

## **EMPIRICAL EVIDENCE OF QUANTITY THEORY OF MONEY IN U.K.**

**Debesh Bhowmik\***

*\*Retired Principal, E-mail: debeshbhowmik269@gmail.com*

### **ABSTRACT**

#### **Article History**

Received : 18 April 2020

Revised : 24 April 2020

Accepted : 19 June 2020

Published : 14 September 2020

#### **Key words**

Quantity theory,  
causality,  
cointegration,  
vector error correction

#### **JEL Classification**

Codes: C22, C32, E41, E52,  
E61

The paper seeks to verify the quantity theory of money in UK during 1844-2016 by applying regression model, cointegration and vector error correction model and found that there is unidirectional causality from money to price level and there is one cointegrating equation. Vector Error Correction Model showed long run causality from money supply to price level and the speed of adjustment of error correction was 1.60% per annum which tends to equilibrium insignificantly. The double log regression model revealed that the relation is non proportional and positive and significant. Vector error correction model is stable and nonstationary.

## **I. INTRODUCTION**

The quantity theory of money was first developed by Bodin (1566) who thought that the price level was solely a function of the quantity of money. He explained that the value of purchasing power of money varies proportionally with quantity of money in circulation in the sense that doubling of money will double price level and halve the value of monetary unit.

Hume(1752) explained that countries with an increasing money supply would face inflation due to rise in prices of goods and services while countries with decreasing money

supply experience deflation due to decrease in prices of goods and services. When a country is in the gold standard face positive trade balance, gold will flow into the country so that value of export exceeds the value of import, then money supply will rise in positive trade balance country and fall in negative trade balance country to restore equilibrium. This is known as price-specie-flow mechanism.

Later, Thornton (1802) formulated the quantity theory framework that incorporated paper money under fractional reserve banking system and theorized theory of demand for real money that made velocity of components of the money stock. He had developed the idea of a modern central bank that controls the overall liabilities of commercial banks. Even in the recent analysis his work challenges the modern policy makers to defend the institutional procedures which were applied to anchor the nominal values of economic system (Hetzl, 1987).

In short, the quantity theory of money states that the stock of money is the main determinant of the price level satisfying some propositions, [i] price level will vary in exact proportion to changes in the quantity of money so that the demand for real cash balance and its counterpart circulation velocity of money are completely stable, [ii] causality should run from money to price level, [iii] money is neutral, [iv] nominal stock of money is exogenous.

In 18<sup>th</sup> century David Hume and Richard Cantillon made distinction between long run stationary equilibrium and short run movement towards equilibrium and also showed difference between long run neutrality and short run neutrality of money.

Fisher (1911) and Pigou (1917) argued that total stock of money and bank deposits would be a constant multiple of the monetary base or stock of money which is governed by [i] high powered monetary base, [ii] the bank's desired reserve to deposit ratio, [iii] the public's desired cash to deposit ratio. Fisher's quantity equation  $MV=PT$  implies that total value of money expenditures in all transactions =total value of all items transacted. He assumed full employment where total output does not change and transaction velocity is stable and causality of money to price level is assured. Subsequently, Pigou wrote the quantity equation as  $1/P=kR/M$  where R denotes the real resources, k is the reciprocal velocity, M is the money stock.

Humphrey (1984) analyses the details of equations of quantity theory historically throughout the world before Pigou and Fisher which are described below.

British monetarists, John Briscoe(1694) and Henry Lloyd(1771) wrote same interpretation without velocity of money as  $P=M/Q$  where Q is the quantity of goods exchanged for money assuming that prices are being determined in a single transaction involving the one time exchange of entire stock of money for entire stock of goods.

In 1856, Francis Bowen presented the equation as:  $gs=mr$ , where  $g$  is the quantity of goods sold,  $s$  is the number of times the goods are sold,  $r$  is the rapidity of circulation,  $m$  is stock of money. It expresses the equivalent between flow of goods and services and flow of money. Simon Newcomb (1885) corrected the equation as follows:  $VR=KP$ , where  $V$  is the volume of currency  $R$  is the average rapidity of circulation,  $K$  is the number of real transaction and  $P$  is the price level. He concluded that price varies proportionally with stock of money.

