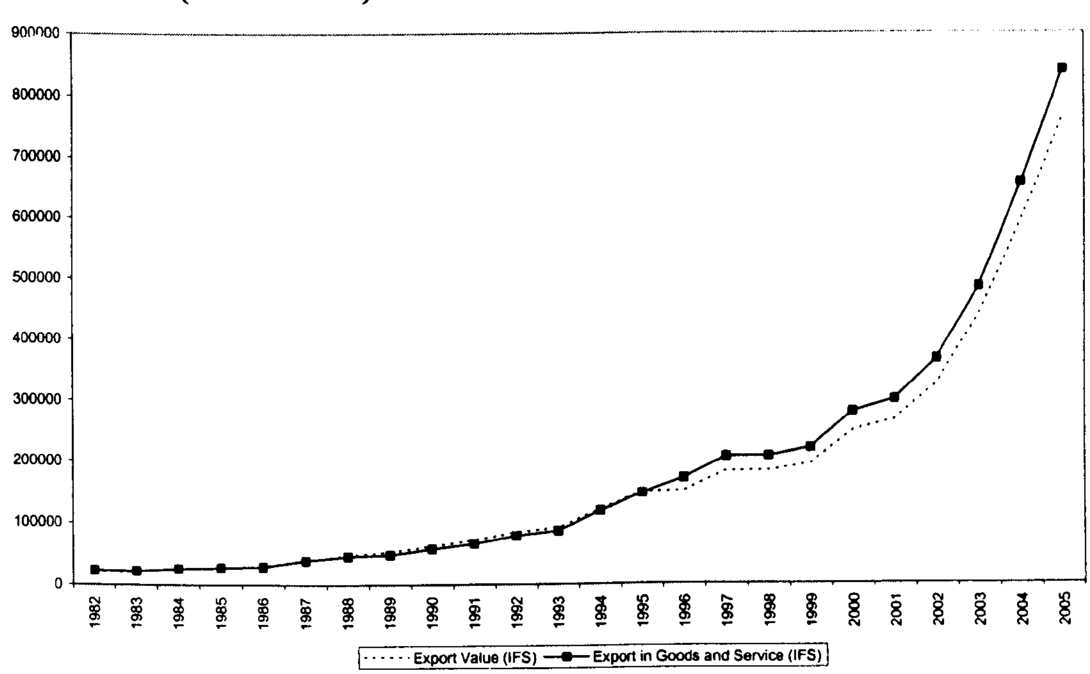
14. Nominal and Real Current Account

Current account is the sum of net trade, net IPD flows and net transfer. *IFS* provides data of current account for China in USD from 1982 to 2005 (line 78ALDZF), while data before 1982 is not available and need to be expressed in an approximation.

14.1. Nominal and Real Net Trade

IFS provides data for goods exports (line 78AADZF), services credit (line 78ADDZF), goods imports (line 78ABDZF) and service debit (78AEDZF) for China from 1982 to 2005 in USD. The sum of the first pair gives exports in goods and service and the sum of the second pair gives imports in goods and services. *IFS* also provides export and import values for China in USD from 1960 to 2005 (lines 70DZF and 71DZF)[38]. We compared export and import values with exports and imports in goods and service for the overlapping period (1980-2005) and found they are very close (Figures 6.15 and 6.16). Hence we construct the adjustment factors based on the three overlapping years of 1982, 1983 and 1984, which are 0.96 and 1.03, and multiply the export and import values before 1982 by the adjustment factors. Therefore, for the period 1960-1981, exports and imports in goods and services are approximated by adjusted export and import values; for the period 1982-2005, actual data are used. Exports and imports are plotted in Figure 6.17. Then the nominal net trade is the gap between the two series and is converted into CNY using the nominal exchange rate N. The real trade balance is obtained by adjusting the nominal value by GDP price deflator.

Figure 6.15. Export Value (IFS) and Exports in Goods and Services (IFS) (Million USD)



[38]According to notes of *IFS*, export and import values cover merchandise trade. Therefore, services are not included in these two series. This explains the gaps between export/import values and export/import in goods and services. However, in the early and mid-1980s, export/import values and export/import in goods and services are almost identical, implying trade in services are negligible. For the years prior to 1982, we expect that trade in service carries even smaller weights due to China is

Figure 6.16. Import Value (IFS) and Imports in Goods and Services (IFS) (Million USD)

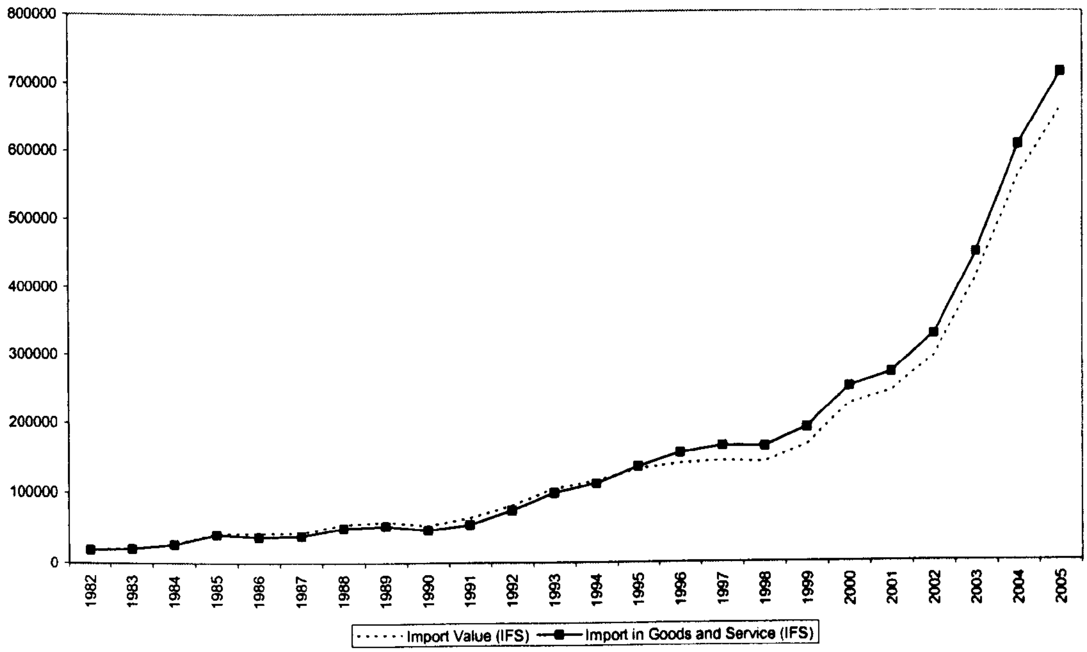
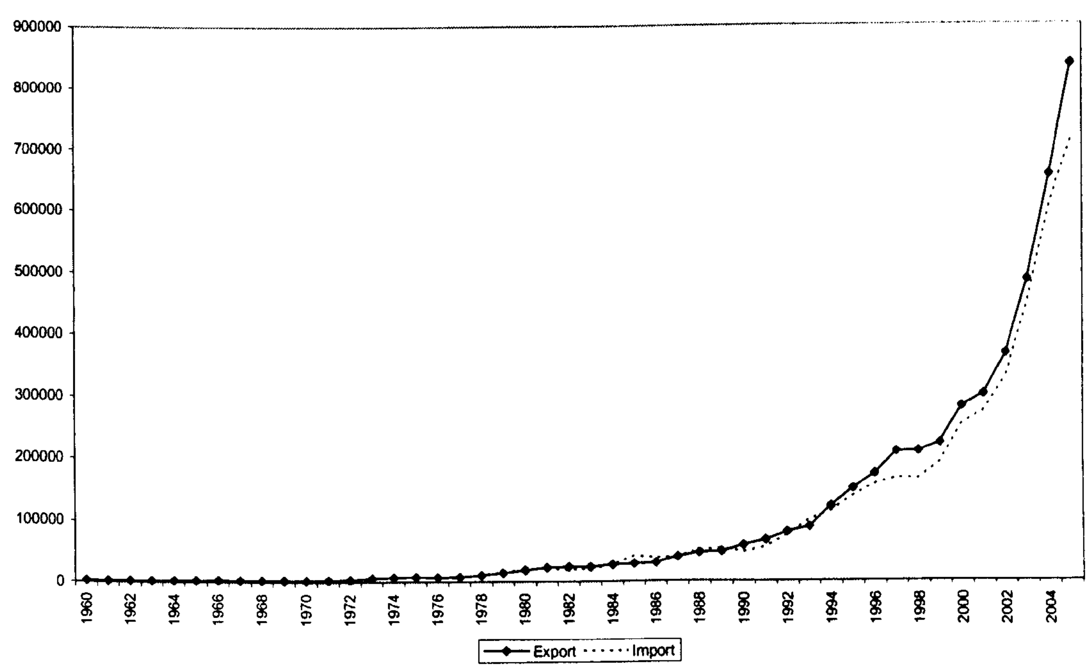


Figure 6.17. Exports and Imports (Million USD)



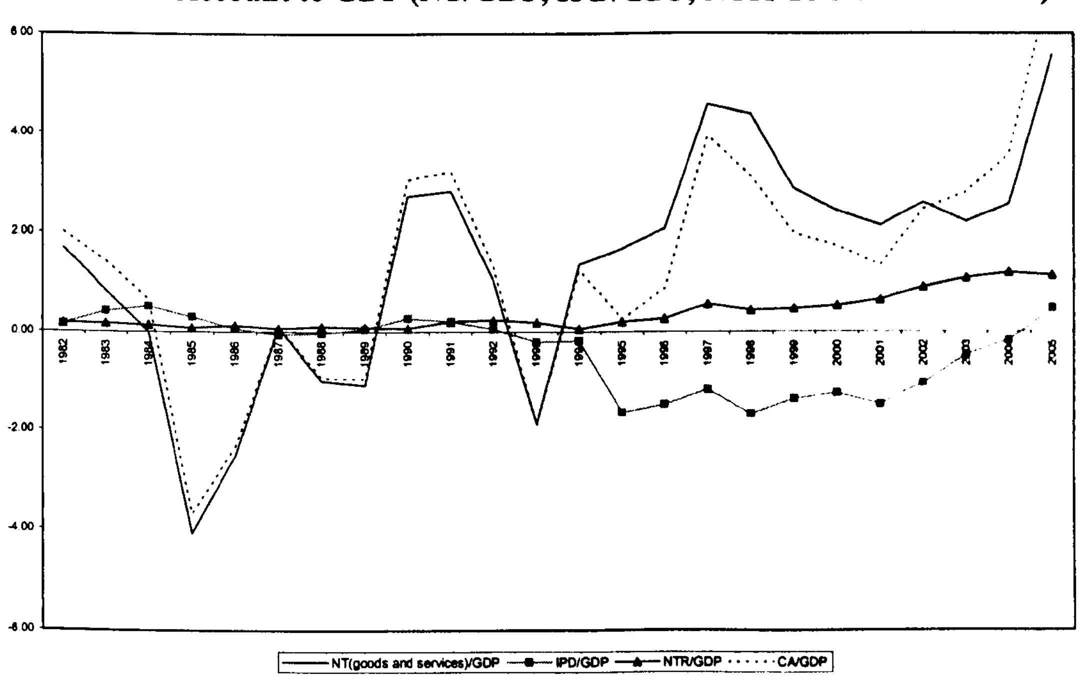
economically more closed. Therefore, during 1960-1982, export/import values are very close

14.2. Nominal and Real Net IPD Flows (*NIPD*) and Net Transfer (*NTR*)

IFS provides IPD credit and debt (lines 78AGDZF and 78AHDZF) and current transfer credit and debt (lines 78AJDZF and 78AKDZF) for China from 1982 to 2005 in USD. The sum of the first pair gives the net IPD flows and that of the second pair gives the net transfer. They are converted into CNY using the nominal exchange rate N.

For the period prior to 1982, data is not available. For the period 1982-2005, when data is available from *IFS*, we convert current account, balance in goods and service (line 78AFDZF), net IPD flows and net transfer into CNY using nominal exchange rate N and then calculate the ratios of current account, balance in goods and service, net IPD flows and net transfer to GDP. The results are illustrated in Figure 6.18.

Figure 6.18. Ratios of Net Trade, Net IPD flow, Net Transfer and Current Account to GDP (NT/GDP, IPD/GDP, NTR/GDP and CA/GDP)



approximations to export/import in goods and services.

Before 1994, on the one hand, the fluctuation of current account/GDP ratio was mainly represented by the net trade/GDP ratio; on the other hand, net IPD/GDP and net transfer/GDP ratios (especially the latter) had very smooth tendencies, fluctuating within the narrow bands of -0.21%-0.51% and 0.06%-0.24% respectively. Based on their relative stable and small ratios, we use the averages of the net IPD/GDP and net transfer/GDP ratios for the period 1982-1994, which are 0.12% and 0.13% respectively, to approximate the ratios before 1982. For years prior 1982, by multiplying the two ratios by GDP we obtain the nominal values of net IPD flows and net transfer in CNY respectively.

