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Institute of Political Studies

- Qiriga

Evaluation of China's FOREX Policy: Equilibrium Exchange Rate Perspective

Master thesis

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Author: **- Qiriga**

Supervisor: **Ing. Vilém Semerák M.A., PhD.**

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Abstract

This thesis investigated China's foreign exchange policy from the equilibrium exchange rate perspective, using the Fundamental Equilibrium Exchange Rate model with multiregional dimension. The core question is whether Renminbi is misaligned (over- or undervalued) from 2001 to 2017. The result indicated that the bilateral nominal exchange rate of Renminbi against the US dollar was undervalued from 2002 to 2013, reaching a peak of 34.2% in 2007. In the rest of the years, it was overvalued slightly against the US dollar. As to the real effective exchange rate (REER) of Renminbi, it was overvalued in the first three years of the 2000s, then went through the period of undervaluation of 9 years, with a smaller degree compared with the bilateral exchange rate. It is shown that from 2013 the REER of Renminbi had been overvalued for several years until it was undervalued again in 2017 by 2%.

Keywords

FEER, Renminbi, exchange rate misalignment, multinational model, real effective exchange rate

Abstrakt

This thesis investigated China's foreign exchange policy from the equilibrium exchange rate perspective, using the Fundamental Equilibrium Exchange Rate model with multiregional dimension. The core question is whether Renminbi is misaligned (over- or undervalued) from 2001 to 2017. The result indicated that the bilateral nominal exchange rate of Renminbi against the US dollar was undervalued from 2002 to 2013, reaching a peak of 34.2% in 2007. In the rest of the years, it was overvalued slightly against the US dollar. As to the real effective exchange rate (REER) of Renminbi, it was overvalued in the first three years of the 2000s, then went through the period of undervaluation of 9 years, with a smaller degree compared with the bilateral exchange rate. It is shown that from 2013 the REER of Renminbi had been overvalued for several years until it was undervalued again in 2017 by 2%.

Klíčová slova

FEER, Renminbi, exchange rate misalignment, multinational model, real effective exchange rate

Declaration of Authorship

1. The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

2. The author hereby declares that all the sources and literature used have been properly cited.

3. The author hereby declares that the thesis has not been used to obtain a different or the same degree.

Prague, May 8, 2019 Signature: - Qiriga

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Institute of Political Studies
Faculty of Social Sciences
Charles University in Prague Date: 10.09.2018

Author:	Qiriga ---	Supervisor:	Ing. Vilém Semerák M.A., PhD.
E-mail:	1119604967@qq.com	E-mail:	vilem.semerak@fsv.cuni.cz
Phone:	+420 775 959 721	Phone:	
Specialisation:	IEPS	Defense Planned:	June 2019

Proposed Topic:

Evaluation of China's FOREX policy: equilibrium exchange rate perspective

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Topic Characteristics:

China, as the world's fastest-growing major economy, is chasing behind the United States tightly. It is now the largest trading nation in the world and is playing a prominent role in international trade. Due to its large weight of economy, the Chinese policy towards international trade is studied carefully all over the world, especially its foreign exchange policy. In this thesis, I want to focus on the evaluation of China's foreign exchange policy, using equilibrium exchange rate perspective, a tool applied and being developed by large amount of economists. As we all know, there is a substantial gap in trade imbalance among world great powers, especially between China and the United States. As China's foreign exchange reserve kept high in all those years, its control over the Renminbi is under fierce attack. The undervaluation of Renminbi by Chinese government is being acknowledged by more and more scholars. My task in this thesis is to test whether there is a misalignment in Chinese currency, if so, to what extent. In my study, I will use methodologies of FEER (fundamental equilibrium exchange rate) to acquire the most adequate real exchange rate in medium term. For data, I am going to use the World Bank data, the OECD data, together with the IMF data. If necessary, I will also explore extra data from other resources or collect it myself.

Working hypotheses:

1. The exchange rate of Chinese Renminbi is misaligned or undervalued.
2. The misalignment of Yuan has been decreasing continuously in the recent decade.
3. The trade war between the United States and China will have some influence on the FEER of Renminbi in 2018.

Methodology:

Using partial equilibrium model as theory basis, I will utilize econometric methods in panel setting and Hodrick-Prescott filter to calculate FEER of Renminbi. Moreover, the sensitivity analysis will be applied to calculate the FEER in various scenarios of future.

Outline:

1. Introduction
    a. Brief History of Chinese Exchange Rate Regime
    b. Sign of Misalignment of Renminbi
    c. Overview of Methodologies
    d. Literature Review

2. Model
    a. Introduction of FEER
    b. Partial Equilibrium Model
    c. Eternal Equilibrium
    d. Internal Equilibrium
    e. Result of Estimation
3. Sensitivity Analysis
4. Conclusions
5. References / Bibliography
6. Appendices

References / Bibliography:

[1] Šmídková, K. (2003): *Estimating the FEER for the Czech Economy*, Macroeconomics 0303014, EconWPA.
[2] Wang, Yaije & Hui, Xiaofeng & Soofi, A. (2007): *Estimating Renminbi (RMB) Equilibrium Exchange Rate,* Journal of Policy Modeling 29 (2007): pp. 417-429.
[3] Cheung, Yin-Wong & Chinn, M. & Fujii, Eiji (2007): *The Overvaluation of Renminbi Undervaluation,* Journal of International Money and Finance, 26 (2007): pp. 762-785.
[4] MacDonald, R. (2000): *Concept to Calculate Equilibrium Exchange Rates: An Overview*, Economic Research Group of the Deutsche Bundesbank.
[5] Wren-Lewis, S. & Driver, R. & Williamson, J. (1998): *Real Exchange Rates for the Year 2000,* Peterson Institute Press: Policy Analyses in International Economics, Peterson Institute for International Economics, number 54.
[6] Jeong, S. & Mazier, J. (2003): *Exchange Rate Regimes and Equilibrium Exchange Rates in East Asia*, Presses de Sciences Po: Revue Economique, 2003/5 Vol. 54: pp 1161.
[7] Coudert, V. & Couharde, C. (2005): *Real Equilibrium Exchange Rate in China*, CEPII.
[8] Williamson, J. (2006): The Target Current Account Outcomes, Washington: Institute for International Economics.

Author ..... Supervisor .....

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Acronyms

BEER	Behavioral Equilibrium Exchange Rate
LOOP	Law of One Price
NAIRU	Non-accelerating Inflation Rate of Unemployment
FEER	Fundamental Equilibrium Exchange Rate
RMB	Renminbi
USD	United State Dollar
CNY	Chinese Yuan
GDP	Gross Domestic Product
US	United States
IMF	International Monetary Fund
WTO	World Trade Organization
REER	Real Effective Exchange Rate
PEER	Permanent Equilibrium Exchange Rate
NATREX	Natural Real Exchange Rate
PPP	Purchasing Power Parity
UIP	Uncovered Interest Parity
ITMEER	Intermediate-term Model-based Equilibrium Exchange Rate
CHEER	Capital-enhanced Equilibrium Exchange Rate
DEER	Desired Equilibrium Exchange Rate

1: Introduction

During the 2000s, China ran a large current account surplus for several years, which was subject of contentious debate among countries, especially the United States whose large current account deficit had been continuing for decades and without much sign of reduction around the time. Although there was no explicit evidence, China was under a huge wave of criticism for the suspected manipulation of its currency which further intensified because of the fast growth of Chinese foreign exchange reserves. As a result, lots of studies on the appropriate value of the exchange rate of Chinese Yuan have been conducted, all with their different methodologies and results.

But in the 2010s, as China's current account balance begins to return to a relatively "normal" level, it seems like the passion of academy is fading: there are not as many studies or papers contributed to the topic as before. In spite of this, I am still interested in researching the topic and answering questions like what the current situation of the exchange rate of China is.

By this paper, I would like to study the equilibrium value of the exchange rate of Renminbi, with the most recent data. When deciding which model to use, I have chosen the Fundamental Equilibrium Exchange Rate (FEER) with a multiregional dimension. As to the time frame, the medium-term with the period between 2001 and 2017 is used.

To serve the goal, the paper is divided into two parts with eleven chapters. The first part deals with the historical and theoretical background. And the second part covers the contents of the actual model and the methodology, together with the final estimation of the FEER of Chinese Yuan.

After the introduction chapter, the following chapter briefly sums up the history of the Chinese exchange rate regime which is further subdivided into four smaller periods. In the third chapter, some traditional indicators like foreign exchange reserve and current account/ GDP ratio are examined to give some advice on whether the currency is at its equilibrium value or not, at first sight. The first part is ended with chapter four and chapter five, which are the introduction of the overview of methodologies and literature review respectively.

In the second part, the sixth chapter is for introducing the methodology used, the Fundamental Equilibrium Exchange Rate. Its concept, advantages, and disadvantages are discussed in detail. In the seventh chapter, the actual model, the multinational model is introduced and all the needed data and equation forms are explained carefully. The eighth and ninth chapter gives detailed information and estimation methods of the two most important components of the whole model, which are the external balance and the internal balance. The tenth chapter gives the final result of the FEER of China. In the eleventh chapter, I summarized the whole study. Appendices and references are included after the conclusion.

2: The Brief History of China's Exchange Rate Regime

In this chapter, the history of the exchange rate regime of the People's Republic of China is briefly introduced. Since its establishment, the country has undergone several drastic changes in its modern history. These changes have not only meant a huge political institutional shift but also impacted the exchange rate regime the country was using as well. To make it simpler, the history is subdivided into four periods, including the process of nation-building (1949-1952), the era of the socialist economy (1953-1980), the dual exchange rate regime era (1981-1994) and the managed floating exchange rate regime era (1994-present). Each period has its unique political, economic and social characteristics which decided the final choice on exchange rate regime by the authority.

2.1. The process of nation-building: 1949-1952

On 1st December 1948, the People's Bank of China began to issue its new currency called Renminbi (RMB or CNY), whose main task was to unify the collapsed national currency system and to control the situation of hyperinflation in the war-torn country. Renminbi's first official exchange rate with American dollar was announced at the northern coastal city Tianjin on January 18th, 1949, set at 80 CNY/USD. As Shanghai in June and Guangzhou in January 1950 taken over by the People's Liberation Army successively, foreign exchange markets were established in both the above area and the local institutions announced their own exchange rates with the United States dollar (USD), based on the actual economic situation and their demands for foreign currency.

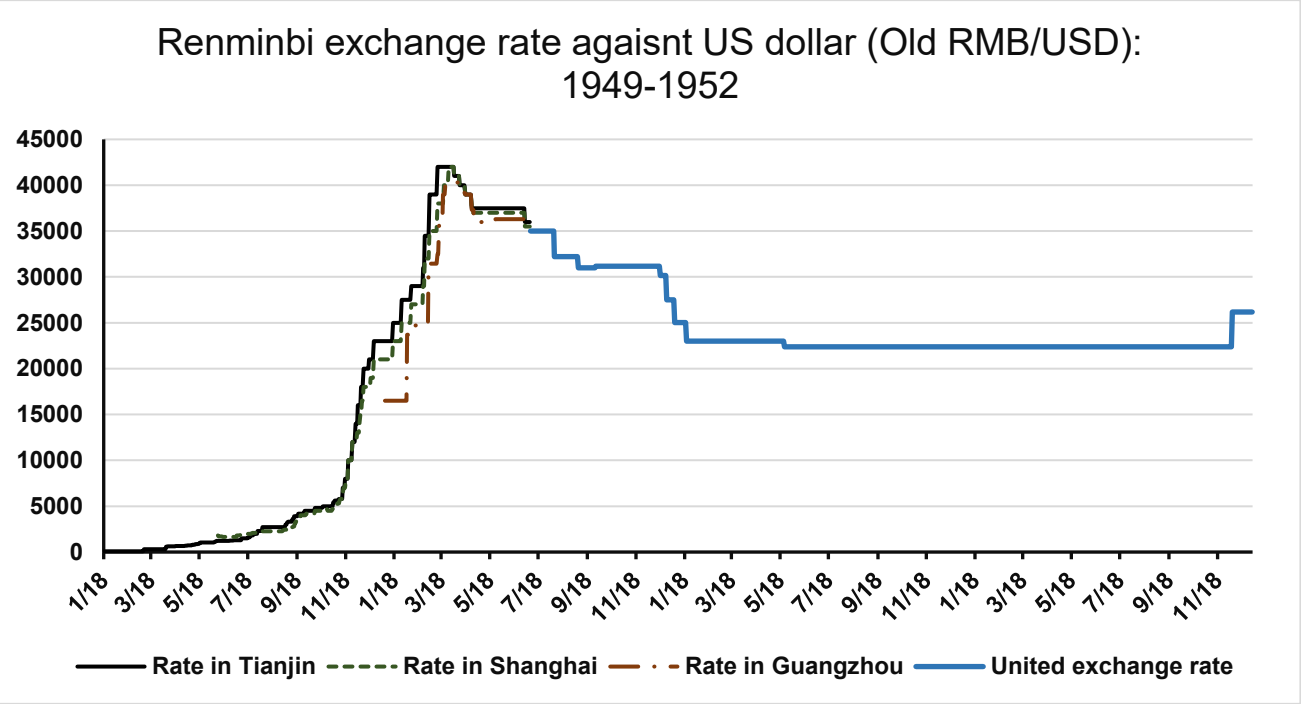
Before the unification of exchange rates, to import main resources and technology for developing the economy, the guideline on setting exchange rate was to encourage export,

limit imports of luxurious, and support remittance (“奖出限入，照顾侨汇”). The severe inflation resulted in a continuing devaluation of the RMB. In March 1949, the exchange rate in Tianjin was 600 RMB/USD. But in March 1950, the same rate increased to 42,000 RMB/USD.

After the first National Financial Work Conference, on July 8th, 1950, the exchange rate of RMB was unified across the country and managed unanimously by the People’s Bank of China. The foreign exchange markets were destroyed.

During the Korean War between 1950 and 1952, Chinese foreign exchange policy turned to encourage both export and import (“进出口兼顾”) to support its needs of goods under the background of the international sanctions. The currency began to appreciate under the guidance of the central government. In May 1951, after revaluation for 15 times from March 1950, the exchange rate decreased from 42,000 to 22,380, changed by 46.7%. In this period, there was also a huge change in China’s main trade partners. In 1950, the trade with western countries (including Japan, the United States, Western Germany, France, etc.) constituted 35.9% of the total international trade volume, while the socialist countries like the Soviet Union and eastern European countries took up 31.37%. In 1952, the trade with western countries decreased to 2.33% of the total volume, while the number with the socialist countries almost doubled, increased to 61.06%. Figure 2.1 shows the exchange rate of renminbi from 1949 to 1953.

Figure 2.1: RMB/USD in 1949-1952



Source: Data from 汇价手册，中国金融出版社，1986.

Note: Exchange rate is central parity rate (the average of selling and buying rate).

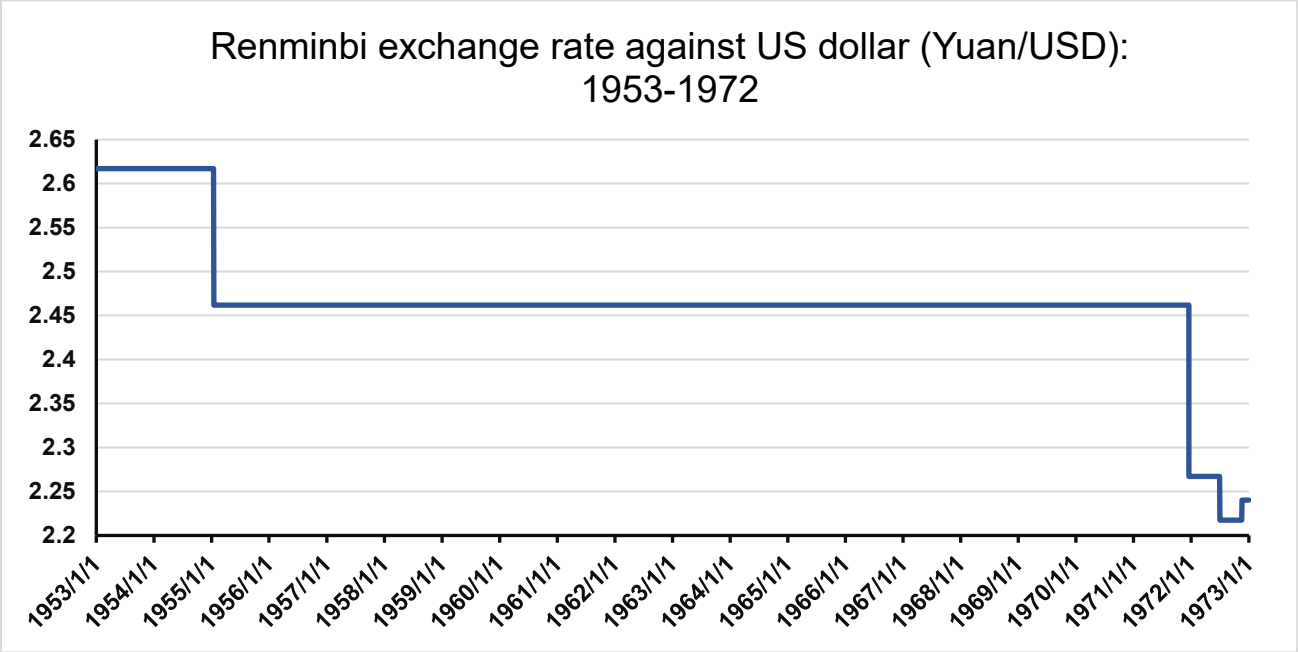
2.2. The Era of the Socialist Economy: 1952-1980

From 1953, as the first Five-Year Plan started, China formally entered the socialist era. National economy and all sorts of foreign trade came under the tight regulation of the central government. As to exchange rate, though Renminbi was officially announced against the British Pound out of political reason, Chinese authority was still using the peg to the United States dollar as its exchange rate policy.

In this period, China faced several economic setbacks because of national and international turbulence. The Great Leap Forward period (1959-1961), the Cultural Revolution (1966-1976), the breakdown with the Soviet Union (the 1960s), all caused a huge decline in the Gross Domestic Product (GDP) growth. However, the exchange rate remained uninfluenced in the whole period despite the volume of foreign trade shrank tremendously.

On first March 1955, the People's Bank of China issued new Renminbi, whose change rate with the old one is 1:10,000. From then on, the exchange rate of RMB/USD stayed at 2.4618 for almost fifteen years.

Figure 2.2: RMB/USD in 1953-1972



Source: Data from 汇价手册，中国金融出版社，1986.

Note: Exchange rate is central parity rate (the average of selling and buying rate).

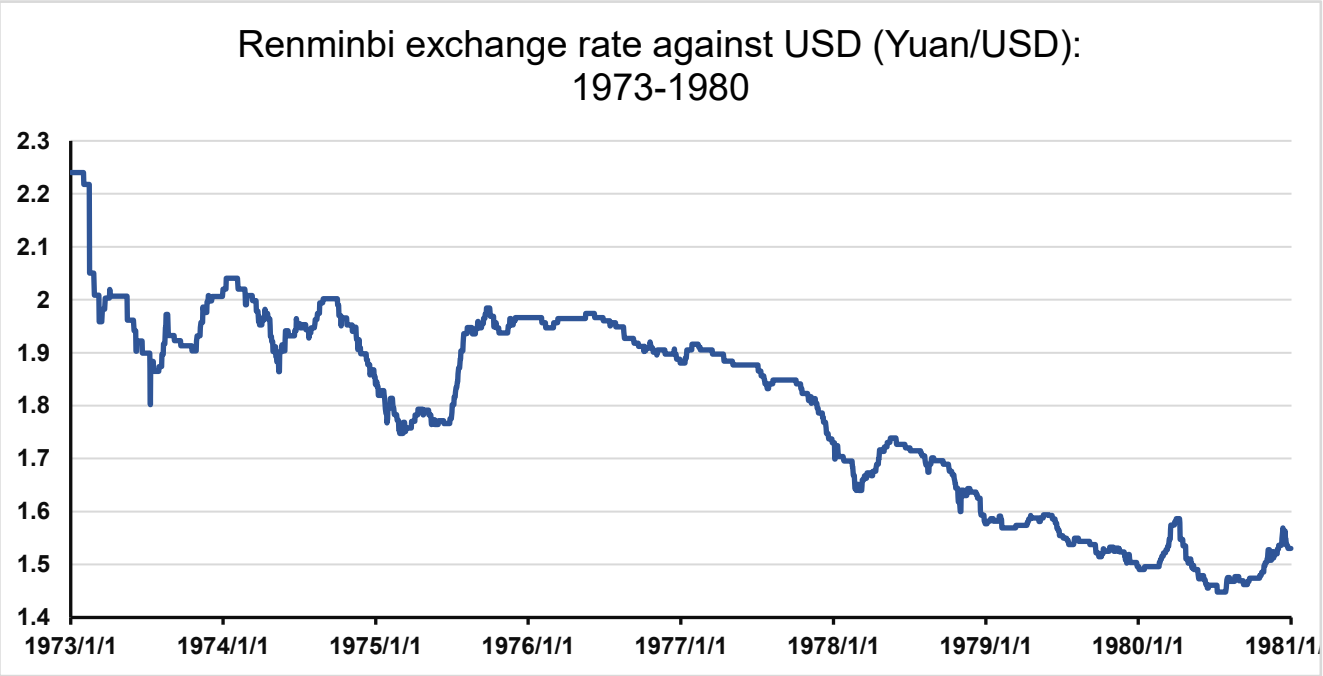
The breakdown of the Bretton Woods system in 1973 directly resulted in floating exchange rates in western countries. As pegging to American Dollar became more and more difficult to the socialist economy, the Chinese exchange rate regime switched to the method of pegging to a basket of foreign currencies with some considerations on the market of foreign exchanges. The basket contained all currencies from its main trade partners, including Japanese Yen, German Mark, Swiss Franc, English Pound, the American Dollar, etc. The method of actual calculation and the weight of currencies remained secret until now.

