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Patterns of trends and cycles of Nominal Effective Exchange Rate and Real Effective Exchange Rate of Chinese Renminbi

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Abstract
The paper endeavors to explore the cyclical trends, cycle, seasonal variation and trend of the NEER and REER of RMB of China from 2014M1 to 2020M5 by applying Hamilton regression filter which has been also passed through ARIMA forecast model for 2024M12.The the paper found that both NEER and REER are cubic in trend where the former showed two phases and the later showed three phases of inverse s shaped in cyclical trend. Their cycles consist of many peaks and troughs and seasonal variations are v shaped. The duration of downswings for both NEER and REER are loo long but upswing periods are short. Their ARIMA projections are stationary, convergent and significant for 2024M12 which had no heteroscedasticity problems.
Keywords: Cyclical trend, seasonal variation, cycle, NEER, REER, Hamilton filter, ARIMA model.
JEL Classification codes: C32, E32, E42, F31, F33, G15, O16, N20

I. Introduction

During 1898-1935, China was in silver standard where silver served as denominator in currency of China. The Yangli was the dollar-tael exchange rate i.e. actual market price of silver dollar (1.0802 fine silver troy oz of Shanghai tael=33.5989 grams of fine silver and Eagle Dollar contains 0.78802 of silver).Then, Chinese silver standard regime was eventually a rival standard of the global monetary market and it was fact that from 1989M1 to 1933M3,Yangli in Shanghai and Tianjin appreciated more than 8% during Boxer rebellion after 1900 and 10% in 1911 revolution but it depreciated by 3% in 1932 rural crisis (Ma & Zhao,2018).It was reality that during the great depression from 1929M1 to 1935M12,China was in silver standard and the behavior of exchange rate of US$ per 100 Chinese Dollar revealed that it was U shaped when the price level had a volatile cyclical fluctuation (Lai & Gau,2003).

The Renminbi is the official currency of China in which Yuan is considered as the basic unit. In 1948, December 1, China first introduced Renminbi as the currency. China adopted fixed exchange rate system from 1949 to late 1970s allowing overvaluation in the planned economy. In October,1980,government allowed to introduce internal settlement rate of RMB as 2.8 to 1 US$ and

was permitted to devalue although in 1978,the dual track currency system was instituted. During 1980 to early 1990, RMB was more convertible and dual track currency system was abolished. In 2013,the RMB became convertible on current account but not in capital accounts. Finally, from October 1,2016,RMB entered into SDR basket .

In July,2005, RMB was allied with US dollar in daily trading price in interbank foreign exchange market and allowed to float under a narrow band of 0.3% around central parity which was extended to 1% in 14 April,2012, and to 2% in 17 March 2014 respectively. The RMB denominated bank deposits were liberalized in July 2010.From 1997 to 2005,Chinese government pegged RMB to US dollar at about 8.3RMB per US$ and since 2005 July 21,China lifted the peg to US$ and introduce a flexible mechanism of exchange rate.

During 1953-1978, the value of RMB was fixed at an official rate of RMB as 2.46 per US$ until 1971 when Bretton Woods collapsed. In 1974, August 19, Yuan was pegged to trade weighted basket of currencies and it was 1.53RMB per US$ before economic reform. From 1979 to 1995,Chinese exchange rate policy experienced a round trip change and dual exchange rate system was emerged in 1981 to avoid loss of export and since 1.1.1985,China fixed 2.80RMB=1US$ rate. Again in April,1991,China started to follow managed floating exchange rate system and from July21,2005,RMB was moved to more flexible rate while RMB appreciated by 16.27% during 2005July - 2010July.(UKEssays,2018).

Thus, in brief, China was in dual track exchange rate system from 1979 to 1984 but from 1985 to 1993 swap rate was fixed at 8.7RMB per US$ along with official rate of 5.7RMB per US$. The exchange rate system was managed float with a narrow band from 1994 to 2005 June where RMB floated from ±0.15% to ±0.3% around reference rate of Peoples Bank of China. Lastly, from 2005July to update now, China started to follow freely floating exchange rate system and turned into market oriented floating exchange rate system from 2015 August 11(Si,2014).

During the exchange rate regimes in China, the value of RMB has changed many times. From 1998 to June 2005,it was pegged to 8.28 RMB per US$ whereas from November 2013 to November 2015,REER of RMB rose by 11.9% with 61 major currencies and depreciated against US$ by 4.6% and REER of RMB again fell by 6.5% from December 2015 to December 2017 and started to appreciate by 0.5% from December 2018.Moreover,RMB depreciated against US$ by 8.8% from August 2015 to December 2016 and it again appreciated by 4.6% against US$ from January 2017 to December 2017 and it again fell down up to May 2018 and there after it started to appreciate till date.(Morrison,2019).

The misalignment of Chinese exchange rate as opposed by USA is something different if it is analyzed on the patterns of NEER and REER of China from 2014M1 to 2020M5 during the course of floating exchange rate mechanism in the globalized world. In the yearly data, it was found that Chinese export to USA were increasing with upswing of NEER and REER of China before 2015. But from 2015 to 2016 and to 2017, both NEER and REER of China fell down and the China's export to USA had declined. On the other hand, from 2017 to 2018, Chinese REER and NEER have been stepped up which implied to increase China's export to USA but converse was true when the rates were declines from 2018 to 2019 the export to USA also declined. Thus, there are cyclical trends of both NEER and REER so that Chinese exports to USA may have downswing trend. But, the situations for Euro Area and the rest of the world are rather different. Even, the cyclical behavior of NEER and REER of China as observed from monthly data were rather more critical with the movement of Chinese export to USA and the rest of the world. Therefore, the currency war or trade war between China and USA should be reconsidered in an alternative way.

In this paper, the author has tried to show the cyclical trend and cyclical patterns as well as seasonal variations of NEER and REER of China for the recent years from 2014M1 to 2020M5 so that the RMB exchange rate policy can be understood clearly to justify misalignments.

II.Important Studies

There are a few important economic literatures which explained the misalignment or currency manipulator of China's role in the exchange rate mechanism and the patterns of NEER and REER of RMB. Goldstein (2004) explained that China continued to run surplus on current and capital accounts and restricted on capital flows amid global imbalance so that RMB was compelled to devalue by 15 to 25 per cent. Author argued that China is a currency manipulator being 4th largest exporter and 3rd largest importer and opined that the revaluation of RMB would improve China's prospects for healthy, sustainable non-inflationary economic growth and also good for rest of the world.

