

Research on Equilibrium Exchange Rate of RMB - Tendency Prediction and Empirical Test between Exchange Rate and Trade Balance

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Abstract—This paper studies the equilibrium exchange rate of RMB. According to the ERER theory, using data from China Statistical Yearbook, China Balance of Payments Statistics, Bank for International Settlements, National Bureau of Statistics, General Administration of Customs and Wind database, this paper considers tariffs, trade barriers, government fiscal policies, and capital flows between countries as well as analyzes the balance of the trading market. The results show that the actual effective exchange rate of the common name currency fluctuates slightly around the equilibrium exchange rate. The main contributor to China's trade surplus is domestic and foreign income instead of the RMB exchange rate. In addition, this article predicts that China's technological progress will have a significant impact on the RMB equilibrium exchange rate. Since China is a developing country, the continuous improvement of technological level has stimulated the appreciation of the renminbi. At the same time, technological progress in the United States has a devaluation effect on the renminbi. This will lead to an increase in the number of high-tech products exported by the United States to China and an increase in the demand for the U.S. dollar in the Chinese foreign exchange market, leading to the appreciation of the U.S. dollar and the relative depreciation of the renminbi. Finally, the interest rate shocks in China and the United States have little effect on the equilibrium exchange rate of the renminbi. In summary, this article proposes to vigorously develop my country's non-trade industries based on the "Balassa-Samuelson" effect. What's more, the process of interest rate marketization should be accelerated.

Keywords-ERER theory model; Johansen co-integration test; China's trade surplus; Balassa-Samuelson effect; J curve effect

1 INTRODUCTION

Since the 1990s, there have been many monetary crises in various countries, leading to turbulence in the international financial market; thus the exchange rate system of different countries has been constantly adjusted. Since 2005, the exchange rate of China's RMB against the US dollar has appreciated by about 30%. However, there have been widespread controversies on RMB's reasonable valuation, China's chronic trade surplus and RMB's exchange rate imbalance.

In the context of globalization, RMB should be internationalized, and the reformation of RMB has become accelerating. After the Asian financial crisis, currencies in East Asia and Southeast Asia had dramatically depreciated, bringing shocks to the exporting industries and causing a great depression. Under the pessimistic economic background, many firms closed down and millions of people became unemployed. At that time, the RMB was taught to depreciate, just like other currencies. Due to modest trade openness and excellent government handling, mainland China was barely affected and RMB did not significantly depreciate. After joining WTO in 2004, China's economy took off, and the talk of the appreciation of RMB began to appear.

The debate about whether RMB should appreciate has caused many economic and political disputes. There are frequent trade frictions between China and the U.S.; the U.S. government blames the undervaluation of RMB for economic problems and thus transfers the domestic contradictions. In 2010, then-President Obama pointed the finger at China in his speech and publicly called for China to adopt a market exchange rate system [1]. After that, in 2011, he applied new legislation to slap punitive tariffs for manipulating currency, intending to label China as a currency manipulator. Ben Bernanke, chairman of the Federal Reserve, has also said that China's response to the inflation problem is not to let the RMB appreciate but to restrain domestic demand by raising interest rates based on a constant exchange rate. In recent years, the core contradiction of the trade war between China and the U.S. is also about the great trade surplus caused by the reasonableness of RMB's exchange rate. The U.S. government has imposed \$200 billion of tariff on China's exported goods and services, intending to "punish" China for the dollar earned from the U.S. by "undervalued" RMB for many years [2].

The research on the reasonableness proof of RMB has become one of the most heated political focuses. To solve this problem, it is necessary to calculate the exchange rate that an economy applies to achieves equilibrium both inside and outside. By comparing the exchange rate with the actual effective exchange rate, the real exchange rate level of the economy under the current economic environment can be judged.

There are valuable meanings in the research of RMB's equilibrium exchange rate. Firstly, with the internationalization of RMB on track, a reasonable and adequate exchange rate policy plays an important role in economic growth. The measured equilibrium exchange rate of RMB can be a reference of the effective exchange rate, promoting a healthy operation of the economy. Moreover, since the reform and opening up, China has been thought to be an export-relying country. With the growing trade surplus, many countries have criticized that China controlled the currency to earn export competitiveness. Therefore, studying whether the valuation of the RMB exchange rate is reasonable is conducive to refuting the criticism from abroad. In this paper, by using rigorous academic methods and collecting reliable data, I will work out the equilibrium exchange rate of RMB, analyze and evaluate the current situation of the RMB exchange rate, and give some personal suggestions.

2 LITERATURE REVIEW

In 1964, Samuelson (1964) found out that productivity levels that produced the goods are different [3]. The resulting trade exchanges between the two countries when prices of the different exchange rates are not the utterly consistent equilibrium exchange rate, and the

equilibrium exchange rate will differ as a result of other factors such as productivity and produce distortion. It cannot be fully expressed in terms of the purchasing power of the two countries.

Dixit and Stiglitz (1979) changed the applicable scope of the PPP theory and proved that the real exchange rate would no longer become stable as predicted by traditional PPP and parity due to micro factors such as labor productivity [4].

Chinese researchers also made many contributions to the development of PPP theory: Yu Qiao (1998) calculated the price index in China from 1992 to 1997 [5]. It is concluded that the exchange rate of RMB is significantly overvalued against major currencies (such as the US dollar) in the framework of purchasing power parity theory, and it is even more overvalued in countries with more trade exchanges with neighboring countries. In their research published in the 21st century, Li Yaxin and Yu Ming (2002) believed that the RMB exchange rate was always undervalued compared with its own economic development from the reform and opening up to 1995 [6]. Since 1996, peripheral countries were seriously affected by today's Asian crisis, and the RMB began to overvalue in 1997 and 1998, and then the overvalue gradually narrowed.

Jin Zhongxia (1995) calculated the equilibrium exchange rate of RMB from 1978 to 1981, 1985 to 1987 and 1991 to 1993 based on the FERR model. And the equilibrium exchange rate from 1970 to 1977, 1982 to 1984 and 1988 to 1990 was undervalued [7].

Zhang Guangbin and Li Xiaoqin (2003) analyzed the FEER theory and established an empirical model based on FEER [8]. A series of empirical analyses found that the RMB exchange rate did not exhibit misalignment at the macro level and its valuation was in line with the equilibrium exchange rate under the current state. The use of the research of domestic scholars is tiny, and the conclusion is far, the basic element which can explain the currency equilibrium theory temporarily does not comply with the conditions of developing countries in our country, because our country does not conform to the model's assumptions for a long time. As a result, it can't reflect the equilibrium exchange rate's actual situation.

Under the research of many Chinese scholars, the equilibrium theory of exchange rate of basic factors does not conform to the theory of developing countries in China temporarily because China does not conform to the premise hypothesis of the model for a long time, and the results cannot reflect the most practical situation of China's equilibrium exchange rate.

Tang Yahui and Chen Shoudong (2010) used the Beer model to measure the changes in the equilibrium exchange rate of RMB after being disturbed by sudden historical factors [9]. They focused on analyzing the change of the equilibrium exchange rate of RMB when the Asian financial crisis occurred around 1997. The Beer mode focuses on historical events, which are subjectively determined to be the disturbance of sudden factors. The inflection points of the equilibrium exchange rate of RMB measured based on the Beer Model were all in the period of exchange rate reform in 2005. From the Asian financial crisis to the exchange rate reform, the RMB exchange rate was undervalued. However, due to the differences in selecting key events, the resulting final degree is quite different.

Stein (1994) initially put forward the theory of NATREX in his paper and explained the exchange rate of the United States and other countries [10]. The changing trend of the exchange rate is the same as the change trend of microeconomic factors used, which is also consistent with the actual situation.

Chu Youyang (2004) found that the RMB exchange rate had been undervalued from 1977 to 1994, but it did not get rid of the undervalued state until 1995 and gradually overvalued [11]. In particular, due to the Asian financial crisis in 1997-1998, the depreciation and overvaluation of currencies in peripheral countries increased. Interest rates rose sharply in 1999 to prevent the economy from overheating and the government intervened to cool it. At this time, due to the slowdown of economic growth, the RMB exchange rate depreciated, but the overvalued state still lasted until 2001 before China entered the WTO.

Zhang Xiaopu (2000) recorded the impact of various real variables on the equilibrium exchange rate of RMB since 1978 in his revised ERER model, and these variables significantly affected the trend of the equilibrium exchange rate of RMB [12]. The final conclusion shows that the RMB exchange rate has been significantly undervalued twice since the reform and opening up.

Wang Weiguo and Huang Wanyang (2005) published an article on the equilibrium real exchange rate model of RMB in 2005 [13]. The variable selection and empirical conclusions in this paper provide a very powerful study on the equilibrium exchange rate of RMB. In his research, there is a co-integration relationship between RMB real effective exchange rate and domestic macroeconomic indicators. In the error correction model, it is found that the RMB exchange rate has the ability of correction and the ability of correction is very strong, which shows the resilience of China's economy. The final conclusion shows that the real exchange rate in 2001 was 7.8% higher than the equilibrium exchange rate, the real exchange rate in 2002 was 4.1% higher than the equilibrium exchange rate, and the real exchange rate in 2003 was 3.9% lower than the equilibrium exchange rate.

