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Keywords: nominal effective exchange rate, real effective exchange rate, cointegration, vector error correction model, long run causality, short run causality.

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Keywords: nominal effective exchange rate, real effective exchange rate, cointegration, vector error correction model, long run causality, short run causality.

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I. INTRODUCTION

The exchange rate plays an important role in a country's trade performance whether determined by exogenous shocks or by policy. Real exchange rate measures the relative price of domestic goods relative to foreign ones and is an indicator of international competitiveness of a country. The implication of macroeconomic variables on the real exchange rate changes has received sizable attention by scholars with considerable contributions being made to both the empirical understanding and the theory of exchange rate determination. Significant developments in econometrics, along with the growing availability of high value data, have inspired scholars to conduct a vast amount of empirical work on exchange rate determination either in monetary approach or in macro-economic approach.

Historically, China has structural volatility and misalignment of nominal or real exchange rate behaviour showing long run smooth cyclical trend, seasonal fluctuations and cycles consisting of many peaks and troughs (Bhowmik,2020) especially after the revolution. The reasons are many folds: political as well as economical. There are many economic factors which determine the NEER and REER of Chinese RMB in which growth of GDP, FDI, money supply, inflation rate, trade openness, terms of trade, balance of trade, total international liquidity, and the stock exchange indices are important. Moreover, it may be pro-cyclical or counter-cyclical. The political regimes can influence the characteristics of exchange rate fluctuations which were also evident in China. In recent years, China activated liberalisation policy including globalisation so that it became the world most competitive economy and now it is the world's second largest economy and thereby it has a strong competition with USA and Euro Area and have been enjoying trade surplus with them and the surplus have been mounting gradually for which China has been pressured by USA and EU to appreciate its RMB so that current account surplus may be reduced to increase world welfare especially in USA. Even, USA also claimed that China is the currency manipulator so that the USA had not been benefiting in international trade and finance. Even, the internationalisation of Chinese Yuan which had entered into SDR basket in IMF for which China has been able to start international finance specially in capital and financial integration getting bigger shares and holding largest foreign exchange reserves has benefited China to be a hegemonic currency dominator which is a great shock to the dollar domination.

As a regional hegemon, China is capable of pressurising its regional trading partners to use RMB to finance their trade with China, otherwise, the dollar-centric global currency system will continue to constrain the scope and pace of the international use of the RMB in near future (Sohn,2015).Eight country-VAR model of RMB exchange rate from 1/5/2016 to 30/9/2016 when RMB was not in SDR basket and from 1/10/2016 to 1/3/2017 when RMB was included in SDR basket revealed that the comparison of impulse response function of two sets of VAR model showed that the dominance of RMB and US dollar in Asian bloc is still persisted on because China-Asia financial integration minimised exchange rate risk and lower transaction cost(Wong, Pong & AuYong,2017).

In this context, Chinese RMB appreciation and depreciation policy as a managed dictator in the floating exchange rate regime has emerged as a mismatch adjustment mechanism in the international payment system. As a result, China is forced to open its capital account convertibility and should allow freely floating exchange rate of RMB to reach equilibrium mechanisms in order to avoid being a currency manipulator.

During the above background, the paper tried to find out the chief determinants of real and nominal effective exchange rates of Chinese RMB so that impact on real and monetary economy of China could be found out where balance of trade(BOT), foreign direct investment inflows (FDI), total international liquidity (liquidity), terms of trade (TOT), trade openness(TO) and Shanghai Composite Index(SCI) of China were included as determinants from 1990 to 2019 respectively.

II. THE IMPORTANT STUDY MATERIALS

In this theme, there are many economic and political literatures available in which the author has mentioned some relevant studies that would help the research work of the theme. Zhang (2001) examined BEER approach during 1952-1997 to measure the misalignment of Chinese currency, and concluded that the RMB was overvalued in China's central planning period but that economic reforms brought the real exchange rate closer to its equilibrium level.

Zhang (2002) also examined equilibrium real exchange rate (ERER) and behavioural equilibrium exchange rate (BEER) models for RMB by using cointegration analysis, the Hodrick-Prescott (H-P) filter and other econometric models during 1978-1999 and found that the exchange rate of RMB is close to the equilibrium level in 1999 but was misalignment since 1978.

The study of Wang et al (2007) concluded that the RMB fluctuates around its long-run equilibrium level within a narrow band - i.e. the RMB had not been consistently undervalued. The author used Johansen Maximum Likelihood cointegration method to estimate BEER.

Cheung, Chinn and Fujii (2007) found that the RMB was undervalued under various alternative conditions, but admitted that the statistical evidence was weak.

Aziz (2008) examined the real exchange rate on balance of trade during 1977 – 2005 in Bangladesh,by applying the VECM method and showed that the real exchange rate has a significant impact on balance of trade both in the short-run and long-run. The Granger causality test affirms the causal relation between exchange rate and balance of trade of Bangladesh. The impulse response functions (IRF) also support the positive impact of real effective exchange rate on balance of trade in the long run.

Theoretically, Rodrik (2008) argues that overvaluation is bad and undervaluation is good for growth, particularly in developing countries.

In addition to that Saborowski (2009) suggests that in the developing countries capital inflows, particularly FDI, lead to a real appreciation but this effect is attenuated if the economy disposes of a deep financial sector. Even, the study of MacDonald and Vieira (2010) concluded that a more depreciated (appreciated) real exchange rate helps (harms) long-run growth especially for the developing and emerging countries.

Combes et al (2010) studied REER on capital flows in the 42 developing countries for the period 1980–2006 and found that aggregate capital inflows are positively correlated with appreciation of the REER. Mapenda (2010) used Johansen cointegration and the Vector Error Correction Model (VECM) to evaluate the long-run determinants of the exchange rate in Ghana and Nigeria taking the terms of trade, trade restrictions, domestic interest rates, foreign aid inflow, income, money supply, world inflation, government consumption expenditure, world interest rates, capital controls and technological progress as influencing factors. The findings revealed that any increase in government consumption expenditure, the terms of trade, net foreign aid inflow and openness significantly led to currency depreciation, while an increase in world cocoa prices appreciated the Ghanaian currency. On the other hand, an increase in world oil prices and government consumption expenditure appreciated the Nigerian currency, whereas a rise in net foreign assets devalued the Naira. The Naira exchange rate was overvalued within the period 1980 to 1983 and undervalued within the period 1984 to 1991.

Hua (2011) examined exchange rate appreciation of RMB of 29 Chinese provinces during 1987-2008 in panel data using GMM method and real exchange rate appreciation and found a negative effect on the economic growth and also negative effect on employment, export, foreign direct investment and industrial production share respectively. Moreover, it had a positive effect on capital intensity, educational level and efficiency.

Pan and Guo (2012) used Pesaran bound testing method to examine the dynamic relations between the exchange rate of Chinese RMB, foreign direct investment (FDI) and economic growth and found that the appreciation of Chinese RMB is beneficial for foreign direct investment.