Rossi (2005) opined that a forced appreciation of RMB led to a decrease in international trade where 50% or more appreciation could have negative effect in China as well as in the world economy.

Cline and Williamson (2007) estimated by reviewing all studies during 2000-2007 and concluded that the simple average for bilateral real appreciation given by BEER and FEER approach are smaller at 25 and 36 per cent whereas the simple average for multilateral real revaluations in BEER and FEER approaches are even more moderate at 18 and 20 per cent respectively. There are considerably more agreements among enhanced-PPP estimate than among the BEER estimate.

Su (2009) showed that REER of RMB from 1994Q1 to 2008Q2 was appreciated by 45.87% and NEER of RMB by 20.78% and the value of RMB in 2005 was close to the value in early 1996 which was about 10 per cent less than the height of the Asian Financial crisis in mid-1997.

Ahmed(2009) examined that China pegged RMB with US$ until mid-2005.Chinese government allowed gradual appreciation of RMB until 2010.After the peg was suspended, a trend of appreciation of REER and NEER of RMB were observed until 2010 having RMB/US$ rate constant and the dollar was appreciating against other major currencies. Due to dollar weakness REER has moved down. The cumulative appreciation of REER of RMB since 2005 has been about 13% which lowered China's huge trade surplus.

Dadush and Ali (2010) concluded that the appreciation of RMB would help China's economy and would balance the rest of the world but USA and Italy would be losers for their increasing trade deficit with China.

Zhang and Sato(2011) showed that during 1994M1 -2009M8 ,Chinese NEER appreciation expands so that the US trade deficit and the rest of the world increased cyclically where RMB/US$ had no influence on trade deficit in which Mckinnon (2010) also believed that under financial globalization forcing China to appreciate its currency is neither necessary nor sufficient for reducing its trade surplus.

Bhowmik (2016) estimated ARIMA (1,0,1) model of Chinese Yuan per US$ rate during 2010M1-2016M1 which showed that nominal rate is stationary although the actual series contains depreciation and appreciation. The conditional variance of nominal rate was highly volatile. Author explained that Chinese RMB entered into SDR basket from 1-10-2016 which will improve Chinese economy more healthier because one per cent increase in Chinese holding in SDR reserve per year led to 0.987% increase in export per year during 1968-2013 significantly .Moreover, one per cent increase in Chinese global share of SDR per year lead to 0.9638% increase in Chinese global share of export during 1980-2013 significantly.

BIS (2017) found that Chinese currency has been appreciating over last 20 years against broad basket of currencies in which index rose from 75 to 117 (August 2016) with highest peak of 127.4 in July 2015. A sharp appreciation occurred between 2014 and 2015.Central bank of China depreciated by 4%

against US$ in August 2015 with the pressure of US. Since then, the NEER of RMB has constantly been decreasing.

Cheung and He (2019) estimated RMB misalignment during 1994-1997,1998-2004,2005-2008,2009-2010,2011-2014 respectively. The highest misalignment was observed during 1998-2004 and 2005-2008 and the median of the 2011-2014 period was smaller than the median from other periods. The ratio of under-valuation to non-under valuation estimates for 2011-2014 was the smallest.

Jitaru and Dumitraeciuc (2019) concluded that the EU trade deficit was not due to RMB depreciation rather its deepening which needs to increase EU imports from China because EU has a chronic and quasi-continuous trade deficit.

III.Methodology and source of data

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

$Y_{t+8}=\alpha_0+\alpha_1 y_t+\alpha_2 y_{t-1+}\alpha_3 y_{t-2}+\alpha_4 y_{t-3}+v_{t+8}$

Or, $V_{t+8=}y_{t+8}+\acute{\alpha}_0+\acute{\alpha}_1 y_t+\acute{\alpha}_2 y_{t-1}+\acute{\alpha}_3 y_{t-2}+\acute{\alpha}_4 y_{t-3}$

So, $y_t=\alpha_0+ \alpha_1 y_{t-8}+\alpha_2 y_{t-9+}\alpha_3 y_{t-10}+\alpha_4 y_{t-11}+v_t$

Therefore, $V_t= y_t-(\acute{\alpha}_0+\acute{\alpha}_1 y_{t-8}+\acute{\alpha}_2 y_{t-9}+\acute{\alpha}_3 y_{t-10}+\acute{\alpha}_4 y_{t-11})$ where $\acute{\alpha}_i$ 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 trend as well as any strictly seasonal components.

It also applies random walk: $y_t=y_{t-1}-\varepsilon_t$ where d=1 and $\omega_t^h=\varepsilon_{t+h}+\varepsilon_{t+h-1}+\ldots\ldots\ldots\ldots+\varepsilon_{t+1}$

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 census X-13 packages.

STL technique was used by applying methodology of Cleveland et al (1990). STL can be explained as:

$Y_k=T_k+S_k+R_k$ where Y_k=Observed variable component, T_k=trend component, S_k=Seasonal component, R_k=remainder component=$Y_k-T_k-S_k$ and $|R_k|$ will have a small or zero weight. Here k=1,2…..n.

Since monthly data of Nominal Effective Exchange Rate (NEER) and Real Effective Exchange Rate (REER) were used from 2014M1 to 2020M5, so v_t becomes:

$V_t= y_t-(\acute{\alpha}_0+\acute{\alpha}_1 y_{t-24}+\acute{\alpha}_2 y_{t-25}+\acute{\alpha}_3 y_{t-26}+\acute{\alpha}_4 y_{t-27})$

Even Hamilton regression filter can be used for ARIMA(p,d,q) model for forecasting at date. So, Box and Jenkins (1976) model of ARIMA(p,d,q) is applied in the Hamilton regression filter model for prediction in the following manner.

$V_t=a+\alpha_i v_{t-i}+\varepsilon_t+\beta_i\varepsilon_{t-i}$

Where a=constant, α_i=coefficient of AR process, β_i=coefficient of MA process, v_{t-i}=AR process, ε_{t-i}=MA process, i=1,2,3……n.

By applying Cochrane and Orcutt (1949) model, the projection of NEER and REER were calculated by simple semi-log linear trend line.

The cubic semi-log linear trend model can be found from this equation given below.

$Log(x)=a_1+a_2 t +a_3 t^2+a_4 t^3$

where x=variable, a_1=constant, a_2, a_3, a_4 are coefficients, t=time

The definitions of trade weighted 6 countries Chinese REER and NEER are given below.