3 FUNDAMENTAL THEORY

3.1 Purchasing Power Parity Theory (PPP)

The theory of purchasing-power parity holds that the domestic purchasing power of a country's currency is equal to that of its currency abroad. The core idea is that, ideally, when the local currency is converted into a foreign currency equivalent, goods and services purchased abroad are indistinguishable from goods and services received at home. According to the theory of absolute purchasing power parity put forward by Cassel in the early 1920s, the exchange rate between countries is related to the number of commodities that their currencies can buy in the two countries respectively. And the purchasing power level of a country's currency is negatively correlated with the price level [14]. If the inflation rate is different between the two countries, the long-term currency's ability to buy goods will change, and the country's currency experiencing inflation will depreciate. Although under this theory, external factors will affect the exchange rate in the short term, the real exchange rate will fluctuate between purchasing power equilibrium in the long term. The two real price levels required in absolute purchasing power parity are difficult to obtain, so the theory of relative purchasing power parity comes into being. In the theory of relative purchasing power parity, the currency exchange rate in the base period is obtained. That PPP exchange rate is the product of the rate of exchange of the price level of two countries in a certain period and the exchange rate in the base period.

3.2 Fundamental Equilibrium Exchange Rate (FEER)

In the early 1980s, Williamson raised the basic factor equilibrium exchange rate theory [15]. The capital account was introduced for the first time as an equilibrium determinant of exchange rates. For the first time, this theory divides the situation when an economy reaches equilibrium into internal and external aspects. Internal equilibrium is the output under the condition of low and continuous inflation and full employment. External equilibrium is the state of long-term capital flows between two economies.

The FEER model focuses on the current account, ultimately for macroeconomic equilibrium. The current account expresses the relationship between aggregate domestic and foreign output and demand and the real effective exchange rate. FEER model can calculate equilibrium exchange rate according to domestic and foreign total output, demand and capital account.

3.3 Behavioral Equilibrium Exchange Rate Theory (BEER)

Clark and MacDonald raised the Beer model in 1998 [16]. Based on macroeconomic factors, internal and external equilibrium, the model also puts forward the concept of time direction, taking into account medium - and long-term direction, short-term temporary changes and some sudden factors in the world, which is widely applicable.

The situation of internal and external equilibrium has not been considered by the behavioral equilibrium theory. Secondly, the different understanding of the impact of major events will cause fundamental differences in the final paper results. Therefore, the persuasion of this model is also questionable.

3.4 Natural Real Exchange Rate Theory (NATREX)

NATREX is raised by Stein in 1994. The theory is mainly based on the micro-level and external equilibrium. This theory does not consider the periodicity of economic development and the change of the external environment, and only studies the equilibrium exchange rate with the balance of international payments as the main entry point. The basic points of this theory are: (1) micro-factors such as residents' productivity can explain the trend of real exchange rate; (2) The influence of external debt on the equilibrium exchange rate is reflected in the direction of external debt use; (3) Current account improvement is achieved through non-monetary and trade policy methods, such as changing the balance between investment and savings.

3.5 Equilibrium Real Exchange Rate Theory (ERER)

Edwards first put forward the equilibrium fundamental exchange rate theory in 1989 [17]. Later, Edwards (1994) added internal and external influence conditions and some restrictive assumptions based on the original theory, further completing the theory [18]. The main content of this theory is the price of tradable goods relative to Non-traded goods, in this relative price of internal and external equilibrium at the same time. This model studies the fundamental factors that affect the equilibrium exchange rate and puts forward the influence of trade, tariffs, foreign capital and technology. Empirical research shows that macroeconomic variables are the main factors affecting the long-term equilibrium real exchange rate. In the short term, the real exchange rate is also affected by monetary disturbances.

The above researches show that equilibrium real exchange rate theory is the closest to China's reality among the current major exchange rate determination theories.

Uzun, Samuel H. Szewczyk and Raj VarmaUzun, Samuel H. Szewczyk and Raj VarmaUzun, Samuel H. Szewczyk and Raj VarmaUzun, Samuel H. Szewczyk and Raj VarmaBasic Assumption:

Equilibrium real exchange rate (ERER) is the relative price of non-traded goods and tradable goods. The internal equilibrium is generated by variables such as tariffs, trade barriers, government fiscal policies, and capital flows between countries. When clearing, internal equilibrium is achieved; external equilibrium is achieved when the current and future current account balances are consistent with long-term sustainable capital.

4 DERIVATION OF THE REVISED ERER MODEL

The internal equilibrium of the Equilibrium Real Exchange Rate (ERER) is determined by tariffs, whether there are trade barriers, government fiscal policies, capital flows between countries, etc. It is the price of traded goods relative to non-traded goods. When the Non-traded market is cleared now and in the future, internal equilibrium will be achieved; external equilibrium will be achieved when the current and future current account balances are consistent with long-term sustainable capital flows.

Let's begin with the internal equilibrium:

$$A = EXP_P + EXP_G \quad (1)$$

In (1), A is the domestic absorption, EXP_P is the total expenditure in private sector, EXP_G is the total expenditure of government sector. Internal equilibrium requires the clearing of the Non-traded goods market, Non-traded goods expenditure could be considered:

$$EXP_N = EXP_{PN} + EXP_{GN} \quad (2)$$

EXP_{PN} and EXP_{GN} are the total expenditure on Non-traded goods of private and government sectors.

$$EXP_{GN} = g_n \cdot EXP_G = g_n \cdot g \cdot GDP \quad (3)$$

In (3), g_n is the proportion of the expenditure on goods to the total government expenditure, g is the proportion of the government expenditure to GDP .

According to the previous assumption, the price of private sector spending on Non-traded goods is mainly affected by the prices of domestic tradable goods and Non-traded goods, thus:

$$\begin{aligned}
EXP_{PN} &= d_{PN}(P_{IM}, P_{EX}, P_N) \cdot EXP_P \\
&= d_{PN}(P_{IM}, P_{EX}, P_N) \cdot (A - EXP_G) \\
&= d_{PN}(P_{IM}, P_{EX}, P_N) \cdot (A - g \cdot GDP)
\end{aligned} \tag{4}$$

Substitute (2) and (3) into (4), we can get the expenditure function (5) of Non-traded goods:

$$\begin{aligned}
EXP_N &= EXP_{PN} + EXP_{GN} \\
&= d_{PN}(P_{IM}, P_{EX}, P_N) \cdot (A - g \cdot GDP) + g_n \cdot g \cdot GDP
\end{aligned} \tag{5}$$

Ideally, the aggregate demand for Non-traded goods equals to the expenditure to it, thus we can get the formula (6):

$$\begin{aligned}
DEP_N &= EXP_N = d_{PN}(P_{IM}, P_{EX}, P_N) \\
&\quad \cdot (A - g \cdot GDP) + g_n \cdot g \cdot GDP
\end{aligned} \tag{6}$$

The prices of the three types of goods affect the proportion of the supply of Non-traded goods to the *GDP*, see formula (7):

$$S_n = S_n(P_{IM}, P_{EX}, P_N) \cdot GDP \tag{7}$$

When the internal equilibrium is reached, the aggregate supply of Non-traded goods equal to the aggregate demand of Non-traded goods, see formula (8):

$$\begin{aligned}
d_{PN}(P_{IM}, P_{EX}, P_N) \cdot (A - g \cdot GDP) + g_n \cdot g \cdot GDP \\
= S_n(P_{IM}, P_{EX}, P_N) \cdot GDP
\end{aligned} \tag{8}$$

Subtract *GDP* for both side of the equation and we get formula (9):

$$d_{PN}(P_{IM}, P_{EX}, P_N) \cdot \left(\frac{A}{GDP} - g \right) + g_n \cdot g = S_n(P_{IM}, P_{EX}, P_N) \tag{9}$$

The prices of internationally traded goods imported and exported are determined by the international prices, which are P_{IM}^* and P_{EX}^* (denominated in US dollars) respectively. Generally speaking, developing countries have tariffs to a certain extent as trade protection, which are represented by net import and export tax rates, net import tax rates t_{IM} and net export tax rates t_{EX} .

$$P_{EX} = E \cdot (1 - t_{EX}) P_{EX}^* \tag{10}$$

$$P_{IM} = E \cdot (1 - t_{IM})P_{IM}^* \quad (11)$$

In (1.12) and (1.13), E represents the nominal exchange rate, the real exchange rate e is expressed as $e = E \cdot \frac{\text{Price of foreign goods}}{\text{Price of domestic goods}}$, which is:

$$e = E \cdot \frac{P^*}{P} \quad (12)$$

Substitute (10), (11) to (12), since the price of international traded goods cannot be subtracted by the price of Non-traded goods, the real exchange rate can be expressed by:

$$e = \frac{P_N}{E \cdot P_{EX}^\alpha \cdot P_{IM}^{(1-\alpha)}} \quad (13)$$

Substitute the equation from (1) to (8) into (13), the equation of the real exchange rate influencing factors for the equilibrium of non-traded goods can be obtained, which is:

$$e = e\left(\frac{A}{GDP}, f(P_{IM}^*, P_{EX}^*), t_{IM}, t_{EX}, \frac{EXP_G}{GDP}\right) \quad (14)$$