In this post-Bretton Woods era, there were huge fluctuations in the exchange rate of RMB as a result of the great inflation of the 1970s of the United States. It was partly due to the lack of experience of Chinese financial authority as they had been accustomed to the fixed

exchange rate regime in the early years. Moreover, out of the ideology of Marxism, the exchange rate of RMB was revalued deliberately to avoid the so-called exploitation from capitalist countries.

The foreign exchange rate regime did not change as China turned to open-up policy in 1978, resulted in a high surge in the trade deficit in the late 1970s. Figure 2.3 shows the movement of the official Chinese exchange rate in this period.

Figure 2.3: RMB/USD in 1973-1980



Source: Data from 汇价手册，中国金融出版社，1986.

Note: Exchange rate is central parity rate (the average of selling and buying rate).

2.3. Dual Exchange Rate Era: 1981-1994

In December 1978, the 3rd Plenary Session of the 11th Central Committee of the Communist Party of China was held. The conference marked the beginning of the transition to a market economy for China. Deng Xiaoping with his reformist allies initiated the “Reform and

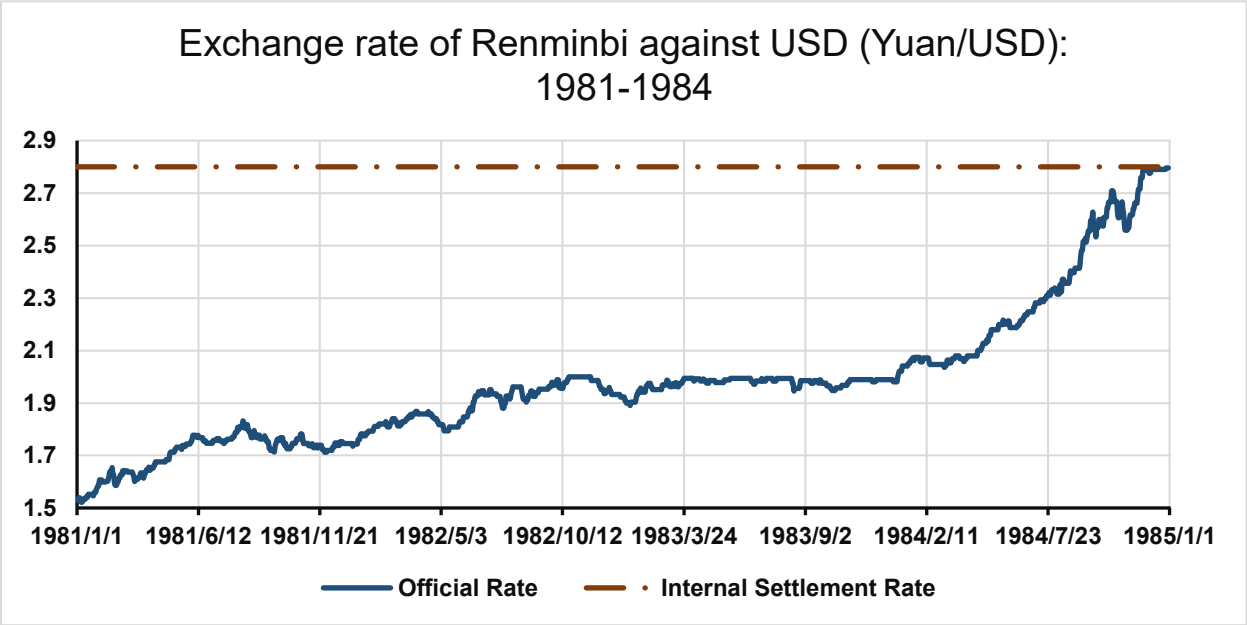
Opening-Up" policy, which began to led the whole country into a market-driven economic era.

As the demand for foreign currency and foreign direct investments grew fiercely within this new market economy, the exchange rate of Renminbi could not only focus on stability or national dignity anymore. The pressure on encouraging export to earn foreign exchange reserves surged and pushed the authority to find out methods to devalue the already revalued Renminbi. From January 1981 to December 1984, China formally adopted a dual exchange rate regime, where the official rate coexisted with the so-called internal settlement rate. The internal settlement rate was set at 2.8 Yuan/USD with the consideration of purchasing power parity of tradable goods plus 10% of profit for Chinese export enterprise. According to Xu and Zhu (2002), the fundamental cause for the dual rate system stems from the difficulty of authorities to settle the problem of Chinese internal price, which was highly distorted under planned economy era.

The dual exchange rate regime gave rise to rampant illegal activities at that time, created chances for scalpers to make money through the black market. To avoid these activities, the government issued Foreign Exchange Certificate to foreigners from 1979, which only made the situation worse. The Foreign Exchange Certificate system was abolished in 1994 finally.

Figure 2.4 shows the development of the exchange rate of Renminbi during 1981-1984. The reasons of the devaluation of the official rate of Renminbi in this period could be credited to the peg to basket policy in 1981-1983 and Chinese authority's acceptance of the suggestion from the International Monetary Fund (IMF) to coalesce two rates during 1984.

Figure 2.4: RMB/USD in 1981-1984



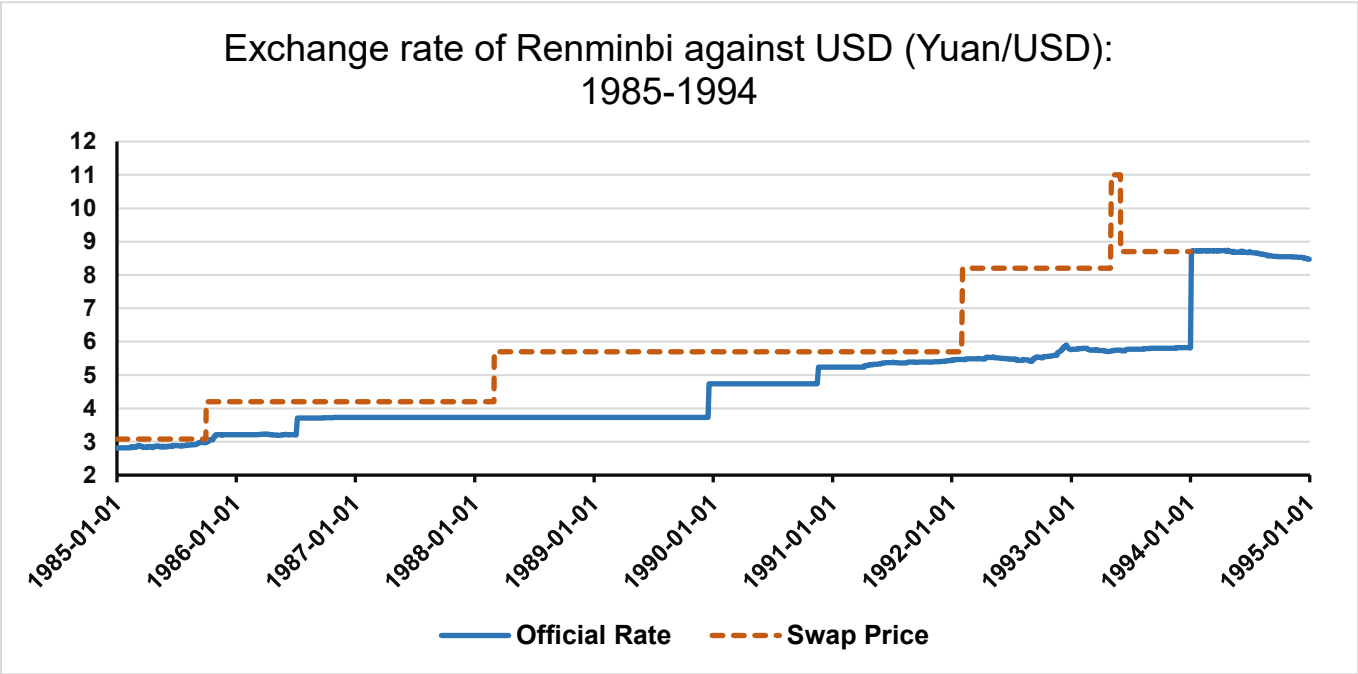
Source: Data from 汇价手册，中国金融出版社，1986.

Note: Exchange rate is central parity rate (the average of selling and buying rate).

In 1985, though the dual rate regime was officially removed, there was a new form of the dual system continued to exist up until 1994, which stems from the Chinese version of the foreign exchange swap market. The swap market was originally developed to deal with the imbalance of demand for foreign exchange among export and import enterprises, while resulted in the soaring price of the swap because of scarcity. The swap price had reached as high as 10 Yuan/USD one time during the early 1990s. Most of the data of swap price are unavailable now.

The following Figure 2.5 shows the Renminbi exchange rate movement in 1985-1994. What we could notice is that Renminbi was continuing its depreciation in the whole period, firstly quite slowly and periodically, then more abruptly. The reason behind depreciation is due to the pressure of inflation and trade balance deficit before 1990 and to authority's willingness to increase foreign exchange reserve to support open up policy after 1990. The exchange rate regime was also changed during these ten years, that the former peg to basket regime replaced with the managed floating from January first, 1986.

Figure 2.5: RMB/USD in 1985-1994



Source: Data from Federal Reserve Bank of St. Louis, 2019.

Note: Official rate is selling rate of Yuan. The data of Swap Price is from Xu and Zhu (2002), lacks accuracy.

2.4. Managed Floating of Renminbi: 1994-present

On January first, 1994, as the swap price of Renminbi was abolished, there was a debate over on which value the new official rate should be set. Ding (2014) guessed the equilibrium value of Renminbi against USD at that time was at 7.5, while Xu and Zhu (2002) guessed it as 6.5. Finally, the exchange rate was decided on 8.7 Yuan/USD, which was under suspicions of excessive depreciation by many Chinese scholars and may result in the then appreciation of Renminbi in the following years.

From September of 1997 to July 2005, as the Asian financial crisis broke out, Chinese authority adopted the exchange rate policy of peg to the U.S. dollar at 8.2765 Yuan/USD, which gained it a huge reputation among the world for its contribution to protecting global economic stability. After China's membership in the World Trade Organization (WTO) in

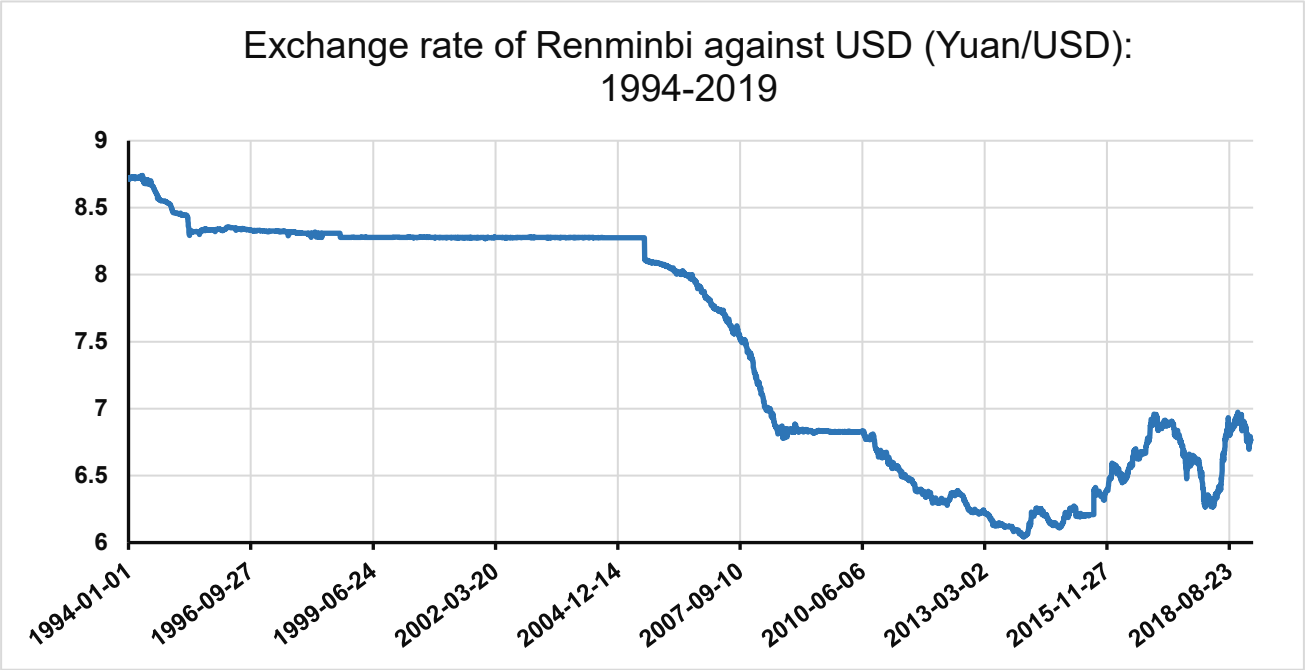
December 2001, there was a constant pressure to appreciate Renminbi, which was finally carried out from 2005, when the exchange rate regime moved to the principle of the peg to the basket with management and a floating band of +/- 0.3%. The pressure was also partly due to the appreciation of RMB in real terms because of inflation. Again, in May 2007, the width of the floating band increased to +/- 0.5%. However, the process of appreciation was disrupted in the summer of 2008, when the global financial crisis started. China adopted the same policy to handle the crisis, which was to peg to the American dollar at 6.83. Unlike last time in the Asian Crisis, the action brought harsh criticize from the world.

In June 2010, China again turned to the regime of managed floating and peg to the basket, and in the following December of 2012, increased the width of the floating band to +/-1%. In March 2014, the same band was added to +/-2% furthermore.

On August 11th, 2015, China also attempted an ambitious exchange rate policy to try to switch to a more market decided floating regime, which was called “811 Exchange Rate Reform”, but unfortunately, it did not work out successfully and forced the authority to abandon after three days (Yu & Xiao, 2017). From then on, the exchange rate policy has always been fluctuating between two trends of floating (especially when Renminbi is depreciating under the market mechanism) and management from the government (when Renminbi is under pressure from appreciation, authority always utilize the counter-cyclical factor and foreign exchange risk reserve ratio to eliminate risk).

Figure 2.6 shows the most recent movement of Renminbi exchange rate against the dollar. Although the Chinese exchange rate regime is still far from the total floating regime, the overall trend illuminates to us the government is trying wholeheartedly in that direction.

Figure 2.6: RMB/USD in 1994-2019



Source: Data from Federal Reserve Bank of St. Louis, 2019.

3: Suspected Sign of Misalignment of Renminbi

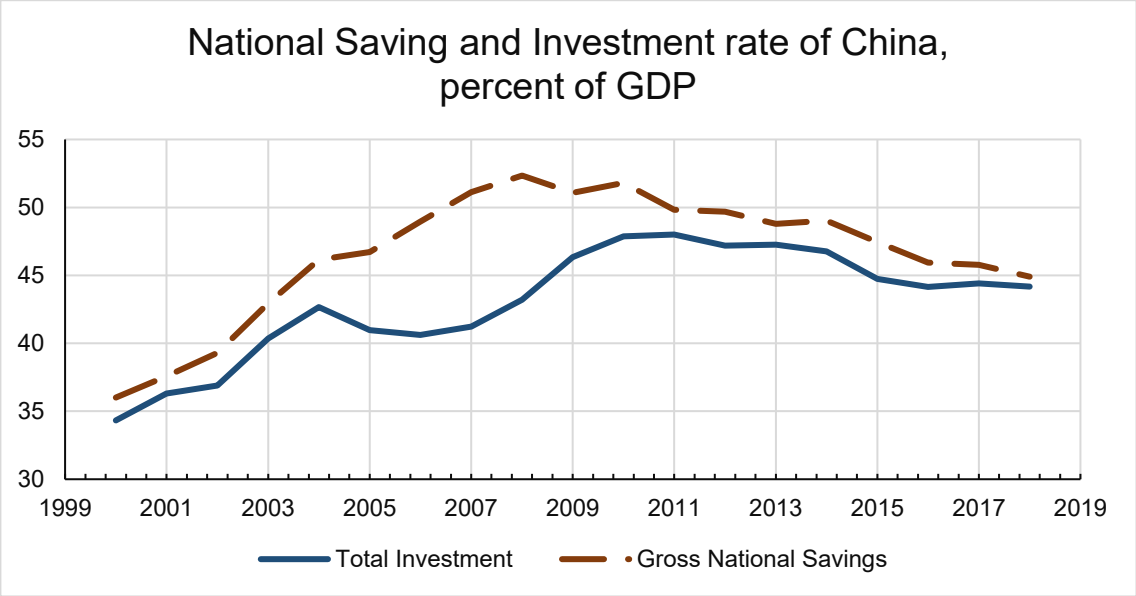
There are several indicators available when examining signs of misalignment of a currency. Firstly, according to some hypothesis like the ‘stages of development’, emerging countries like China should have a current account deficit as a result of its necessity to import foreign capital to fuel development (Roldos, 1996). While the actual data from recent decades reveals the exact opposite trend. The following Figure 3.1 shows the data of the current account balance of China (as a percentage of GDP) from 2000 to 2018. As shown in the figure, the percentage of the current account in GDP increased ceaselessly in the first half of the 2000s and reached its vertex at 9.889% in 2007. The continuous high surplus in current account sometimes may indicate the possible existence of undervaluation of the Chinese currency, for the purpose of gaining competitive advantages in export. While, after its peak in 2007, the degree of Chinese current account surplus decreased quickly and returned to a quite reasonable level between 0% and 3%.

Figure 3.1: Current account balance of China

Source: IMF, *World Economic Outlook*, October 2018.

Although the currency has been under critical suspicion of undervaluation during the 2000s, the phenomena in current account surplus could also be explained from the financing side, the difference between national saving and investment (Couderte & Couharde, 2005). As shown in Figure 3.2, though there were high investment rates throughout the years, the saving rate, at the same time, always surpassed it. And the degree of the difference between saving and investment rates has been consistent with the surpluses on the current account. From Figure 3.2, it is easy to see that the difference between the two rates is biggest in around 2007, which is the same year when the current account surplus reached its peak. The extreme high saving rate in China has two probable sources, high private saving and high public saving originates from the state-owned companies (Kuijs, 2005). As to high private saving rates, there are some explanations in the literature which states that it may partly result from its special demographic structure especially after the implementation of the 'One Child Policy', and partly from the lack of standard pension system which caused the people to concern about their retire life and saves much(Modigliani & Cao, 2004).

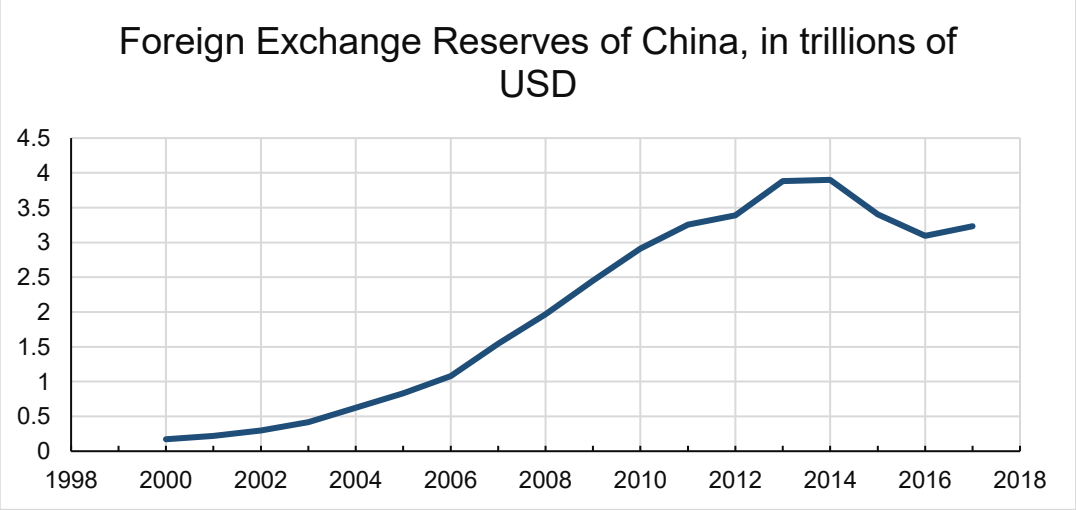
Figure 3.2: National saving and investment rate of China



Source: IMF, *World Economic Outlook*, October 2018.

Secondly, during the 2000s, lots of concerns over the undervaluation of Renminbi stemmed from the huge accumulation of foreign exchange reserve by China's central bank, the People's Bank of China. It was widely reported that the huge accumulation partly resulted from the Chinese government's efforts to prevent the appreciation of Renminbi, which could be seen as a sign of attempts to preserve the undervaluation of the currency. In 2014, the foreign exchange reserve reached its peak at $3.8 trillion U.S. dollar. Since then, as China's current account surplus returns to 'normal' level and the impact of the Global Financial Crisis on world economy diminishes gradually, the foreign exchange reserve shows somehow a decreasing trend. However, the current amount of foreign exchange reserve is far above the two common benchmarks used internationally, which are three months' equivalent of imports and a hundred percent of short-term external debt in foreign currency. Both the criteria amounts below one trillion U.S. dollar for China. The foreign exchange reserve of China is shown in Figure 3.3 below.

