Renminbi Undervaluation and the U.S.-China Bilateral Trade Balance

Author: Hyun-ji Choi

Persistent link: http://hdl.handle.net/2345/519

This work is posted on eScholarship@BC, Boston College University Libraries.

Boston College Electronic Thesis or Dissertation, 2007

Copyright is held by the author, with all rights reserved, unless otherwise noted.
Renminbi Undervaluation
and the U.S.-China Bilateral Trade Balance

by

Hyun-ji Choi

Submitted in partial fulfillment
of graduation requirements for the degree of

Bachelor of Arts

Boston College
International Studies Program
May 2007
Abstract

This paper examines the impact of the fixed exchange rate policy and the undervaluation of the Chinese currency (Renminbi) on the U.S.-China bilateral trade balance. Due to China’s fixed exchange rate policy during the last decade, many have suspected that the Renminbi has been undervalued, and that this undervaluation has contributed to the expansion of the U.S. trade deficit. Based on previous studies, the first part of this paper explores Chinese economic policy and the possible consequences of the fixed exchange rate and the undervaluation of the Renminbi. The second part of the paper examines the following through empirical analysis: (1) the misalignment of the Renminbi through the behavioral equilibrium exchange rate (BEER) approach, (2) the relationship between the real exchange rate of the Renminbi and the U.S.-China bilateral trade balance and (3) the relationship between the undervaluation and the US bilateral trade deficit with China. The results indicate that the undervaluation of the Renminbi is neither substantial nor permanent. Moreover, the devalued Renminbi does not significantly increase China’s trade surplus with the United States. The U.S. bilateral trade deficit with China is not permanently adversely affected by Renminbi undervaluation.
Renminbi Undervaluation and the U.S.-China Bilateral Trade Balance

Introduction

One of the fundamental tenets of free trade is that currencies should float - or at the very least, move along with market forces. The reason for this is that a free-floating currency allows large trade imbalances to self-correct, as the country with a large trade deficit sees its imports become more expensive and its exports become less expensive. Unfortunately, the Chinese government intervenes in the market to keep its currency, the Renminbi, artificially low, which allows China to artificially inflate its exports and reduce its imports. Their continued manipulation is a form of protectionism, and it throws the whole global trading system out of balance (C. Schumer and L. Graham, a Commentary in the Wall Street Journal).

Senator Schumer and Senator Graham’s words demonstrate a great concern about China’s current exchange rate policy. China’s exchange rate policy is regarded as so-called “protectionism,” which bars free trade among countries in the world. Some claim that China has been manipulating its trade policy through protectionism to encourage its economic growth. The authorities of many countries, the U.S. authorities in particular, keep their eyes on China’s economic policy because the enormous and sudden expansion of the Chinese economy is considered a great threat to them.

The excerpt shows that China’s exchange rate policy has been one of the hottest issues in current international economics. China has maintained its fixed exchange rate regime for more than a decade, at a rate that has been believed to be undervalued against other currencies. The fixed exchange rate is considered a stimulus for China’s economic growth. China adopted an export-led growth strategy supported by a competitive level of exchange rate, a successful economic development strategy previously used by Japan, South Korea, Taiwan, and other Asian economies (Eichengreen, 2006). The
undervaluation of the Renminbi\(^1\) is also known to cause China’s excessive accumulation of foreign reserves, contributing to global payment imbalances (Goldstein, 2006). Since China’s accession to the World Trade Organization (WTO), the debate on China’s exchange rate policy has increased. Joining the WTO meant a more open market that can cause fluctuations in the financial markets of China (Xu, 2004). Many economists and policy makers claimed that China needed to switch its exchange rate regime to a more flexible one in order to cope with its more liberalized economy (Jinlong and Shengjun 2004, Xu 2004).

Due to a large accumulation of foreign reserves and a rapid growth in exports to the world, other countries accused China of manipulating its currency for its own economic growth, while financially harming others. China’s exchange rate policy has been an important issue in the U.S. policy as well. The U.S. claims that the U.S. trade deficit, which has widened to around $791 billion in 2005, has mostly come from the bilateral trade deficit with China.\(^2\) The U.S. trade imbalance with China reached more than $100 billion in 2003. China’s rapid accumulation of foreign reserves, which recently was estimated at $1 trillion, has been cited by critics for years as evidence that the exchange rate of China’s currency is too low (Hufbauer and Wong, 2004).

On the other hand, China has been reluctant to revalue its currency and switch its exchange rate regime to a more flexible one because it believes that an appreciation of the Renminbi can damage China’s economic development and financial stability

---

1 The Renminbi, literally “people’s currency,” is the official currency of China, whose unit is the yuan.

2 The figure of the U.S. trade deficit is obtained from the U.S. Bureau of Economic Analysis website. For more detailed information, visit [http://www.bea.gov/newsreleases/international/transactions/transnewsrelease.htm](http://www.bea.gov/newsreleases/international/transactions/transnewsrelease.htm)
(Goldstein, 2006). China believes that its rapid economic development has been based mainly on the large volume of exports, which is partly driven by the low exchange rate of the Renminbi.

On July 21st 2005, the People’s Bank of China (PBOC) announced a revaluation of the Renminbi by 2.1%, from 8.28 yuan per dollar to 8.11 yuan per dollar, after receiving pressure from other countries’ financial authorities. The PBOC also claimed that China would pursue a managed floating regime for its exchange rate policy (Spiegel, 2005). Under a managed floating regime, the authorities are ready to intervene in the foreign exchange market by buying the currency when it is rising, and selling when it is falling (Frankel, 1999).

Even though China has revalued its currency and switched its exchange rate regime to a more flexible type, the Renminbi issue is still considered problematic in international economics. There are still voices that advocate for a further Renminbi revaluation because the initial revaluation in 2005 is considered insufficient (Lardy and Goldstein, 2005). On the other hand, Eichengreen (2006) claims that the Renminbi revaluation in 2005 was a sufficient start to adjust Renminbi misalignment and to correct global payment imbalances. There still is no sufficiently clear evidence as to how much the Renminbi has been undervalued and whether the undervaluation has actually influenced the trade balance of China and its trading partners. For a better understanding of the Chinese exchange rate policy, it is important to verify the magnitude of the undervaluation and the impact of China’s exchange rate policy on international trade.
This paper first identifies the reasons why China’s current fixed exchange rate policy and a possible undervaluation of the Renminbi are crucial issues to international economics. This paper particularly focuses on the value of the Renminbi and its impact on the U.S.-China bilateral trade balance. Through this paper, I further examine the magnitude of Renminbi undervaluation and its impact on the U.S.-China trade balance through empirical analysis.

This paper consists of two distinct parts. The first part of this paper explores China’s economic policy along with the projected consequences of pursuing fixed exchange rate policy and currency undervaluation, as well as the implication of China’s exchange rate policy for the U.S. The second part of this paper is based on empirical research which investigates the following: (1) the magnitude and the direction of Renminbi misalignment by estimating the behavioral equilibrium exchange rate (BEER) through a vector error correction model (VECM) specification, (2) the effect of the Renminbi real exchange rate on China’s trade balance with the Unites States, using a VECM specification and an impulse-response function (IRF), and (3) the verification of whether Renminbi undervaluation has influenced the U.S. bilateral trade deficit with China, by applying a vector autoregression (VAR) representation and an IRF.
I. China’s Economic Policy and its Fixed Exchange Rate

I.1. China’s Economic Policy at a Glance

Prior to economic reforms, China’s economy was essentially based on central planning governed by a communist regime. However, China has gradually opened up its economy since the late 1970s and has transformed from a centrally planned economy to a major part of the world economy based on a free market. The Chinese authorities executed a wide range of economic reforms after opening the market in 1978. The key economic reforms included a reduction and eventual elimination of mandatory export planning, an increase in foreign exchange retention quotas, and access to foreign exchange adjustment centers at a more depreciated market-determined exchange rate (Cerra and Saxena, 2002). China’s open market gave China a growing role in

![Figure 1. Growth in China's GDP and Exports](image)

*Figure 1. Growth in China's GDP and Exports (in billions of yuan) 1978-2005*

Source: IMF International Financial Statistics
international trade and attracted a huge amount of foreign direct investment (Dées, 2001).

China’s economic growth has been fueled by the economic policies of the Chinese authorities. Although the free market theory supports minimum intervention of a government, the experiences of China have confirmed an important role of the government in carrying out economic reforms and implementing economic policies to cope with crisis (Chow, 2000). The Chinese government has successfully supported an export-led economic growth. Figure 1 presents the change in China’s nominal GDP and exports from 1978 to 2005.

The Chinese government also launched several currency reforms along with the economic reforms since the late 1970s. In January 1981, China devalued its currency by half and introduced a dual exchange rate: the official rate at 1.5 yuan per dollar and the internal settlement rate at 2.8. The authorities steadily devalued the official exchange rate in the 1980s and made a substantial single-step devaluation in 1986 and in 1989 (Lardy, 2005). In 1994, China unified the official and secondary exchange rate at the prevailing swap-market rate, 8.7 yuan per dollar. The unification of exchange rate led to an approximately 50% depreciation of the official exchange rate, with 7% effective devaluation. The Renminbi appreciated by about 5% from 1994 to 1997, until the Asian financial crisis in 1997 broke out. At the time of the Asian financial crisis, yuan reached a nominal level of 8.28 per dollar and the level has been fixed until the revaluation in 2005 (Eichengreen 2006). The Figure 2 shows the change in the yuan per dollar nominal exchange rate from 1994 to 2004.
The centrally planned system of the Chinese economy has substantially weakened. Unlike other centrally planned economies where the authorities intervene in the market for redistribution of the wealth, the Chinese government has intervened in the market to stimulate economic growth through economic reforms. The active engagement of the government in the market resulted in a remarkable economic growth of China today.