In (14), $f(P_{IM}^*, P_{EX}^*)$ represents how the price of internationally traded goods affects the real exchange rate. The price of internationally traded goods for import and export is determined by the terms of trade of each country. Since the domestic inflation rate of both parties is not considered when the import and export traded goods are traded, the ratio of average CPI in developed regions to domestic CPI (CPI) in developed regions is added to the long-term trade. The price of the product is revised to prevent situations such as “internal depreciation and external rise”, denote $f(P_{IM}^*, P_{EX}^*)$ with $TRA \cdot CPI$, and write (14) as linear:

$$\begin{aligned} \log(e) = & \alpha_0 + \alpha_1 \log\left(\frac{A}{GDP}\right) + \alpha_2 \log(TRA) \\ & - \alpha_3 \log(OPEN) + \alpha_4 \log\left(\frac{EXP_G}{GDP}\right) + \alpha_5 \log(CPI) \end{aligned} \quad (15)$$

$OPEN = \frac{Import + Export}{GDP}$, and it reflects the import and export tariff rate, trade environment, terms of trade, exchange control and other factors. Looking at the external conditions again, the current account balance $CA = GDP - A$. In external equilibrium, the current account balance is equal to the capital account balance $CA = KA$, which will be affected by capital flows between countries, domestic and foreign interest rates, and forward exchange rates, as shown in the formula (16):

$$KA = f(NCI, r_t^*, EXP_N, [t(\log(e_{t+1})) - \log(e_t)]) \quad (16)$$

In the formula (16), NCI represents the net capital inflow, r_t^* represents the domestic and foreign interest rate differential, EXP_N non-traded goods expenditure, $t(\log(e_{t+1}))$ represents the expected value of the real exchange rate at time $t + 1$ at time t , due to the external equilibrium, $CA = KA$. Substituting formula (6) into formula (16), we get:

$$\frac{A}{GDP} = 1 - f\left(\frac{NCI}{GDP}, r_t^*, EXP_N, \sigma, [t(\log(e_{t+1})) - \log(e_t)]\right) \quad (17)$$

In (17), σ represents the proportion of non-tradable goods expenditure in total consumption, which is a constant. Therefore, the linear function is:

$$\log\left(\frac{A}{GDP}\right) = \beta_0 + \beta_1 \log\left(\frac{NCI}{GDP}\right) + \beta_2 \log(r_t^*) - \beta_3 \log([t(\log(e_{t+1})) - \log(e_t)]) \quad (18)$$

In order to find the equilibrium exchange rate when internal and external equilibrium is reached, substituting (18) into (15), we have (19):

$$\begin{aligned} \log(e_t) = & \alpha_0 + \alpha_1(\beta_0 + \beta_1 \log\left(\frac{NCI}{GDP}\right) + \beta_2 \log(r_t^*) \\ & - \beta_3 \log([t(\log(e_{t+1})) - \log(e_t)])) \alpha_0 \\ & + \alpha_1 \log\left(\frac{A}{GDP}\right) + \alpha_2 \log(TRA) - \alpha_3 \log(OPEN) \\ & + \alpha_4 \log\left(\frac{EXP_G}{GDP}\right) + \alpha_5 \log(CPI) \end{aligned} \quad (19)$$

The real exchange rate dynamic function (20) is:

$$\begin{aligned} & \log(e_t) - \gamma_t \log(e_{t+1}) \\ = & \delta_0 + \delta_1 \log(TRA) + \delta_2 \log\left(\frac{NCI}{GDP}\right) + \delta_3 \log(r_t^*) \\ & + \delta_4 \log\left(\frac{EXP_G}{GDP}\right) + \delta_5 \log(CPI) - \delta_6 \log(OPEN) \end{aligned} \quad (20)$$

When all variables in the formula are long-term equilibrium values, the real exchange rate corresponds to the equilibrium exchange rate. Let the equation take the derivative of the variable δ , and $\delta = [\delta_0, \delta_1, \delta_2, \delta_3, \delta_4, -\delta_5, \delta_6]$:

$$F = [1, \log(TRA), \log\left(\frac{NCI}{GDP}\right), \log(r_t^*),$$

$$\text{Log}\left(\frac{EXP_G}{GDP}\right), \log(CPI), \log(OPEN)] \quad (21)$$

Finally, we can get the dynamic function of equilibrium exchange rate:

$$\log(\bar{e}_t) = \sum_{i=0}^{\infty} \gamma^i \delta_t' \bar{F}_{t+i} \quad (22)$$

From (21) and (22), it is known that the factors affecting the equilibrium exchange rate is the terms of trade (*TRA*), the ratio between net capital flow ($\frac{NCI}{GDP}$) and *GDP*, the ratio between home interest rate and foreign interest rate (r_t^*), the ratio between government expenditure and *GDP*, the ratio between and foreign CPI (*CPI*) and the economic openness (*OPEN*).

5 VARIABLE SELECTION AND SOURCE OF DATA

5.1 Variable Description

Terms of trade refer to the total profit and loss of a country's imports and exports within a certain period of time, reflecting the trading environment in which the country is located. In this paper, the statistical data of the General Administration of Customs since 1980 is used, in which the import and export prices are respectively the Chinese commodity import price index and the Chinese commodity export price index. The terms of trade index are calculated by the quotient of the export price index and the import price index of a country's commodities. When the import price index is higher than the export price index, the trade index drops. The trade deficit will expand or the trade surplus will decrease, the demand for export products will increase, and the currency will appreciate. Otherwise, the currency will depreciate.

The degree of economic openness has the following meanings : (1) the way a country opens to the outside world and the cost it has paid; (2) the degree of participation of foreign capital in domestic economic activities. In the early stage of China's reform and opening up, the degree of capital flow was not high and the qualification of investment openness was strict. Therefore, the degree of economic openness was reflected by the degree of trade openness. Changes in foreign trade amount also included the influence of the net import and export tariff rate in the model. The proportion of a country's total imports and exports in its GDP reflects its degree of opening to the outside world, and the proportion in GDP also reflects its degree of external dependence.

Net capital inflow (NCI) is the net flow of international direct investment. Considering that the unit is different from other variables, this paper introduces the quotient of net international direct investment and gross national product to represent this variable, so that we can more intuitively feel the changes of international capital investment in China since the reform and opening up and the impact on the exchange rate. In general, the more net capital inflows, the stronger the currency becomes.

The Consumer Price Index is a measure of the year-on-year increase or decrease in the Price of Consumer goods, services and other goods that people buy. When measuring the prices of international import and export tradable goods, domestic and international inflation rates will vary over time. In the long run, developing countries with capital flow control are prone to a

situation similar to "internal depreciation and external rise", which will cause certain errors in the equilibrium exchange rate. Therefore, this paper selects the ratio of the average CPI in developed regions to the domestic CPI (CPI) and takes the cumulative value of each year after 1980 as the ratio to effectively offset the factors affecting the price of tradable goods.

Government expenditure refers to a country (or region) that performs public functions, takes the necessary financial funds expenditure activities. It can be divided into the following two points: First, government purchases, such as infrastructure construction, legislation and justice, national defense armaments and education, are included in GDP. Data other than transfer payments and bond interest equal to GDP have been excluded from the assumptions. In this paper, the premise hypothesis (3) has proposed that there is no public debt; Therefore, government expenditure here refers specifically to government purchases. Since the government expenditure cannot reflect the change directly, the quotient between the government expenditure and the gross national product is expressed.

The difference between domestic and foreign interest rates (r^*) refers to the difference between domestic and foreign currency interest rates. The interest rates adopted by different countries are different. When choosing, the current international monetary system is still dominated by the US dollar, and the US dollar is the international settlement currency. Therefore, when selecting the difference between domestic and foreign interest rates in this paper, the quotient between Chinese domestic inter-bank offered rate and the federal funds benchmark rate of the United States is chosen to represent the difference.

5.2 The Source of Data and the Data Processed

In this paper, relevant data were selected from China Statistical Yearbook, China Balance of Payment Statistics, Bank for International Settlements, National Bureau of Statistics, General Administration of Customs and Wind database to ensure the authenticity and effectiveness of the data. The data processing method is as follows:

Real effective exchange rate is a multilateral exchange rate, which is not anchored by a single country's exchange rate. From the derived equation, the real exchange rate is needed to do was explained variables, the real effective exchange rate is measured and published, including the 16 trading partners, the trade weighted calculation, because the real effective exchange rate can more accurately describe the exchange rate change on the influence of internal and external equilibrium, this paper uses the indicators in the empirical analysis. Since all countries have been affected by the Asian financial crisis in 1997 to varying degrees, the purchasing power of RMB has also declined significantly for a period of time after 1997.

The terms of trade index is expressed by the quotient of the export and import trade price indexes compiled by the General Administration of Customs. In the early stage of China's reform and opening up, the total volume of import and export trade was small and the variety fluctuated greatly. After the 1997 Asian financial crisis, China's growth stabilised terms of trade index fell, a situation that did not abate until 2008, when the world economy was recovering from the financial crisis.

The degree of economic openness is expressed by the proportion of the total amount of imports and exports in GNP. The change of China's import and export value mainly experienced three stages : (1) From 1979 to 2002, the proportion of China's total import and export value in GDP

increased gradually, and remained at 33% before and after the Asian financial crisis in 1997; (2) From 2003 to 2006, due to China's entry into the WTO, China began to show a trend of further expansion, reaching a peak of 63.9% in 2006. (3) Since 2007, China has gradually reduced its dependence on foreign trade economy due to changes in its own development.