Figure 3.3: Foreign exchange reserve of China

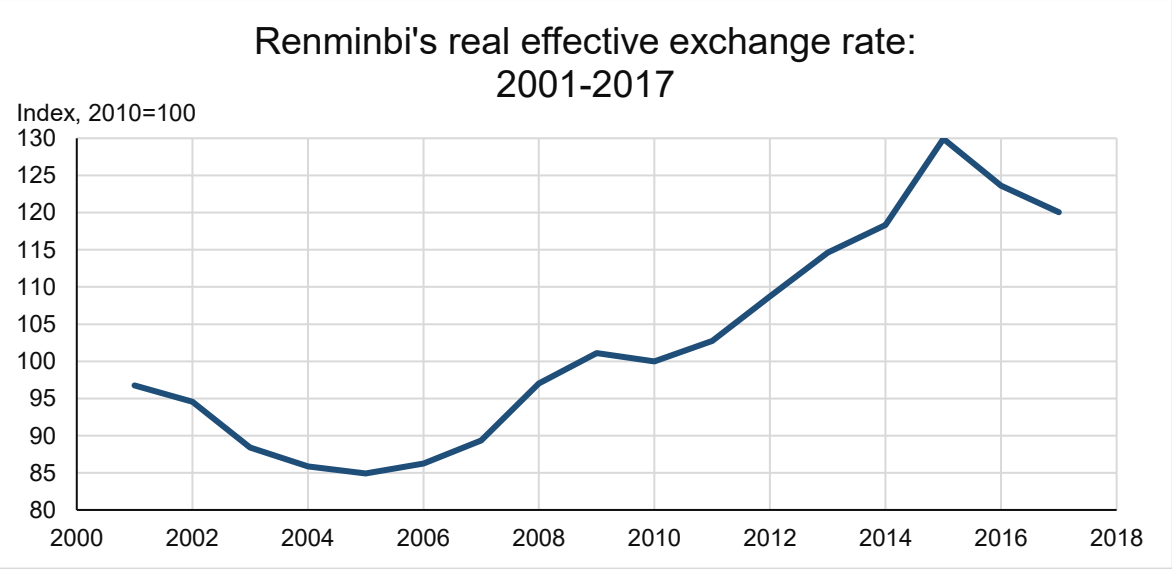


Source: the World Bank Open Data.

Thirdly, the movement of the real effective exchange rate (REER) also could be used to judge one currency's position. According to the Balassa-Samuelson effect, if a country's productivity growth is faster than the rest of the world, its currency's real effective exchange

rate should be likely to show appreciation. In China's case, as the country has been witnessing a period of huge productivity growth during the past decades, the REER of Renminbi should experience continuous appreciation. Figure 3.4 shows this exact appreciating trend for Renminbi despite some short periods like 2001-2005 and 2015-2017. Economists like Coudert & Couharde (2005) have suspected the existence of undervaluation in Renminbi during the period 2001-2005. For the most recent depreciation of Renminbi's REER, Gagnon (2018) attributes it partly to a reversion of the sharp upward spike in 2014-2015, partly to the reduction of China's barriers to imports of goods and service. However, the actual relationship between the trend of appreciation of the REER of Renminbi and China's improving productivity growth still needs further detailed research.

Figure 3.4: Real effective exchange rate of Renminbi



Source: the Word Bank Open Data.

From all these indicators, we could only conclude that the Renminbi was suspected of undervaluation much more during the 2000s than the 2010s. These indicators alone are not sufficient and appropriate to claim that the Renminbi was undervalued or overvalued during some time period. It is necessary to use more complicated and theoretically sound approaches or models to make a conclusion.

4: Overview of Methodologies

There is no consensus among economists on what equilibrium exchange rates exactly mean, especially when the time frame of research interests differ. To state one extreme strand, economists like Beryl Sprinkel, the former chairman of the U.S. Council of Economic Advisers, asserted that there is no difference exists between equilibrium exchange rate and the actual rate which is cleared by the market in real time. The statement itself actually refutes the very existence of any forms of misalignment among currencies (Krugman, 1990). While, when examining the 'equilibrium value' of currency, most economists do not rely on this definition of market-led nominal rates. What they truly interested in is mostly the equilibrium value that is consistent with the nation's fundamental factors such as price level, potential output, and government policies. Any misalignment from that equilibrium value could cause distortions in economic performance and development.

The word "equilibrium" has different economic meanings in all short, medium and long-run models. Citing the discussion of Clark and MacDonald (1997), the equilibrium exchange rate of a currency can be illustrated as the following relationship:

$$e_t = \beta' Z_t + \theta' T_t + \varepsilon_t$$

Where e_t represents the exchange rate at time t; Z_t is the long or medium-run fundamental effects; T_t are the dynamic or transitory effects which can impact the exchange rate in the short term; ε_t is the random disturbance.

The short-run equilibrium is attained when the random disturbance like an asset bubble is excluded from the relationship, and both fundamental elements and transitory effects have their actual value (Driver & Westaway, 2005). Also, according to Williamson (1983), the

short run equilibrium, or by him the current equilibrium exchange rate, is achieved when the market has the full knowledge of the relevant economic values so that it can act rationally toward that. The short-run equilibrium exchange rate can be characterized as:

$$e_t^{ST} = \beta' Z_t + \theta' T_t$$

The medium run equilibrium exchange rate is quite compatible with the definition given by Nurkse (1950), which is achieved when the domestic economy is under both internal and external balance. The internal balance is reached when the country is functioning at their potential capacity, which means there is no output gap, and at the same time, the employment rate is at the NAIRU level (the non-accelerating inflation rate of unemployment). Moreover, all the other countries should also be at their internal balance, which is translated as the external balance condition for the interested economy. However, the external balance does not mean to make the current account of all economies to be zero, as it is almost unrealistic. The balance is reached as long as the flow is sustainable. The following shows the equation of medium-run equilibrium exchange rate:

$$\hat{e}_t = \beta' \hat{Z}_t$$

Where long or medium run economic fundamental factors $\hat{Z}_t$ are at their trend value.

As to long-run equilibrium exchange rates, it is attained when the economy, after a long period of development and time period, reached its stock-flow equilibrium, which means there is no more asset stock change. The definition can be written as:

$$\bar{e}_t = \beta' \bar{Z}_t$$

Where long term economic fundamental factors $\bar{Z}_t$ are at their equilibrium level in the long run.

When it comes to calculating the actual value of equilibrium exchange rates, there is no omnipotent methodology available. Equilibrium value intended for different usages and

purpose has to be dealt with unique and special treatments, especially with the different time frame. As a result, economists have developed a huge variety of methodologies and models with their own advantages and disadvantages, trying to deal with the economic problem.

One of the oldest methodologies which is still being widely used is the purchasing power parity (PPP) approach, first developed by Swedish economist Gustav Cassel in 1918, claims the nominal or real bilateral exchange rate should equal the ratio of national price levels of relevant countries. In the case of absolute PPP the price levels will be equalized (unlike in the case of the relative PPP, where a stable price difference will exist).

The core foundation for the theory of the measure is the law of one price (LOOP), which states identical commodities should have the same price regardless of their location. Although the approach is exposed to criticism for defects of the LOOP in empirical utilization (such as the existence of trade restriction, non-tradability of some goods, and difference in preference of consumers in different location), it is still supported by empirical tests when applied in a very long time period (Taylor & Taylor, 2004). While, at the same time the results can also vary fundamentally when the different national price levels are selected in the study (for example, consumer price indices, producer price indices, wholesale price indices, unit labor cost measures, GDP deflators, and export price indices, etc.).

To overcome the shortcomings of the PPP, the Harrod-Balassa-Samuelson effect (the Balassa-Samuelson effect in short) was introduced in the PPP theory by Bela Balassa (1964) and Paul Samuelson (1964) independently for the purpose of explaining “the Penn effect”, which states that the price of non-tradable goods and services in less developed countries tends to be lower compared with developed ones. The price level in the Balassa-Samuelson effect is composed of the tradable and non-tradable price level, where price levels in tradable sector are same all over the world while the price level of non-tradable sectors depends on the productivity of tradable sector of the country. In the end, according to the theory, the real exchange rates of fast-growing economies tend to appreciate against the

relatively slow ones. The theory is widely used in the study of equilibrium exchange rates but not without its own problem. The theory is shown effective when applied to cross-section data, while its application in time-series data appears not so successful (Isard & Symansky, 1996).

There is no strong evidence in empirical studies that indicates fast-growing economies experience real exchange rates appreciate, especially in the case of China. The link is proved to be very weak (Coudert & Couharde, 2005). Overall, the adjusted PPP approach fails to provide solid explanations for real exchange rates movements of countries.

In the 1980s, there was a considerable amount of methods dedicated to calculating medium to long-run equilibrium exchange rates, under the background of hot debates over the sign of the Plaza Accord and the Louvre Accord by G-7 countries. This proliferation of new methodologies shares a common feature of including important fundamental and macroeconomic factors into models which could have impacts on real exchange rates and were previously neglected by the PPP and its variant versions. These fundamental factors are assumed important in maintaining external and internal balance among economies, whether include short term determinants or not. Among the models, the fundamental equilibrium exchange rate (FEER) and the behavioral equilibrium exchange rate (BEER) are used most frequently on the Chinese case.

The FEER approach, first created by John Williamson in 1983, has been popularized by economists Williamson (1985, 1994), Wren-Lewis (1992), Isard and Faruqee (1998), and Clark et al. (1994). According to this theory, internal balance is defined as the desired output level consistent with a non-accelerating inflation rate of unemployment (NAIRU) and low sustainable inflation rate, while equilibrium external balance requires capital flows which is sustainable or not harmful to world economic development. Compared with other methods, the approach shows its great advantages when utilizing panel-data to analyze the equilibrium exchange rate of a currency, for its ability to incorporate the interdependence of

the world trade. Yet, the model is also criticized for subjective judgment involved in setting target current accounts of interested economies when calculating equilibrium external balance. At the same time, the involvement of subjective judgment also indicates the fact that the FEER is widely consulted in normative applications like government policies. A small variant of the FEER has also been used in literature sometimes, under the name of Desired Equilibrium Exchange Rate (or DEER), which is proposed by economists such as Bayoumi et al. (1994) and Artis and Taylor (1995). Using the concept of optimal fiscal policy, the DEER tries to avoid the normative elements in the FEER approach while less popular among economists.

Another approach widely used is the Behavioral Equilibrium Exchange Rate (BEER), first developed by Macdonald (1997) and Clark and Macdonald (1998). Since the approach is a reduced version of the balance model using only one equation to calculate real equilibrium exchange rates, it is very easy and flexible to apply when compared with the FEER. The underlying theory of the BEER is based on the uncovered interest parity (UIP) without the effect of expected inflation differential. When using econometric tools to estimate real equilibrium exchange rate of the BEER, long to middle run economic fundamentals (mostly terms of trade, the relative price of non-tradable to tradable goods, and net foreign assets) and short-run fundamentals (real interest rate differentials) are both included, and the approach can be applied in calculating equilibrium exchange rates in medium term as well as short term. However, the biggest disadvantage of the BEER approach also exists in its simplicity, that the BEER is a statistical methodology, which results in selecting variables of estimation more or less based on personal interests. In the case of China, the BEER also shows some degree of flaws inherent in the approach itself. As Renminbi has undergone misalignment or more precisely undervaluation in recent decades, the statistical method of the BEER always brings distortion in its result which could not be avoided easily. However, this kind of disadvantage has been partly overcome by using panel data instead of time series since 2006. Like the FEER, there is also a variant for the BEER approach, which is the Permanent Equilibrium Real Exchange Rate (PEER) first created by Clark and

MacDonald (2000). Using empirical tools to divide economic fundamentals from the BEER approach into permanent (non-stationary) and transitory (stationary) components, the PEER approach mainly focuses on the permanent one to estimate equilibrium exchange rates for the purpose of policy analysis.

In 1994, Stein developed a new methodology called Natural Rate of Exchange (NATREX), which could be reached “when speculative and cyclical factors are removed whilst unemployment is at its natural rate” (You & Sarantis, 2012), partly for his effort to capture the nature behind the “mysterious” convergence process of actual exchange rates to its equilibrium value, which is absent in both the BEER and the FEER approach. The NATREX is actually an extension of the PPP and the FEER approach, incorporating short, medium and long term variables. The popular fundamentals (in the NATREX called disturbances to productivity and social thrifts) in estimation include average labor productivity (GDP/employment), the ratio of government expenditure over GDP, and terms of trade.

There are also two approaches dedicated to studying short-run equilibrium exchange rate issues, developed on the framework of the PPP and UIP, namely the Capital-enhanced Equilibrium Exchange Rates (CHEER) developed by Juselius (1991) and the Intermediate-Term Model-based Equilibrium Exchange Rates (ITMEER) developed by Wadhwani (1999). The two approaches share lots of common assumptions with only a slight distinction. The theoretical framework of the CHEER is based on the PPP and the nominal UIP without risk premia, while the theory of the ITMEER is built on assumptions of the nominal UIP including a risk premia and expected future movements in real exchange rates determined by fundamentals (Driver & Westaway, 2013).

In the case of developing countries, one methodology named the Equilibrium Real Exchange Rate (ERER) is used now and then, which was defined by Edwards in 1989 and further developed by Elbadawi (1994), Montiel (1999).

5: Literature Review

The study on the misalignment of Renminbi from its equilibrium exchange rate has experienced different phases in recent decades. The issue was first paid tremendous attention from scholars when China was under great pressure to stop the alleged manipulation of its exchange rate when entering the World Trade Organization (WTO). The debate even accelerated during the first half of the 2000s up until the global financial crisis in 2008, for the reason of China's startling accumulation of foreign reserves and huge current account surplus. However, this passion seems to be fading away from the second half of the 2010s, which could be observed easily from the decreasing number of publications on the topic. These days it seems that only some limited number of authors and institutions like the PIIE (Peterson Institute of International Economics) are still active on the estimation of equilibrium exchange rates of Renminbi. The potential reason could be that the misalignment of Renminbi is not under suspicion of severe undervaluation like in the early 2000s.

Although the economic data released by the Chinese government has been doubted constantly for its authenticity, scholars managed to estimate Renminbi's equilibrium exchange rate using different methodologies and time frame. The study on misalignment was dominated by voices of undervaluation in the 2000s while the magnitude of their results varies a little bit. Things begin to be controversial in recent years for less and less consensus is reached over the misalignment, even on whether Renminbi is undervalued or overvalued. The difference in estimated results could be originated from different choices of methodologies (Cheung et al., 2007), the difference in assumptions underlying estimation methods (Dunaway et al., 2009), or varied definitions of Renminbi's exchange rate, publication types and author's affiliations (Korhonen & Ritola, 2011).

The literature studying the equilibrium exchange rate of Renminbi can be divided into three categories approximately, based on the approach they use. Firstly, the PPP is a popular methodology for its simplicity to apply, and its various versions are still being applied in China's case. The following table 5.1 shows some results from the study which conducted the PPP approach to estimate Renminbi's misalignment.

Table 5.1: Estimates of Undervaluation and Required Appreciation of Renminbi Using PPP Approach

Authors/Notes	Estimated Year	Undervaluation(%)		Required Appreciation (%)	
		REER	USD	REER	USD
Frankel (2004)/B-S	2000		-36		56
Coudert and Couharde (2005)/B-S,C	2003		-33 to -29		41 to 50
Chang and Qin (2004)/S	2003		-22.5		29
Bosworth (2004)/S,T	2004		-40		67
Wang (2004)/B-S	2004	-5		5	
Subramanian (2010)/ICP 2005, B-S	2005		-30		43
Cheung, Chinn and Fujii (2007)/B-S	2007		-50		100
Almas et al. (2017)/ICP 2011,B-S	2011		-8 to 0		0 to 9

Note: REER: Real Effect Exchange Rate; B-S: with Balassa-Samuelson effect; S: simple PPP without Balassa-Samuelson effect; ICP: International Comparison Programme (World Bank); T: time series; C: cross section; The minus sign means undervaluation. "Undervaluation" of X% needs "Required Appreciation" of 100*[1/(1-0.01*X)-1].
Source: Acquired from Cardoso and Duarte (2017) with specific adaption.

Apart from the study on Table 5.1, there are lots of authors conducted panel studies using the modified PPP approaches. Zhang and Chen (2014) used ratio model, a deviation of the PPP with Balassa effect, to estimate Renminbi's misalignment in the time frame of 1980-2012. The result shows that Renminbi was overvalued all these three decades, with a declining trend from 91.1% in 1980 to 20.5% in 2012. Another study from Cheung et al. (2017) estimated Renminbi's misalignment in the year 2005, 2009, 2011 and 2014, using non-linear Penn effect model. Its overall conclusion is that Renminbi was fairly valued by 2011, while undervalued in 2005 and overvalued in 2014. In the study of Garroway et al.

(2012), two versions of the PPP were used on Renminbi in the time frame of 1990-2007, one from WDI (World Development Indicators of ICP 2005) and another from PWT 6.3 (Penn World Tables). Its conclusion is that, when using WDI, Renminbi was undervalued in 1990-1991, 1994-1998, 2003-2007; when using PWT 6.3, Renminbi was undervalued in all years.

Secondly, there are also great amounts of studies utilizing the Behavioral Equilibrium Exchange Rate (BEER) approach. Table 5.2 summarizes results from these studies.

Table 5.2: Estimates of Undervaluation and Required Appreciation of Renminbi Using BEER Approach

Authors/Notes	Estimated Year	Undervaluation(%)		Required Appreciation (%)	
		REER	USD	REER	USD
Bénassy-Quéré et al. (2004)	2001	-14	-31 to -29	16	41 to 44
Coudert and Couharde (2005)	2002		-18		22
Funke and Rahn (2005)/T	2002	-6 to -3	-11	3 to 6	12
Wren-Lewis (2004)	2002		-18 to -16		19 to 22
Wang (2004)/T	2003	0		0	
Bénassy-Quéré (2006)	2004	-31 to -24	-37 to -23	31 to 45	30 to 59
Cheung et al. (2009)/P	2005	-50 to 0		0 to 100	
Macdonald and Dias (2007)	2007	-30 to -7		8 to 42	
Stolper and Fuentes (2007)	2007		-7		7
Reisen (2009)/C	2008	-12		14	

Note: REER: Real Effect Exchange Rate; T: time series; P: panel data; C: cross section; The minus sign means undervaluation. “Undervaluation” of X% needs “Required Appreciation” of 100*[1/(1-0.01*X)-1].
Source: Acquired from Cardoso and Duarte (2017) with specific adaption.

As to the BEER, Zhang and Chen (2014) have contributed to the study of Renminbi’s equilibrium value in the period of 1980-2012. Their estimation concludes that Renminbi was overvalued at 39.4% in 1980 and had been continuously depreciating until its point at

overvaluation of 2.9% in 1990. Then, Renminbi began to be undervalued from -2.1% in 1991 all the way to its peak at -31.4% in 2005. From 2011, the currency was overvalued again at 8.8% in 2011 and 11.4% in 2012.

Thirdly, the FEER has been another popular approach widely used in China's case. Table 5.3 shows the corresponding results from various publications while the list is not exhaustive.

Table 5.3: Estimates of Undervaluation and Required Appreciation of Renminbi Using FEER Approach

Authors/Notes	Estimated Year	Undervaluation(%)		Required Appreciation (%)	
		REER	USD	REER	USD
Jeong and Mazier (2003)	2000	-33	-38	49	60
Wang (2004)/T	2003	-5 to 0		0 to 5	
Coudert and Couharde (2005)/P	2003	-23	-35 to -31	30	44 to 54
Wren-Lewis (2004)	2003		-18 to -16		19 to 22
Goldstein (2004)/T	2004	-30 to -15		18 to 43	
Goldstein and Lardy (2006)	2004	-26 to -17		20 to 35	
Cline (2005)	2005	-17	-31	21	45
Anderson (2006)	2006		-20 to -15		18 to 25
Cline (2007)	2007	-15 to -10	-28 to -25	11 to 18	34 to 39
Goldstein & Lardy (2007)	2007	-38 to -26		35 to 60	
Stolper & Fuentes (2007)	2007		-13		15
Cline & Williamson (2009)	2009	-20		25	

Note: REER: Real Effect Exchange Rate; T: time series; P: panel data; The minus sign means undervaluation.
"Undervaluation" of X% needs "Required Appreciation" of 100*[1/(1-0.01*X)-1].
Source: Acquired from Cardoso and Duarte (2017) with specific adaption.

Some authors also used other methodologies different from the above three in estimating Renminbi's misalignment. For example, Agya & Jun (2015) used the NATREX model to

study misalignment of yuan against American Dollar in the period of 1980-2014. What they found out is that Renminbi was relatively within its equilibrium value all these years except some short period like 1993-1994. The newest article (until February 2019) on Renminbi's equilibrium exchange rate is by Giannellis & Koukouritakis (2018), who used the balance of payment approach to estimate equilibrium value against the dollar in 1991-2016. In its result, Renminbi was slightly overvalued in periods 1991-1993, 1997-2002, and 2015-2016, while was undervalued in periods 1994-1996 and 2004-2013. According to Hall et al. (2013), Renminbi was undervalued persistently in 2000-2009, with the undervaluation peaking at about 20% in 2004 and 2007. Gan et al. (2013) also found out that RMB was undervalued in 2004-2007 using Equilibrium Real Exchange Rate (ERER) approach. Again, in the article of You and Sarantis (2012), the authors used an extended NATREX model to study Renminbi's equilibrium exchange rate against the basket of 14 currencies in the period of 1982-2010. What they found is that RMB was overvalued in 1982-1985 as well as 1997-2003, while undervalued in the rest of the years.

6: Introduction to the FEER Concept

When defining the concept of the Fundamental Equilibrium Exchange Rate, its creator Williamson (1994) used the following words: it is " the exchange rate that is consistent with macroeconomic balance, meaning the simultaneous achievement of internal and external balance". The definition, although gives a general 'direction', is far from a crystal-clear recipe how to apply the FEER in actual research. This chapter will be dedicated to explaining the details further on the methodology and corresponding concepts.

Firstly, the most important thing of the FEER is that, by the definition of Williamson (1983, 1994), it is a real effective exchange rate. By real, it is meant that the FEER is only sensitive to economic factors in inflation-adjusted terms and shows indifference to the monetary policy as well as short-term shocks. By effective, it is meant that the FEER is a multilateral trade-weighted exchange rate, and a change in one of its bilateral exchange rate could not guarantee changes in the FEER (Williamson, 1991). Furthermore, the word "fundamental" in its name indicates that it "abstracts from short-term factors and emphasizes instead determinants that are important over the medium term" (Clark & MacDonald, 1998).

