

The equilibrium exchange rate of RMB 2000-2011: a BEER approach

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Abstract

In response to the critics that accuse China of manipulating its exchange rate and maintaining it under a substantially low level, this study applied a robust co-integrating analysis to estimate the Behavioural Equilibrium Exchange Rate of Chinese renminbi. A 6-variable VAR model was built up and the Johansen-Juselius co-integrating analysis was applied to test if there is co-integrating movement between the variables. The findings show that the real effective exchange rate of renminbi could mostly be explained with statistical significance by five fundamentals, viz. the degree of openness, government expenditure, net export, productivity and net foreign assets. The actual real effective exchange rate is fluctuating around its equilibrium level in a narrow band moderately and consequently there is no evident undervaluation or misalignment of renminbi in a long-run perspective from 2000Q1 to 2011Q4. Moreover, the slight misalignment of renminbi reveals a sound current exchange rate regime in China.

Student Declaration

I, Ming Song, declare that the Master by Research thesis entitled, '*The equilibrium exchange rate of RMB 2000-2011: BEER approach*', is no more than 60,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Signature



Date 25-03-2013

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List of Publications and Awards

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Chapter 1 Introduction

1.1 Debate over Chinese Renminbi: Is It Undervalued?

The prominence of recent interest in calculating the equilibrium exchange rate may arguably be attributable to two factors, the movement of certain currencies including the UK sterling and the Chinese renminbi (RMB) and secondly the development of the regional European Union. This study focuses on the Chinese renminbi (the official currency of People's Republic of China), which has shown a great impact on today's global market. The exchange rate of renminbi has received critical reviews with a debate over whether renminbi is overvalued or undervalued. The International Monetary Fund (IMF) *2011 Country Report for China* found that renminbi remained substantially under the level consistent with the medium-term fundamentals¹. In response Chinese representatives Jianxiong He and Zhengxin Zhang argued that it is weak to conclude renminbi is undervalued based on reserve changes, the recent real effective exchange rate movement and the medium-term current account. In contribution to this report, they also pointed out that the IMF assessment 'ignored the trend exchange rate movement and the far-reaching legally-binding rebalancing measures that will be implemented in the future medium term'(IMF 2011).

These debates reveal the great pressure on the renminbi to appreciate. Internally the appreciation of renminbi would be encouraged in favour of rebalancing the economy towards domestic demand, strengthening the macroeconomic policy framework and promoting financial reform, according to IMF(2011). External pressure to appreciate can be seen in the recent United States Senate bill passing which calls for the US Treasury Department to identify countries whose currencies are fundamentally misaligned and instructs the US Commerce Department to impose tariffs on imports from those countries. The bill was seen as a measure of redressing the perception that China has been manipulating its currency and holding it at an artificially low level. Moreover, the appreciation of renminbi is of great significance to individual firms internally and externally. For example, according to Eichengreen and Tong(2011), firm level data shows that expected renminbi appreciation has a positive effect on foreign exporters but a negative impact on those providing inputs for the country's processing exports.

Is renminbi really undervalued as many have argued? Should the Chinese government take measures to mediate the misalignment and make renminbi appreciating in a short time? These questions rely on the direction and extent to which renminbi has deviated, if at all, from its equilibrium level. These questions have drawn the attention of many researchers who have attempted to calculate the equilibrium exchange rate of renminbi using different approaches. However, these studies have conflated rather than clarified to these issues, as evidenced in the

¹ Current estimates of the IMF's Consultative Group on Exchange Rates indicate that the renminbi is undervalued by 3 percent (ERER approach), 17 percent (ES approach), and 23 percent (MB approach).

wide ranging results from their empirical studies in estimating equilibrium exchange rate of renminbi. Table 1 summarizes the results from a sample of these studies, showing that estimated misalignment of renminbi ranges from no misalignment to 65% deviation.

Table 1.1 Estimate of Misalignment of Renminbi

Researcher	Estimated Misalignment	Assessment Year	Approach
Sato, et al(2011)	Bilateral ER undervalued by 65% ²	2008	International Input-Output table
Jingtao Yi(2010)	Undervalued by 19%	2004	Macroeconomic Balance
Cline and Williamson(2010)	Effective ER undervalued by 21.4%; bilateral ER undervalued by 40.2%	2009	Fundamental Equilibrium Exchange Rate
Cheung, Chinn, and Fujii(2007)	There is little statistic evidence of undervaluation	2004	Extended Purchasing Power Parity
Yizhong Wang(2010)	Effective ER undervalued by 20%	2008 to 2010	Prior Equilibrium Exchange Rate
You and Sarantis(2011)	Undervalued by 16.8%	2009	Fundamental Equilibrium Exchange Rate

Note: ER denotes exchange rate; *bilateral ER* is the exchange rate versus US dollar.

According to Dunaway and Li(2005) the variance on estimates of renminbi is attributable to several reasons including difference in methodology, an array of variables used as proxies for the fundamental determinants of equilibrium exchange rate and different time phases in which some of the data might be dated. It is even arguable researchers are influenced by their subjective judgments when considering the underlying equilibriums. Additionally, many approaches might be difficult to implement in transition economies like China, as structural changes would make the underlying economic relationships unstable. Considering the array of variables, it is dubious that results arising from these studies could offer a reliable benchmark for the evaluation of renminbi. In contradistinction, the methodology of the study is premised upon the necessity to calculate the equilibrium real exchange rate of renminbi under prevailing economic factors, taking into consideration that current economic transition and structural change play important roles in real exchange rate determination.

² Base year is 2000 when China's current account was relatively balanced from 1999-2001.

1.2 Purpose of the study

1.2.1 Research Questions

The main purpose of this study is to calculate the equilibrium exchange rate of renminbi under prevailing fundamentals by employing the Behavioral Equilibrium Exchange Rate (BEER) approach. Concurrently, by discussing prominent structural changes during economic transition in, this study aims to improve our understanding of factors in the movement of real exchange rate of renminbi from 2000Q1 to 2011Q4.

The research questions guiding the study are listed as follows:

1. What is the equilibrium exchange rate of renminbi
 - During economic transition in China, what factors may have influenced the actual movement of equilibrium exchange rate of renminbi?
 - What is the renminbi behavioral equilibrium exchange rate?
2. Is renminbi undervalued, as many have argued
 - By comparing the theoretical behavioral equilibrium exchange rate and actual real exchange rate of renminbi, what is the misalignment in recent years?
 - If it exists, what caused large scale of misalignment?
3. Policy recommendation
 - Should Chinese government encourage renminbi to appreciate to its equilibrium level in a comparably short time?
 - Does the misalignment indicate that the exchange rate regime in China has to be adjusted?

1.2.2 Research Scope

Prior to this study, no determinative answer has been given to the dispute of whether renminbi is undervalued or not over the past 11 years. Accordingly, the focus of this study is to provide a benchmark for assessment of renminbi misalignment by calculating the equilibrium exchange rate. Although the equilibrium exchange rate calculated from BEER approach often compromises a feature of forecasting, this benchmark should not be used to determine if renminbi ought to appreciate or depreciate in the future. This is partly because the starting point of BEER approach in Clark and MacDonald(1999) is the theorem of uncovered interest parity and the model has been adjusted for the existence of a time-varying risk premium, so it contains expectations of future levels of the real exchange rate. However, the short-term movement of actual exchange rate caused by such interest rate differentials is omitted in this research because the focus is in long-run evaluation of the exchange rate.

1.3 Outline of the Thesis

To achieve the research objectives, this study is presented across five chapters, with this chapter containing a brief overview of the research method and a short summary.

Chapter 2 examines key structural changes that have been argued to influence the movement of real exchange rates. These structural changes include exchange rate regime reform, trade liberalization and changes in economic growth.

Commencing with an introduction of the economic equilibrium conditions that are used to construct many empirical models, Chapter 3 reviews the methods estimating equilibrium exchange rates. This leads into a discussion on traditional PPP with regards to its restrictiveness and the so-called 'PPP puzzle'. The empirical models discussed in this chapter all start with the proposition that PPP is inadequate to describe and determine equilibrium exchange rate in the long run perspective. Chapter 3 also contains a review of the recent empirical studies calculating equilibrium exchange rate of renminbi employing these approaches.

Significantly, chapter 4 specifies the reason why the BEER model is used in this study and develops a theoretical framework consisted of a 6-variable VAR model. Chapter 4 then defines the variables in the model and conducts stationary test to each variable before applying the Johansen-Juselius co-integrating test to make sure that all variables are co-integrated in the same order. The lag length of the VAR model is determined and then a VEC model is developed based on the VAR model. The rank of the VEC model and related deterministic components are discussed and tested. Chapter 4 concludes with applying the behavioral equilibrium exchange rate calculations, based on the estimated equation in the VEC model.

Chapter 5 summarizes the empirical findings of this study and discusses the misalignment in the sample period. It also provides recommendations on RMB exchange rate policy and related adjustment on macroeconomic regulation.

1.4 Overview of the Methodology

By employing the BEER approach, this study estimates the equilibrium exchange rate of renminbi under prevailing economic fundamentals using quarterly data from 2000Q1 to 2011Q4. BEER is abbreviated for Behavioral Equilibrium Exchange Rate and was first introduced by Ronald McDonalds and Peter B. Clark(1999) based on the co-integration framework of Johansen and Juselius(1995).

1.4.1 What is Equilibrium Exchange Rate?

The equilibrium exchange rate is one of the most important concepts in open macroeconomics. Early literature discussing equilibrium exchange rate dates back to 1918 when Gustav Cassel(1921) developed the measure of Purchasing Power Parity based on the 'Law of One Price' (LOOP). According to LOOP, identical goods will have the same price in different markets when the prices are expressed in terms of one currency, holding in abeyance transaction costs and official barriers to trade. Purchasing Power Parity (PPP) is often the first measure many would think of and turn to when asked if a currency is undervalued or overvalued.

The development of econometrics enables researchers to test PPP in many economies producing the so-called 'PPP puzzle', which is concerned with the high volatility of real exchange rates in a short time and a low mean reversion speed(Rogoff 1996). More recently, alternative approaches measuring equilibrium exchange rates have been developed which take as a starting point that PPP is not sufficient for constructing an equilibrium exchange rate, these approaches rely on real factors that drive exchange rate away from its equilibrium level calculated by PPP.

The economic equilibrium underpinning some approaches may be recognized from their names, such as the monetary balance model, the enhanced PPP approach and the capital enhanced equilibrium exchange rate approach. However, the variance underlying these alternate economic theories and assumptions makes it difficult to give an identical definition of equilibrium exchange rate in terms of their calculation. In fact, the BEER approach itself does not even necessarily encompass the notion of macroeconomic balance that appears in most literature. Some frameworks are designed around the result of equilibrium exchange rates, for example, equilibrium exchange rates that would finally lead to trade balance or monetary balance. In comparison, other frameworks focus on how equilibrium exchange rates are determined and what should account for the short-term movement of real exchange rate. Moreover, the time frame is also an important factor in equilibrium exchange rate discussion. According to Drive and Westaway(2005) typology of equilibrium exchange rates may be developed as long-, medium- and short-term. The model that will be used in this study relates closely to the long-run equilibrium concepts. A detailed review of equilibrium exchange rate calculation is given in chapter 3.

1.4.2 Estimating Behavioral Equilibrium Exchange rate of Renminbi

Following Clark and MacDonald(1999), the actual real exchange rate could be determined as

$$q_t = \beta_1' z_{1t} + \beta_2' z_{2t} + \tau T_t + \varepsilon_t \quad (1.1)$$

Where z_{1t} and z_{2t} are vectors influencing the exchange rate over the long and medium run, T_t is a transitory vector affecting the real exchange rate in the short run, β and τ are reduced-form coefficients of the vectors.

The choice of each vector variable is based on Clark and MacDonald(1999), Montiel(1999) and Edwards(1989) and will represent key structural changes during economic reform in China.

By the application of co-integrating test, it will be revealed if there is co-movement between the fundamentals and the actual real effective exchange rate. The main procedures include:

- Stationary analysis of the variables
- Johansen-Juselius cointegration analysis
- Estimation of current equilibrium exchange rate

1.4.3 Measuring Exchange Rate Misalignment

1.4.3.1 Measuring Current Exchange Rate Misalignment

According to Clark and MacDonald(1999), the current equilibrium exchange rate could be defined for a position where transitory and random terms in equation (1.1) are zero:

$$q'_t = \beta'_1 z_{1t} + \beta'_2 z_{2t} \quad (1.2)$$

Thus current exchange rate misalignment is given as

$$cm_t = q_t - q'_t = q_t - \beta'_1 z_{1t} - \beta'_2 z_{2t} = \tau T_t + \varepsilon_t \quad (1.3)$$

Therefore, current misalignment is simply the sum of the transitory and random errors.

1.4.3.2 Measuring Total Exchange Rate Misalignment

According to Clark and MacDonald(1999), current values of economic fundamentals may deviate from sustainable levels. This paper also defines total misalignment tm_t as the difference between the actual and real rate given by the sustainable values of the economic fundamentals. This is denoted as:

$$tm_t = q_t - \beta'_1 z_{1t}^* - \beta'_2 z_{2t}^* \quad (1.4)$$

where z_{1t}^* and z_{2t}^* are the equilibrium values of the long-term and medium-term fundamentals.

Note that the calibration of the fundamentals at their sustainable levels could either be achieved by subjective judgment or by simply using a statistical filter. This study will use the Hodrick-Prescott filter to smooth the time series data.

1.4.3.3 Interpreting Exchange Rate Misalignment

The misalignment of renminbi could be interpreted as a percentage defined as:

$$Mis_RMB = \frac{q_t - q'_t}{q'_t} * 100\% \quad (1.5)$$

1.5 Summary

In this Chapter, the research objective was defined as measuring the equilibrium exchange rate using the BEER approach in response to current debate over real exchange rate of renminbi. The research scope is refined as to depict the misalignment of renminbi from its equilibrium level in the sample period rather than predict any future movement. It is stressed in this chapter that calculating the equilibrium exchange rate of renminbi should incorporate some significant factors reflecting economic reform in China. However, further discussion is needed to identify relevant factors and how they would affect the movement of real exchange rate of renminbi. Accordingly, the next chapter reviews the research background and demonstrates select aspects of economic reform relevant to the real exchange rate determination.

Chapter 2 Research Background: Economic Transition in China

2.1 Introduction

In chapter 1 the research question was defined as whether renminbi has been over- or undervalued and how much was any misalignment, it also summarize the basic approach of this study. Chapter 4 answers the research question and discusses the complicated mechanism of exchange rate formation, this discussion clarified why the BEER approach was selected. Chapter 2 considers many aspects of current economic transition, which influence the renminbi real exchange rate, indicating the weakness in some exchange rate theories explanations of fluctuations in the short to medium run.

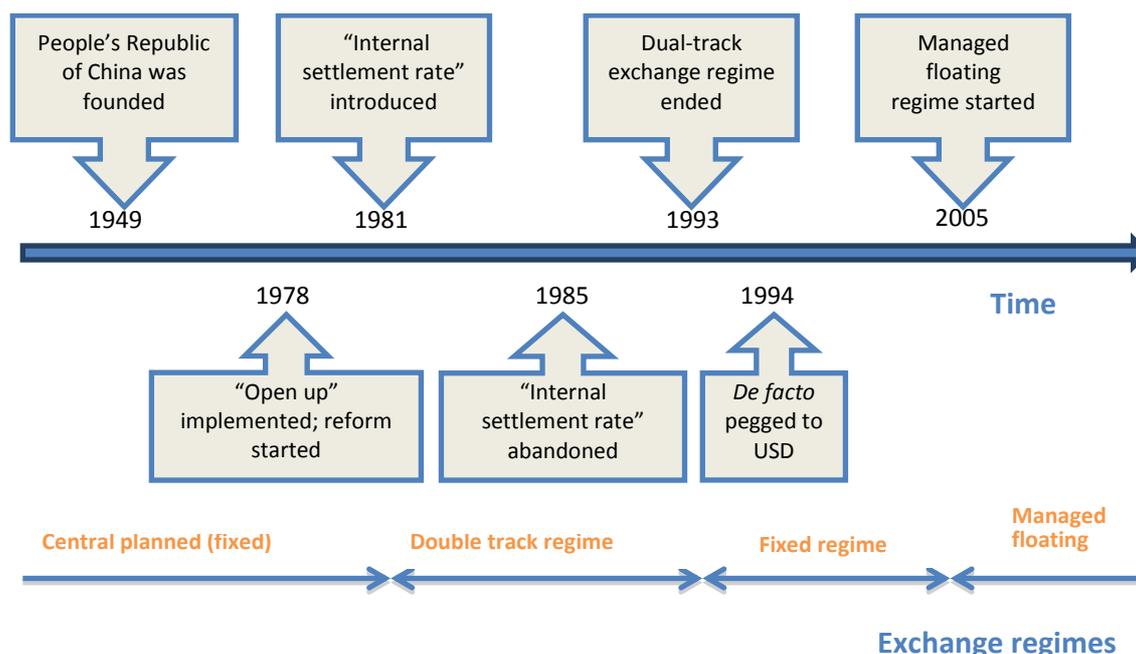
Since the People's Republic of China government was founded in 1949, it experienced an almost completely independent economy. From that time, the exchange rate regime had been seen as "fixed" or "managed/manipulated floated" with several major recognizable changes. These changes are concomitant with its economic reform, which started in 1978 and has transformed China from a centrally planned economy to an increasingly market-oriented economy. China's transition included a series of reforms in many areas, ranging from agricultural to industrial sectors, from a system of price determination to wage, from product market to labor market and from internal monetary market adjustment to external trade balance management.

As these economic reforms have directly and indirectly influenced the determination of the real exchange rate, chapter 2 selects for review some of the salient changes that have been widely discussed to be related to the fluctuation of real exchange rate. Section 2.2 contains a review on the exchange rate regime of renminbi. Section 2.3 to Section 2.4 discusses trade liberalization in China and the ongoing change on economic growth pattern and their potential impact on the real exchange rate. Section 2.5 summarizes the chapter.

2.2 Exchange Rate Regime Reform in China

Financial reform holds significant weight during the transition of the Chinese economy, involving broadening channels of financial intermediation, modernizing framework of monetary management and stronger government supervision and regulation. Significantly, these reforms manifest in the form of market-determined prices for interest and exchange rates and the reform of exchange rate regime can be seen as a way to liberalization. The timeline in Figure 2.1 shows the key events in RMB exchange rate regime reform and lists the history of exchange regimes.

Figure 2.1 Timeline of key events in RMB exchange rate regime reform



2.2.1 Exchange Rate Regime under Central-planned Economy

The exchange rate of renminbi was pegged to the U.S. dollar at 2.4618 in terms of Yuan before China implemented the *Open-up Policy*³ in 1978. When the Bretton-Wood system collapsed in 1973 the bilateral exchange rate of renminbi had to be adjusted in an effort to control the cost of imports. At that time, the renminbi was considered overvalued by 60% based on China's export prices at that time.

2.2.2 Double-track Exchange Rate Regime

China adopted a dual exchange rate in 1981 in order to balance the trade as well as maintain the benefits of a strong currency. One rate was known as the 'internal settlement rate' at 2.80 RMB/USD, the other being the 'official rate' for non-trade sector. The Bank of China created the foreign exchange swap market with the approval of the Chinese government, who permitted fluctuations of the swap exchange rate around the internal settlement rate within a band of +/- 10%.

³ For more about open-up policy, see: http://en.wikipedia.org/wiki/Chinese_economic_reform

Following external pressure from IMF⁴ and the United States the internal settlement rate was abolished in January 1985 to achieve a unitary exchange rate in the foreign exchange swap markets, which in turn determined the exchange rate in international markets. However, this market driven exchange rate deviated from the official exchange rate sharply. Table 2.1 shows the official exchange rate, internal settlement rate and swap rate at relevant times from 1980 to 1993. The swap rate was 6.5 in terms of Yuan while the official rate was only 3.72 in 1986.

Table 2.1 RMB exchange rate under dual-track regime (Yuan per U.S dollar)

Year	Official rate 1980-93	Internal settlement rate 1980-84	Swap rate 1980-93
1980	1.530	2.80	2.80
1981	1.750	2.80	2.80
1982	1.920	2.80	2.80
1983	1.980	2.80	2.80
1984	2.800	2.80	2.80
1985	3.200	N/A	3.20
1986	3.720	N/A	6.50
1987	3.720	N/A	6.50
1988	3.200	N/A	6.00
1989	4.720	N/A	5.70
1990	5.220	N/A	5.50
1991	5.430	N/A	5.93
1992	5.750	N/A	6.80
1993	5.800	N/A	8.70

Data sources:

Official rate: from IMF: International Financial Statistics, end of period data.

Internal settlement rate & swap rate: from Yang, Yin et al(2007).