I.2. Choice of Exchange Rate Regime

After the Asian financial crisis in 1997, economists started advocating for a “corner solution” as an ideal exchange rate policy for a country. The corner solution suggests that a country should choose either a completely fixed exchange rate regime or a free floating regime because the intermediate regimes cannot be viable over the long-run.
The notion of a corner solution is based on the impossible trinity theory, which explains that the determination of exchange rate regime depends on the following three economic goals: exchange rate stability, monetary independence, and financial market integration. Figure 3 presents the diagram of the impossible trinity theory. The theory explains that an economy can attain any pair of these goals, but cannot achieve these three goals simultaneously. China chose exchange rate stability through a fixed exchange rate policy and gave up financial market integration by restricting international capital flow in and out of the country. A fixed exchange rate

Figure 3. The Impossible Trinity Theory

---

The intermediate regimes include adjustable peg, crawling peg, basket peg, target zone or band, and managed float (Frankel, 1999).
regime is known to restrict the monetary autonomy of a country's central bank. However, China was able to pursue an independent monetary policy along with the fixed exchange rate because China’s interest rate did not have to be determined by the world interest rate due to its sterilized intervention that restricts capital flow. Frankel (1999) recognizes a limitation of the corner solution of choosing a fixed exchange rate regime. He argues that the incapability of choosing all three goals simultaneously does not prevent an economy from giving up on two of the goals, or to have half-stability and half-independence. Moreover, for a large country such as China, a fixed exchange rate system is not likely to be sustainable.\textsuperscript{4} China is placed in a situation where it has to give up the fixed exchange rate policy because of its liberalized economy and reduced trade barriers. However, China tries to mitigate its overheating economy through cutting off government spending and raising domestic interest rates rather than revaluing its currency (Frankel, 2005).

There are several different opinions on China’s exchange rate regime about whether China has to maintain its fixed exchange rate or it has to switch to a more flexible one. Frankel (2005) insists that China needs to implement a more flexible exchange rate regime because its economy is large enough to have a stronger currency. Jinlong and Shengjun (2004) support a stable Renminbi exchange rate because it guarantees appropriate foreign capital inflows. They claim that a sudden shift to a free floating regime will cause large financial fluctuations, which can harm the health of the

\textsuperscript{4} Williamson (1991) suggests that a fixed rate regime can be pursued only when a country has a small open economy and is willing to set its inflation rate consistent with the rate of the country to whose currency it pegs. China does not satisfy these conditions.
Chinese economy. Instead of an immediate shift to a free floating, they suggest an exchange regime shift to a “narrow” band policy to China.

I.3. Consequences of Fixed Exchange Rate Regime

Although a firm-fixing exchange rate regime brings financial stability to a certain extent, it has several drawbacks. When an exchange rate is determined at a rate far from its equilibrium level, a fixed exchange rate policy would cause a permanent currency misalignment, misstating the value of foreign reserves and the trade. Historically, the countries with fixed exchange rates have experienced more currency undervaluation or overvaluation than the ones with floating regimes have because pursuing a fixed exchange rate policy requires a control over free international trade and financial asset level (Xu, 2004).

A fixed exchange rate can also cause a misstatement of the underlying current account balance. Lardy (2005) claims that China’s underlying current account surplus in 2003 and 2004 is significantly higher than the measured surplus because of an unsustainable expansion of the Chinese economy that is difficult to measure. Moreover, the fixed Renminbi has caused its trade-weighted value to decline since 2002.

Jinlong and Shengjun (2004) state that the Chinese central bank’s excessive intervention in the foreign exchange market is one of the shortcomings of the fixed Renminbi. Even though the foreign exchange market clears under the fixed Renminbi rate, this market clearing is an artificial balance under the intervention of the central bank. In addition, the fixed Renminbi rate increases the opportunities of arbitrage through illegal evasion of foreign exchange, which makes it difficult to manage the
capital account of foreign exchange earnings.

Another problem with the fixed exchange regime in China is that the fixed Renminbi prevents a more market-based monetary policy by limiting the extent of independent monetary policy (Eichengreen, 2006). Even though the Chinese central bank can maintain monetary autonomy through sterilized intervention in the foreign exchange market, international capital flows are hard to control in China’s rapidly growing economy. The central bank also has a burden of preventing the domestic inflation through insuring a growing foreign exchange reserve because a decrease of reserves results in inflation.

Roberts and Tyers (2003) suggest that China needs a more flexible exchange rate policy as its capital markets become more integrated with the world economy. A fixed exchange rate regime in a large open market can deteriorate the monetary autonomy, enlarge variation in prices and output due to increased capital mobility, and increase the risk of speculative attacks on the currency under adverse economic conditions. Having a fixed exchange rate against other currency does not make the exchange rate stay stable all the time because the target currency at which the exchange rate gets fixed can also become unstable (Goldstein, 2006).

I.4. Consequences of Currency Undervaluation

It is widely believed that the Renminbi has been undervalued during the last decade, even though the magnitude of the undervaluation has not been verified. Frankel (2005) claims that the real value of the Renminbi has been low, not only compared to the U.S. dollar, but also substantially below the equilibrium level for a country with a similar
economic development to China. If the Renminbi was truly undervalued as Frankel has suggested, what would be the consequences of the undervaluation?

Goldstein (2006) explains that the undervalued Renminbi causes speculative capital inflows and a large trade surplus in China that lead to a large accumulation of international reserves. The high level of foreign reserve accumulation can spill over into a rapid expansion of bank credit that affects the quality of loan decisions. This can result in serious fiscal consequences in the Chinese economy.

Jinlong and Shengjun (2004) suggest that the undervalued Renminbi does not have much stimulating effect on the export growth as it has been believed. They claim that for a sound export growth, steady growth of foreign direct investment must be secured through a stable and healthy macroeconomic environment and a stable exchange rate policy. Generating lower export prices and higher import prices through the undervaluation is not the best way to secure China's export growth even though this method can improve its trade surplus. Once the Renminbi is devalued, China’s import price rises and subsequently its export cost will rise because China uses many imported components to produce its export goods. Lower import prices can be beneficial because it can improve domestic industries through competitions between the domestically produced goods and the imported goods. Rather than creating positive impacts on export growth, the undervaluation may deteriorate trade conditions, discredit the Renminbi, and can cause further devaluation. In addition, keeping a low exchange rate does not make the exports substantially cheaper to foreign consumers because the exports of some products such as textiles are restricted by import quotas of the importing
countries.

The low value of the Renminbi does not only cause problems in the Chinese economy, but it also influences other currencies. Since the world economy is integrated, Renminbi undervaluation may cause a new round of devaluation of the currencies of neighboring countries. Alba (1999) studied systematic relationships between China’s and Southeast Asia’s exchange rates. Alba’s study found that the devaluation of the Renminbi in 1994 may have affected the returns and volatility of the currencies of Thailand and the Philippines.

Thus, if the Renminbi was truly undervalued, it would bring negative consequences to the Chinese economy and the world economy at once, deteriorating internal and external economic equilibrium.

I.5. After China’s Renminbi Revaluation in 2005

Following China’s revaluation of its currency in July 2005, economists started examining the effectiveness of the revaluation and the new managed floating exchange rate regime. There are two main perspectives on the recent Renminbi revaluation; some consider the revaluation sufficient while others claim that China is still in need for a substantial revaluation.

Eichengreen (2005) proposes a slight upward revaluation of the Renminbi with a gradual shift of the exchange rate regime from a pegged regime to a managed floating regime, supporting the 2005 revaluation. Eichengreen insists that a sudden revaluation can make the Chinese economy unstable. A small revaluation is better for controlling domestic credit and it allows the economy to easily adapt to a more flexible exchange
On the other hand, Goldstein (2006) suggests that the revaluation of the Renminbi in July 2005 was not large enough to correct the misalignment of the currency or to adjust the global payment imbalance. He insists that the Renminbi is still undervalued by a significant amount, even after the revaluation.

I.6. The Implication of China’s Exchange Rate Policy for the United States

The U.S. trade deficit is creating fears that it could hurt U.S. industries, destroy jobs in the U.S., and eventually harm the overall U.S. economy. The U.S. has been accusing China for enlarging the U.S. trade deficit through a large volume of low price exports to the U.S. Griswold (2001), however, states that the factors that cause trade deficits are mainly macroeconomic factors such as investment flows, not unfair trade barriers or losing competitiveness in international trade. Griswold further indicates that America’s trade deficit is still sustainable if the U.S. remains a safe and profitable place for world’s savings. Cooper (2005) states that the large U.S. current account deficit is not only sustainable, but it is a natural feature of today’s highly globalized economy.