In a book written by Wren-Lewis and Driver (1998), two defining characteristics that distinguish the FEER are listed. First, "FEERs are medium-term construct". The medium-term equilibrium is a flow equilibrium that does not require unchanging asset stocks and "is associated with a current account (or target current account) that is not need to be zero". Second, most works on FEERs share the assumption that "aggregate trade flows depend on the real exchange rate through competitiveness effect". More specifically, what it illustrates is that "if changes in the real exchange rate are to have a finite influence on aggregate trade, then the equilibrium exchange rate becomes a variable that can potentially be influenced by the equilibrium value of any other macroeconomic quantity" (Wren-Lewis &

Driver, 1998). These two characteristics will provide the theoretical base for my whole estimation in this paper.

As to the two balances, the internal balance is given as a condition after the “acceptance of the historically determined wage rate and achievement of a level of effective demand such as to sustain the highest level of activity consistent with the control of inflation” (Williamson, 1994); the external balance is defined as a desired external position “in terms of a current account target rather than overall balance. A minimum criterion is to require that the current account outcome is sustainable. This rules out the possibility of very large current account deficits financed by massive inflows attracted by exceptionally high interest rates” (Williamson, 1994). Or make it easier, internal balance is reached when the economy produces at its potential output level, and external balance is kept as long as the “the balance of payments is in a sustainable position over a medium-term horizon, ensuring external debt sustainability” (Egert, 2004).

When it comes to calculating the actual number of FEERs, Egert (2004) suggested that there are two operational questions should be addressed at first. One is associated with deciding the potential output level of economies (the internal balance), and the other is about deciding the sustainable current accounts (the external balance) for countries to assure. For the first problem, there are two solutions available most often: either using pure statistical tools like the Hodrick-Prescott (HP) filter or the Beveridge-Nelson decomposition to decompose historical data of real GDP growth into trend and cyclical components, in which the trend value represents the corresponding potential output level; or using the production function model which is based on economic theory to estimate the potential output level. Although the statistical approach is much easier to apply, there are no supporting economic meanings in it. For the production function approach, sometimes the availability of relevant data poses the biggest problem. As to the second problem, determining the target current account, there are also two methods used regularly by different economists: either by depending on theories like the intertemporal model, the debt stages theory or the life-cycle

hypothesis to decide the appropriate current account target (Jovanovik, 2007); or viewing the current account " in terms of saving-investment balance ($CA = S - I$)" (Egert, 2004) to estimate it with appropriate econometrics models, using explanatory variables such as dependency ratio, net foreign asset position, the openness index, and general government balance as a percentage of GDP.

Regarding the calculation of FEERs, there are mainly two kinds of approaches exist in the literature. One is the general equilibrium model that takes both internal and external balance into its consideration, which is a complete macroeconomic model of an economy. Papers written in this group includes Willaimson (1983), Coudert and Couharde (2002), and Jeong and Mazier (2003a, 2003b). The general equilibrium models, although have the advantages of consistency and completeness, and taking into accounts the feedback effects and hysteresis effects, also draws criticism for its lack of transparency (the impacts of individual factor on FEERs cannot be distinguished and studied easily) and difficulties in building proper macro-econometric models (Wren-Lewis & Driver, 1998).

The second approach is called the partial equilibrium model, which is used in papers such as Costa (1998), Genorio and Kozamernik (2004), and Cline (2008). The partial equilibrium model, for simplicity, only deals with the foreign trade of an economy to calculate equilibrium exchange rates, which makes it much easier to apply. While, it is also criticized for its oversimplification and failure to incorporating feedback effects of real exchange rate on output level.

In this paper, I will use the multinational model proposed by Jeong and Mazier (2003a, 2003b) to calculate the FEER of Chinese currency. The model is built on both internal and external balance, and have the advantage of calculating equilibrium exchange rates at the world equilibrium level. The following several chapters will dig into details of the model.

7: Multinational Model- to Calculate the FEERs

7.1. The Trade Equations

The model to calculate the FEER of Renminbi in this paper is mainly based on the multinational approach used in the papers Jeong & Mazier (2003a, 2003b), Jeong et al. (2010), and Aflouk et al. (2010). It includes equations representing China's trade structure as well as its main trade partners': the United States, Japan, South Korea, and the Euro area. In addition, the indicator of the rest of the world is also included to guarantee the equilibrium at the world level. The equations of the approach could be written as follows:

Foreign trade volume equations:

Export volume equations

$$X_i = X_{0i} DM_i^{\eta x_i} COMPX^{\varepsilon x_i}$$

$$DM_i = \prod_{j \neq i} M_j^{\alpha_{ij}}$$

$$COMPX_i = (PMX_i / PX_i)$$

Import volume equations

$$M_i = M_{0i} DI_i^{\eta m_i} (PD_i / PM_i)^{\varepsilon m_i}$$

with $i = \{1 = \text{Japan}, 2 = \text{South Korea}, 3 = \text{China}, 4 = \text{United States}, 5 = \text{Euro zone}\}$.

World trade equilibrium in value and in volume:

Equilibrium in volume

$$\prod_i X_i^{wx_i} = \prod_i M_i^{wm_i}$$

Equilibrium in value

$$\prod_i (PX_i X_i / E_i)^{vx_i} = \prod_i (PM_i M_i / E_i)^{vm_i}$$

with $i = \{1 \sim 6, 6 = \text{rest of the world}\}$.

Price equations:

Export price equations $PX_i = PMX_i^{\alpha x_i} P_i^{1-\alpha x_i}$

$$PMX_i = \prod_{j \neq i} (E_i PX_j / E_j)^{\lambda_{ij}}$$

Import price equations $PM_i = PMM_i^{\alpha m_i} PD_i^{1-\alpha m_i}$

$$PMM_i = \prod_{j \neq i} (E_i PX_j / E_j)^{\mu_{ij}}$$

Consumer price equations $PD_i = PM_i^{a_i} P_i^{1-a_i}$

Real effective exchange rates $R_i = \prod_{j \neq i} [(PD_j / E_j)^{\nu_{ij}} / (PD_i / E_i)]$

with $i = \{1 \sim 6, 6 = \text{rest of the world}\}$.

Current account:

Current account equations $B_i = PX_i X_i - PM_i M_i - i_i E_i F_i$

$$B_{res} = -\sum_{i=1}^{5} B_i$$

with $i = \{1 = \text{Japan}, 2 = \text{South Korea}, 3 = \text{China}, 4 = \text{United States}, 5 = \text{Euro zone}\}$.

The definition of variables appeared in the above equations is as follows: X, exports in volume; DM, world demand in volume; DI, internal demand in volume; $COMPX$, export price competitiveness; PX, export prices; PMX, world export prices; M, imports in volume; PM, import prices; PMM, world import prices; PD, consumer prices; P, producer prices; E, nominal bilateral exchange rate compared with the American dollar, and as a result, when $E_4 = 1$, the relationship (1$= E_1 Japanese Yen= E_2 Korean Won= E_3 Chinese Yuan= E_5 Euro= E_6 Imagined monetary unit of the rest of the world) holds; R, real effective exchange rates; B, current account; i, interest rates; F, net external position in US dollars. The consumer price equation is included in consideration of the feedback effect between consumer prices and import prices.

The weights in equations of the world trade equilibrium in volume and in value wx_i , wm_i , vx_i and vm_i represent the shares of the country or region i in the world exports in volume, the world imports in volume, the world exports in value and the world imports in value respectively (Jeong & Mazier, 2003b). Their method of calculating and values are available in Appendix A.

The weights of the real effective exchange rate (v_{ij}) are taken to be equal to the share of the imports and exports of trade partner j in the total trade (import and export) of country i ; the weights of the world import price (μ_{ij}) equals the share of the import of country i from country j in the total import of country i ; the weights of the world export price (λ_{ij}) are the share of the "importance" of competitor j on third markets; the weights in the world demand volume equation (α_{ij}) are taken to be equal to the shares of country j 's import from country in the total export of country i . Their actual method of calculating and corresponding values are available in Appendix B.

For the sake of simplification, we would follow the methodology of Jeong & Mazier (2003b), using logarithmic differentials of the above trade equations to calculate the FEERs of each country or area. The logarithmic differential form of a variable is represented by its lowercase. For example, $e = dE / E = (E - E^e) / E^e$ for the bilateral exchange rates, and $x = dX / X = (X - X^e) / X^e$ for the export volume. The e in the upper right-hand of the variables refers to the equilibrium value of the corresponding variable. All the trade equations are transformed into the following form (Jeong&Mazier, 2003b):

$$x_i = \eta_{xi} \sum \alpha_{ij} m_j + \varepsilon_{xi}(pmx_i - px_i)$$

$$pmx_i = \sum \lambda_{ij}[(px_j - e_j) + e_i]$$

$$m_i = \eta_{mi} di_i + \alpha_{mi}\varepsilon_{mi}(pd_i - pmm_i)$$

$$pmm_i = \sum \mu_{ij}[(px_j - e_j) + e_i]$$

$$\sum wx_i * (x_i + px_i - e_i) = \sum wm_i * (m_i + pm_i - e_i)$$

$$\sum vx_i * x_i = \sum vm_i * m_i$$

$$px_i = \alpha_{xi} pmx_i + (1 - \alpha_{xi}) p_i$$

$$pm_i = \alpha_{mi} pmm_i + (1 - \alpha_{mi}) pd_i$$

$$pd_i = a_i pm_i + (1 - a_i) p_i$$

$$r_i = e_i - pd_i + \sum v_{ij}(pd_j - e_j)$$

However, there is one exception in the meaning of lowercase, that is of the variable current account (B), defined as follows:

$$b_i \equiv B_i / P_i Y_i - B_i^e / P_i^e Y_i^e = d(B_i / P_i Y_i) = \mu_i d(B_i / PM_i M_i)$$

$$= \mu_i d(PX_i X_i - PM_i M_i - i_i E_i F_i) / PM_i M_i) = \mu_i dT_i - \mu_i d(i_i E_i F_i / PM_i M_i)$$

$$= \mu_i dT_i - \mu_i (i_i E_i F_i / PM_i M_i)(e_i - pm_i - m_i)$$

$$= \mu_i T_i (px_i + x_i - pm_i - m_i) - \mu_i T_i \sigma_{xi}(e_i - pm_i - m_i)$$

Where $T_i = PX_i X_i / PM_i M_i =$ terms of trade (ratio of value of exports to value of imports); $\mu_i = PM_i M_i / P_i Y_i =$ degree of openness; $F_i =$ net external position in US dollars; $i_i =$ interest rates; $\sigma_{xi} = i_i E_i F_i / PX_i X_i =$ ratio of external debt services to exports, (Jeong and Mazier, 2003). The terms of trade, degree of openness and ratio of external debt services to exports

are all calculated exogenously, using the data from the World Bank database. Among them, the ratio of external debt services to exports is represented by the net primary income of the country for easy availability of data, while its value should be turned into its opposite by multiplying with -1.

In this paper, the two equations of the world trade equilibrium in volume and in value are changed into more appropriate geometric form than the old arithmetic ones used in Jeong & Mazier (2003a, 2003b). In the original papers, it is written as following forms which are not changeable into the logarithmic differential form:

Equilibrium in volume $\sum_i X_i = \sum_i M_i$

Equilibrium in value $\sum_i PX_i X_i / E_i = \sum_i PM_i M_i / E_i$

The FEER in the multinational model is obtained when internal and external equilibrium are achieved simultaneously. In the model, the misalignment from internal equilibrium level is represented by di_i, the logarithmic differential form of internal demand in volume, and the misalignment of external equilibrium is represented by b_i (percentage of GDP). The two variables are exogenous in the multinational model, which means their value should be acquired beyond the trade structure equations. In this paper, different methods are tried in estimating the values of the two variables.

The multinational model has 35 endogenous variables (x_i, m_i, px_i, pm_i, pd_i for six countries and region; five bilateral exchange rates e_i) with 35 equations (the equations of x_i, m_i, b_i for five countries without the rest of the world; the equations of px_i, pm_i, pd_i for six countries and region; two equations of world trade equilibrium). The producer price P_i is assumed to be at its equilibrium level in medium term, which means the value of the

lowercase p_i equals to zero. Since all the equations are already turned into linear differential logarithmic forms, it is easy to calculate the required variables by simply using the 35*35 Matrix methodology, as follows:

$$M = \begin{bmatrix} 0 & \eta x1 * \alpha 12 & \eta x1 * \alpha 13 & \dots \\ \eta x2 * \alpha 21 & 0 & \eta x2 * \alpha 23 & \dots \\ \eta x3 * \alpha 31 & \eta x3 * \alpha 32 & 0 & \dots \\ \dots & \dots & \dots & \ddots \end{bmatrix}, \quad N = \begin{bmatrix} m1 \\ m2 \\ m3 \\ \vdots \end{bmatrix}, \quad L = \begin{bmatrix} 0 \\ 0 \\ 0 \\ \vdots \end{bmatrix}$$

$$M * N = L,$$

$$N = M^{-1} * L.$$

7.2. The Trade Bloc Elasticity of the Equations

Still, following the methodology of Jeong and Mazier (2003a, 2003b), we will not calculate the trade bloc elasticities of the above equations ourselves. Plenty of existing works could provide us trustworthy options for the six countries and region. Table 7.1 lists these available results and used methodologies.

Table 7.1：trade bloc elasticity of the equations

		ε_x	ε_m	α_x	α_m	η_x	η_m
Japan	MIMOSA	1.26	1.47	0.19	0.56	1.01	1.50
	NIGEM	1.19	0.61	0.24	1.00	1.00	1.69
	Wren-Lewis	1.36	1.16	0.16	0.78	0.91	1.20
	OECD	1.05	0.40	0.28	0.51	1.00	1.00
China	Dees	0.71	1.02	0.56	0.66	0.75	1.04
	Brillet	0.66	0.46	0.85	0.60	1.00	0.98
	OECD	1.50	0.50	1.00	1.00	1.00	1.57
US	MIMOSA	0.91	1.44	0.09	0.50	1.04	1.56
	NIGEM	0.52	0.61	0.00	1.00	1.00	2.52
	Wren-Lewis	0.96	1.35	0.19	0.55	1.12	2.00
	OECD	0.60	0.33	0.07	0.36	1.00	1.00
Euro Area	ECB	0.50	0.81	0.50	0.51	1.00	0.51
	Herve	1.39	0.30	0.75	0.64	1.05	1.06
Korea	Barell	2.2	1.2	1	1	2	1.20
	Kim	1.111	0.102			1.29	1.593
Rest of the World	Jeong&Mazier(Ad hoc)	1.00	1.00	0.50	1.00	1.00	1.00
	Jeong&Mazier	0.58	1.66	0.65	1.02	1.00	1.35

Source: Jeong & Mazier (2003a, 2003b).

In our estimation, we will select the MIMOSA model for Japan, the result of Dees for China, the result of Wren-Lewis for United States, the result of Herve for the Euro area, the result of Barell for South Korea, the result of Jeong and Mazier for the rest of the world.

However, when it comes to the elasticity of import prices in the consumer price equation (a_i), the papers of Jeong & Mazier (2003a, 2003b) never give values or possible sources. To

solve this problem, the estimation result of the elasticity in long run by Herve et al. (2010) is utilized. The results are shown in Table 7.2. Among them, the value of South Korea and China simply take the world average value, as it is not explicitly given by Herve et al. (2010). The value of rest of the world is suggested by Jeong and Mazier (2003a, 2003b).

Table 7.2：import price elasticity

	Japan	Korea	China	the U.S.	the Eurozone	rest of the world
ai	0.15	0.2	0.2	0.08	0.11	0.2

Source: Herve et al. (2010) and Jeong&Mazier(2003a, 2003b).

8: External Equilibrium

The external equilibrium, or the sustainable current account in the medium term, could run at either deficit or surplus level, depending on the actual situation of economies. In the papers, Jeong & Mazier (2003a, 2003b), Jeong et al. (2010), and Aflouk et al. (2010) the current account targets of the five economies in the multinational model (except the rest of the world) are calculated by using panel data econometric model. To state the actual estimation process, for example, in Jeong et al. (2010), the data from 19 industrial countries between 1980-2003 is estimated in the hope for determining the current account targets of the United States, the United Kingdom (replaced Korea in this case), Japan, and the Euro area, and another set of data from 20 emerging countries during the same time period is collected for estimating the current account target of China. The explanatory variables used in the estimation are as follows: initial stock of net foreign assets at the beginning of each period of four years as percent of GDP (expected with positive sign); child dependency ratio, or the population under the age of 15 years old as percent of population aged 15 to 64 years old (expected with negative sign); old dependency ratio, or the population over the age of 65 years old as percent of population aged between 15 to 64 years old (expected with negative sign); output gap in percent of potential GDP (expected with negative sign). With three kinds of specification methods used (the Pooled Ordinary Least Squares, the cross-section specification with country fixed effects and temporal effects), the results of the estimation are all significant and reasonable.

When I apply the similar panel data econometric model on a newer time period (1994-2017) with slightly different country groups to estimate the five economies' (Japan, South Korea, China, the United States, the Eurozone area) target current accounts (or external equilibrium), although the F-test seems to be quite significant, lots of theoretically important variables miss statistical significance, in addition to the troublesome estimation of the target

current account of the United States. The target current account of the U.S. appears to be around 0%, which conflicts with most of the economists' estimation that is around -3% (Ahearne et al., 2007).

As a result, when deciding these target current accounts, I need to turn to another approach which is also widely used (Cline, 2009) (Freund, 2000), that is determining it subjectively after careful considerations of the actual economic situations as well as other influential economists' estimations. Firstly, several theories or hypothesis are available for reference in the process of judgment.

The intertemporal model of saving and investment, developed by Abel & Blanchard (1982), states that in developing countries, investments should show a tendency to surpass savings to boost the lagged-behind economy, which will make the current account deficit more likely to happen. Another theory, the theory of debt stages suggests that developing countries tend to have current account deficit, while the industrialized countries tend to have current account surplus because capitals will flow from abundant places to relatively scarce ones (Jovanovik, 2007). Also, according to the life-cycle hypothesis, as working-age people tend to have higher saving rates, a "young" country is more likely to have current account surplus, while an "aging" country tends to have lower current account position. In addition, the intertemporal model of current account states that the current account can be viewed as a change in the net foreign asset position of a country and large deficits sometimes can be optimal and sustainable as long as the relevant economic agents maximize utility (Obstfeld & Rogoff, 1994).

In this paper, for the sake of simplification, the target current account suggested by Cline and Williamson in their several papers (2009, 2010, 2011, 2012a, 2012b) will be directly used for the relevant five economies (Japan, South Korea, China, the United States, and the Euro area). The following table 8.1 summarizes their results. The target current account is shown as a percentage of GDP.

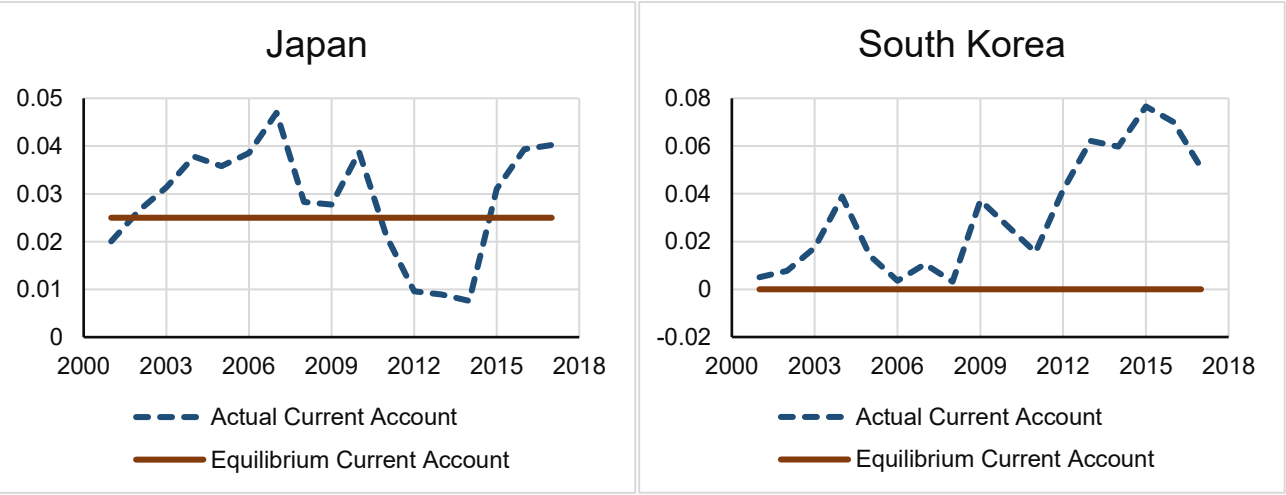
Table 8.1: Results from Cline & Williamson.

Papers	Year	B_1^e	B_2^e	B_3^e	B_4^e	B_5^e
Cline & Williamson (2008)	2009	3.12	-0.04	4.29	-3.03	-0.04
Cline & Williamson (2009)	2012	1.6	2.1	4.2	-2.8	-1.0
Cline & Williamson (2010)	2015	2.0	2.0	3.0	-3.0	0.6
Cline & Williamson (2011)	2016	2.8	0.1	3.0	-3.0	-0.5
Cline & Williamson (2012a)	2017	2.1	1.0	3.0	-3.0	1.2
Cline & Williamson (2012b)	2017	2.3	0.2	3.0	-3.0	1.3

Source: the Peterson Institute of International Economics.