2.2.3 De Facto Pegged to U.S Dollar

In an effort to deepen its overall economic reform, the Chinese government adopted a market-oriented and managed-floating exchange rate regime, which ended the double-track exchange rate regime on January 1st 1994. Although this exchange rate policy was seen as *de facto* pegged to U.S dollar at that time, a target band was set for renminbi convertibility for current account transactions. Concurrently, China's foreign exchange trading center commenced operation which is seen as the beginning of China's inter-bank foreign exchange market.

During the Asian Financial Crisis in 1997 renminbi was under immense pressure to depreciate but remained stable, consequently, the exchange rate was considered as a *de facto* to U.S dollar at 8.28 in terms of Yuan. One of the most significant factors accounting for the stability of renminbi during the Asian Financial Crisis was China's massive foreign exchange reserve. Notably, at the end of June 2005 the foreign exchange reserve totaled 711 billion U.S dollars with a huge trade surplus.

⁴ According to IMF, dual exchange rate system is allowed only to deal with short-term, balance-of-payments problems, and IMF suggested that China return to a unitary exchange rate.

To balance the economy and keep development sustainable, the People’s Bank of China issued the Public Announcement on Reforming the RMB Exchange Rate Regime (People’s Bank of China 2005). China claimed that it intended move to a managed floating exchange rate regime based on market demand and supply to achieve greater flexibility, which necessitated switching a from dollar-pegged to a basket-pegged regime. However, due to the central bank intervention, daily fluctuation was restricted within a 3% variation.

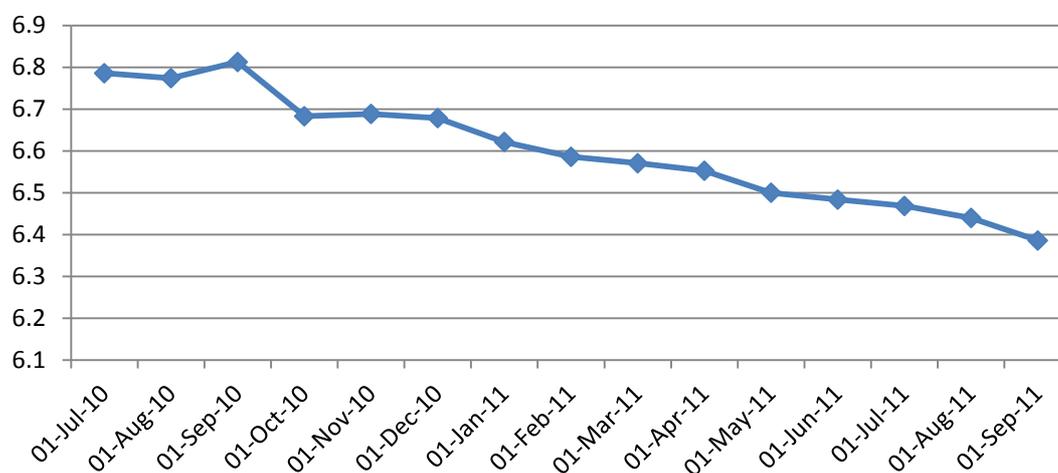
2.2.4 Managed Floating System since Mid-2005

From July 2005 until July 2008 a cumulative nominal appreciation of 21% against the US dollar occurred, resulting in a nominal RMB-USD rate of 6.827 Yuan. To enhance the renminbi exchange rate flexibility, the People’s Bank of China in June 2010 extended reforms of the RMB exchange rate regime, stating:

In further proceeding with reform of the RMB exchange rate regime, continued emphasis would be placed to reflecting market supply and demand with reference to a basket of currencies. The exchange rate floating bands will remain the same as previously announced in the inter-bank foreign exchange market. (People’s Bank of China 2010)

Figure 2.2 shows the impact of this policy on the movement of bilateral exchange rate of renminbi vis-à-vis U.S. dollar from July 2010 to September 2011. It is observable that the renminbi has achieved greater flexibility compared to historical levels.

Figure 2.2 Bilateral Exchange Rate of Renminbi (Yuan per Dollar)



Data source: IMF Exchange Rate Archives by Month

2.3 Renminbi Exchange Rate, Trade Liberalization and Current Account Imbalance

2.3.1 Commercial Policy and Real Exchange Rate

Trade systems have been an important component in the overall strategy of reforming China's economic system. While tradable goods are arbitrated in international markets, their prices are to some extent influenced by external commercial policy, holding in abeyance other factors such as transportation fees and consumer behaviors. Meanwhile, it is generally accepted that price levels calibrate the levels of real exchange rates irrespective of whether the nominal exchange rate is officially fixed by the central bank or floated according to supply-demand factors. In synthesis, it is believed that there is a correlation between commercial policy and real exchange rate.

Sebastian and Van Wijnbergen(1989) identified literature supporting two propositions concerning this relationship. Proposition (1) is that the increase of import tariffs will result in an appreciation of the real exchange rate and proposition (2) is that the worsening of the terms of trade will result in a depreciation of the real exchange rate. Devereux and Connolly(1996) demonstrated that these propositions hold true when the real exchange rate is defined as the ratio of external to internal prices rather than as the price of traded goods to non-traded goods. Reinforcing this observation Obstfeld and Rogoff(1995a, 1995b) hold the view that a more open economy should exhibit a less volatile real exchange rate⁵. This is because more imported goods can provide a channel for a quick adjustment of the domestic aggregate price level, which in turn reduces short-run effect of a money supply or real shock on the real household balances and therefore reduces the scope of such a shock to develop real effects on either domestic consumption or the real exchange rate(Hau 2002; Obstfeld & Rogoff 2000).

Confirmation of this relationship emerges from the empirical evidence gathered by Hau(2002) from a cross section of forty-eight countries, to assert that differences in trade openness can explain a large part of the cross-country variation in the volatility of the trade-weighted effective real exchange rate.

While trade systems have been an important component in the overall strategy of reforming the economic system in China, this study will consider the impact of trade policy or openness on real exchange rate movement. Section 2.3.2 is a brief review of the commercial policy reform in the past 30 years.

2.3.2 Overview of Commercial Policy Reform and Development

China has relevantly experienced 4 phases of Commercial policy reform, each of which has impacted on its present exchange rate regime.

2.3.2.1 Central-planned Trade System before 1978

During the centrally planned economic period, import and export of China was decided in details by the State Planning Commission. Their import plan encompassed

⁵ Vice versa, it has been argued that exchange rate volatility affects the volume of trade to some extent by some researchers, e.g., Koray and Lastrapes(1989).

90 percent of all imports and was specifically designed to increase the supplies of machinery and equipment and industrial materials that were in short supply. Foreseeably, the exchange rate and relative price did not play an important role in determining the foreign trade in China. Consequently, the efficiency of domestic resource allocation was quite low and many exports did not enjoy a comparative advantage in production and producers had no incentive to expand their business.

2.3.2.2 Trade Reform from 1978 to 2000

China's planned trade scheme was gradually dismantled from 1978 and largely abandoned by the end of 1990s. Progressively, its foreign trade authority was decentralized being allocated across provinces, municipalities, industrial sectors and enterprises. The Chinese government experimented in new forms of trade including processing trade, compensation trade and border trade. Special economic zones were established to introduce foreign capital and gain experience in production and management.

Later relevant government functions were separated from enterprises. As a result, administrative procedures for approving imports and exports were simplified and the previous planning framework was abandoned in order to establish more direct links between production and trade. The Chinese government also established a system of export tax-rebates into a fund for encouraging exports and different tariff rates for exports and imports, to acclimatize the need for changing the management of trade from direct administrative control to indirect means. This forced a comprehensive modification of China's Tariff Law during this period. A contractual system was implemented in both trading and manufacturers in the export sector as well as to the relationship between local and central government. Significantly, the central government did not provide subsidies for any price differential.

Local governments were allowed to increase their retention of more foreign exchange and the central government allowed trading companies and enterprises to trade their foreign exchange at market prices in foreign exchange swap market. Enterprises enjoyed increasing freedom in their use foreign exchange rates and tariffs to adjust trade by a series of measures such as phasing out export subsidies and narrowing the regional differences in foreign exchange retention rates, As a result, enterprises were encouraged to be fully responsible for their profits and losses in order to be competitive both domestically and internationally.

China's import system had also been adjusted by a series of measures including a unilateral reduction of tariff rates for a wider range of commodities, abandonment of import adjustment taxes, reduction of the coverage of import licensing and a re-examination and subsequent abandonment of internal documentation for import management.

China's trade system reform attained broad ranging achievements before 2000, including expansion of trade and improvements in welfare, reduction in anti-export bias, changes of the role of the government in trade management, reduction in tariff and an establishment of link between domestic and international prices through

price system reforms⁶. Expanding and deepening these reform remained necessary for China's accession to WTO status after 2000(Garnaut & Song 1999).

2.3.2.3 Trade Reform Deepened by World Trade Organization (WTO) Accession

China formally joined the WTO on 11 December 2001 under a series of conditions. Consequently, trade reforms have been deepened before and after conditional accession due to the *Trade Policy Review Mechanism* of WTO. Additionally, China has made several commitments for its WTO accession including tariff reduction on imported goods, decreasing non-tariff trade barriers, changes on trading and investment regimes and more concern to its trading partner safeguards. Three weeks later after its accession, China lowered its average tariff rate by 0.6 percentage points to 10.4 percent discarding most of the import quotas, licenses, designated trading practices and other non-tariff barriers. Instantly, the overall trade regime was designed to be tariff-driven. Concurrently, where foreign participation was previously nonexistent or marginal, key service sectors were gradually opened such as telecommunications, financial services and insurance. Principles of non-discrimination were applied to market accession protocols including national treatment. Additionally, China agreed to fully implement the Trade-Related Investment Measures (TRIMs) and Trade-Related Aspects of Intellectual Property Rights (TRIPs) upon unconditional accession(Rumbaugh & Blancher 2004).

2.3.2.4 Trade Policy after 2007

Simultaneously with China's rapid economy growth, its current account surplus has accumulated resulting in the introduction of tightening measures at the beginning of 2007. The Ministry of Finance and State Administration of Taxation adjusted export duty rebates on 2,831 products that accounting for 37 percent of commodities covered by the custom tariff on 1 July 2007. The Ministry of Commerce and the General Administration of Customs twice changed the catalogue of prohibited commodities in processing trade in 2007 and 2008.

The tightening policy did not last long once the global financial crisis greatly impacted the United States and European Union causing a sharp decrease on China's exports. This unprecedented pressure forced the Chinese government into action against this decrease to absolve the un-exported commodities in the second half of 2008. As a result, the Ministry of Finance and The State Administration of Taxation raised export duty rebate rates on textiles, apparels and other products. At the same time, a series of policy documents were released aimed at stimulating and regulating foreign investment.

2.3.3 International Trade and Balance of Payments (BOP) Surplus in China

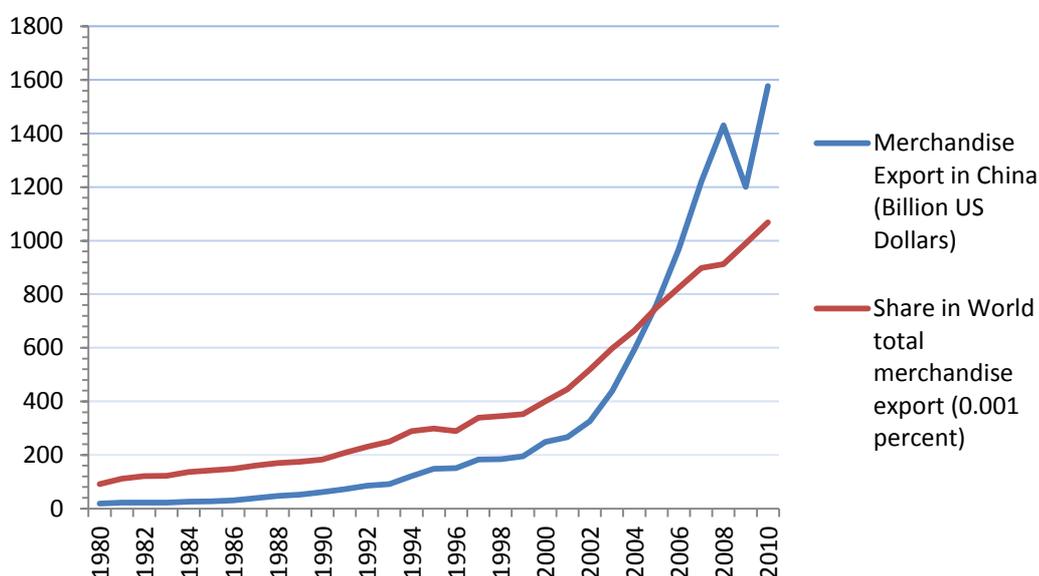
2.3.3.1 Increasing Integration with World Economy

International trade in China has expanded since the opening of its economy in 1979. For the past 30 years, the merchandise export growth rate measured by constant price in U.S dollars compared with world total merchandise export (figure 2.3) shows

⁶ In fact, domestic prices of most traded goods had largely converged to international prices by the mid-1990 as a result of tariff reduction and domestic price liberalization(Rumbaugh & Blancher 2004).

that its merchandise export keeps a double digit growth of 16.1 percent, which is more than the world average growth rate of 6.9 percent.

Figure 2.3 Merchandise export of China 1980-2010



Simultaneously with China’s exports penetrating into industrial countries (Table 2.2), it has become an important export destination for regional economies. Exemplifying this change, China now accounts for more than 22 percent of Japan’s export, which were only 2 percent in 1990.

Table 2.2 Market share in Major Export Market

Imports from China divided by total imports, in percent				
	1980	1990	2000	2010
Japan	3.1	5.1	14.5	22.1
United States	0.0	0.5	8.6	19.4
European Union	0.6	0.7	6.2	18.9

Note: *Market share* is calculated as imports from China divided by total imports (in percent)
Data source: WTO, Statistics Database, Trade Profiles

In synthesis, China’s integration with the world economy became increasingly intensive from speed to scope. China’s growth trend appears able to be maintained for a number of years, despite being faced with many problems associated with the export-oriented growth economy. This is comparable with the historical evidence from Japan and other newly industrialized countries in Asia, such as South Korea and Singapore, in terms of their respective growth rate over an extended period(Rumbaugh & Blancher 2004)

2.3.3.2 Changes in Composition of Trade

The composition of export from China has diversified greatly over the past 30 years, from initially heavy reliance on materials and light manufacturing goods to more sophisticated electronics, as shown in Figure 2.4-a and Figure 2.4-b.

Figure 2.4 China Export Commodities Comparison

Figure 2.4-a China Export Commodities 1980

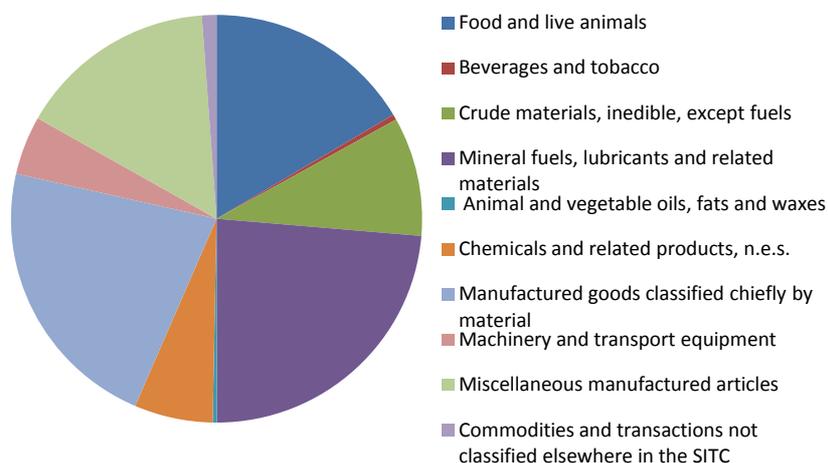
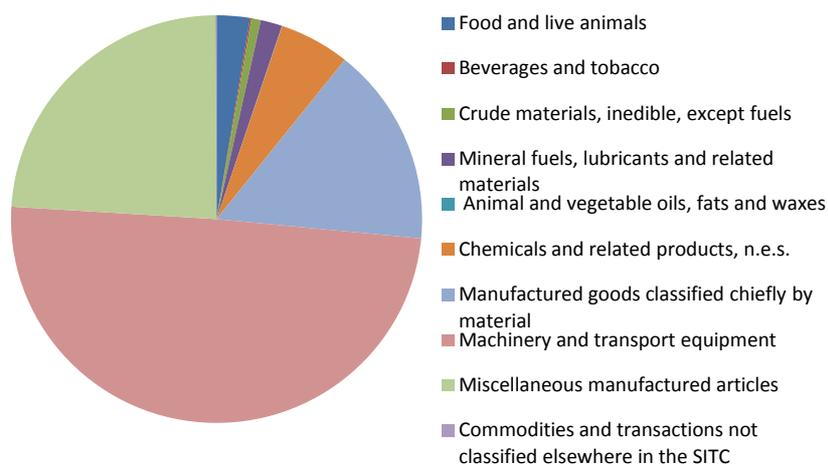


Figure 2.4-b China Export Commodities 2010



Data source: National Bureau of Statistics of China: Annual Data, External Economy

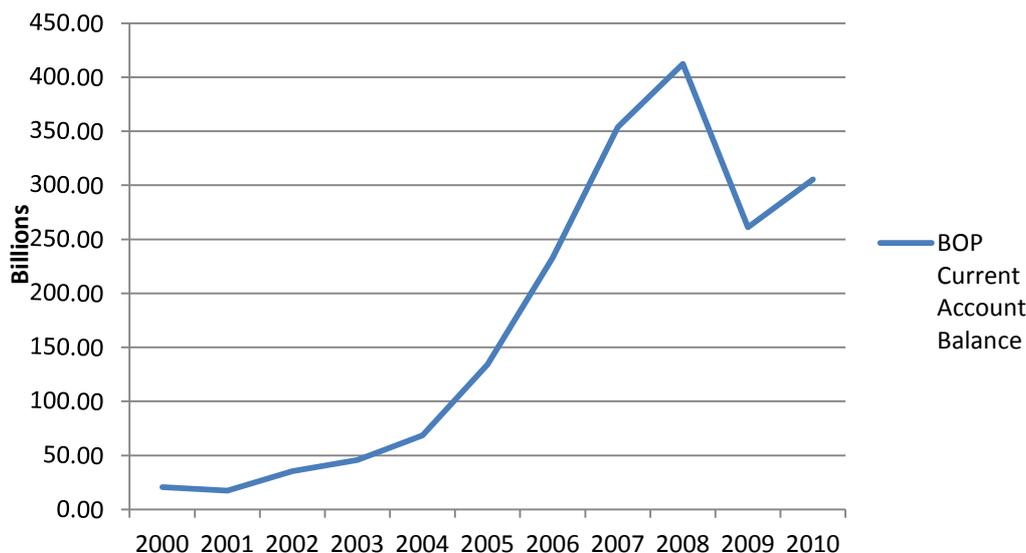
In the early 1990s, light manufacturing exported goods account for more than 40 percent of total export in China, including footwear, clothing, toys, and other miscellaneous manufactured goods. By the end of the first decade in 21st century, machinery and transport equipment represented the largest proportion of exports, while the share of miscellaneous manufactured goods declined from 42 percent in 1993 to 24 percent in 2010.

Imports related to processing and the production of export materials, occupied the largest share of the composition of China's import. This increased vertical specialization can be seen in the rapid growth of export of electronic integrated circuits and micro-assemblies.

2.3.3.3 Large Current Account Surplus since 2000

Considering the above import and export activities, China Export growth rate has outpaced import in China since 2000, which gives the exaggerated current account surplus arrived at in recent years (Figure 2.5). By 2006 China has the largest current account surplus in the world reaching 360 billion in US dollars in 2007, equal to 15 percent of its GDP. Notably, this organic outcome became a major contention between China and its trade partners.

Figure 2.5 Current Account Balance of China 2000-2010 (US dollars)



Data source: World Bank Data: Economic Policy and External Debt

2.3.4 Exchange Rate and Current Account Imbalance

According to Rosenberg, current account imbalance could affect exchange rates through three channels. These channels are (1) current account imbalance can influence the supply of and demand for individual currency, (2) current account imbalance can shift the residence of financial wealth among deficit and surplus countries, which could lead to shifts in global asset preferences. Lastly, (3) concerning debt sustainability, currency of countries with sizable debts are expected to depreciate to ensure that the debt are stabilized at a deemed sustainable level (Rosenberg 2003).

Rogoff (1996) brings up another empirical theory about the relationship between current account imbalance and real exchange rate from a long-run perspective, viz. sustained current account deficits are associated with currency depreciation. Rogoff (1996) asserts there is sufficient empirical evidence supporting this correlation that it may be theoretically rationalized, viz.

... For example, a temporary productivity shock can easily improve a country's current account (saving rises as current income exceeds permanent income) while causing deterioration in a country's terms of trade (by raising current supply of the home good)... (Rogoff 1996)

That a positive connection between openness and economic growth in China is uncontested(Lardy 2003). As is articulated further in 2.4, the possible correlation between economic growth and currency appreciation⁷ in the long run makes it reasonable to further discuss how trade policy would influence real exchange rate movement. Despite this, trade surplus does not always indicate appreciation for individual currency.