Moreover, China is among half of the IMF member countries that maintain the fixed exchange rate regime, yet the U.S. blames only China for pegging its currency. Since China is considered a great threat to developed countries such as the U.S. because of its fast growing market power, the pressure on China to revalue its currency can be a political action to restrain China from becoming more influential in the world. It is possible that the actual misalignment of the Renminbi would not have as much negative impact on the U.S. economy as the U.S. authority has been claiming.
Thus, China’s exchange rate policy is not only a matter of international economics, but also a matter of international politics. It is important to identify whether the Renminbi is truly undervalued and to measure the extent to which it is undervalued. The second part of this paper examines the misalignment of the Renminbi and its effect on the U.S.-China bilateral trade balance through empirical analyses.

II. The Renminbi Exchange Rate and the U.S.-China Bilateral Trade Balance

II.1. Measuring Renminbi Misalignment through Estimation of the Equilibrium Exchange Rate

II.1.1. Equilibrium Exchange Rate: Theories and Approaches

The first task of measuring the misalignment of a currency is to determine the equilibrium real exchange rate. The equilibrium real exchange rate is the level of the real exchange rate that matches with the external equilibrium (a sustainable current account), and the internal equilibrium (the full-employment level) (Edwards, 1989). A currency misalignment is calculated through the difference between the actual real exchange rate and the equilibrium real exchange rate (the long-run equilibrium exchange rate, in most cases).\(^5\) Identifying and measuring the misalignment of a currency’s exchange rate – whether it is overvalued or undervalued – is a challenging task because it is difficult to estimate the equilibrium level which is the benchmark of the currency misalignment measurement. One of the major difficulties of determining the equilibrium real exchange rate is that the equilibrium level is not observable through

---

\(^5\) The long-run equilibrium exchange rate is distinguished from the current equilibrium exchange rate. According to Williamson (1983), the current equilibrium rate depends on temporary factors such as interest rates that fluctuate along the business cycle.
empirical data. Another difficulty is that different methods may identify different levels of equilibrium exchange rates. Among various approaches to the equilibrium real exchange rate determination, I introduce the following two approaches: the fundamental equilibrium exchange rate (FEER) approach and the behavioral equilibrium exchange rate (BEER) approach.

II.1.1.A. Fundamental Equilibrium Exchange Rate (FEER) Approach

The approach for assessing the long-run equilibrium exchange rate through economic fundamentals was developed by Williamson (1983). Williamson defines a currency misalignment as a “persistent departure of the exchange rate from its long-run equilibrium level.” He specifies the long-run equilibrium currency level as the fundamental equilibrium exchange rate (FEER). The FEER is the exchange rate “which is expected to generate a current account surplus or deficit equal to the underlying capital flow over the cycle, given that the country is pursuing ‘internal balance’ as best it can and not restricting trade for balance of payments reasons.” Thus, the FEER is consistent with macroeconomic balance that brings the current account into the equilibrium. This equilibrium is identified as the sustainable capital account set at full employment values with low and sustainable inflation, simultaneously achieving both internal and external balance. In order to determine the FEER level of a currency, one needs to find the size of the capital flows that maximize welfare of the economy.

The notion of the FEER is more conceptual and normative than practical. The FEER is the exchange rate that is consistent with internal and external balance, but it is difficult to identify the internal balance and the external balance in an economy because
of their ambiguity. Williamson (1994) identifies several shortcomings of determining the FEER that comes from the ambiguity of the normative notions of the internal and external balance. The internal balance implies high output level with the inflation control, which is unclear in identifying a unique value because the ‘control of inflation’ has to specify how far and how fast the inflation should be adjusted. The notion of the external balance is also normative. The external balance is achieved when a capital flow finances current account imbalance with no change in reserves. However, the balance cannot be achieved at a fixed level because different levels of interest rates change capital flows, subsequently affecting the level of current accounts and exchange rates. Due to the ambiguity in the notion of internal and external balance, the FEER is difficult to be determined through empirical data. However, the FEER model sets up guidelines for estimating the long-run equilibrium exchange rate.

II.1.1.B. Behavioral Equilibrium Exchange Rate (BEER) Approach

Clark and MacDonald (1998) point out that the FEER approach does not incorporate the effects of economic factors that influence the actual behavior of exchange rates. Even though the FEER approach estimates an equilibrium exchange rate level that remains unchanged as long as nothing disturbs the positions of internal and external balance, it is uncertain whether the exchange rate will be in equilibrium in a behavioral sense over the medium-run and the long-run. Clark and MacDonald introduce the behavioral equilibrium exchange rate (BEER) approach that “relates to the deviation between the actual exchange rate and the value given by the estimated equilibrium relationship.” The FEER model assesses the current value of a country’s real exchange
rate through considerable parameter estimations involving the current account model, the potential output level of the country, and the capital account equilibrium. In comparison, the BEER model calculates the equilibrium exchange rate level by using actual data of specified economic fundamentals that determine the actual real exchange rate. The BEER model is more flexible to use than the FEER model because one can choose the economic fundamentals to calculate the equilibrium rate according to the characteristics of the country’s economy such as trade patterns, economic policies, etc. Moreover, the BEER approach does not involve the concept of internal and external balance of economy, *per se*. Through estimating the equilibrium level of the economic factors, the BEER’s statistical approach in explaining the behavior of real exchange rates can be used to assess exchange rates in a similar way that the FEER approach is used.

Based on the framework of the BEER approach, several studies estimated the equilibrium exchange rate of the Renminbi in order to figure out about whether it has been undervalued compared to its equilibrium level. Zhang (2001) estimated the misalignment of the Renminbi based on data from 1950s, estimating the BEER through specified economic fundamentals. Zhang found the existence of a chronic overvaluation in China during the central planning period (pre-reform period, 1957-1977), a level that is closer to the equilibrium after the economic reforms (after 1978), and a substantial real depreciation of the Renminbi since 1981. Goh and Kim (2006) also used the BEER approach to estimate the misalignment of the Chinese currency. They found no evidence that the Renminbi has been undervalued during the last several years, claiming that the real exchange rate of the Renminbi has been quite close to the equilibrium level.
II.1.2. Estimation of Renminbi Misalignment through the BEER Model

The first piece of the empirical analyses of this paper determines whether the Renminbi has been substantially undervalued as it has been believed to be. This study estimates Renminbi misalignment through measuring the difference between the behavioral equilibrium exchange rate (BEER) and the real effective exchange rate (REER) as well as the difference between the BEER and the dollar per yuan bilateral real exchange rate.

II.1.2.A. Basic Framework

This section introduces the framework of estimating the behavioral equilibrium exchange rate based on the model introduced by Baffes et al. (1999). According to Baffes et al., the equilibrium real exchange rate is defined as the “steady-state” real exchange rate for given sustainable values of fundamentals. This concept is developed into the following equation:

\[
\ln e^*_t = \beta' F^p_t
\]

where:
- \( e^*_t \) = equilibrium real exchange rate
- \( F^p_t \) = vector of economic fundamentals

The natural log of the equilibrium exchange rate is used on the left hand side because the natural log makes it easier to identify the elasticity of the equilibrium rate with respect to the change of the economic fundamentals. The lower case \( t \) denotes the time period at which the data are measured. In order to estimate the parameter \( \beta \), we need an empirical model that is consistent with Equation (1) with observable variables of economic fundamentals. However, it is difficult to find the relationship between the real equilibrium exchange rate and the fundamentals because the equilibrium exchange rate
level is unobservable. In order to estimate the parameter of the economic fundamentals, therefore, we need to transform this equation into an equation of actual real exchange rate \((e_t)\) as a function of observable fundamentals with a disturbance term \((\omega_t)\) that is a mean-zero and stationary random variable.

\[
\ln e_t = \beta' F + \omega_t
\]  

(2)

The basic assumption of this theory is that the economic fundamentals automatically converge toward their equilibrium value. The shocks that cause the exchange rate to depart from its equilibrium in the short run should bring eventual convergence to the relationship in Equation (1). A vector error correction model (VECM) captures this feature of eventual convergence of the variables in the long-run while retaining the elements from both Equation (1) and Equation (2). The VECM can be represented as the following equation:

\[
\Delta \ln e_t = \alpha(\ln e_{t-1} - \beta' F_{t-1}) + \sum_{j=1}^{p} \mu_j \Delta \ln e_{t-j} + \sum_{j=0}^{p} \gamma_j \Delta F_{t-j} + \nu_t
\]  

(3)

where \(F_t\) is the vector of economic fundamentals and \(\nu_t\) is an independently identically distributed (i.i.d.), mean-zero, and stationary random variable. Equation (3) implies that the equilibrium real exchange rate can be identified econometrically.

This approach of estimating the equilibrium exchange rate is the BEER approach because the real exchange rate is determined by a specified set of observable explanatory variables. The BEER is not exclusively a long-run concept; rather this approach can be used to explain cyclical movements in the actual real exchange rate when we choose transitory economic fundamentals on the right hand side of the equation. However, the
BEER approach can measure the long-run equilibrium exchange rate through identifying the real exchange rate as a function of long-run economic fundamentals in the model. Zhang (2001) assumed that when the relationship in Equation (2) holds, the real exchange rate has a mean reversion property over the long-run, gravitating around the mean value. The mean of the cointegrated relationship between actual real exchange rate and economic fundamentals, therefore, can be identified as the equilibrium exchange rate which the actual real exchange rate approaches over the long run. In this relationship, we assume that the economic fundamentals that are measured empirically come close to their mean value, that is, the sustainable level.