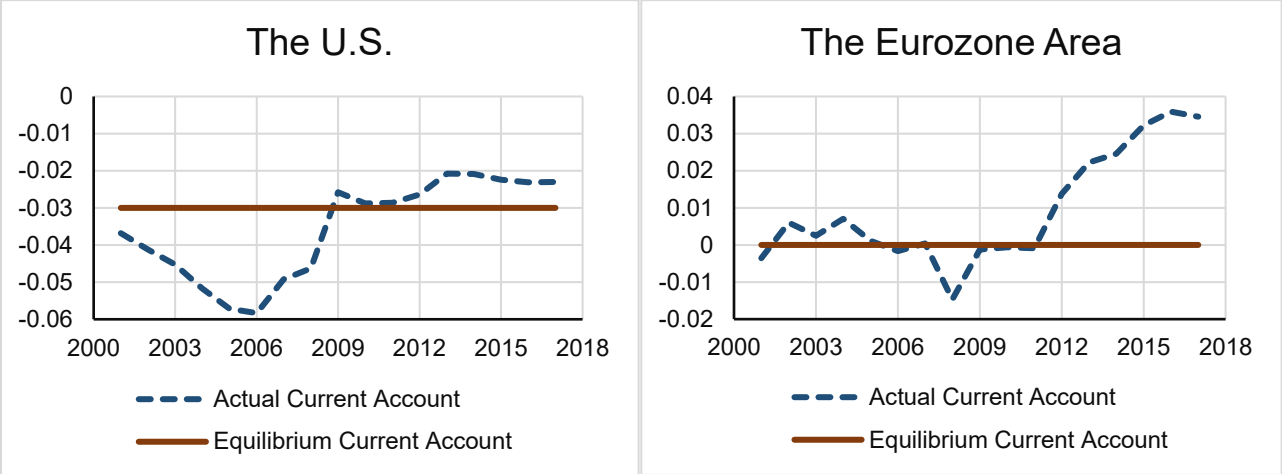
Finally, the target current accounts of the five economies during the time period 2001-2017 are chosen as follows: Japan at +2.5%; South Korea at 0%; China at +3%; the United States at -3%; the Eurozone area at 0%. Figure 8.1, Figure 8.2 and Figure 8.3 shows the five economies' actual current accounts as a percentage of GDP together with their target value all across the year 2001 and 2017.

Figure 8.1: Japan and South Korea's target current account



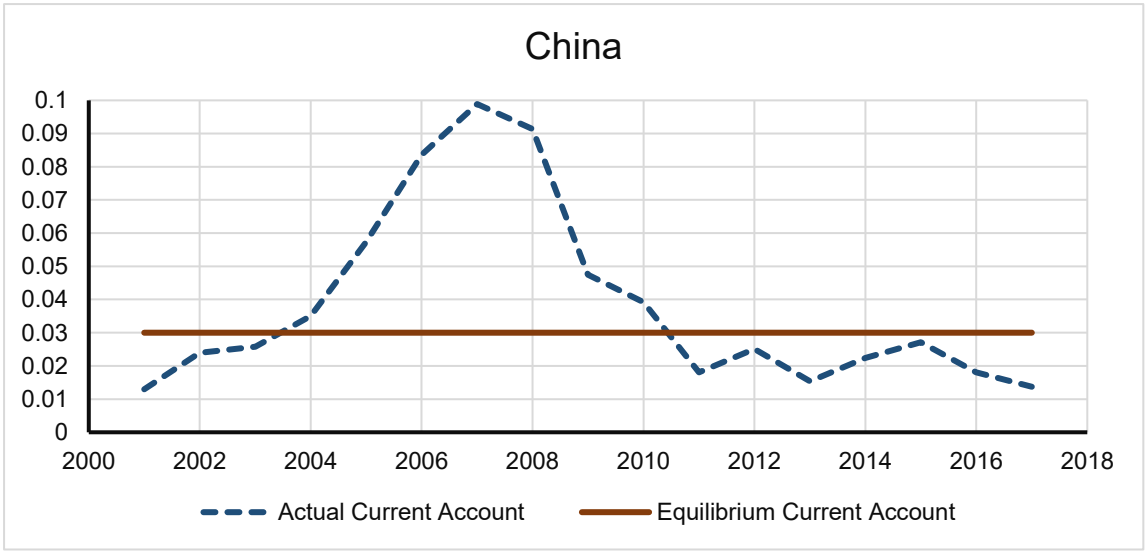
Source: the World Bank Database (2019).

Figure 8.2: The U.S. and the Euro area's target current account



Source: the World Bank Database (2019).

Figure 8.3: China's target current account



Source: the World Bank Database (2019).

9: Internal Equilibrium

The internal equilibrium, by definition in economics, equals the potential output level which is attained when the interested country produces under low unemployment and inflation rate, or in short, under the NAIRU (the non-accelerating inflation rate of unemployment). For the sake of simplification, the paper will directly use the concept and data from the output gap (as a percentage of potential GDP) to represent the misalignment of internal equilibrium or the logarithmic differential form of the internal demand in volume (di).

When calculating the output gap, there are lots of different methods available. While among them, the production function approach stands out as the one theoretically most reliable and meaningful. It uses relevant production factors like employment rate to estimate the potential output level of a country. Unfortunately, as some data in developing countries is almost impossible to access, especially the unemployment rate, the production function approach is only usable in the case of developed countries.

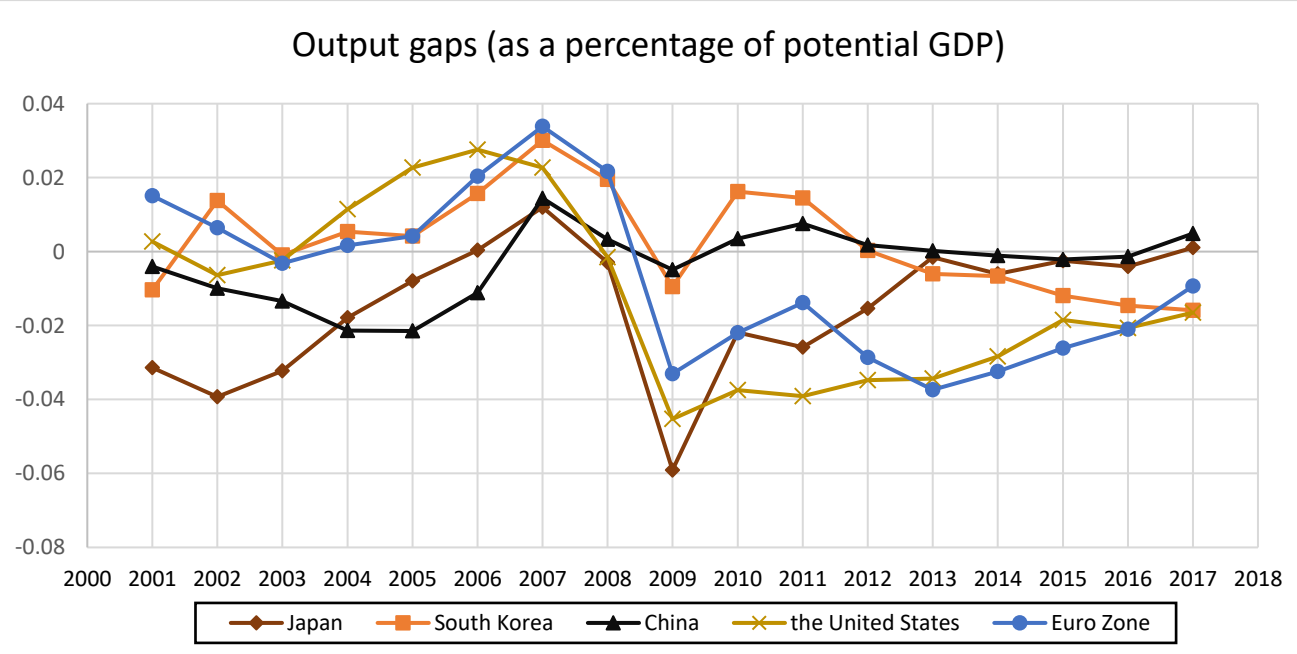
For the four developed economies from the multinational model (Japan, South Korea, the United States, and the Euro area), the OECD has been publishing the data of output gap as a percentage of potential GDP, which is estimated by the production function approach. For China, a much easier methodology is applied to attain the value of the output gap, which is the Hodrick-Prescott filter (the HP filter). However, one should also know that the HP filter is a purely statistical methodology which lacks any economic meaning in it. Besides, as Hamilton (2016) indicates, the HP filter has several drawbacks which prevent it from being a good method to use. “These drawbacks include: (1) The HP filter produces series with spurious dynamic relations that have no basis in the underlying data-generating process; (2) Filtered values at the end of the sample are very different from those in the middle, and are also characterized by spurious dynamics; (3) A statistical formalization of the problem

typically produces values for the smoothing parameter vastly at odds with common practice, e.g., a value for λ far below 1600 for quarterly data." (Hamilton, 2016).

We used the HP filter on real gross domestic product over the period 1995-2017 for estimating China's output gap. China's real GDP data comes from the World Bank database.

The HP filter decomposes an observed variable into trend and cycle components, and in the process, the selection of the smoothness penalty λ has the deciding power (Hamilton, 2016). When utilizing the HP filter to decompose the annual data, there is a huge ambiguity on the selection of the value of λ. Its creators Hodrick and Prescott (1997) recommended λ=100, while McMorrow and Roeger (2001) suggested λ=10, and Ravn and Uhlig (2001) set it at λ=6.25. A series of experiments with different λ values (2, 5, 10, 15 and 100) were carried out (with Chile and Mexico's data) and the results were compared with the output gap data of only two developing countries (Chile and Mexico) provided by the OECD. Finally, the λ of China is decided at 15. The following figure 9.1 displays the output gap data of five economies from the multinational model between the year 2001 and 2017.

Figure 9.1: Internal equilibrium of the economies



Source: the OECD and author's estimation.

During the early 2000s, the Japanese economy has experienced a lasting period of recession triggered by the earlier Asian Financial Crisis up until around 2006, when there was a sign of recovery, while the trend was disrupted by the Global Financial Crisis again in 2008. The Japanese economy has recovered to its equilibrium level around 2013. The South Korean economy knew a quite long expansion period in the 2000s despite a small recession in 2009. However, from about 2012, the country saw a lasting recession until 2017. For China, in the early 2000s, the country's economy has contracted for several years until 2007. Since 2012, the economy seems to be at its equilibrium level.

During all these seventeen years, the United States and the Eurozone area have shared some degree of similar periods. Despite a small recession in 2002 and 2003 that may be caused by the dot com bubble, both economies showed expansions before the Financial Crisis in 2008. After the crisis, although experiencing continuous improvement, the two still have not reached their potential level.

10: Estimation of the FEERs

With the internal and external balance estimated in previous chapters, the actual calculation of the misalignment of the currencies could be conducted, both of the nominal bilateral exchange rates against the U.S. dollar (e_i) and the real effective exchange rates (r_i). The result is shown in Table 10.1. The minus sign means that the currency is overvalued in the period and the plus sign means the opposite situation (undervaluation). From the table, we could see the misalignment in bilateral and real effective terms most of the time have the same sign but of different magnitudes.

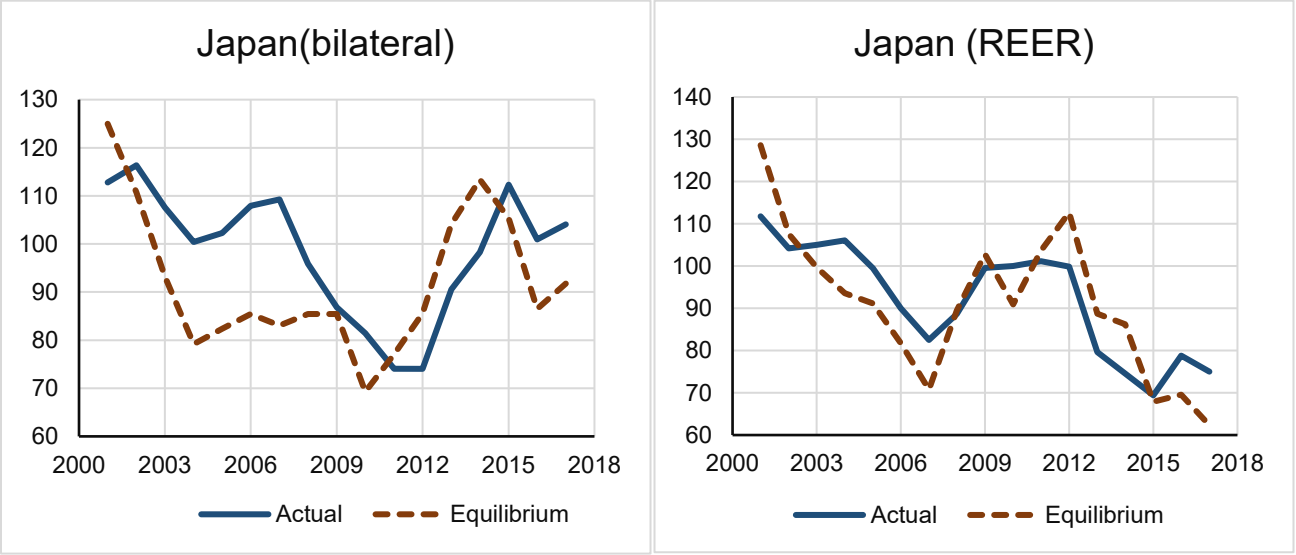
Table 10.1: Estimation results (1=Japan; 2=Korea; 3=China; 4=the United States; 5=the Euro area; 6=rest of the world)

	Nominal bilateral					Real effective					
	e1	e2	e3	e5	e6	r1	r2	r3	r4	r5	r6
2001	-9.8	1.3	-10.7	11.9	10.9	-13.1	-1.5	-13.4	-6.2	5.3	5.5
2002	5.1	12.8	3.8	17.9	12.9	-3.2	3.5	-5.2	-10.9	7.9	2.7
2003	15.4	18.7	8.6	17.3	11.7	5.3	6.9	-2.2	-11.7	7.0	0.6
2004	26.8	30.8	15.3	16.4	12.7	13.3	14.1	1.0	-14.2	4.3	0.0
2005	24.2	22.8	23.8	18.5	15.3	9.1	5.4	8.0	-16.0	4.4	0.7
2006	26.3	20.3	31.7	14.7	15.8	10.1	2.1	15.1	-16.7	-0.1	1.5
2007	31.5	20.2	34.2	-2.5	14.0	16.6	3.1	19.5	-13.8	-15.3	5.5
2008	12.2	15.1	31.6	3.0	14.0	-0.9	0.4	18.5	-12.7	-9.2	5.0
2009	1.6	15.1	15.3	-2.0	2.9	-3.2	8.4	11.0	-3.5	-5.2	0.2
2010	17.6	15.4	12.2	-3.2	7.1	10.0	6.4	5.3	-6.6	-9.4	3.1
2011	-3.9	9.0	4.0	15.6	-9.3	-2.4	8.9	5.4	2.3	19.4	-13.5
2012	-13.4	9.7	4.1	14.0	-7.9	-11.3	9.8	6.0	2.4	17.5	-11.2
2013	-13.0	10.8	-3.8	8.5	-5.2	-10.2	11.5	-1.4	2.7	11.6	-5.9
2014	-13.3	11.0	-2.6	3.9	2.9	-13.5	8.8	-3.7	-1.1	2.4	1.7
2015	6.6	15.5	-2.5	-4.9	10.2	2.2	9.4	-7.5	-4.9	-10.6	9.1
2016	16.7	15.1	-6.4	-3.0	6.4	13.3	10.4	-9.8	-3.3	-6.6	5.9
2017	13.4	7.0	-7.1	7.6	-23.0	20.4	13.5	2.0	10.2	20.4	-20.2

Source: Author's calculation.

The data of actual nominal bilateral exchange rates against the US dollar is from the OECD database, the data of the actual real effective exchange rates of the four countries (Japan, South Korea, China, and the United States) is from the World Bank Database, while the data of actual real effective exchange rate of the Euro area is from the European Central Bank Database (Consumer Price Index-deflated).

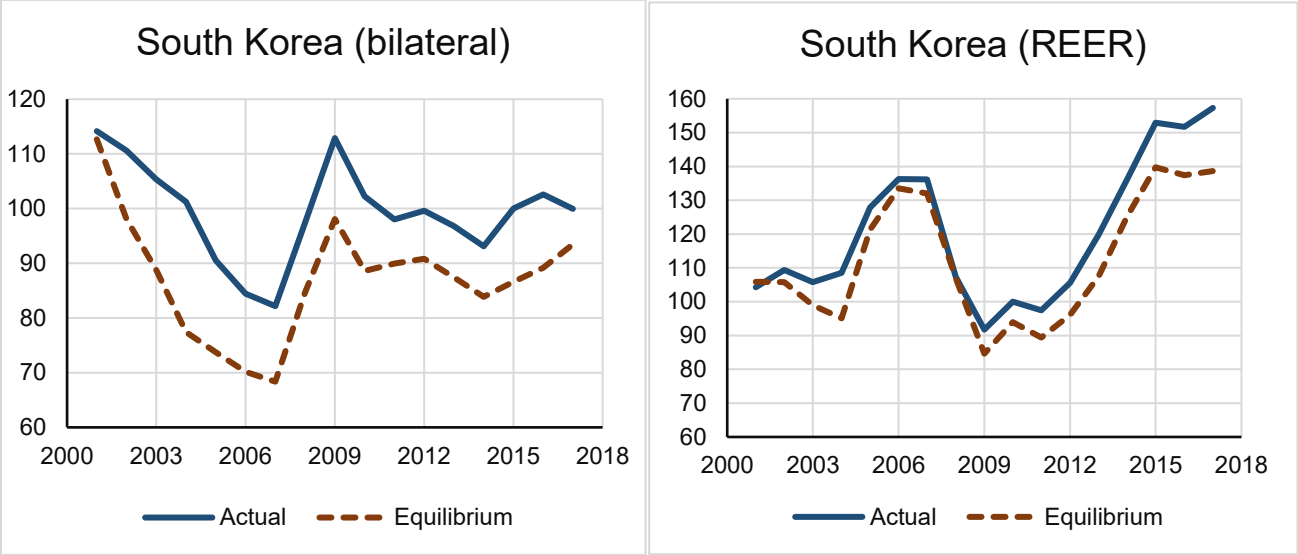
Figure 10.1: Japan's actual exchange rates and equilibrium exchange rates (the bilateral, 2000=100) (the REER, 2010=100).



Source: author's calculation.

Figure 1 shows the calculation results of the Japanese equilibrium exchange rate between 2001 and 2017. As can be seen from the figure, the bilateral exchange rate of the yen against the US dollar was undervalued from 2002 to 2011, and again from 2015 to 2017. Between 2011 and 2015, there was a small period of overvaluation. When it comes to the REER, it has the same situation as the bilateral nominal exchange rate, except for a short period in 2008 and 2009 when the Yen experienced overvaluation. Overall, it seems like the degree of undervaluation of the Japanese Yen, both of the bilateral and the REER, has been deepening in the most recent years.

Figure 10.2: South Korea's actual exchange rates and equilibrium exchange rates (the bilateral, 2000=100) (the REER, 2010=100).

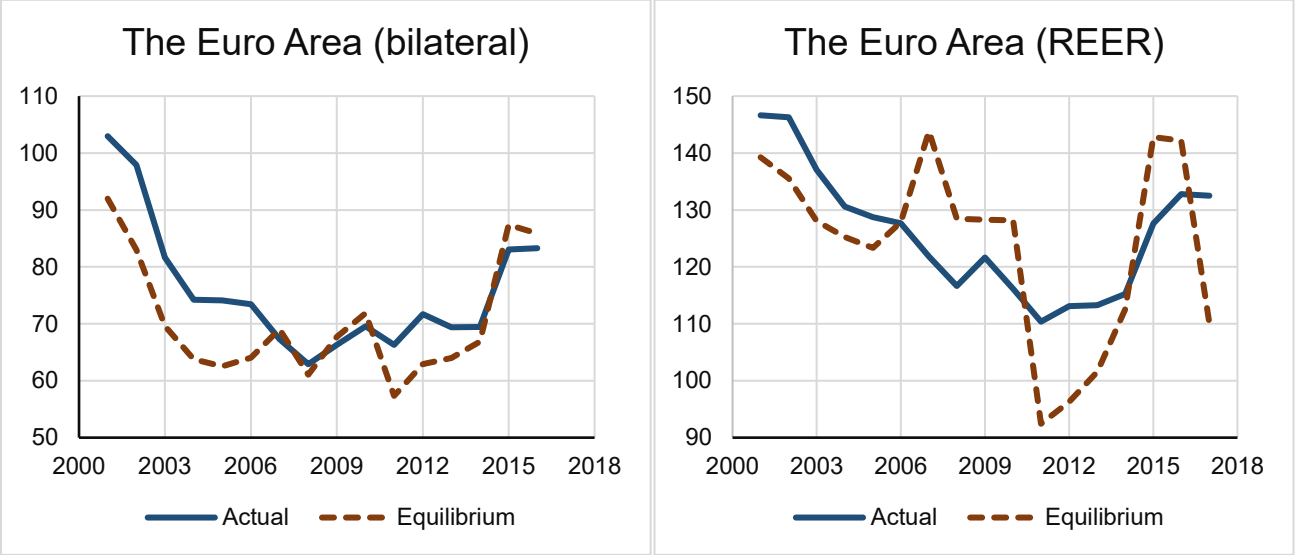


Source: author's calculation.

The situation of South Korean Won is much simpler. As shown in Figure 10.2, the currency has been undervalued all these years except for 2001 when the REER of Won was overvalued slightly. In terms of the REER, the misalignment seems much smaller. Moreover, in the period 2005-2008, the real effective exchange rate was almost equal to its equilibrium value.