While China has been widely accused of deliberately manipulating its currency to fuel its exports, some researchers argued that there is some evidence that Chinese trade flows responds to changes in real exchange rate(Cline & Kim 2010) and this is asserted despite any elasticity is not reliably estimated(Cheung, Y-W, Chinn & Fujii 2009). Others suggest that exchange rate policy alone will not be sufficient to reduce the Chinese trade surplus especially taken in the context of a trend increase in China's manufacturing capacity(Cheung, Y-W, Chinn & Fujii 2009).

This study posits that it is necessary to investigate if real exchange rate is correlated with trade policy, if so, to what extent it would be affected by trade policy and current account structure.

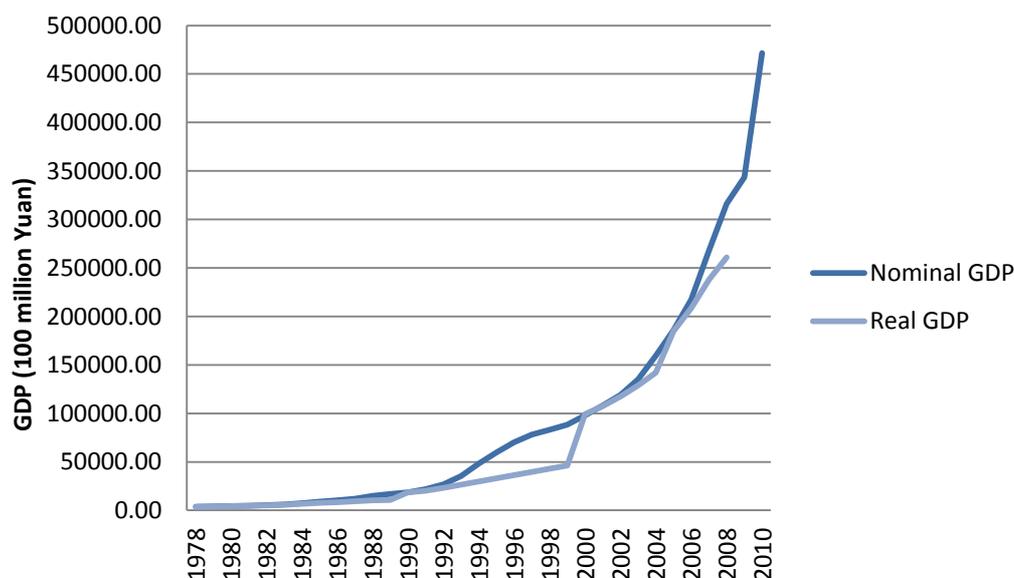
⁷ There is also a popular empirical theory about the relationship between growth rate and real exchange rate. According to Rodrick(2008), undervaluation of a currency could stimulate economic growth, especially for developing countries such as China, India, South Korea and Uganda, etc. However, from a long-run perspective, the positive correlation between economic growth and currency appreciation could be theoretically rationalized as explained in section2.4.

2.4 Economic Growth and RMB Exchange Rate

2.4.1 Economic Growth Rate since 1978

Since its Economic Reform, China has achieved great economic growth while keeping the price relatively stable across the last three decades. The growth rate has been 16.4 percent at average in nominal gross domestic product (GDP) since 1978 (Figure 2.6).

Figure 2.6 Gross Domestic Product (GDP) of China 1978-2011



Data source: National Bureau of Statistics of China: Annual Data, National Accounts

Note: Price levels are adjusted every five years in calculating real GDP.

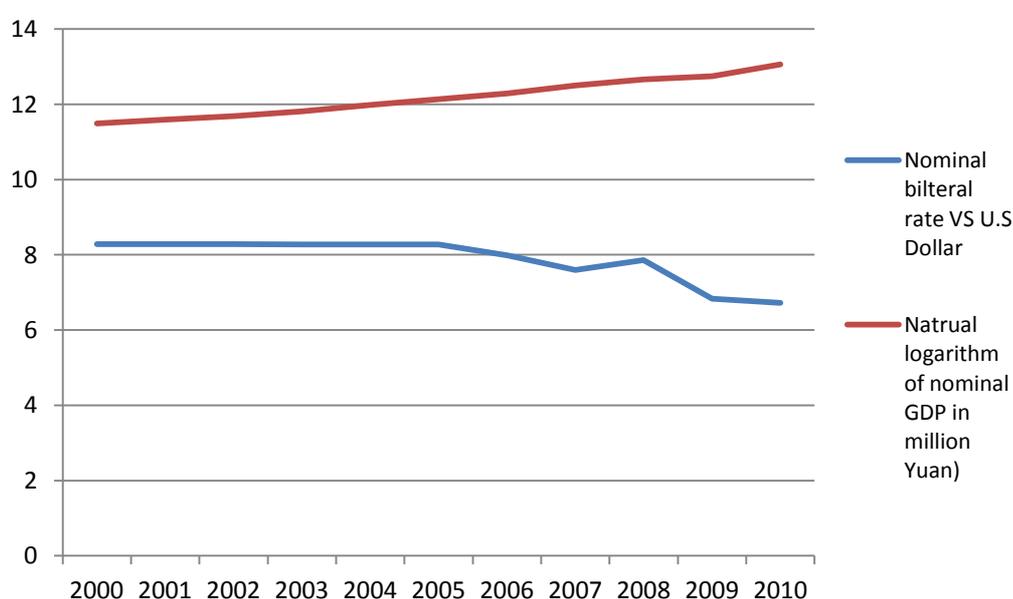
2.4.2 Economic Growth and Real Exchange Rate

Long-run cycles of exchange rates may bear some common features with long-run business cycles in developed countries. According to Rosenberg(2003), the empirical evidence from the Deutschemark, Japanese Yen and U.S Dollar well support this proposition. By comparing the fluctuation of these currencies with their long-run PPP equilibrium values, he finds that the magnitude of USD exchange rate movements in each cycle has generally been large and the length of the cycle tends to be longer than the business cycle.

According to modern macroeconomic theories, the supply of domestic currency would change if there were an increase or decrease in total output, which affects the real exchange rate. The different type of shocks, such as real demand, nominal/monetary supply or supply factors, may work as shocks to goods and monetary market, or long-run productivity, which in turn would cause the fluctuation in output, the exchange rate and the aggregate price level. Moreover, the shocks could be identified with regard to their impact on real exchange rate. As Chadha and Prasad (1997) indicated, the sharp appreciation of the Japanese Yen in 1993 and 1995 was attributable to nominal and demand shocks, while supply shocks have played a smaller role.

In many emerging countries, the relationship between economic growth and currency appreciation could be closely related in a comparably short run, especially for floating rate. In fact, according to Duarte et al. (Duarte, Restuccia & Waddle 2007), the volatility of real exchange rate in developing countries is larger than that in developed countries such as United States, which is found to be related to standard business cycles and other macroeconomic aggregates. For the case of China, before adopting the flexible exchange rate regime, a fixed exchange rate is often seen as a tool to stimulate both its export and its economy. However, the evidence from the first decade after its accession to WTO shows that there is also a positive relationship between economic growth and currency appreciation (Figure 2.7), especially after 2005 when the Chinese government started a basket-based adjustment under the managed-float regime, which allowed more flexibility of the renminbi exchange rate.

Figure 2.7 Nominal exchange rate appreciation VS economic growth: China 2000-2010



Data source: National Bureau of Statistics of China: Annual Data

2.4.3 Transform Economic Growth Pattern, Government Spending and Real Exchange Rate

2.4.3.1 Long-run Trend to Transform Economic Growth Pattern in China

The main driving force of China's economic growth has been its rapid growth in exports. However, as export-led growth strategies began to show their weakness in sustainable development issues, environmental concerns, independence of monetary policy and loss of natural resources and labours. China is making an effort in adjusting its growth strategy both externally and internally. Since the large population makes it possible to stimulate domestic demand surge in a comparably short time, it saw a boom of government expenditure past after the 2008 global financial crisis. This is often seen as one of the most significant reasons why China was able to recover from the crisis in a relatively short period.

It is anticipated that China will take additional measures to transform its growth model from its export-incentive one. This involves strengthening its pension and health care system to reduce the precautionary motive for household saving, achieving an expansion of employment, a greater appreciated exchange rate and an increase in deposit rates. This measure together with a higher wage and interest rates combined with a reduction of the oligopoly power of firms in some sectors are aimed at reducing the excess rent and increasing corporate saving(IMF 2011).

Synthesizing these measures, over a longer horizon, the transformation of China's growth model is likely to lead to growth that is lower than historical levels. Despite this, it requires observing that China will be more sustainable, inclusive and have a positive impact on people's livelihoods(IMF 2011).

2.4.3.2 Government Spending and Real Exchange Rate

Though it may be difficult to measure the transformation of growth patterns inclusive of all relevant aspects such as improvements in pension and health care systems, one significant factor in this issue is government spending on its expansion fiscal policy could stimulate the domestic demand in a short-run. This was broadly used in China especially after the global financial crisis in 2008.

A separate issue for another study is the relationship between government spending and real exchange rate remains to be a subject of debate. Prior to Rogoff(1996) postulating that the 'PPP puzzle' could relate to difference in productivity between countries, sustained current account deficits and government spending, Froot and Rogoff(1991) suggest that among EMS countries government spending could be a significant determinant of real exchange rate. This earlier observation was rationalized by suggesting government spending could fall more on non-tradable goods compared with private spending, which in turn leads to an increase in the real exchange rate. They further suggested that the effect is short-run when capital and labor is not perfectly mobile across sectors. They considered exchange rates would always be tied down by productivity and other supply factors.

While Backus et al.(1994) used a standard open-economy model to predict that a rise in government purchases appreciates the real exchange rate, recent empirical research based on structural vector auto-regressions has documented different results. Specifically, an exogenous increase in government purchases in a given country triggers a depreciation of its real exchange rate. In response Kollmann (2010) argued that this puzzle was raised by the assumption in Froot and Rogoff(1991) and also Backus and Smith (1993), viz. government purchases are unproductive. Kollmann(2010) uses a model where real exchange rate may depreciate in response to a rise to government purchases if these purchases increase domestic private sector productivity. The result shows that a very small dose of public sector externality is sufficient to generate this depreciation.

In synthesis, it is reasonable in real exchange rate determination to consider the impact of economic growth and related macroeconomic factors, such as aggregate investment and government spending during significant structural and growth pattern transformation in China.

2.5 Summary

In this chapter, contextualized with a brief review of the previous exchange rate regime in China, key factors from its economic transition were identified and discussed with respect to their impact on real exchange rate as the research background. These factors included trade liberalization, economic growth, financial liberalization and labor market structure change. From this discussion, it can be asserted that real exchange rate of renminbi is driven by many fundamental factors.

The next Chapter contains a literature review of selected relevant theories in equilibrium exchange rate estimation as well as recent empirical studies that illuminate both the determination and selection of this study's variables as proxies for the economic fundamentals.

Although many existing equilibrium exchange rate models are imperfect for thoroughly understanding exchange rate determination, they do share common relationships within real economic environments. Therefore, it is necessary to review these models before specifying why Behavioural Equilibrium Exchange Rate approach is chosen over other approaches.

Chapter 3 Literature Review

3.1 Introduction

Chapter 2 discussed some of the salient structural changes during economic reform in China with regards to their influence over renminbi exchange rate movement. Following this discussion chapter 3 reviews the empirical methods estimating equilibrium exchange rate with regards to their theoretical implications of underlying economic equilibrium relationships. Consequently, this review indicates that selecting the method to calculate equilibrium exchange rate should follow the research interest and be based on the proper time frame.

Earliest attempts at measuring equilibrium exchange rate could date back to 1918 when Gustav Cassel(1921) developed the measure of Purchasing Power Parity⁸(PPP). Development in modern economic methods allows researchers to test the PPP proposition in different countries, which in turn creates the 'PPP puzzle'. In response to the insufficiency of the PPP proposition to explain the equilibrium exchange rate determination, researchers develop alternative ways to estimate equilibrium exchange rate. These alternative methods differ from each other in terms of underlying economic equilibrium relationship, consideration of different deterministic variables and estimation method, which creates an array of definitions of equilibrium exchange rate. Notably, although each method is distinctive from other approaches, they are mostly constructed based on simple macroeconomic theorems introduced in next section.

Compared with those macro-fundamentals approaches, it is noteworthy that micro-structural approach has become increasingly popular in the exchange rate literature to estimate the equilibrium level of exchange rate in the short run. This micro-structural approach focuses on how key players in foreign exchange market interact and drive the movements of exchange rate(Evans & Lyons 2004; Lyons 2001). However, it is commonly believed that macro-fundamentals approaches remain to be of significance in explaining fluctuation of real effective exchange rates especially in the medium and long run(MacDonald 2007). Following this discussion the rest of this chapter is organized as followed. Section 3.3 is a typology of empirical approaches to estimating equilibrium exchange rate based on underlying macroeconomic equilibrium relationships, starting with a discussion of the restrictiveness of PPP proposition and the so-called 'PPP Puzzle'. Section 3.4 reviews recent empirical studies in the case of China and evaluates those studies with regard to their consideration of the fundamentals during China's economic reform. Section 3.5 gives a summary to this chapter.

⁸ While Early PPP was articulated by scholars of Salamanca school in sixteenth century Spain, and discussed by classical economists such as John Stuart Mill, Viscount Goschen, Alfred Marshall and Ludwig von Mises, Cassel was really the first to treat PPP as a practical empirical theory(Rogoff 1996).

3.2 Theoretical Frameworks: Equilibrium Conditions

This section introduces equilibrium theorems discussing exchange rate determination. This includes purchasing power parity, interest rate parity, balance of payment equilibrium and macroeconomic balance. These theorems provide a framework under which the empirical models are considered in section 3.3.

3.2.1 Purchasing Power Parity

The proposition of purchasing power parity has been widely used to measure equilibrium exchange rates, especially in long run. While PPP is one measure independently in itself in equilibrium exchange rate literature, it is also a relationship which underpins other exchange rate frameworks including the monetary balance approach discussed in Section 3.2.3.

Traditional PPP hypothesis develops from the 'law of one price' (LOOP), with a two-country and single-product condition which assumes that goods are homogeneous and there is no barrier to trade such as transportation costs and tariffs, then PPP could be interpreted as:

$$P_t^i = S_t P_t^{i*}, (3.1)$$

where p^i is the price of good i and S is nominal exchange rate in terms of domestic currency; asterisk denotes foreign magnitude. What makes absolute PPP or LOOP function is arbitrage.

When it comes to n goods manufactured assuming homogeneity and absence of trade impediments, PPP could be interpreted as:

$$S_t = P_t / P_t^*, (3.2)$$

where P_t and P_t^* are price levels in each country. The price level could be calculated as:

$$P_t = \sum_{i=1}^n \alpha^i P_t^i, (3.3)$$

where α^i is the weight used to aggregate the individual prices and $\sum_{i=1}^n \alpha^i = 1$. It is also assumed that the weight of each goods are identical across countries.

Considering the exchange rate in real terms and abstracting the price level from the nominal exchange rate, real exchange rate Q_t could be expressed as:

$$Q_t = S_t P_t^* / P_t. (3.4)$$

Alternatively, when transformed into logs, it may be expressed as:

$$q_t = s_t + p_t^* - p_t. (3.4')$$

Lower case letters mean natural logarithm forms. If absolute PPP holds, it can be concluded that $Q_t = 1$ and $q_t = 0$. A premise of this expression is that there is no correlation between real exchange rate and nominal exchange rate. The implication is that real exchange rates will be a constant value where absolute PPP represents a

long-run relationship since the mechanism making PPP hold is arbitrage, which is expected to take time to finish the process.

An alternate version of PPP being referred to as *relative PPP* which uses the differentials of the variables may be described as follows,

$$\Delta s_t = \Delta p_t - \Delta p_t^* \quad (3.5)$$

This equation indicates that countries with relatively high inflation rate in a given period of time would experience currency depreciation. Compared with absolute PPP, this form is less controversial. This is because it does not by necessity assume that there is equilibrium between price level and nominal exchange rate in the base year. Instead, it depicts the direction and extent of nominal exchange rate movement according to the change of price levels (MacDonald 2007).

In practical application, Ex Ante PPP assists to understand how the traditional PPP proposition is applied to real analysis. According to Ex Ante PPP, the expected change in the spot exchange rate would equal to the difference in expected national inflation rate. Therefore, a high-inflation country should see its currency depreciate over time, and *vice versa*.

3.2.2 Interest Rate Parity

The LOOP applies to both commercial and asset markets. As previously discussed, PPP is an arbitrage condition that illustrates the relationship between price levels and real exchange rates. In comparison, the interest rate parity assumes that risk-adjusted expected real returns on financial assets will be the same in foreign markets as in domestic markets in the absence of market imperfections. To express interest rate parity as an equation, let $F_{t,k}$ denote the forward rate in a k -period and S_t denote the spot rate, then $i_{t,k}$ and $i_{t,k}^*$ are the interest rate over a maturity of k in domestic and foreign asset market. It may be roughly presented as:

$$\frac{F_{t,k}}{S_t} = \frac{1+i_{t,k}^*}{1+i_{t,k}} \quad (3.6)$$

This equation assumes that the interest rate parity will remain true if the ratio of forward and spot exchange rate equals to the ratio of foreign and domestic nominal interest rates. Alternatively, investors may theoretically arbitrage on the foreign exchange market and make risk-free returns. Literature commonly distinguishes between uncovered interest parity (UIP) and covered interest rate parity (CIP).

3.2.2.1 Covered Interest Rate Parity (CIP)

According to CIP, the interest rate difference between two countries' currencies is equal to the percentage difference between the forward exchange rate and spot exchange rate, assuming that there is absolute capital mobility and perfect asset substitutability. Taking the natural logarithm in equation 3.6 and using the approximation $\ln(1 + x) \approx x$, CIP holds if,

$$f_{t,k} - s_t = i_{t,k} - i_{t,k}^* \quad (3.7)$$

According to equation 3.7, when the domestic rate is lower than foreign interest rate the forward price of the foreign currency will be lower than the spot rate, and *vice versa*. The difference in the interest rate between two countries will cause a forward rate premium or discount, in an opposite direction to the difference for each country's foreign currency.

3.2.2.2 Uncovered Interest Rate Parity (UIP)

According to UIP, the return from investing the same amount money on domestic currency deposit and foreign currency are expected to be equal when converting the proceeds back into domestic currency at the future expected exchange rate. To express UIP as an equation, let $E(S_{t+k})$ denote the market expectation based on the observation of interest rate difference, UIP can be presented as

$$E(s_{t+k}) - s_t = i_{t,k} - i_{t,k}^* \quad (3.8)$$

Compared with CIP, UIP is not an arbitrage condition. Instead, the expected exchange rate is unknown at time t and therefore nonzero deviations from UIP do not necessarily imply that there are arbitrage profits due to the foreign exchange risk associated with future exchange rate movement (Ullrich 2009).

3.2.3 Balance of Payments Equilibrium

The standard balance of payment equilibrium under the flexible exchange rate regime, assuming the absence of foreign exchange market intervention, may be described as,

$$ca_t = -ka_t \quad (3.9)$$

Where ca_t and ka_t denote respectively the current and capital account of the balance of payments. Also assuming no minor components, the current account can be determined as:

$$ca_t = nx_t + i_t' nfa_t \quad (3.10)$$

where nx_t denotes net exports and $i_t' nfa_t$ represents the interest payments on net foreign assets, either of which may be influenced by exchange rate fluctuation. Net exports may be considered to be determined by:

$$nx_t = \alpha_1(s_t + p_t^* - p_t) + \alpha_2 y_t^* - \alpha_3 y_t, \quad \alpha_1, \alpha_2, \alpha_3 > 0 \quad (3.11)$$

where s , p and y denotes spot exchange rate, price level and output respectively in their natural logarithm forms at time t , asterisk denotes a foreign magnitude.