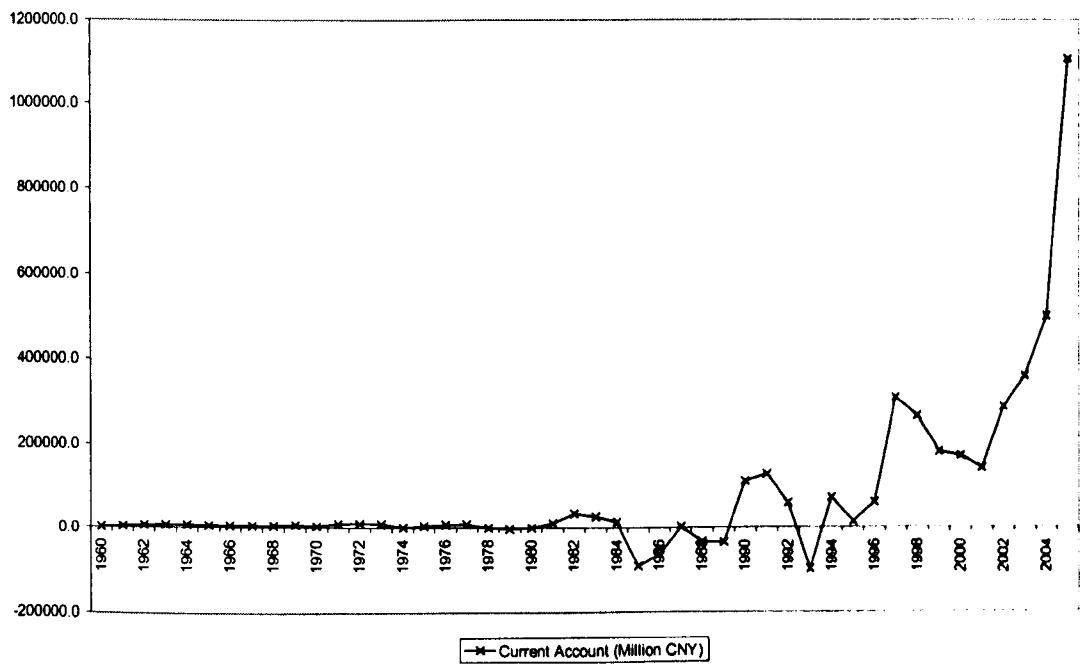
Therefore, nominal net IPD flows and net transfer in CNY prior 1982 are approximated; data after 1982 are collected from *IFS* and converted into CNY using nominal exchange rate N. Real net IPD flows and net transfer in CNY are obtained by adjusting the nominal values by GDP price deflator and they are plotted in Figures 6.5 and 6.6.

14.3. Nominal and Real Current Account

For the period 1982-2005, nominal current account in USD is collected from *IFS* (line 78ALDZF) and is converted into CNY by using the nominal exchange rate N. For the period 1960-1981, the sum of nominal and net trade, net IPD flows and net transfer, all in CNY, gives the nominal current account. The nominal current account in CNY for the period 1960-2005 is plotted in Figure 6.19. As we can see, before 1982, the current account was quite insignificant. This is mainly due to the fact that the main contributor of current account—net trade was relatively low, as both exports and imports were fairly small (Figure 6.21). Since 1982, the scale of current account has increased dramatically, with 5 years of deficit and 6 years of surplus for the period

1982-1993, and 12 years of consecutive surplus since 1994. Especially, the current account has been growing with an average annual growth rate of 78.6% for the period 2002-2005. The real current account is derived by adjusting the nominal current account (in CNY) by the GDP price deflator.

Figure 6.19. Nominal Current Account (Million CNY)



15. Real Current Account/GDP Ratio (CAY)

The real current account/GDP ratio is derived by dividing the real current account (in CNY) by real GDP and then multiplying by 100.

16. Relative Price of Capital to Output (B)

Price indices of capital (p_{K1} and p_{K2}) based on capital series $K1$ and $K2$ are constructed in Chapter 5 (Section 5.2.16). Relative price indices of capital to output are the price of capital adjusted by the price of output and they are referred to as B_1 and B_2.

Chapter 7

An Extended FABEER Model for China: The Nominal CNY/USD Rate in a Multi-Country Model

7.1 Introduction

The existing literature on the equilibrium exchange rate of China often focuses on the real exchange rate[1]. To our knowledge, only three papers examine the equilibrium nominal exchange rate; i.e. Jeong and Mazier (2003), Wren-Lewis (2004a) and Funke and Rahn (2004). The nominal exchange rate is directly observable. It is then adjusted using relative prices to obtain the real exchange rate. However, the problem is that the relative prices themselves vary amongst studies and it is possible that, other things equal, the misalignments could vary due to the adoption of different price indices. Furthermore, it is the nominal exchange rate, rather than the real exchange rate, that is adjusted by the government. Therefore, in this chapter, we provide an evaluation of the equilibrium nominal exchange rate of China to extend the existing literature in two aspects. First, theoretically, the equilibrium nominal exchange rate is modelled along the lines of the Five Area Bilateral Equilibrium Exchange Rate (FABEER) model of Wren-Lewis (2003, 2004a), which has not been applied to China except for one year, 2002, by Wren-Lewis (2004a). We extend the FABEER model from several perspectives to make it applicable to China. Second, while existing studies on the nominal exchange rate of China cover the post-reform period only, we empirically investigate the equilibrium nominal rate for both pre- and post-reform periods.

Typical partial equilibrium models estimate effective exchange rates for each country modelled, and these can then be transformed to recover the bilateral exchange rates.

The FABEER model of Wren-Lewis (2003) works with bilateral normal rates directly. The five areas are the US, Euro area, UK, Japan (referred as major four countries afterwards) and the rest of the world. For each bloc, the model contains trade volume equations and trade prices equations, plus manufacturing trade prices equations. In each case trade is split between exports and imports. Together with an equation for net IPD flows, this provides a complete model of the current account for each bloc, conditional on exogenous inputs for output, commodity prices, interest rates, assets stocks, and of course the exchange rate itself. The model is solved for an equilibrium exchange rate by finding the set of bilateral nominal exchange rates that deliver current accounts compatible with the exogenous assumptions about their sustainable levels. 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. Outside the blocs, there is a residual sector—the rest of the world. At first sight, it may appear as if there is a missing exchange rate in the system: the average rate for this residual sector. However, this rate appears implicitly through rest of the world export prices, which is an endogenous variable along with the model's explicit bilateral rates[2].

Wren-Lewis (2004a) includes China into the FABEER model and estimates the FEER for the nominal bilateral rate of the CNY against the USD for a single year of 2002. In this chapter we extend the FABEER model in the following four perspectives.

(1) Wren-Lewis (2004a) includes China in the FABEER model of the major four countries, with China modelled recursively. Hence movements in the Chinese

[1] Please refer to Chapter 2 for a review of existing studies for China.

economy have no impact on other blocs, based on the assumption that China is a small country. However, the rationale of including China into the group of the major four countries is left unjustified—why China and these four specific economic blocs and not other countries? In our extended FABEER model, China is clearly the country of interest. The criterion for choosing other economic blocs 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[3]. Based on such a criterion, apart from China, 11 other blocs are included in the model: Australia, Canada, Euro area, Hong Kong (China), Japan, Korea, Malaysia, Singapore, Thailand, United States and the United Kingdom (Table 7.1). They account for over 80% of China's total trade with the world.

Table 7.1. 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
Euro Area		11.74
Asia	Hong Kong, China	24.75
	Korea	4.75
	Malaysia	1.19
	Singapore	2.18
	Thailand	1.04
UK		1.61
Australia		1.68
Canada		1.86
Total		82.99

Note: the Euro area includes twelve countries: Austria, Belgium, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain.

(2) Wren-Lewis (2004a) solves the equilibrium exchange rate for China in 2002 by finding the bilateral exchange rate which makes the current account consistent with

[2] For this reason, in the rest of this paper, we will only mention the major four countries (the US, Euro area, UK and Japan) in the FABEER model.

[3] As explained later, we are only interested in the equilibrium bilateral nominal exchange rate of the CNY against USD. Hence, the problem of whether Chinese trade prices and volumes have feedback to the other 11 main trade partners does not arise here.

the sustainable current account. The sustainable current account is assumed to be certain percentage of output. In our study, we model and estimate the sustainable current account as savings minus investment based on individual savings and investment functions for two reasons. First, it allows us to estimate the sustainable current account that is determined by economic fundamentals that reflect the unique features of the Chinese economy. Second, our study investigates the equilibrium exchange rate for China for the long period 1960-2005. Assuming the sustainable current account to be a certain fixed percentage of GDP (as Wren-Lewis (2004a) does) may be plausible for a single year. However, it could be misleading for the whole sample period as the sustainable current account evolves during the sample period, reflecting the evolution of the fundamentals.

(3) In Wren-Lewis (2004a), there is no breakdown of trade values into volumes and prices for China. Also the coefficients in the trade value equations are calibrated rather than estimated. This is partially due to data limitation, but on the other hand using calibrated coefficients has been a standard operation in the FABEER model (Wren-Lewis, 2003, 2004a, 2004b). Though calibrated coefficients are obtained based on existing studies, it is argued by Wren-Lewis (2003) that it could be a limitation of the model. In addition, existing studies often estimate trade coefficients for post-reform period while information for the pre-reform period is limited. In our study, we split trade values into volumes and prices. We therefore construct consistent time series for export/import volumes and prices for China, and all equations are estimated.

(4) The FABEER model delivers bilateral exchange rates for all countries against the USD simultaneously while taking into account the interactions amongst blocs. The predicted import volume and predicted export prices, through which the interactions take place, are computed based on calibrated coefficients. In our study, the country of

interest is China and the objective is to derive the bilateral nominal exchange rate of CNY against the USD that takes into account the trend effect of other blocs on China[4], rather than derive the rates simultaneously for all countries in the group. Based on such an intention, trend current account (including four trade equations) and sustainable current account for China will be estimated, while the predicted import volume and predicted export prices for other blocs will be obtained by applying HP-filter to actual values to avoid the uncertainty arising from calibrated coefficients.

In terms of data, we construct a unique data set of consistent time series for China since 1960. The data base consists of trade-related variables (i.e. export/import prices, export/import volumes, competitiveness, commodity price, real output, domestic price) and economic fundamentals which have not been employed by previous studies. In addition, import volumes and export prices are collected for China's 11 trade partners for the same sample period. Such a data base enables us to estimate the income and price elasticities of China's international trade for both pre- and post-reform period while existing literature covers only the latter period. It also allows us to investigate the evolution of the sustainable current account over the sample period, which is determined by the evolving fundamentals.

The chapter is organised as follows. Section 7.2 sets out the extended FABEER model for China. Section 7.3 presents empirical estimation of the FEER for the nominal bilateral exchange rate and investigates the misalignments. Section 7.4 concludes.

[4] We refer to the "interactions" amongst economic blocs in Wren-Lewis (2003) as "trend effect" of other blocs on China as we are only interested in the equilibrium bilateral nominal exchange of CNY against the USD and hence effect of China on other blocs does not arise here.

7.2. The Extended FABEER Model for China

7.2.1. Trend Current Account

The trend current account consists of full trend trade balance, trend interest profits and dividends (IPD) flows and the trend net transfer. The difference between trend trade balance and full trend trade balance is that the former satisfies the internal balance condition and the latter in addition takes into account the trend effect of China's main trade partners on China.

7.2.1.1. Full Trend Net Trade Balance

In the FABEER model of Wren-Lewis (2003), the export/import volume (X and M), and the export/import prices (XP and MP) of country i are expressed as

$$X_i = (\sum_{i \neq j} M_j, XCOM_i) \Rightarrow X_i = (\sum_{i \neq j} M_j, \frac{\sum_{j \neq i} h_{ij} MXP_j}{MXP_i}) \quad \textit{export volume equation} \quad (7.1)$$

$$XP_i = \left[\left(\sum_{j \neq i} h_{ij} MXP_j \right)^{\gamma} (P_i / N_i)^{1-\gamma} \right]^{\alpha} CXP_i^{1-\alpha} \quad \textit{export prices equation} \quad (7.2)$$

$$M_i = (Y_i, MCOM) \Rightarrow M_i = (Y_i, \frac{MMP_i}{P_i / N_i}) \quad \textit{import volume equation} \quad (7.3)$$

$$MP_i = \left[\left(\sum_{j \neq i} v_{ij} MXP_j \right)^{\phi} (P_i / N_i)^{1-\phi} \right]^{\beta} CMP_i^{1-\beta} \quad \textit{import prices equation} \quad (7.4)$$

where $XCOM$, MXP and CXP denote export competitiveness, manufacturing export prices and commodity export prices; $MCOM$, MMP and CMP are corresponding import variables; Y, P and N are real output, domestic output price and nominal exchange rate (domestic currency per US dollar); α , β, ϕ and γ are parameters. i denotes individual country and j denotes all the other countries except country i.

$\sum_{i \neq j} M_j$ denotes total demand of import volume by other blocs. $\sum_{j \neq i} h_{ij} MXP_j$ and $\sum_{j \neq i} v_{ij} MXP_j$ are the world manufacturing export and import prices respectively, measured as the weighted average of other countries' manufacturing import and export prices. The weights h_{ij} and v_{ij} are derived from manufacturing trade data.

In Wren-Lewis' (2004a), trade for China is separated into manufacturing (differentiated) goods and commodities (identical goods) for year 2002. In our study, given the relatively long data span, 1960-2005, data of manufacturing goods are limited not only for China, but also for some other countries. Hence the trade volume and trade prices equations will be modelled at an aggregate level as in Barisone, Driver and Wren-Lewis (BDW) (2006). Therefore, equations (7.1)-(7.4) can be rewritten as

$$X_i = (\sum_{i \neq j} M_j, XCOM_i) \Rightarrow X_i = (\sum_{i \neq j} M_j, \frac{\sum_{j \neq i} h_{ij} XP_j}{XP_i}) \quad \textit{export volume equation} \quad (7.5)$$

$$XP_i = \left[\left(\sum_{j \neq i} h_{ij} XP_j \right)^{\gamma} (P_i / N_i)^{1-\gamma} \right]^{\alpha} CXP_i^{1-\alpha} \quad \textit{export prices equation} \quad (7.6)$$

$$M_i = (Y_i, MXOM) \Rightarrow M_i = (Y_i, \frac{MP_i}{P_i / N_i})_i \quad \textit{import volume equation} \quad (7.7)$$

$$MP_i = \left[\left(\sum_{j \neq i} v_{ij} XP_j \right)^{\phi} (P_i / N_i)^{1-\phi} \right]^{\beta} CMP_i^{1-\beta} \quad \textit{import prices equation} \quad (7.8)$$

$$NT_i = X_i (\sum_{i \neq j} M_j, \frac{XP_i}{\sum_{j \neq i} h_{ij} XP_j}) XP_i \left[\left(\sum_{j \neq i} h_{ij} XP_j \right)^{\gamma} (P_i / N_i)^{1-\gamma} \right]^{\alpha} CXP_i^{1-\alpha}$$

$$- M_i (Y_i, \frac{MP_i}{P_i / N_i})_i MP_i \left[\left(\sum_{j \neq i} v_{ij} XP_j \right)^{\phi} (P_i / N_i)^{1-\phi} \right]^{\beta} CMP_i^{1-\beta} \quad (7.9)$$

where NT denotes the net trade; i denotes China and j denotes China's 11 main trade partners. Hence N denotes the nominal exchange rate of the Chinese Yuan against the US Dollar (CNY/USD). An increase (decrease) in N indicates a depreciation (appreciation) of the RMB.