Wicksell (1906) analysed that a decrease in the money stock would induce a proportional fall in spending and therefore prices restore real balances to their desired level. It indicates that there is proportional relationship between money stock and price level through real balance effects. Wicksell believed that the theory is valid for pure cash economies in which bank will not issue checkable deposits and all transactions are mediated by gold currency where a demand for a fixed quantity of real gold balances ensures that price move proportionally to money in the long run (Humphrey, 1997).

According to Marshall (1923) the price level is determined by nominal stock of money per unit of real money demand which can be expressed as  $P=M/D$  where  $P$ =aggregate price,  $M$ =nominal money stock,  $D$ = demand for real cash balance  $M/P$ . The real money demand  $=D(Y)=kY$  where  $k$ = proportion of real national income  $Y$  which is hold by public. The eight factors which can influence  $k$  are [i] marginal utility of holding money, [ii] marginal utility of holding over resources in the form of goods rather than money, [iii] expected rate of return to holding earning assets, [iv] expected inflation, [v] bank credit instruments, [vi] institutional factors, [vii] degree of confidence and [viii] unforeseen shocks. Thus,  $k=k(z)$  is the cash balance function where  $z$  depends on above 8 factors and  $k>0$ . This approach also follows long run neutrality of money and causality is unidirectional from money to price level and it does not ignore price-specie-flow-mechanism. Marshall admitted Rupee depreciation also. His purchasing power parity theory explained the international distribution of world money under metallic standard and fixed exchange rate. He showed how fluctuations of money stock produce corresponding movements in real wage and interest rate and oscillation of output and employment (Humphrey, 2004).

Post quantity theory is renowned as new monetary economics in which Keynes (1923; 1936), Friedman (1956), Patinkin (1956) are well known introducing new ideas and thoughts. Keynes (1936) himself is famous for his consumption theory, liquidity trap, inflexible wage rate and involuntary unemployment which create a new wave in economics. His theory of demand for money challenged the existence of quantity theory of money. However, Friedman (1956) in explaining quantity theory noted that inflation is always and everywhere a monetary phenomenon and in the long run increased monetary growth increases prices but does not really affect output. Friedman modified Keynes demand for

money and noted that the demand for real money balance increases where permanent income increases and declines when the expected returns on bonds, stocks or goods increase in competing with the expected returns on money which includes both the interest paid on deposits and services that banks provide to depositors (Hammond, 1999).

In this paper, the author tried to show quantity theory of money empirically in U.K. from 1844 to 2016 by applying the simple double log regression model, Granger Causality test, Johansen cointegration test and vector error correction respectively where the whole sale price index was considered as price level and broad money was treated as money supply. Even, the author employs behavior and patterns of money supply and price level of UK during the specified period through the models of structural breaks, ARIMA models, Hamilton Filter model and semi-log linear trend lines respectively.

## **II. LITERATURE REVIEW**

Ashra et al (2004) examined the nexus between money supply, output and price level in India and found that there exists a bi-directional causality between money supply and price level and money is neutral.

Wen (2006) exemplified that the close long run relationship between inflation and money growth may not necessarily be driven by purely monetary forces but rather by forces of permanent movement in GDP and non-monetary shocks. He found that the correlation between money growth and inflation across different horizon or frequencies reaches 0.85 in the long run at frequency zero and never exceeds 0.4 at horizons which equal to or shorter than the business cycles about 2 to 8 years. It suggests also that Friedman is right and changes in inflation and changes in money growth are closely related in the long run.

Ozgur and Levant (2007) studied empirically in Turkey on the relation between money supply and price level during 1987Q1-2006Q4 by applying Granger Causality, Johansen cointegration and vector autoregression models and observed that money supply and price level was near proportional and money was neutral.

Mishra (2010) verified short run and long run causalities among money supply, price level and output in India during 1950-51-2008-09 using vector autoregression analysis and revealed that there are short and long run bidirectional causalities between money supply and output and long run unidirectional causality between money supply and price level. Moreover, there is short run uni-directional causality between output and price level and there is bi-directional causality between money supply and price level respectively.