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

Where n= number of countries, i=ith currency, e=exchange rate home, e_i=exchange rate 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)

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

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

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

W_i=countries weight of the currency

Monthly data of Nominal Effective Exchange Rate (NEER) and Real Effective Exchange Rate (REER) at CPI based have been collected from the International Financial Statistics (IMF) from 2014M1 to 2020M5.

(SEATS=Signal Extraction in ARIMA Time Series; TRAMO=Time Series Regression with ARIMA noise, Missing values and Outliers; STL= Seasonal Trend Decomposition using Loess)

IV.Findings from econometric models

[1] Trend of NEER

The non-linear trend of NEER of Chinese RMB during 2014M1-2020M5 has been estimated below in which it is upward followed by downward trend and then moved upward significantly.

$Log(NEER)=4.7196+0.00876t-0.000254t^2+1.94E-06t^3+u_i$

(363.62)* (6.12)* (-5.96)* (5.41)*

R^2=0.428, F=18.213*, AIC=-4.328, SC=-4.206, DW=0.135, NEER=Nominal Effective Exchange Rate of RMB, t= period (monthly), n=77, *=significant at 5% level, u_i=error

In Figure 1, the trend line of NEER has been plotted in which non-linear trend is inverse S shape.

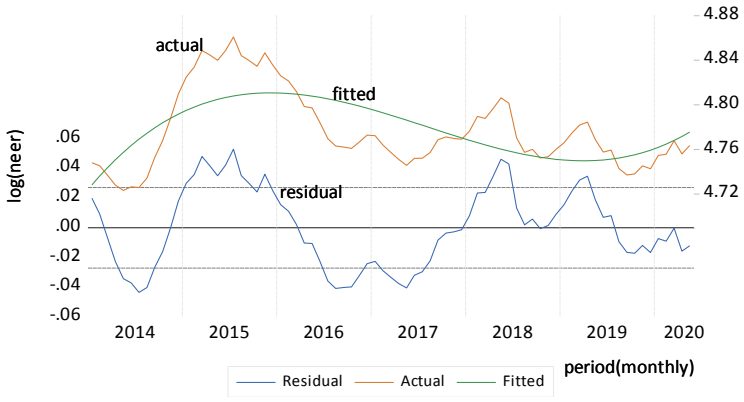

Figure 1: The trend of NEER

Source-Plotted by author

The residual stability test of the trend line of NEER is showed stable according to CUSUM of square test except during 2018M1-2018M8 and 2015M6-2016M11 respectively for the problem of autocorrelation. In Figure 2, the stability test is shown vividly.

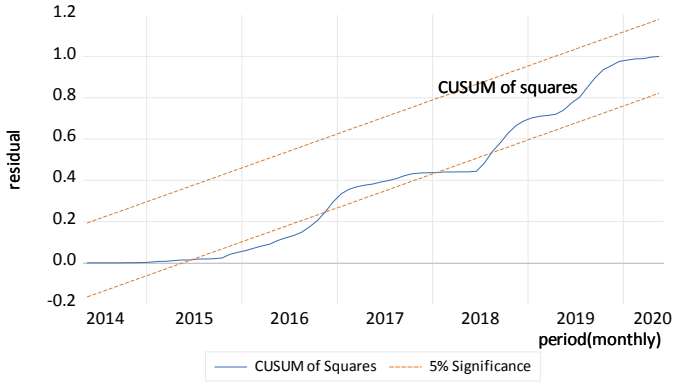

Figure 2: Stability test of trend of NEER
Source-Plotted by author.

[2] Decomposition of NEER of RMB

The decomposition of cyclical trend, cycle, seasonal variation, remainder and seasonally adjusted cycle of NEER of Chinese RMB during 2014M1-2020M5 has been estimated through the Hamilton regression filter which is given below.

$Log(NEER)_t=4.8005-0.429log(NEER)_{t-24}+0.1796log(NEER)_{t-25}-0.0617log(NEER)_{t-26}+0.3044log(NEER)_{t-27}+v_t$

(16.63)* (-1.50) (0.36) (-0.127) (1.08)

R^2=0.214, F=3.07*, SC=-5.23, AIC=-5.42, DW=0.37, n=50, v_t= residual, period=2016M4-2020M5, *=significant at 5% level.

Thus, the residual or Hamilton regression filter becomes,

$v_t= Log(NEER)_t-[4.8005-0.429log(NEER)_{t-24}+0.1796log(NEER)_{t-25}-0.0617log(NEER)_{t-26}+0.3044log(NEER)_{t-27}]$

This v_t has been decomposed through the STL method which is depicted in Figure 3 where in panel 1, the cycles of NEER of RMB which consists of mainly four peaks and five troughs along with short cycles are shown. In panel 2, the smooth cyclical trend with only one peak was found in which the downward trend took long four years and eight months. Firstly, it is upward then it turns to downward trend. In panel 3, the v shaped seasonal fluctuations with equal amplitudes have been obtained. In panel 4, the remainder having short cycles has been moving around the equilibrium level with one long trough and peak. In panel 5,the seasonally adjusted cycles mainly showing downward trend with many short period cycles were found.