Using the estimated coefficients in equations (7.5)-(7.8) 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. 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, HP-filtered rather than actual import volume and export prices of other countries are used. The trend trade balance at this stage allows for the trend effect, hence becomes the full trend trade balance.

7.2.1.2. Trend Current Account

As in Chapter 6 (equations (6.7) and (6.8)), which follows Hristov (2002) and BDW (2006), we regard IPD flows as exogenous while taking into account the effect of exchange rate revaluation and smoothing the series using the HP-filter

$$\overline{IPD} = \left(1 + \frac{FEER - N}{N}\right)\overline{(IPDC - IPDD)} \tag{7.10}$$

with smoothed series denoted by "$\bar{\ }$". However, now the revaluation effect, $\frac{FEER-N}{N}$, is measured in nominal term[5].

The last component of trend current account is the trend net transfer. Following Hristov (2002) and BDW (2006), as in Chapter 6, we regard the net transfer as exogenous and obtain the trend net transfer using the HP-filter. Therefore, the trend current account for China is the sum of full trend net trade, trend IPD flows and trend net transfer.

7.2.2. Sustainable Current Account

For the purpose of estimating the equilibrium nominal bilateral exchange rate of CNY against the USD, we will only model the sustainable current for China. Existing applications of FABEER model (Wren-Lewis, 2003, 2004a, b) employ off-model projections of sustainable current account. In particular, Wren-Lewis (2004b) assumes the sustainable current account for China in 2002 to be 1% or 0% measured as a ratio to GDP. As discussed above, this may be feasible for a single year but could be misleading for a data span of 1960-2005 as the sustainable current account evolves over time. Therefore, we adopt the same method used in Chapter 6 and model the sustainable current account as savings minus investment (equation (6.9)). However, relative variables in equation (6.9) between China and the US are now replaced by effective variables that reflect the relative fundamentals between China and its 11

[5] 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 (7.10) as data on IPD return (or interest rate) and composition of different currencies in assets is not available.

main trade partners. These effective variables include effective unit labour cost and effective interest rate[6]. Therefore, the sustainable current account is determined by

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

$$\text{where } Z = (\underset{+}{TFP}, \underset{-}{CREP}, \underset{-}{DEP}, \underset{+}{ERULC}, \underset{-}{RRC}, \underset{+}{FR}, \underset{+}{B}, \underset{+}{TAX}, \underset{-}{GI},) \tag{7.11}$$

where FR and $ERULC$ are effective foreign interest rate and effective unit labour cost.

7.3 Empirical Results

As in previous chapters, we use Johansen cointegration methods to test for long-run relationships. Before carrying out the cointegration tests, we test for the stationarity of the variables using ADF unit root test with the lag length chosen by the general to specific procedure suggested by Campbell and Perron (1991). The detailed procedures of the ADF and cointegration tests are the same as in Chapter 5.

Based on results in Table 7.2, the ADF test cannot reject the null of a unit root at 1% for all variables. Hence all variable are regarded as nonstationary. ADF tests for the first difference of the nonstationary variables show that all of them are $I(1)$ processes at 1% (except XPCN, CXPCN and CMPCN are at 5%) significance level hence they can enter into a cointegration relationship. The ADF statistics with lags chosen by AIC confirm the results obtained by the general to specific methods.

[6] We would like to construct effective rate of return but it is impossible due to data limitation. Therefore, as in Chapter 5, we use relative return to capital (RRC) in this section instead of effective rate of return to capital. FR and ERULC are the same time series as in Chapter 5. In this chapter, China's main trade partners are Australia, Canada, Euro Area, Hong Kong (China), Japan, Korea, Malaysia, Singapore, Thailand, United States and the United Kingdom. In Chapter 5, they are Australia, Canada, Hong Kong (China), Japan, Korea, Malaysia, Singapore, Thailand, United States and the United Kingdom plus France, Germany, Italy and Netherlands from the Euro area. Therefore, the difference is in that this chapter we include the whole Euro area (including 12 countries) while in Chapter 5 we include 4 countries out of the Euro area. However, if one looks at the sum of the trade weights of the rest 8 countries in the Euro area with China, it is less than 2% (Tables 7.1 and 5.9) and

Table 7.2. Unit Root Tests (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
XCN	3	1.38	0.9986	-3.91	0.0044	3	1.38	0.9986	-3.91	0.0044
WTCN	1	-0.82	0.8030	-4.33	0.0013	2	-0.70	0.8359	-3.67	0.0082
XCOMCN	0	-1.41	0.5689	-7.05	0.0000	1	-2.22	0.2033	-4.68	0.0005
MCN	2	0.79	0.9927	-5.03	0.0002	2	0.79	0.9927	-5.03	0.0002
YCN	2	1.17	0.9975	-6.14	0.0000	2	1.17	0.9975	-6.14	0.0000
MCOMCN	0	-1.06	0.7226	-6.01	0.0000	0	-1.06	0.7226	-6.01	0.0000
XPCN	3	-1.97	0.2976	-3.20	0.0271	3	-1.97	0.2976	-3.20	0.0271
WXPCNh	1	-1.88	0.3405	-3.63	0.0090	1	-1.88	0.3405	-3.63	0.0090
PCN	0	-1.80	0.3745	-5.63	0.0000	1	-1.91	0.3236	-5.63	0.0000
CXPCN	2	-1.23	0.6513	-3.41	0.0163	2	-1.23	0.6513	-3.41	0.0163
MPCN	1	-1.43	0.5575	-3.71	0.0073	1	-1.43	0.5575	-3.71	0.0073
WXPCNv	0	1.68	0.9759	-5.47	0.0000	1	1.60	0.9715	-4.12	0.0001
CMPCN	2	-1.39	0.5805	-3.56	0.0110	2	-1.39	0.5805	-3.56	0.0110
ERULC	0	-1.36	0.5925	-7.03	0.0000	0	-1.36	0.5925	-7.03	0.0000
FR	0	-2.34	0.1634	-6.75	0.0000	0	-2.34	0.1634	-6.75	0.0000

Note: Critical values for 1%, 5% and 10% are -3.57, -2.93 and -2.60 respectively.

As i=China, X_i=XCN=China's export volume to its main trade partners; $\sum_{i \neq j} M_j$ =WTCN=total import volume of China's main trade partners; $XCOM_i$=XCOMCN=export competitiveness of China, M_i=MCN=China's import volume from its main trade partners; Y_i=YCN=real output of China; $MCOM_i$=MCOMCN=import competitiveness of China; XP_i=XPCN=export prices index of China, $\sum_{j \neq i} h_{ij} XP_j$ =WXPCNh=export prices of China's main trade partners in the export prices equation; P_i=PCN=domestic price index (GDP price deflator) of China; CXP_i=CXPCN=commodity export prices index of China; MP_i=MPCN=import prices index of China; $\sum_{j \neq i} v_{ij} XP_j$ =WXPCNv=export prices of China's main trade partner in the import prices equation; CMP_i=CMPCN=commodity import prices of China; ERULC=effective relative unit labour cost; FR= foreign interest rate.
All variables are measured in natural logarithm except FR. The ADF test for other fundamentals is available in Table 6.1 and hence not listed here.

hence is mathematically insignificant. Therefore we believe using FR and ERULC from Chapter 5 will not alter the results.

7.3.1. Full Trend Net Trade Balance

In this section we first estimate the four trade equations for China. A constant and a time trend and/or a dummy are incorporated in equations (7.5)-(7.8)[7]. The export and import volume equations are estimated for the whole sample period (1960-2005). A dummy for 1985 is also introduced in the export volume equation[8]. In terms of the trade prices equations, similar to Chapter 6, freely estimated coefficients of the commodity prices for the whole sample period were implausibly high or low. Hence we had to impose the coefficients. As in Chapter 6, we fixed the coefficients on the commodity prices to the average commodity composition of trade between 1980-2005, which are 0.24 and 0.20 in export and import prices equations respectively. For the export prices equation, as the trend is insignificant, we introduced a dummy for 1972[9] and it yielded significant results. The import prices equation was estimated for the sub-period 1970-2005 and the coefficients on all variables were imposed (with the constant estimated)[10].

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[7]Similar to Chapter 6, when equations (7.5)-(7.8) were estimated without including constants, trends and/or dummies, most of the coefficients in the trade equations were either implausible or statistically insignificant. Therefore, apart from constants, we also considered trends. Some dummies were also introduced to capture the effect of government policies on foreign trade.

[8] On 1st of Jan 1985 the "Dual Exchange Rate System" was abolished by the Chinese government. Therefore, we introduced a dummy for 1985 into the export volume equation to evaluate the effect of this policy change. Since the "Dual Exchange Rate System" was originally designed to stimulate exports, we expect the dummy to be negatively signed.

[9] During the period 1960-1971, the nominal exchange rate of CNY against the USD was fixed. Since 1972, the nominal exchange rate has been adjusted many times, mainly large depreciation against the USD and fixed since 1994. Therefore, we expected that change in the exchange rate policy, mainly from fixed to adjustments and fixed again, would have some impact on the export prices. Therefore we incorporated dummies for 1972 and 1994 while only the former turned out to be significant. It implies that the adjustment of the nominal exchange rate, mainly depreciation against the USD, had a negative effect on (reduces) the export prices that are measured in USD.

[10] For the import prices equation, similar to Chapter 6, there is no significant cointegrating vector when we estimate the whole sample period, with or without trend and/or dummy. Hence, we decided to exclude the turbulent 1960s. We did obtain a significant cointegrating vector for the sample period 1970-2005 but the coefficients were implausible. Hence we decided to impose the coefficients. Following estimation in Chapter 6 (Table 6.4), coefficients of WXPCNv and PCN are imposed to be 0.65 ($=\phi\beta=0.81*0.8$) and 0.15 ($=(1-\phi)\beta=0.19*0.8$) respectively. After these operations, the estimated coefficient on time trend was still not significant. As the average growth rate of real import prices during the period 1980-2005 was 0.002, we imposed the coefficient to be 0.002

In terms of the lag length of VAR, we started with maximum lag of 3 and tested downward using the AIC. For all trade equations, VAR (1, 2) was chosen. Regarding number of significant cointegrating vectors (CVs), we use the 5% significance level as in Chapter 6.

The results of the estimations of the four trade equations are shown in Table 7.3. Max-eigenvalue statistic suggests only one CV at 5% significance level for all four trade equations while trace statistic suggests only one CV at 5% for import volume equations and more than one CVs for all others. We chose the results based on the max-eigenvalue statistic as Banerjee et al. (1986, 1993) suggest that the max-eigenvalue statistic is more reliable in small samples. Therefore, there is one significant cointegrating vector for all four trade equations. The adjustment factors for these trade equations are all negative and significant at 1% (except at 5% for import prices equation), ensuring the stability of all trade equations in the long-run. All estimated coefficients are correctly signed and statistically significant at 5% (except coefficient of domestic price (PCN) in export prices equation at 10%). The coefficients are further summarised in Table 7.4.

In the export volume equation, export competitiveness and the sum of total imports of China's main trade partners (WTCN) have coefficients of 2.02 and 0.87 respectively. It implies that export volume is more responsive to changes in relative prices than changes in foreign demand. On the contrary, import competitiveness and real domestic demand (YCN) have coefficients of -0.30 and 0.61 respectively, suggesting that domestic demand (income) is more important than the relative price in determining import volume. Though the coefficients are different numerically, the results in this section tell the same story as in Chapter 6. However, it is interesting to notice that, in absolute values, all coefficients in this section are higher than in

Table 7.3. Johansen Cointegration Results of Trade Volumes and Prices Equations

	Hypothesized No. of CE(s)	Trace Statistic	5% Critical Value	1% Critical Value	p-value	Max-Eigen Statistic	5 % Critical Value	1% Critical Value	p-value
Export Volume Equation	None	98.81*	69.82	77.82	0.0001	34.47*	33.88	39.37	0.0156
	At most 1	60.89*	47.86	54.68	0.0019	12.04	27.58	32.72	0.0524
Import Volume Equation	None	61.15*	47.86	54.68	0.0018	32.19*	27.58	32.72	0.0122
	At most 1	29.05	29.80	34.46	0.0608	16.50	21.13	25.86	0.1968
Export Prices Equation	None	89.17*	69.82	77.82	0.0007	41.05*	33.88	39.37	0.0059
	At most 1	48.11*	47.86	54.68	0.0047	24.67	27.58	32.72	0.1128
Import Prices Equation	None	93.03*	69.82	77.82	0.0003	40.44*	33.88	39.37	0.0071
	At most 1	52.59*	47.86	54.68	0.0168	21.16	27.58	32.72	0.2667

Normalized cointegrating coefficients (std.err. in parentheses)

Export Volume Equation	XCN	WTCN	XCOMCN	T	D85	C
	1.0000	-0.8718	-2.0195	-0.0905	0.2277	12.1559
		(0.0719)	(0.2259)	(0.0057)	(0.0883)	
	Adjustment coefficient (std.err. in parentheses)					
	D(XCN)	-0.6058				
		(0.1416)				
Import Volume Equation	MCN	YCN	MCOMCN	T	C	
	1.0000	-0.6067	0.2996	-0.0839	-1.8274	
		(0.1824)	(0.1366)	(0.0175)		
	Adjustment coefficients (std.err. in parentheses)					
	D(MCN)	-0.5580				
		(0.1462)				
Export Prices Equation	XPCN	WXPCNh	PCN	CXPCN	D72	C
	1.0000	-0.6663	-0.0937	-0.2400	0.1322	-0.1168
		(0.0525)	(0.0525)	(0.0000)	(0.0521)	
	Adjustment coefficients (std.err. in parentheses)					
	D(XPCN)	-0.4801				
		(0.1612)				
Import Prices Equation	MPCN	WXPCNv	PCN	CMPCN	T	C
	1.0000	-0.6500	-0.1500	-0.2000	-0.0020	0.3194
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	
	Adjustment coefficients (std.err. in parentheses)					
	D(RMP)	-0.1919				
		(0.0866)				

Note: "*" denotes rejection of the hypothesis at the 5% level. Critical values are taken from MacKinnon *et al* (1999).