Ajao and Igbekoyi (2013) applied VECM and GARCH models for the determinants of real exchange rate volatility in Nigeria from 1981 to 2008 and found that the openness of the economy, government expenditures, interest rate movements and the lagged exchange rate were the significant variables that influence real exchange rate volatility.

Kiptui and Ndirangu (2016) examined cointegration test among real exchange rate of Kenya with real GDP, productivity, Money supply, government expenditure for the period of 2000Q1-2014Q4 and found that economic growth appreciates the real exchange rate and productivity has a negative effect on the real exchange rate and money supply has a negative impact on depreciation of domestic currency and an increase in government expenditure appreciates the real exchange rate. However, the exchange rate was overvalued during the periods of 2006-2008 and 2011-2013 and minor overvaluation was found in 2014Q4 of 4%.

Waheed (2016) studied the impact of real effective exchange rate misalignment on economic growth in Nigeria using an annual data spanning 1960 to 2011 using purchasing power parity (PPP) and generalized method of moment (GMM) approaches and found that lower misalignment of exchange rate happened in flexible exchange rate regime and impact on economic growth is negative from misalignment in GMM method.

Wang and Wei (2017) examined the relationships between exchange rates, economic growth and foreign direct investment applying the TVP- VAR model using monthly data from China for the period 2001-2016. A positive shock in the real exchange rate slows down FDI inflows, with no evidence to support the contractionary devaluation theory in China, which suggests that an increase in the real RMB exchange rate generally causes a negative influence on China's economic growth.

Fu (2017) used cointegration, Granger Causality test and VECM taking the quarterly data from 1994 to 2016 and found that the appreciation of RMB has a negative effect on Chinese economic growth. The correlation between total export and real effective exchange rate is negative. Meanwhile, the correlation between total import and real effective exchange rate is negative. And the appreciation of RMB will decrease FDI. Bhowmik (2017) examined REER of India during 1970-2015 with its determinants of growth rate, current account deficit (% of GDP), openness, FDI inflows and foreign exchange reserves and found that the REER has been declining at the rate of 0.2028% per year with five structural breaks in 1976,1986,1992,2004, and 2010 respectively. REER has bidirectional causalities with growth rate, current account balance and FDI but it has unidirectional causalities with openness and foreign exchange reserves. There are three cointegrating equations and REER depreciation led to an increase in growth rate, FDI inflows and foreign exchange reserves significantly.

In the developmental aspect, Bresser-Pereira (2019) concluded that the key determinant of underdevelopment is the overvaluation of REER which certainly hamper investment, industrialization, technical progress and growth.

Goda and Priewe (2020) studied determinants of REER in 15 emerging economies during 1996-2016 and showed that the cycle of commodity prices plays a significant role for the six commodity producing countries but has no significant effect on the "industrial EME" when "structural forces" of the REER, namely real GDP growth and each country's commodity terms of trade, and a currency crisis are dummy. Also, it was found that increasing (decreasing) commodity prices lead to an appreciation (depreciation) of "commodity EME" currencies, whereas they have no effect on the currencies of "industrial EME".

III. SOURCES OF DATA AND METHODOLOGY

The paper assumes:

NEER=Nominal Effective Exchange Rate of RMB by CPI index
REER=Real Effective Exchange Rate of RMB by CPI index
FDI=Foreign Direct Investment inflow of China in million US$
BOT=Balance of Trade of China in million US$
Liquidity=Total foreign exchange reserves of China in billion US$ excluding gold.
SCI=Shanghai Composite Index
TO=Trade Openness of China (in %)
TOT=Terms of Trade of China (2000=base year)
The data of NEER, REER, and liquidity, were collected from International Financial Statistics (IMF). The data of BOT and FDI were taken from UNCTAD. The data on TO and TOT were retrieved from globaleconomy.com and the data of SCI were retrieved from statista.com respectively.
The definitions of trade weighted 6 countries Chinese REER and NEER are given below.

$$\text{REER}=\sum_{i=1}^{n}[\left(\frac{e}{e_i}\right)\left(\frac{p}{p_i}\right)]^{w_i}$$

Where n= number of countries, i=ith currency, e=exchange rate home, e_i=exchange rate of ith country, p_i=price index of ith country by CPI, p=price index of the home country by CPI, w_i=weight (IMF 's SDR measure)

$$\text{NEER}=\sum_{i=1}^{n}[(\frac{s_i}{s_i^*})]^{w_i}$$

Where s_i = *exchange rate of the national currency against the ith currency*

s_i^* = *exchange rate of the national currency against the currency of the i during the base period*

W_i=The country's weight of the currency

Trade Openness (TO) $=\sum(X+M)/2/GDP$ x100 where X=export and M=import and GDP=Gross Domestic Product of China in current prices Balance of Trade (BOT)=X-M in million US$ in current prices.

Hamilton (2018) regression filter model is expressed in the following manner.

$Y_{t+8}=\alpha_o+\alpha_1 y_t+\alpha_2 y_{t-1+}\alpha_3 y_{t-2}+\alpha_4 y_{t-3}+v_{t+8}$

Or, $V_{t+8=}y_{t+8}+\dot{\alpha}_o+\dot{\alpha}_1 y_t+\dot{\alpha}_2 y_{t-1}+\dot{\alpha}_3 y_{t-2}+\dot{\alpha}_4 y_{t-3}$

So, $y_t=\alpha_o+\alpha_1 y_{t-8}+\alpha_2 y_{t-9+}\alpha_3 y_{t-10}+\alpha_4 y_{t-11}+v_t$

Therefore, $V_t= y_t-(\dot{\alpha}_o+\dot{\alpha}_1 y_{t-8}+\dot{\alpha}_2 y_{t-9}+\dot{\alpha}_3 y_{t-10}+\dot{\alpha}_4 y_{t-11})$ where $\dot{\alpha}_i$ are estimated coefficients.

$V_{t+h}=y_{t+h}-y_t$ is the difference i.e. how the series changes over h periods. For h=8, the filter $1-L^h$ wipes out any cycle with frequencies exactly one year and thus taking out both long run trends as well as any strictly seasonal components.

It also applies to random walk: $y_t=y_{t-1}-\varepsilon_t$ where d=difference=1 and $\omega_t^{(h)}$=stationary component=$\varepsilon_{t+h}+\varepsilon_{t+h-1}+\dots\dots\dots\dots+\varepsilon_{t+1}$ where ε_t= white noise.

Regression filter reduces to a difference filter when applied to a random walk. Hamilton suggested h=8 for business cycles and h=20 for studies in financial cycles. Regression v_t converges in large samples to $\alpha_1=1$ and all other $\alpha_j=0$. Thus, the forecast error is $v_{t+h}=y_{t+h}-y_t$.

The equation- v_t can be decomposed into trend, cycle and seasonally adjusted cycle through SEATS/TRAMO or STL or by census X-13 packages.

The cointegration test and Vector Error Correction Model were applied by using Johansen model (1988). The Wald test (1943) was applied to verify short run causality and the long run causality was analysed through the cointegrating equations.