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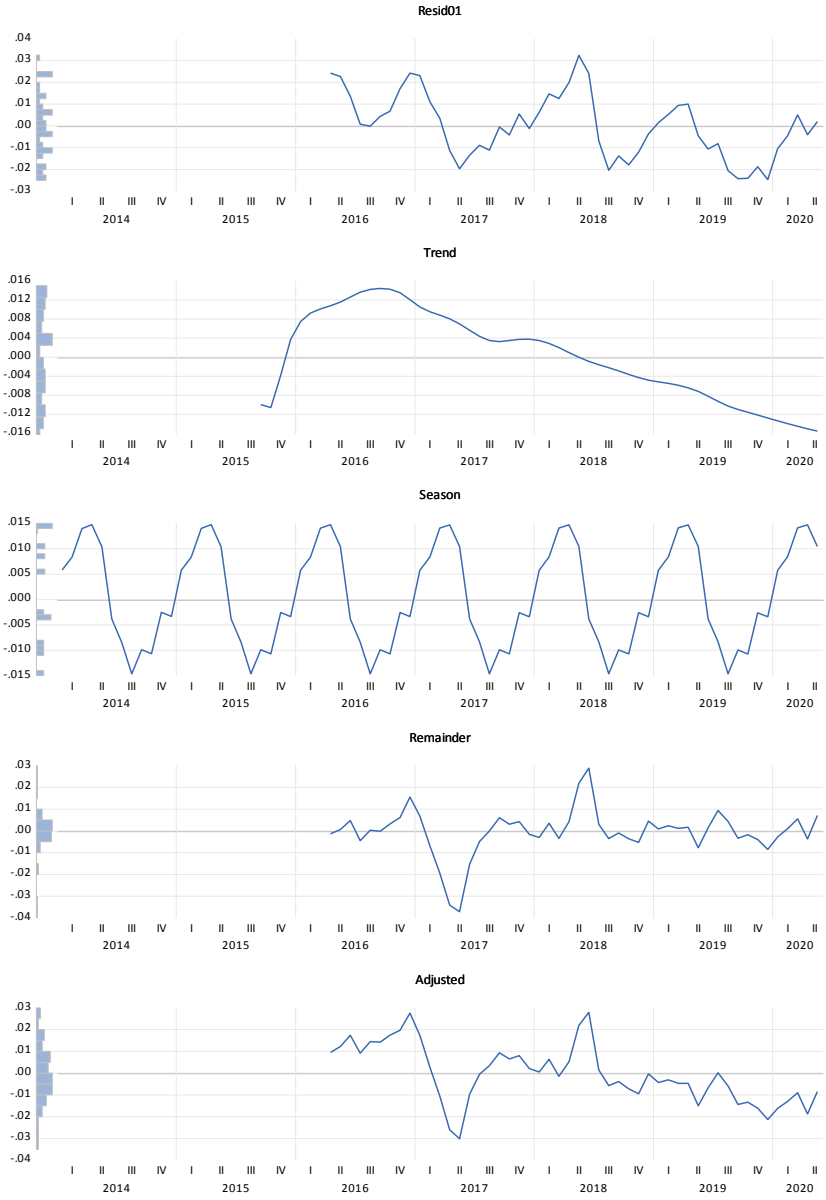


Figure 3: Decomposition of Hamilton filter in NEER of RMB
Source-Plotted by author

In Figure 4,the cyclical trend and the cycle of NEER of RMB after decomposition from Hamilton regression filter have been depicted in a composite figure and found that the smooth cyclical trend of NEER has been rising very quickly with short duration whereas it is steadily falling with a long duration but the cycle showed many peaks and troughs in downward fashion.

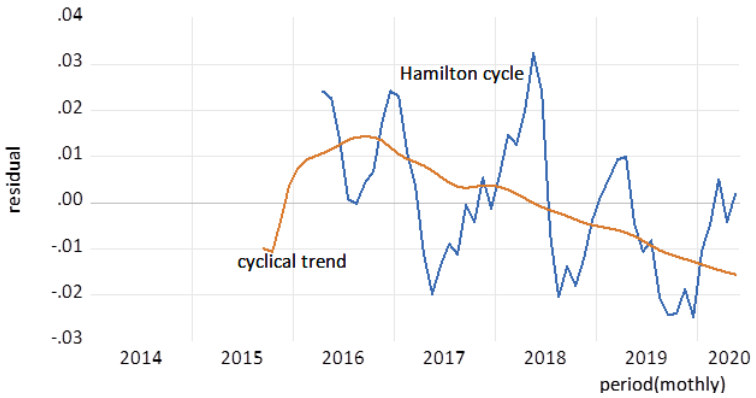
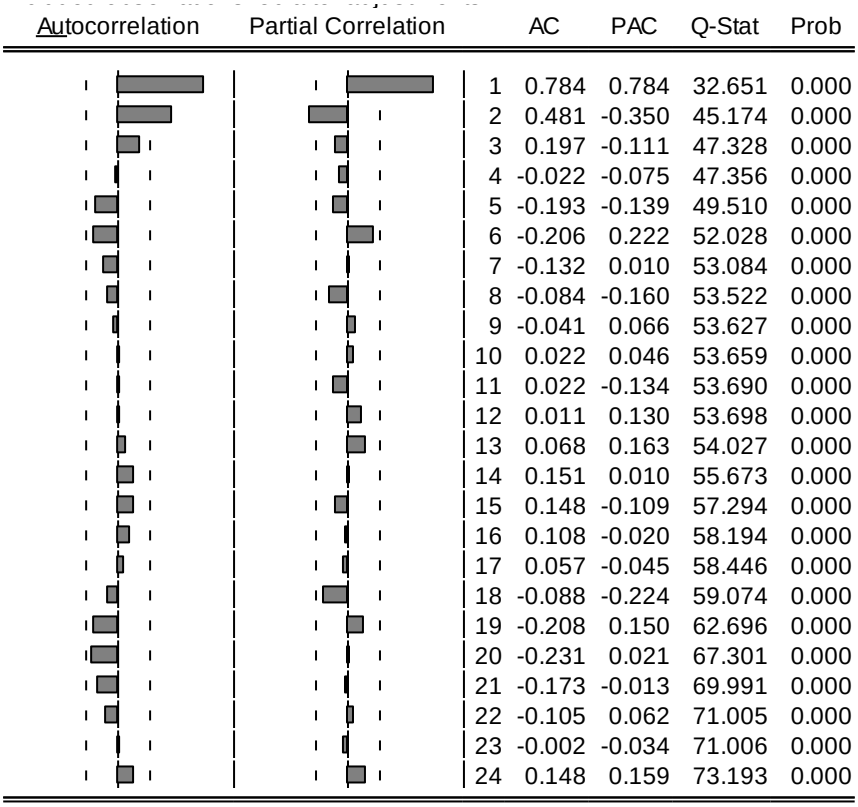


Figure 4: Trend and cycle of NEER
Source-Plotted by author

The seasonal fluctuations of the NEER of RMB have been verified with the patterns of autocorrelation and partial autocorrelation functions where ACF declined and stood negative at lag 4 which turned into positive at lag 10 and again became negative at lag 18 and turned into positive at lag 24 and so on. The PACF has changed positive to negative randomly with one spike at lag 1. All the Q statistic are significant within 1% level. In Figure 5,these variations of ACF and PACF have been shown.