Table 7.4. Trade Volumes and Prices Equations

Export Volume (XCN)				Import Volume (MCN)		
Trade Partners' Activity (WTCN)	Competitiveness (XCOMCN)	Trend (T)	Dummy (D85)	Domestic Activity (YCN)	Competitiveness (MCOMCN)	Trend (T)
0.87	2.02	0.090	-0.23	0.61	-0.30	0.084

Export prices (XPCN)				Import prices (MPCN)			
Trade Partners (WXPCNh)	Domestic (PCN)	Commodity (CXPCN)	Dummy (D72)	Trade Partners (WXPCNv)	Domestic (PCN)	Commodity (CMPCN)	Trend (T)
0.67	0.09	0.24^F	-0.13	0.65^F	0.15^F	0.20^F	0.002^F

Note: Superscript "F" denotes the parameters are fixed. Dummies (D) are at 1984 and 1972 for export volume and export prices equations respectively. All equations are estimated for 1960-2005 except import prices equation is estimated for 1970-2005.

Chapter 6, especially in the export volume equation. This suggests that the trade relationship between China and its main trade partners is closer than that between China and the world as a whole. Both time trends are positive, 0.090 and 0.084 in export and import volume equations respectively. The dummy for 1985 has the expected negative sign and is highly significant, implying that the abolition of the dual exchange rate system at the beginning of 1985 had a negative effect on China's export[11].

Turning to trade prices equations, as mentioned above, the coefficients of commodity prices are fixed at 0.24 and 0.20 in export and import prices equations respectively. In the export prices equation, the weighted export prices of China's main trade partners (WXPCNh) has a coefficient of 0.67 and the domestic price (PCN) has a coefficient of 0.09. This implies that 88% and 12%[12] of China's export prices is determined by the former and latter respectively, which is similar to the findings in Chapter 6. The dummy for 1972 has the expected negative sign, suggesting the adjustment of the

[11] We did also incorporate dummy at early 1980s in the export volume equation in Chapter 6. It is negatively signed but statistically insignificant.

nominal exchange rate had a negative effect on export prices. In terms of the import prices equation, though it provides less insights as coefficients for all variables apart from constant are imposed, we did find one significant cointegrating vector amongst the variables.

Based on the coefficients in Table 7.4 and the actual values of variables, we obtain the predicted trade volumes and prices and hence the predicted exports and imports, which are depicted in Figures 7.1 and 7.2. Then we impose the internal balance condition to derive the trend net trade of China. However, such trend net trade does not allow for the trend effect of China's main trade partners on China. Therefore, the final step is to allow for such effect by applying the smoothed import volume and export prices of China's trade partners into the trend net trade. Thus we obtain the full trend net trade. These three series of net trade are plotted against the actual net trade in Figure 7.3.

Looking at the predicted and actual exports (Figure 7.1), they followed each other quite closely with the former higher than the latter before 1985. The reverse was observed after 1985. A similar pattern emerged for predicted and actual imports (Figure 7.2), though the deviations were slightly wider. The predicted and trend net trade (Figure 7.3) were very close (almost overlapping). The predicted, trend and full trend net trade were close to the actual net trade before the early 1980s. Since the mid-1980s, they were higher than the actual net trade for most of the years, especially after the end of 1990s.

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[12] 88%=0.67/(0.67+0.09)*100%; 12%=0.09/(0.67+0.09)*100%.

Figure 7.1. Predicted and Actual Exports (Million USD) (in Natural Log)[13]

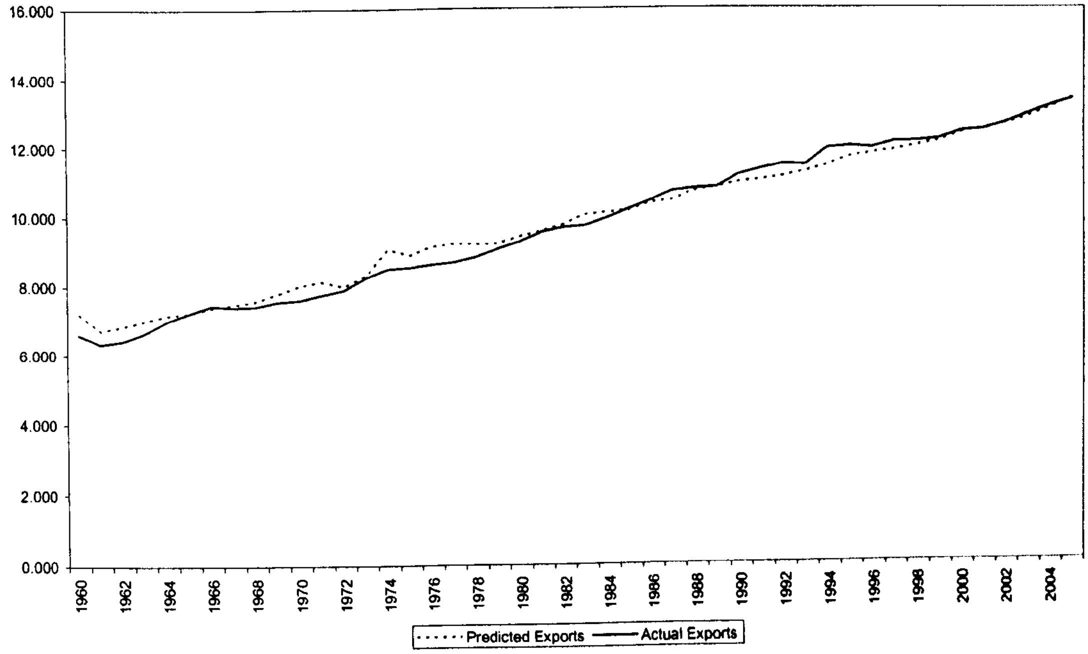
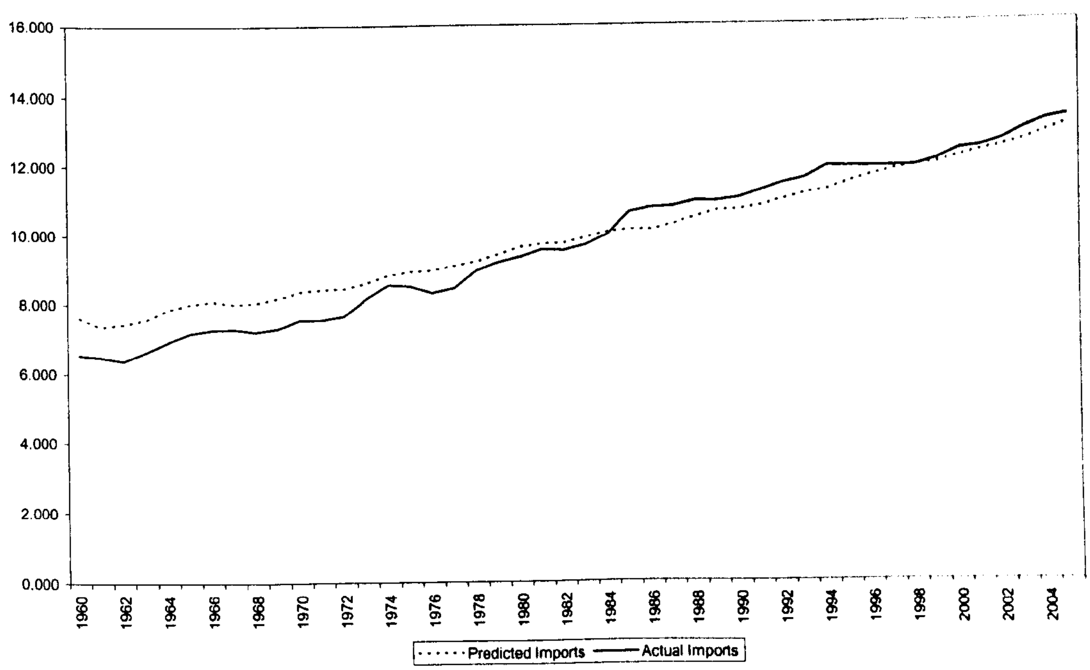


Figure 7.2. Predicted and Actual Imports (Million USD) (in Natural Log)



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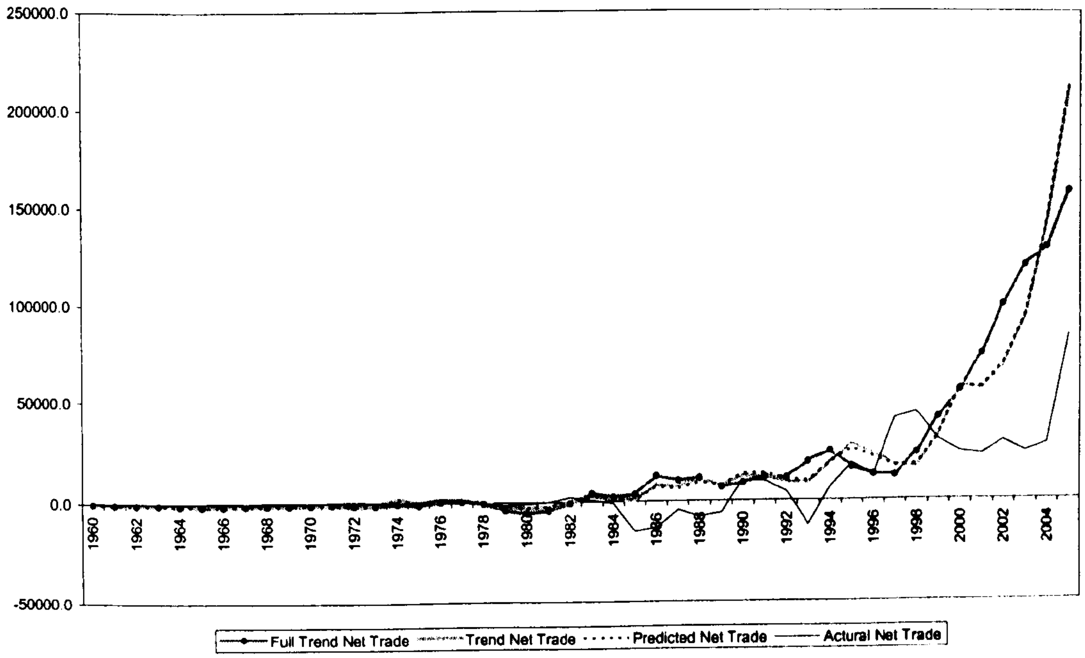
13 Predicted Exports in constant prices= (Predicted Export Volume*Predicted Export Prices)/100; Predicted Imports in constant prices= (Predicted Import Volume*Predicted Import Prices)/100.

Figure 7.3. Predicted, Trend, Full Trend and Actual Net Trade (Million USD)



7.3.2. Trend Current Account

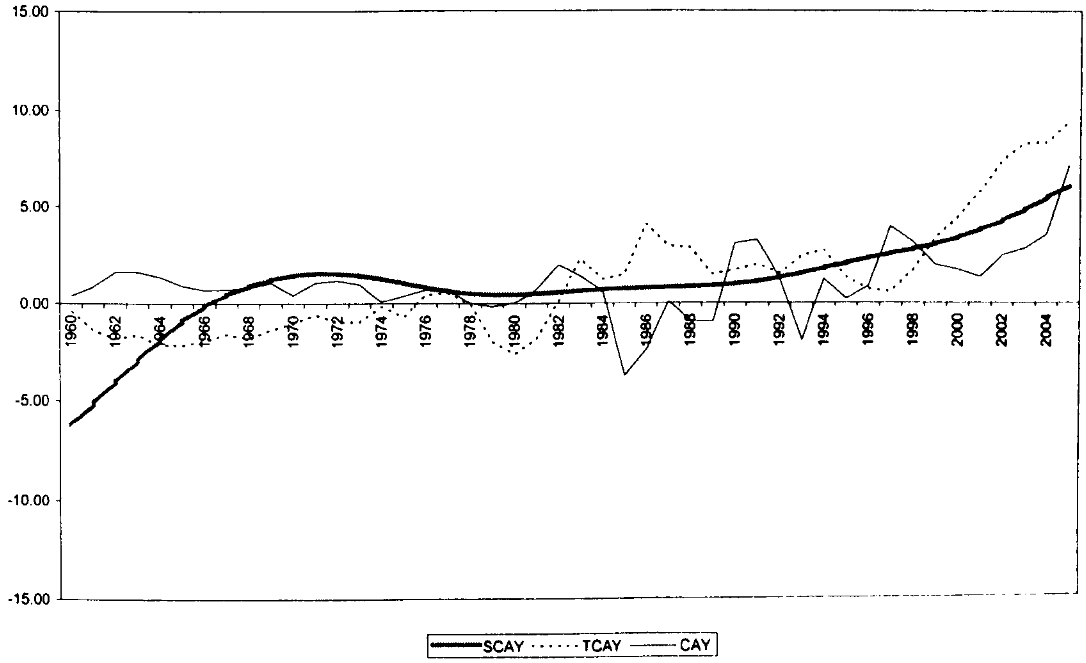
The trend current account is the sum of the full trend net trade, trend IPD flows and trend net trade. The last two components are obtained by using the same methods as in Chapter 6. The trend current account is shown against the actual current account, both measured as a percentage of GDP, in Figure 7.4. The trend current account stayed below the actual current account until 1982. The opposite pattern was observed since 1999, with the trend current account rising dramatically and much faster than the actual current account. During the rest of the period the two series were quite close apart from a comparatively large divergence in the mid-1980s.