IV. IMPORTANT OBSERVATIONS FROM ECONOMETRIC MODELS

4.1 Findings on trends of NEER

The non-linear trend of NEER of Chinese RMB during 1990-2019 has been estimated and is shown below.

$Log(NEER)=5.0428-0.1235t+0.0077t^2$

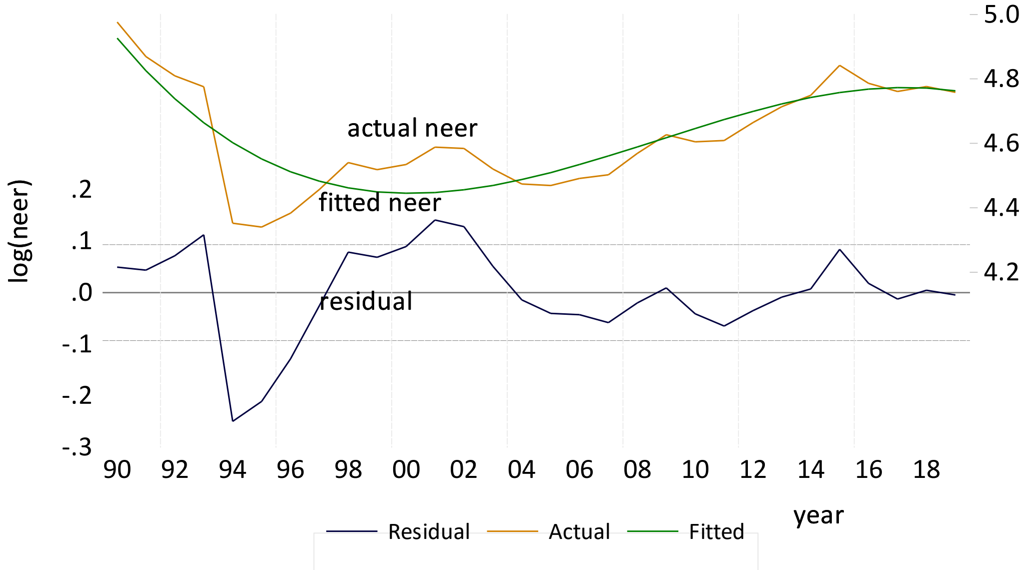
(64.98)* (5.79)* (4.87)*

$-0.000131t^3+u_i$

(-3.88)*

R^2=0.703,F=30.58,AIC=-1.78,SC=-1.59,DW=0.86 ,NEER=Nominal Effective Exchange Rate of Chinese RMB, n=30,*=significant at 5% level.

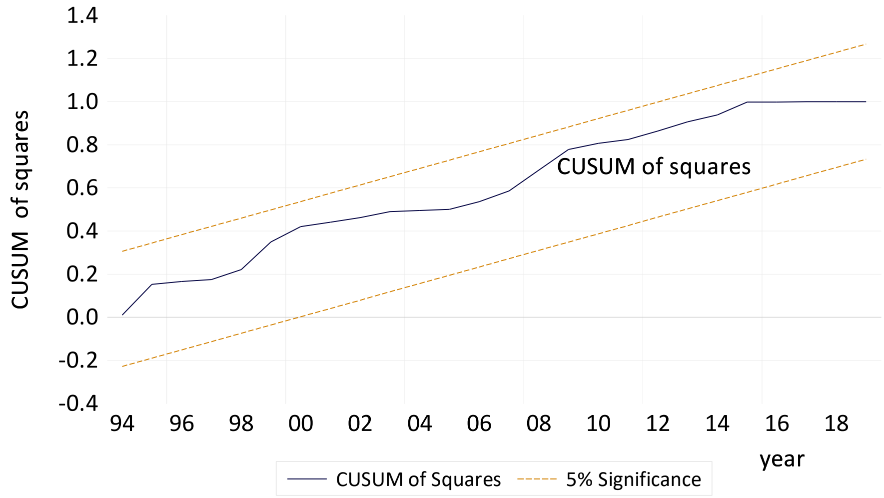
This estimate implies that the non-linear trend of NEER showed three distinct phases: First of all, NEER is decreasing, secondly it is upward and thirdly it started to decline significantly. This is shown in Figure 1 where actual and estimated trend lines have been depicted clearly.



Source:Plotted by author

Figure 1: Trend of NEER

This non-linear trend line of NEER during 1990-2019 is found fully stable because the CUSUM of squares test is significant at 5% level which is given below.



Source: Plotted by author

Figure 2: Stability test of non-linear trend

To analyse the decomposition of NEER of RMB of China from 1990 to 2019, the Hamilton regression filter is applied and its estimated equation is given below.

$\text{Log(NEER)}_t = 1.367 + 0.4706\log(\text{NEER})_{t-4}$

(1.12) (1.44)

$+0.191\log(\text{NEER})_{t-5} + 0.0182\log(\text{NEER})_{t-6}$

(0.434) (0.041)

$+0.0356\log(\text{NEER})_{t-7} + v_t$

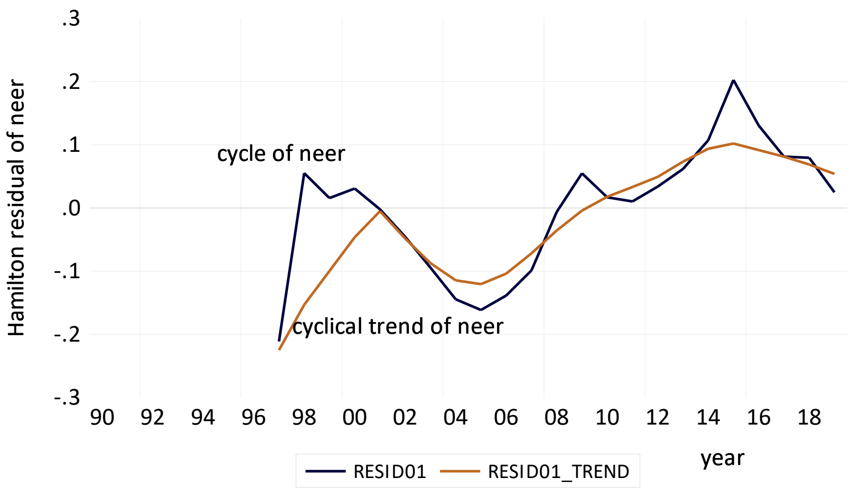
(0.101)

$R^2=0.412$, $F=3.16^*$, $DW=0.369$, $n=23$ after adjustment (1997-2019),

Thus, the residual of filter v_t represents the cyclical fashion of NEER through STL method.

$v_t = \text{Log(NEER)}_t - [1.367 + 0.4706\log(\text{NEER})_{t-4} + 0.191\log(\text{NEER})_{t-5} + 0.0182\log(\text{NEER})_{t-6} + 0.0356\log(\text{NEER})_{t-7}]$

The STL method revealed that the smooth cyclical trend of NEER of RMB consists of two peaks and one trough in which upswing takes longer time than downswing. The cycle consists of three peaks and two troughs showing many ups and downs. In Figure 3, the composite diagram of both cyclical trend and cycle are shown clearly



Source: Plotted by author.