According to equation 3.11, the first item is an expression of price competitiveness which is assumed to be positively related to net export. A rise in domestic income could have a negative impact on net export for its impact on import and positive impact for the consideration of foreign income growth. Meanwhile, the capital account is assumed to be a determined according to the equation below:

$$ka_t = \mu(i_t - i_t^* - \Delta s_{t+k}^e) \quad (3.12)$$

where Δs_{t+k}^e is the first difference operator. If $\mu \rightarrow \infty$, equation 3.12 reduces to uncovered interest parity condition. Equation 3.12 indicates that the interest rate

spread will cause a capital account balance change until this effect is removed by a change on the expectation of investors on the future exchange rate movement. In combining both, the balance of payments exchange rate equation may be obtained as:

$$s_t = p_t - p_t^* + \frac{\alpha_2}{\alpha_1} y_t - \frac{\alpha_3}{\alpha_1} y_t^* - \frac{1}{\alpha_1} i_t' n f a_t - \frac{\mu}{\alpha_1} (i_t - i_t^* - \Delta s_{t+k}^e) \quad (3.13)$$

Equation 3.13 can be seen as a general way to interpret the determination of real exchange rate that satisfies balance of payment equilibrium under floating exchange rate. Empirically, balance of payment equilibrium may be defined in two ways. Firstly, it may be considered as a situation where normal net capital flows equals the underlying current account balance, alternatively stated, there is no change in international reserves. Secondly, it may be defined as that current account balance equals a ratio of net foreign assets to GDP or other structural norms (Dunaway & Li 2005). According to MacDonald (MacDonald 2007), the balance of payments equilibrium is not steady state equilibrium because it is not stock-flow model, however, it provides meaningful consideration for a medium-equilibrium model construction: most the existing equilibrium exchange rate models are derived from this proposition for assessment purposes.

3.2.4 Internal and External Equilibrium (Macroeconomic Balance)

The macroeconomic balance has been popular since the explicit recognition of permanent deviation from PPP. Compared to balance of payments equilibrium, which to some extent represents an external balance, macroeconomic balance takes both external balance and internal balance into consideration. According to Swan (1963), macroeconomic balance is believed to be a level of output at which the employment rate and low inflation rate can be achieved (NAIRU⁹) and the net savings generated at this output level have to be equal to current balance.

Under this equilibrium framework exchange rates are determined not only by PPP but are also influenced by interest rate and monetary supply, which in turn indicates the macroeconomical properties of real exchange rate. Under this circumstance, the real exchange rate may not be considered as a price for currency/capital assets or as commercial products that could be traded across the board. Instead, it acts more as a 'price' which can be used as a lever to adjust economic structures from output to consumption (Jiang 2006). According to Peter Isard (2007), the PPP-related approaches and estimated exchange rate can be seen as price-based methodologies. Variations of the macroeconomic balance approaches can be seen as quantity-based methodologies.

The equilibrium exchange rate is then defined as a rate that satisfies both internal and external balance, while the general favour of the framework in determining the exchange rate may be expressed as:

$$S(W) - I(X) = CA(\hat{q}, Y) = -KA(Z) \quad (3.14)$$

⁹ In monetarist economics, NAIRU is an acronym for 'non-accelerating inflation rate of unemployment', and refers to a level of unemployment below which inflation rises.

Where S denotes national savings, I denotes investment spending, W, X, Y and Z are vectors of variables that were chosen to interpret internal and external equilibrium condition, \hat{q} is the real exchange rate consistent with internal-external balance.

Compared with the balance of payment equilibrium, the internal-external equilibrium is more a stock-flow equilibrium because it requires the current account surplus consistent with a 'sustained' level. The intention of the internal-external balance underpins many empirical equilibrium exchange rate models including the Fundamental Equilibrium Exchange Rate (FEER) and the Natural Real Exchange Rate (NATREX). FEER is defined as 'real exchange rate which is consistent with macroeconomic balance, which is identified as the rate that brings the current account into equality with the underlying or sustainable capital account, where the determinants of both the current and capital accounts have been set at their full employment values' (Clark & MacDonald 1999). What distinguish the models are the different vectors of variables that determine the macroeconomic balance.

In next section reviews relevant empirical approaches to calculate equilibrium exchange rate. These approaches are built upon the economic theorems previously introduced and are becoming increasingly popular, assisted by the fastening pace of globalization and developments of regional currencies.

3.3 A Review of Empirical Models in Medium- to Long-Run

This section starts with a discussion of the restrictiveness of PPP itself as a method to calculate equilibrium exchange rate and a brief introduction of the so-called 'PPP puzzle'. Section 3.3.1 also discusses why PPP is not a good measure of equilibrium exchange rate, including inherent PPP limitations, the impact of real factors driving real exchange rates and the complexity of real exchange rate determination, this discussion contends that it is reasonable to consider alternative methods to measure equilibrium exchange rate. This section concludes by reviewing the FEER, the NATREX and the BEER approaches which rely on the frameworks introduced in section 3.2 and those 'real factors' that cause permanent deviation of real exchange rate from their PPP-value.

3.3.1 Restrictiveness of PPP and 'PPP Puzzle'

Conceptually, absolute PPP or relative PPP is restrictive in scope in many aspects. Firstly, PPP assumes that goods are identical across the countries. While this might be true for the goods manufactured by multinational companies such as Nike or Motorola, it is often not the case when it comes to agricultural products such as coffee, tea and tobacco. Many goods are imperfectly substitutable between different countries. This makes trade unpredictable in terms of its motives, rather than simple arbitrage spurred by real price differentials considering nominal exchange rates. Thus the fundamental mechanism is questionable in terms of those imperfectly substitutable goods.

Secondly, another assumption of PPP may be invalid, that the weights of goods –the α s – which are used to construct the price levels are identical across countries (MacDonald 2007). This necessarily involves various assumptions that influence the output and price and finally the weights of goods, remaining as somehow reasonable across countries with similar levels of development and cultural background. Specifically, that despite these factors PPP remains valid, notwithstanding the impact of additional factors, including consumer behaviour, i.e. how much money they would like to spend on food, but also that the weight of government expenditure on say infrastructure construction in any specified year, will remain constant. For countries at different levels of development and different consumer behaviours, it is unreasonable to apply PPP as having the same weights in terms of computing the price levels.

Thirdly, PPP is premised on the assumption of an absence of transaction costs across the countries. However, in the real world the cost of transportation and trade barriers such as tariffs are not so insignificant as to be ignored. Furthermore, some non-price costs or barriers, such as quotas, local content requirements and some legal issues often make it more difficult to deal with international trade. Possible invisible trade barriers also include the price discrimination imposed on different countries caused by market segmentation, for example, 220-volt lamps are not popular in the U.S.(Rogoff 1996).

Finally, it implicitly assumed that all goods used to construct the price levels are traded. However, few aggregate price measures include only tradable goods. The issue of whether non-tradable goods should be included in tests of PPP has been

debated (MacDonald 2007) and opinions vary from strict exclusion of non-tradable goods to broadly covering a wide range of commodities. Some have even argued that price measures should abandon tradable goods and focus on non-tradable goods (Frenkel 1976). Exacerbating this discussion is the boundary between tradable goods and non-tradable goods become blurry when there is some innovation in transaction cost. Some prefer using a continuum of goods whose degree of tradability depends on transaction cost (Obstfeld & Rogoff 1995a).

A separate PPP concern the so-called 'PPP Puzzle' which was identified and raised by Rogoff (1996). To explain, consider that while equation 3.4 implies a steady state of nominal exchange rate and equation 3.5 indicates a reversion of exchange rate to equilibrium, most PPP proponents would argue absolute PPP is a level to which exchange rate gravitates. They argue that deviation may happen due to change on financial factors, such as monetary shocks, asset bubbles and government intervention in foreign exchange market (Officer 1976). This can be expressed by modifying the equation 3.4' to:

$$q_t = \rho q_{t-1} + \beta + \epsilon_t \quad (3.15)$$

where ρ is the parameter of mean reversion, ϵ_t is a random error term, and β is constant. If exchange rate is at equilibrium, then external shocks are extinguished by exchange rate reverting to a new state of:

$$\bar{q} = \beta / (1 - \rho) \quad (3.16)$$

The speed of this reversion could be described by the introduction of *half-life*, which is the time it takes for half of a shock to PPP to be extinguished. Traditionally, money neutrality suggests *half-life* should be around 1 year. However, using data prior to and during the post-Bretton Woods, a spate of empirical studies found that there is a statistically significant mean reversion, despite this the half-life falls within 3 to 5 years (Rogoff 1996). According to Rogoff (1996), the 'PPP puzzle' was described as,

... How can one reconcile the enormous short-term volatility of real exchange rates with the extremely slow rate at which shocks appear to damp out? ... It is not difficult to rationalize slow adjustment if real shocks – shocks to tastes and technology – are predominant. But existing models based on real shocks cannot account for short-term exchange rate volatility...

Rogoff (1991) also addresses three modifications to long-run PPP that have been discussed in the literature, viz. that productivity differs between countries (Balassa 1964; Samuelson 1964), sustained current account deficits (Bayoumi et al. 1994) and government spending (Froot & Rogoff 1991) would have significant influence over real exchange rate determination. While these modifications are useful in some circumstances, they are not universal enough to supplant PPP as long-run exchange rate determination.

Economists expend effort in order to explain the 'PPP Puzzle' from alternative perspectives. One effort argues that transaction costs (e.g. transportation costs) to some extent account for the slow adjustment speeds of real exchange rate (Sercu, Uppal & Van Hulle 1995). Other related research efforts have focused on how much

transaction cost are correlated with nominal exchange rate volatility(Wei & Parsley 1995) and the implications of transaction costs for non-linear exchange rate behaviour(Obstfeld & Taylor 1997). Another explanation relates to market structure, such as *pricing to market* or price discrimination across the global market(Krugman 1986). According to empirical research later conducted by Knetter(1989), the price in the exporter's currency is a mark-up over marginal cost which is determined by the elasticity of demand in different markets. Market structure theories and productivity differences as explanations, do assist to understand the persistent deviation of real exchange rate from the PPP-estimation, however, an alternative interpretation of the cause of this persistence requires explicit recognition that there are real determinants of real exchange rates(MacDonald & Deutsche Bundesbank 2000).

3.3.2 The Fundamental Equilibrium Exchange Rate

Based on the macroeconomic balance analysis of Swan(1963), Williamson(1994) developed the concept of Fundamental Equilibrium Exchange Rate (FEER) which can be defined as 'a real effective exchange rate that simultaneously ensures internal and external balance', In FEER, internal balance is identified as the level of output consistent with both full employment and low inflation and external balance is characterized as the sustainable net flow of resources. The literature of FEER has grown considerably since the popularity of the concept of macroeconomic balance by a group of economists (Bayoumi et al. 1994; Williamson 1994; Wren-Lewis 1992).

According to Williamson(1994), FEER involves two major steps. Firstly, FEER identifies the external balance by equating current account balance to capital account balance. The current account is a sum of net trade balance and returns on net foreign assets, which are assumed to be a function of the real effective exchange rate and full employment output of the local and foreign economy. Secondly, The FEER approach builds up the equation in order to calculate the equilibrium exchange rate.

The most popular method of constructing an empirical FEER model, focuses on an estimated current account equation and setting it equal to a sustainable capital account(Wren-Lewis 1992). The procedure to apply the FEER approach essentially involves five steps(Égert, Balázs, Halpern & MacDonald 2006):

- Determine a targeted current account position;
- Estimate the elasticity of the trade account with regards to domestic and foreign outputs and to the REER,
 $Trade\ Balance = f(Y, Y^*, REER)$ (3.17);
- Calculate of the change in the REER that would achieve the targeted current account¹⁰;

¹⁰ Step 3 is supposed to calculate the change in the REER that would place domestic and foreign outputs on their potential path as well as the targeted current account; since it is hard to achieve these objectives at the same time, it is just assumed that internal balance in both the home and foreign economies is achieved without the help of REER (Égert, Balázs, Halpern & MacDonald 2006; Wren-Lewis 1992).

- Determine the change in the REER that would make the current account adjusted for the internal balance to move to its target value, which is actually the total misalignment; and
- If necessary, calculate the bilateral equilibrium nominal exchange rate from the equilibrium REER.

Šmídková *et al*(2002) and Bulíř and Šmídková (2005) proposed that external debt target is introduced in the framework based on the framework of Williamson(1994) and Wren-Lewis(1992), which would widen the horizon of the original FEER from the medium to long run. This variant of the FEER is called 'Fundamental Real Exchange Rate' which imposes a long-run external debt target that is expected to converge in the long run.

Canvassing various discussions about the theoretical implications of FEER, this study synthesizes relevant considerations as follows.

- The implication of 'Equilibrium' in FEER approach

The empirical FEER models are based on what is known as macroeconomic equilibrium, as discussed in section 3.2.4. There are many factors included in the macroeconomic equilibrium, including economic growth, real interest rate, fiscal policy or the determinants of savings and investment. All these factors play important roles in current account and external debt sustainability, which is the focus of macroeconomic balance considerations. In fact, for open economies, the definition of equilibrium exchange rate is associated with external balance in terms of sustainable current account and external balance. FEER is built up on the concept of macroeconomic equilibrium, which is in line with this implication.

- The Implication of 'Equilibrium exchange rate' in FEER approach

According to Wren-Lewis(1992), FEER is 'a method of calculation of a real effective exchange rate which is consistent with medium term macroeconomic equilibrium', viz. FEER itself is not a theory about how exchange rates are determined. FEER does not provide a framework in which the real exchange rates are constructed directly as other models do, such as the Permanent Equilibrium Exchange Rate and Behavioural Equilibrium Exchange Rate approaches. Under these approaches, equilibrium exchange rates are determined by a given equation containing different time-framed components.

Additionally, the way to calculate the actual misalignment of the currency implicitly indicates that in the medium to long run, the actual real exchange rate would converge to this theoretical level. Rather than calculate the equilibrium exchange rate directly as other models do, FEER first calculates a change in real exchange rate from the equations. Then based on this change in real effective exchange rate interpreted as 'theoretical misalignment', the equilibrium exchange rates can be obtained.

- The subjectivity of FEER approach

The FEER approach involves an obvious degree of subjectivity, which naturally varies across uses in application. Specifically, before constructing the FEER model, researchers must decide the determinants of potential output growth associated with low inflation rate, then determine the targeted current account position which is required to be sustainable to the economic growth. Obviously, this can be interpreted in many ways, such as a stabilized external debt-to-GDP ratio or saving-to-investment ratio. Compounding this subjectivity, in operating the FEER approach, researchers must also estimate the elasticity of the current account with respect to foreign and domestic output as well as real effective exchange rate. Consequently, an extra layer of judgment has to be imposed before the FEER can be calculated (Égert, Balázs, Halpern & MacDonald 2006; MacDonald & Deutsche Bundesbank 2000).

FEER appears deceptively attractive because it encapsulates the basic idea of macroeconomic balance, which seems more solid than PPP and its extended forms. Motivated by different research interests, some researchers raise selected problems or issues associated with the theoretical implications in applying FEER in empirical analysis. These issues may be relevantly categorized as follows.

- Difficulty in interpreting 'true' equilibrium over medium run

As the process of deriving a FEER does not require the estimation of a full dynamic model, an immediate consequence is that FEERs are subject to hysteresis effects since the medium-term current account would be affected by temporary shocks (Driver & Westaway 2005). Similarly, according to Dunaway and Li (2005), the underlying current account might be able to reflect the structural changes with regards to their likely effects on the external position to some extent. However, as is the cases for many transition countries, if the structure changes over the time, the targeted current account might be questionable.

- Inaccuracy in estimating equilibrium exchange rate

As FEER places significant reliance on trade elasticity, this may result in an inaccurate estimation of the FEER trajectory (Siregar & Rajan 2006). If FEER only captures the changes in net trade balance and assumes that the impact on net foreign assets/external debt only be exogenously determined, the size of the required real exchange rate appreciation may be overestimated. This is explained in the assumption being questionable since there is evidence that shows a correlation between real exchange rate and net foreign assets (Obstfeld & Rogoff 1995b).

- Possible lack of important variables that effect exchange rate

As long as the positions of internal and external balance remain undisturbed, the misalignment calculated from FEER would not change. Consequently, the theoretical FEER calculated from the misalignment would remain the same. Conditionally, if there were change in other factors that could have an effect on exchange rate in the medium run and these were not included in FEER framework, the equilibrium exchange rate calculated from FEER approach is likely to fail to explain the

movement of real exchange rate associated with change on these factors(Clark & MacDonald 1999).

- Difficulty in understanding the mechanism of exchange rate convergence

As previously discussed, the actual real exchange rate is indicated to converge to the FEER-level. The dependent assumption of the model is that this divergence of the actual real exchange rate from the FEER will set in motion forces that will eventually eliminate this divergence. Significantly, this adjustment is not specified in the model, which consequently provides limited understanding in real exchange rate behaviours(Égert, Balázs, Halpern & MacDonald 2006).

3.3.3 The Natural Real Exchange Rate

Stein(1994) developed the Natural Rate of Exchange (NATREX) which is also based on internal-external balance framework. In contradiction to FEER, the NATREX approach distinguishes equilibrium real exchange rates at two horizons, viz. in the medium term and long run. While the real exchange rate under the medium term is quite similar as it is in FEER, the long run definition is slightly different with regards to the determination of internal balance, as it is defined in terms of full capacity utilization rather than NAIRU(Égert, Balázs, Halpern & MacDonald 2006).

Under NATREX the economic equilibrium is distinctly similar to what is described by Nurkse(1945) and Williamson(1994). It includes the idea of balance of payments equilibrium which is discussed further below. Cumulatively, NATREX is defined as the rate that would prevail if speculative and cyclical factors could be removed while unemployment is at its natural rate. Stein(2001) has also described the criteria that determine the sustainable level of the equilibrium exchange rate, requiring that,

- It is consistent with internal balance. This is a position where the rate of capacity utilization is at its longer run stationary mean.
- It is consistent with external balance. This is a position where investors are indifferent between holding foreign or domestic assets at the given level of exchange rate.
- At the equilibrium real exchange rate where there is no reason for the exchange rate to appreciate or depreciate, interest rates between the two countries would converge to a stationary mean. And
- The condition for external balance in the long run is that the ratio of the foreign debt to GDP stabilizes at a tolerable level.

The framework of the NATREX approach relies on two broad pillars according to these criteria. Commencing with building up the external balance equation, known as the national income accounting equation:

$$I - S + CA = 0 \quad (3.18)$$

Where I is the desired investment, S denotes the desired saving and CA is the desired current account. All the terms are *desired* rather than *actual* levels, which indicates these are factors that ensure the economy is operating at capacity output

and expectations about inflation are met. The level of desired saving and investment depend on the existing stock of capital, wealth and net debt.

Next the national account identity equation is constructed:

$$\frac{C}{Y} + \frac{I}{Y} + \frac{NX}{Y} = 1 \quad (3.19)$$

The components in equation 3.19 can be constructed in these equations,

$$\frac{I}{Y} = f\left(a, \frac{K}{Y}, r, Q\right) \quad (3.20a)$$

$$\frac{C}{Y} = f\left(\frac{K}{Y}, \frac{FDEBT}{Y}, Z\right) \quad (3.20b)$$

$$\frac{NX}{Y} = f\left(Q, \frac{D}{Y}, \frac{D^*}{Y}, TOT\right) \quad (3.20c)$$

where K is the capital stock, $FDEBT$ is foreign debt, D and D^* is the demand in domestic and foreign market, TOT is the terms of trade, r is interest rate and Z is a vector of exogenous variables that are disturbances to productivity and social thrift. By substituting equations 3.20 into identity 3.19, the medium-term NATREX Q can be calculated.

Stein(1995) illustrates the difference between medium and long-run NATREX introducing two conditions, viz. a decrease in saving and a rise in productivity. Under both conditions the medium-term NATREX would appreciate, because decreased saving and rise in productivity both imply an increase in consumption, in turn that would result in worsening the current account and foreign debt and lead to capital inflows that cause the real exchange rate to appreciate. Finally the appreciation restores the internal and external balance.

In the long run, however, the impact of reduced saving and increased productivity would lead to different results. Long-run impact of growth in productivity would still cause NATREX to appreciate, because in addition to foreign debt, social capital stock would increase as well which would in turn make further productivity growth and higher GDP with higher savings. As a comparison, decreased saving would depreciate the NATREX, because increased foreign debt causes interest payments to rise and currency depreciation would help to improve the trade balance to service the debt(Égert, Balázs, Halpern & MacDonald 2006).

The theoretical implications of the NATREX approach are discussed below.

- The concept of 'Equilibrium'

NATREX relies on the idea of macroeconomic balance in its long run analysis, as does the FEER approach. The balance of payments equilibrium is captured according to its medium-run equilibrium description. The medium-run position under the NATREX framework can be characterized by some conditions including the domestic securities market clearing, cyclical and short-term speculative capital flows cancelling out and any difference between investment and saving representing the excess flow of supply of tradable long-term securities. Under the NATREX framework, internal

balance is assumed to hold in both long run and medium equilibrium (MacDonald & Deutsche Bundesbank 2000).

- The concept of 'Equilibrium exchange rate'

The equilibrium exchange rate calculated from NATREX approach can be seen as 'dynamic'. When the desired saving and investment change, the NATREX will fluctuate accordingly and will converge to a new level in the long run when there is no further change in the fundamentals (Siregar & Rajan 2006). NATREX compares with FEER from medium and long run as NATREX captures the process of convergence of actual exchange rate from the deviation to the equilibrium values.