Amin (2011) tested empirical verification of quantity theory in Bangladesh during 1976-2006 by applying ADF, PP, Granger Causality and Johansen cointegration test and

observed unidirectional causality from money supply to inflation which supports the views of quantity theorists.

Hillinger, Sussmuth and Sunder (2012) verified  $M=kY$  in 148 countries including Finland, Germany, Netherlands, Portugal, Spain and UK of EU during 1961-2009 and found that in high inflation countries, the correlation between money growth and inflation is lower and significant. There is no difference in explaining stability between low and high inflation countries. In spite of substantial fluctuations in the short run, long run stability was observed.

Alimi (2012) examined quantity theory econometrically in Nigeria from 1960 to 2009 using Johansen cointegration test which revealed the monetarists view between money supply and inflation showing unidirectional causality but inflation does not follow causal relation from inflation to interest rate which was explained by Fisher hypothesis.

Teles, Uhlig and Azevedo (2015) studied in low, medium and high inflation countries in OECD taking 1970-2005 data in explaining the relationship between money growth and inflation and found that scatter data between them in US and other countries fall in  $45^\circ$  from the origin. But if it spits into implicit adoption inflation targeting the result of one to one relation deteriorates where variability of inflation is reduced. So, further research is necessary in this field.

Jerome (2016) studied empirically in Mexico, Canada and USA during 1985-2014 on the nexus between money supply, velocity, inflation and output by applying ordinary least square and observed that there is positive relation between money supply, output and price level in all three countries but relation with velocity and inflation is negative for all of them. The relationships are significant.

Bhowmik (2019) studied quantity theory of money empirically in India during 1960-2015 taking both whole sale and consumer price indices and fit the data in double log bivariate regression model and also used Johansen cointegration and VECM and found that there is no proportionality relation between price level and money supply. Johansen model confirmed one cointegrating equation and VECM showed unstable and nonstationary with slow error correction process but there is unidirectional causality from money supply to price level.

### **III. METHODOLOGY AND SOURCE OF DATA**

The trend lines have been calculated by semi-log linear regression model. Structural breaks were shown by using Bai-Perron model (2003). Decomposition of trend, cycle and seasonality of the money supply and price level of UK during 1884-2016 have been applied by the Hamilton filter model (2018). ARIMA model was applied to show AR process and

MA process for convergence or divergence. Granger Causality test was done to check causal relation between money supply and price level of U.K. After verifying the unit root by Augmented Dickey-Fuller test, Johansen (1988) unrestricted rank cointegration test was applied for long run association between two variables and vector error correction showed long run causality. CUSUM square stability test was used to verify the stability of the relationship. Cholesky one standard deviation innovation method was tested to verify impulse response functions. The data on money supply measured by broad money(M2) and price level measured by whole sale price index of UK from 1844 to 2016 were collected from Bank of England’s Millennium macroeconomic data for UK.

#### IV. OBSERVATIONS FROM THE MODELS

##### [i] Patterns and trends

Money supply of UK has increased by 5.31% per year from 1844 to 2016 which is significant at 5% level.

$$\text{Log}(m)=4.163+0.05318t$$

(33.47)\* (42.89)\*

$R^2=0.91$ ,  $F=1839.57$ ,  $DW=0.0057$  where  $m$ =money supply of UK,  $t$ =year, \*=significant at 5% level.

Since DW is very low which implies existence of auto-correlation. This trend line is plotted in Figure 1 below. The trend line turns into insignificant if autocorrelation problem is removed.

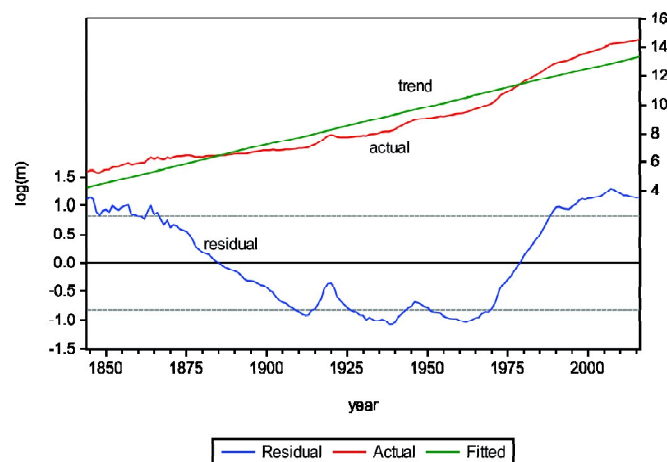


Figure 1: Trend of money supply

Source: Plotted by author

Whole sale price index indicates the price level of UK from 1844 to 2016 which has increased by 2.91% per year significantly whose trend line is given below.