	AC	PAC	Q-Stat	Prob
1	0.784	0.784	32.651	0.000
2	0.481	-0.350	45.174	0.000
3	0.197	-0.111	47.328	0.000
4	-0.022	-0.075	47.356	0.000
5	-0.193	-0.139	49.510	0.000
6	-0.206	0.222	52.028	0.000
7	-0.132	0.010	53.084	0.000
8	-0.084	-0.160	53.522	0.000
9	-0.041	0.066	53.627	0.000
10	0.022	0.046	53.659	0.000
11	0.022	-0.134	53.690	0.000
12	0.011	0.130	53.698	0.000
13	0.068	0.163	54.027	0.000
14	0.151	0.010	55.673	0.000
15	0.148	-0.109	57.294	0.000
16	0.108	-0.020	58.194	0.000
17	0.057	-0.045	58.446	0.000
18	-0.088	-0.224	59.074	0.000
19	-0.208	0.150	62.696	0.000
20	-0.231	0.021	67.301	0.000
21	-0.173	-0.013	69.991	0.000
22	-0.105	0.062	71.005	0.000
23	-0.002	-0.034	71.006	0.000
24	0.148	0.159	73.193	0.000

Figure 5: Nature of ACF and PACF of residuals
Source-Plotted by author

Hamilton regression filter residual of NEER of RMB has passed through ARIMA (2,0,0) forecasting model for 2025 which was selected from 25 best models and revealed that the estimated model by

maximum likelihood method is convergent, significant and stationary and the volatility is minimum and significant.

$V_t=0.00088+0.5162v_{t-2}+0.000156\sigma^2_t$

(0.23) (4.0)* (4.38)*

$R^2=0.259$,F=8.21*,AIC=-5.79,SC=-5.67,DW=0.66,AR roots=±0.72,n=50,*=significant at 5%.

In Figure 6,the forecast ARIMA model for 2024M12 has been plotted in which the forecast line has been approaching equilibrium steadily which is shown by green lines and is surrounded by vertical green lines showing significant levels.

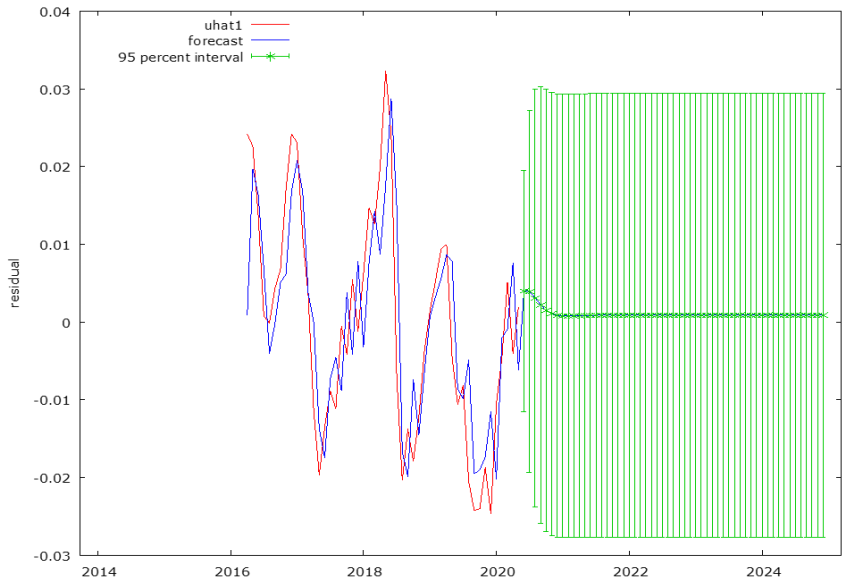


Figure 6: ARIMA forecast line for 2024M12
Source-Plotted by author

This model has no heteroscedasticity problem because $nR^2=0.684959$ whose probability of Chi-square (2) =0.710 which is accepted for no heteroscedasticity at null hypothesis where n=48, $R^2=0.014270$. The estimated equation is given below by ARCH(2) method.

$\varepsilon^2_t=6.70E\text{-}05-0.11197\varepsilon^2_{t-1}+0.027862\varepsilon^2_{t-2}+\check{e}_t$

(3.63)* (-0.75) (0.18)

DW=2.01, AIC=-15.81, SC=-15.69, F=0.325, *=significant at 5% level.

[3] Trends of REER

Real Effective Exchange Rate of Chinese Renminbi from 2014M01 to 2020M05 has cubic form of non-linear trend where it is increasing at first phase then it is declining and thereafter it is upswing steadily i.e. its shape is inverse S type. The estimated nonlinear trend is given below where all coefficients of t are significant at 5% level although it has autocorrelation problem since DW is very low.

$\text{Log (REER)}=4.736+0.01016t-0.000303t^2+2.44E\text{-}06t^3+u_i$

(387.18)* (7.53)* (-7.57)* (7.21)*

$R^2=0.46$, F=20.73*, AIC=-4.44, SC=-4.32, DW=0.17, REER=Real Effective Exchange Rate of RMB of China, *=significant at 5% level, n=77

In Figure 7, the nonlinear trend line of REER of RMB from 2014M1 to 2020M5 has been depicted where the declining period is very long than its upswings.

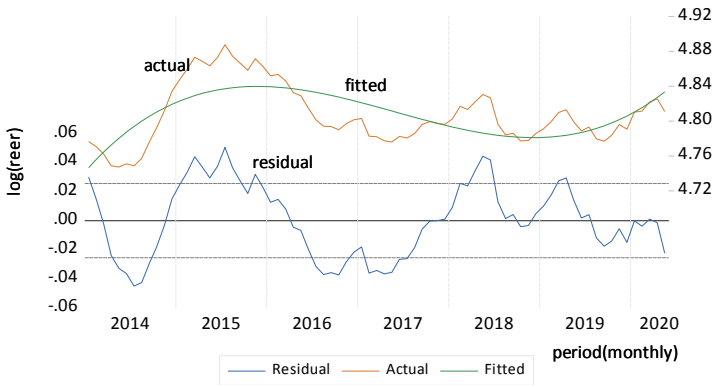


Figure 7: Trend of REER
Source-Plotted by author

Residual test for stability of the trend line of REER of RMB assured that it is stable because the CUSUM of square line falls within the range of significant level of 5% except during 2015M6-2016M10.It is seen in Figure 8.

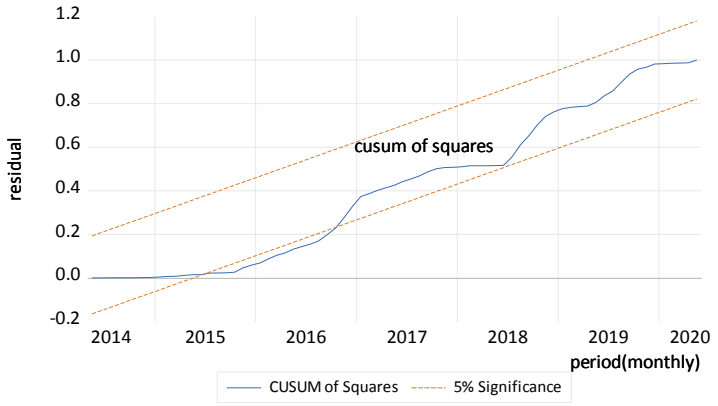


Figure 8: Stability test of REER trend
Source- Plotted by author

[4] Decomposition of REER

The Hamilton regression filter model is estimated for REER of Chinese RMB from 2014M1 to 2020M5 to find the decomposition in which the residual v_t represents the cycle of the series.