II.1.2.B. Elements of the Long-Run Economic Fundamentals for the BEER Estimation

Based on this framework of the equilibrium exchange rate estimation, we can build a specific model by choosing a set of economic fundamentals to identify the level of an equilibrium exchange rate. There are many economic fundamentals that influence the level of the actual real exchange rate. Some of these fundamentals only have a transitory or a short-term effect on the real exchange rate and other fundamentals have a permanent effect on it over the long-run. Edwards (1989) suggested that in determining the economic fundamentals necessary to estimate an equilibrium exchange rate, it is important to distinguish the economic fundamentals that have long-run effects as permanent shocks from the ones that have short-run effects as temporary shocks.

Clark and MacDonald (1998) developed this framework further, suggesting the way to distinguish the long-run equilibrium exchange rate from the current equilibrium exchange rate in the BEER model. They identified that the current equilibrium
exchange rate consists of the long-run equilibrium exchange rate and the real interest differential, that is, the difference between the domestic real interest rate and the foreign real interest rate. This framework is expressed in the following equation:

\[ e_t = \bar{e} + (r_t - r_t^*) \]

\[ e_t = \text{current equilibrium exchange rate} \]

\[ \bar{e} = \text{long-run equilibrium exchange rate} \]

\[ r_t = \text{domestic real interest rate} \]

\[ r_t^* = \text{foreign real interest rate} \]

As shown in Equation (4), we subtract the real interest differential from the current equilibrium exchange rate to obtain the long-run equilibrium exchange rate level. This procedure enables us to eliminate the cyclical fluctuations of the current equilibrium rate that is caused by the changes in the real interest rate. The BEER estimation of this paper does not take account of the real interest rate differential, not only for the simplicity of the estimation, but also to focus only on the examination of the long-run equilibrium exchange rate.

Clark and MacDonald (2004) further assumed that the long-run equilibrium exchange rate has two variables in its function: the Balassa-Samuelson effect (the relative price of nontraded to traded goods) and net foreign assets.\(^6\) These factors satisfy the conditions that determine the long-run equilibrium exchange rate through simultaneous attainment of internal and external equilibrium. The sustainable level of the Balassa-Samuelson effect implies an internal equilibrium. In the internal equilibrium, the nontraded goods market clears in the current period and is expected to be in equilibrium.

---

\(^6\) In earlier work, Clark and MacDonald (1998) included terms of trade as one of the economic fundamentals that determines long-run equilibrium real exchange rate.
in the future as well. The sustainable level of net foreign assets implies the external equilibrium where the current account balance is compatible with long-run sustainable capital flows (Edwards, 1989).

On the other hand, Montiel (1999) identified several additional economic fundamentals that determine a long-run equilibrium exchange rate, consisting of the following categories: domestic supply-side factors, fiscal policy, changes in the international economic environment, and commercial policy. The domestic supply-side factors include the Balassa-Samuelson effect and the fiscal policy component includes the composition of government spending on traded and nontraded goods. The factors that are related to the changes in the international economic environment include terms of trade in domestic economy, external transfer availability, changes in the world real interest rates, changes in world inflation, etc. The commercial policy factor includes the degree of trade liberalization.

When we apply this concept of economic fundamentals to the estimation of the Renminbi equilibrium exchange rate, we need to consider unique economic fundamentals that reflect particular conditions of the Chinese economy and China’s economic relations to its trading partners. For example, the Chinese economy’s rapid growth and strong export sector have to be taken into account in estimating the long-run equilibrium exchange rate of the Renminbi. It is also important to note that China has limited data available on the economic fundamentals. We need to build the equilibrium exchange rate model for China based on the available economic data.

Zhang (2001), Goh and Kim (2006) have examined the misalignment of the
Chinese currency, identifying the difference between the equilibrium exchange rate and the actual real exchange rate. Zhang (2001) identified the long-run economic fundamentals as technological progress, government consumption, export growth rate, and the degree of openness to trade. Based on the data of these selected fundamentals, Zhang identified the equilibrium real exchange rate and examined the deviations of the actual real exchange rate from the equilibrium rate. Goh and Kim (2006) identified the economic fundamentals that affect the Renminbi exchange rate in the long run. Their results showed that government expenditure, the degree of openness, and technological progress affect the equilibrium exchange rate in the long run.

II.1.2.C. Model

This section introduces the model for estimating the behavioral equilibrium exchange rate (BEER) of the Renminbi and the method of calculating Renminbi misalignment. For the BEER estimation, the variables are chosen based on the results of previous studies on the similar topic that are mentioned in the previous section. The following equation is developed by expressing the equilibrium exchange rate as a function of the variables of the identified economic fundamentals.7

\[ \ln e^*_t = \beta_0 + \beta_1 \ln TOT_t + \beta_2 \ln NFA_t + \beta_3 \ln Open_t + \beta_4 \ln Invest_t + \omega_t \]  

(5)

---

7 I originally planned to include the following set of variables: terms of trade, the Balassa-Samuelson effect, net foreign assets, technological progress (measured as GDP per capita), government consumption, investment, and openness to trade. The data for the Balassa-Samuelson effect, that is, the price ratio of the traded goods to the non-traded goods, is not available for China. The variables of technological progress and government consumption are excluded from the model because they are either statistically insignificant or cause serious multi-collinearity among the variables. The terms of trade variable later gets dropped among the long-run fundamentals in the cointegration analysis later in this paper.
In this model, the relationship between the natural log of the real effective exchange rate (lnREER) and the economic fundamentals is examined to figure out the equilibrium level of the REER. All variables are expressed in the natural log form.

After estimating the long-run equilibrium exchange rate of the Renminbi, we can calculate Renminbi misalignment, that is, the difference between the actual real exchange rate and the long-run equilibrium exchange rate given by sustainable values of economic fundamentals in the long run.\(^8\)

\[ Misalignment_t = e_t - e_t^* \]  

Here, \( e_t \) is the actual real exchange rate and \( e_t^* \) is the long-run equilibrium exchange rate determined by Equation (5). The first piece of the empirical analyses of this paper identifies Renminbi misalignment in terms of the real effective exchange rate (REER), subtracting the calculated BEER from the REER. It also identifies Renminbi misalignment in terms of the dollar per yuan bilateral real exchange rate.

II.1.2.D. Results and Analysis

This section estimates the BEER based on quarterly data from 1994 to 2004. I decided to start the series of the real exchange rate and the economic fundamentals from

---

\(^8\) Clark and MacDonald (1998) distinguish the notion of current misalignment and total misalignment. Current misalignment is the difference between actual real exchange rate and real exchange rate given by the current values of economic fundamentals. The misalignment to be identified in this research is the total misalignment.
1994 because the dual exchange rate of the Renminbi was unified in 1994. If the data series includes the earlier years, the data of the variables can have a structural break in 1994, which can complicate the estimation. Since much of the quarterly data for China was available only up to 2004, I estimate my model over a ten-year span. In order to uncover the long-run relationship of the variables, this paper uses a vector error correction model (VECM) that provides long-run cointegrating vectors with short-run adjustment parameters. In a VECM, cointegrating vectors indicate the long-run relationship among the variables, and adjustment parameters indicate the short-run adjustment speed to the long-run equilibrium levels. In order to apply a VECM specification, one needs to verify whether each variable is non-stationary through a unit-root test.

Previous studies used the augmented Dickey-Fuller (ADF) test statistics to test the null hypothesis that there is a unit root against the alternate hypothesis that there is none.\(^9\) This paper uses the Dickey-Fuller-GLS (DF-GLS) test statistics instead of the ADF test, because DF-GLS test is known to have significantly greater power than the

---

augmented Dickey-Fuller test. The DF-GLS unit root test provides the maximum number of lags and the optimal lag length of a variable and shows the test statistics and the critical values for each lag.

The results of the DF-GLS test statistics are shown in Table 1. The DF-GLS test showed that all the variables, lnREER, lnTOT, lnOpen, lnNFS, and lnInvest, have a unit root. The variables that do not appear to have a unit root are excluded from the model.11

After verifying whether the variables have a unit root, I selected the lag order for the model according to the lag-order selection statistics. While the Swartz-Bayesian information criterion (SBIC) indicated 1 optimal lag, the final prediction error (FPE), Akaike’s information criterion (AIC), and the Hannan and Quinn information criterion (HQIC) all indicated 4 lags as optimal.

After selecting the lag order as 4 based on these statistics, I conducted the Johansen cointegration test for the set of variables that turned out to have a unit root. The Johansen cointegration test is an essential tool for estimating the number of cointegrating relationships in a multivariate model. In order to show evidence of cointegrating relationships in a multivariate model with \( K \) number of variables, the Johansen cointegration test should indicate \( r \) number of ranks, where \( 0 < r < K \). The maximum rank of zero indicates no cointegrating relationships among the variables.