The change of China's consumer price index is the quotient of the average consumer price index of developed countries and China's consumer price index compared with the change of the international market price index. There are still some underdeveloped regions in the world where the consumer price index fluctuates greatly, which will affect the change of the world average consumer price index. Moreover, China's trade with underdeveloped regions does not account for a large proportion, while the consumer price stability in developed countries is also the main factor for China's trade with. In calculation, the ratio of the cumulative value of each year after 1980 is used to offset the influence of inflation within a country on the real effective exchange rate.

Government expenditure adopts the data of government expenditure from the National Bureau of Statistics over the years, and the proportion of government expenditure in GNP has remained stable. Government spending has always been between 13% and 15%, and in the years after the economic crisis in 1997 and 2008, government spending as a proportion of GDP would rise to a certain extent due to the need for government investment to drive the economy.

Interest rate differentials are used at home and abroad is the benchmark interbank lending rates and the fed funds rate ratios measure, because the bank in China by 1996 has yet to reform, the inter-bank money flow is not often, so there is no interbank interest rates. Here the paper uses the one-year deposit interest rate instead of inter-bank lending rates by 1997.

5.3 The Statistical Data Description

	REER	TRA	OPEN	NCI	CPI	GOV	logr
1980	2.8086	0.9076	0.1239	0.0109	1.0570	0.1375	2.3177
1981	2.4943	0.9997	0.1525	0.0188	1.1459	0.1318	2.8449
1982	2.3811	1.1575	0.1470	0.0093	1.2173	0.1321	1.7891
1983	2.3411	1.0391	0.1435	0.0124	1.2644	0.1396	1.3290
1984	2.0864	0.9355	0.1714	0.0210	1.3092	0.1507	1.4949
1985	1.7702	0.6431	0.2252	0.0148	1.2618	0.1421	1.1250
1986	1.2891	0.7222	0.2464	0.0193	1.2187	0.1385	0.9444
1987	1.1232	0.9107	0.2533	0.0202	1.1717	0.1311	0.9250
1988	0.9349	0.8597	0.2526	0.0228	1.0219	0.1250	0.8764
1989	1.0783	0.8891	0.2449	0.0234	0.9072	0.1319	0.8126
1990	0.9612	1.1598	0.2931	0.0230	0.9232	0.1366	0.8650
1991	0.8578	1.1260	0.3288	0.0255	0.9347	0.1400	0.7520
1992	0.7709	1.0524	0.3351	0.0432	0.9097	0.1444	0.4657
1993	0.6812	0.9467	0.3154	0.1181	0.8185	0.1435	0.2997
1994	0.7528	0.9492	0.4190	0.1343	0.6770	0.1409	0.4173
1995	0.8393	0.9384	0.3823	0.1205	0.5935	0.1331	0.5788
1996	0.9283	0.9437	0.3356	0.1313	0.5614	0.1320	0.4433
1997	1.0000	0.9318	0.3381	0.1282	0.5576	0.1375	0.5185
1998	1.0589	0.8940	0.3148	0.1269	0.5707	0.1495	0.8361
1999	1.0064	0.8158	0.3296	0.1025	0.5871	0.1637	1.4136
2000	1.0109	0.7462	0.3915	0.0790	0.5980	0.1684	2.5783
2001	1.0571	0.7335	0.3805	0.0733	0.6067	0.1641	1.5681
2002	1.0300	0.7002	0.4221	0.0754	0.6213	0.1607	0.7750
2003	0.9568	0.6585	0.5126	0.0581	0.6253	0.1531	0.5001
2004	0.9275	0.6188	0.5905	0.0521	0.6141	0.1463	0.5986
2005	0.9178	0.6171	0.6216	0.0636	0.6174	0.1480	1.9264
2006	0.9301	0.6121	0.6395	0.0569	0.6226	0.1482	2.3348
2007	0.9632	0.6063	0.6128	0.0639	0.6071	0.1463	2.1096
2008	1.0459	0.5737	0.5579	0.0448	0.5929	0.1449	0.7610
2009	1.0935	0.6223	0.4327	0.0395	0.5979	0.1475	0.1483
2010	1.0845	0.5600	0.4884	0.0625	0.5877	0.1459	0.1010
2011	1.1125	0.5406	0.4823	0.0636	0.5728	0.1524	0.0304
2012	1.1791	0.5555	0.4530	0.0456	0.5693	0.1576	0.0481
2013	1.2550	0.5622	0.4310	0.0524	0.5625	0.1588	0.0306
2014	1.2846	0.5778	0.4120	0.0485	0.5591	0.1582	0.0295
2015	1.4043	0.6477	0.3607	0.0157	0.5531	0.1622	0.0592
2016	1.3518	0.6523	0.3282	-0.0126	0.5464	0.1636	0.1780
2017	1.3122	0.6191	0.3335	0.0161	0.5470	0.1632	0.3617
2018	1.3292	0.6031	0.3329	0.0231	0.5462	0.1654	0.7019
2019	1.3235	0.6123	0.3191	0.0127	0.5382	0.1671	0.9468

Figure 1. Data Description

	REER	TRA	OPEN	NCI	CPI	GOV	logr
Mean	124.3344	0.7810	0.3614	0.0515	0.7598	0.1476	4.9938
Median	106.8630	0.7279	0.3353	0.0452	0.6106	0.1463	1.3022
Maximum	280.8569	1.1598	0.6395	0.1343	1.3092	0.1684	33.9387
Minimum	68.1161	0.5406	0.1239	-0.0126	0.5382	0.1250	0.3515
Std. Dev.	50.1959	0.1899	0.1338	0.0398	0.2593	0.0120	9.1478
Skewness	1.7462	0.4444	0.2757	0.7669	0.9692	0.1218	2.4098
Kurtosis	5.1806	1.8926	2.6022	2.5657	2.3382	1.9173	7.4499

Figure 2. Statistical Description of Data

5.4 Trend Chart of Each Variable



Figure 3. The trend chart of real effective exchange rate



Figure 4. The trend chart of terms of trade

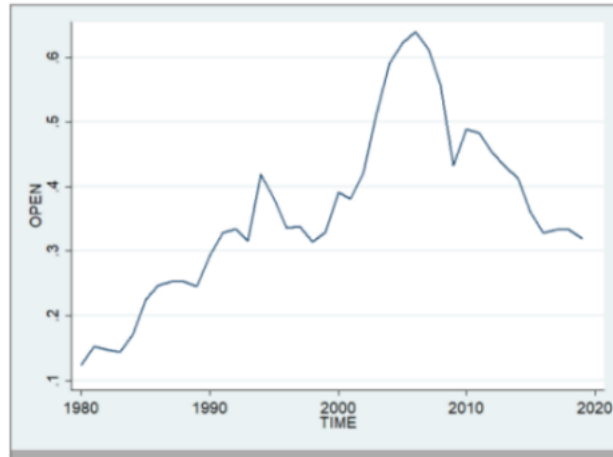


Figure 5. The trend chart of opennes



Figure 6. The trend graph of net capital flow

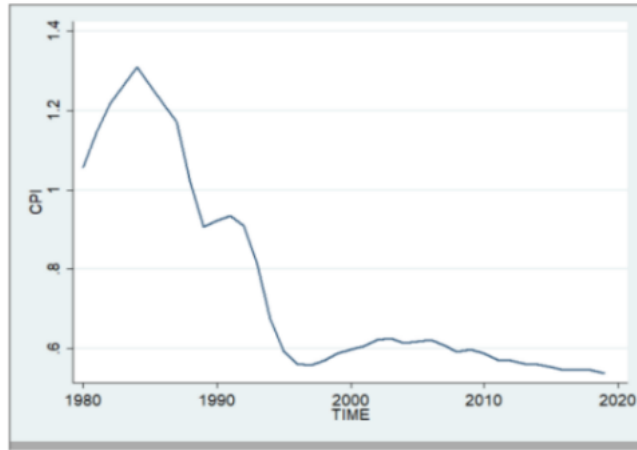


Figure 7. The trend graph of consumer price index

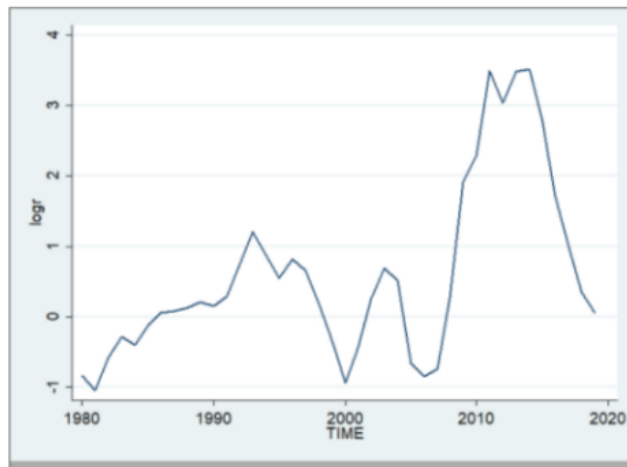


Figure 8. The trend graph of differences of interest rate

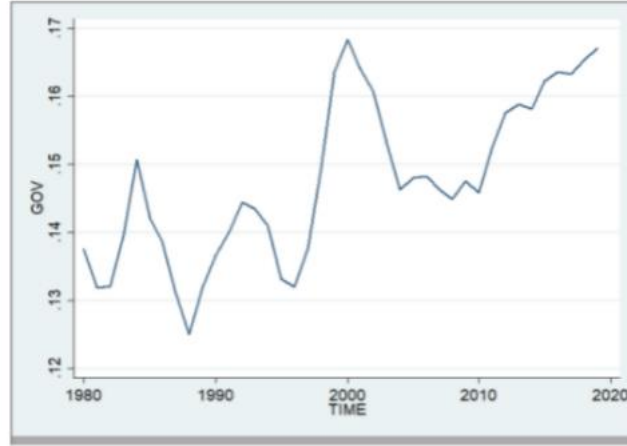


Figure 9. The trend graph of government spending

6 DATA ANALYSIS

6.1 The Unite Root Test

For function (23):

$$\begin{aligned} \Delta\gamma_t = & \beta_0 + \delta\gamma_{t-1} + \gamma_1\Delta\gamma_{t-1} + \gamma_2\Delta\gamma_{t-2} \\ & + \dots + \gamma_p\Delta\gamma_{t-p+1} + \gamma_t + \varepsilon_t \end{aligned} \quad (23)$$