Figure 3: Cycle and trend of NEER

4.2 Findings on cointegration and VECM on NEER

Johansen Unrestricted Cointegration Rank Test in Trace and Max-Eigen statistic among the first difference series of log(NEER), log(BOT), log(FDI),log(Liquidity), log(SCI), log(TO) and log(TOT) during 1992-2019 after adjustment is given below which confirmed that the above variables have long run association among them which consist of four cointegrating equations.

Table 1: Johansen cointegration test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.986417	290.1132	125.6154	0.0000
At most 1 *	0.878914	169.7439	95.75366	0.0000
At most 2 *	0.825679	110.6287	69.81889	0.0000
At most 3 *	0.732591	61.71665	47.85613	0.0015
At most 4	0.408548	24.78536	29.79707	0.1692
At most 5	0.178523	10.08048	15.49471	0.2746
At most 6 *	0.150720	4.574253	3.841466	0.0324
		Max-Eigen Statistic		
None *	0.986417	120.3693	46.23142	0.0000
At most 1 *	0.878914	59.11519	40.07757	0.0001
At most 2 *	0.825679	48.91205	33.87687	0.0004
At most 3 *	0.732591	36.93129	27.58434	0.0024
At most 4	0.408548	14.70488	21.13162	0.3101
At most 5	0.178523	5.506229	14.26460	0.6770
At most 6 *	0.150720	4.574253	3.841466	0.0324

Source-Calculated by author

* denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values; Observations=28, period=1992-2019 after adjustment, assumption-linear deterministic trend'

The estimated vector error correction model has been arranged in Table 2 where it was observed that the equations showed high R^2 values with low AIC and SC. The change of NEER is positively related with the previous period changes of BOT, FDI, TO and TOT insignificantly but is negatively related with changes of the previous year total liquidity and Shanghai Composite Index insignificantly. The change of BOT is positively associated with the previous period change of total liquidity and negatively related with the previous period change of FDI significantly. The change of FDI has positive impact on the previous period change of TOT and negative impact on the previous period change of NEER significantly. The change of total liquidity is negatively associated with the previous period changes of NEER and BOT significantly. The change of Shanghai Composite Index has significant negative impact on the previous period change of FDI and TO but is positively related with TOT.

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Table 2: The estimated equations of VECM of NEER

Error Correction:	d (log (NEER)	d(log (BOT))	d(log (FDI))	d(log(L)	d(log (SCI))	d(log (TO))	d(log (TOT))
CE1	-0.4091	10.735	-0.4572	-0.1535	3.5295	0.2099	0.3087
	[-2.320]*	[3.636]*	[-1.783]	[-0.411]	[3.397]*	[0.504]	[1.581]
CE2	0.0277	-1.1079	0.0871	0.0697	0.1279	0.0307	0.0164
	[1.957]	[-4.667]*	[4.229]*	[2.3235]*	[1.531]	[0.918]	[1.050]
CE3	-0.0855	2.9669	-0.3501	0.6341	1.0456	0.0794	0.0874
	[-1.436]	[2.975]*	[-4.042]*	[5.027]*	[2.979]*	[0.564]	[1.326]
CE4	-0.0013	0.1715	0.0108	-0.4819	-0.5059	-0.0789	-0.0910
	[-0.027]	[0.201]	[0.147]	[-4.484]*	[-1.692]	[-0.658]	[-1.619]
d(logNEER)	0.2640	4.8562	-1.0557	-1.1360	0.3610	-0.6723	0.2456
	[1.259]	[1.384]	[-3.465]*	[-2.560]*	[0.292]	[-1.358]	[1.058]
d(log(BOT (-1))	0.0110	0.0513	-0.0603	-0.0893	-0.0111	-0.0319	0.0029
	[0.859]	[0.238]	[-3.224]*	[-3.276]*	[-0.147]	[-1.049]	[0.205]
d(log(FDI (-1)))	0.0146	-3.1920	0.5333	-0.0160	-1.0908	-0.2603	-0.0185
	[0.207]	[-2.691]*	[5.178]*	[-0.106]	[-2.613]*	[-1.556]	[-0.235]
d(log(L (-1))	-0.0408	6.0340	0.1156	0.1904	-0.2366	-0.0920	0.0882
	[-0.795]	[7.161]*	[1.581]	[1.786]	[-0.798]	[-0.774]	[1.582]
d(log(SCI (-1))	-0.0214	0.9647	0.1041	0.0203	0.5508	0.0869	-0.0039
	[-0.540]	[1.451]	[1.804]	[0.241]	[2.353]*	[0.927]	[-0.088]
d(log(TO (-1))	0.0659	-2.5362	0.2271	-0.0889	-2.3108	0.0592	0.0009
	[0.451]	[-1.037]	[1.069]	[-0.287]	[-2.686]*	[0.171]	[0.005]
d(log(TOT (-1))	0.0699	-12.072	1.4427	1.3220	-4.9706	-0.0038	0.1425
	[0.176]	[-1.817]	[2.501]*	[1.573]	[-2.126]*	[-0.004	[0.324]
C	0.00286	-0.5549	0.0297	0.1348	0.2163	0.0527	-0.0159
	[0.192]	[-2.222]*	[1.373]	[4.269]	[2.462]*	[1.497]	[-0.968]
R-squared	0.8873	0.9501	0.9647	0.9376	0.7994	0.4273	0.3826
F-statistic	11.461	27.711	39.480	21.876	5.7974	1.0855	0.9015
Akaike AIC	-3.2628	2.3728	-2.5145	-1.7625	0.2841	-1.5444	-3.0591
Schwarz SC	-2.6918	2.9437	-1.9436	-1.1915	0.8551	-0.9734	-2.4882

t values are in the third brackets,*=significant at 5% level

Source-Calculated by author

The short run causality was found from the Wald test where the probability values of Chi-square (1) have been rejected for null hypothesis of no causality all of which are represented in Table 3 which revealed that BOT has short run causality with FDI and total liquidity. FDI has short run causality with NEER, BOT and TOT. Moreover, total liquidity has short run causality with NEER and BOT. And, SCI has short run causality with FDI, TO and TOT respectively.

Table 3: The short run causality of NEER

Srl no	Short run Causality from ....to........	$X^2(1)$	Probability	Ho=No causality	Causal relation
1	From FDI to BOT	7.2426	0.0071	Rejected	-ve
2	From Liquidity to BOT	51.2809	0.000	‘’	+ve
3	From NEER to FDI	12.0077	0.0005	‘’	-ve
4	From BOT to FDI	10.3942	0.0013	‘’	-ve
5	From TOT to FDI	6.2560	0.0124	‘’	+ve
6	From NEER to Liquidity	6.5544	0.0105	‘’	-ve
7	From BOT to Liquidity	10.7376	0.0010	‘’	-ve
8	From FDI to SCI	6.8295	0.0090	‘’	-ve
9	From TO to SCI	7.2158	0.0072	‘’	-ve
10	From TOT to SCI	4.5214	0.0335	‘’	-ve

Source- Calculated by author.