7.3.3. Sustainable Current Account

The sustainable current account is estimated based on equation (7.11) using Johansen cointegration methods[14]. Again due to the large number of fundamentals, we adopted

[14] Given that the current account/GDP ratio (CAY), contains negative values, we can not take the logarithms. Hence the sustainable current account equation is estimated in linear form.

Figure 7.4. Sustainable (SCAY), Trend (TCAY) and Actual (CAY) Current Account (as a percentage of GDP)



the same strategy as in Chapter 5, i.e. keeping the core variables (productivity, dependency ratio, financial liberalisation) in all equations and dropping the ones that are not significant. In terms of the lag length of VAR, we started with maximum lag of 3 and tested downward using AIC. For all experiments, VAR (1, 1) was chosen. In terms of choosing the number of cointegrating vectors (CVs), we relied on max-eigenvalue statistic for reasons argued before. The results of the Johansen cointegration estimations are shown in Table 7.5.

The max-eigenvalue statistic suggests one CV at both 1% and 5% for equations E and F, and one CV at 5% for equations D. The adjustment factors are all negative and significant at 1% for equations D and F and at 10% for equation E, ensuring the long-run stability of the equations. All coefficients are significant at 5%, except RRC1 in equation D and GI in equation E which are not significant. In each equation, most of the fundamentals have the expected signs. In all three cases, the foreign real interest

Table 7.5. Johansen Cointegration Results for the Sustainable Current Account[15]

	Hypothesized No. of CE(s)	Trace Statistic	5 % Critical Value	1% Critical Value	p-value	Max-Eigen Statistic	5% Critical Value	1% Critical Value	p-value
Equation D	None	157.66*	125.62	135.97	0.0001	50.07*	46.23	52.31	0.0185
	At most 1	107.58*	95.75	104.96	0.0060	39.71	40.08	45.87	0.0549
Equation E	None	248.41*	197.37	210.05	0.0000	71.40*	58.43	65.00	0.0017
	At most 1	177.02*	159.53	171.09	0.0039	47.33	52.36	58.67	0.1496
Equation F	None	121.36*	97.75	104.96	0.0003	53.96*	40.08	45.87	0.0008
	At most 1	67.40	69.82	77.82	0.0768	28.30	33.88	39.37	0.2000

Normalized cointegrating coefficients (std.err. in parentheses)

Equation D	CAY	TFP1	CREP	DEP	ERULC	RRC1	FR	C
	1.0000	-1.6292	0.2706	0.1999	-2.0010	-0.1199	0.5246	-13.8326
		(0.4123)	(0.0466)	(0.0956)	(0.7477)	(0.1403)	(0.2022)	
	Adjustment coefficient (std.err. in parentheses)							
	D(CAY)	-0.2650						
		(0.1041)						

Equation E	CAY	TFP1	CREP	DEP	ERULC	B1	FR	GI	TAX1	C
	1.0000	-1.7398	0.4302	0.3740	-2.2968	0.2481	0.8649	-0.0694	-0.4636	-57.6595
		(0.4709)	(0.0465)	(0.1452)	(1.0585)	(0.0896)	(0.2490)	(0.0578)	(0.1705)	
	Adjustment coefficient (std.err. in parentheses)									
	D(CAY)	-0.1413								
		(0.0809)								

Equation F	CAY	TFP1	CREP	DEP	ERULC	FR	C
	1.0000	-1.5340	0.2620	0.2512	-2.4945	0.6453	-16.9701
		(0.3757)	(0.0405)	(0.0900)	(0.6650)	(0.1895)	
	Adjustment coefficient (std.err. in parentheses)						
	D(CAY)	-0.2816					
		(0.0935)					

Note: "*" denotes rejection of the hypothesis at the 5% level. Critical values are taken from MacKinnon *et al* (1999).

[15] Similar to Chapter 6, when we incorporated TFP2 instead of TFP1, we also found one econometrically plausible results. However, when using TFP2, sustainable current account relative to GDP turned to be positive before middle 1980s and negative after that, which was the opposite of the actual current account. Therefore we only reported cointegrating results based on TFP1.

rate (FR) is wrongly signed and highly significant. Initially we calculated sustainable current account based on coefficients in all three equations D-F and HP-filtered fundamentals. However, sustainable current account based on equation E was abnormally low (negative) in the 1960s and extremely large (positive) after the mid-1990s compared with the actual values. This may due to the extremely large and negative constant in equation E, which is rather unrealistic. In addition, the adjustment factor is significant only at 10%, compared with 1% in equations D and F. Sustainable current accounts based on equations D and F are quite close for the whole period. Since RRC1 in equation D is wrongly signed and insignificant, we decided to compute the sustainable current account based on equation F.

Equation F

$$CAY = 1.5340TFP1 - 0.2620CREP - 0.2512DEP + 2.4545ERULC - 0.6453FR + 16.97$$

In equation F, all coefficients are correctly signed (except FR) and significant at 1% significance level.

Based on the coefficients in equation F and HP-filtered fundamentals we obtain the sustainable current account measured as a percentage of GDP. It is referred to as SCAY. We plotted SCAY against actual (CAY) and trend (TCAY) current account (all as a percentage of GDP) in Figure 7.4. SCAY turned from negative to positive in 1967 and remained positive thereafter. Furthermore, it was stable between 1967 and early 1990s, varying within 0-1.5%. Since early 1990s the series had been increasing gradually from 1.5% to 6.1% in 2005. Compared with CAY, SCAY was much smoother, with CAY varying around it. Compared with the TCAY, SCAY remained above TCAY throughout the period 1965-1982. Since 1983, the TCAY had been higher than SCAY, except during 1995-1999. Such a relationship between the sustainable current account and the trend current account suggests that the RMB has been persistently overvalued from middle 1960s until 1982 and undervalued since 1983, except over the period 1995-1999.

7.3.4. The FEER and Misalignments

The trend current account is obtained by treating the nominal exchange rate as exogenous. Hence the nominal exchange rate must adjust to match the trend current account with the sustainable current account. Based on our trend and sustainable current account estimates, we solve for the equilibrium nominal exchange rate, or the nominal FEER, that delivers such a match and plot it in Figure 7.5. The misalignment rates are illustrated in Figure 7.6. Abnormally large undervaluation occurred from 1960-1964, which is probably due to the disastrous "Great Leap Forward" campaign from end of 1950s to early 1960s. Hence, the years 1960-1964 are ignored in Figure 7.6 and we focus on the period 1965-2005. Table 7.6 summarises the findings on misalignment rates[16].

Table 7.6. Summary of Findings—FEER for Nominal Bilateral CNY/USD Rate

1965-1982 There were 18 years of consecutive overvaluation with an AMR of 28%		1983-2005 Undervaluation occurred in 18 out of 23 years except 1995-1999.		
1965-1977	1978-1982	1983-1994	1995-1999	2000-2005
There was fixed nominal exchange rate until 1971 and small adjustments from 1972-1982.		(large depreciation of nominal exchange rate)	(Fixed nominal exchange rate)	(Fixed nominal exchange rate)
There were relatively large MRs in this period. AMR for this period is 31% with the peak MR at 44% in 1968.	In this early post-reform period MRs were relative smaller. AMR for this period was 20% with peak MR at 33% in 1980.	There were 12 years of consecutive undervaluation. AMR for this period was 13% with the peak MR at 30% in 1986.	There were 5 years of consecutive overvaluation. AMR for this period was 9% with the peak MR at 13% in 1996.	There were 6 years of consecutive undervaluation. AMR for this period was 10% with the peak MR at 14% in 2003.

Note: AMR and MR refer to average misalignment rate and misalignment rate respectively.

[16] ADF tests show that the misalignment rates in Figures 7.6 is stationary at 5%.

Figure 7.5. FEER and Actual Nominal Bilateral CNY/USD Exchange Rate

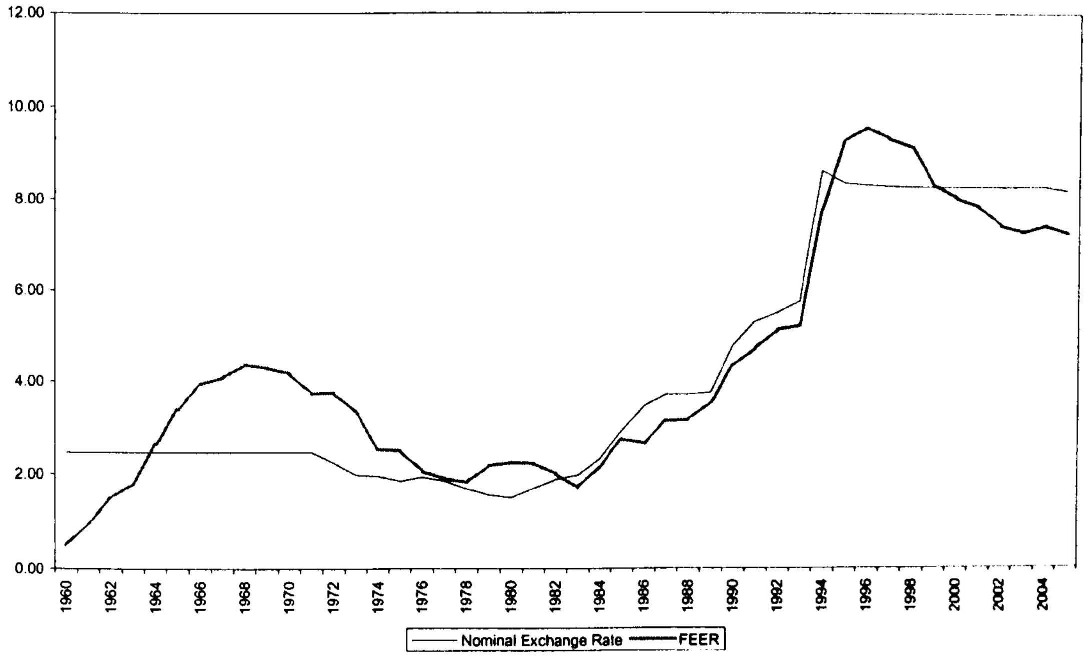
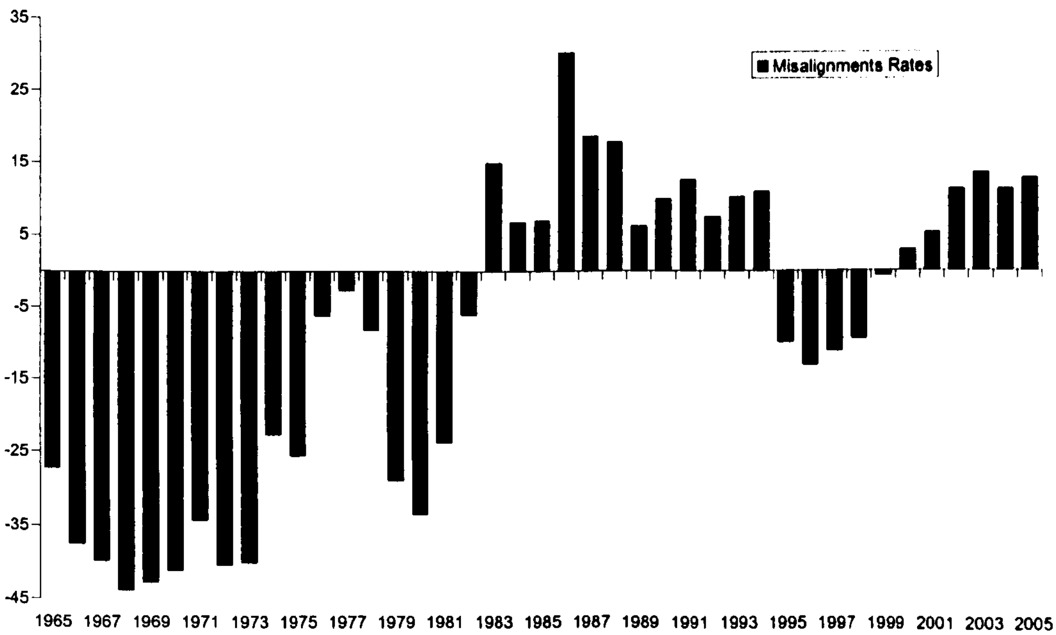


Figure 7.6. Misalignment Rates between Actual Nominal Bilateral CNY/USD Exchange Rate and FEER (%)



Note: Misalignment rate=(N-FEER)/FEER*100%; a positive (negative) misalignment rate implies an undervaluation (overvaluation) of the RMB. N denotes the nominal bilateral CNY/USD exchange rate.