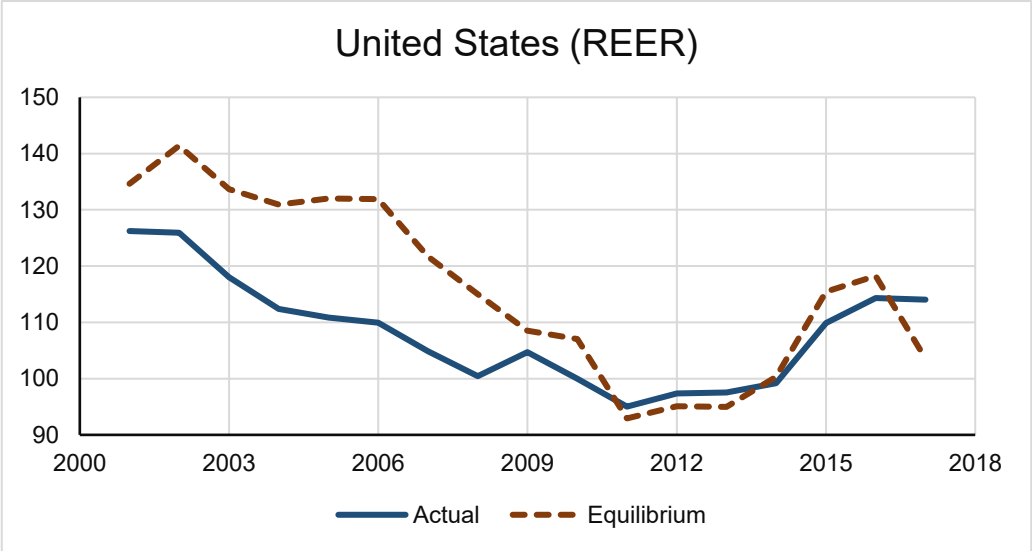
According to Figure 10.3, in 2001-2007 and 2011-2014, the equilibrium exchange rate of the euro against the US dollar had been lower than its actual bilateral exchange rate. In other years, bilateral exchange rates hovered around its equilibrium value. Its equilibrium real effective exchange rate fluctuates greatly. The real effective exchange rate of the euro was undervalued in the years 2001-2005 and 2011-2014 and was overvalued at other times, except in 2006 when the REER was almost equal to its equilibrium value.

Figure 10.3: the Euro area's actual exchange rates and equilibrium exchange rates (the bilateral, 2000=100) (the REER, 2010=100).



Source: author's calculation.

Figure 10.4: the United States' actual and equilibrium REER (2010=100).

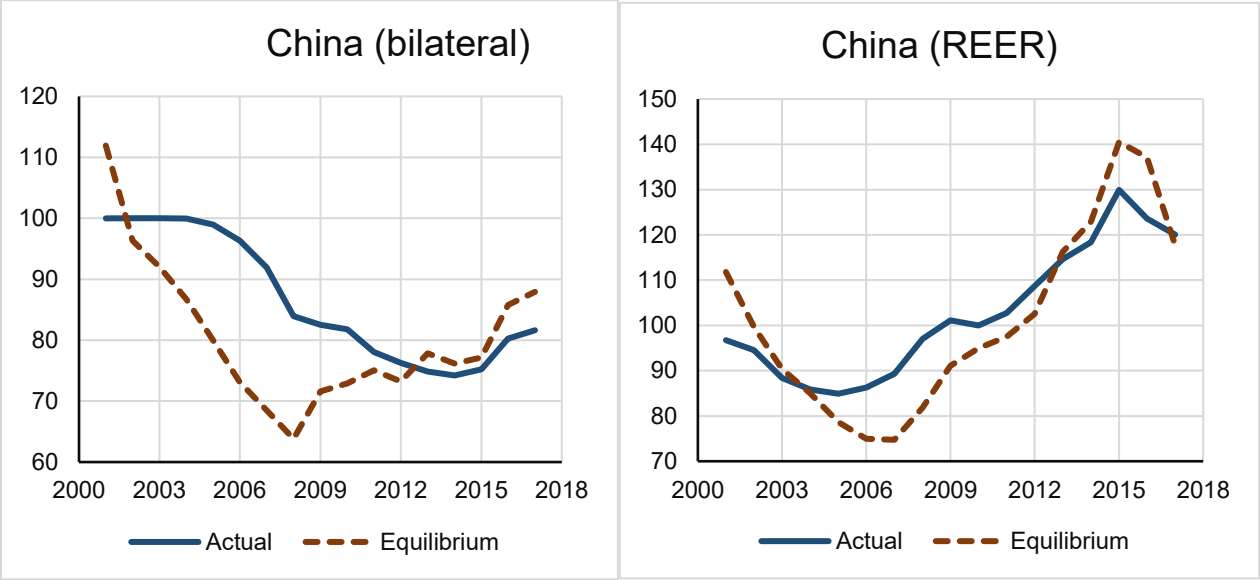


Source: author's calculation.

Since the bilateral exchange rate of the US dollar against the US dollar has no meaning. Here we only have the real effective exchange rate of the US dollar to analyze. As can be seen from Figure 10.4, the situation in the United States is quite special. For a long time from

2001 to 2010, its real effective exchange rate has always been overvalued. Only after that, its exchange rate is considered to be in the vicinity of its equilibrium value.

Figure 10.5: China's actual exchange rates and equilibrium exchange rates (the bilateral, 2000=100) (the REER, 2010=100).



Source: author's calculation.

After overvalued by 10.7% in 2001, the bilateral exchange rate of Renminbi against the US dollar entered a period of undervaluation for quite a long time up until 2013, when the currency began to be overvalued. The biggest undervaluation happened in 2007, the same year when the current account surplus (percentage of GDP) reached its peak. From Figure 10.5, it seems like the degree of overvaluation against the US dollar begins to grow in the last years. As to the REER of Renminbi, it was overvalued in the first three years of the 2000s. Then, the undervaluation continues for 9 years, while with a smaller degree compared with its bilateral exchange rate. The peak of the undervaluation also happened in 2007. From 2013, the currency's REER had been overvalued for several years until it was undervalued slightly again in 2017 with 2%.

11: Conclusion

When this paper was completed in the spring of 2019, there was a trade war ongoing fiercely between the world's two biggest economies, the United States and China (if we do not count the European Union as a single economy). Although the central theme of this time was not of the exchange rate misalignment and current account surplus, studying the equilibrium exchange rate of Renminbi could still bring unique insights into our understanding of the current debate. In addition, this paper somehow has the role of filling the academic gap on the topic in recent years, and hopefully could provoke and stimulate further studies on the similar topic, as it is still far from solutions.

As a master dissertation, this paper is limited in its ambition and focus. Its purpose is not to argue the point whether Renminbi is undervalued or overvalued all these years. Rather, it is mainly to show how one of the most popular methodologies, the Fundamental Equilibrium Exchange Rate, is utilized in the literature on China's case.

The whole study has the following framework: firstly, the history of China's exchange rate regime is mentioned, which is followed by the introduction of some simple indicators available when used as a "sign" of misalignment; then, the overview of methodologies and literature review is touched briefly; in the model part, the detailed introduction of the FEER is conducted together with the actual approach, the multinational approach; finally, the estimation of the FEER of Chinese Renminbi in the time frame 2001-2017 is completed.

The results are overall very satisfactory, consistent with other economists' findings (especially Giannellis & Koukouritakis, 2018) in many cases, and could give explanations to empirical phenomena with economic logic. What is more, the multiregional dimension of the approach gives the calculation results of China's most important trade partners, which is

essential when analyzing the interdependence of the countries' exchange rate policy. When using the model given by Jeong & Mazier (2003a, 2003b), I also made some adjustments to the world trade equilibrium equations in volume and in value to make it more suitable for linear calculations.

The final result shows that the equilibrium exchange rate of Renminbi against the US dollar is probably overvalued in 2001 and during the period 2013-2017, and there is an undervaluation between the year 2002 and 2012. The peaks of overvaluation (around 10.7%) and undervaluation (around 34.2%) are in 2001 and 2007 respectively. As to the equilibrium REER of Renminbi, the peaks appear in the same year as the equilibrium bilateral rate but with a slightly smaller magnitude. The biggest overvaluation is 13.4% in 2001 and the biggest undervaluation is 19.5% around 2007. But unlike the bilateral exchange rate results, the REER of Renminbi is almost in the vicinity of its equilibrium value in 2017.

This study is far from perfect. There are at least three places that can be further improved. First, the target current accounts are based on subjective judgments in this study, so that they are fixed values for all the interested years. A better solution should be the dynamic target current account based on the econometric method proposed in the original model of Jeong & Mazier (2003a, 2003b). Its dynamic characteristics can reflect the actual economic situation of the corresponding country in a given year. Second, when estimating the internal equilibrium of China, a more theoretical based approach should be used instead of purely statistical tools like the HP filter. Third, the trade bloc elasticity used in this study is relatively old and does not reflect well the current foreign trade position of countries. When the study was completed, there was still no better option than the one from original papers (Jeong & Mazier, 2003a and 2003b). If a newer and more complete trade bloc elasticity appears, it will make the study more convincing.

Appendix A: Coefficients of the World Trade Equilibrium Equations.

Table A.1: The shares of the economy i in the world export in value, (1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	VX_1	VX_2	VX_3	VX_4	VX_5	VX_6
2001	0.0574	0.0227	0.0355	0.1338	0.3020	0.4486
2002	0.0563	0.0233	0.0413	0.1245	0.3075	0.4471
2003	0.0554	0.0238	0.0479	0.1113	0.3175	0.4441
2004	0.0550	0.0258	0.0534	0.1039	0.3133	0.4486
2005	0.0515	0.0255	0.0598	0.1012	0.2965	0.4655
2006	0.0484	0.0253	0.0667	0.0993	0.2895	0.4708
2007	0.0457	0.0254	0.0727	0.0963	0.2954	0.4645
2008	0.0445	0.0254	0.0758	0.0933	0.2865	0.4745
2009	0.0412	0.0270	0.0786	0.0999	0.2851	0.4681
2010	0.0453	0.0286	0.0846	0.0978	0.2617	0.4820
2011	0.0409	0.0298	0.0892	0.0937	0.2550	0.4913
2012	0.0395	0.0302	0.0952	0.0962	0.2427	0.4962
2013	0.0350	0.0300	0.1003	0.0970	0.2481	0.4897
2014	0.0356	0.0297	0.1031	0.0994	0.2533	0.4788
2015	0.0363	0.0295	0.1110	0.1064	0.2537	0.4631
2016	0.0382	0.0286	0.1053	0.1060	0.2626	0.4591
2017	0.0359	0.0286	0.1048	0.0992	0.2596	0.4720

Source: author's calculation.

Calculation method:

$$VX_i = \frac{X_i}{X_w}$$

Where X_i is the total export value of the economy i, X_w is the total export value of the world.

The data is from the World Bank Database.

Table A.2: The shares of the economy i in the world import in value, (1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	vm_1	vm_2	vm_3	vm_4	vm_5	vm_6
2001	0.0547	0.0223	0.0236	0.1791	0.2908	0.4295
2002	0.0513	0.0232	0.0266	0.1768	0.2905	0.4316
2003	0.0486	0.0231	0.0444	0.1639	0.2992	0.4207
2004	0.0478	0.0238	0.0493	0.1578	0.2978	0.4234
2005	0.0473	0.0245	0.0509	0.1569	0.2875	0.4329
2006	0.0457	0.0257	0.0537	0.1523	0.2854	0.4373
2007	0.0426	0.0258	0.0563	0.1399	0.2906	0.4448
2008	0.0449	0.0267	0.0590	0.1312	0.2838	0.4545
2009	0.0419	0.0259	0.0668	0.1277	0.2800	0.4577
2010	0.0432	0.0280	0.0754	0.1282	0.2588	0.4664
2011	0.0444	0.0303	0.0837	0.1225	0.2522	0.4669
2012	0.0458	0.0299	0.0877	0.1244	0.2329	0.4793
2013	0.0420	0.0284	0.0932	0.1212	0.2353	0.4799
2014	0.0427	0.0276	0.0965	0.1234	0.2382	0.4715
2015	0.0391	0.0258	0.0968	0.1337	0.2356	0.4691
2016	0.0382	0.0251	0.0962	0.1347	0.2438	0.4620
2017	0.0377	0.0261	0.0997	0.1308	0.2432	0.4625

Source: author's calculation.

Calculation method:

$$\mathrm{vm}_{\mathrm{i}} = \frac{M_{\mathrm{i}}}{M_{\mathrm{w}}}$$

Where M_i is the total import value of the economy i, M_w is the total import value of the world.

The data is from the World Bank Database.

Table A.3: The shares of the economy i in the world export in volume, (1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	wx_1	wx_2	wx_3	wx_4	wx_5	wx_6
2001	0.0605	0.0260	0.0351	0.1300	0.2956	0.4528
2002	0.0625	0.0281	0.0427	0.1233	0.2885	0.4549
2003	0.0656	0.0309	0.0537	0.1203	0.2799	0.4496
2004	0.0684	0.0336	0.0609	0.1200	0.2758	0.4413
2005	0.0690	0.0343	0.0714	0.1218	0.2711	0.4325
2006	0.0706	0.0368	0.0815	0.1231	0.2683	0.4196
2007	0.0717	0.0400	0.0917	0.1235	0.2646	0.4085
2008	0.0740	0.0435	0.1004	0.1281	0.2630	0.3910
2009	0.0619	0.0483	0.0990	0.1281	0.2550	0.4078
2010	0.0699	0.0510	0.1113	0.1281	0.2510	0.3887
2011	0.0672	0.0582	0.1214	0.1299	0.2509	0.3723
2012	0.0652	0.0603	0.1254	0.1307	0.2461	0.3723
2013	0.0628	0.0605	0.1321	0.1315	0.2427	0.3704
2014	0.0662	0.0603	0.1332	0.1332	0.2434	0.3637
2015	0.0661	0.0587	0.1273	0.1321	0.2492	0.3666
2016	0.0659	0.0581	0.1272	0.1302	0.2499	0.3688
2017	0.0643	0.0565	0.1333	0.1262	0.2474	0.3723

Source: author's calculation.

Calculation method:

$$wx_i = \frac{vx_i}{xv_i}$$

Where vx_i is the previous share of the economy i in the world export in value, xv_i is the export unit value index (2000=100). The data is from the World Bank Database.

Table A.4: The shares of the economy i in the world import in volume, (1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	wm_1	wm_2	wm_3	wm_4	wm_5	wm_6
2001	0.0583	0.0238	0.0230	0.1801	0.2866	0.4282
2002	0.0578	0.0258	0.0254	0.1838	0.2761	0.4311
2003	0.0561	0.0264	0.0461	0.1817	0.2642	0.4254
2004	0.0544	0.0262	0.0504	0.1825	0.2574	0.4291
2005	0.0518	0.0251	0.0528	0.1803	0.2505	0.4396
2006	0.0492	0.0258	0.0575	0.1772	0.2473	0.4431
2007	0.0469	0.0261	0.0614	0.1694	0.2435	0.4527
2008	0.0452	0.0262	0.0638	0.1611	0.2366	0.4670
2009	0.0455	0.0276	0.0746	0.1577	0.2357	0.4588
2010	0.0440	0.0276	0.0791	0.1584	0.2269	0.4640
2011	0.0434	0.0292	0.0869	0.1552	0.2194	0.4659
2012	0.0443	0.0292	0.0894	0.1552	0.2081	0.4738
2013	0.0431	0.0288	0.0959	0.1516	0.2045	0.4760
2014	0.0449	0.0285	0.1001	0.1535	0.2063	0.4667
2015	0.0455	0.0292	0.0988	0.1595	0.2125	0.4546
2016	0.0459	0.0291	0.1032	0.1592	0.2163	0.4463
2017	0.0446	0.0294	0.1060	0.1589	0.2114	0.4498

Source: author's calculation.

Calculation method:

$$wm_i = \frac{vm_i}{mv_i}$$

Where vm_i is the previous share of the economy i in the world import in value, mv_i is the import unit value index (2000=100). The data is from the World Bank Database.

Appendix B: Coefficients of the world demand, world export price, competitor import price, and real effective exchange rates equations.

B.1: Calculation method of the coefficients of the world demand equation (a_{ij})

$$a_{ij} = \frac{X_{i\to j}}{X_{w\to j}}$$

Where $X_{i\to j}$ is the export of the economy i to the economy j, $X_{w\to j}$ is the export of the whole world to the economy j. The data is from the World Integrated Trade Solution Database.

Table B.1.1: coefficients of the world demand.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}	a_{21}	a_{23}	a_{24}	a_{25}	a_{26}
2001	0.2233	0.1443	0.1160	0.0608	0.1088	0.0570	0.0846	0.0297	0.0188	0.0430
2002	0.2263	0.1520	0.1103	0.0551	0.1082	0.0526	0.0906	0.0302	0.0195	0.0442
2003	0.2405	0.1588	0.0998	0.0566	0.1078	0.0529	0.0971	0.0292	0.0199	0.0457
2004	0.2442	0.1566	0.0943	0.0551	0.1090	0.0567	0.1054	0.0315	0.0221	0.0487
2005	0.2294	0.1444	0.0893	0.0466	0.1040	0.0546	0.1116	0.0273	0.0232	0.0485
2006	0.2079	0.1386	0.0853	0.0422	0.0952	0.0540	0.1038	0.0251	0.0204	0.0506
2007	0.1952	0.1353	0.0815	0.0421	0.0911	0.0510	0.1015	0.0257	0.0193	0.0505
2008	0.1798	0.1384	0.0731	0.0373	0.0911	0.0483	0.1012	0.0245	0.0182	0.0523
2009	0.1805	0.1263	0.0671	0.0327	0.0846	0.0511	0.0998	0.0266	0.0211	0.0562
2010	0.1800	0.1261	0.0688	0.0332	0.0943	0.0521	0.0986	0.0286	0.0197	0.0589
2011	0.1602	0.1134	0.0640	0.0312	0.0845	0.0605	0.0939	0.0283	0.0182	0.0605
2012	0.1489	0.1000	0.0690	0.0282	0.0802	0.0581	0.0932	0.0286	0.0168	0.0575
2013	0.1365	0.0837	0.0649	0.0250	0.0670	0.0541	0.0943	0.0301	0.0156	0.0557
2014	0.1185	0.0824	0.0602	0.0242	0.0633	0.0502	0.0948	0.0325	0.0156	0.0561
2015	0.1157	0.0810	0.0604	0.0258	0.0630	0.0477	0.1016	0.0335	0.0168	0.0558
2016	0.1284	0.0862	0.0642	0.0288	0.0668	0.0479	0.0942	0.0328	0.0173	0.0550
2017	0.1459	0.0984	0.0655	0.0289	0.0658	0.0572	0.1053	0.0334	0.0186	0.0614

Source: author's calculation.

Table B.1.2: coefficients of the world demand.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	a_{31}	a_{32}	a_{34}	a_{35}	a_{36}	a_{41}	a_{42}	a_{43}	a_{45}	a_{46}
2001	0.1553	0.1105	0.0515	0.0391	0.0762	0.1986	0.1958	0.0893	0.1367	0.3230
2002	0.1684	0.1230	0.0642	0.0446	0.0918	0.1788	0.1788	0.0844	0.1234	0.2940
2003	0.1821	0.1388	0.0787	0.0581	0.1090	0.1594	0.1663	0.0785	0.1129	0.2660
2004	0.1920	0.1535	0.0917	0.0669	0.1235	0.1399	0.1445	0.0729	0.1040	0.2484
2005	0.1910	0.1727	0.1072	0.0800	0.1433	0.1243	0.1356	0.0743	0.0987	0.2489
2006	0.1864	0.1841	0.1182	0.0835	0.1629	0.1214	0.1342	0.0825	0.0943	0.2435
2007	0.1976	0.2027	0.1304	0.0981	0.1801	0.1213	0.1247	0.0808	0.0977	0.2281
2008	0.1987	0.2234	0.1333	0.0988	0.1866	0.1139	0.1052	0.0792	0.0923	0.2238
2009	0.2298	0.2050	0.1557	0.1066	0.2013	0.1201	0.1094	0.0801	0.0993	0.2292
2010	0.2240	0.1985	0.1622	0.1206	0.2199	0.1119	0.1120	0.0776	0.0934	0.2288
2011	0.2261	0.2008	0.1630	0.1182	0.2290	0.1003	0.1052	0.0729	0.0878	0.2279
2012	0.2271	0.2122	0.1711	0.1133	0.2495	0.1048	0.1023	0.0767	0.0904	0.2319
2013	0.2344	0.2203	0.1779	0.1117	0.2671	0.1018	0.1007	0.0787	0.0921	0.2263
2014	0.2325	0.2308	0.1829	0.1188	0.2765	0.1040	0.1023	0.0807	0.0924	0.2278
2015	0.2530	0.2661	0.1960	0.1320	0.2929	0.1165	0.1142	0.0860	0.1065	0.2294
2016	0.2544	0.2602	0.1897	0.1285	0.2777	0.1244	0.1175	0.0875	0.1085	0.2283
2017	0.2929	0.2811	0.2087	0.1353	0.2727	0.1443	0.1323	0.0963	0.1083	0.2233

Source: author's calculation.

Table B.1.3: coefficients of the world demand.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	a_{51}	a_{52}	a_{53}	a_{54}	a_{56}	a_{61}	a_{62}	a_{63}	a_{64}	a_{65}
2001	0.1051	0.0980	0.1029	0.1493	0.4490	0.4839	0.3723	0.5789	0.6535	0.7446
2002	0.1072	0.1031	0.1059	0.1566	0.4617	0.4930	0.3687	0.5671	0.6387	0.7574
2003	0.1075	0.1027	0.1086	0.1587	0.4715	0.4981	0.3517	0.5570	0.6336	0.7524
2004	0.1071	0.0988	0.1066	0.1563	0.4704	0.5043	0.3590	0.5584	0.6262	0.7520
2005	0.0952	0.1006	0.0950	0.1497	0.4554	0.5348	0.3617	0.5748	0.6265	0.7516
2006	0.0873	0.0985	0.1010	0.1456	0.4478	0.5509	0.3752	0.5740	0.6257	0.7597
2007	0.0901	0.0999	0.1020	0.1490	0.4501	0.5400	0.3775	0.5803	0.6134	0.7429
2008	0.0828	0.0899	0.1047	0.1443	0.4462	0.5563	0.4017	0.5766	0.6247	0.7533
2009	0.0934	0.0939	0.1103	0.1503	0.4288	0.5055	0.4113	0.5835	0.6003	0.7403
2010	0.0844	0.0879	0.1069	0.1383	0.3982	0.5275	0.4216	0.5908	0.6022	0.7331
2011	0.0835	0.0901	0.1125	0.1388	0.3981	0.5295	0.4437	0.6073	0.6060	0.7446
2012	0.0859	0.0899	0.1072	0.1404	0.3809	0.5241	0.4466	0.6229	0.5909	0.7513
2013	0.0907	0.0992	0.1045	0.1429	0.3838	0.5189	0.4433	0.6388	0.5842	0.7556
2014	0.0884	0.1065	0.1138	0.1465	0.3763	0.5249	0.4419	0.6283	0.5779	0.7489
2015	0.0928	0.1095	0.1069	0.1489	0.3589	0.4900	0.3945	0.6245	0.5612	0.7190
2016	0.0994	0.1072	0.1154	0.1519	0.3723	0.4738	0.3868	0.6168	0.5613	0.7169
2017	0.1144	0.1198	0.1333	0.1602	0.3769	0.3912	0.3210	0.5666	0.5322	0.7088

Source: author's calculation.