---

10 See Elliott, Rothenberg, and Stock (1996) for further discussion about the DF-GLS techniques.
11 I decided to use the real effective exchange rate (lnREER) variable instead of the dollar per yuan bilateral real exchange rate (lnBRER) because the DF-GLS test does not show a strong unit root evidence for lnBRER. lnBRER’s DF-GLS tau statistic is -2.754 and the null hypothesis of having a unit root is rejected at the 10% level of significance (-2.690), at the optimal lag 5. The GDP per capita variable (lnGDPpc) was originally included in the model, but it is excluded because the DF-GLS test statistics does not show strong unit root evidence for the variable.
The variables can be non-stationary when \( r = 0 \), but the variables are not related to one another with the zero cointegrating rank. When the maximum rank indicates a full rank \( (r = K) \), all variables are stationary. In this case, there is no long-run trend among the specified variables. \( 0 < r < K \) is the only case where the variables exhibit long-run relationships that can be identified through a vector error correction model (VECM).

Table 2 reports the statistics for the Johansen cointegration test. The cointegration test showed that the model has at most two cointegrating ranks, at both 1% and 5% significance levels. This means that there are at most two cointegrating relationships \( (r \leq 2) \) among the specified variables. Based on the results of the cointegration test and the lag selection criteria, I chose 2 ranks and 4 lags in order to obtain the estimation of cointegrating relationships through a vector error correction model (VECM).

To estimate the coefficients of the cointegrating vectors, restrictions were imposed on the cointegrating relationships based on 2 cointegrating ranks. The VECM

<table>
<thead>
<tr>
<th>Maximum Rank (H0)</th>
<th>Eigenvalue</th>
<th>Trace statistics</th>
<th>5%</th>
<th>1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>105.5159</td>
<td></td>
<td>68.52</td>
<td>76.07</td>
</tr>
<tr>
<td>1</td>
<td>0.72379</td>
<td>56.6248</td>
<td>47.21</td>
<td>54.46</td>
</tr>
<tr>
<td>2</td>
<td>0.53678</td>
<td>27.3816*</td>
<td>29.68</td>
<td>35.65</td>
</tr>
<tr>
<td>3</td>
<td>0.38458</td>
<td>8.9342</td>
<td>15.41</td>
<td>20.04</td>
</tr>
<tr>
<td>4</td>
<td>0.16322</td>
<td>2.1629</td>
<td>3.76</td>
<td>6.65</td>
</tr>
<tr>
<td>5</td>
<td>0.05533</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Trend: Constant  
Lags: 4  
Obs.: 38

* The statistic is significant at both 5% and 1% Critical Value.
determines the coefficients of cointegrating vectors ($\beta$), and the parameters of the short-run adjustment speed ($\alpha$). With 2 cointegration ranks, the VECM produces two cointegrating equations by normalizing a different variable for each equation. I started by normalizing the lnREER as the first vector, and lnTOT as the second vector.\textsuperscript{12} Table 3 presents the results of the VECM specification that contain the coefficients of cointegrating vectors ($\beta$) and the short-run adjustment speed parameters ($\alpha$).

Based on the identified beta coefficients through the VECM specification, the following linear equation is estimated for the long-run relationship between the real effective exchange rate and the specified economic fundamentals.

\textbf{Table 3. Cointegration Analysis with Johansen Normalization Restrictions for BEER Model}

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta$</th>
<th>$\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnREER</td>
<td>1.0000000</td>
<td>-0.9003232</td>
</tr>
<tr>
<td></td>
<td>(-2.52)</td>
<td></td>
</tr>
<tr>
<td>lnTOT</td>
<td>Dropped</td>
<td>-0.1850648</td>
</tr>
<tr>
<td></td>
<td>(-1.69)</td>
<td></td>
</tr>
<tr>
<td>lnNFS</td>
<td>-0.3312781</td>
<td>0.8529916</td>
</tr>
<tr>
<td></td>
<td>(-16.65)</td>
<td>(0.96)</td>
</tr>
<tr>
<td>lnOpen</td>
<td>0.1771069</td>
<td>-2.9504440</td>
</tr>
<tr>
<td></td>
<td>(5.19)</td>
<td>(-2.07)</td>
</tr>
<tr>
<td>lnInvest</td>
<td>0.4628533</td>
<td>-0.1049330</td>
</tr>
<tr>
<td></td>
<td>(8.23)</td>
<td>(-1.16)</td>
</tr>
<tr>
<td>Constant</td>
<td>-5.4066180</td>
<td></td>
</tr>
</tbody>
</table>

Chi^2: 3096.336
P-value: 0.0000

\textsuperscript{12} Given set of variables (lnREER, lnTOT, lnNFA, lnOpen, lnInvest), I tried several different VECM specifications, changing the second vector of normalization each time. lnREER is always the first vector to be normalized because the purpose of this study is to find the long-run relationship between lnREER and other variables. For the second normalizing vector, I tested lnTOT, lnNFA, lnOpen, and lnInvest respectively. The results showed that setting lnTOT as the second normalizing vector gave the best result, showing that all three remaining $\beta$ coefficients of other variables are statistically significant.
\[
\ln BEER = 0.3312781 \ln NFS - 0.1771069 \ln Open - 0.4628533 \ln Invest \\
+ 5.406618
\]

(7)

In this model, all the variables are expressed in the natural log form. The sign of each coefficient is opposite from what appears on the result in Table 3 because the estimates of the VECM puts all the endogenous variables on one side of the equation. Since the estimated equation above puts all the variables except for \( \ln BEER \) on the right side of the equation, the sign of all the estimates of other variables change.

In Equation (7), a positive coefficient indicates that the increase in the variable causes an appreciation of the real effective exchange rate. The positive sign of the variable \( \ln NFA \) indicates that an increase in net foreign assets is likely to appreciate the Renminbi, which is consistent with the study of Clark and MacDonald (1998, 2004). An increase in either openness to trade or investment is likely to depreciate the Renminbi against other currency. This result is consistent with the study of Zhang (2001), which suggested that investment and openness to trade are likely to depreciate the Renminbi. The negative \( \alpha \) coefficient on \( \ln REER \) (\( \approx -0.9 \)) indicates that the real effective exchange rate adjusts negatively to the disequilibrium error of the real exchange rate with statistical significance. The variable \( \ln Open \) has a significant negative adjustment parameter whereas other variables, including \( \ln NFA \), \( \ln TOT \), and \( \ln Invest \), do not possess statistically significant adjustment parameters.

The movements of the real effective exchange rate (REER) and the calculated BEER from 1994 to 2004 are graphed in Figure 4. Figure 4 shows an interesting fact that the BEER actually moves along closely with the REER. Given that the increase in
the REER indicates an appreciation, the currency is considered undervalued when the REER line lies below the BEER line. Since the BEER in the Figure 4 is obtained through plugging quarterly data of the economic fundamentals directly into Equation (7), the level of the BEER appears to abruptly jump from one quarter to the next. The BEER in Figure 4 cannot be identified as the long-run equilibrium exchange rate because it is estimated by using the actual data of the economic fundamentals for each corresponding time period instead of using their equilibrium level. The BEER in Figure 4 reflects the behavioral equilibrium at each quarter, not the long-run equilibrium.

In order to figure out the long-run equilibrium exchange rate, one needs to identify the equilibrium levels of the economic fundamentals. Since equilibrium levels of the economic fundamentals are not observable, the fluctuating patterns of the data of
each variable are arbitrarily smoothed by the Hedrick-Prescott (H-P) filter.\textsuperscript{13} The long-run equilibrium exchange rate is calculated by simply plugging in the smoothed series of the variables in Equation (7). It is necessary to note that the equilibrium levels of the economic fundamentals derived by the H-P filter do not correspond to the notion of the internal balance of the full-employment level because they are arbitrarily calculated. Figure 5 shows the calculated long-run BEER whose economic fundamentals have been smoothed using the H-P filter. The REER of the Renminbi in this graph does not show any serious problem of undervaluation. The REER appears to fluctuate mildly around the equilibrium exchange rate level. The REER of the Renminbi appears to be undervalued prior to 1996, from 1999 to 2001, and after 2003. The result shows no evidence of persistent undervaluation of the Renminbi in terms of the REER. This

\textsuperscript{13} Clark and MacDonald (1998) also used the Hedrick-Prescott filter to smooth out the variables of economic fundamentals to estimate their equilibrium level.
finding is consistent with some of the previous studies on the measurement of Renminbi misalignment. Funke and Rahn (2005) estimated Renminbi undervaluation by estimating the BEER of the Renminbi. They found no evidence of serious undervaluation of the Renminbi in terms of the REER level. Goh and Kim (2006) also found that the Renminbi real exchange rate was near the equilibrium level in the past several years.

The results in Figure 4 and Figure 5 show the magnitude and the direction of Renminbi misalignment in terms of multilateral real exchange rates. Since the multilateral real exchange rate is different from the bilateral real exchange rate, the results so far do not explain Renminbi misalignment against the U.S. dollar in particular. In order to examine the misalignment of the bilateral real exchange rate, I transformed the BEER level into dollar per yuan level.14 Since it was unclear whether the Renminbi was overvalued or undervalued at the starting point of the observation (1994Q1), I arbitrarily assumed that the bilateral real exchange rate was exactly at the long-run equilibrium level for an easier transformation of the BEER into dollar per yuan level.15

Figure 6 presents the relationship between the dollar per yuan bilateral real exchange rate (BRER) and the transformed BEER. Arbitrarily considering its starting point to be at the equilibrium level, the bilateral real exchange rate is graphed with the

---

14 The bilateral real exchange rate is identified as \( \frac{E_{US} \cdot P_{China}}{P_{US}} \), where \( E_{US} \) refers to the nominal exchange rate (the U.S. dollar per yuan), and \( P_{China} \) and \( P_{US} \) refer to the price index of China and the U.S., respectively. In this study, the GDP deflator is used as the price index. For further discussion of the bilateral real exchange rate, see Hinkle and Nsengiyumva (1999).