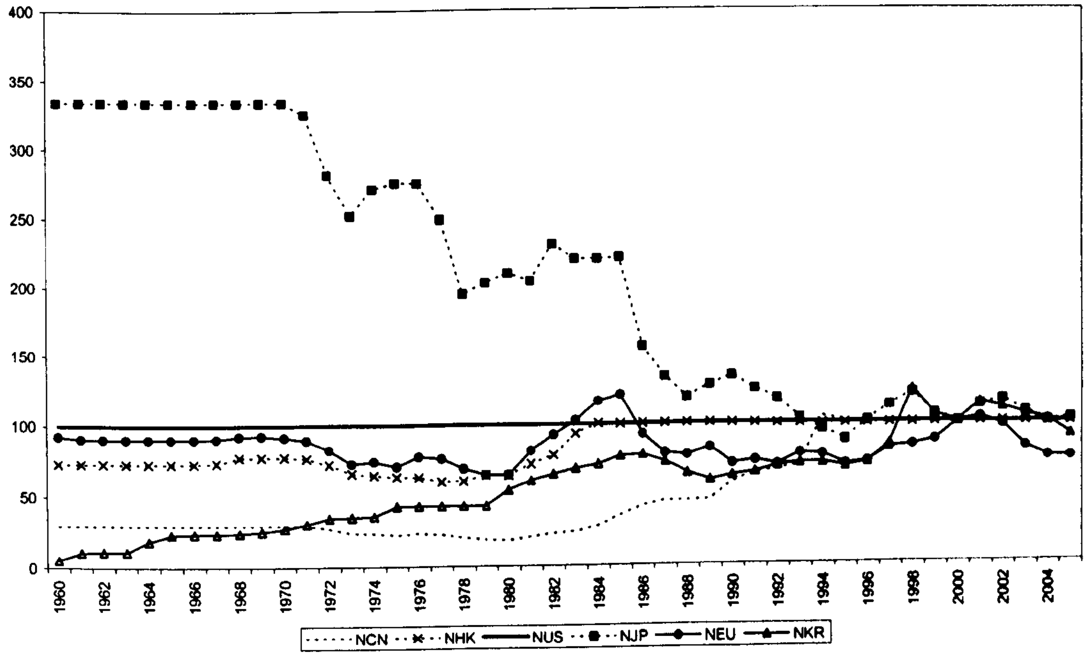
The relationship between the actual nominal exchange rate and FEER suggests overvaluation of the RMB before early 1980s and undervaluation thereafter. We can divide the period 1965-2005 into four sub-periods: 1) 1965-1982, overvaluation; 2) 1983-1994, undervaluation; 3) 1995-1999, overvaluation, 4) 2000-2005, undervaluation.

During the period 1965-1982, the nominal bilateral CNY/USD rate was below the FEER, which suggests he RMB was persistently overvalued with an average misalignment rate of 28%. Until 1978, there had been overall nominal appreciation of the currencies of China's main trade partners (especially Japan) against the USD (Figure 7.7)[17]. The Chinese government also appreciated the value of RMB by decreasing the nominal exchange rate of CNY against the USD. However, unlike China's main trade partners, such appreciation of RMB was artificial and was not supported by economic fundamentals. Sustainable current account, determined by economic fundamentals, suggests depreciation was needed rather than appreciation. The average overvaluation was 31% from 1965 to 1977, with the severest undervaluation of 44% occurring in 1968[18]. During the early post-reform period 1978-1982, the USD appreciated against the currencies of China's main trade partners. The Chinese government accordingly depreciated the RMB from 1.8 CNY per USD in 1978 to 2.0 in 1982. Furthermore, development in the fundamentals delivers a stable, but relatively lower, sustainable current account, posing less pressure on nominal depreciation. Hence, nominal overvaluation was reduced to an average of 20% in this early post-reform period.

[17] We choose China's top 5 trade partners in Figure 7.7, the US, Japan, HK, Euro area and Korea.

[18] Despite overall appreciation against the USD from 1966 to 1978, there was mild depreciation of currencies of China's main partners against the USD in 1968 (i.e. HK and Euro area) while at the same time the nominal exchange rate of CNY against USD was fixed. Such a contrast explains the large overvaluation in 1968.

Figure 7.7. Nominal Exchange Rate Indices of China and its Top 5 Main Trade Partners against the USD[19] (2000=100)



During 1983-1985, the USD appreciated against the currencies of China's main trade partners (except Japan). Accordingly, the Chinese government depreciated the RMB from 2.0 CNY per USD to 2.9. Undervaluation during these three years may suggest that the pace of the artificial depreciation might had been too large and too fast. Since 1986, the USD had been depreciating against China's main trade partners (except the HK Dollar which was pegged to USD at 7.8HKD per USD since 1984) while the Chinese government further depreciated the RMB from 3.6 CNY per USD in 1986 to 8.6 in 1994. This led to further persistent undervaluation from 1986 to 1994, with the highest undervaluation of 30% in 1986. For the whole second period (1983-1994), on average, the RMB was undervalued by 13%.

Over the period 1995-1999, the nominal USD appreciated against currencies of China's main trade partners (except HKD) while the nominal exchange rate of CNY/USD was fixed at 8.3. The development in the economic fundamentals also

[19] NCN, NHK, NUS, NJP, NEU, NKR in Figure 7.7 denote nominal exchange rate of the China, Hong

called for depreciation. These led to nominal overvaluation of the RMB at an average of 9% over this period.

During the most recent period 2000-2005, the nominal USD had been depreciating against currencies of China's main trade partners (except HKD). Meanwhile, the nominal rate of CNY/USD was still fixed. The requirement for nominal appreciation of the RMB might have been more severe had the development of the economic fundamentals not brought the sustainable current account surplus to its highest levels in the whole sample period. The average misalignment rate for this period was 10%. The misalignment rates showed an increasing tendency of undervaluation in this period. The highest misalignment had occurred in the last four years with an average of 12%. We highlighted the three current account series and misalignment rates since 2000 in Table 7.7.

Table 7.7. Current Account and Misalignment Rates (%) in the Nominal Exchange Rate: 2000-2005

Year	2000	2001	2002	2003	2004	2005
CAY	1.7	1.3	2.5	2.8	3.6	7.2
TCAY	4.5	5.8	7.4	8.3	8.4	9.4
SCAY	3.2	3.7	4.2	4.8	5.6	6.3
Implied Misalignment (%)	-3.0	-5.4	-11.3	-13.6	-11.3	-12.8

Note: minus implies undervaluation.

We compare the FEER for the nominal bilateral exchange rate in this chapter (nominal FEER) with the FEER for the real bilateral exchange rate obtained in Chapter 6 (real FEER) (Figure 7.8). During the two periods 1965-early 1970s and late 1990s-2005, the deviations between the two FEER series were much smaller than that in the rest of the period. The large gap between the two FEER series from early 1970s to late 1990s could be explained by the fact that the world export prices were much higher than China's domestic price deflator (Figure 7.9). During the period 1965-1982,

Kong, the US, Japan, Euro area, Korea against the USD.

Figure 7.8. Actual Nominal and Real CNY/USD Exchange Rates, and FEERs

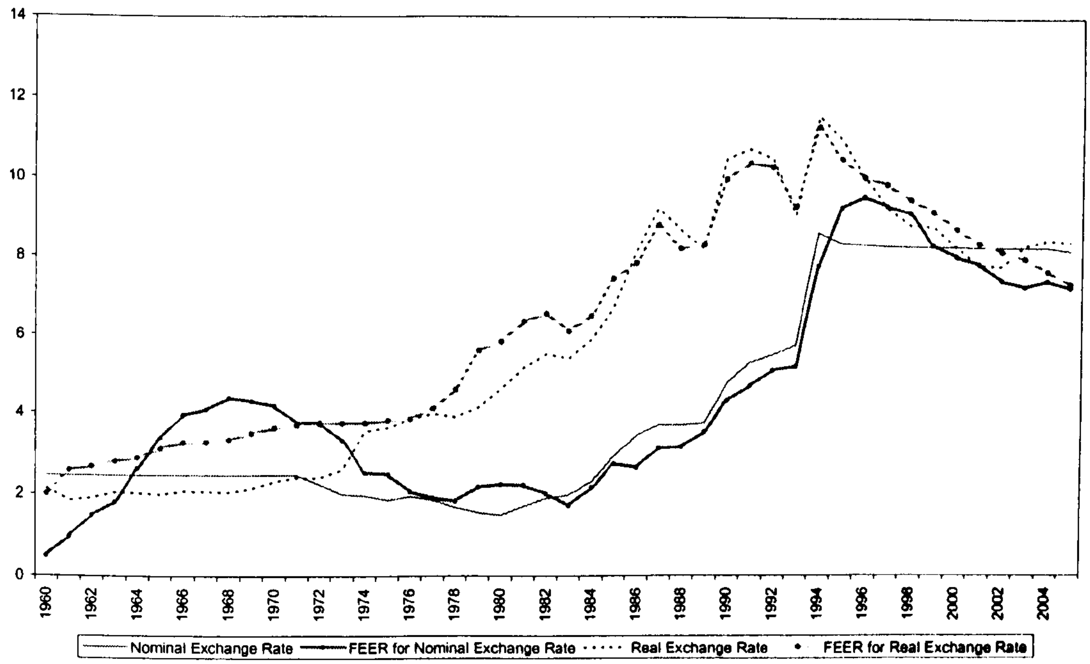
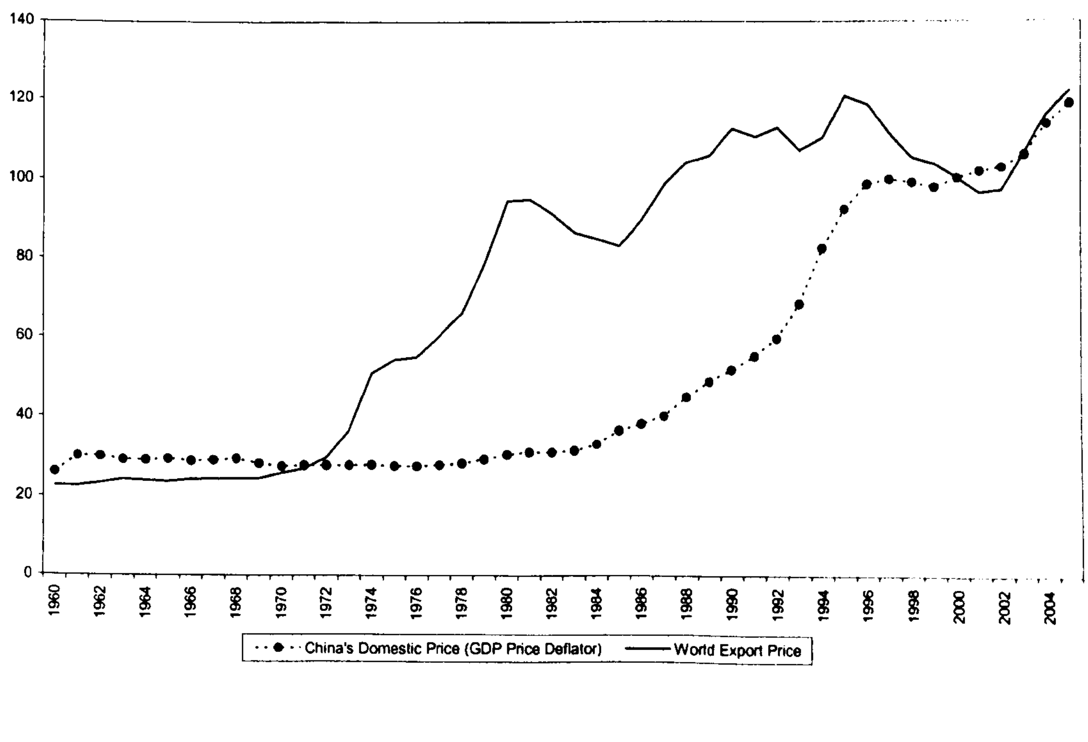


Figure 7.9. China's Domestic Price (GDP Price Deflator) and World's Export Prices



both nominal and real FEER series suggested overvaluation, though the latter suggested 3 more years of overvaluation until 1985. From the mid-1980s to 2005, both series showed undervaluation in most years. It is worth noticing that both FEER series suggested undervaluation since the end of 1990s, with an increasing trend of undervaluation, especially during 2003-2005. Therefore, the overall patterns of the misalignments based on the nominal and real FEER are consistent.

Next we compare our findings with other studies assessing the equilibrium nominal bilateral exchange rate of China. Based on the FEER model, Jeong and Mazier (2003) and Wren-Lewis (2004a) evaluate the equilibrium nominal exchange rate for China for the period 1982-2000 and year 2002 respectively. For the overlapping period 1982-2000, our findings are overall similar to Jeong and Mazier (2003), who find undervaluation in most years from the early-1980s to early-1990s, overvaluation in the mid-1990s, and undervaluation since 1996. However, our findings suggest a much smaller magnitude of undervaluation than Jeong and Mazier's (2003), especially from late 1990s afterwards. For instance, Jeong and Mazier's (2003) suggest an undervaluation of 60% for the period 1997-2000, while in our study, not only the undervaluation starts one or two years later, but also the average undervaluation is 10% for the period 2000-2005 with the highest rate at 14% in 2003 (Table 7.6). For the year 2002, Wren-Lewis (2004a) suggests an undervaluation of 20% and 28% based on 1% and 0% sustainable current account relative to GDP respectively, higher than what is suggested by our study (11%).

Jeong and Mazier (2003) and Wren-Lewis (2004a) compute the trend current account for China based on multi-country models; the former includes China, Japan, South Korea, US and the Euro area, and the latter includes China, Japan, UK, US and the Euro area. In our study, we included a much larger number of countries (11 of

China's trade partners) apart from China. Trade with these countries accounts for over 80% of China's aggregate trade. Furthermore, instead of calibrating coefficients in the trade equations based on existing studies or on assumptions (as in Jeong and Mazier (2003) and Wren-Lewis (2004a)), we estimated the coefficients in the trade equations using cointegration methods. Last but not least, Wren-Lewis (2004a) does not estimate the sustainable current account but employs assumptions for China (0% and 1% of GDP). Jeong and Mazier (2003) use the savings-minus-investment norm following Debelle and Faruqee (1998) and Chinn and Prasad (2000) and estimate the sustainable current account in a panel of 18 emerging countries to obtain the coefficients for the fundamentals for China. However, as emphasised in Chapter 6, the fundamentals used in Debelle and Faruqee (1998) are designed for industrial countries, and the fundamentals included in Chinn and Prasad (2000) are for a group of developing countries but China is not included in the group. In our study, we incorporated fundamentals that reflect the unique features of the Chinese economy into the sustainable current account estimation. In addition, Jeong and Mazier (2003) obtain coefficients in the sustainable current account using pooled least squares methods. In our study, the sustainable current account was estimated using cointegration methods, which we think are more appropriate for estimating long-term equilibrium relationships. Therefore, for reasons explained above, we are inclined to believe that our estimates for the nominal FEER are more reliable.