B.2: Calculation method of the coefficients of the world export price equation (λ_{ij})

$$\lambda_{ij} = \sum_{p=1;p\neq i}^{N} \frac{X_{i\to p}}{X_{w\to p} - X_{i\to p}} * \frac{1}{X_{i\to x}} * \sum_{r=1;r\neq i,p}^{N} X_{r\to p}$$

Where $X_{i\to j}$ is the export of the economy i to the economy p, $X_{w\to j}$ is the export of the whole world to the economy j. The data is from the World Integrated Trade Solution Database. The calculation method is from Herve et al. (2010).

Table B.2.1: coefficients of the world export price.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	λ_{12}	λ_{13}	λ_{14}	λ_{15}	λ_{16}	λ_{21}	λ_{23}	λ_{24}	λ_{25}	λ_{26}
2001	0.0411	0.0687	0.1986	0.2861	0.4055	0.1024	0.0697	0.2037	0.2725	0.3517
2002	0.0439	0.0817	0.1831	0.2963	0.3951	0.1048	0.0783	0.1840	0.2799	0.3530
2003	0.0469	0.0958	0.1716	0.2995	0.3860	0.1068	0.0890	0.1679	0.2829	0.3534
2004	0.0513	0.1090	0.1634	0.3012	0.3750	0.1076	0.0982	0.1556	0.2796	0.3590
2005	0.0514	0.1256	0.1618	0.2916	0.3696	0.1022	0.1085	0.1556	0.2645	0.3693
2006	0.0506	0.1367	0.1569	0.2822	0.3737	0.0961	0.1214	0.1602	0.2724	0.3499
2007	0.0513	0.1501	0.1522	0.2874	0.3590	0.0946	0.1336	0.1559	0.2823	0.3336
2008	0.0532	0.1559	0.1531	0.2917	0.3461	0.0944	0.1393	0.1568	0.2880	0.3216
2009	0.0573	0.1620	0.1561	0.2813	0.3432	0.0888	0.1487	0.1604	0.2794	0.3226
2010	0.0599	0.1750	0.1589	0.2690	0.3370	0.0955	0.1591	0.1581	0.2620	0.3252
2011	0.0590	0.1773	0.1540	0.2662	0.3435	0.0853	0.1678	0.1577	0.2675	0.3217
2012	0.0560	0.1933	0.1548	0.2588	0.3371	0.0800	0.1788	0.1603	0.2574	0.3234
2013	0.0543	0.2010	0.1474	0.2543	0.3430	0.0690	0.1857	0.1562	0.2579	0.3313
2014	0.0551	0.2060	0.1476	0.2518	0.3394	0.0662	0.1926	0.1566	0.2575	0.3270
2015	0.0561	0.2222	0.1501	0.2428	0.3289	0.0666	0.2023	0.1583	0.2454	0.3274
2016	0.0543	0.2122	0.1499	0.2501	0.3335	0.0701	0.1950	0.1587	0.2554	0.3209
2017	0.0609	0.2136	0.1509	0.2573	0.3172	0.0738	0.2009	0.1651	0.2723	0.2879

Source: author's calculation.

Table B.2.2: coefficients of the world export price.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	λ_{31}	λ_{32}	λ_{34}	λ_{35}	λ_{36}	λ_{41}	λ_{42}	λ_{43}	λ_{45}	λ_{46}
2001	0.0985	0.0415	0.2276	0.2811	0.3513	0.1376	0.0565	0.1063	0.4874	0.2122
2002	0.1005	0.0417	0.2093	0.3000	0.3485	0.1324	0.0557	0.1200	0.4806	0.2113
2003	0.1011	0.0426	0.1928	0.3105	0.3530	0.1290	0.0557	0.1352	0.4671	0.2129
2004	0.1034	0.0460	0.1812	0.3166	0.3529	0.1281	0.0586	0.1479	0.4580	0.2075
2005	0.1003	0.0451	0.1808	0.3120	0.3619	0.1216	0.0591	0.1685	0.4463	0.2045
2006	0.0962	0.0461	0.1837	0.3215	0.3525	0.1116	0.0603	0.1851	0.4340	0.2090
2007	0.0951	0.0468	0.1835	0.3390	0.3356	0.1054	0.0588	0.2004	0.4259	0.2096
2008	0.0935	0.0476	0.1823	0.3391	0.3375	0.1035	0.0598	0.2061	0.4223	0.2083
2009	0.0878	0.0530	0.1912	0.3403	0.3278	0.0974	0.0649	0.2212	0.4079	0.2085
2010	0.0969	0.0563	0.1948	0.3248	0.3272	0.1079	0.0677	0.2398	0.3822	0.2025
2011	0.0889	0.0592	0.1973	0.3343	0.3203	0.0975	0.0693	0.2493	0.3881	0.1958
2012	0.0895	0.0591	0.2107	0.3428	0.2979	0.0924	0.0672	0.2707	0.3773	0.1924
2013	0.0797	0.0595	0.2154	0.3639	0.2815	0.0776	0.0650	0.2844	0.3772	0.1957
2014	0.0756	0.0602	0.2185	0.3613	0.2843	0.0735	0.0652	0.2950	0.3714	0.1949
2015	0.0778	0.0612	0.2261	0.3547	0.2801	0.0732	0.0653	0.3132	0.3513	0.1969
2016	0.0812	0.0591	0.2200	0.3566	0.2832	0.0776	0.0638	0.2964	0.3606	0.2016
2017	0.0820	0.0651	0.2157	0.3603	0.2770	0.0785	0.0713	0.2931	0.3644	0.1927

Source: author's calculation.

Table B.2.3: coefficients of the world export price.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	λ_{51}	λ_{52}	λ_{53}	λ_{54}	λ_{56}	λ_{61}	λ_{62}	λ_{63}	λ_{64}	λ_{65}
2001	0.1806	0.0698	0.1229	0.4603	0.1664	0.2699	0.0899	0.1527	0.2624	0.2250
2002	0.1829	0.0731	0.1501	0.4268	0.1672	0.2549	0.0928	0.1779	0.2514	0.2231
2003	0.1842	0.0771	0.1807	0.3956	0.1623	0.2438	0.0947	0.2126	0.2322	0.2167
2004	0.1853	0.0826	0.2048	0.3713	0.1560	0.2344	0.1042	0.2386	0.2164	0.2065
2005	0.1725	0.0797	0.2309	0.3623	0.1546	0.2127	0.1061	0.2766	0.2087	0.1959
2006	0.1577	0.0815	0.2574	0.3519	0.1516	0.2018	0.0990	0.2974	0.2142	0.1876
2007	0.1529	0.0826	0.2877	0.3373	0.1395	0.1925	0.0964	0.3154	0.2128	0.1829
2008	0.1516	0.0852	0.2976	0.3331	0.1325	0.1810	0.0942	0.3351	0.2157	0.1740
2009	0.1367	0.0887	0.3089	0.3259	0.1398	0.1667	0.1034	0.3341	0.2187	0.1771
2010	0.1436	0.0885	0.3164	0.3066	0.1450	0.1721	0.1057	0.3484	0.2009	0.1730
2011	0.1293	0.0907	0.3274	0.3049	0.1478	0.1645	0.1070	0.3523	0.1976	0.1786
2012	0.1199	0.0843	0.3459	0.3002	0.1497	0.1586	0.1075	0.3477	0.2066	0.1796
2013	0.1021	0.0826	0.3716	0.2957	0.1479	0.1448	0.1120	0.3450	0.2150	0.1832
2014	0.0953	0.0822	0.3767	0.2906	0.1553	0.1346	0.1091	0.3573	0.2112	0.1878
2015	0.0924	0.0797	0.3888	0.2816	0.1574	0.1311	0.1117	0.3588	0.2104	0.1880
2016	0.0998	0.0798	0.3755	0.2860	0.1589	0.1405	0.1061	0.3470	0.2124	0.1939
2017	0.1012	0.0898	0.3754	0.2837	0.1499	0.1382	0.1043	0.3579	0.2116	0.1881

Source: author's calculation.

B.3: Calculation method of the coefficients of the competitor import price equation (μ_{ij})

$$\mu_{ij} = \frac{X_{j\to i}}{X_{w\to i}}$$

Where $X_{j\to i}$ is the export of the economy j to the economy i, $X_{w\to j}$ is the export of the whole world to the economy i. The data is from the World Integrated Trade Solution Database.

Table B.3.1: coefficients of the competitor import price.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	μ_{12}	μ_{13}	μ_{14}	μ_{15}	μ_{16}	μ_{21}	μ_{23}	μ_{24}	μ_{25}	μ_{26}
2001	0.0570	0.1553	0.1986	0.1051	0.4839	0.2233	0.1105	0.1958	0.0980	0.3723
2002	0.0526	0.1684	0.1788	0.1072	0.4930	0.2263	0.1230	0.1788	0.1031	0.3687
2003	0.0529	0.1821	0.1594	0.1075	0.4981	0.2405	0.1388	0.1663	0.1027	0.3517
2004	0.0567	0.1920	0.1399	0.1071	0.5043	0.2442	0.1535	0.1445	0.0988	0.3590
2005	0.0546	0.1910	0.1243	0.0952	0.5348	0.2294	0.1727	0.1356	0.1006	0.3617
2006	0.0540	0.1864	0.1214	0.0873	0.5509	0.2079	0.1841	0.1342	0.0985	0.3752
2007	0.0510	0.1976	0.1213	0.0901	0.5400	0.1952	0.2027	0.1247	0.0999	0.3775
2008	0.0483	0.1987	0.1139	0.0828	0.5563	0.1798	0.2234	0.1052	0.0899	0.4017
2009	0.0511	0.2298	0.1201	0.0934	0.5055	0.1805	0.2050	0.1094	0.0939	0.4113
2010	0.0521	0.2240	0.1119	0.0844	0.5275	0.1800	0.1985	0.1120	0.0879	0.4216
2011	0.0605	0.2261	0.1003	0.0835	0.5295	0.1602	0.2008	0.1052	0.0901	0.4437
2012	0.0581	0.2271	0.1048	0.0859	0.5241	0.1489	0.2122	0.1023	0.0899	0.4466
2013	0.0541	0.2344	0.1018	0.0907	0.5189	0.1365	0.2203	0.1007	0.0992	0.4433
2014	0.0502	0.2325	0.1040	0.0884	0.5249	0.1185	0.2308	0.1023	0.1065	0.4419
2015	0.0477	0.2530	0.1165	0.0928	0.4900	0.1157	0.2661	0.1142	0.1095	0.3945
2016	0.0479	0.2544	0.1244	0.0994	0.4738	0.1284	0.2602	0.1175	0.1072	0.3868
2017	0.0572	0.2929	0.1443	0.1144	0.3912	0.1459	0.2811	0.1323	0.1198	0.3210

Source: author's calculation.

Table B.3.2: coefficients of the competitor import price.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	μ_{31}	μ_{32}	μ_{34}	μ_{35}	μ_{36}	μ_{41}	μ_{42}	μ_{43}	μ_{45}	μ_{46}
2001	0.1443	0.0846	0.0893	0.1029	0.5789	0.1160	0.0297	0.0515	0.1493	0.6535
2002	0.1520	0.0906	0.0844	0.1059	0.5671	0.1103	0.0302	0.0642	0.1566	0.6387
2003	0.1588	0.0971	0.0785	0.1086	0.5570	0.0998	0.0292	0.0787	0.1587	0.6336
2004	0.1566	0.1054	0.0729	0.1066	0.5584	0.0943	0.0315	0.0917	0.1563	0.6262
2005	0.1444	0.1116	0.0743	0.0950	0.5748	0.0893	0.0273	0.1072	0.1497	0.6265
2006	0.1386	0.1038	0.0825	0.1010	0.5740	0.0853	0.0251	0.1182	0.1456	0.6257
2007	0.1353	0.1015	0.0808	0.1020	0.5803	0.0815	0.0257	0.1304	0.1490	0.6134
2008	0.1384	0.1012	0.0792	0.1047	0.5766	0.0731	0.0245	0.1333	0.1443	0.6247
2009	0.1263	0.0998	0.0801	0.1103	0.5835	0.0671	0.0266	0.1557	0.1503	0.6003
2010	0.1261	0.0986	0.0776	0.1069	0.5908	0.0688	0.0286	0.1622	0.1383	0.6022
2011	0.1134	0.0939	0.0729	0.1125	0.6073	0.0640	0.0283	0.1630	0.1388	0.6060
2012	0.1000	0.0932	0.0767	0.1072	0.6229	0.0690	0.0286	0.1711	0.1404	0.5909
2013	0.0837	0.0943	0.0787	0.1045	0.6388	0.0649	0.0301	0.1779	0.1429	0.5842
2014	0.0824	0.0948	0.0807	0.1138	0.6283	0.0602	0.0325	0.1829	0.1465	0.5779
2015	0.0810	0.1016	0.0860	0.1069	0.6245	0.0604	0.0335	0.1960	0.1489	0.5612
2016	0.0862	0.0942	0.0875	0.1154	0.6168	0.0642	0.0328	0.1897	0.1519	0.5613
2017	0.0984	0.1053	0.0963	0.1333	0.5666	0.0655	0.0334	0.2087	0.1602	0.5322

Source: author's calculation.

Table B.3.3: coefficients of the competitor import price.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	μ_{51}	μ_{52}	μ_{53}	μ_{54}	μ_{56}	μ_{61}	μ_{62}	μ_{63}	μ_{64}	μ_{65}
2001	0.0608	0.0188	0.0391	0.1367	0.7446	0.1088	0.0430	0.0762	0.3230	0.4490
2002	0.0551	0.0195	0.0446	0.1234	0.7574	0.1082	0.0442	0.0918	0.2940	0.4617
2003	0.0566	0.0199	0.0581	0.1129	0.7524	0.1078	0.0457	0.1090	0.2660	0.4715
2004	0.0551	0.0221	0.0669	0.1040	0.7520	0.1090	0.0487	0.1235	0.2484	0.4704
2005	0.0466	0.0232	0.0800	0.0987	0.7516	0.1040	0.0485	0.1433	0.2489	0.4554
2006	0.0422	0.0204	0.0835	0.0943	0.7597	0.0952	0.0506	0.1629	0.2435	0.4478
2007	0.0421	0.0193	0.0981	0.0977	0.7429	0.0911	0.0505	0.1801	0.2281	0.4501
2008	0.0373	0.0182	0.0988	0.0923	0.7533	0.0911	0.0523	0.1866	0.2238	0.4462
2009	0.0327	0.0211	0.1066	0.0993	0.7403	0.0846	0.0562	0.2013	0.2292	0.4288
2010	0.0332	0.0197	0.1206	0.0934	0.7331	0.0943	0.0589	0.2199	0.2288	0.3982
2011	0.0312	0.0182	0.1182	0.0878	0.7446	0.0845	0.0605	0.2290	0.2279	0.3981
2012	0.0282	0.0168	0.1133	0.0904	0.7513	0.0802	0.0575	0.2495	0.2319	0.3809
2013	0.0250	0.0156	0.1117	0.0921	0.7556	0.0670	0.0557	0.2671	0.2263	0.3838
2014	0.0242	0.0156	0.1188	0.0924	0.7489	0.0633	0.0561	0.2765	0.2278	0.3763
2015	0.0258	0.0168	0.1320	0.1065	0.7190	0.0630	0.0558	0.2929	0.2294	0.3589
2016	0.0288	0.0173	0.1285	0.1085	0.7169	0.0668	0.0550	0.2777	0.2283	0.3723
2017	0.0289	0.0186	0.1353	0.1083	0.7088	0.0658	0.0614	0.2727	0.2233	0.3769

Source: author's calculation.

B.4: Calculation method of the coefficients of the real effective exchange rate equation (v_{ij})

$$v_{ij} = \frac{(X_{i\to j} + X_{j\to i})}{(X_{i\to w} + X_{w\to i})}$$

Where $X_{i\to j}$ is the export of the economy i to the economy j, $X_{w\to i}$ is the export of the whole world to the economy i. The data is from the World Integrated Trade Solution Database.

Table B.4.1: coefficients of the real effective exchange rates.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	v_{12}	v_{13}	v_{14}	v_{15}	v_{16}	v_{21}	v_{23}	v_{24}	v_{25}	v_{26}
2001	0.0603	0.1096	0.2599	0.1165	0.4537	0.1585	0.1164	0.2030	0.1012	0.4208
2002	0.0621	0.1253	0.2439	0.1110	0.4577	0.1514	0.1361	0.1923	0.1032	0.4170
2003	0.0652	0.1463	0.2124	0.1152	0.4609	0.1538	0.1631	0.1726	0.1029	0.4076
2004	0.0695	0.1554	0.1921	0.1137	0.4692	0.1516	0.1783	0.1591	0.1028	0.4082
2005	0.0683	0.1586	0.1842	0.1027	0.4862	0.1449	0.1989	0.1416	0.1076	0.4069
2006	0.0675	0.1620	0.1817	0.0990	0.4898	0.1354	0.2009	0.1336	0.1014	0.4287
2007	0.0656	0.1717	0.1692	0.1011	0.4925	0.1242	0.2130	0.1240	0.0978	0.4410
2008	0.0642	0.1765	0.1503	0.0955	0.5135	0.1165	0.2196	0.1080	0.0928	0.4631
2009	0.0686	0.2062	0.1455	0.0927	0.4870	0.1104	0.2245	0.1062	0.0946	0.4642
2010	0.0691	0.2065	0.1380	0.0837	0.5028	0.1114	0.2283	0.1093	0.0842	0.4668
2011	0.0716	0.2098	0.1308	0.0847	0.5031	0.1093	0.2242	0.1032	0.0808	0.4825
2012	0.0684	0.2018	0.1446	0.0805	0.5047	0.1044	0.2310	0.1052	0.0762	0.4832
2013	0.0673	0.2062	0.1474	0.0828	0.4963	0.0937	0.2435	0.1068	0.0769	0.4791
2014	0.0629	0.2069	0.1483	0.0832	0.4988	0.0831	0.2438	0.1142	0.0806	0.4784
2015	0.0600	0.2110	0.1627	0.0850	0.4814	0.0767	0.2628	0.1252	0.0810	0.4544
2016	0.0612	0.2108	0.1681	0.0901	0.4698	0.0825	0.2550	0.1275	0.0826	0.4525
2017	0.0687	0.2315	0.1737	0.0941	0.4320	0.0853	0.2607	0.1248	0.0851	0.4441

Source: author's calculation.

Table B.4.2: coefficients of the real effective exchange rates.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	v_{31}	v_{32}	v_{34}	v_{35}	v_{36}	v_{41}	v_{42}	v_{43}	v_{45}	v_{46}
2001	0.1579	0.0638	0.1529	0.1132	0.5122	0.1008	0.0300	0.0412	0.1517	0.6763
2002	0.1502	0.0669	0.1569	0.1125	0.5136	0.0963	0.0311	0.0517	0.1553	0.6657
2003	0.1461	0.0690	0.1513	0.1221	0.5116	0.0891	0.0307	0.0636	0.1578	0.6587
2004	0.1384	0.0728	0.1498	0.1234	0.5156	0.0836	0.0318	0.0732	0.1558	0.6557
2005	0.1246	0.0737	0.1552	0.1240	0.5225	0.0787	0.0285	0.0843	0.1503	0.6581
2006	0.1126	0.0696	0.1581	0.1255	0.5342	0.0749	0.0274	0.0938	0.1474	0.6565
2007	0.1042	0.0683	0.1472	0.1302	0.5501	0.0706	0.0273	0.1012	0.1516	0.6493
2008	0.1033	0.0708	0.1390	0.1337	0.5532	0.0642	0.0254	0.1015	0.1491	0.6597
2009	0.1003	0.0678	0.1405	0.1305	0.5609	0.0591	0.0268	0.1174	0.1518	0.6449
2010	0.0979	0.0672	0.1360	0.1300	0.5689	0.0597	0.0293	0.1241	0.1394	0.6475
2011	0.0933	0.0653	0.1290	0.1285	0.5840	0.0557	0.0287	0.1235	0.1366	0.6556
2012	0.0847	0.0636	0.1326	0.1141	0.6049	0.0588	0.0280	0.1284	0.1342	0.6505
2013	0.0744	0.0631	0.1307	0.1075	0.6242	0.0547	0.0285	0.1344	0.1358	0.6466
2014	0.0712	0.0634	0.1344	0.1134	0.6176	0.0521	0.0304	0.1374	0.1383	0.6419
2015	0.0676	0.0658	0.1452	0.1089	0.6125	0.0525	0.0316	0.1464	0.1429	0.6266
2016	0.0711	0.0638	0.1466	0.1142	0.6043	0.0556	0.0313	0.1439	0.1463	0.6228
2017	0.0748	0.0678	0.1551	0.1227	0.5797	0.0562	0.0325	0.1553	0.1500	0.6061

Source: author's calculation.