It is important to note that Shanghai Composite Index, Trade Openness and Terms of Trade have long run causal relationships with Nominal Effective Exchange Rate, Balance of Trade, Foreign Direct Investment inflows and Total Liquidity respectively all of which are significant. The Trade Openness and Terms of Trade have positive causalities and Shanghai Composite Index has negative causalities with them but the causality between NEER and TOT is found insignificant. All these have been verified from the following cointegrating equations.

a. $Z_{1t-1}=-0.4091\log(NEER)_{t-1}-0.2081\log(SCI)_{t-1}+0.74\log(TO)_{t-1}+0.096\log(TOT)_{t-1}-4.15$

(-2.32)* (-12.19)* (3.45)* (0.94)

b. $Z_{2t-1}=-1.1071\log(BOT)_{t-1}-4.937\log(SCI)_{t-1}+5.037\log(TO)_{t-1}+6.664\log(TOT)_{t-1}-23.327$

(-4.66)* (-9.47)* (3.27)* (2.14)*

c. $Z_{3t-1}=-0.3501\log(FDI)_{t-1}-1.295\log(SCI)_{t-1}+2.207\log(TO)_{t-1}+5.534\log(TOT)_{t-1}-4.152$

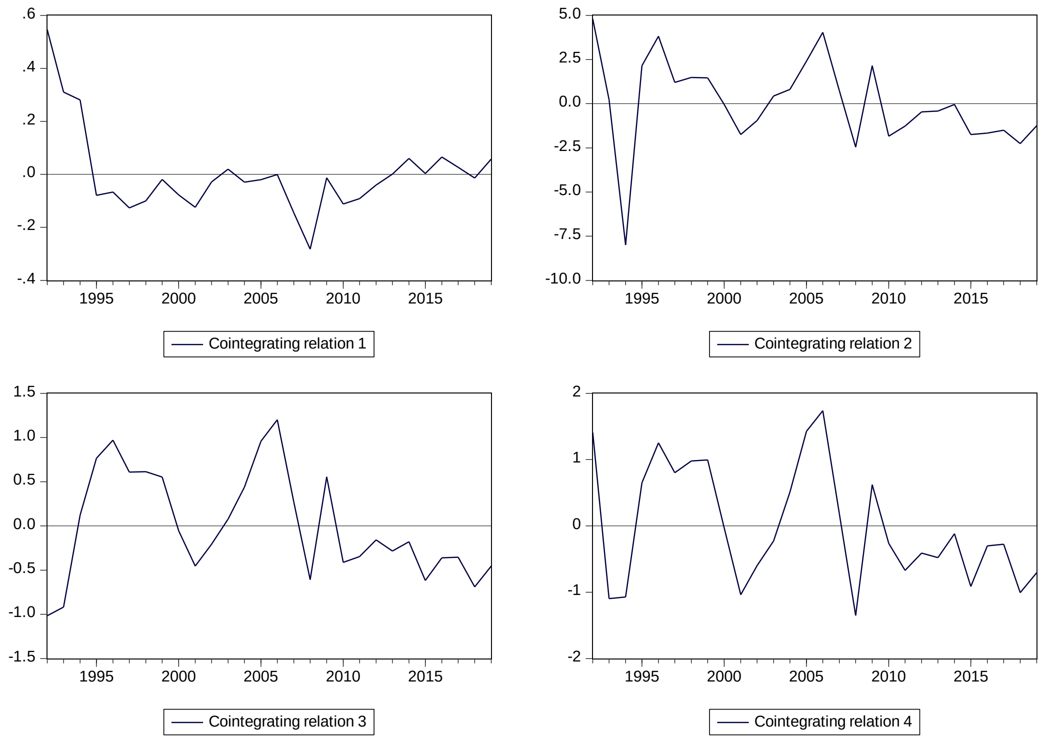
(-4.04)* (-8.48)* (4.89)* (6.06)*

d. $Z_{4t-1}=-0.4819\log(Liquidity)_{t-1}-2.464\log(SCI)_{t-1}+2.763\log(TO)_{t-1}+12.213\log(TOT)_{t-1}-53.74$

(-4.48)* (-9.62)* (3.65)* (7.98)*

*=significant at 5% level

The above four cointegrating equations have been approaching towards the equilibrium significantly but equation [a] is marginally departed because the t value of the regression coefficient between TOT and NEER became insignificant. How these four cointegrating equations have been marching towards equilibrium are shown in the following figures.



Source-Plotted by author.

Figure 4: Cointegrating equations of NEER

4.3 Findings on trends of REER

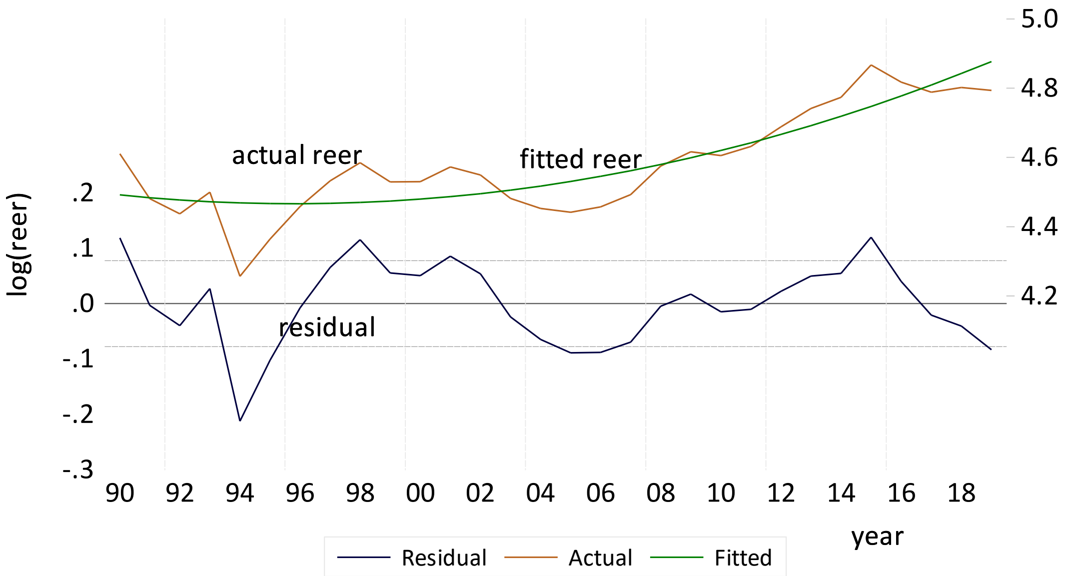
The quadratic function of REER of Chinese RMB from 1990 to 2019 has been estimated by semi-log non-linear trend model and is placed below.

$$\text{Log(REER)}=4.5014-0.01039t+0.000764t^2+u_i$$

$$(99.07)^* \quad (-1.538) \quad (3.610)^*$$

R^2=0.745, F=39.52*, DW=0.89, AIC=-2.18, SC=-2.04, REER=Real Effective Exchange Rate of RMB, *=significant at 5% level, n=30.