$Log(REER)_t=5.1011-0.2899log(REER)_{t-24}-0.00338log(REER)_{t-25}+0.0692log(REER)_{t-26}+0.1613log(REER)_{t-27}+v_t$

(17.66)* (-1.12) (-0.0078) (0.160) (0.634)

$R^2=0.140$, F=1.84, AIC=-5.41, SC=-5.21), DW=0.403, n=50, period=2016M04- 2020M05 after adjustment.

Hence the residual v_t becomes as follows:

$V_t= Log(REER)_t –[5.1011-0.2899log(REER)_{t-24}-0.00338log(REER)_{t-25}+0.0692log(REER)_{t-26}+0.1613log(REER)_{t-27}]$

This residual v_t is decomposed by STL method to get the cycle, smooth cyclical trend, seasonal variation ,remainder and the seasonally adjusted cycle respectively which have been depicted in Figure 9 where in panel 1,the cycle of REER consists of mainly four peaks and troughs with short period cycles where the period of downturns are smaller than the periods of upturns. In panel 2, the smooth cyclical trend was found in which there are three phases. The first phase represents upswing which is short period, then in the second phase the downturn begins with a much longer period and afterwards it is increasing in the third phase. The seasonal variation of REER is V shaped with equal amplitudes which is depicted in panel 3. The remainder is moving around the equilibrium with one exception in downswing which is shown in panel 4. Lastly, the seasonally adjusted cycle consists of many short cycles of peaks and troughs with one big amplitude in downswing. All the panels are clearly visible in Figure 9.

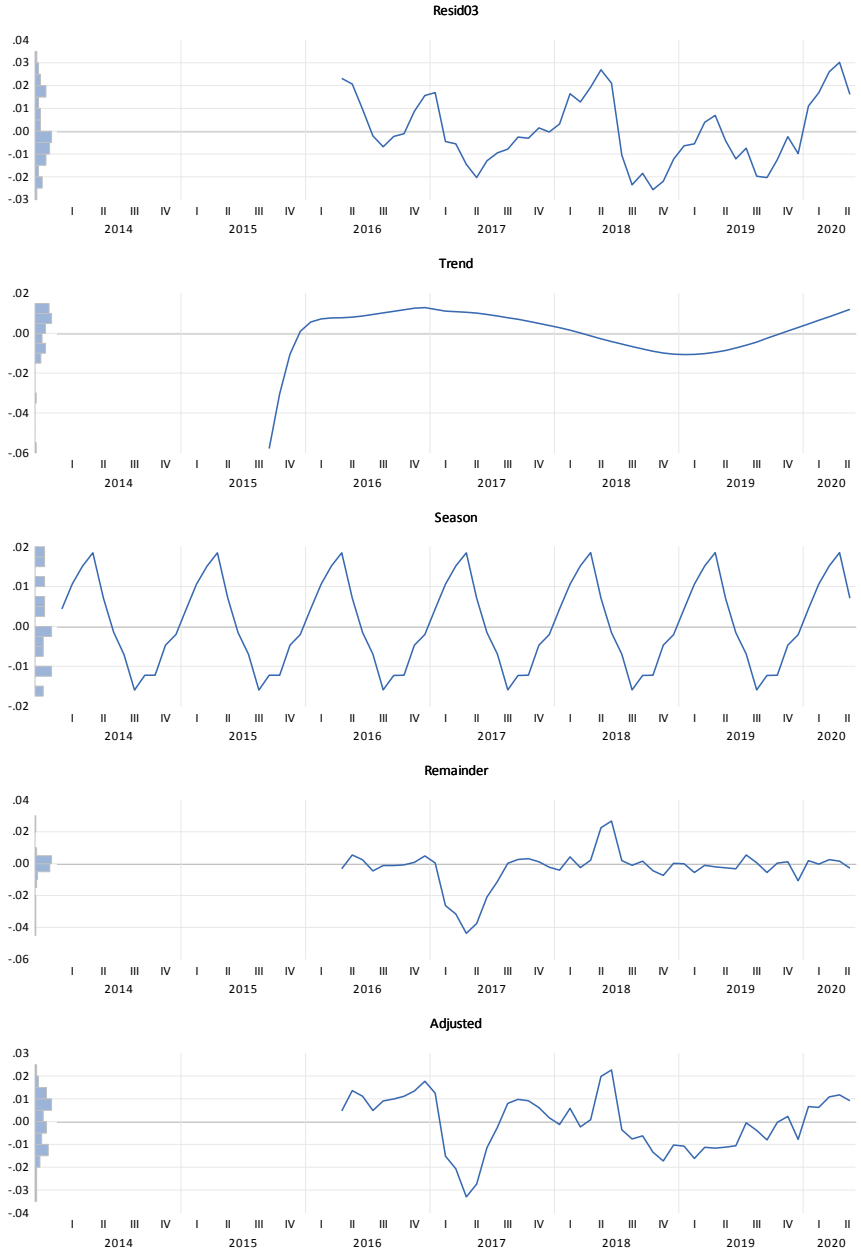


Figure 9: Decomposition of REER of RMB of China
Source- Plotted by author
In Figure 10, the composite picture of trend and cycle of REER of RMB of China after Hamilton regression filter was plotted where smooth trend covers entire cyclical period and is consisting of three phases of changes in which depreciation of REER took longer time than its appreciation period. The cyclical behavior showed four prominent peaks and troughs.