$$\text{Log}(p) = -0.9575 + 0.0291t$$

$$(-8.25) * (25.15)^*$$

$R^2=0.78$ ,  $F=632.94^*$ ,  $DW=0.01236$ , where  $p$ =whole sale price index. The trendline suffers from problem of autocorrelation and is plotted below. If the model is removed from autocorrelation problem then the estimated trend line became insignificant.

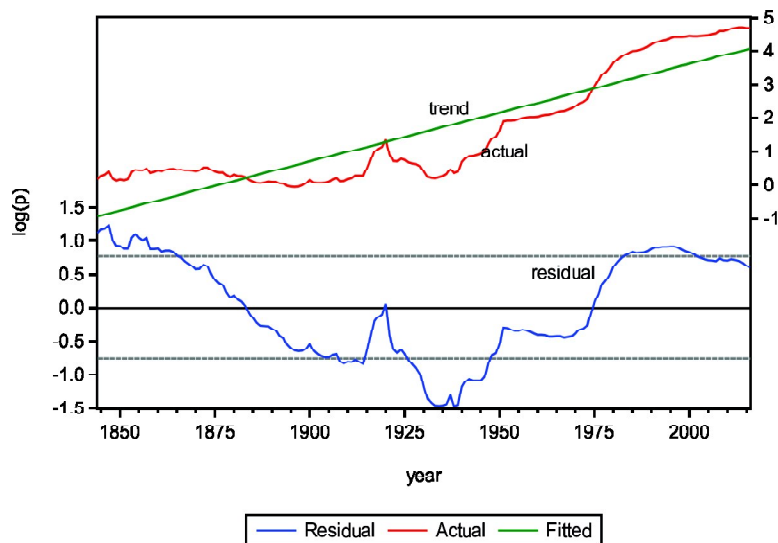


Figure 2: Trend line of whole sale price index

Source: Plotted by author

ARIMA(3, 1, 3) model has been fitted using maximum likelihood method to show the autoregression and moving average processes of the money supply of UK from 1844 to 2016 where all the coefficients of AR and MA are significant at 5% level where the AR and MA roots are less than one which lie in the unit circle that indicates stability and stationary and both AR(3) and MA(3) processes are convergent. So, ARIMA(3, 1, 3) is stable and stationary. The estimated ARIMA(3, 1, 3) of money supply is given below.

$$d\log(m)_t = 0.052 + 0.737d\log(m)_{t-3} + \varepsilon_t - 0.453\varepsilon_{t-3} + 0.0032\sigma_t^2$$

$$(6.21)^* (5.25)^* \quad (-2.59)^* (12.44)^*$$

$R^2=0.14$ ,  $F=9.76^*$ ,  $DW=1.23$ ,  $SC=-2.72$ ,  $AIC=-2.85$ , AR roots=0.90,  $-0.45 \pm 0.78i$ , MA roots=0.77,  $-0.38 \pm 0.67i$ ,  $AC_1=PAC_1=0.382$ ,  $AC_3=0.024$ ,  $PAC_3=-0.057$

The estimated or fitted and actual lines of ARIMA(3, 1, 3) of money supply have been depicted in the Figure 3 where the fitted line is convergent to equilibrium.