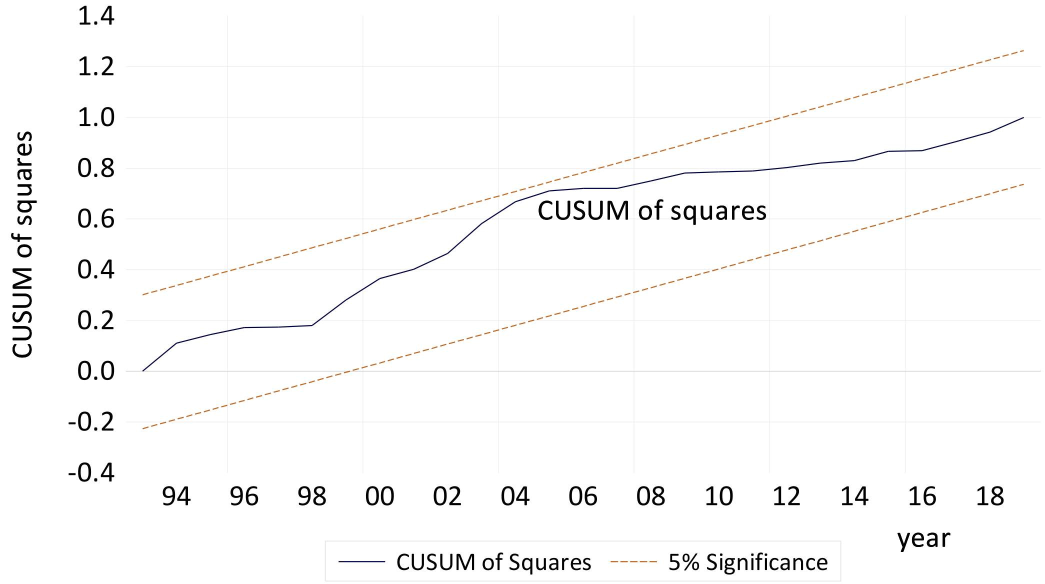
The estimate of quadratic trend of REER implies that it is insignificantly downward and then it is significantly upward during the period which is depicted in Figure 5. The period of upward trend is too long than the period of downswing.



Source- Plotted by author

Figure 5: Non-linear trend of REER

The residual CUSUM of squares test is fully significant at 5% level which reveals that the non-linear trend is stable and is shown in Figure 6 below.



Source- Plotted by author.

Figure 6: CUSUM of squares test of REER trend

The REER of RMB of China during 1990-2019 can be decomposed into trend, cycle, cyclical variations through the regression filter of Hamilton model using STL or SEATS/TRAMO methods.

The regression filter of Hamilton is estimated below in which v_t represents the residuals that contain cycles of REER.

$$Log(REER)_t=1.367+0.4706log(REER)_{t-4}+0.1917log(REER)_{t-5}+0.0182log(REER)_{t-6}+0.035log(REER)_{t-7}+v_t$$

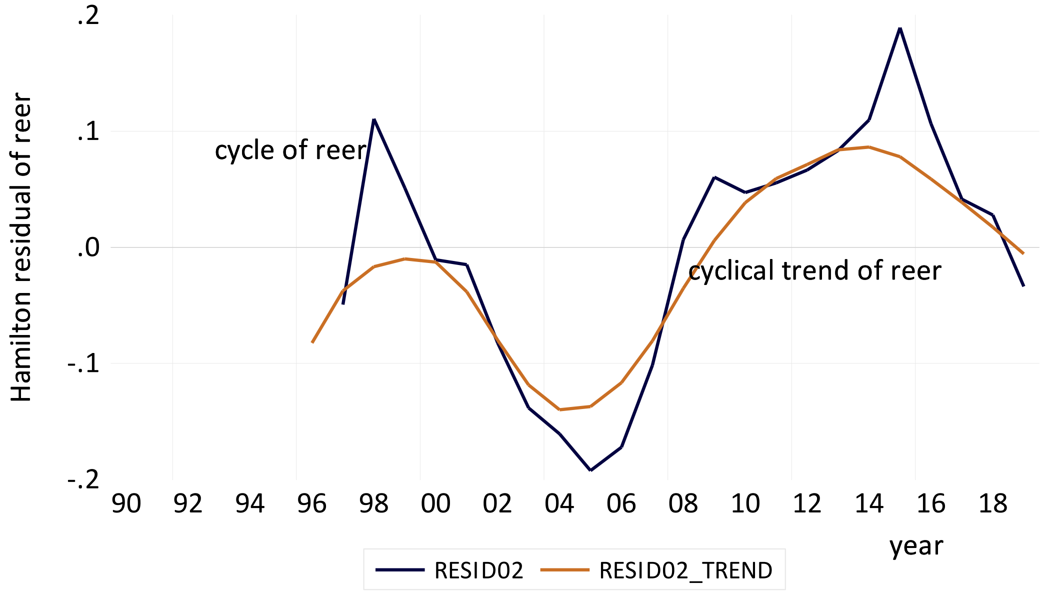
(1.12) (1.44) (0.43) (0.04) (0.10)

$R^2=0.41,F=3.16^*,DW=0.369,n=23$ (adjusted for 1997-2019)

Thus, v_t can be found as:

$$V_t= Log(REER)_t-[1.367+0.4706log(REER)_{t-4}+0.1917log(REER)_{t-5}+0.0182log(REER)_{t-6}+0.035log(REER)_{t-7}]$$

Using the STL method, it was found that the cycle of REER contains three peaks and one trough with small cycles where upswings took 10 years and downswing took 7 years. The smooth cyclical trend consists of two peaks and one trough and the cyclical variation is v shaped. In Figure 7,the cycle and the trend are plotted clearly.



Source- Plotted by author

Figure 7: Trend and cycle of REER

4.4 Findings of Cointegration and VECM on REER

The unrestricted Johansen rank test assuming linear deterministic trend during 1990-2019 for first difference series of log(REER), log(BOT), log(FDI), log(liquidity), log(SCI), log(TO), log(TOT) respectively have been conducted and found that there are long run association among them and the test revealed that there are four significant cointegrating equations as have been confirmed by Trace statistic and Max-Eigen statistic.