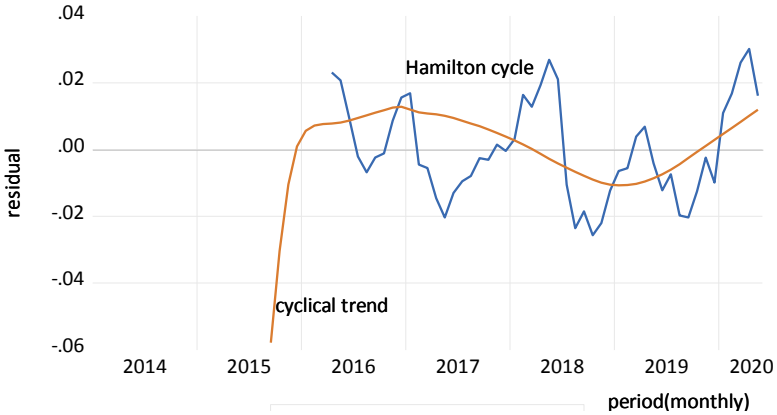
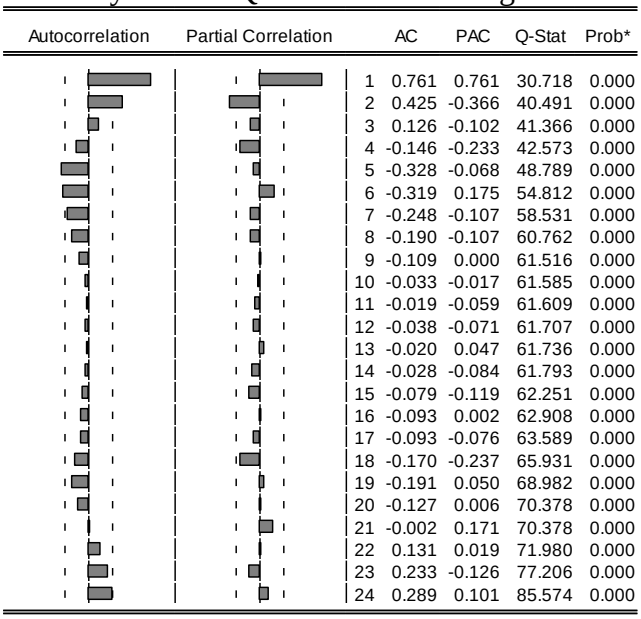


Figure 10: Trend and cycle of REER
Source-Plotted by author
The seasonal fluctuations have been confirmed by the behavior of autocorrelation and partial autocorrelation functions of the Hamilton residuals where it was found that ACF steadily declines from positive to negative values from lag 4 and lag 22 and the PACF varies from positive to negative values randomly and the Q statistic showed significant at 1% level. All these were shown in Figure 11 below.



	AC	PAC	Q-Stat	Prob*
1	0.761	0.761	30.718	0.000
2	0.425	-0.366	40.491	0.000
3	0.126	-0.102	41.366	0.000
4	-0.146	-0.233	42.573	0.000
5	-0.328	-0.068	48.789	0.000
6	-0.319	0.175	54.812	0.000
7	-0.248	-0.107	58.531	0.000
8	-0.190	-0.107	60.762	0.000
9	-0.109	0.000	61.516	0.000
10	-0.033	-0.017	61.585	0.000
11	-0.019	-0.059	61.609	0.000
12	-0.038	-0.071	61.707	0.000
13	-0.020	0.047	61.736	0.000
14	-0.028	-0.084	61.793	0.000
15	-0.079	-0.119	62.251	0.000
16	-0.093	0.002	62.908	0.000
17	-0.093	-0.076	63.589	0.000
18	-0.170	-0.237	65.931	0.000
19	-0.191	0.050	68.982	0.000
20	-0.127	0.006	70.378	0.000
21	-0.002	0.171	70.378	0.000
22	0.131	0.019	71.980	0.000
23	0.233	-0.126	77.206	0.000
24	0.289	0.101	85.574	0.000

Figure 11: ACF and PACF of REER from Hamilton filter
Source-Plotted by author
The Hamilton regression filter of REER of Chinese RMB can be pass through the ARIMA (2,0,1) forecast model which is selected from the best 25 models in which AIC is minimum and its estimate is given below. Here AR and MA processes are significant and convergent. The roots of AR and MA are less than one which also implies that the model is stationary and stable.

V_t=0.00227+0.5857v_{t-2}+ε_t+0.867ε_{t-1}+7.77E-05σ^2_t
(0.41) (3.21)* (7.49)* (5.0)*
R^2=0.637, F=26.97*, AIC=-6.44, SC=-6.29, DW=1.55, AR roots=±0.77, MA root=-0.87, n=50, *=significant at 5% level.
This ARIMA(2,0,1)forecast model for 2024M12 has been depicted in Figure 12 in which the forecast line from 2020M6 to 2024M12 is marked by green lines which are covered by vertical lines that ranged at the 5% significant level and is steadily approaching towards equilibrium in the cyclical fashion with reducing volatility and then by linearly mode.

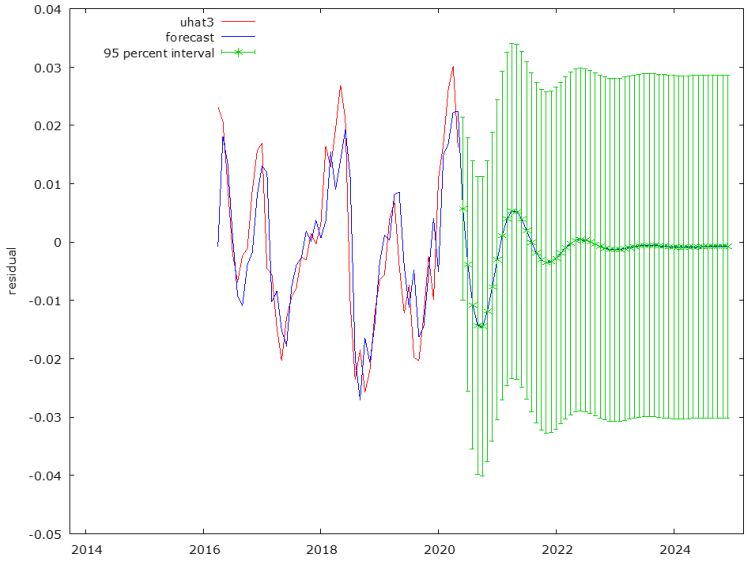


Figure 12: Forecast ARIMA of REER for 2024M12
Source-Plotted by author

This forecast model has no problem of heteroscedasticity since nR^2=0.3392 whose probability of Chi-square (2) =0.8440 which implies that it is accepted for no heteroscedasticity at null hypothesis where n=48, R^2=0.007068. The estimated residual squares are given below by ARCH (2) method.
ε^2_t=7.46E-05-0.0381ε^2_{t-1}+0.0724ε^2_{t-2}+$\check{e}_t$
(2.92)* (-0.257) (0.49)
F=0.160, SC=-14.95, SC=-14.83, DW=2.01, $\check{e}_t$= error ¸ *=significant at 5% level, ε^2_{t-i}= residual squares of estimated ARIMA(2,0,1) model where i=0,1,2,……..n.
Lastly, the Hamilton regression filter in analyzing the decomposition of NEER and REER of RMB in China from 2014M1 to 2020M5 expressed that the behavior of cycles of NEER and REER has no fundamental and structural difference because both of them consists of mainly four peaks and troughs where highest peak achieved prior to 2018 and 2020 and highest trough was at prior to 2019 respectively which were observed in Figure 13.