- NATREX and analysis for transition countries

According to Stein (1995), the discussion of the impact of productivity in medium and long run makes it suitable for the analysis of currency's appreciation in transition countries. Many researchers used a reduced form of NATREX to calculate the equilibrium exchange rate (Égert, Balázs, Halpern & MacDonald 2006),

$$q = f\left(a, \frac{K}{Y}, r, \frac{NFA}{Y}\right) \quad (3.21)$$

3.3.4 The Behavioural Equilibrium Exchange Rate

Designed to describe the actual behaviour of real exchange rate with regards to the change of economic fundamentals, the BEER approach was first introduced by Clark and MacDonald (1999). While FEER and NATREX assume macroeconomic equilibrium as their basic theoretical analysis framework, the notion of 'macroeconomic balance' is absent in the BEER approach. The starting point of the BEER approach is that there are real determinants of real exchange rates, which can be obtained by observation and properly interpreted by statistical approaches. Under BEER, the behaviour of nominal exchange rate and real exchange rate can be explained in terms of economic fundamentals in reduced-form econometric equations.

Although researchers under the NATREX approach use reduced-form equations with identical variables, there remain differences to the BEER approach. According to Stein (2001), the primary difference between the BEER and the NATREX is that the latter takes as its point of departure the specific theoretical dynamic stock-flow model to arrive at a reduced form, where the equilibrium real exchange rate depends upon relative thrift and relative productivity differences. Clark and MacDonald (1999) pointed out that reduced-forms exchange rate equations differ in their identification of short-run factors, medium- and long-run fundamentals and the extent to which these fundamentals are calibrated at their sustainable values.

The construction of actual real exchange rate under the BEER approach starts from the equation below (Clark & MacDonald 1999):

$$q_t = \beta_1' z_{1t} + \beta_2' z_{2t} + \tau T_t + \varepsilon_t \quad (3.22)$$

Where z_{1t} and z_{2t} are vectors influencing the exchange rate over the long and medium run, T_t is a transitory vector affecting the real exchange rate in the short run, β and τ are reduced-form coefficients of the vectors. By cointegration relation test, it

will be revealed if there is co-movement between the variables and actual real effective exchange rate and the coefficients could be estimated.

After the coefficients are obtained, the current equilibrium exchange rate could be defined as for a position where transitory and random terms in equation (3.22) are zero:

$$q'_t = \beta'_1 z_{1t} + \beta'_2 z_{2t} \quad (3.23)$$

Current exchange rate misalignment then is given as:

$$cm_t = q_t - q'_t = q_t - \beta'_1 z_{1t} - \beta'_2 z_{2t} = \tau T_t + \varepsilon_t \quad (3.24)$$

Therefore, current misalignment is simply the sum of the transitory and random errors. As the current values of economic fundamentals could deviate from the sustainable level, Clark and MacDonald(1999) also defines total misalignment as the difference between the actual and real rate given by the sustainable values of the economic fundamentals. This is denoted as:

$$tm_t = q_t - \beta'_1 z_{1t}^* - \beta'_2 z_{2t}^* = (q_t - q'_t) + [\beta'_{1t}(Z_{1t} - \bar{Z}_{1t}) + \beta'_{2t}(Z_{2t} - \bar{Z}_{2t})] \quad (3.25)$$

Where z_{1t}^* and z_{2t}^* are the equilibrium values of the long-term and medium-term fundamentals. The calibration of the fundamentals at their sustainable levels could either be achieved by subjective judgment or just using statistical filter, such as Beveridge-Nelson decomposition and Hodrick-Prescott filter. Consequently, total misalignment can be interpreted as the sum of current misalignment plus the impact of change of fundamentals on real exchange rates.

In their empirical analysis using the BEER approach, Clark and MacDonald(1999) construct a model starting with the risk-adjusted real interest parity relationship. Assuming that real exchange rate is determined by 'long-run' or systematic component of real exchange rate and short-run volatile factors, the actual real exchange rate can be written as:

$$q_t = f(r_t - r_t^*, nfa_t, tot_t, tnt_t) \quad (3.27)$$

where nfa_t denotes net foreign assets, tot_t denotes relative price of tradable to non-tradable goods and tnt_t denotes the terms of trade, which can be seen as the fundamentals of determining the 'long-run' or systematic component of real exchange rate. With $r_t - r_t^*$ denotes real interest rate differentials, which is interpreted as short-run volatile factors contributing to real exchange rate movements.

The theoretical implications of the BEER approach are discussed below.

- The concept of 'Equilibrium'

Ignoring the PPP doctrine the basic theoretical assumption of the BEER approach is that there are real determinants of exchange rates, which can be roughly classified into short-run factors and medium and long-run fundamentals. BEER is based on the rigorous statistical testing of relationship between real exchange rates and those

assumed fundamentals. The notion of economic equilibrium is absent in the BEER. Although the actual BEER model starts from UIP, it does not necessarily imply that the BEER approach is based on UIP condition. Instead, UIP is used as a factor explaining the short-run fluctuation of exchange rates.

However, the absence of equilibrium in BEER could be adjusted by subjective judgment of the sustainable values of the fundamentals, as is applied under the FEER approach. Or alternatively, by smoothing the time series by a statistical filter to differentiate the long-run value from transitory parts (Baffes, John et al. 1997; Elbadawi 1994). Additionally, the choice of actual fundamentals/variables is inspired by macroeconomic equilibrium condition, which implicitly indicates that to some extent the BEER approach could comprise some features of macroeconomic balance. Some researchers (Siregar & Rajan 2006) also consider that the BEER and the PEER – as discussed later – as extensions of the FEER approach. Consequently, BEER may still be used to assess exchange rates in the manner in which the FEER approach has been used with their similar consideration of macroeconomic balance (Clark & MacDonald 1999).

- The concept of 'Misalignment'

According to the equation 3.26, total misalignment of the currency at any point of the time could be decomposed into the effects of transitory factors, random disturbance, and the extent to which the economic fundamentals are away from their sustainable values. In the BEER approach, the distinction between the current misalignment and total misalignment is made explicit (MacDonald 2007). Therefore, the BEER is more general in that it can in principle be used to explain cyclical movements in the real exchange rate (Clark & MacDonald 1999). Compared with the BEER approach, the FEER, NATREX and PEER approaches focus on the calculation of total misalignment because they do not distinguish the causes of the deviation by necessity. Approaches such as Capital Enhanced Equilibrium Exchange Rate (CHEER) place emphasis on current misalignment because they are designed for short-term analysis of real exchange rate movement.

- The concept of 'Equilibrium Exchange Rate'

Compared with FEER, the calculation of the BEERs is not a normative one, as it is free from subjective notions of 'sustainable external balance' and 'internal balance' (Siregar & Rajan 2006). The analysis does not impose any particular functional forms from economic theories, instead the links between the real exchange rate and fundamentals are data-determined. Additionally, BEER considers UIP as a short-run cyclical factor that may contribute heavily to medium- to long-run movement real exchange rate. The adoption of UIP in BEER allows it capture the source of exchange rate changes in the capital account as well as in the current account. As was raised in the first consideration, choosing the fundamentals could reflect the similarity between the BEER approach and the FEER approach in capturing the basic economic balance conditions. This similarity between the BEERs and FEERs is comparable in terms of the way economic fundamentals/equilibrium are determined. This relationship will be further discussed in the PEER approach, which is essentially a variant of the BEER approach.

- The BEER approach in developing countries

The BEER has been widely used for the analysis of currencies in developing countries. By adding more conditioning variables that could describe the structural change in these economies, the models are adjusted for the explanation of real exchange rate movement. MacDonald(2007) gave recognition to the pioneering study of Edwards(1989), who first estimated the following specification for 12 developing countries using data over the period 1962-82,

$$q_{it} = f \left(\Delta\%TFPROD, TOT, \frac{GC}{GDP}, OPEN, CAPCON, s, q_{it-1} \right) \quad (3.28)$$

Where $\Delta\%TFPROD$ is the rate of growth of total factor productivity, TOT is the terms of trade, GC is government consumption, $OPEN$ is proxy for trade policy, and $CAPCON$ is the severity of capital controls. Following this framework, the research in developing countries has been updated by Elbadawi(1994) for seven Latin American countries, Montiel(1999) for five Southeast Asian countries, Husted and MacDonald(1998) and Chinn(1998) for East Asian countries, and MacDonald and Ricci(2002) for South African countries.

Clark and MacDonald(2004) developed the Permanent Equilibrium Exchange Rate (PEER) approach which can be seen as a variant of the BEER approach. As the emphasis of the BEER approach is to describe the movement of real exchange rate and distinguish the source of currency misalignment, medium-term BEERs do not necessarily require fundamentals to be at their sustainable levels because it does not include the misalignment caused by the deviation of fundamentals from their equilibrium levels. Therefore, directed at depicting the equilibrium exchange rate in the long-run in terms of the fundamentals at sustainable-levels, Clark and MacDonald(2004) defined PEER to be derived from BEER estimates. By separating out the factors underlying the BEER into their permanent and transitory components, the PEER excludes transitory elements in the BEER estimation. This can be done using statistical techniques such as Beveridge-Nelson decomposition, which indicates that the equilibrium levels of the fundamentals are of statistical meaning rather than economical meaning. An alternative ways is to estimate the equilibrium levels of the fundamentals(Égert, B. 2004), therefore, the PEER is comparable with the FEER in the terms of the way economic fundamentals/equilibrium are determined.

3.3.5 Summary of the Empirical Approaches

From previous discussions, empirical approaches in estimating equilibrium exchange rate are distinguished in terms of their theoretical implications from the notion of 'equilibrium', time frame, fundamentals in specific calculation and interpretation of currency misalignment. Most existing estimation approaches share some properties as follows.

- Starting point

All empirical approaches starting with the view that PPP is insufficient for equilibrium exchange rate calculation. They dismiss PPP as not realistic premised in favour of recognizing that there are real factors driving real exchange rate away from a PPP-value. Despite this common ground, the difference of these approaches arises

generally from three issues, including agreement on exactly what are these real factors, consensus on which way these real factors can be constructed to determine equilibrium real exchange rate and on alignment of which method to model for testing and analysis.

- Theoretical Framework

Although these theories agree on the insufficiency of PPP, they themselves do not reject that in the very long-run, PPP still acts as an appropriate measure for equilibrium exchange rate determination. Some models still assume that PPP would hold in long-run discussion, e.g. some PPP-extended approaches. Other approaches take macroeconomic balance as the theoretical assumption for the construction of the models, e.g., FEER and NATREX. Frequently it is the combination of the parity conditions, e.g. CHEER and BEER, which to some extent helps explain the complicate mechanisms of exchange rate determination.

- Time Frame

The construction of equilibrium exchange rate may also be distinguished by the time concept. For example, NATREX is a medium to long run concept, while the BEER-determined exchange rate is often a short to medium term concept or a combination. Underpinned by the respective conceptual framework, each approaches selection of a time frame impacts on the determination of their equilibrium exchange rate.

The next section, this study examines recent empirical studies in calculation of renminbi equilibrium exchange rate under BEER single-equation models.

3.4 Recent Empirical Studies in Renminbi Estimation

Recent popular approaches to estimate equilibrium exchange rates were reviewed in the last section, continuing on this section reviews empirical studies in calculating renminbi exchange rate from the BEER approach or reduced-form single-equation models. Many studies estimating equilibrium exchange rate of renminbi are inspired by the double surplus of current account and capital account of China and trade friction between China and its partners. Some research includes the export or trade surplus of China in their empirical models to examine the correlation between trade and exchange rate. In light of the reverse effect of exchange rate on trade balance, it is technically difficult to define if trade balance by itself is a fundamental in exchange rate determination

3.4.1 Latest Estimation of Renminbi

Goh and Kim(2006) estimated the equilibrium exchange rate of renminbi across 1978 to 2002 based on a reduced-form model. They considered monetary policy as transitory factors that would not affect the equilibrium exchange rate in the long run, and the dynamic adjustment of actual real exchange rate to the equilibrium level when building up the estimation equation. They used the Granger-Engle two-step test to reveal that government expenditures, productivity and the degree of trade restrictions in the economy are the real fundamentals that affect the renminbi. Their research concluded that there is no prominent evidence that renminbi is significantly undervalued in 2001 and 2002 and the speed of adjustment is that 45% of the misalignment will be eliminated within a year.

Li(2006) estimated the equilibrium exchange rate of renminbi from 1980 to 2003 based on a single-equation model. In specifying the explanatory variables, the author considered four variables as influencing the real effective exchange rate in the long run, being terms of trade, openness, government expenditure and foreign reserves. The estimation result indicated that real effective exchange rate of RMB fluctuates round the equilibrium level of exchange rate since 1980s and that basic economic factors such as term of trade and opening-up affect the REER more markedly than fiscal policy, monetary policy and foreign exchange reserve.

Wang *et al*(2007) estimated the long-run equilibrium real effective exchange rate of renminbi from 1980 to 2004 based on the Johansen co-integration test. Based on the Clark and McDonald's (1999) BEER model, Wang *et al*.(2007) took a dynamic adjustment of real exchange rate into consideration. The result asserted that money supply, foreign reserve stock and productivity are important explanatory variables of renminbi long-run equilibrium value and that actual real exchange rate fluctuate around its long-run equilibrium value in a narrow band of 5% especially in the last few year of the sample period. The results also imply that monetary policy in China would not play a significant role by necessity in the trade surplus.

Chen *et al*(2008) estimated the misalignment of renminbi from 1997q1 to the 2007q3 based on a BEER model, using the Beveridge-Nelson decomposition and a vector error correction model of the exchange rate as a function of macroeconomic fundamentals. The research considered that renminbi has been fluctuating moderately around its long run equilibrium value with an undervaluation of up to 4%

and an overvaluation of up to 6% at various points in time since 1997. This was consistent with many recent studies employing alternative econometric methodologies to determine the equilibrium exchange rate. Since the real effective exchange rate has derived from equilibrium and was sticky in that it took over five years to correct 50% of the short run misalignment, this finding contradicted the widely argued proposition that renminbi was consistently overvalued.

Peng *et al*(2008) estimated the internal equilibrium exchange rate from 1990Q1 to 2003Q4 based on both a BEER model and a PEER model. The study chose as their independent variables net foreign assets, government expenditure, openness, terms of trade and productivity. The empirical results indicated that renminbi was undervalued approximately by 15% from 2002Q2 to 2003Q4, with a high sensitivity to productivity, current account change and government spending. Notably, the commercial policy variable (openness) turned out to be insignificant in this research.

Du and Deng(2009) estimated the relationship between real effective exchange rate and real interest rate gap based on a BEER model after relevant renminbi exchange rate regime reforms. They chose 4 variables as long-run determinants of real exchange rate, this included productivity, bilateral interest rates differential, the openness and government expenditure from quarterly data of 1992Q1-2006Q4. The result from the Johansen co-integration test shows that renminbi was undervalued since 2002Q3 and the influence of interest rate over exchange rate is not as strong as other variables in this research.

Li(2009) estimated the equilibrium real exchange rate of renminbi from 1980 to 2007 and calculated the real exchange rate misalignment. The estimation result of a 7-variables VAR model showed that the real exchange rate of renminbi substantially deviated from equilibrium level most of the time, especially when China adopted the de facto pegged exchange rate regime during 1995-2004. Further specification of the VEC model shows that renminbi can modify misalignment by itself with an adjusting speed of about 5 years. In order to correct the misalignment and avoid currency crisis, the author suggests that China should adopt a more flexible exchange rate regime.

Su(2009) estimated the equilibrium level of real effective exchange rate from 1999Q1 to 2007Q4 and their respective exchange rate misalignment. Based on a reduced-form model, the study identified the terms of trade, openness, government expenditure, productivity and money supply as explanatory variables in determining the long-run equilibrium levels of renminbi. The Johansen-Juselius co-integration analysis is used in this research and the estimation result indicates that there is a co-integrating relationship between the variables and the extent of the misalignment is not very large. In consideration of the behaviours of renminbi in recent years, it was undervalued by 6.7% from 2005Q3 to 2007Q4.

Chen(2010) built a co-integration framework with structural breaks in the deterministic trend based on the BEER approach to estimate the equilibrium exchange rate of renminbi from 1994Q1 to 2007Q4. In this model, Chen(2010) uses two variables as the proxy of Balassa-Samuelson Effect in his research, specifically terms of trade and real GDP per capita in order to avoid the possible misspecification

of the terms of trade for B-S effect. The main finding of the study reveals that renminbi was overvalued during the Asian financial crisis and subsequently in 2001-2002. This study also found a slight overvaluation after the exchange rate regime reform in 2005.

3.4.2 Reflection on Previous Empirical Study

Renminbi valuation is often presented as controversial in various studies, this study comments on selected issues underpinning some of these studies.

Firstly, unanimity is absent in the varying definitions of the variables of renminbi exchange rate model specifications. There are two popular ways to define the real exchange rate, the first may be termed by 'internal real exchange rate' which is the ratio of non-tradable to tradable prices. In this variable, there is no direct relationship between the nominal exchange rate and this definition of real exchange rate, while the nominal exchange rate is either fixed driven by commodity prices in world market. This was used by Peng *et al* (Peng, Lee & Gan 2008) and Li (Li, Y 2009). A second varying definition is known as the 'external real exchange rate' in contrast with the 'internal real exchange rate'. This is often defined as the nominal exchange rate expressed in home currency per unit of foreign currency. The real exchange rate shows the shift on the nominal exchange rate or the change between the foreign and domestic price levels over a period of time. The real effective exchange rate is calculated based on external real exchange rate. Based this research interest, it is commonly believed that real effective exchange rate could better describe a nation's competitiveness in foreign trade and overall performance in appreciation or depreciation.

The second divergence involves the time frame of the samples. Some studies (Goh & Kim 2006; Li, Q 2006; Li, Y 2009; Wang, Yajie, Hui & Soofi 2007) use yearly data in their calculation. Compared with quarterly data, yearly data is less precise in expressing the behaviour of real exchange rate. A dependent question arises, that is in order to enlarge the size of sample especially for those who use yearly data, the researchers included data before 1994 (Du & Deng 2009; Li, Q 2006; Li, Y 2009; Peng, Lee & Gan 2008; Wang, Yajie, Hui & Soofi 2007) and even early back to 1978 (Goh & Kim 2006). At that time the Chinese government used the currency price as a tool to plan its economy and stimulate foreign trade and there co-existed an official rate and market rate which was known as double-track exchange rate system. Consequently, this invasive and intensive government regulation limits the value of that sample data for the discussion of equilibrium exchange rate.

Another observation relates to the consideration of structural change during economic growth. The main structural changes in respect of foreign exchange are exchange rate regime reform and economic growth pattern change, which occurred throughout the first decade of 21st century. Consequently, it is necessary to consider those factors in estimating equilibrium exchange rate. Some studies (Chen, Jeff, Deng & Kemme 2008; Li, Q 2006) do not take change on productivity into consideration. Other studies (Goh & Kim 2006; Li, Y 2009; Wang, Yajie, Hui & Soofi 2007, p. 21) assume that price was sticky and use aggregate money supply as a proxy of financial development, considering it a long-run fundamental in real exchange rate

determination. This is debatable for the case of China when it comes to the question that the stick price assumption still holds, assuming in a 30-year span and if financial development as a real determinant could be described by a nominal magnitude.

Disagreement emerges when assessing the varying approaches to a uniform proxy for Balassa-Samuelson (B-S) Effect. According to B-S Effect, differences between countries in relative productivity in their trade sector and non-trade sector would result in deviation of the currency from its PPP-determined values¹¹. Two popular ways to define relative productivity is the price of non-tradable goods to tradable goods (TNT) and income per capita (CAPITA). The former could be calculated as the CPI/PPI ratio, the later could be represented by the real GDP per capita. As was pointed out, the CPI/PPI ratio could be influenced by factors other than B-S Effect such as relative demand effects, tax changes or nominal exchange rate (Chinn 1997) and prices for some services are not entirely market-determined because of restrictions or barriers on free movement of labours between different sectors (Dunaway & Li 2005). Therefore, B-S Effect would possibly be misspecified by the CPI/PPI ratio accordingly the results of studies including this variable would be questionable (Peng, Lee & Gan 2008; Wang, Yajie, Hui & Soofi 2007).

In synthesis, despite numerous empirical estimations of renminbi equilibrium exchange rate the issues discussed above demonstrate that there is lack of evidence that renminbi is misaligned in the recent period after 2010. Consistent with this assertion, this study will use recent data to estimate renminbi based on a co-integration framework in the next chapter.

¹¹ It has been argued that there is no strong B-S Effect in China because low unemployment rate as one of the basic assumption in B-S Effect is absent in China, and the spillover of the increased wage from tradable to non-tradable sectors would be missing under this condition (Dunaway & Li 2005).