15 The studies that examined the misalignment of the Renminbi provided inconsistent evidence about whether the currency was overvalued or undervalued in 1994. (Zhang (2001), Goh and Kim (2006), and Funke and Rahn (2005)).
transformed BEER. The graph shows that the bilateral real exchange rate has been undervalued since 1997 relative to the 1994 level, the period after the Asian financial crisis broke out and China started pegging its currency against the U.S. dollar. Figure 6 also shows that the magnitude of the bilateral real exchange rate rose again and came closer to the 1994 level in 2004. Since this estimation only uses the relative level of the BEER to calculate Renminbi misalignment, it is difficult to claim that the misalignment is correctly identified. The fact that the real dollar per yuan rate came closer to the arbitrary equilibrium level around 2004, however, shows us the Renminbi has not been permanently and substantially undervalued.

Thus, the BEER estimation shows that the Renminbi’s multilateral real exchange rate, the REER, has not been persistently undervalued during the past decade. On the other hand, the bilateral real exchange rate of the Renminbi in terms of the U.S. dollar
appears to be undervalued from 1997 to 2004 relative to the level in 1994 when the Chinese authorities unified the dual exchange rate system. However, both results do not show a persistent undervaluation in the real Renminbi.

II.2. Relationship between the Renminbi Real Exchange Rate and China’s Trade Balance with the United States

II.2.1. Model

This section examines the relationship between the yuan per dollar bilateral real exchange rate (BRER) and the China’s trade balance with the United States. To examine this relationship, I applied the approach that is used by Baharumshah (2001)’s study that examined the effect of exchange rate on bilateral trade balance of Malaysia and Thailand. This approach is based on the Mundell-Fleming framework that establishes a quantitative relationship between the real exchange rate and the resource balance. This model is not only simple, but it also captures the effect of the exchange rate and the income level of both the domestic and the foreign economy. The model is derived from the export supply and the import demand between a pair of trading partners in a bilateral trade, under the assumption that exports and imports are important substitutes. Under this assumption, the demand for imports is a function of relative price of imports and domestic GDP. This condition is expressed as,

\[ MD_D = MD_D (RP^M_D, Y_D), \]  

where \( MD_D \) is the domestic import demand, \( RP^M_D \) is the relative price of imports in terms of the domestic currency, and \( Y_D \) is the domestic GDP. The subscripts D and F denote

16 For a slightly different version of the framework, see Ahlers and Hinkle (1999).
domestic and foreign while the superscripts X and M denote exports and imports respectively. The relative price of imports in the domestic economy can be expressed as follows:

\[
RP_D^M = \frac{E_D \cdot P_F^X}{P_D} = \left( \frac{E_D}{P_D} \right) \left( \frac{P_F^X}{P_F} \right) = RER_D \cdot RP_F^X
\]  

(9)

Here, \( E_D \) denotes the nominal exchange rate, a unit of foreign currency in terms of domestic currency. \( P_F^X \) is the foreign export price in terms of the foreign currency, \( P_D \) and \( P_F \) respectively indicate domestic and foreign price index for all goods, \( RER_D \) is the bilateral real exchange rate defined as \( \left( E_D \cdot P_F / P_D \right) \), and \( RP_F^X \) is the relative price of foreign exports. When we substitute Equation (9) into Equation (8), we obtain the following import demand equation for the domestic economy:

\[
MD_D = MD_D \left\{ \left( RER_D \cdot RP_F^X \right) Y_D \right\}
\]  

(10)

The foreign import demand for domestic exports (\( MD_F \)) can be expressed in a similar way to Equation (10).

\[
MD_F = MD_F \left\{ \left( \frac{RP_D^X}{RER_D} \right) Y_F \right\}
\]  

(11)

Here, \( RP_D^X \) is the relative price of domestic exports to the foreign economy and \( Y_F \) is the foreign GDP level.

Since the domestic imports are equal to the foreign exports and vice versa, the domestic import demand (\( MD_D \)) is equal to the foreign export supply (\( XS_F \)), and the domestic export supply (\( XS_D \)) is equal to the foreign import demand (\( MD_F \)). This condition is expressed as follows:
From this condition, we can derive the domestic trade balance (TB) as the following ratio:

\[ \frac{MD_D}{MD_F} = \frac{XS_F}{XS_D} \]  \hspace{1cm} (12)

Even though the trade balance is usually defined as the arithmetic difference between the value of exports and imports, this study measures the trade balance as the ratio of the import value and the export value because it is easier to express in logarithmic form. \(^{17}\) Using a logarithmic form enables the coefficients to be interpreted as elasticity. It is also worth noting that when a ratio of exports and imports \((X/M)\) is transformed into the logarithmic form \((\log(X/M))\), the ratio can be expressed as the arithmetic difference between the log of exports and the log of imports \((\log(X) – \log(M))\).

Assuming that the relative price of exports in foreign and domestic economies \((RP^X_D, RP^X_F)\) are constant, we obtain a general equation derived from Equation (13).

\[ TB = TB(RER_D, Y_D, Y_F) \]  \hspace{1cm} (14)

Thus, the trade balance, the ratio of domestic exports to imports, is expressed as a function of the bilateral real exchange rate, the domestic GDP, and the foreign GDP. Taking the natural log on the both sides of the equation, we obtain Equation (15). Since this piece of analysis examines China’s trade balance with the United States, we apply the

---

\(^{17}\) Many studies that examined the relationship between real exchange rate and trade balance used the ratio of imports and exports to measure the trade balance. (Gomes and Senne Paz 2005, Onafowora 2003, Baharumshah 2001, etc)
data of China and the U.S.:

\[
\ln TB_{China,t} = \beta_0 + \beta_1 \ln Y_{China,t} + \beta_2 \ln Y_{US,t} + \beta_3 \ln RER_{China,t} + \varepsilon_t ,
\]

(15)

where \( \varepsilon_t \) is the statistical disturbance term. The sign on the coefficient of \( \ln RER \) is expected to be positive if the Marshall-Lerner condition holds, that is, if a real depreciation of the Renminbi improves China’s trade balance with the United States.\(^{18}\)

To examine the relationship between trade balance and real exchange rate in Equation (15), I apply a VECM specification and an impulse-response function.

II.2.2. Preliminary Results

To investigate the relationship between the Renminbi real exchange rate and China’s trade balance with the United States, I set up an equation with the following variables: the trade balance (\( \ln TB \)), denoted as the ratio of the nominal volume of the Chinese exports to imports, the level of China’s GDP and the U.S. GDP at constant price (\( \ln Y_{China} \), \( \ln Y_{US} \)), and the bilateral real exchange rate (\( \ln RER \)). Quarterly data from 1981 to 2004 are used for this empirical analysis. The bilateral real exchange rate in this section is identified as yuan per dollar (different from the RER used in the previous empirical analysis section).

Before applying the VECM to this multivariate model in Equation (15), each variable was tested through the DF-GLS unit root test. The results of the DF-GLS test statistics are presented in Table 4. The trade balance (\( \ln TB \)) and the bilateral real exchange rate (\( \ln RER \)) accept the null hypothesis of having a unit root whereas the China

\(^{18}\) The Marshall-Lerner condition states that, ceteris paribus, a real depreciation improves the trade balance, when export and import volumes are sufficiently elastic with respect to the real exchange rate (Krugman and Obstfeld, 2006).
GDP (ln$Y_{China}$) and the U.S. GDP (ln$Y_{US}$) do not show a strong unit root evidence. The test result of the variable ln$RER$ is not shown in Table 4 because its optimal lag is set at zero. The DF-GLS test does not show the test result at 0-lag. However, lnRER shows a strong evidence of the unit root at all other lags, accepting the null hypothesis of having a unit root.

I conducted different types of the unit-root tests to see whether other tests would also show the same results as the DF-GLS test. I conducted the KPSS test and the augmented Dickey-Fuller (ADF) Test with trend. The KPSS unit root test sets the null hypothesis as I(0) stationary process against the alternative hypothesis of having a unit root. The variables ln$Y_{China}$ and ln$Y_{US}$ significantly reject the null hypothesis of the KPSS test. The result of the KPSS test suggests that these two variables have a unit root. The ADF test shows that both ln$Y_{China}$ and ln$Y_{US}$ have a unit root as well. The results of the KPSS test and the ADF test are presented in Appendix B. Based on these three different kinds of unit root tests, I decided to include all the variables in the VECM specification.

<table>
<thead>
<tr>
<th>Table 4. Unit-Root Test (DF-GLS) for Trade Balance and RER model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>ln$Y_{China}$</td>
</tr>
<tr>
<td>ln$Y_{US}$</td>
</tr>
<tr>
<td>ln$RER$</td>
</tr>
</tbody>
</table>
II.2.3. Results and Analysis

The lag length of the model is selected through the lag selection order criteria. Since Akaike’s information criterion (AIC), the Hannan and Quinn information criterion (HQIC), and the Swartz-Bayesian information criterion (SBIC) all selected two lags, I applied two lags to specify the VECM with the set of variables. Johansen’s cointegration test indicates that this set of variables cannot reject the null hypothesis of one maximum rank, at both 5% and 1% levels of significance. The result of the Johansen cointegration test is shown in Table 5. Based on these tests, I specified the VECM with one cointegration rank and two lags to determine the coefficients of the cointegrating vectors.