Table 4: Cointegration test of REER

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.987408	306.5401	125.6154	0.0000
At most 1 *	0.912354	184.0491	95.75366	0.0000
At most 2 *	0.841695	115.8844	69.81889	0.0000
At most 3 *	0.700501	64.27387	47.85613	0.0007
At most 4 *	0.465458	30.51579	29.79707	0.0413
At most 5	0.219252	12.97814	15.49471	0.1156
At most 6 *	0.194266	6.048052	3.841465	0.0139
		Max-Eigen Statistic		
None *	0.987408	122.4910	46.23142	0.0000
At most 1 *	0.912354	68.16468	40.07757	0.0000
At most 2 *	0.841695	51.61054	33.87687	0.0002
At most 3 *	0.700501	33.75808	27.58434	0.0071
At most 4	0.465458	17.53766	21.13162	0.1481
At most 5	0.219252	6.930085	14.26460	0.4974
At most 6 *	0.194266	6.048052	3.841465	0.0139

Source-Calculated by author

* denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values

The vector error correction model for REER of Chinese RMB during 1992-2019 (after adjustment) is estimated and the values of coefficients of the above respective variables with their t statistic have been arranged in the Table 5. All the estimated equations are highly significant with high R^2 and significant F with low AIC and SC. It is important to note that dlog(REER) is not significantly related to any variable. But, dlog (BOT) is positively related with dlog(liquidity) and dlog(SCI) of the previous period significantly and is negatively associated with dlog (FDI) and dlog(TOT) of the previous period significantly. Again, dlog (FDI) is positively correlated with log(liquidity) and log(TOT) of the previous period and is negatively related with log(REER) and log(BOT) of the previous period significantly. Even, dlog (liquidity) is negatively correlated with log(REER) and log (BOT) of the previous period significantly. The dlog (SCI) has negative impact on log(TO) of the previous period significantly and dlog(TO) is negatively related with log(REER) and log(BOT) of the earlier period significantly.

Table 5: Estimated VECM of REER

EC	d(log (REER)	d(log (BOT))	d(log (FDI))	d(log (LIQUIDITY))	d(log (SCI))	d(log (TO))	d(log (TOT))
CE1	-0.1162	15.690	-0.5501	-1.1658	2.1626	-0.2150	0.3902
	[-0.723]	[7.029]*	[-2.170]*	[-3.608]*	[1.967]*	[-0.614]	[2.411]*
CE2	0.0241	-1.4211	0.0982	0.0865	0.1111	0.0618	0.0052
	[1.668]	[-7.073]*	[4.305]*	[2.976]*	[1.123]	[1.964]	[0.360]
CE3	0.0431	0.8794	-0.2187	0.7078	0.5393	0.1443	0.0343
	[1.668]	[-7.073]*	[-4.305]*	[2.976]*	[1.123]	[1.964]	[0.360]
CE4	-0.0661	0.7457	-0.0449	-0.4462	-0.2321	-0.1433	-0.0605
	[-1.492]	[1.210]	[-0.642]	[-5.005]*	[-0.765]	[-1.484]	[-1.356]
d(log(REER (-1))	0.3446	4.2518	-1.0333	-1.5000	-1.3219	-1.4788	0.3438
	[1.574]	[1.397]	[-2.991]*	[-3.406]*	[-0.882]	[-3.101]*	[1.558]
d(log(BOT (-1))	0.0178	0.2305	-0.0596	-0.1121	-0.0595	-0.0653	0.0097
	[1.443]	[1.339]	[-3.053]*	[-4.502]*	[-0.702]	[-2.421]*	[0.783]
d(log(FDI (-1))	0.0092	-1.6586	0.5773	0.1348	-0.2576	-0.1386	0.0183
	[0.209]	[-2.699]*	[8.275]*	[1.516]*	[-0.851]	[-1.439]	[0.411]
d(log (LIQUIDITY (-1))	0.0042	5.0855	0.2311	0.2888	-0.3238	-0.0144	0.0595
	[0.093]	[7.965]*	[3.188]*	[3.125]*	[-1.029]	[-0.144]	[1.286]
d(log(SCI (-1)))	0.0492	1.5628	0.0898	-0.0755	0.4973	0.0354	0.0255
	[1.276]	[2.911]*	[1.473]	[-0.971]	[1.88125]	[0.421]	[0.657]
d(log(TO (-1))	-0.0287	-4.1288	0.1908	0.1110	-2.1240	-0.0627	0.0240

	[-0.200]	[-2.072]*	[0.843]	[0.385]	[-2.165]*	[-0.200]	[0.166]
d(log(TOT (-1))	-0.2140	-17.135	1.6619	2.4148	-3.3484	0.9475	-0.0697
	[-0.547]	[-3.156]*	[2.696]*	[3.073]	[-1.252]	[1.113]	[-0.1772
C	-0.0016	-0.7583	0.0229	0.1342	0.1475	0.0569	-0.0260
	[-0.127]	[-4.135]*	[1.100]	[5.059]	[1.633]	[1.982]	[-1.957]
R-squared	0.8189	0.9693	0.9626	0.9498	0.7585	0.5653	0.5440
F-statistic	6.5805	45.995	37.501	27.530	4.5706	1.8922	1.7358
Akaike AIC	-3.3774	1.8861	-2.4649	-1.9795	0.4695	-1.8202	-3.3623
Schwarz SC	-2.8064	2.4570	-1.8940	-1.4086	1.0404	-1.2492	-2.7913

*Source-Calculated by author, *=significant at 5% level. In third brackets there are t values. n=28(adjusted 1992-2019), EC=Error Corrections, CE=cointegrating equations.*

The short run causal relations were tested through the Wald test in the estimated system equations of the VECM in which the probability values of the Chi- square test have been checked at H0=null hypothesis of no causality. All the findings of the causal relationships in the short run are given below in Table 6 in which it was found that BOT has significant short run causal relations with FDI, liquidity, SCI and TO respectively. Moreover, FDI has short run causal relations with REER, BOT, liquidity and TOT respectively. Total liquidity has significant short run causal relations with REER, BOT and TOT and TO has short run causal relations with REER and BOT and SCI respectively.

Table 6: The short run causality of REER

Serial No	Short causality from......to.....	$X^2(1)$	Probability	H0=no causality	Causal relation
1	From FDI to BOT	7.2867	0.0069	rejected	-ve
2	From Liquidity to BOT	63.4413	0.0000	”	+ve
3	From SCI to BOT	8.4759	0.0036	”	+ve
4	From TO to BOT	4.2956	0.0382	”	-ve
5	From REER to FDI	8.949	0.0028	”	-ve
6	From BOT to FDI	9.3255	0.0023	”	-ve
7	From Liquidity to FDI	10.1636	0.0014	”	+ve
8	From TOT to FDI	7.2708	0.0070	”	+ve
9	From REER to Liquidity	11.6067	0.0007	”	-ve
10	From BOT to Liquidity	20.268	0.000	”	-ve
11	From TOT to Liquidity	9.4469	0.0021	”	+ve
12	From TO to SCI	4.6876	0.0458	”	-ve
13	From REER to TO	9.6190	0.0019	”	-ve
14	From BOT to TO	5.8619	0.0155	”	-ve

Source: Calculated by author

The system equations of the estimated VECM for REER revealed that there are four cointegrating equations all of which have been moving towards equilibrium where equation [a] is not significant at 5% level and all the equations imply that REER,BOT,FDI and liquidity of China have long run causal relations with SCI,TO and TOT respectively in which TO and TOT have positive causal relations and SCI has negative causality with the stated variables. The equation [a] and [b] have marginally departed from equilibrium due to insignificant relations with TOT.