Figure 3.1 Variables in the Single-Equation Estimations

Researches	Data	Dependent variables	Explanatory variables:											
			B-S	M2	NFA	OPEN	TOT	GOV	RIP	INV	FRES	CPFL	E	
Goh and Kim(2006)	1978-2002(A)	REER(CPI)	CAPITA	√		√	√	√	√		√		√	√
Li(2006)	1980-2003(A)	REER(CPI)			√	√	√	√						
Wang et al.(2007)	1980-2004(A)	REER(CPI)	TNT	√			√			√		√		
Chen et al.(2008)	1997Q1-2007Q3	REER(CPI)			√	√	√	√						
Peng et al.(2008)	1990Q1-2003Q4	P (t)/P (nt)	TNT		√	√	√	√						
Du and Deng(2009)	1992Q1-2006Q4	REER(CPI)	CAPITA				√		√	√				
Su(2009)	1999Q1-2007Q4	REER (CPI)	CAPITA	√		√	√	√						
Li(2009)	1980-2007(A)	P (t)/P (nt)	CAPITA	√		√	√	√	√		√			
Chen(2010)	1994Q1-2008Q3	REER(CPI)	TNT;CAPI TA		√	√	√							

Notes:

Data: Y-Y(A) means annual data.

Dependent variables: REER (CPI) = real effective exchange rate based on the CPI; P (t)/P (nt) = internal real exchange rate

Explanatory variables: B-S = Balassa-Samuelson Effect variable, CAPITA =GDP per capita, TNT =relative price of non-tradable goods to tradable goods, M2 =money supply (real domestic credit), NFA =net foreign asset to GDP, OPEN =measure of openness, TOT =terms of trade, GOV =government consumption to GDP, RIP =real interest rate differential, INV = investment rate, FRES =total foreign reserve accumulated, CAFL =sum of total foreign liabilities and total foreign assets (absolute values) to GDP, and E =nominal bilateral exchange rate to USD.

3.5 Summary

In this chapter, equilibrium conditions that form the foundation of modern exchange rate analysis were introduced. Methods of equilibrium exchange rate measurement were reviewed with regards to their theoretical assumptions and empirical approaches. Also recent empirical studies in the case of China were reviewed and assessed in terms of their consideration of the fundamentals during economic transition and other issues related to the robustness of the empirical results.

Although empirical evidence exists that indicates renminbi is to some extent misaligned, the results are significantly different from each other. The large variance on renminbi estimation is attributed to the difference of theoretical assumptions, variable definition, estimation period and methodologies. In the next chapter we commence with an explanation of why the BEER approach is used in this research and introduce the variables and data sources for this research. Following this economic analysis and evaluation is applied to the renminbi equilibrium exchange rate.

Chapter 4 Econometric model and Data analysis

4.1 Introduction

The research background in chapter 2 identified some structural changes occurring in China, asserting their influence the behaviours of the real exchange rate. Chapter 3 then reviewed different theoretical propositions and empirical methods approaching equilibrium exchange rate determination. Based on the premises of these past chapters, this chapter rationalizes selection of the BEER approach and introduces the econometric methods used in this research. Following this, the co-integration test is performed to estimate the coefficients of the fundamentals and the BEERs of renminbi is calculated for both current and long run dimensions based on the co-integration estimation results.

Central to this study's findings, section 4.2 extensively considers the selection of the BEER approach and the development of an empirical econometric model, focusing on the expected sign of each variable and their significance. Section 4.3 then defines the variables and the consequential data source, followed by section 4.4 which contains the econometric analysis of this study. Firstly, the stationary test of the variables is performed to make sure that they are co-integrated in the same order. Once the time-series properties of the variables are determined, they can enter the co-integrating space and be tested if there is a co-integrating movement between them. Next a vector autoregressive (VAR) model is built up and the lag length is determined and tested by the residuals. After the VAR model is specified as lag length of two a vector error correction (VEC) model is developed based on the VAR model and the rank of the VEC model is tested together with the deterministic components needed for the VEC specifications. Finally, the VEC is estimated and the current and long run BEERs are calculated based on the estimation result. Section 4.5 gives a summary of the Chapter.

4.2 The BEER model

This research agrees with the basic assumption of the BEER approach that there are real factors other than PPP, determining the movement of real exchange rate of renminbi. Additionally, the reason for choosing the BEER approach in this study is listed below:

- Time frame

The time frame of this research is 2000Q1-2011Q4. It is not long enough for either the PPP-related test or macroeconomic balance approaches to estimate the real exchange rate. It is unreasonable to consider an 11 year time frame 'short-run' given the fact that China is experiencing structural transformation throughout many sectors in this period and there are many fundamental changes. In light of all the methods reviewed in the last chapter, the BEER approach best distinguishes the real exchange rate with regards to the nominated time frame by estimating the correlation between real exchange rate and short-term factors and real fundamentals.

- Research interest

As specified in chapter 1, the primary research interest is to calculate the equilibrium exchange rate to provide a benchmark for assessment of RMB misalignment and understand the source of any such misalignment. With the analysis of the real fundamentals, the BEER approach distinguishes the misalignment caused by the effect of transitory factors, the random disturbances and the extent to which the economic fundamentals differ from their sustainable values.

- Inclusion of real factors

By assuming that there are real factors in renminbi real exchange rate determination, it is postulated that the construction of the BEER model properly estimates the movement of real exchange rate with regards to the change in these real factors during China's relevant economic transition. Section 3.3.4 highlights the benefits of previous research in applying the BEER approach in developing or transition economics for the analysis of currency evaluation (Chinn 1998; Edwards, S. 1989; Elbadawi 1994; MacDonald & Ricci 2002), this research provides proper references in selection of variables in this study.

Montiel(1999) believes that all the long-run fundamentals for the real exchange rate can be consolidated within a single equation analysis framework. Based on Elbadawi(1994), Edwards(1994; 1999) and Montiel(1999), the fundamentals could be generally expressed as:

- Terms of trade (TOT)
- Government expenditure (GOV)
- Controls over capital flows (NFA)
- Commercial policy (OPEN)
- Technology progress (PROD)
- Monetary supply (M2)

- The ratio of investment (INV)

According to Montiel(1999), These fundamentals can be categorized into four groups:

- Domestic supply side factors such as gross domestic production, average wages/ income and productivity
- Fiscal policy variable such as government expenditure/debt
- Changes in international economic environment, such as terms of trade and the level of world economy development
- Commercial policy variable such as openness

If we consider that monetary policy is a transitory variable in China and net export has stronger incentive effect on economy rather than investment, it follows from the previous discussion that the equilibrium real exchange rate in this research then can be determined by productivity (PROD), net export (NEP), the level of government expenditure (GOV), commercial policy (OPEN) and the level of capital control (NFA). Consequently, taking the natural logarithm form of each variable and transforming the model into linear form, the empirical model in this research can be obtained as:

$$reer_t = f(prod, nep, gov, open, nfa) \quad (4.1)$$

A brief *priori* discussion of the signs of all variables is summarized as below.

The development on productivity can be seen as the source of the systematic change on domestic supply. Therefore, according to the Balassa-Samuelson Effect(Balassa 1964), real exchange rate appreciates if the relative productivity increases because it creates excess demand in both tradable and non-tradable sectors. The sign of the variable *prod* is expected to be positive.

In short-run, according to the discussion in chapter 2, an increase on net export might worsen trade balance and bring more surpluses which stimulates the demand for domestic currency. In medium-run, growth on export is one of the source of economic growth and it could lead to currency appreciation while the positive relationship between export and economic growth is proven in China. Therefore, the sign of *nep* is expected to be positive as well.

The structure and level of government expenditure could theoretically cause a movement in real exchange rates, and similarly an increase in government expenditure on non-tradable goods could induce a real exchange rate appreciation. Alternatively, if it falls more on tradable sectors it would raise the demand for imported goods causing a trade deficit and currency depreciation. Though the effect of total government expenditure on real exchange rate is indefinite, here it is considered as a policy instrument of change of economic growth pattern (see the discussion in chapter 2) and expect a positive sign of the variable *gov*. Accordingly, Edwards(1989) found empirical evidence from 12 developing countries of the fact that increasing government expenditure induces a currency appreciation.

Traditionally the degree of openness is seen through the indicators of commercial policy and trade liberalization, which have an important impact on the long-run equilibrium exchange rate. Increasing openness through lowering trade barriers

would likely worsen the trade balance and allow foreign goods to enter the country more freely. Therefore, we expect a negative sign of the variable *open*.

The last variable is net foreign asset position which is accumulated by trade surplus. If there is a continuous current account deficit, the foreign asset would be reduced which might cause a raise in the net foreign credit. This requires the future trade surplus to balance the net foreign asset. While currency depreciation would help bring trade surplus and facilitate the compensation, a negative relationship is expected between net foreign asset and currency appreciation. Therefore, the sign of the variable *nfa* is supposed to be negative.

The definition of each variable and details of the source of this studies quarterly data will be explained in the next section.

4.3 Variables Definitions and Data Sources

4.3.1 Real Effective Exchange Rate (REER)

In this research, *real effective exchange rate* (REER) is used as a dependent variable that is defined as the ratio of domestic price index of home country vis-à-vis the price index of its main trading partners (equation 4.3). The Consumer Price Index (CPI) based trade weighted REER is given as in index form at the base time of 2005. An increase in REER indicates an appreciation of the renminbi. Compared with bilateral '*external real exchange rate*', REER captures the competitiveness of a country against its trading partners. This variable is expressed in logs as *reer*:

$$reer = \ln(REER) = \sum \omega_i \ln \left(\frac{S_i^* CPI}{CPI_i} \right) \quad (4.2)$$

ω_i is the trade weight of country i , CPI and CPI_i is Consumer Price Index in China and country i . S_i^* is the relevant price of the bilateral exchange rate of country i compared to base year.

SOURCE: The quarterly REERs are from the *IFS online*.

4.3.2 Productivity (PROD)

Following Goh and Kim(2006) and Du and Deng(2009), *etc.*, the per capita real GDP can be used as a proxy for productivity. It can be calculated as:

$$Real\ GDP = \frac{Nominal\ GDP}{GDP\ Deflator} * 100 \quad (4.3)$$

$$Per\ capita\ real\ GDP = real\ GDP / population \quad (4.4)$$

The base year of GDP deflator is 2005 because the population is only available in yearly data, which is used for the calculation in each season in that year.

SOURCE: The quarterly nominal GDP and GDP deflator and yearly population are from *IFS online*.

4.3.3 Net Export (NEP)

Since the export oriented growth strategies have lead economic development for the last century, this research uses net export instead of investment rate as many empirical researches do. The *net export* variable is expressed as the natural logarithm of the ratio of net export to nominal GDP to eliminate relative price differentials:

$$nep = \ln(NEP) = \ln \left(\frac{Net\ export}{nominal\ GDP} \right) \quad (4.5)$$

Adjusted by seasonal average bilateral rate, nominal GDP is calculated by U.S dollar to match the net export in the same currency.

SOURCE: The quarterly net export and period average bilateral rate to U.S dollar is from the *IFS online*.

4.3.4 Government Expenditure (GOV)

The *government expenditure* variable is *GOV* and is used in its natural logarithm form as *gov*. Because government expenditure was calculated based on nominal price in each year, to eliminate any price differentials, total government expenditure is adjusted by being divided by nominal GDP:

$$gov = \ln(GOV) = \ln\left(\frac{\text{Total government expenditure}}{\text{Nominal GDP}}\right) \quad (4.8)$$

The total government expenditure and nominal GDP are both calculated in home currency.

SOURCE: Total government expenditure: 2000q1-2010q4 is converted from yearly data obtained from *China Statistical Yearbook 2011*, in Eviews by *Quadratic-match sum* method¹²; 2011q1-2011q4 is from *the Ministry of Finance of P.R.C. online*.

4.3.5 Openness (OPEN)

Openness is used as a proxy for the measurement of a country's commercial policy. In this research, it uses the ratio of total trade to nominal GDP as a proxy for openness (equation 4.5):

$$open = \ln(OPEN) = \ln\left(\frac{EX+IM}{\text{nominal GDP}}\right) \quad (4.7)$$

The nominal GDP has also been transformed into U.S dollar.

SOURCE: The *IFS online*.

4.3.6 Net Foreign Assets (NFA)

According to Montiel(1999), if the net foreign asset position can respond to policy changes rapidly enough, then it can be regarded as an endogenous variable without constituting a fundamental. Following Wang *et al.*(2007), the *total foreign reserves (excluding gold)* held by China's central bank is used as a proxy for *net foreign assets* in this research. It is calculated as a natural logarithm form of its ratio to real GDP:

$$nfa = \ln(NFA) = \ln\left(\frac{\text{Total foreign reserves(excluding gold)}}{\text{Real GDP}}\right) \quad (4.9)$$

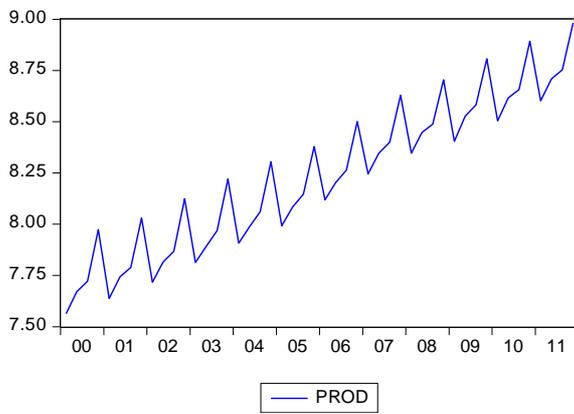
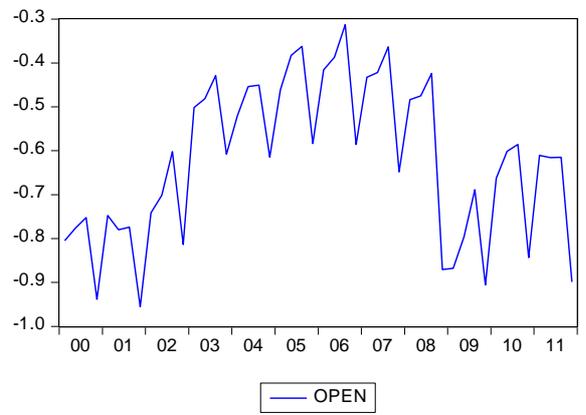
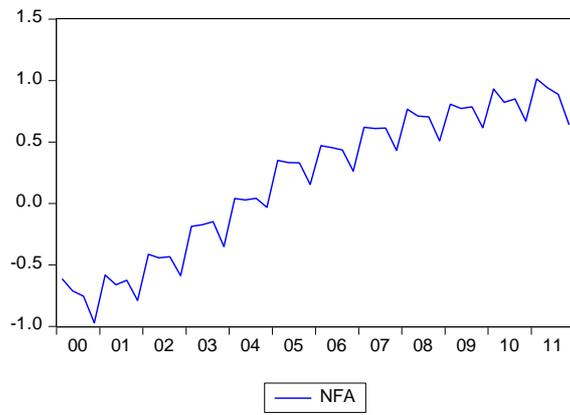
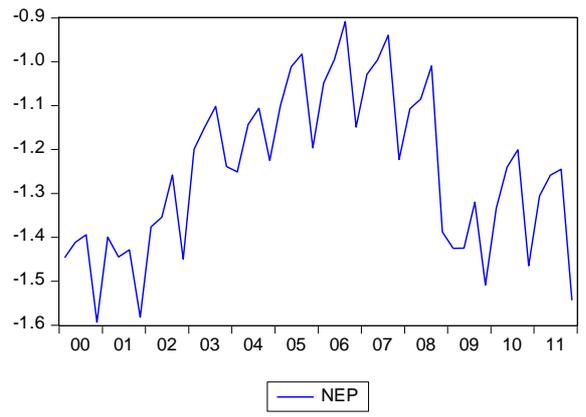
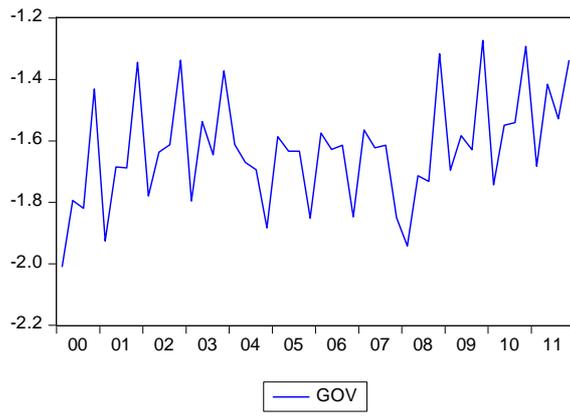
SOURCE: The quarterly total foreign reserves (excluding gold) held by the central bank of China is from the *IFS online*.

Below are the line charts of all original variables (Figure 4.1). As seasonality is obvious for the variables *nep*, *open*, *nfa*, *gov* and *prod*, Eviews was used to de-seasonalized before the preliminary time series analysis¹³.

¹² *Quadratic-match sum* method performs a proprietary quadratic interpolation of the low frequency data, after it is divided by the number of observations.

¹³ For *tot* and *prod*, they are adjusted according to moving average method (Multiplicative) in Eviews; for the other variables, because they cannot be de-seasonalized using *multiplivative* method while being negative after natural logarithm transform, here they are de-seasonalized by *additive* method.

Figure 4.1 The Variables before De-seasonalized

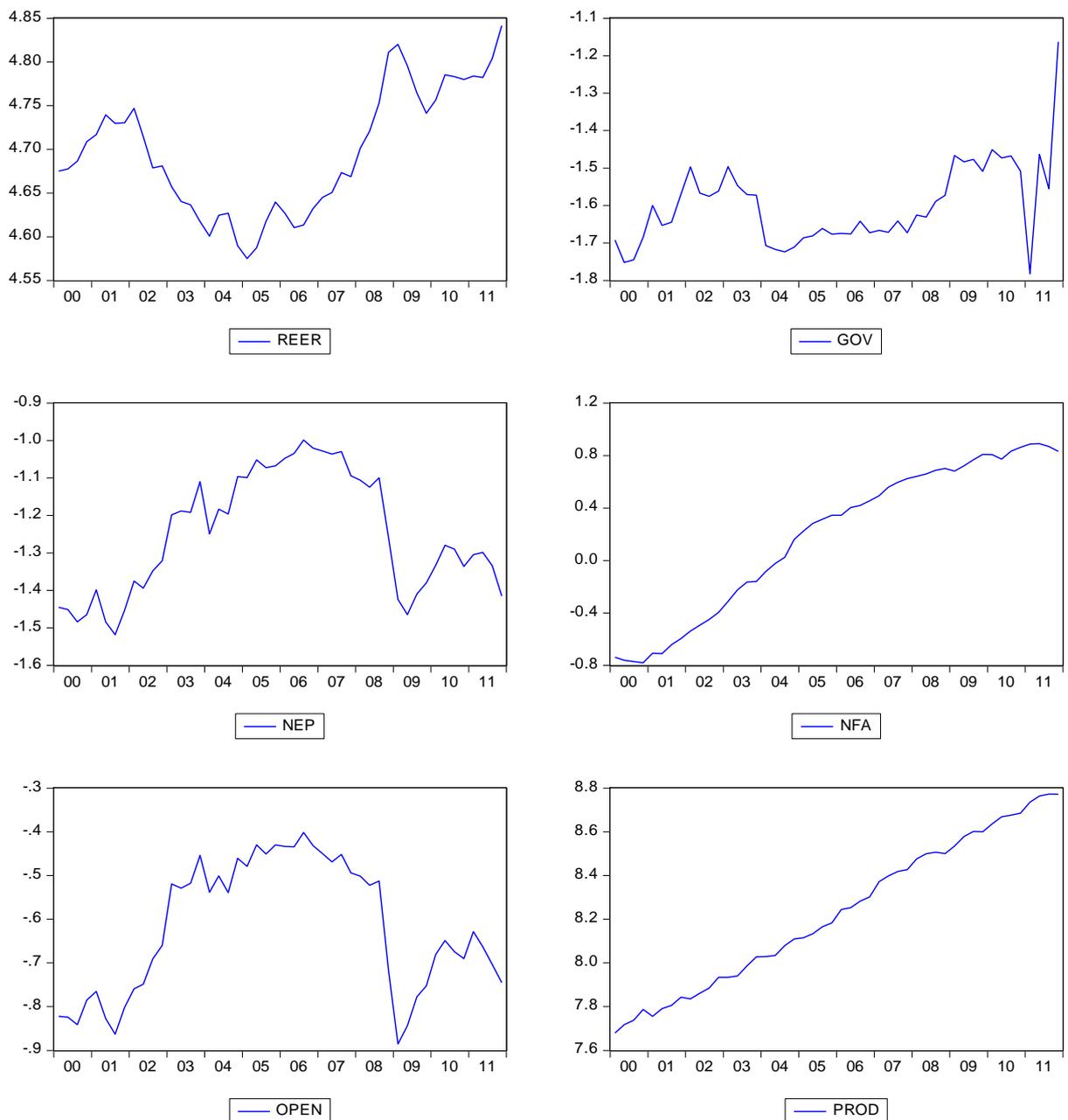


4.4 Econometric Methods

4.4.1 Testing of the Existence of Unit Roots

Prior to conducting estimation of an econometric model containing time series data, it was necessary to confirm the dynamic properties of the data, viz. whether they are stationary or non-stationary. From figure 4.2, the intercepts and trends of the variables are evident and without statistical tests would not be visible as stationary.