The variable lnTB is normalized in the VECM specification because this study examines the effect of the foreign and domestic GDP and the real exchange rate on the trade balance. The estimates of the coefficients on the cointegrating vectors and the adjustment parameters are presented in Table 6. The results indicate that China’s GDP

<table>
<thead>
<tr>
<th>Maximum Rank (H0)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>5%</th>
<th>1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>56.2462</td>
<td>47.21</td>
<td>54.46</td>
</tr>
<tr>
<td>1</td>
<td>0.29442</td>
<td>22.7673*</td>
<td>29.68</td>
<td>35.65</td>
</tr>
<tr>
<td>2</td>
<td>0.12537</td>
<td>9.9077</td>
<td>15.41</td>
<td>20.04</td>
</tr>
<tr>
<td>3</td>
<td>0.09552</td>
<td>0.2693</td>
<td>3.76</td>
<td>6.65</td>
</tr>
<tr>
<td>4</td>
<td>0.00280</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trend: Constant</td>
<td>Lags: 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obs.: 96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at both 5% and 1% level
has a positive relationship to the trade balance and the U.S. GDP has a negative relationship to the trade balance; both relationships are statistically significant.¹⁹ The coefficient of the variable \( \ln RER \) indicates that a depreciation has a negative impact on the trade balance, contrary to the expectation; yet, its t-value indicates that it is not statistically significant. Thus, it does not appear that the Renminbi real exchange rate has a significant long-run relationship to China’s trade balance with the United States.

After obtaining the results of the VECM specification, I applied an impulse-response function (IRF) to examine how shocks in China’s GDP, the U.S. GDP, and the bilateral real exchange rate affect the trade balance in the short-run and in the long-run. I set \( \ln Y_{\text{China}} \), \( \ln Y_{\text{US}} \), and \( \ln RER \) as the impulse variables, and \( \ln TB \) as the response variable in the model. The results of the VECM-IRF are shown in graphs, in Figure 7-A and Figure 7-B.

¹⁹ Note that the signs of the coefficients of cointegrating vectors are interpreted in the opposite way as they are in the previous section of the BEER estimation.
Figure 7-A contains three graphs of the IRFs for a side-by-side comparison of the impact of each variable on the trade balance. In each graph, the horizontal axis indicates the time span measured in quarters and the vertical axis indicates the response of lnTB to one standard deviation shock of each impulse variable. Since the trade balance response is expressed in the natural logarithm, the magnitude of the response can be interpreted as the percentage change of China’s trade balance with the United States.

It appears that the shock in China’s GDP has a permanently positive impact on China’s trade balance with the United States. The U.S. GDP appears to have a small positive impact on the trade balance in the short run, but a permanent negative effect on China’s trade balance. Compared to the impact of the two countries’ GDP, the impact of the real exchange rate on the trade balance appears very small.
Figure 7-B shows an enlarged graph of the IRF that shows the impact of the real exchange rate on the trade balance. In order to effectively show the impact of the real exchange rate on the trade balance, the Y-axis that shows the magnitude of the trade balance response is re-scaled into smaller range than the one in Figure 7-A. It appears that in the short run, the real depreciation of the Renminbi against the U.S. dollar has a positive impact in the short run; however, this impact dies out as the time proceeds.

II.3. Renminbi Undervaluation and the U.S. Trade Deficit with China

The last piece of empirical analysis of this paper is to examine whether and the extent to which Renminbi undervaluation has impact on the U.S. trade deficit with China. Even though there are abundant studies on the relationship between real exchange rate and trade balance, no previous studies examined the effect of a country’s currency
misalignment on the magnitude of trade deficits of its trading partner. To examine the relationship between the level of Renminbi undervaluation and the U.S. bilateral trade deficit with China, I set up a very simple model, including two variables: the natural log of Renminbi undervaluation ($\ln\text{Under}_{\text{China}}$) and the U.S. trade deficit ($\ln\text{Deficit}_{\text{US}}$). I use the level of Renminbi undervaluation that is calculated in the first part of the empirical analysis section.\(^{20}\) The model is represented as the following equation:

$$
\ln\text{Deficit}_{\text{US}} = \alpha_0 + \alpha_1 \ln\text{Under}_{\text{China}} + \varepsilon_t, \\
$$

(16)

where the bilateral trade deficit of the U.S. against China ($\ln\text{Deficit}_{\text{US}}$) is a function of Renminbi undervaluation ($\ln\text{Under}_{\text{China}}$) and the random disturbance term $\varepsilon_t$ that is mean-zero and stationary. In order to use the natural log value for each variable in the model, the U.S. bilateral trade deficit is expressed as the ratio of the U.S. imports to the exports ($\ln(M/X)$, where $M$ is imports and $X$ is exports). The undervaluation here is expressed as the natural log of the ratio of equilibrium exchange rate to the actual real exchange rate ($\ln(BEER/RER_{\text{China}})$), so that the increase in the variable means increase in undervaluation. If the undervaluation of the Renminbi adversely influences the U.S. trade balance, the coefficient of the variable $\ln\text{Under}_{\text{China}}$ ($\alpha_1$) in the equation has to be positive.

To disclose the long-run relationship between Renminbi undervaluation and the U.S. bilateral trade deficit with China, I decided to conduct Johansen’s cointegration test in order to verify whether the two variables have a long-run relationship. 6 lags are

\(^{20}\) The calculated values of the dollar per yuan bilateral real exchange rate and the behavioral equilibrium exchange rate are used to set up the variable $\ln\text{Under}_{\text{China}}$. See Section II.1.2.D.
chosen for the estimation according to the following lag selection criteria: the final prediction error (FPE), Akaike’s information criterion (AIC), and the Hannan and Quinn information criterion (HQIC). The result of the Johansen test is shown in Table 7.

<table>
<thead>
<tr>
<th>Maximum Rank (H0)</th>
<th>Eigenvalue</th>
<th>Trace Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Statistic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>0</td>
<td>0.27786</td>
<td>9.9891</td>
</tr>
<tr>
<td>2</td>
<td>0.24231</td>
<td></td>
</tr>
</tbody>
</table>

Trend: Constant
Lags: 6
Obs.: 36

The Johansen test for cointegration rejects the maximum rank of one, which means that all the variables in the model are I(0) stationary. This indicates that there is no long-run relationship between Renminbi undervaluation and the U.S. trade deficit with China. Since the cointegration test indicates a full rank among the variables, the VECM specification is not feasible for this model. Thus, I decided to use a vector autoregression (VAR) representation to examine the impact of Renminbi undervaluation on the U.S. trade deficit with China. A graph of an impulse-response function (IRF) is used to show the impact of Renminbi undervaluation on the U.S. trade deficit.

Figure 8 presents the graph of the VAR-IRF, where \( \ln\text{Under}_{China} \) is the impulse variable and \( \ln\text{Deficit}_{US} \) is the response variable. The result of the IRF indicates that the undervaluation of the Renminbi causes some volatility in the U.S. trade deficit in the short run. Figure 8 shows that a shock of Renminbi undervaluation initially decreases

---

21 Even though the Swartz-Bayesian information criterion (SBIC) indicated 3 lags, this result is neglected here because all the other lag selection order criteria selected 6 lags.
the U.S. trade deficit by around 8%. After the initial negative impact, some positive impacts that reach up to 10% increase in the U.S. trade deficit are shown. However, the impact of Renminbi undervaluation on the U.S. deficit fluctuates around negative values and positive values. In the long-run, the fluctuating response of the U.S. trade deficit fades away as the impact of Renminbi undervaluation dies out.

The empirical analysis of Renminbi undervaluation and the U.S. bilateral trade deficit against China suggests that we cannot tell whether the undervaluation of the Renminbi has a permanent positive impact on the U.S. trade deficit in the long-run. It appears that the undervaluation of the Renminbi causes some volatility of the U.S. trade deficit with China in the short-run. The volatility in the U.S. trade deficit caused by Renminbi undervaluation appears substantial, ranging from -8% to 10%. This implies
that Renminbi undervaluation causes some short-run and medium-run instability in the U.S. trade balance, rather than a permanent adverse impact.