Table B.4.3: coefficients of the real effective exchange rates.
(1=Japan, 2=South Korea, 3=China, 4=the U.S., 5=the Euro area, 6=rest of the world.)

	v_{51}	v_{52}	v_{53}	v_{54}	v_{56}	v_{61}	v_{62}	v_{63}	v_{64}	v_{65}
2001	0.0457	0.0151	0.0308	0.1532	0.7552	0.0978	0.0345	0.0767	0.3757	0.4154
2002	0.0417	0.0159	0.0353	0.1479	0.7592	0.0961	0.0359	0.0900	0.3541	0.4240
2003	0.0422	0.0160	0.0448	0.1378	0.7592	0.0963	0.0361	0.1070	0.3278	0.4328
2004	0.0411	0.0170	0.0501	0.1294	0.7624	0.0967	0.0386	0.1194	0.3106	0.4348
2005	0.0366	0.0181	0.0563	0.1257	0.7632	0.0968	0.0382	0.1324	0.3069	0.4257
2006	0.0332	0.0170	0.0607	0.1201	0.7690	0.0915	0.0399	0.1436	0.2975	0.4275
2007	0.0320	0.0163	0.0678	0.1150	0.7689	0.0877	0.0414	0.1613	0.2770	0.4326
2008	0.0291	0.0156	0.0695	0.1062	0.7796	0.0882	0.0439	0.1624	0.2653	0.4402
2009	0.0274	0.0174	0.0794	0.1105	0.7653	0.0798	0.0473	0.1890	0.2600	0.4240
2010	0.0277	0.0173	0.0909	0.1068	0.7572	0.0871	0.0502	0.2078	0.2593	0.3956
2011	0.0269	0.0168	0.0918	0.1020	0.7625	0.0828	0.0520	0.2163	0.2537	0.3952
2012	0.0260	0.0161	0.0877	0.1065	0.7637	0.0811	0.0509	0.2313	0.2568	0.3800
2013	0.0240	0.0160	0.0864	0.1061	0.7674	0.0713	0.0494	0.2485	0.2503	0.3803
2014	0.0232	0.0170	0.0921	0.1099	0.7578	0.0693	0.0503	0.2495	0.2537	0.3772
2015	0.0239	0.0178	0.0955	0.1243	0.7385	0.0658	0.0485	0.2613	0.2652	0.3592
2016	0.0255	0.0173	0.0957	0.1249	0.7366	0.0663	0.0474	0.2529	0.2656	0.3678
2017	0.0250	0.0182	0.1009	0.1232	0.7326	0.0599	0.0495	0.2488	0.2597	0.3821

Source: author's calculation.

References

Abel, A.B. & O.J. Blanchard (1983): "An Intertemporal Model of Savings and Investment." *Econometrica*, 1983/5 , **51**: pp. 675-92.

Aflouk, N., S. Jeong, J. Mazier & J. Saadaoui (2010): "Exchange Rate Misalignments and International Imbalances: a FEER Approach for Emerging Countries." *La Documentation Francaise: Economie Internationale*, 2010/4, **124**, pp. 31-74.

Ahearne, A., W.R. Cline, K.T. Lee, Y.C. Park, J. Pisani-Ferry & J. Williamson (2007): "Global imbalances: Time for action." *Policy Brief*, **07(4)**, Washington, D.C.: Peterson Institute for International Economics.

Agya, A.A. & D. Jun (2015): "Estimate of equilibrium real exchange rate and misalignment of Chinese Yuan vis-a-vis US dollar." *Academic Journal of Economic Studies*, **1(3)**, pp. 148-165.

Almas, I., M. Grewal, M. Hvide & S. Ugurlu (2017): "The PPP approach revisited: A study of RMB valuation against the USD." *Journal of International Money and Finance*, **77**, pp. 18-38.

Anderson, J. (2006): *The Complete RMB Handbook (fourth edition)*. Hong Kong: UBS.

Artis, M. & M. Taylor (1995): *The Effect of Misalignment on Desired Equilibrium Exchange Rates: Some Analytical Results,* in "European Currency Crises and after" (ed. C. Bordes, E. Girardin & J. Mélitz), pp. 179-198. Manchester University Press.

Balassa, B. (1964): "The Purchasing Power Parity: a Reappraisal." *Journal of Political Economy*, **72**, pp. 584-96.

Bayoumi, T., P. Clark, S. Symansky & M. Taylor (1994): *The robustness of equilibrium exchange rate calculations to alternative assumptions and methodologies*, in "Estimating Equilibrium Exchange Rates." (ed. J. Williamson), pp. 19-60. Washington, D.C.: Institute of International Economics.

Bénassy-Quéré, A., P. Duran-Vigneron, A. Lahrèche-Révil & V. Mignon (2004): *Burden Sharing and Exchange Rate Misalignments with the Group of Twenty*, in "Dollar Adjustment: How Far? Against What?" (ed. C.F. Bergsten & J. Williamson), Washington, D.C.: Institute for International Economics, pp. 69-94.

Bénassy-Quéré, A., A. Lahrèche-Révil & V. Mignon (2006): "World Consistent Equilibrium Exchange Rates." *CEPII working paper*, **2006(20)**.

Bineau, Y. (2010): "Renminbi's misalignment: A meta-analysis." *Economic Systems*, **34(3)**, pp. 259-269.

Bosworth, B. (2004): "Valuing the Renminbi." *Paper presented at the Tokyo Club Research Meeting* (February).

Cardoso, A. & A. Duarte (2017): "The Impact of the Chinese Exchange Policy on Foreign Trade with the European Union." *Brazilian Journal of Political Economy*, Vol. 37, **4(149)**, pp. 870-893.

Cassel, G. (1918): "Abnormal deviations in international exchanges." *Economic Journal*, **28**, pp. 413-15.

Chang, G.H. & S. Qin (2004): "How much is the Chinese currency undervalued? A quantitative estimation." *China Economic Review*, **15(3)**, pp. 366-371.

Cheung, Y.W., M.D. Chinn & E. Fujii (2007): "The overvaluation of Renminbi undervaluation." *CESifo Working Paper*, **1918**, Munich: Center for Economic Studies and Ifo Institute (CESifo).

Cheung, Y.W., M. Chinn & E. Fujii (2009): "Pitfalls in Measuring Exchange Rate Misalignment." *Open Economies Review*, **20**, pp. 183-206.

Cheung, Y.W., M.D. Chinn & X. Nong (2017): "Estimating currency misalignment using the Penn effect: It is not as simple as it looks." *International Finance*, **20(3)**, pp. 222-242.

Chinn, M.D. & E.S. Prasad (2003): "Medium term determinants of current accounts in industrial and developing countries: an empirical exploration." *Journal of International Economics*, **59**, pp. 47-76.

Clark, P. B. & R. MacDonald (1997): "Exchange rates and economic fundamentals: a methodological comparison of BEERs and FEERs." *paper presented at Conference on Exchange Rates*, Strathclyde University.

Clark, P.B. & R. MacDonald (1998): "Exchange rates and economic fundamentals: A methodological comparison of BEERs and FEERs." *IMF Working Paper*, **67**.

Clark, P.B. & R. MacDonald (1999): *Exchange rates and economic fundamentals: a methodological comparison of Beers and Feers*, in "Equilibrium Exchange Rates" (ed. J. Stein & R. MacDonald), pp. 285-322. Kluwer, Boston, MA.

Clark, P.B. & R. MacDonald (2000): "Filtering the BEER: A Permanent and Transitory Decomposition." *Working Paper*, **00(144)**, IMF.

Clark, P. B., L. Bartolini, T. Bayoumi & S.A. Symansky (1994): "Exchange rates and economic fundamentals: A framework for analysis." *Occasional paper rep*, **115**, Washington, DC: International Monetary Fund.

Cline, W.R. (2005): "The United States as a Debtor Nation." Washington: Institute for International Economics and Center for Global Development.

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

Cline, W.R. (2008): "Estimating Consistent Fundamental Equilibrium Exchange Rates." *Working Paper 08-6*, Washington, D.C.: Peterson Institute for International Economics.

Cline, W., J. Williamson (2009): "2009 Estimates of Fundamental Equilibrium Exchange Rates." *Policy Brief,* **09(10)**, Washington, D.C.: Peterson Institute for International Economics.

Cline, W.R. & J. Williamson (2010):"Estimates of fundamental equilibrium exchange rates." *Policy Brief*, **10(15)**. Washington, D.C.: Peterson Institute of International Economics.

Cline, W.R. & J. Williamson (2011): "Estimates of fundamental equilibrium exchange rates, May 2011." *Policy Brief*, **11(15)**, Washington, D.C.: Peterson Institute of International Economics.

Cline, W.R. & J. Williamson (2012a): "Estimates of fundamental equilibrium exchange rates, May 2012." *Policy Brief*, **12(14)**, Washington, D.C.: Peterson Institute of International Economics.

Cline, W.R. & J. Williamson (2012b): "Updated estimates of fundamental equilibrium exchange rates." *Policy Brief*, **12(23)**, Washington, D.C.: Peterson Institute of International Economics.

Costa, S. (1998): "Determination of the Equilibrium Real Exchange Rate for the Portuguese Economy Using the FEER." *Economic Bulletin*, Banco de Portugal.

Coudert, V. & C. Couharde (2002): "Exchange Rate Regimes and Sustainable Parities for CEECs in the Run-up to EMU Membership." *CEPII Working Paper*, **2002(15)**.

Coudert, V. & C. Couharde (2005): "Real Equilibrium Exchange Rate in China." *Working Paper*, 2005/01, Paris: CEPII.

Ding, Z.J. (2014): "中国的国际金融专题", *Speech*, Beijing: University of International Economics and Business.

Driver, R. L. & P.F. Westaway (2005): "Concepts of equilibrium real exchange rates." *Bank of England Working Paper*, **248**.

Driver, R.L. & P.F. Westaway (2013): *Concept of Equilibrium Exchange Rates*, in "Exchange Rates, Capital Flows and Policy." (ed. R. Driver), Routledge International Studies in Money and Banking.

Dunaway, S., L. Leigh & X.M. Li (2009): "How robust are estimates of equilibrium real exchange rates: The case of China." *Pacific Economic Review*, **14(3)**, pp. 361-375.

Égert, B. (2004): "Accessing Equilibrium Exchange Rates in CEE Acceding Countries: Can We Have DEER with BEER without FEER? A Critical Survey of the Literature." *Bank of Finland BOFIT Discussion Paper*, **1(2004)**.

Elbadawi, I. (1994): *Estimating Long-Run Equilibrium Real Exchange Rates*, in "Estimating Equilibrium Exchange Rates." (ed. J. Williamson), Washington, D.C.: Institute for International Economics. ISBN: 9780881320763.

Faruqee, H., P. Isard (1998): "Exchange rate assessment: Extensions to the macroeconomic balance approach." *IMF Occasional Paper*, **167**, Washington, D.C.: International Monetary Fund.

Federal Reserve Bank of Kansas City, (2004): "Global Demographic Change: Economic Impacts and Policy Changes" Jackson Hole Conference.

Frankel, J.A. (2004): "On the Yuan: The Choice between Adjustment under a Fixed Exchange Rate and Adjustment under a Flexible Rate." *paper presented at a IMF seminar on China's Foreign Exchange System*, Dalian, China.

Freund, C. L. (2000): "Current account adjustments in industrialized countries." *International Finance Discussion Papers*, **692**, URL: <http://www.federalreserve.gov/pubs/ifdp/2000/692/ifdp692.pdf>, [Read 27th of April 2019].

Funke, M. & J. Rahn (2005): "Just how undervalued is the Chinese renminbi?" *World Economy*, **28 (4)**, pp. 465-489.

Gan, C., B. Ward, S.T. Ting & D.A. Cohen (2013): "An empirical analysis of China's equilibrium exchange rate: A co-integration approach." *Journal of Asian Economics*, **29**, pp. 33-44.

Gagnon, J.E. (2018): *A stability-oriented exchange rate policy for China: 2018 edition*, in "US–China economic relations: From conflict to solutions—Part I." (ed. J. M. Ha & A. Posen), *PIIE Briefing*, **18(1)**, Washington, D.C.

Garroway, C., B. Hacibedel, H. Reisen, & E. Turkisch (2012): "The renminbi and poor-country growth." *The World Economy*, **35(3)**, pp. 273–294.

Genorio, H. & D. Kozamernik (2004): "FEER Estimates-The Slovenian Case." *Prikazi in Analize*, **XII(1)**, Bank of Slovenia.

Giannellis, N., & M. Koukouritakis (2018): "Currency Misalignments in the BRIICS Countries: Fixed Vs. Floating Exchange Rates." *Open Economies Review*, **29(5)**, pp. 1123-1151.

Goldstein, M. (2004): *China and the renminbi exchange rate*, in "Dollar Adjustment: How Far? Against What?" (ed. C.F. Bergsten & J. Williamson), **17**, Washington, D.C.: Institute for International Economics.

Goldstein, M. & N. Lardy (2006): "China's Exchange Rate Policy Dilemma." *American Economic Review*, **96(2)**, pp. 422-26.

Goldstein, M. & N. Lardy (2007): "China's Exchange Rate Policy: An Overview of Some Key Issues." Paper prepared for the conference on China's Exchange Rate Policy, Washington, D.C.: Peterson Institute for International Economics.

Hall, S.G., A. Kenjegaliev, P.A.V.B. Swamy & G.S. Tavlas (2013): "Measuring currency pressures: the cases of the Japanese Yen, the Chinese Yuan and the UK Pound." *Journal of the Japanese and International Economies*, **29**, pp. 1-20.

Hamilton, J.D. (2016): "Why you should never use the Hodrick–Prescott flter." *UCSD Department of Economics Working Paper*, URL: <https://doi.org/10.3386/w23429>, [Read 21st of March 2019].

Hervé, K. et al. (2010): "The OECD's New Global Model." *OECD Economics Department Working Papers*, **768**, OECD Publishing.

Higgins, M. (1998): "Demography, National Savings, and International Capital Flows." *International Economic Review*, **39(2)**, pp. 343–69.

Hodrick, R.J. & E.C. Prescott (1997): "Postwar US business cycles: An empirical investigation." *Journal of Money,Credit and Banking*, **29**, pp. 1-16.

Isard, P. & H. Faruqee (1998): "Exchange Rate Assessment: Extensions of the Macro-economic Balance Approach." *IMF Occasional Paper*, **167**, pp. 1-79.

Isard, P. (2007): "Equilibrium Exchange Rates: Assessment Methodologies." *IMF Working Paper*, Washington, D.C.: International Monetary Fund.

Isard, P. & S. Symanski (1996): "Long Run Movements in Real Exchange Rates, from Exchange Rate Movements and Their Impact on Trade and Investment in the APEC Region." *Occasional Paper*, **145**, (ed. Takatoshi Ito et al.), Washington, D.C.: International Monetary Fund.

Jeong, S. & J. Mazier (2003a): "Exchange Rate Regimes and Equilibrium Exchange Rates in East Asia." *Presses de Science Po: Revenue Economique*, **54**, pp. 1161-1182.

Jeong, S. & J. Mazier (2003b): "Equilibrium exchange rates of eight East Asian currencies: A fundamental equilibrium exchange rate (FEER) approach." *CEPN Working Paper*, **09**, Paris: Centre d'Economie de l'Université Paris Nord.

Jeong, S., J. Mazier & J. Saadaoui (2010): "Exchange Rate Misalignments at World and European Levels: a FEER Approach." *La Documentation Francaise: Economie Internationale*, **121**, pp. 25-584.

Jovanovik, B. (2007): "Calculating the fundamental equilibrium exchange rate of the Macedonian Denar." Unpublished Master's thesis.

Juselius, K. (1991): *Long-run Relations in A Well Defined Statistical Model for the Data Generating Process: Cointegration Analysis of the PPP and UIP Relations between Denmark and Germany*, in "Econometric Decision Models: New Methods of Modeling and Applications." (ed. J. Gruber), New York: Springer Verlag.

Korhonen, I. & M. Ritola (2011): *Renminbi Misaligned — Results from Meta Regressions*, chapter 4 in "Asia and China in the Global Economy." (ed. Y.W. Cheung & G. Ma), pp. 97-122, Singapore: World Scientific Publishing Company.

Kuijs, L. (2005): "Investment and Saving in China." *World Bank Policy Research Paper*, **3633** (June). Available at SSRN: http://ssrn.com/abstract=756985.

Krugman, P. (1990): *Equilibrium Exchange Rates*, in "International Policy Coordination and Exchange Rate Fluctuations" (ed. W.H. Branson, J.A. Frenkel & M. Goldstein), pp. 159-196. University of Chicago Press, ISBN: 0-226-07141-3.

Lee, J., G.M. Milesi-Ferreti, J.D. Ostry, A. Prati & L.A. Ricci (2008): "Exchange rate assessments: CGER methodologies." *Occasional Papers*, **261**, Washington, D.C.: International Monetary Fund.

Lee, J., G.M. Mileso-Ferretti & L. Ricci (2006): "Methodology for CGER Exchange rate Assessments." Washington, D.C.: International Monetary Fund.

MacDonald, R. (1997): "What determines real exchange rates? The long and short of it." *IMF Working Paper*, **21**.

MacDonald, R. & P. Dias (2007): "BEER Estimates and Target Current Account Imbalances." Paper presented to a workshop at the Peterson Institute sponsored by Bruegel, KIEP, and the Peterson Institute.

McMorrow, K. & W. Roeger (2001): "Potential Output: Measurement Methods, "New" Economy Influences and Scenarios for 2001-2010 -- A Comparison of the EU15 and the US." *Economic Papers European Commission Directorate-General for Economic and Financial Affairs Working Pape*r, **150**.

Modigliani, F.S.L. & Cao (2004): "The Chinese Saving Puzzle and the Life-Cycle Hypothesis." *Journal of Economic Literature*, vol. **XLII**, March, pp. 145-170.

Montiel, P. J. (1999): *The long-run equilibrium real exchange rate: conceptual issues and empirical research*, in "Exchange rate misalignment: concepts and measurement for developing countries." (ed. P.J. Montiel & L.E. Hinkle), New York: Oxford University Press.

Nurkse, R. (1950): *Conditions of International Monetary Equilibrium*, in "Theory of International Trade." (ed. H. S. Ellis & L. A. Metzler), Philadelphia: Blakiston Co.

Obstfeld, M. & K. Rogoff (1994): "The intertemporal Approach to the Current Account." *Working Papers*, **4893**, NBER.

Philip, R.L. & G.M. Milesi-Ferretti (2017): "International Financial Integration in the Aftermath of the Global Financial Crisis." *Working Paper*, **17(115)**, Washington, D.C.: International Monetary Fund.

Ravn, M. & H. Uhlig (2001): "On Adjusting the HP-Filter for the Frequency of Observations." *CEPR Working Paper*, **9750**.

Reisen, H. (2009): "On the Renminbi and Economic Convergence" , Vox.EU.

Roldos, J. (1996): "Human capital, borrowing constraints, and the stages of the balance of payments." *Manuscript*, IMF.

Samuelson, P.A. (1964): "Theoretical Notes on Trade Problems." *Review of Economics and Statistics*, **46**, pp. 335-46.

Siregar, R.Y. & R.S. Rajan (2006): "Models of Equilibrium Real Exchange Rates Revisited: A Selective Review of the Literature." *Discussion Paper*, **0604**, Center for International Economic Studies.

Stein, J.L. (1994): *The Natural Real Exchange Rate of the US Dollar and Determinants of Capital Flows*, in "Estimating Equilibrium Exchange Rates." (ed. J. Williamson), Washington, D.C.: Institute for International Economics.

Stolper, T. & M. Fuentes (2007): "GSDEER and Trade Elasticities." Paper presented to a workshop at the Peterson Institute sponsored by Bruegel, KIEP, and the Peterson Institute, February.

Subramanian, A. (2010): "New PPP-Based Estimates of Renminbi Undervaluation and Policy Implications." *Policy Brief*, **PB10-8**, Washington, D.C.: Peterson Institute for International Economics.

Taylor, A.M. & M.P. Taylor (2004): "The purchasing power parity debate." *Journal of Economic Perspectives*, **18**, pp. 135-58.

Wadhwani, S.B. (1999): "Currency Puzzles." *Speech Delivered*, 16th September 1999, London: London School of Economics.

Wang, T. (2004): *Exchange Rate Dynamics*, in "China Growth and Integration into the World Economy: Prospects and Challenges." (ed. E. Prasad), *IMF Occasional Paper*, **232**, Washington, DC: International Monetary Fund.

Williamson, J. (1985): "The Exchange Rate System Policy Analyses in International Economics." (rev.ed), Washington: Intstitute for International Economics.

Williamson, J. (1994): "Estimating Equilibrium Exchange Rates." Washington, D.C.: Institute for International Economics.

Williamson, J. (1983): "The exchange rate system." *Policy Analyses in International Economics*, **5**, Washington, D.C.: Institute for International Economics.

Williamson, J. (1991): "FEERs and the ERM." *National Institute Economic Review*, **137**, pp. 45-50.

Wren-Lewis, S. (1992): *On the analytical foundations of the Fundamental Equilibrium Exchange Rate*, in "Macroeconomic Modelling of the Long Run." (ed. C.P. Hargreaves), Aldershot: Edward Elgar, pp. 323-338.

Wren-Lewis, S. (2004): *The Needed Changes in Bilateral Exchange Rates*, in "Dollar Adjustment: How Far? Against What?" (ed. C.F. Bergsten & J. Williamson), Washington, D.C.: Institute for International Economics, pp.37-68.

Wren-Lewis, S. & R.L. Driver (1998): "Real Exchange Rates for the Year 2000." Washington: Institute for International Economics.

Xu, S.Q. & Z.L. Zhu (2002): *1949-2000 年的人民币汇率史*. 上海财经大学出版社. ISBN: 9787810498319.

Yang, F. (2005): "人民币汇率制度历史回顾." *中国经济史研究*, **04**, pp. 59-64.

You, K., & N. Sarantis (2012): "Structural breaks and the equilibrium real effective exchange rate of China: A NATREX approach." *China Economic Review*, **23(4)**, pp. 1146-1163.

Yu, Y.D. & L.S. Xiao (2017): "完成 811 汇改：人民币汇率形成机制改革方向分析." *国际经济评论*, 1, pp. 23-41.

Zhang, Z., L. Chen (2014): "A New Assessment of the Chinese RMB Exchange Rate." *China Econ. Rev.*, **30**, pp. 113-122.