We also compare our study with Funke and Rahn (2004), who examine the nominal bilateral equilibrium exchange rate for the period 1994-2002 for China, but use the BEER model. For the overlapping years, our results are very similar to Funke and Rahn (2004), who find overvaluation before 1997 and undervaluation thereafter. Interestingly, the magnitude of misalignment is quite close, i.e. before 1997, Funke and Rahn (2004) find overvaluation under 10% (under 13% in our study); after 1997, they find undervaluation under 17% (below 14% in our study)[20].

7.4. Conclusions

This chapter presents an application of the extended FABEER model to China's nominal bilateral exchange rate of the CNY against the USD. It is the first extended FABEER application that covers both pre- and post-reform periods. It is also the first time the equilibrium nominal CNY/USD exchange rate is estimated for such a long period.

Another contribution of this chapter is that we extend Wren-Lewis' (2003, 2004a) FABEER model in several important ways. First, in Wren-Lewis (2004a) China is added in the FABEER model of Wren-Lewis (2003) which includes only four countries (the US, Euro area, UK and Japan). In this chapter, apart from China, 11 of China's main trade partners are included. Trade with these partners accounts for over 80% of China's total trade. Second, instead of assuming the sustainable current account to be a certain percentage of GDP as Wren-Lewis (2004a), we model and estimate the sustainable current account. This extension allows us to incorporate into the sustainable current account fundamentals that reflect the unique features of the Chinese economy but have not been employed by other studies. Third, in Wren-Lewis (2004a), trade values are not divided into volumes and prices. In this chapter, we split trade values into volumes and prices, and then estimate export/import volume and prices equations separately. Fourth, rather than calibrating the coefficients as in Wren-Lewis (2004a), we apply the HP-filter to obtain the smoothed values of the two

[20] There is no previous study on nominal equilibrium exchange rate that covers the pre-reform period. The only exception is Zhang (2001), who assesses the equilibrium real bilateral exchange rate for the

interaction variables (import volume and export prices) for China's 11 main trade partners.

An additional contribution is the construction of a unique data set of consistent time series, which includes a wide range of economic fundamentals, Euro variables, and trade-related variables for China and its 11 trade partners since 1960s. Such a data set allows us to carry out econometric investigation of the trend and sustainable current account for both pre- and post-reform periods. We then compute the FEER that matches the trend current account with the sustainable current account and finally calculate the misalignments.

The main findings of this chapter can be summarised as follows. First, we found one cointegrating vector for each trade equation and for the sustainable current account equation. Second, in the estimation of trend current account, we found: 1) the export volume equation suggests that increases in China's export volume are mainly due to improvements in its price competitiveness; 2) the import volume equation suggests that China's demand for imports is more income elastic than price elastic; 3) the Marshall-Lerner condition holds in China; 4) the export prices equation indicates that China's export prices are mainly determined by the world trade prices; 5) though these findings are similar to those in Chapter 6, the coefficients for activity (demand) and price competitiveness are all higher (more elastic), implying that the trade relationship between China and its main trade partners is closer than that between China and the world.

Third, in the estimation of the sustainable current account, we found: 1) the significant fundamental determinants are total factor productivity, dependency ratio, financial liberalisation, effective relative unit labour cost and foreign interest rate; 2)

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period 1952-1997 using BEER model. Interestingly, for the pre-reform period, our findings are similar the sustainable current account (measured as a percentage of GDP) is negative until 1966, positive and stable (within 1.5%) from 1967 until 1993, and has been increasing gradually and steadily since then from 1.5% to 6%.

Fourth, comparing the estimated FEER and the actual nominal CNY/USD exchange rate, we found persistent overvaluation of the RMB from 1965 to 1982, with the misalignment rates during 1965-1977 being much larger than those during the early reform period 1978-1982. For the period 1983-2005, comparison between FEER and nominal CNY/USD rate suggest that RMB was undervalued except for 1995-1999. The misalignment rates were much smaller than those during 1965-1982. During 1983-1994, when artificial depreciation of RMB was conducted by the government by raising the nominal exchange rate of CNY against the USD, there were 12 years of consecutive undervaluation with an average misalignment rate of 13%. During 1995-1999, when there was appreciation of the USD against the major currencies and the CNY was fixed against the USD, we found 5 years of consecutive overvaluation at an average of 9%. For the most recent and controversial period 2000-2005, we did find 6 years of consecutive undervaluation with an increasing trend. However, the average misalignment rate was 10% with the peak of 14% in 2003. Theses misalignments are much smaller than those implied by previous studies.

to Zhang (2001), who finds chronic overvaluation before 1978.

Appendix 7.A. Data Sources and Variable Measurement

The main data sources are *International Financial Statistics* (*IFS*), *Eurostat*, *Direction of Trade Statistics* (*DOTs*). The data span is 1960-2005. All indices are with 2000 as base year (2000=100) unless otherwise stated. Fundamentals (in equation (7.11)) that have been discussed in the data section in Chapter 5 (Section 5.2) are not repeated here.

Economic blocs included in the extended FABEER model to China 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 (Table 7.1), 12 in total. We refer to them as China, Euro area and the 10 blocs.

As data for the Euro area is not available until late 1990s, synthetic Euro area time series are needed. 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

$$X_t^{EURO} = \prod_{k=1}^{12} \left(X_t^k\right)^{y_k} \tag{7.12}$$

where $k =$ the 12 Euro countries: Austria, Belgium, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain[21] and the weights attached to each countries (y_k) are collected from Maeso-Fernandez *et al* (2001)[22]: 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,

[21] Greece is treated as a member of the Euro area over the entire period.
[22] These weights has been used in other studies (i.e. Schnatz and Osbat, 2003)

4.90[23]. Synthetic Euro time series constructed based on equation (7.12) include import and export prices. The earliest year, from which data for Euro area import and export prices is available, is 1995. The data is provided by *Eurostat*. After constructing synthetic Euro area import and export prices, we choose 3 overlapping years (1995, 1996 and 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 are adjusted by multiplying by the adjust factors for the period 1960-1994. Combining the adjusted synthetic Euro area import and export prices for the period 1960-1994 with the Euro area import and export prices from the *Eurostat* for the period 1995-2005, we obtain the series for the whole period 1960-2005. 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 is collected for *DOTs*.

1. Export Value and Import Value

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. Data for the Euro area is measured as the sum of the 12 Euro countries.

2. Export prices and Import prices

Export prices ($XPCN$) and import prices ($MPCN$) of China (in USD) are discussed in Chapter 5 (Section 5.2.14). Data for export and import prices (in USD) (2000=100) for the 10 blocs and 12 Euro countries is collected from *IFS* (lines 76.ZF and

[23] Following Maeso-Fernandez *et al* (2001), the weights for Belgium and Luxembourg are merged.

76.X.ZF)[24][25]. For the period 1995-2005, export and import unit values for the Euro area are collected from *Eurostat*[26]. Synthetic Euro area export and import prices are measured based on equation (7.12), with X_t^k = country k 's export and import prices with k refers to the 12 Euro countries. For the overlapping years (from 1995 to 2005), the synthetic series based on data from *IFS* are quite close to series provided by *Eurostat* (Figures 7.10 and 7.11). We adjust data from the period 1960-1997 by the adjustment factors[27].

3. Import Volume

First we add up each individual country's import 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. Total import value of the Euro area is the sum of the 12 Euro countries. Then by dividing import value (in USD) by import prices index and multiplying by 100, we obtain the import value in constant prices for China (MCN), the 10 blocs, and the Euro area.

4. Export Volume for China (XCN)

By dividing China's export value (in USD) by export prices index and multiplying by 100, we obtain the export value in constant prices for China (MCN).

[24] When export and import prices (lines 76.ZF and 76.X.ZF) are not available, unit export and import values from *IFS* are used (lines 74.ZF and 75.ZF).

[25] However, data for Hong Kong (China), Korea, Malaysia, Singapore and France is only available for the periods of 1968-2005, 1963-1005, 1960-1987, 1979-2005 and 1990-2005 respectively. For the four Asian countries and regions, missing data during the period 1960-2005 are filled by the export and import prices of Asia that is available form *IFS* (line 74 DZF and 75 DZF) for period 1960-2005. For France, Germany's export and import prices for the period 1960-1989 are used as an approximation of France's. Adjustment factors are calculated based on the first three overlapping years and apply to all approximations.

Figure 7.10. Export Prices Index: Synthetic and from *Eurostat*

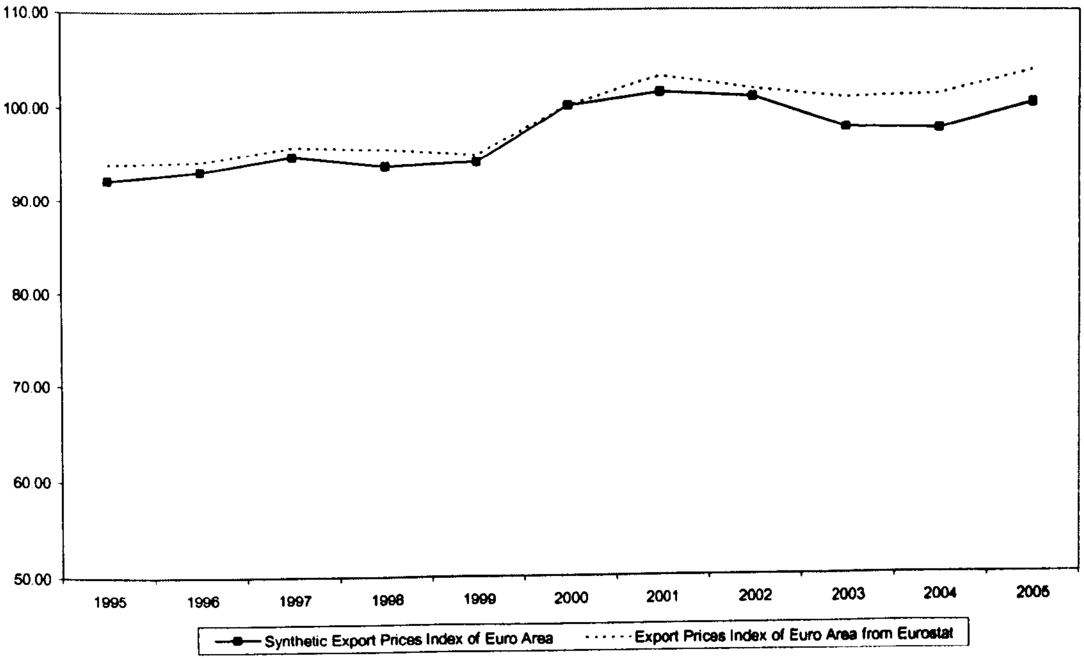
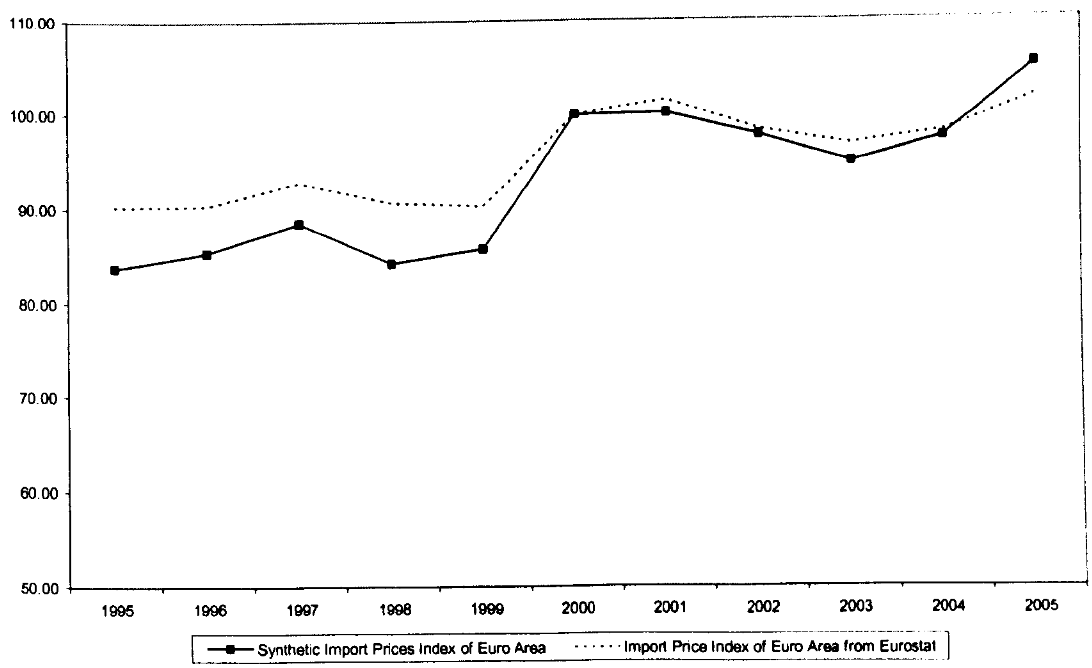


Figure 7.11. Import Prices Index: Synthetic and from *Eurostat*



[26] *IFS* also provides unit value of export and import for the Euro area, but with a shorter time span 1999-2005. Therefore we collect data from Eurostat.

[27] The adjustment factors for export and import prices are both very close to unity (1.01 and 1.06).

5. Nominal CNY/USD Rate (N), GDP Price Deflator (PCN) and Real GDP (YCN) for China.

Nominal CNY/USD rate is collected from *IFS*. It is converted to an index for later usage. GDP price deflator for China is explained in Chapter 5 (Section 5.2.2). However, in this chapter it is adjusted by N and converted into USD. The real GDP for China is obtained as the nominal GDP (in USD) adjusted by GDP price deflator (in USD).

6. Export Competitiveness for China ($XCOMCN$)

Export competitiveness for China is defined as the world export prices in export equation ($\sum_{j \neq i} h_{ij} XP_j$), which is discussed below, divided by the China's export prices.