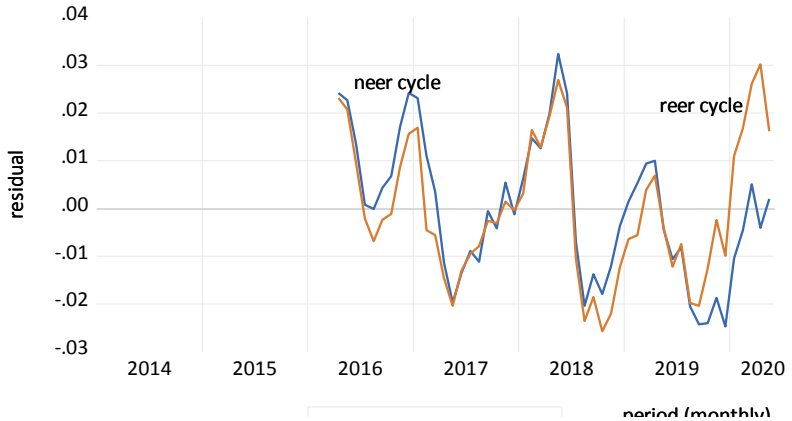


Figure 13: Cycles of NEER and REER of RMB compared
Source-Plotted by author

But the smooth cyclical trends of both NEER and REER of Chinese RMB from 2014M1 to 2020M5 are not identical rather trend of NEER consists only one upswing and downswing and duration of upswing is very short and on the other hand, the trend of REER has three phases: upswing, downswing and again upswing where period of downswing is rather longer than the short periods of upswings. These are clear in the figure 14.

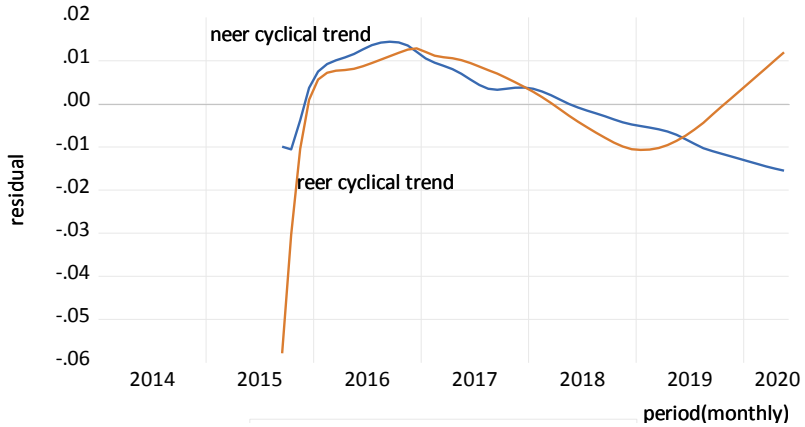


Figure 14: Trends of NEER and REER compared.
Source-Plotted by author

V.Limitations and future research

One crucial point is that ARIMA (p, d, q) forecast model has been passed through Hamilton regression filter residual to find the future cyclical behavior which may emerge serious debates. Even, methodological issues may differ in verifying heteroscedasticity test. If NEER and REER could be converted into trade weighted 36 countries then impact on international trade would better due to changes in NEER and REER and the cyclical trend, seasonal patterns and cycles might vary from above explanations. Therefore, there is enough scope to explore in these areas of research.

VI.Policy reconsiderations

According to Article 3004 of the Omnibus Trade and Competitiveness Act of 1988, China is labeled as currency manipulator by USA and was tried by force to depreciate Yuan with respect to Dollar. It is fact that RMB/US$ rate was stable during the global financial crisis and but, before the managed float regime from 2005July to 2015July, RBM was appreciated against Dollar by 26% that implied higher inflow of capital and higher trade surplus. Therefore, the pressure is intensified to depreciate RMB in

terms of Dollar. Thus ,China should frame its currency policy in way that it should not fear to introduce freely floating exchange rate policy with capital account liberalization, institutional reforms, create more liquidity, new monetary policy and manage its currency volatility(Das,2019).From the BIS record it was found that NEER and REER of RMB have been appreciated by 38% and 47% respectively from 2005 to June 2019 which were highest among G 20 economies. Therefore, China can adopt new currency policy to fight against currency manipulator such that RMB is pegged with dollar and depreciate against Dollar and even move to freely floating exchange rate system(Kwan,2019). Moreover, the Peoples Bank of China can maintain continuity and stability of foreign exchange administrative policies, enhancing liberalization, facilitate cross-border trade and investment, improve in capital flows policies with development of capital market infrastructure vis-à-vis reform in managed float by changing bands of adjustment around the central parity. When RMB as an international currency reserve will increase by nearly 30-40% and bond or shares holdings of foreign countries enhanced by 20% or above, then China should adopt convertibility in capital account and make RMB to float freely in the international market so that China would be no longer as currency manipulator.

VII. Conclusions

The paper concludes that the cubic form of nonlinear trend line of NEER of RMB of China from 2014M1 to 2020M5 is inverse s shaped with significant upward and downward trends. Hamilton filter showed that cyclical trend is downward followed from upswing and the cycle consists of many peaks and troughs and the seasonal variation is v shaped which is also verified by the patterns of ACF and PACF of residual of regression filter. ARIMA (2,0,0) forecast for 2025 model passes through the regression filter which was found convergent, stationary and significant. It had no heteroscedasticity problem. Similarly, REER of RMB of China during 2014M1 - 2020M5 was found cubic showing upswing followed by downswing and then upswing significantly whose CUSUM of squares test is stable. Decomposition of REER of RMB was found by Hamilton filter where cyclical trend had three phases with inverse s shaped having short duration recovery with long duration downswing. The cycle has many peaks and troughs and the seasonal variation is v shaped which was verified by the behavior of ACF and PACF respectively. ARIMA (2,0,1) forecast model for 2025 passes through Hamilton regression filter which showed convergent, stationary and significant reducing volatility. This forecast model had no heteroscedasticity problem. Lastly, the cyclical behavior of both NEER and REER of Chinese RMB are more or less identical but the cyclical trends are not similar where REER consists of three phases and NEER consists of two phases respectively. Both NEER and REER showed long period downswing but REER has two short duration upswings.

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