Figure 4.2 Graphs of Endogenous Variables



The stationary test can be achieved by testing the presence of unit root. If a series does not hold at least one unit root (*i.e.* non-stationary series), the regression might falsely imply an economic relationship when the series is combined with other series to form a stationary co-integration relationship.

To formally test for non-stationary time-series, this study used the Augmented Dickey-Fuller (ADF) test devised by Dickey and Fuller(1979). According to the ADF test, for any time series Y_t , the test equation could be written as:

$$\Delta Y_t = \mu + \alpha Y_{t-1} + \beta_t + \sum_{j=1}^p c_j \Delta Y_{t-j} + \varepsilon_t \quad (4.10)$$

where μ is the constant mean of time series Y_t , p is the lag length. The lagged first-differenced terms are added to control for the possibility that the error terms is auto-correlated.

The ADF is to test the null hypothesis: $H_0: \alpha = 0$, which implies that the time series Y_t is non-stationary and there is at least one unit, against the alternative hypothesis: $H_a: \alpha < 0$, which implies that Y_t is stationary. Lag length p is determined according to Schwarz Information Criteria (SIC). In cases that a trend is found to be statistically significant, the ADF test is conducted with a trend in Eviews and the results are shown in Table 4.1:

Table 4.1 The ADF Unit Root test for the variables (Based on SIC, maxlag=9)

Level I(0)								
Time series	Trend	Lags	ADF	1%Level	5%Level	10%Level	Reject H ₀	Prob.
<i>reer</i>	No	2	-0.280	-3.585	-2.928	-2.602	No	0.918
<i>prod</i>	Yes	4	-2.232	-4.186	-3.518	-3.189	No	0.460
<i>nep</i>	Yes	0	-1.004	-4.166	-3.509	-3.184	No	0.934
<i>nfa</i>	Yes	0	0.918	-4.166	-3.509	-3.184	No	0.999
<i>gov</i>	Yes	3	-1.202	-3.589	-2.930	-2.603	No	0.666
<i>open</i>	Yes	0	-1.307	-4.166	-3.509	-3.184	No	0.874

Level I(1)								
Time series	Trend	Lags	ADF	1%Level	5%Level	10%Level	Reject H ₀	Prob.
<i>D(reer)</i>	No	1	-4.165	-3.581	-2.927	-2.601	Yes	0.002
<i>D(prod)</i>	Yes	3	-2.559	-4.186	-3.518	-3.190	No	0.300
<i>D(nep)</i>	Yes	0	-6.247	-4.171	-3.511	-3.186	Yes	0.000
<i>D(nfa)</i>	Yes	0	-5.218	-4.171	-3.511	-3.186	Yes	0.001
<i>D(gov)</i>	Yes	2	-4.391	-3.589	-2.930	-2.603	Yes	0.000
<i>D(open)</i>	Yes	0	-5.878	-4.171	-3.511	-3.186	Yes	0.000

Note: All the determination of if to reject the null hypothesis is at 5% significance level; *Prob.* is MacKinnon one-sided p-values.

The results indicate that all variables except for *prod* are not able to be rejected by the null hypothesis at $I(0)$, but can be rejected by the null hypothesis at $I(1)$. This indicates that they are integrated of order one, $I(1)$. For *prod*, the null hypothesis cannot be rejected in first difference at 5% significance level. According to Harris(1995), the unit roots test has the pitfall of low power, from which it can be assumed that the evidence of series of *prod* being $I(2)$ is very weak. Further test using Phillips-Perron Unit Root Test shows that the result rejects the null hypothesis (Table 4.2).

Table 4.2 The Phillips-Perron Unit Root test on $D(prod)$

Null Hypothesis: D(PROD) has a unit root
 Exogenous: Constant
 Bandwidth: 19 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-9.841972	0.0000
Test critical values:		
1% level	-3.581152	
5% level	-2.926622	
10% level	-2.601424	

*MacKinnon (1996) one-sided p-values.

Therefore, it can be assumed that all variables can be considered as stationary in first difference. In other words, they are integrated of order one, $I(1)$, which meets the basic criteria for estimating long-run relationships.

4.4.2 The Johansen-Juselius Multivariate Approach

Once the series in the model appear to be integrated of the same order one, the co-integration can be tested. Various single-equation co-integration test methods exist, including the Engle and Granger two-steps approach and the Dynamic Ordinary Least Squares approach. If however, there is evidence of more than one co-integration relationship, those two named approaches may not be able to detect the relevant additional relationships. To accommodate, this study utilizes the Johansen-Juselius Multivariate Approach as the co-integration test method. The advantage of Johansen-Juselius Multivariate Approach is that it can reveal the number of co-integration vectors as well as the relationships.

4.4.2.1 The Vector Auto-Regression (VAR) Model

The Johansen-Juselius Multivariate Approach starts with a VAR model with white noise, non-stationary, n variables vector X_t , and each has k lags:

$$X_t = \mu + \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + \dots + \Pi_k X_{t-k} + \Phi D_t + \epsilon_t \quad (4.11)$$

where X_t is a vector of where n variables are considered as stationary in first differences, Π_i is a matrix of nn parameters, μ is a vector of constants, ϵ_t is a random disturbance and D_t is a vector of deterministic term. The number of lags, k , in the VAR model has to be specified before estimation by diagnostic tests; once the model with optimal lag length passes the diagnostic tests, the VAR model can be developed to a Vector Error Correction (VEC) Model.

4.4.2.2 Lag Length Specification and Diagnostic Test

In the specification of the lag length of a VAR model, it starts with a model of arbitrary lag length and compares the likelihood ratio with the values of different criteria in Eviews. The appropriate lag length from each column would be indicated with an asterisk '*'. Due to relatively short data, it specifies lag length of 2 at the start of an unrestricted VAR estimation. The result is listed as shown in Table 4.3:

Table 4.3 VAR Lag Length Selection Criteria

Endogenous variables: REER GOV NEP NFA OPEN PROD
 Exogenous variables: C
 Sample: 2000Q1 2011Q4
 Included observations: 45

Lag	LogL	LR	FPE	AIC	SC	HQ
0	319.1610	NA	3.64e-14	-13.91827	-13.67738	-13.82847
1	593.0817	462.6216*	9.44e-19*	-24.49252*	-22.80630*	-23.86391*
2	628.0391	49.71719	1.08e-18	-24.44618	-21.31463	-23.27877
3	656.2854	32.64015	1.93e-18	-24.10157	-19.52469	-22.39536

* indicates lag order selected by the criterion
 LR: sequential modified LR test statistic (each test at 5% level)
 FPE: Final prediction error
 AIC: Akaike information criterion
 SC: Schwarz information criterion
 HQ: Hannan-Quinn information criterion

The result indicates that a lag length of one is preferable. The diagnostic test is then performed with regards to autocorrelation, normality and heteroskedasticity of the residuals. The results of the residuals test is shown as below:

Table 4.4 Residuals Test of Lag Length One

Diagnostic tests	Test Result	Degree of Freedom	Prob.
Auto-correlation LM	LM1 38.414 (No Serial Correlation)	36	0.3607
Normality Test (Jarque-Bera)	130.071 (Normally Distributed)	12	0.000
Heteroskedasticity Test (No Cross Terms)	525.818 (No Heteroskedasticity)	504	0.2425

Note: P-values are at significance level of 5%.

The results indicate that none of the system tests reject the null hypothesis since the test results are all greater than the 5% significance P-values. Therefore, VAR(1) is not wrongly specified and it shows sufficient adequacy to proceed with the co-integration analysis. The subsequent step is to develop the VAR model into a Vector Error Correction Model.

4.4.2.3 The Vector Error Correction (VEC) Model

Since all the variables are co-integrated at first difference, the VAR model can be rewritten into a Vector Error Correction Model as below:

$$\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \Phi D_t + \epsilon_t \quad (4.12)$$

where $\Gamma_i = -I + \Pi_1 + \Pi_2 + \dots + \Pi_i$; $\Pi = -I + \Pi_1 + \Pi_2 + \dots + \Pi_k$; and I is the identity matrix. The rank of matrix Π , gives the number of co-integration relationships (also known as *co-integrating rank*). Generally considered, there are three possible cases to review:

- $r = 0$, the system is not co-integrated and the variables in X_t are integrated in order of one or higher. In this case, it would be appropriate to estimate the model in first difference;
- $r = n$, the variables in X_t are stationary in levels; and
- $0 < r \leq n - 1$, where Π could be decomposed into the product of two distinct matrices α and β : $\Pi = \alpha \cdot \beta'$, and the β contains the long-run equilibrium parameters of the variables.

Noticeably, the rank of Π is crucial in determining the number of distinct co-integrating vectors. As a preliminary step before any statistic estimation on the matrices α and β , it is necessary to establish the appropriate configuration of the deterministic components in the VEC model. That is, whether there is a trend and/or intercept in the co-integrating space and if there is a trend determine if it is linear or quadratic. Since the choice of deterministic component in the multivariate model may influence the distributions of the rank test statistics, it is suggested that a joint hypothesis test be used in determining the rank and deterministic components as demonstrated in next part. Once the rank and deterministic components are identified, the estimation of α and β and tests of the rank of Π could proceed.

4.4.2.4 Determining the Rank and the Deterministic Components in the VEC Model

Since the choice of deterministic component in the multivariate model may influence the distributions of the rank test statistics, it is advised that a joint hypothesis test be used in determining the rank and deterministic components. According to Johansen(1995), there are five deterministic trend cases to be considered in a VAR:

- Case 1: there is either no linear trend or intercept in the data or co-integration space;
- Case 2: there is no linear trend in level data; the intercept is restricted to lie within the co-integration space;
- Case 3: there is linear trend in level data; the intercept is unrestricted, lying outside the co-integration space;
- Case 4: there is linear trend in long-run model included in the co-integrating space; and
- Case 5: there is quadratic trend in long-run model in the co-integrating space.

While not certain which trend and intercept assumption to use, research may refer to the summary of all 5 trend assumptions in Johansen Co-integration test. The lags interval as '1 to 1' was chosen since the lag length in the VAR model was specified as 1 and here the lags interval denotes the lags of first differenced terms used in the auxiliary regression. The results are shown in Table 4.5:

Table 4.5 Johansen Co-integration Test Summary

Sample: 2000Q1 2011Q4
 Included observations: 47
 Series: REER GOV NEP NFA OPEN PROD
 Lags interval: No lags
 Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	3	3	1	1	2
Max-Eig	1	2	1	1	1

*Critical values based on MacKinnon-Haug-Michelis (1999)

The last row shows the number of co-integrating relations under the null hypothesis. Since case 5 (i.e. there are intercepts and quadratic trends) is rarely used in economic theories(Dennis et al. 2006), we consequently choose case 3, viz. that there is intercept but no linear trends in the co-integrating space. Table 4.6 presents the results of Trace test and the Maximum Eigenvalue test on case 3:

Table 4.6 Unrestricted Cointegration Rank Test

Table 4.6-aTrace

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.578841	106.6875	95.75366	0.0072
At most 1	0.399127	66.04450	69.81889	0.0964
At most 2	0.340613	42.10406	47.85613	0.1558
At most 3	0.241562	22.53118	29.79707	0.2699
At most 4	0.154778	9.535955	15.49471	0.3181
At most 5	0.034140	1.632623	3.841466	0.2013

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 4.6-b Maximum Eigenvalue

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.578841	40.64297	40.07757	0.0432
At most 1	0.399127	23.94043	33.87687	0.4599
At most 2	0.340613	19.57288	27.58434	0.3715
At most 3	0.241562	12.99522	21.13162	0.4527
At most 4	0.154778	7.903332	14.26460	0.3886
At most 5	0.034140	1.632623	3.841466	0.2013

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

From the results, it is evident that the null hypothesis of no co-integrating vector (none in the first column) is rejected under both tests, while the null hypothesis that there are utmost one co-integrating vectors cannot be rejected. Subsequently, it can be concluded that there is only one co-integrating vector, accordingly the rank of Π is one.

Since all series in the VAR model are co-integrated in first difference and the rank and deterministic components in VEC model are tested and specified, it is appropriate to estimate the VEC model under those restrictions.

4.4.2.5 VEC Model Estimation Results

After determining the rank and the deterministic configuration, this research proceeds to estimate the co-integrating coefficients. The lag length of VER model is specified as zero (no lags) and the estimated co-integrating vector is normalized on real effective exchange rate. The results of the estimation are shown as below:

Table 4.7 Estimation Results of the VEC Model

Variables	reer	gov	nep	nfa	open	prod	c
Co-efficients	1	-0.2764	-0.2115	0.1256	0.4996	-0.2816	-2.8011
Standard errors	N/A	0.04631	0.1181	0.0495	0.1106	0.0794	N/A
t-value	N/A	-5.9682	-1.7916	2.5358	4.5169	-3.5479	N/A

All the parameters of the co-integrating vectors are statistically significant at 5% level. Consequently, the long-run equilibrium equation of the real effective exchange rate may be expressed as:

$$beer = 2.8011 + 0.2764gov + 0.2115nep - 0.1256nfa - 0.4996open + 0.2816prod \quad (4.13)$$

The coefficients of the economic fundamentals carry the information of the direction of their impact on the real effective exchange rate. This accords with the expectation discussed in Section 4.3, viz. the expected signs of openness and net foreign assets are negative, while the government expenditure, productivity and net export is expected to have positive influence over real effective exchange rate.

The output of the equation indicates that an increase on government expenditure, productivity and net export by one percent would induce an appreciation of the real effective exchange rate respectively by 0.276 percent, 0.281 percent and 0.212 percent. Additionally, an increase on openness and net foreign asset would cause a depreciation of the real effective exchange rate respectively by 0.500 percent and 0.126 percent approximately.

4.4.2.6 Adjustment of Actual Exchange Rate

The matrix of α is known for containing the adjusting parameters in the VEC Model. When there is a gap arising between the actual real rate and its equilibrium level, the actual rate would tend to converge to its equilibrium level. The source of the deviation would drive the adjustment either to a new level of equilibrium or the original level of equilibrium (MacDonald & Ricci 2004). The adjustment of coefficients

reflects the dynamic self-correcting mechanism of the error correction model. Generally, the absolute value of an adjustment coefficient indicates the adjustment speed of the actual rate.

Table 4.8 Adjustment Coefficients of the VEC Model

Error Correction:	D(REER)	D(GOV)	D(NEP)	D(NFA)	D(OPEN)	D(PROD)
CointEq1	0.188525 (0.11532) [1.63478]	1.254809 (0.49595) [2.53009]	-0.725383 (0.31802) [-2.28092]	-0.130098 (0.19386) [-0.67109]	-1.164803 (0.27807) [-4.18891]	0.056603 (0.11110) [0.50950]
C	0.003544 (0.00307) [1.15619]	0.011259 (0.01318) [0.85399]	0.000646 (0.00845) [0.07642]	0.033419 (0.00515) [6.48503]	0.001644 (0.00739) [0.22242]	0.023235 (0.00295) [7.86760]

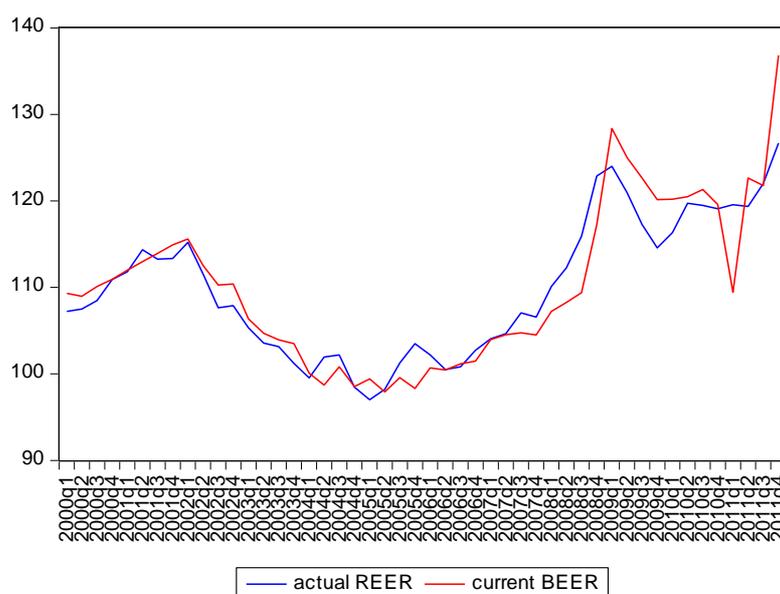
According to table 4.8, the coefficient of $D(reer)$ indicates that on average the adjusting speed of actual real effective exchange rate to the equilibrium level is approximately 5.3 quarters ($1/0.1885=5.3$).

4.4.3 Estimating the Renminbi BEERs and Misalignments

4.4.3.1 Current BEERs and Current Misalignment

Estimating current BEERs of renminbi is calculated with the actual values of the fundamentals, using equation 4.13. Note that all the variables are at their natural logarithm form, this research then converts them to their exponential form again. Figure 4.3 plots the estimated equilibrium level of effective exchange rate in comparison with actual REERs:

Figure 4.3 Actual REERs versus Current BEERs (2000q1-2011q4)



In short term, the periods when current BEERs are above actual REERs are the undervaluation parts, while the periods when the actual REERs are above the current BEERs are the overvaluation parts. From the above line chart, it is visually

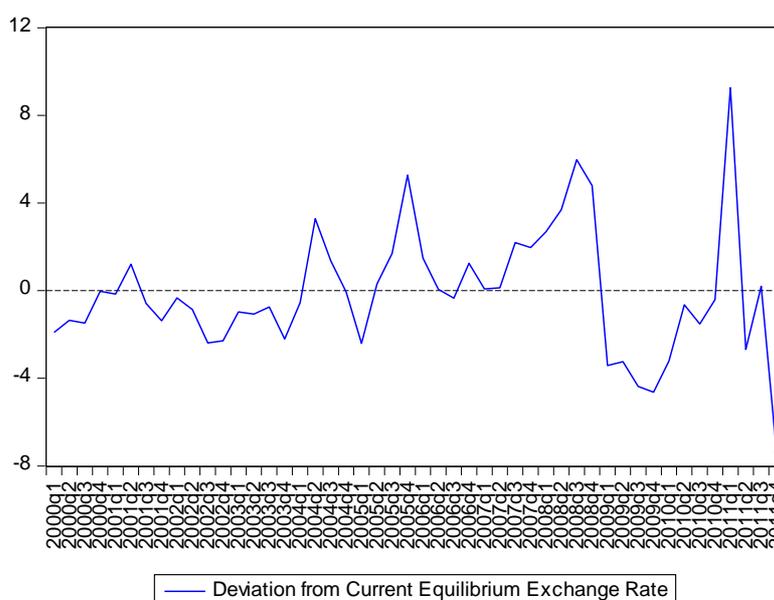
noteworthy that real fundamentals could explain most of the behaviors of the real effective exchange rate. The actual REERs are fluctuated around the theoretical 'BEERs' in a comparatively narrow band. The fact that fundamentals are able to account for the most part of the movements of actual REERs reflects the 'behavioral equilibrium' in the BEER framework.

The difference between the actual REERs and current BEERs indicates the extent to which renminbi is deviated from its equilibrium values. Accordingly, the current misalignment can be computed being expressed as:

$$Mis_current = \frac{Actual\ REER_t - Current\ BEER_t}{Current\ BEER_t} * 100\% \quad (4.14)$$

Figure 4.4 plots the percentage deviations of the actual REER from the equilibrium levels. Note that this misalignment arises from unobserved transitory factors and random error terms such as speculative bubbles based on extrapolative expectations (Clark & MacDonald 1999). However, the fundamentals by themselves may not be on their long-run equilibrium level. As mentioned in Chapter 3, under the FEER and the NATREX approach, fundamentals are calibrated with regards to macroeconomic equilibrium, e.g. internal and external balance. In contradistinction, this calibration is absent as well as the notion of 'economic equilibrium' in the BEER approach. Nevertheless, this could be adjusted by subjective judgment of the sustainable values of the fundamentals, as is applied under the FEER approach. Or alternatively, by smoothing the time series by a statistical filter to differentiate the long-run value from transitory parts (Baffes, John et al. 1997; Elbadawi 1994). The adjusted values of fundamentals may then be used to estimate the long-run BEERs and long-run currency misalignment in equation 4.13.