7. Import Competitiveness of China ($MCOMCN$)

Import competitiveness for China is defined as domestic import prices (in USD) divided by the domestic GDP price deflator (in USD).

8. World Export Prices in Export Prices Equation of China ($\sum_{j \neq i} h_{ij} XP_j = WXPCNv$)

In the partial equilibrium model, the world export prices in the export prices equation is a weighted average of export prices of all 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). In our model i=China. The total export values and export prices for the Euro area and the 10 blocs have been explained above.

9. World Export Prices in Import Prices Equation of China ($\sum_{j \neq i} v_{ij} XP_j = WXPCNv$)

In the partial equilibrium model, the world export prices in import prices equation is 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. Data for China's import value from each individual main trade partners (Euro area and the 10 blocs) has been explained above. The sum provides China's total import value from its main trade partners included in the model. Export prices for Euro area and the 10 blocs have been explained above.

10. World Import Volume in Export Volume Equation of China ($\sum_{i \neq j} M_j = WTCN$)

In the partial equilibrium model, for country i, the world import volume is measured as the sum of import in constant price of all countries in the model (except country i). In our model i=China. Hence world import volume for China equals the sum of import in constant price of its main trade partners (Euro area and the 10 blocs). Import volumes for Euro area and the 10 blocs have been explained above.

11. Commodity Export ($CXPCN$) and Commodity Import ($CMPCN$) Prices of China

Commodity export and import prices have been explained in Chapter 6 (Appendix 6. C). However, they are both in USD in this chapter.

Chapter 8
Conclusions

8.1. Summary of Contributions and Findings

The major objective of this thesis is to investigate the equilibrium exchange rate of the Chinese RMB. The theoretical base of this research are Stein's (1994) NATREX, Williamson's (1994) FEER and Wren-Lewis' (2003, 2004a) FABEER models. Empirical estimations are carried out to obtain the equilibrium exchange rates for the real bilateral CNY/USD, nominal bilateral CNY/USD, and the real effective exchange rates. The time span includes both pre- and post-reform periods.

The thesis makes a number of theoretical and empirical contributions. First, at the theoretical level, this thesis extends the NATREX and FABEER models, and modifies the FEER model in various perspectives to make them applicable to China. Through such extensions and modifications, we are able 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. In addition, in the multi-country model in Chapter 7, this thesis includes 11 of China's main trade partners apart from China. Many of these trade partners have never been included in any previous studies that estimate the equilibrium exchange rate for China. Trade with these 11 countries accounts for over 80% of China's foreign trade.

The second contribution of this thesis is the construction of a large data set of consistent time series for a wide range of economic fundamentals, trade-related variables, Euro variables, and real effective exchange rate since the early 1950s. Compared with previous studies that cover only the port-reform period or years after the millennium, the time span of this thesis is 1952-2005, covering both pre- and post-reform periods. The effective exchange rate is *for the first time constructed* backwards to 1960 incorporating trade partners that account for over 80% of China's foreign trade. In addition, total and net factor productivity are estimated based on the production function. This is the first time that total factor productivity is estimated when rural transformation is taken into account, and that total and net factor productivity are used in the examination of China's equilibrium exchange rate. This rich data set allows us to estimate equilibrium exchange rates and sustainable current account that take into account various economic fundamentals. The trade-related variables enable us to estimate the export/import prices and volumes equations separately and then derive the trend current account for the period 1960-2005. It is worth mentioning that in previous FEER and FABEER applications for China, trend current account is obtained based on calibrated coefficients, or based on estimated coefficients but only estimated for a single year.

Third, on the empirical side, this thesis provides for the first time a comprehensive application of the extended NATREX, FEER and FABEER models to China in order to estimate the equilibrium exchange rates for the real bilateral CNY/USD, nominal bilateral CNY/USD and the real effective exchange rates, and to calculate the misalignments. It is the first time the equilibrium exchange rate for the nominal bilateral CNY/USD and the real effective exchange rates are estimated for both pre- and post-reform periods (1960-2005). It is also the first comprehensive study that investigates all three different measures of the exchange rate.

The main findings of this thesis can be summarised from the following two perspectives: determinants of the equilibrium RMB and misalignments. Regarding the determinants, cointegrating relationships are found in all chapters, thus supporting the existence of the equilibrium relationships between the fundamentals and the exchange rates and the sustainable current account. More importantly, the equilibrium relationships are overall consistent with the predictions of the theoretical models. Irrespective of the theoretical model and measures of the exchange rate, factor productivity and relative unit labour cost turned out to be the most crucial determinants of the equilibrium value of the exchange rates as they are significant in all estimations. The terms of trade which appear only in the extended NATREX model are significant in the estimations of NATREX for both real bilateral and real effective exchange rates. The dependency ratio and financial liberalisation are significant in all estimations except in the case of NATREX for the real effective exchange rate. The relative rate of return to capital is significant in the cases of NATREX and FEER for the real bilateral CNY/USD exchange rate. Government investment, rural transformation and tax ratio, US real interest rate, and foreign real interest rate are, respectively, significant in the cases of NATREX for the real bilateral exchange rate, NATREX for the real effective exchange rate, FEER for the real bilateral exchange rate, and FEER for the nominal bilateral exchange rate.

With regards to misalignments, first, the estimates suggest that in general that the RMB had been overvalued in the pre-reform period and undervalued in the post-reform period[1]. Second, the misalignments rates are relatively larger in the pre-reform period and smaller in the post-reform period. Third, the misalignment rates are relatively smaller during early 1970s-early 1990s, when there were nominal exchange rate adjustments conducted by the Chinese government, and larger before early 1970s and after the 1990s, when the nominal exchange rate was fixed. Fourth, for the most controversial post-reform period, especially the last five years, this thesis finds

[1] The only exception is the real bilateral exchange rate in the case of the extended NATREX model, where undervaluation in the pre-reform period and overvaluation in the post-reform period are found. However, the misalignments have been within a narrow band of ±6%. Based on all other results found in this thesis and results found by existing studies, we are inclined to believe that the results for the real bilateral CNY/USD exchange rate based on the FEER model are more realistic.

undervaluation, confirming the results of previous studies. However, the misalignments have not been as large as those suggested by most existing studies. Fifth, though the misalignments for the post-reform period are comparatively moderate, they show increasing trends over the most recent 3-5 years. As our estimations take into account economic fundamentals that reflect the unique features of the Chinese economy but have not been used by previous studies, and our empirical results are consistent across models and measures of the exchange rate, we are inclined to believe that our findings are more reliable than those of previous studies.

8.2. Policy Implications

A number of policy implications follow from the empirical findings of this thesis. The first policy implication concerns the flexibility of the exchange rate system. Findings for the misalignments indicate that, across the whole pre- and post-reform period, they 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.

Second, in the more controversial post-reform period, in particular since the beginning of the 21st century, a general picture of undervaluation has been found in this thesis. This implies that China has gained unfairly competitiveness against its trade partners via fixing the nominal value of its currency. Continuation of such a *de facto* fixed foreign exchange rate system would lead to China's trade partners imposing restrictions on imports from China. Indeed, we have seen European Union and the US imposing quotas and higher tariffs on textiles and other goods imported from China. Furthermore, this thesis finds that there is an increasing trend in the magnitude of undervaluation since the beginning of the new millennium. Hence, even if China ignores the threat of trade restrictions by other countries on its exports, continuing keeping the RMB below its long-term equilibrium value via fixing the nominal rate would not be sustainable.

The third implication considers weather China should switch immediately to a floating exchange rate, or increase gradually the flexibility of the exchange rate system and adopt the floating exchange rate system ultimately. There seems to be consensus amongst most researchers that a sudden switch to a floating exchange rate will not be feasible for China given its underdeveloped financial market and a gradual or step by step approach is more appropriate (i.e. McKinnon, 2003; Goldstein, 2004; Frankel, 2006; Cappiello and Ferrucci, 2008). This thesis concurs with the majority of the literature, and our argument against a sudden shift is based on a combination of facts and our empirical findings, which are explained in detail below.

Before October 2003, the CNY was sold at a forward discount against the USD in non-deliverable forward markets. But in October 2003 it flipped to a forward premium which further widened substantially in 2004 (Frankel and Wei, 2007). The economic fundamentals that determinate the equilibrium exchange rate evolve gradually, and there were no reported major changes in foreign exchange policy. So what happened around October 2003? The US Treasury Secretary John Snow visited China in September 2003. His visit was followed by a sequence of activities by the Secretary himself and various institutions, aiming at urging China to increase exchange rate flexibility[2]. Such episodes indicate that speculators' expectations are

[2] Refer to Frankel and Wei (2007) for detailed activity carried out by The US Treasury Secretary John Snow and various institutions such as G-7 in September and October 2003, urging China to pursue a more flexible exchange rate regime.

largely influenced by political pressure from industrial countries, especially the US, rather than by developments in the economic fundamentals.

Turning to the empirical evidence, this thesis finds that currently the RMB is undervalued but the misalignments have been relatively modest compared to those suggested by most existing studies. On the basis of these misalignments, the immense political pressure from the US demanding sizeable revaluation of the RMB is unwarranted. Such an argument is confirmed by Frankel and Wei (2006), whose econometrical 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, rather than driven by investigating the economic fundamentals as in this thesis. If the undervaluation, which is determined by economic fundamentals, is relatively modest, but the political pressure from the US demanding sizeable revaluation is asymmetrically immense, there is a serious risk that once the exchange rate is floated, enormous speculations fueled by the political pressure will push the RMB not just closer to its equilibrium value, but also to excessive overvaluation. Furthermore, China's financial market, as discussed in Chapter 3, has a development history of less than twenty years, comparing to over a century in industrial countries. It is still underdeveloped and does not yet has the competence to cope with an abruptly floating exchange rate system followed by enormous international speculation. Hence, an immediate switch to a floating exchange rate may not be a feasible option for China in the near future.

The policy implications so far advocate greater flexibility in the nominal exchange rate system but not a sudden adoption of a floating exchange rate regime. 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. Based on our empirical findings, our fourth policy implication sets out some suggestions regarding the current practice of the Chinese central bank. On the one hand, our empirical results suggest that not only the bilateral CNY/USD exchange rate, but also the real effective exchange rate is undervalued. On the other hand, though the central bank does not reveal it, studies suggest that the implicit weight of the USD in the basket is strikingly high: over 90% (e.g. Eichengreen, 2006; Frankel and Wei, 2007). Hence the first suggestion would be to increase gradually the weights of other currencies in the basket, with the trade weights as reference. Otherwise, even if the misalignments in the bilateral CNY/USD is reduced, substantial misalignments in the real effective exchange rate of the RMB may remain[3]. Such an argument is reinforced by the statistical evidence shown in Table 3.7. One is that the share of China's imports from the US has been declining from 19.6% in 1980 to 7.5% in 2006. The second fact is that the share of China's exports to the US has been stable since 2000 and declining since 2005, while the share of China's exports to the EU has been increasing from 9.7% in 1992 to 19.6% in 2006. If the current trend continuous, the EU will overtake US as China's largest export destination in the near future. The third fact is that Asian countries (except Japan) are becoming more and more important trade partners for China. For instance, in 2006, South Korea alone accounted for 11% of China's imports (higher than the US) and 5% of China's export. In the same year, trade with the four Asian countries (South Korea, Singapore, Malaysia and Thailand) accounted for 19% of China's imports (same as the US plus EU) and 10% of China's exports (same as Japan). Hence the weights of Euro and other Asian currencies (e.g. Korea Won) in the basket should be increased correspondingly. China may also gain unfairly competitiveness when the USD depreciates against other major currencies, which has been the case since 2002.

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

On 21st May 2007, the floating band of the CNY against the USD increased cautiously from daily ±0.3% to ±0.5% while that of the CNY against other currencies has remained under the discretion of the central bank. This discretionary band has been kept at ±1.5% since June 2005[4]. If the flexibility of the exchange rate is to be increased, the second suggestion is that broader floating bands should be adopted not only for the CNY/USD rate, but also for the exchange rate of the CNY against other currencies (e.g. the Euro, Korea Won) to reflect the changes in trade weighs. For instance, if China's trade with the Euro area occupies a rising share in China's foreign trade, then not only the weight of the Euro in the basket should be increased, but also the floating band of the CNY against the Euro should be broadened accordingly. However, it is important to stress that, before the ultimate floating is realised, relative modest but frequent adjustments to the exchange rate would be preferred to large and infrequent adjustments.

8.3. Suggestions for Future Research

There are a number of potential extensions to the thesis. First, the Chinese economy may be subject to structural breaks. For instance, the implementation of the reform and opening-up policy in 1978 is the start of China's transformation from a centrally-planed economy to a market-oriented economy. Hence unit root and cointegration tests that allow for structural breaks could provide some useful information about the relationship between the economic fundamentals and the exchange rate. However, to implement tests that allow for structural breaks may encounter the problems of not having enough number of observations. Increasing the frequency of the data would be

[4] This discretionary band is stated by the State Administration of Foreign Exchange and available at http://www.safe.gov.cn/model_safe/laws/law_detail.jsp?ID=80600000000000000,25&id=4

a potential solution but even quarterly data before 1990s are not available for most variables for China, let alone monthly data.

Another potential extension is to obtain the bilateral nominal exchange rates of the CNY against the currencies of China's trade partners included in the extended FABEER model. To do so, at the theoretical level, the sustainable current account for each of China's trade partners needs to be modeled. At the empirical level, full trend (including four trade equations) and sustainable current accounts for each of China's trade partners should to be estimated. Then, the FEER for the nominal exchange rate of each currency in the model against the USD could be computed. The FEERs for the nominal bilateral exchange rate of CNY against each of China's main trade partners could thus be obtained. Such estimation would provide useful information for the calculation of broader floating bands for the exchange rate of the CNY against currencies other than the USD. Including China, there are 12 countries in the extended FABEER model in Chapter 7. Hence apart from the theoretical modelling of sustainable current accounts and collecting data for these countries since 1960, there are over 60 equations in total that will need to be estimated. This would therefore be a big project that we leave for future research.

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