Conclusion

This paper analyzes China’s fixed exchange rate policy, the possible undervaluation of the Renminbi, and its impact on the U.S.-China bilateral trade balance. China’s accelerated economic development during the last decade has been fueled by export-led economic growth. The devalued Chinese Renminbi is considered one of the tools that has stimulated export expansion and led to economic development. It is widely understood that China’s fixed exchange rate policy during the last decade caused the undervaluation of the Renminbi. While the nominal level of the currency has stayed at a fixed level, the underlying real value of the currency has become stronger due to economic development and output increase. Previous studies indicate that an undervaluation of a currency results in some negative impact in the world economy without significantly creating positive effects. Renminbi undervaluation does not substantially increase Chinese exports. Since China uses many imported components to produce export goods, an increase in the import price subsequently increases the export price also, so that fewer goods are exported. The undervaluation can also cause a new round of devaluation of the neighboring countries, which can create shocks in international transactions. A persistent undervaluation is problematic acting as a disequilibrium in the financial market that causes both internal and external imbalances in the economy.
Through an empirical analysis, this paper tries to assess the undervaluation of the Chinese Renminbi using the behavioral equilibrium exchange rate (BEER) model, based on the framework developed by Baffes et al. (1999) and Clark and MacDonald (1998, 2004). The results indicate that the real effective exchange rate (REER) of the Renminbi has not been significantly undervalued, but has been mildly fluctuating around the BEER. On the other hand, the bilateral real exchange rate, dollars per yuan, appears to be undervalued after 1997 relative to the level in 1994 when China’s dual exchange rate system was unified. However, the results show that undervaluation of the bilateral real exchange rose again, coming close to the 1994 level in 2004. The results overall do not suggest that the Renminbi has been substantially and persistently undervalued.

In the second piece of the empirical analysis, the impact of the shock in bilateral real exchange rate (yuan per dollar) on China’s bilateral trade balance with the U.S. is examined through a vector error correction model (VECM). The result of the analysis indicates that the depreciation in the Renminbi against the U.S. dollar slightly increases China’s trade balance only in the short run; no large permanent impact on the trade balance is examined given the set of the data.

The third section of the empirical analysis examines the relationship between the magnitude of Renminbi undervaluation and the U.S. bilateral trade deficit with China, using a vector autoregression (VAR) representation. The result indicates that the shock of Renminbi undervaluation causes instability in the U.S. trade deficit with some fluctuations in the short-run and medium-run; however, there appears to be no permanent impact on the U.S. trade deficit.
Overall, the results of the empirical analysis suggest that the undervaluation of the Renminbi is not as problematic as has been assumed by many policymakers and commentators. The real depreciation of the Renminbi does not have a substantial positive impact on China’s trade balance, and the U.S. trade deficit appears not to be greatly affected by the level of Renminbi undervaluation.

It is important to note that estimates of the equilibrium exchange rate can differ greatly according to the method used for the estimation. The BEER model itself can have large variations in its result depending on the set of economic fundamentals chosen. A persistent undervaluation is problematic in theory, but it is difficult to identify the magnitude and the duration of a currency’s undervaluation due to the difficulty of estimating the equilibrium exchange rate.

Although Renminbi undervaluation does not appear to be very problematic in this study, it is still necessary for China to revalue its currency and switch its exchange rate regime to a more flexible type. China has maintained a fixed exchange rate through sterilized intervention in the foreign exchange market. As a result of this sterilized intervention, the People’s Bank of China (PBOC) has accumulated a huge amount of foreign reserves. A more flexible exchange rate regime would reduce the burden of the PBOC of holding large foreign reserves and would facilitate the transactions in the foreign exchange market. Since a fixed exchange rate does not substantially improve the Chinese exports, there is no reason for China to maintain a fixed exchange rate regime. Thus, I believe that the switch to a managed floating regime along with the Renminbi revaluation in 2005 was a good policy decision.
Given China’s growing significance in the world economy, there are a lot of possibilities for further research on China’s exchange rate policy. For example, identifying the misalignment of the Renminbi through different methods of the equilibrium rate estimation or measuring the impact of the 2005 revaluation on Renminbi misalignment and on the trade balance of China’s trading partners other than the U.S. are both plausible topics for future studies.
Appendix

Appendix A: Data Description

A.1. BEER Model

The sample period is from 1994-2004 and the data are quarterly. The descriptions of the variables and sources of the data are presented below.

Real Effective Exchange Rate

This is a multilateral real effective exchange rate of the Chinese currency relative to other countries. This data is derived from the nominal effective exchange rate index, which represents the ratio of an index of the currency’s period average exchange rate to a weighted geometric average of exchange rates for the selected currencies. The real effective exchange rate index represents the nominal effective exchange rate index adjusted for the relative movements in national price indicators of China and other countries. The index is expressed on the base 2000=100. In this index, an increase in the REER represents an appreciation of the currency.

(Source: IMF International Financial Statistics)

Terms of Trade

The terms of trade of a country is defined as the ratio of the domestic export price to the import price relative to the equivalent effective foreign ratio. The index is expressed on the base 2000=100. Since only the annual data was available for China’s terms of trade, the quarterly data are interpolated by the values that are derived by calculating the growth rate for each quarter; the growth rate is derived through the geometric average of the data between two consecutive years in the series.

(Source: The World Bank World Development Indicators database)
**Net Foreign Assets**

The net foreign assets are the total foreign assets minus the total liabilities to foreigners. Since the original data are not adjusted for the inflation, the data for each quarter are adjusted by the GDP deflator. The data are presented as 2000 price, in yuan.

(Source: IMF International Financial Statistics)

**Openness to Trade**

Openness to trade is the sum of the import CIF and export FOB, divided by the total GDP. To express the ratio as percentage, the each calculated value is multiplied by 100. The export, the import, and the GDP data that are used in the calculation are expressed as millions of the U.S. Dollars.

(Source: IMF International Financial Statistics)

**Investment**

Investment is measured by the gross fixed capital formation, which is the total value of a producer’s acquisitions subtracted by disposals, of fixed assets during the accounting period, plus additional values of some non-produced assets. The data are measured in yuan. Since the data are not adjusted for the inflation, the data are adjusted for the price change through China’s GDP deflator. The data are presented at the 2000 price.

(Source: IMF International Financial Statistics)

**Bilateral Real Exchange Rate**

The bilateral real exchange rate is expressed as dollar per yuan, so that an increase would indicate an appreciation of the currency. It is derived from the nominal
bilateral exchange rate and the price index, namely the GDP deflator, of China and the U.S. The data are derived by multiplying the nominal exchange rate and the China GDP deflator (2000=100), divided by the U.S. GDP deflator (2000=100).

(Source: IMF International Financial Statistics)

A.2. RER and Trade Balance Model

The sample period is from the first quarter of 1981 to the second quarter of 2005 and the data are quarterly. The descriptions of the variables and sources of the data are presented below.

Trade Balance

Trade balance here is the bilateral trade balance from the U.S.-China trade. In this section, it is defined as the ratio between the volume of China’s exports to the U.S. to the volume of China’s imports from the U.S. The trade balance is identified as the ratio instead of the difference between the exports and the imports because the data are analyzed in the natural log form in the model. The data of exports and imports are measured in millions of the U.S. dollars.

(Source: IMF Direction of Trade Statistics)

China GDP

China’s GDP is expressed in yuan. Since only annual data are available for China’s GDP, they are transformed into quarterly data. The data from each period is divided by 4, and the growth rate for each quarter is calculated to interpolate the quarterly data. Since the original data from the source are not adjusted for the inflation, they are adjusted by using the GDP deflator. The data are adjusted to the 2000 price.
(Source: IMF International Financial Statistics)

U.S. GDP

The U.S. GDP is expressed in the U.S. dollar, at the 2000 price.

(Source: IMF International Financial Statistics)

Real Exchange Rate

The real exchange rate in this section is the bilateral real exchange rate, expressed as yuan per dollar. It is derived from the nominal bilateral exchange rate and the price index of China and the U.S. The GDP deflator is used as the price index. The data are derived by multiplying the nominal exchange rate and the U.S. GDP deflator (2000=100), divided by the China GDP deflator (2000=100).

(Source: IMF International Financial Statistics)

A.3. Renminbi Undervaluation and the U.S. Deficit Model

U.S. Trade Deficit

The U.S. trade deficit in this section is the U.S. bilateral trade deficit against China. It is defined as the ratio of the U.S. imports from China to the U.S. exports to China. The ratio is used instead of the arithmetic difference because it is expressed in the natural log form in the model.

(Source: IMF Direction of Trade Statistics)
Appendix B: KPSS and ADF Unit Root Test Results of lnY\textsubscript{China} and lnY\textsubscript{US}

Table B-1. Augmented Dickey-Fuller Unit Root Test Result for China GDP (lnY\textsubscript{China}) and U.S. GDP (lnY\textsubscript{US})

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF</th>
<th>1%</th>
<th>5%</th>
<th>10%</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnY\textsubscript{China}</td>
<td>-0.974</td>
<td>-4.047</td>
<td>-3.453</td>
<td>-3.142</td>
<td>0.9476</td>
</tr>
<tr>
<td>lnY\textsubscript{US}</td>
<td>-1.736</td>
<td>-4.040</td>
<td>-3.450</td>
<td>-3.150</td>
<td>0.7347</td>
</tr>
</tbody>
</table>

Table B-2. KPSS Unit Root Test for lnY\textsubscript{China} and lnY\textsubscript{US}

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lag</th>
<th>KPSS stat.</th>
<th>10%</th>
<th>5%</th>
<th>1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnY\textsubscript{China}</td>
<td>0</td>
<td>0.778</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.394</td>
<td>0.119</td>
<td>0.146</td>
<td>0.216</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.266</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.204</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnY\textsubscript{US}</td>
<td>0</td>
<td>0.503</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.259</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.178</td>
<td>0.119</td>
<td>0.146</td>
<td>0.216</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.138</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.115</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
References


*World Economy* 28, no. 4:465-489.

Goh, Ming H., and Yoonbai Kim. 2006. Is the Chinese Renminbi Undervalued? 