Figure 4.4 Current Misalignment of Renminbi (2000q1-2011q4)



4.4.3.2 Decomposition of Time-Series and Long-Run BEERs

It is recognized that economic time series contains irregular or stochastic components. In respect of this, it is important to differentiate between temporary

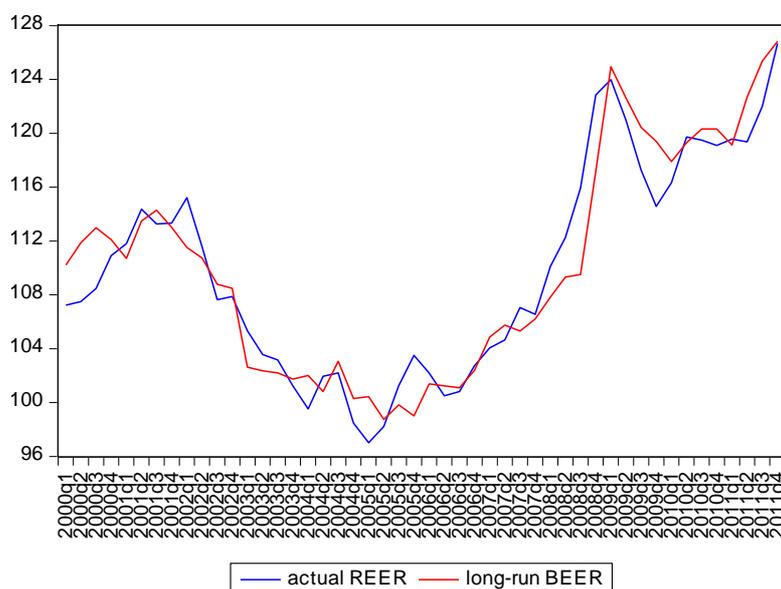
and long-run or permanent movement in the time series. For the calculation of long-run BEERs, it is necessary to obtain the ‘sustainable’ or ‘permanent’ components of the fundamentals. To avoid subjective judgment, we may adopt a technical approach to time series decomposition such as moving average method, the Beveridge-Nelson Decomposition(Clark & MacDonald 2004) and the Hodrick-Prescott Filter(Clark & MacDonald 1999). Note that the Beveridge-Nelson Decomposition and moving average might be problematic with small samples(Baffes, John et al. 1997). In light of these considerations, the Hodrick-Prescott Filter is chosen to smooth the time series. The smooth parameter is set at 1600 for all variables as recommended by Hodrick and Prescott(1997) for quarterly data sets. It also indicates that all the time series are smoothed at the same time trend.

After the time series are smoothed, this research proceeded to calculate the long-run BEERs as follows:

$$\widehat{beer} = 2.8011 + 0.2764\widehat{gov} + 0.2115\widehat{nep} - 0.1256\widehat{nfa} - 0.4996\widehat{open} + 0.2816\widehat{prod} \quad (4.15)$$

where hats mean the time series are at their smoothed value. We have also converted the long-run BEERs from their natural logarithm form to the exponential form. Figure 4.5 shows the long-run BEERs calculated by smoothed variables in equation 4.13 with comparison against actual REERs.

Figure 4.5 Actual REERs versus Long-Run BEERs (2000q1-2011q4)



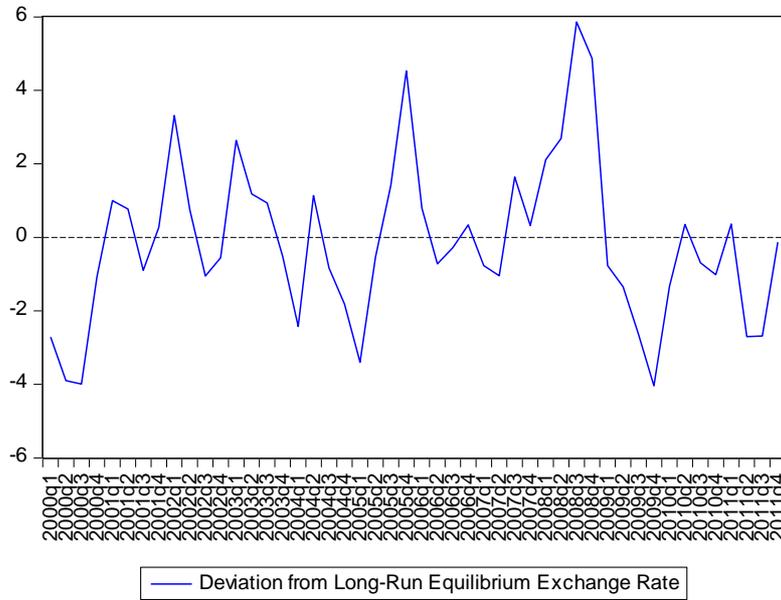
Similarly, the periods when long-run BEERs are above actual REERs are the undervaluation parts, while the periods when the actual REERs are above the long-run BEERs are the overvaluation parts. It can be generally concluded that the long-run equilibrium level of renminbi and its actual REER roughly experience similar appreciations and depreciations during the sample period. The appreciation happened respectively in 2000Q1-2001Q3, 2005Q4-2009Q1 and throughout 2011, while the depreciation happened in 2001Q4-2005Q3 and 2009Q2-2010Q4.

The long-run misalignment of renminbi can be obtained by calculating:

$$Mis_LR = \frac{Actual\ REER_t - Long\text{-}run\ BEER_t}{Long\text{-}Run\ BEER_t} * 100\% \quad (4.16)$$

Figure 4.6 plots the long-run misalignment of renminbi.

Figure 4.6 Long-Run Misalignment of Renminbi (2000q1-2011q4)



4.5 Summary

This chapter discusses the econometric methods used in this research. By using Johansen-Juselius Co-integration method, this research estimates the current and long-run equilibrium levels of the real effective exchange rate and calculates the misalignment based on the analysis of a 6-variables vector.

This study commenced with building up an empirical model based on Baffes *et al.*(1999), Montiel(1999) and Edwards(1989; 1994). After defining the variables, co-integrating estimation was performed. The main steps of the analysis included tests of unit roots, building a VAR model and determining the lag length of the VAR model and developing a VEC model and deciding the rank and deterministic components in the VEC model. Subsequently, this chapter estimated the equilibrium equation (empirical model) and calculated the BEERs, describing the dynamics of the real effective exchange rate and assessing renminbi exchange rate misalignment.

The estimation results are statistically significant with the parameters of all variables in the equilibrium equation being in accordance with expectations. The misalignment of renminbi exchange rate indicates that the deviation of the real effective exchange rate is not eminently large. The REERs fluctuates around the current equilibrium exchange rates in a narrow band of +/- 8 percent over the period of 2000Q1-2011Q4. The band is even smaller from -4% to 6%, after all independent variables are smoothed by H-P filter to move the stochastic components in the time series. Renminbi is not evidently misalignment in this research.

Based on these empirical results, the next chapter summarizes the major finding of this study and answers the research questions. Observations are also provided which identify the limitations of the study and proposes possible directions for further studies of this topic.

Chapter 5 Conclusions

5.1 Introduction

This chapter summarizes the main findings of this study, which answered the following research questions:

- Is there an equilibrium exchange rate for renminbi?
- Has renminbi persistently departed from its long-run equilibrium values? And
- What's the policy implication of this estimation?

To answer these questions, chapter 2 examined relevant issues arising from economic reform in China that required consideration in the study. Chapter 3 reviewed different empirical methods to estimate equilibrium exchange rate. At the beginning of chapter 4, an explanation was provided why the BEER approach is suitable for the discussion of equilibrium exchange rate in this study. Chapter 4 continued with this studies econometric analysis, utilising a 6-variables vector built up with the long-run fundamentals and real effective exchange rate, before conducting Johansen-Jueslius co-integration test. This study then examined the unit roots of each time series to make sure that they are all co-integrated in the same order. The empirical result indicated that all the variables are statistically significant and that they are able to explain most parts of the movement of real effective exchange rate.

Based on the statistical evidence in chapter 4, this chapter summarizes the fundamentals in determining the real effective exchange rate and discusses the possible reasons of recent current misalignment considering the fundamentals in the VAR model. Finally, policy implications are briefly noted with regards to the empirical results. The chapter concludes with limitations of this research and provides potential remedial actions for future studies in this topic.

5.2 Empirical Findings

5.2.1 Fundamentals in Determining the Behavioural Equilibrium Exchange Rate

Visually from figure 4.3 and figure 4.5, the trend of the theoretical current and long-run BEERs are moving along with the actual REERs, which indicates that most of the behaviours of renminbi could be illustrated by the fundamentals.

Empirically, the co-integrating test result indicates that there exists one co-integrating vector among the five fundamentals and real effective exchange rate at the confidence level of 1% and 5% during 2000Q1-2011Q4. This implies that the natural logarithm of real effective exchange rate has a long-run relationship with the five economic fundamentals in their natural logarithms, viz. government expenditure, net export, net foreign assets, the degree of openness and productivity. Moreover, the parameters of these five fundamentals indicate the long-run elasticity of real effective exchange rate to the fundamentals: 0.28, 0.21, -0.13, -0.50 and 0.28 respectively. The signs of the coefficients show that there are positive relationships between real effective exchange rate of renminbi and government expenditures, net export and productivity; and there are negative relationships between real effective exchange rate and net foreign assets and the degree of openness.

Compared with previous studies using co-integrating method, the sign of the coefficient of government expenditure is identity with most studies such as Su(2009), Li(2009) and Peng *et al.*(2008). However, the magnitude of the coefficient is much smaller than existing research, which indicates that government expenditure does has a positive impact in currency appreciation, with the degree of this impact being smaller than previous expectations. Similarly, a unit increase in overall productivity would cause the renminbi to appreciate by 0.21, which is close to Goh and Kim's(2006) estimation of 0.25. There is a sharp difference with regards to the terms of trade, the estimation results ranges from minus 2.01 to 2.03, while the result this study, 0.28, being close to Li(2009), which is 0.38. The negative terms of net foreign assets and the degree of openness are less controversial when compared with other studies. A unit increase in net foreign assets would result in 0.12 unit of currency depreciation, the result is similar to Li(2006) and Chen(2010). Additionally, a unit lowering in trade restriction (a rise in the degree of openness) would lead the currency to depreciate by 0.5, which is similar to Li(2006) and Su(2009).

In synthesis, it may be asserted that the actual real effective exchange rate is significantly determined by the five fundamentals of government expenditure, net export, net foreign assets, the degree of openness and productivity during 2000Q1-2011Q4 as advanced in this research.

5.2.2 The Behaviours of Renminbi: Long-run Perspective

From figure 4.5 in chapter 4, compared with its long-run equilibrium value the behaviours of real effective exchange rate of renminbi bear some features, which may be summarised as follows:

- The long-run trend of the BEERs and actual REERs are identical

The long-run equilibrium level of renminbi and its actual REER roughly experiences several appreciations respectively in 2005Q4-2009Q1 and throughout 2011. The depreciation happened in 2001Q4-2005Q3 and 2009Q2-2010Q4.

- Actual REERs fluctuates around its long-run BEERs in a narrow band

In examining the behaviours of actual REER in details, it is noteworthy that actual REERs fluctuate around the long-run BEERs in a narrow band of +/-4% approximately, with the highest point being 5.86% and lowest point of -4.04%. This indicates that there is no large scale of misalignment during the sample period.

- Renminbi is not misaligned so far

It is also notable that in 2011Q4 the actual REER is quite close to the equilibrium exchange rate, with a minor difference of 0.13%. The misalignment throughout 2010 and 2011 was within 2%, indicating that the renminbi is not significantly misaligned.

5.2.3 Discussion of Possible Source of Misalignment

Though there is no remarkably misalignment during 2001Q-2011Q4, in certain period misalignments the following explanations are advanced:

- 2000Q1-2001Q1: undervalued

This undervaluation can be partly attributed to the post-effect of 1997 Asian Financial Crisis (AFC). After the AFC, most Asian currencies especially Japanese Yen and Korean Dollar appreciated against US dollar, while renminbi was still pegged to the US Dollar because the foreign reserves of China was large enough to maintain the bilateral exchange rate at a comparably steady level. This caused an actual corresponding depreciation of real effective exchange rate of renminbi under its equilibrium level. This undervaluation was later diminished by the fast development of Chinese foreign trade. Real exchange rate came back to a more steady position with a mild fluctuation around the equilibrium level after 2001Q1, until 2005 when the exchange rate regime was adjusted. In this period, since the US dollar had been depreciating against most currencies since 2002 and renminbi was pegged with the US dollar, the real effective exchange rate was experiencing concurrent depreciation. This result corresponds to earlier studies by Goh and Kim(2006), Li(2009) and Wang *et al.* (2007) in the same period.

- 2005Q3-2008Q4: overvalued

In this period, China's export experienced fast growth in various sectors ranging from machinery and transportation equipments manufacture to miscellaneous processing. Comparatively, government expenditure maintained steady growth at the same speed of nominal GDP growth. Additionally, the commercial policy was favourable for international trade. The higher degree of openness facilitated export and investment. As a result, the fast growing external demand stimulated the economy and the real effective exchange rate of renminbi appreciated during this period. Also single-pegged to the US dollar started to reveal its weakness during the fast export growth period. Therefore, the exchange rate regime was adjusted in 2005, in that the renminbi would be pegged to a basket of currency instead of US dollar and the

band of exchange rate fluctuation would be expanded according to the market demand and supply. This reform in exchange rate regime caused a re-adjustment in the bilateral exchange rate of renminbi to US dollars and up to 5.86% overvaluation through this period. The result is similar to Chen(2010) and Chen *et al.*(2008).

- 2009Q1-2011Q4: slightly undervalued

Since the 2008 global financial crisis greatly impacted the United States and European Union, exports from China met with a sharp decrease and this unprecedented pressure forced the Chinese government to take action against this crisis. The Ministry of Finance and The State Administration of Taxation began to raise export duty rebate rates on textiles, apparels and other products. Also, excess government budget was released to stimulate the domestic demand to absorb the un-exported commodities in the second half of 2008. As a result, exports were impaired by the financial crisis. However, this impact is limited when it comes to the exchange rate. The undervaluation was as much as 4% initially after the global financial crisis was revealed, then the resource was re-allocated and commodities were absorbed by domestic demand and the real effective exchange rate started to come back to the long-run equilibrium level.

5.3 Policy Implications

The empirical findings in this study also yield some policy implications, which are discussed below.

Firstly, the mild fluctuation of the real effective exchange rate around its long-run equilibrium level and the small band of this movement indicate a comparably healthy exchange rate regime in China. As it was introduced in chapter 2, the current exchange rate regime in China is still seen as 'managed floating' with a basket peg. The basket includes the currency from the world majority economies, such as the U.S Dollar, Japanese Yen, Euro Dollar and Korean Won. Despite this, it could be recommended that the basket involve an expanded range of currency to calibrate the manage target.

Secondly, the results show that in the long run there are series of fundamentals affecting the behaviour of the real effective exchange rate. Therefore, evaluating and managing the long-run external renminbi exchange rate would be based on evaluation of these fundamentals(Chen, J. 2010). This indicates that adjusting the fundamentals may be used as a tool to manage the exchange rate instead of direct intervention into the foreign exchange market. This is especially true when the currency misalignment is caused by the deviation of fundamentals from their equilibrium levels. The latter is not preferable because any departure of actual real exchange rate from the BEER level would be eventually diminished by the adjustment of the fundamentals in the co-integrating relationship, as indicated by Clark and MacDonald(1999) and this would not be sustainable for the long run economic development.

It is recommended that China moderately expand the floating range of the nominal exchange rate on the basis of setting up a target band. As previously discussed, adjusting the fundamentals is preferred to direct intervention in foreign exchange market. Such a simplistic proposition ignores China's more complicated issues including pollution, uneven income distribution and unbalanced employment rate in different sectors. Adjusting fundamentals brings the risk of disturbing the economic environment and it should not be solely targeted at attaining a comparably fixed exchange rate. A more flexible exchange rate regime could be combined with a broader range of fundamentals management to well balance the economy as well as deepen the economic reform in China.

5.4 Limitations of the Research and Future Research

5.4.1 Limitations of the Research

The majority of empirical studies in the topic of renminbi exchange rate estimation suffer from different limitations. Similarly, there are specific issues this study needed to accommodate.

- Short sample period

The sample period used in this study is comparably short. Generally, the use of a longer time frame and larger sample pool would increase statistical precision in econometric analysis. For example, some decomposition methods (*e.g.* Beveridge-Nelson time series decomposition) would be problematic for small samples.

The sample period in this study is from 2000Q1 to 2011Q4, which contains 48 sets of observations available for the discussion of renminbi exchange rate determination and misalignment. It was chosen because some data was not available in quarterly form before 2000 and our research interest was on the post-2000 period when the trade friction between China and its main trading partners worsened.

- No transitory variables for short-term volatility

The BEER analysis framework contains economic fundamentals that can influence the real effective exchange rate in the long run, as well as transitory variables that might cause short-term volatility of the real exchange rate. This helps to decompose the source of exchange rate misalignment.

This research focused on the long-run determination of real effective exchange rate. Consequently, popular transitory variables in previous literatures are ignored, *e.g.* interest rate differentials and aggregate money supply (M2). Therefore, long-run misalignment could be attributed to only two sources, viz. the random disturbance and the deviation of the fundamentals from their equilibrium values.

- Different measurement of productivity

As previously discussed, there are two popular ways to define productivity as a proxy of Balassa-Samuelson Effect, viz. the relative price of non-tradable goods (TNT) and tradable goods and income per capita (CAPITA). The TNT could be illustrated by a ratio of CPI to PPI. It has been argued that the CPI/PPI ratio could be problematic when used as a proxy for B-S Effect, further, it may also be influenced by factors other than B-S Effect such as relative demand effects, tax changes or nominal exchange rate (Chinn 1997). Additionally, prices for some services are not entirely market-determined because of restrictions or barriers on free movement of labour between different sectors (Dunaway & Li 2005).

In this research the income per capita was used to estimate the productivity, which could lead to different result in the estimation of this economic fundamental from existing studies, holding in abeyance which variable could better describe the technique development in a certain period.

- Negligence of the impact of investment on economic growth

It has been recognized that stimulation on investment, domestic demand and foreign trade could lead to economic growth in different paths (Backus, D.K. & Smith 1993; Kollmann 2010; Nair-Reichert & Weinhold 2001; Rogoff 1996), similarly they can also influence real exchange rate in a comparably long-run.

This research restricted its examination of the impact of change of domestic demand (as government expenditure and average income) and change of net export on the real exchange rate. This is because this research is more interested in the export-led growth transformation into a domestic-demand-led growth, assuming that the development of financial markets in this period would make prominent changes on real exchange rate. The effect of domestic and foreign investment is then omitted.

- Negligence of the important structural break in the deterministic trend

In determining the fundamentals, this study did not take into consideration any foreign demand magnitude. As specified by Montiel (1999), the real exchange rate could be influenced by change in international economic environment such as the terms of trade (TOT) and the level of global economy development. The latter could better describe the overall demand of the foreign magnitude.

In this research, TOT is used to represent the change in international economic environment. Therefore, the impact of the global financial crisis was implicitly contained in this variable, which might otherwise be misspecified.

- Weakness of ADF test

It has been pointed out that the traditional ADF and PP tests as tools for unit root testing, suffers from severe size distortion when the series has a large negative moving average root (Ng & Perron 2001; Schwert 2002). That is, they have low power against the alternative hypothesis that the series is stationary with a large autoregressive root (DeJong et al. 1992). Also, the power of these tests diminish as deterministic terms (constant and/or trend) are added to the test regressions (Chen, J. 2010).

Therefore, the unit root test results might be problematic to some degree. In this research, the variable of productivity was not rejected in the first difference by the ADF test, with a further test by PP approach rejects the null hypothesis at first difference and it is seen as stationary at the first level. According to the discussion above, this interpretation should be dealt with caution.

5.4.2 Future Research

The future research can be improved based on the limitations discussed above. Some remedial actions are recommended as below.

- Longer sample period

To provide a more robust empirical result, a longer sample period could be included to analyse the equilibrium exchange rate of renminbi based on different research interests.

- A dummy variable for structural break

Note that a dummy variable could be used for some significant structural change in the study, e.g. the global financial crisis, to reflect the change in the VAR system. As summarized before, the renminbi was slightly undervalued after the global financial crisis and this post-crisis undervaluation could possibly relate to the change in foreign demand. Further tests including the dummy variable could help to understand the possible impact of financial crisis on the movement of real effective exchange rate of renminbi.

- Involving expanded set of explanatory variables

It is well recognized that based on different research interests, co-integrating analysis is used to test the long-run relationship between exchange rate and different fundamentals. Additionally, some economic fundamental could be interpreted in different ways, e.g., the Balassa-Samuelson Effect could be interpreted either by the relative price of non-tradable goods to tradable goods or income per capita. To provide a more robust empirical result based on reliable data, an expanded set of economic fundamentals could be included in the future research, such as domestic investment and foreign direct investment (FDI) as well as short-term variables such as aggregate money supply (M2) and interest rate differentials.

- Different unit root test approach

Following Chen(2010), the problem of the ADF and PP test for the existence of unit roots when there is a large negative moving average root could be fixed by using a minimum Lagrange Multiplier(Lee & Strazicich 2003) unit root test instead. This is especially true for the time series with structural breaks in the trend (no more than two). Alternatively, the Ng and Perron(Ng & Perron 2001) unit root test could be used as well.

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