The null hypothesis and the alternative hypothesis is function (24):

$$H_0: \delta = 0 \text{ vs } H_1: \delta < 0 \quad (24)$$

ε_t is the white noise, γ_t is the time trend. By applying the OLS method to get the the estimators $\hat{\delta}$ and t statistics (ADF statistics) are obtained. As $Z(t)$ is smaller, it is more likely to reject the null hypothesis. The results of constant term and time trend term are expressed as (c, p, t) . p is the lag order, the maximum lag order is expressed as $p_{max} = \left\lceil 12 \cdot \left(\frac{T}{100}\right)^{\frac{1}{4}} \right\rceil$, and the sample size T is 40, and thus $p_{max} = 40$.

TABLE 1. TABLE OF THE UNIT ROOT TEST OF VARIABLES

	(c,t,p)	statistics	1%	5%	10%	p values	Stable or not
TRA	(c,t,0)	-2.604	-4.251	-3.544	-3.206	0.2782	No
dtra	(c,t,0)	-5.34	-4.26	-3.584	-3.209	0	Yes
OPEN	(c,t,0)	-0.713	-4.251	-3.544	-3.206	0.9723	No

dopen	(c,t,0)	-5.05	-4.26	-3.584	-3.209	0.0002	Yes
NCI	(c,t,0)	-1.353	-4.251	-3.544	-3.206	0.8742	No
dnci	(c,t,0)	-4.896	-4.26	-3.584	-3.209	0.0003	Yes
CPI	(c,t,0)	-0.882	-4.251	-3.544	-3.206	0.958	No
dcpi	(c,t,0)	-4.124	-4.270	-3.584	-3.209	0.0058	Yes
GOV	(c,t,0)	-2.222	-4.251	-3.544	-3.206	0.4773	No
dgov	(c,t,0)	-3.845	-4.26	-3.584	-3.209	0.0144	Yes
logr	(c,t,0)	-1.276	-4.251	-3.544	-3.206	0.8939	No
dlogr	(c,t,0)	-3.751	-4.26	-3.584	-3.209	0.0192	Yes
REER	(c,t,0)	-3.525	-4.251	-3.544	-3.206	0.0368	Yes
dreer	(c,t,0)	-3.964	-4.26	-3.584	-3.209	0.00	Yes

As shown in the ADF test results, d represents the first-order difference of variables. The results show the real effective exchange rate (REER), the first-order difference of terms of trade (TRA), the first-order difference of economic openness (OPEN), and the net capital flow. The first-order difference of the proportion of input to gross national product (NCI) is stable at the significance level of 1%, and the first-order difference of the ratio of the average consumer price index of developed countries to the consumer price index of China (CPI). The first-order difference of the ratio of government expenditure to GDP (GOV) and the logarithm (logr) of the ratio of China's interbank offered rate to the Federal Reserve's benchmark funds rate are stable at the significance level of 5%.

6.2 Johansen Co-Integration Test

If there is a "long-term equilibrium relationship" between multiple unit root variables, the Johansen co-integration test can be carried out to verify such regression [19].

In the cointegration test, the cointegration rank should be firstly determined as (25):

$$H_0: \text{rank}(\Gamma_0) = 0 \text{ vs } H_1: \text{rank}(\Gamma_0) > 0 \quad (25)$$

The larger the cointegration rank h , the less the constraint of matrix Γ_0 is, so the likelihood ratio test can be carried out, which is called "trace statistics". The larger the trace statistics, the more inclined the null hypothesis is to be rejected.

The trace statistic result is shown by the figure below:

TABLE 2. RESULT OF TRACE STATISTIC

rank	parms	LL	eigenvalue	Trace statistic	value
0	98	422.3821	.	272.9563	109.99
1	111	484.8440	0.9658	148.0325	82.49
2	122	514.0102	0.7933	89.7	59.46
3	131	535.3403	0.6843	47.04	39.89
4	138	545.6539	0.4273	26.4126	24.31
5	143	553.1929	0.3346	11.3348*	12.53
6	146	558.8579	0.2637	0.0046	3.84

The test results of the maximum statistic of co-integration rank are shown in the figure below:

TABLE 3. RESULT OF MAXIMUM STATISTIC

rank	parms	LL	eigenvalue	statistic	value
0	112	442.37686	.	123.7292	48.45
1	125	504.24146	0.96471	63.2798	42.48
2	136	535.88135	0.81918	51.2489	36.41
3	145	561.50581	0.7497	44.1353	30.33
4	152	583.57344	0.69664	32.7566	23.78
5	157	599.95173	0.58742	15.4988	16.87
6	160	607.70115	0.34222	7.7272	3.74

There are five linearly independent co-integration vectors in the trace test ("*" in the table).

In the test of the maximum characteristic value, the null hypothesis "cointegration rank is 4" ($32.7566 > 23.78$) was rejected on 5% water level, and the null hypothesis "cointegration rank is 5" ($15.4988 < 16.87$) could not be rejected.

Therefore, the co-integration rank is 5, and the co-integration equation is (26):

$$\begin{aligned}
 REER = & -1.808701TRA - 2.410770OPEN \\
 & +1.291466NCI + 1.666188CPI - 1066336GOV \\
 & +0.268787r + 3.959102
 \end{aligned} \tag{26}$$

The results of co-integration test show that the increase of China's terms of trade (TRA), economic openness (OPEN) and the proportion of government expenditure in GDP (GOV) will lead to the decline of the real effective exchange rate of RMB. The net capital inflow as a proportion of GDP (NCI), the logarithm of the ratio of China's interbank offered rate to the Federal Reserve's benchmark fund rate (R) and the expansion of the quotient of the average consumer price index of developed countries to China's consumer price index (CPI) will lead to an upward adjustment of the real effective exchange rate of RMB.

As the terms of trade index rises, exports will decrease and imports will increase, so the demand for RMB will decrease, and the demand for foreign currencies will increase the depreciation of RMB and the decline of the equilibrium exchange rate of RMB. Its elasticity coefficient is -1.808701.

In terms of the degree of economic openness, the proportion of China's import and export trade has been getting smaller in recent years. The proportion of import and export trade to GDP has also decreased from 63.9% in 2006 to 31.9% in 2019. In economies with perfect domestic demand and relatively complete industrial chain, once the economic openness has a tendency to increase, it is likely to mean the deterioration of domestic economy and the decline of local currency purchasing power. Its coefficient of elasticity is -2.41077.

The proportion of government expenditure in GDP has been relatively stable over the years, and its growth is generally reflected in expanding fiscal deficit internally and increasing liquidity supply to boost investment, which inevitably leads to "money overissuance" and increases in

import and foreign currency demand externally. Since the proportion of government investment to GDP has been stable for many years, the elasticity coefficient is -10.66336.

Net capital inflow represents the proportion of direct investment of foreign capital in China's GNP, and its growth has a positive impact on the real effective exchange rate of RMB. Net capital inflow will lead to trade surplus and make RMB appreciate. As the proportion of net capital inflow is relatively small, its positive impact is general, and the elasticity coefficient is 1.291466.

The ratio of the national average consumer price index to China's consumer price index represents the comparison between the domestic inflation level of China and the average inflation level of developed countries over the years. The higher the value is, the higher the average inflation of developed countries is than that of China. The higher the relative inflation rate is, the weaker the purchasing power of its currency is, which has a positive impact on the real effective exchange rate of RMB. The elastic coefficient is 1.666188. The logarithm of the ratio between China's interbank offered rate and the Federal Reserve's benchmark fund rate represents the interest rate spread between the two countries. Generally speaking, capital will flow into countries with higher interest rates, and the larger the interest rate spread indicates the degree to which China's domestic interest rate is higher than that of the United States, but the impact is small. The elasticity coefficient is 0.0268787.

6.3 Vector Error Correction Model (VECM)

The concept of vector error correction model (VECM) is as follows: assume that $\{\gamma_{1t}, \dots, \gamma_{nt}\}$ is the unit root variable ($n \geq 2$). The random vector γ_n , and the vector autoregressive model considering γ_t is (27):

$$\gamma_t = \alpha + \phi_1\gamma_{t-1} + \phi_2\gamma_{t-2} + \dots + \phi_p\gamma_{t-p} + \varepsilon_t \quad (27)$$

The vector autoregressive model corresponds to the vector error correction model is (28):

$$\begin{aligned} \Delta\gamma_t = & \alpha + \Gamma_0\gamma_{t-1} + \Gamma_1\Delta\gamma_{t-1} + \Gamma_2\Delta\gamma_{t-1} \\ & + \dots + \Gamma_{p-1}\Delta\gamma_{t-p+1} + \varepsilon_t \end{aligned} \quad (28)$$

Where $\delta\gamma_{t-1}$ is the error correction term. When γ_{t-1} deviates from the long-term equilibrium relationship, $\Gamma_0\gamma_{t-1}$ adjusts for $\Delta\gamma_t$ (i.e., error correction).