a. $$Z_{1t-1}=-0.1162\log(REER)_{t-1}-0.3346\log(SCI)_{t-1}+0.3571\log(TO)_{t-1}+0.1294\log(TOT)_{t-1}-4.0197$$
$$(-0.723) \quad (-15.51)^{*} \quad (5.85)^{*} \quad (0.99)$$

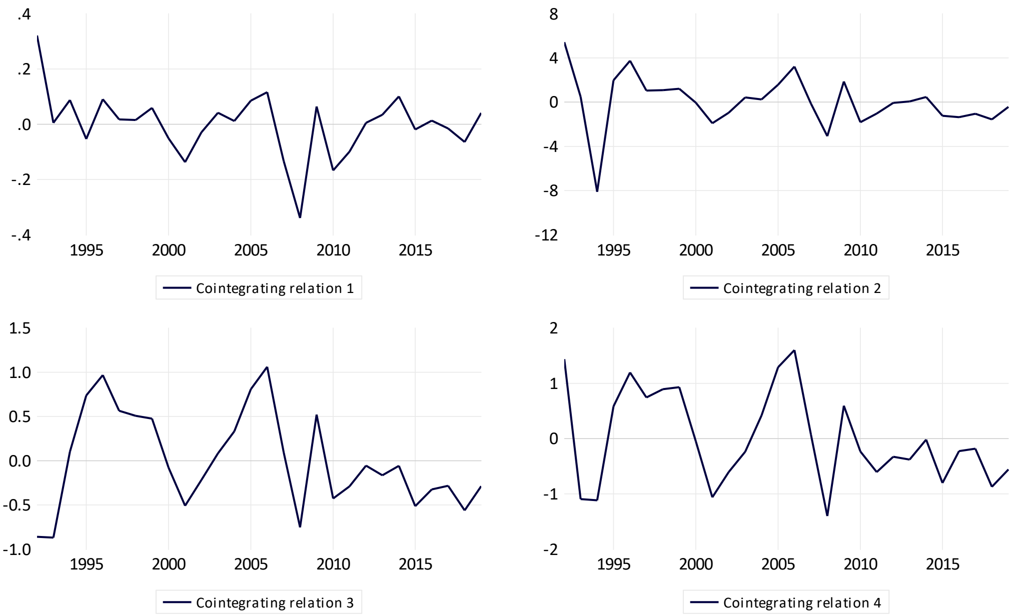
b. $$Z_{2t-1}=-1.421\log(BOT)_{t-1}-4.798\log(SCI)_{t-1}+2.356\log(TO)_{t-1}+1.441\log(TOT)_{t-1}+9.350$$
$$(-7.07)^{*} \quad (-11.59)^{*} \quad (2.01)^{*} \quad (0.57)$$

c. $$Z_{3t-1}=-2.187\log(FDI)_{t-1}-1.299\log(SCI)_{t-1}+1.685\log(TO)_{t-1}+4.286\log(TOT)_{t-1}-27.134$$
$$(-3.17)^{*} \quad (-9.83)^{*} \quad (4.50)^{*} \quad (5.37)^{*}$$

d. $$Z_{4t-1}=-0.446\log(liquidity)_{t-1}-2.407\log(SCI)_{t-1}+2.350\log(TO)_{t-1}+11.327\log(TOT)_{t-1}-18.598$$
$$(-5.005)^{*} \quad (-9.99)^{*} \quad (3.44)^{*} \quad (7.79)^{*}$$

*=significant at 5% level

In Figure 8, the four cointegrating equations have been depicted clearly where the equation [a] is insignificantly approaching towards equilibrium and partly departed from equilibrium and the equation [b] is also showing marginal deviation but the equations [c] and [d] have been significantly converging towards equilibrium.



Source: Plotted by author

Figure 8: Cointegrating equations of REER

V. LIMITATIONS AND FUTURE SCOPE OF RESEARCH

The NEER and REER of Chinese RMB also determined directly or indirectly by GDP growth rate, fiscal deficit (% of GDP), rate of tariff, gold flows and gold price respectively but these data were excluded from the analysis. The paper may replace BOT by adding China's international export share and import share or total liquidity may be replaced by international share of total liquidity. These inclusions will obviously bring out good observations to compare international competitiveness. Thus, there are enough scopes for future research in these extended areas.

VI. POLICY RECOMMENDATIONS

In the long run, increasing NEER and REER of Chinese RMB led to decrease in Shanghai Composite Index i.e. RMB depreciation deteriorated the share indices of China which implies a negative impact on the capital market. In the short run, a decrease in SCI affected a decline in BOT and China became looser in trade and again a decrease in SCI catapulted TO and TOT of China for which China will be gainer in international trade in the short run. In this event, China requires a policy of improvement in the demand for bond, share, mutual funds, institutional foreign investment which will internationalise RMB and all these are needed capital account convertibility of RMB so that RMB can be treated as reserve currency.

Secondly, upswings of NEER and REER led to depreciation of RBM that accelerated trade openness and terms of trade of China in the long run which implied that BOT had increased in China so that USA and other countries forced China to appreciate RMB to retaliate. In the short run, an increase in TO and TOT led to decrease in SCI and BOT both of which have adverse effects on capital market and international trade and this rise in TOT led to increase in liquidity and FDI inflows for which China will gain in capital market and in international trade in the short run. All these impacts provoked China to adopt a policy of freely floating exchange rate of RMB so that China as a currency dictator or retaliator will be wiped out from the USA and the rest of the world.

VII. CONCLUSIONS

The paper concludes that non-linear trend of NEER of Chinese RMB during 1990-2019 is cubic which is initially increasing then it is declining and after that it is downward. It is stable as per CUSUM of squares test. The decomposition of NEER explained that the cyclical trend consists of two peaks and one trough but the cycle consists of four peaks and three troughs where upswings took more years than the downswings. Chinese NEER with its determinants like BOT, FDI, liquidity, SCI, TO and TOT have four significant cointegrating equations and the VECM stated that FDI has short run causalities with NEER and BOT but total liquidity and TOT have short run causalities with BOT and SCI respectively. Moreover, SCI,TO and TOT have long run causal relationships with NEER, BOT, FDI and liquidity respectively. The four cointegrating equations tend to equilibrium significantly with exception that equation one marginally deviates from equilibrium due to insignificant TOT.

The REER of China's RMB during 1990-2019 revealed a nonlinear quadratic trend in which downswing is insignificant but upswing is significant. It is stable according to the CUSUM of squares test. The decomposition of REER from 1990 to 2019 states that the smooth cyclical trend consists of two peaks and one trough but the cycle showed three peaks and one trough where upswing took 10 years and downswing took 7 years and seasonal variation is v shaped. There are four cointegrating equations among REER, BOT, FDI, Liquidity, SCI, TO and TOT respectively where BOT has short run causal relations with FDI, liquidity, and TOT.FDI is relating to cause and effect with REER, BOT, and TOT. Even TO has short run causal relations with REER, BOT and SCI respectively. Two among four cointegrating equations move towards equilibrium significantly which imply that REER,BOT,FDI and liquidity have long run causal relation with SCI,TO and TOT respectively.

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