After the co-integration test and the confirmation of the co-integration rank F, the VECM model is estimated when "rank(Γ_0) = h", and the VECM model is changed into Equation (29):

$$\begin{aligned} \Delta\gamma_t = & \alpha + \Gamma_0\gamma_{t-1} + \Gamma_1\Delta\gamma_{t-1} + \Gamma_2\Delta\gamma_{t-1} \\ & + \dots + \Gamma_{p-1}\Delta\gamma_{t-p+1} + \delta t + \omega_1s_1 + \dots + \omega_ms_m + \varepsilon_t \end{aligned} \quad (29)$$

Where δt is the time trend item, and $\{s_1, \dots, s_m\}$ is the seasonal dummy variable.

Then the vector error correction model is determined. Firstly, the lag order of the difference of each variable is selected as 3. The result of the error correction model is shown in Equation (30):

$$\begin{aligned}
\Delta REER = & -0.6020412\Delta REER_{t-1} - 0.0657664\Delta REER_{t-2} \\
& +0.6392832\Delta TRA_{t-1} + 0.4205679\Delta TRA_{t-2} \\
& -0.2406354\Delta OPEN_{t-1} - 0.4219259\Delta OPEN_{t-2} \\
& +0.7384349\Delta NCI_{t-1} - 0.8456568\Delta NCI_{t-2} \\
& -2.710498\Delta CPI_{t-1} + 0.667604\Delta CPI_{t-2} \\
& +5.325064\Delta GOV_{t-1} - 0.837949\Delta GOV_{t-2} \\
& +0.038566\Delta r_{t-1} + 0.022094\Delta r_{t-2} - 0.7713016\varepsilon_{t-1}
\end{aligned} \tag{30}$$

ε_{t-1} error correction term explains the dynamic adjustment process of RMB real effective exchange rate. If the equilibrium exchange rate determined by macroeconomic variables in the previous period is overvalued compared with the actual effective exchange rate, that is, the actual effective exchange rate is undervalued. Since the coefficient of ε_{t-1} is negative, the equilibrium exchange rate in the current period will adjust downward and the real effective exchange rate of RMB will appreciate. The coefficient of the error correction term represents the ability of the system to self-repair the exchange rate misalignment, and the coefficient of the error correction term is 0.7713016, indicating that China's exchange rate system based on the modified ERER model has a strong ability to repair. Theoretically, when the coefficient of error correction term is 1, the misalignment of exchange rate can be completely corrected within a period of time. Therefore, the closer the absolute value of the coefficient of error correction term is to 1, the stronger the system's ability to adjust.

6.4 Diagnostic Test of Vector Error Correction Model

After estimating the vector error correction model, the diagnostic test of the model is needed [20]. First, we conduct LM test to see if there is autocorrelation among residuals. If there is, the lag order should be increased, as shown in the table below:

TABLE 4. THE RESULT OF LM TEST

Lagrange-multiplier test lag	Chi2	df	Prob>chi2
1	70.7772	49	0.02253
2	77.8079	49	0.00547
H0: no autocorrelation at lag order			

The results showed that the null hypothesis of "no autocorrelation" was accepted. Next, the stability of "VECM" system was checked, and the results were shown in the figure below:

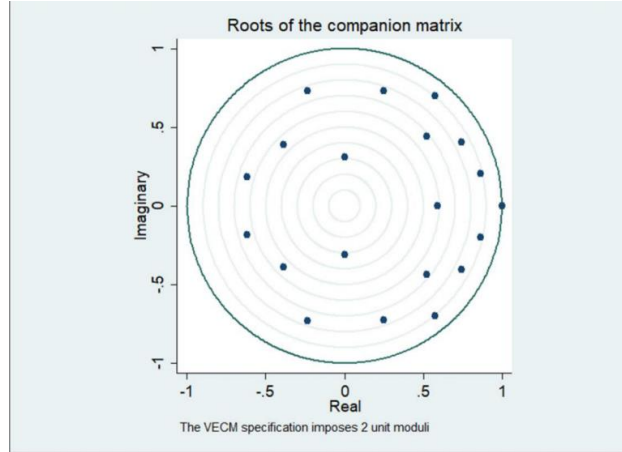


Figure 10. The VECM specification imposes 2 unit moduli

6.5 Vecm System Stability Check

The results show that all the eigenvalues of the adjoint matrix fall in the unit circle, except for the unit roots assumed by the vector error correction model itself (VECM defines 2-unit roots), and the system is stable.

It has discussed above that the factors affecting the equilibrium exchange rate REER are the terms of trade TRA , the proportion of net capital flow and the $GDP \frac{NCI}{GDP}$, the openness of economy $OPEN$, the ratio between government spending and gross domestic production GDP , the interest rate differences $\log r$ and the ratio between the foreign and domestic consumer price index CPI . Therefore, the analysis will be conducted based on the data of effective RMB exchange rate, the gross domestic production, domestic terms of trade, the interest rate differences, openness of economy, relative price level and the government spending.

6.6 H-P Filtering Method to Determine the Long-Term Equilibrium Value Of Economic Variables

The valuation of RMB exchange rate needs to compare the real effective exchange rate with equilibrium exchange rate. In the empirical study in the previous chapter, the co-integration equation of the REAL effective exchange rate of RMB has been estimated, and the stability of the vector error correction model and model system has been determined. Finally, h-P filtering method is used to estimate the long-term equilibrium values of these explanatory variables.

The time series is formed by stacking components with different frequencies. The main method of H-P filtering method is to select the components with higher frequencies from the components with different frequencies and eliminate the components with lower frequencies. The formula (31) is as follows:

$$y_t = y_t^T + y_t^C, t = 1, 2, 3, \dots, T \quad (31)$$

y_t^T is the trend component, y_t is the time series.

This article will influence the economic variables easy condition equilibrium exchange rate (TRA), economic openness (OPEN), net capital inflows, the proportion of GDP (NCI), the average consumer price index (CPI) in the developed countries and China's consumer price index (CPI), the proportion of GDP, government spending (GOV), interbank lending rates and al in China after processing the logarithm (logr) of the ratio of the reserve fund benchmark rate, define the variables named HP_TRA, HP_OPEN, HP_NCI, HP_CPI, HP_GOV, HP_logr, The difference between the filtered value and the original value is sub_tra, sub_open, sub_nci, sub_cpi, sub_gov and sub_logr, respectively. The results are shown by the following graphs:

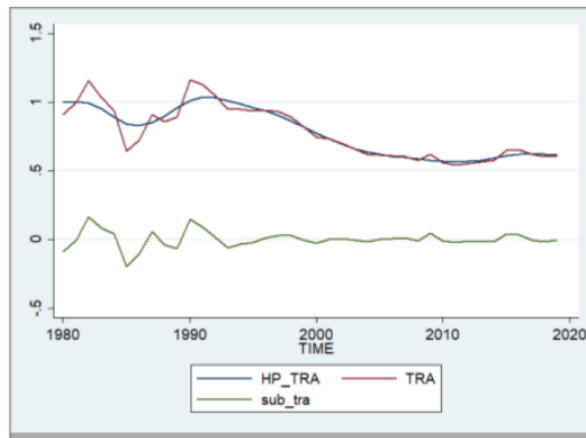


Figure 11. HP_TRA, TRA and sub_tra data processing results

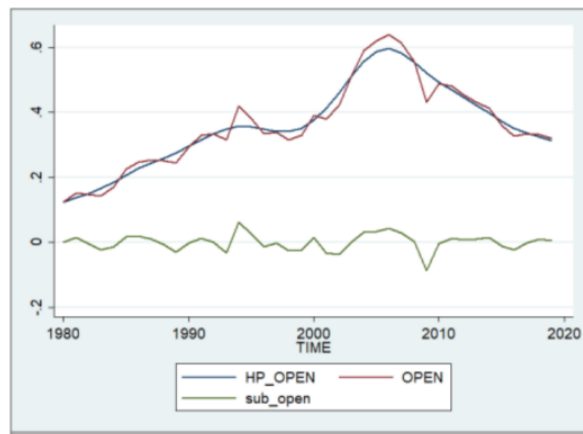


Figure 12. HP_OPEN, OPEN and sub_open data processing results

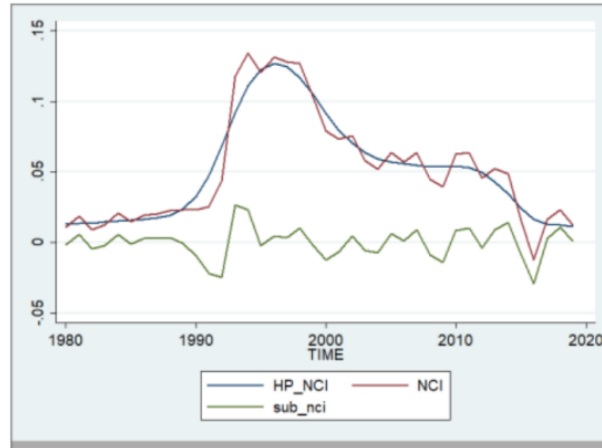


Figure 13. HP_NCI, NCI and sub_nic data processing results

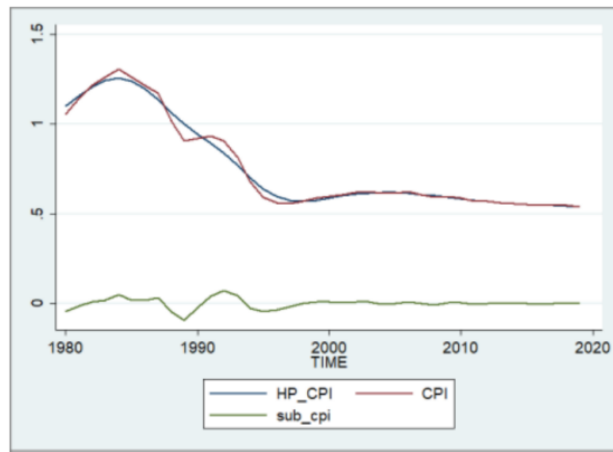


Figure 14. HP_CPI, CPI and sub_cpi data processing results

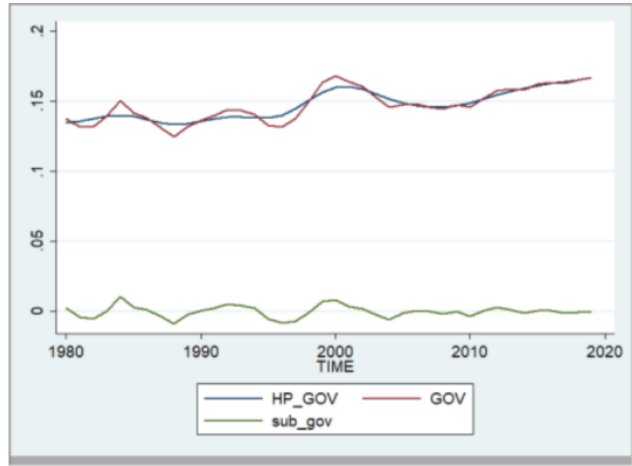


Figure 15. HP_GOV, GOV and sub_gov data processing results

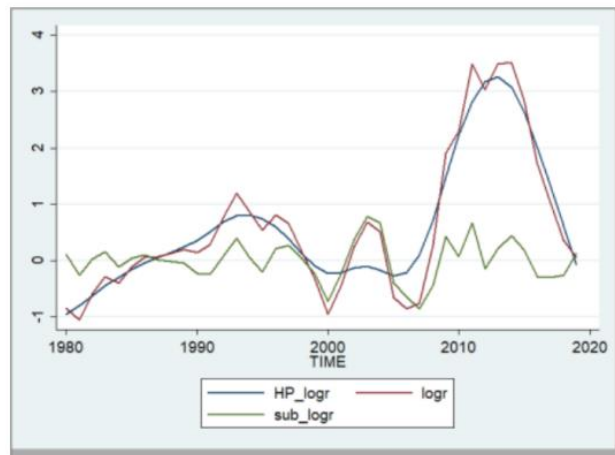


Figure 16. HP_logr, logr and sub_logr data processing results

6.7 Rmb Exchange Rate Misalignment Measurement

After the H-P filtering method is used to process the long-term equilibrium value of economic variables, the comparison diagram of the equilibrium exchange rate and the real effective exchange rate under the modified ERER model is obtained as follows:

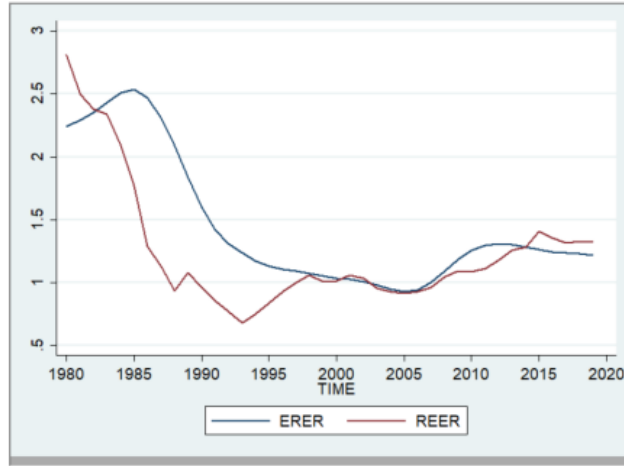


Figure 17. The diagram of the equilibrium exchange rate and the real effective exchange rate under the modified ERER model

The formula (32) for measuring the degree of RMB exchange rate misalignment (ERM) is as follows:

$$ERM = \frac{REER - ERER}{ERER} \quad (32)$$

Where ERER is the equilibrium exchange rate of RMB calculated under the modified ERER model, and REER is the real effective exchange rate of RMB. If $ERM > 0$, it means that the real exchange rate is overvalued; if $ERM < 0$, it means that the real effective exchange rate is undervalued.

The trend of RMB exchange rate misalignment is shown by the following graph:

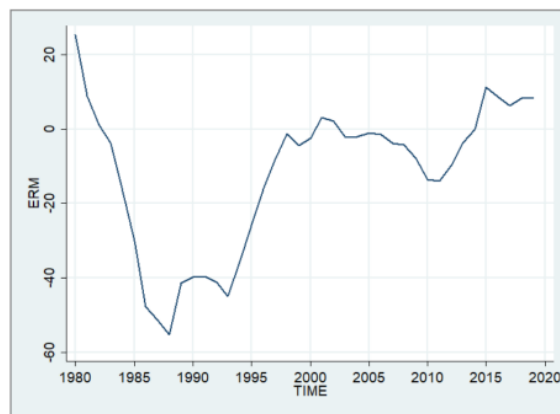


Figure 18. The trend of RMB exchange rate misalignment

The RMB has been significantly undervalued or overvalued in some stages, which is analyzed below.

In the reform of foreign trade management system in 1979, foreign trade was changed from a state monopoly to a decentralized operation by a number of companies. Therefore, the RMB exchange rate needed to be reformed and changed according to the actual situation of import and export. However, the RMB exchange rate system at that time could not adapt to the two aspects of trade and non-trade, which also explained that in 1980, the RMB real effective exchange rate was significantly high and the exchange rate misalignment reached 25.36614%.

In order to solve this unreasonable situation, the Trial Measures for The Internal Settlement Price of Foreign Exchange for Trade were introduced. In 1981, the official exchange rate and the internal settlement price of foreign exchange for trade were adopted simultaneously, with the official exchange rate used for financial transaction settlement and the foreign exchange for trade used for trade settlement. However, the effect of this method is not ideal, and the scope of use of the two exchange rates is not clear, resulting in appreciation.

Mismanagement led to a black market exchange rate. At this time, the exchange rate misadjustment expanded from the rapid wave of 8.871216% in 1981 to -16.74854% in 1984. Later, due to the high inflation in the United States, the Federal Reserve raised interest rates, the external appreciation of the DOLLAR, and the gradual decline of the official exchange rate of RMB, the coexistence of the two exchange rates could no longer be maintained.

During the dual-track exchange rate system, the portion of foreign exchange earnings is handed over at the lower official exchange rate and the rest is handled at the adjusted price. This measure promoted export, currency circulation, and maintained the balance of foreign exchange of foreign-funded enterprises, which was of great significance in the economic environment at that time. During this period, China vigorously developed imports and exports, and the total volume of imports and exports grew rapidly. Due to the rapid growth of exports, the rising export price index led to the continuous rise in terms of trade, resulting in the continuous depreciation of the real effective exchange rate of RMB, which was significantly undervalued during this period, and the most serious imbalance reached -55.2794% in 1988.

In 1988, The State Council stipulated to modify the proportion of foreign exchange retention, allowing the foreign exchange adjustment price to be determined according to the supply and demand relationship in the foreign exchange market, and the official exchange rate coexisted with the foreign exchange rate. Relatively weakened foreign exchange control increased the degree of marketization, the degree of imbalance narrowed.

In the floating exchange rate system managed from 1994 to 2005 and the "peg to a basket of currencies" policy after 2005, the degree of exchange rate misalignment was basically within 20%.

7 AN EMPIRICAL TEST BETWEEN REAL EXCHANGE RATE AND TRADE BALANCE

As mentioned above, some economists believe that China gains export competitiveness through the undervaluation of RMB exchange rate. In the following, a regression model is made to verify

the ability of adjustment of RMB real exchange rate to trade balance. Referred to Mohsen and Brooks (1999), we established a static balance of payments model to serve as the theoretical basis for empirical analysis [21].

Suppose that there are only two open countries trading, and that tradable and non-tradable goods cannot be completely replaced directly. Domestic and foreign demand for imported goods can be written as (33) and (34):

$$D_m = D_m \left(Y, \frac{P_m}{P} \right), \frac{\partial D_m}{\partial Y} > 0 \quad (33)$$

$$D_m^F = D_m^F \left(Y_F, \frac{P_m}{P} \right), \frac{\partial D_m^F}{\partial Y_F} > 0 \quad (34)$$

Demand for imported goods is affected by domestic income and the relative impact of the prices of imported goods and the prices of non-traded goods. The higher the country's real income, the greater the demand for imported goods; The higher the price of imported goods relative to domestic non-tradable goods, the smaller the demand for imported goods. The same conditions apply to foreign countries.

In terms of the supply of tradable goods, it is assumed that the supply of tradable goods is only affected by the relative price of tradable goods, so the equation (35) can be set out as follows:

$$S_x = S_x \left(\frac{P_x}{P} \right) \quad (35)$$

The nominal exchange rate and real exchange rate can be defined as (36) and (37):

$$e = \frac{P_M}{P_x^F} \quad (36)$$

$$q = e \frac{P^F}{P} \quad (37)$$

Where P_m is the price of domestic imported goods measured in domestic currency, and p_x^F is the price of domestic imported goods measured in foreign currency. By rearrange the above equations, we can get the weight of the prices of the imported good measured by domestic and foreign currency, see (38) and (39):

$$p_M = \frac{P_M}{P} = e p_x^F = q \frac{P_x^F}{P^F} \quad (38)$$

$$p_M^F = \frac{P_x}{q} \quad (39)$$

When the equilibrium of the international market is achieved, the domestic demand for imported goods is equal to the supply of foreign exports. We can get (40):

$$D_M = S_x^F, D_M^F = S_x \quad (40)$$

The country's trade balance is the difference between its export earnings and its import expenditures, see (41):

$$TB = p_x S_x - p_M D_M = p_x D_M^F - q P_x^F D_M \quad (41)$$

By combining the above equations, we can get the trade balance function of our country, see (42):

$$TB = TB(q, Y, Y^F) \quad (42)$$

It can be seen from the above formula that a country's trade balance is a function of its domestic income, foreign income and its real exchange rate. There are two kinds of effects of domestic income on trade balance. One is the income effect, that is, the expansion of domestic income will increase the demand for imported goods. Second, if the productivity of domestic substitutes increases and the real income of the country increases, the substitution of foreign imported substitutes will increase the trade balance.

The impact of real exchange rate on trade balance can be divided into long term and short term. In the short term, due to the sticky effect, that is, the production and consumption in the short term cannot react quickly with the price changes, and the import and export volume will not change significantly. However, due to the change of exchange rate, the export income in foreign currency terms is relatively reduced, and the import expenditure in domestic currency terms is relatively increased, thus resulting in the increase of the current account balance deficit or surplus. This phenomenon is known as the J-curve effect. In the long run, a devaluation has a positive effect on the trade balance by raising the price of your imports in your home market and lowering the price of your exports in foreign markets.

According to the above theoretical model, we can establish an econometric model for empirical test, like (43):

$$\ln TB_t = \beta_0 + \beta_1 \ln Y_t + \beta_2 \ln Y_t^F + \beta_4 \ln REER_t + \varepsilon_t \quad (43)$$

Data on domestic income, foreign income and the real effective exchange rate of RMB are obtained from the International Monetary Fund and the Bank for International Settlements.

8 RESULT ANALYSIS

8.1 Unit Root Test

TABLE 5. UNIT ROOT TEST

Variables	Test Type(c,t,p)	ADF	5%	Result
Δtb	(c,0,0)	-3.690	-2.917	stable
Δy	(0,t,2)	-3.755	-3.619	stable
Δy^f	(0,0,1)	-2.198	1.956	stable
$\Delta reer$	(0,0,1)	-2.736	-1.944	stable

The test shows that the variables are all unstable at the original level, and they are all stationary after the first derivative. Therefore, it can be concluded that the variables are first-order integration, and the co-integration analysis can be conducted.

8.2 Johansen Co-Integration Test

In this test, both trace statistics and maximum eigenvalue statistics significantly reject the null hypothesis that there is no co-integration relationship, and confirm the existence of a co-integration relationship. This indicates that there is a long-term linear equilibrium relationship between variables. According to the test, we get the estimated value of the equation parameters by (44):

$$tb_t = 3.257 - 1.146y_t + 2.1171y_t^f - 0.704reer_t \quad (44)$$

TABLE 6. JOHANSEN CO-INTEGRATION TEST

	Eigenvalue	Trace	Null Hypothesis
tb_t		32.59	
y_t	0.5294	(0.00435)	None
y_t^f		11.365	
$reer_t$	0.3578	(0.2487)	1

It can be seen from the coefficient of the co-integration equation that the RMB exchange rate has a long-term impact on the trade balance. If the RMB exchange rate depreciates by 1%, the trade balance will increase by 0.7% in the long run. But the long-term elasticity of the yuan's exchange rate to the trade balance of China and the world's national income to the trade balance. This shows that the main influence on the trade balance is not the exchange rate, which to a certain extent negates the argument of some economists that "China obtains export competition through an undervalued exchange rate".

9 TENDENCY PREDICTION OF RMB EXCHANGE RATE

The RMB exchange rate has always been the research hotspot and focus of domestic and foreign economic theory and practice circles. It is of great theoretical value and practical significance to study the influencing factors and fluctuation trend of RMB exchange rate.

The main methods that China uses to manipulate the exchange rate are respectively controls of exchange rate, controls of currency and pegging to a basket of currencies. The following will simply analyze how these methods work and give a brief prediction on the future tendency of RMB exchange rate.

Let's firstly discuss the interest rate. Monetary policy is another long-term mechanism that affects money inflows and prices in China. The central bank has kept interest rates high since it initially liberalised the currency policy in 2005. In 2014, however, the central bank began to ease local interest rates to offset the slowdown. The easing of interest rates had the effect of dampening the flow of foreign capital into the economy, which subsequently put pressure on the depreciation of RMB. Here, let's assume that both domestic and foreign central banks follow the Taylor rule when making monetary policy [22]:

$$r_t = \psi r_{1-t} + (1 - \psi)(\varphi_\pi \pi_t + \varphi_x x_t) + m_t \quad (45)$$

m_t represents the monetary policy shock of the country, φ_x represents the response coefficient of the national central bank to the output gap and inflation.

After the collecting data and doing a regression analysis, the essay finds out that the increase foreign countries' interest rate will lead to RMB depreciation, and this effect will gently reduce as time passes by; China's interest rate will pose a positive effect in exchange rate and the effect will also reduce as time passes by. This may be because China has gently liberalized the financial market, and foreign currency inflow becomes easier; combined with many well-developing firms in China, attracting more foreign investors. With the growing strength of the Chinese market and the gradual internationalization of the RMB, Chinese finance may gradually become a substitute for the American financial market. Therefore, the impact term of interest rate and the coefficient of price level will gradually decrease over time, that is, its influence of monetary policy will gradually decrease. Over time, as mentioned above, the productivity gap between the two countries will gradually become a major influence on the RMB exchange rate. China is developing very fast, which will make the RMB appreciate. Moreover, China's perilous growth will lead to technological competition with the United States, and the United States will take certain measures to limit China's growth. Assuming there is no financial crisis and the government's strong intervention in the foreign exchange market in the future, the RMB exchange rate will show a long-term trend of slow appreciation with fluctuations.

Foreign currency controls is another method used by Chinese government. China has strict rules on individuals and banks who hold foreign currency, so the currency isn't considered fully convertible. Investors who convert dollars or other foreign currencies into yuan must sell them directly to the People's Bank of China, which adds them to the country's foreign-exchange reserves. The government then prints local currency for use by individuals, companies and banks. China has accumulated large dollar reserves. It currently has the world's largest stockpile of

reserves. The bulk of China's reserves are denominated in dollars and invested in US Treasuries, and are seen by the world's major central banks as a haven for capital. Central banks can also use other instruments, such as derivative contracts, which affect the value of markets and currencies. The advantage of using these instruments is that banks do not have to sell their supply of dollars immediately. This could slow the depletion of its reserves and thus maintain market confidence in its ability to intervene in the future.

China's central bank rarely intervenes directly in the foreign exchange market, usually through state-owned banks, in addition to using its money-market operations and vast foreign exchange reserves. However, China's approach to international financial markets is more conservative. The People's Bank of China influences the offshore market in a variety of ways, including regular and non-cyclical sales of RMB-denominated bills in Hong Kong. This can be used to mop up excess currency circulation and reduce speculative short-selling of the currency. A sound currency and international financial market are bound to attract more foreign investment, which will lead to the appreciation of the RMB exchange rate.

A sustained appreciation of the exchange rate would certainly hurt exports. Exports are one of the three drivers of China's development, and the government is bound to manage the exchange rate to protect exports. In this case, China's policy of pegging to a basket of currencies to set a target exchange rate is a good stabilizer. With a relatively stable exchange rate and a gradually improved international financial market, China has the opportunity to become a major market for foreign investors in the future.

10 CONCLUSION AND SUGGESTION

To sum up, the RMB exchange rate has a trend of appreciation. Exterior reasons include promising Chinese companies, a better financial system and a deregulated market that will attract foreign investment. The internal reasons are that China has a high economic growth rate, a relatively prudent monetary policy and limited substitution of domestic demand for external demand.

Based on the above analysis, we can put forward the following suggestions: First, we should accelerate the market-oriented reform of RMB exchange rate formation mechanism, establish a fully flexible exchange rate formation mechanism, and further give play to the decisive role of market supply and demand in the formation of RMB exchange rate. Secondly, according to the "Balassa-Samuelson effect", we should vigorously develop China's non-tradable industries, improve the labor productivity of non-tradable sectors, narrow the productivity difference between tradable sectors and non-tradable sectors, and slow down the appreciation trend of the medium- and long-term equilibrium exchange rate of RMB [23]. Finally, we should improve the degree of RMB interest rate marketization and accelerate the process of RMB interest rate marketization.

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