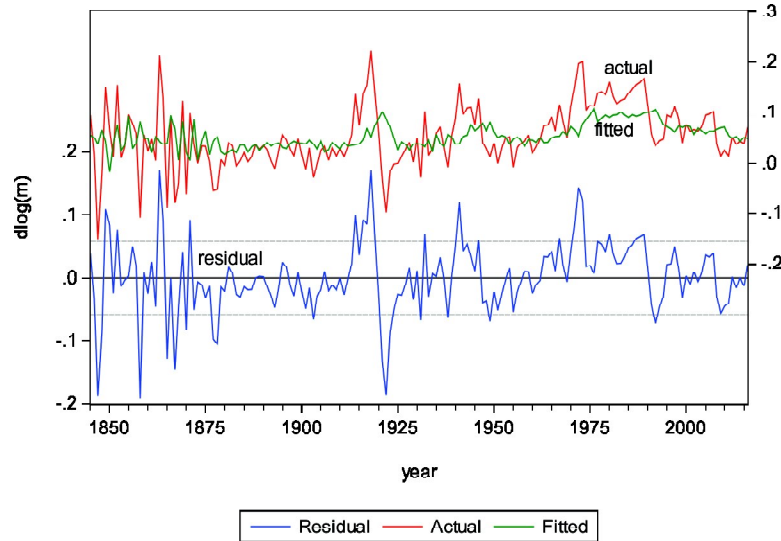


Figure 3: ARIMA(3, 1, 3)

Source: Plotted by author

The best fit of ARIMA(1, 1, 3) of price level of UK during 1844-2016 is estimated below.

$$d\log(p) = 0.0265 + 0.4122d\log(p)_{t-1} + \varepsilon_t + 0.1860\varepsilon_{t-3} + 0.00559\sigma_t^2$$

(1.83)\*      (5.20)\*      (3.22)\*      (19.77)\*

$R^2=0.218$ ,  $F=14.97^*$ ,  $DW=1.93$ ,  $AR\ root=0.41$ ,  $MA\ root=0.29 \pm 0.49i, -0.57$

$AC_1=0.03$ ,  $AC_3=-0.020$ ,  $PAC_1=0.03$ ,  $PAC_3=-0.016$

The AR(1) and MA(3) processes are significant where both the processes are convergent and significant. All of the AR and MA roots are less than one so that the model is stable and stationary where both AC and PAC are significant at 5% level. In Figure 4 the fitted and actual lines of ARIMA (1, 1, 3) of log of price level of UK have been depicted clearly where the fitted line approaches towards equilibrium.

Bai-Perron (2003) model with HAC standard errors and covariance has been applied to get structural breaks of the  $\log(m)$  of UK during 1844-2016 which revealed four structural breaks in 1869, 1916, 1943 and 1980 respectively in which the breaks are upward and significant and are shown in Table 1.



Empirical Evidence of Quantity theory of Money in U.K.

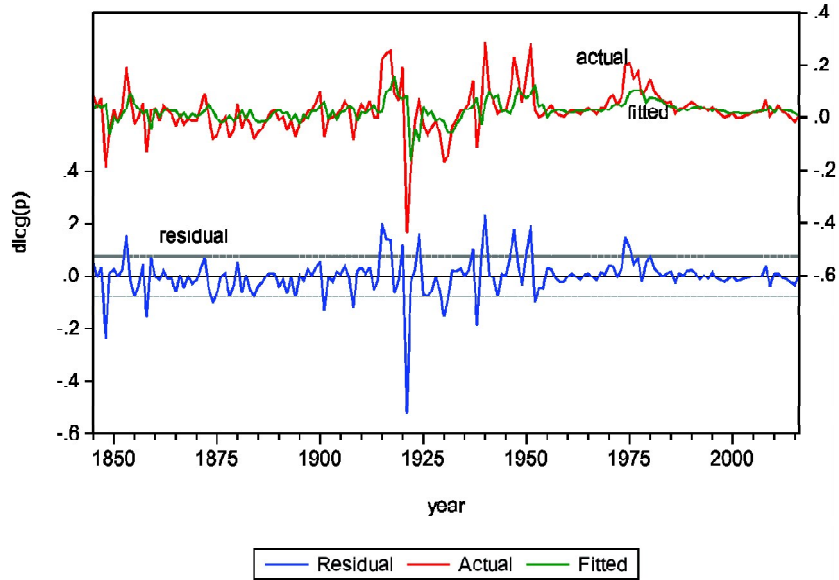


Figure 4: ARIMA(1, 1, 3) of log of price level

Source: Plotted by author

Table 1: Structural breaks of money supply

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.767717	0.131223	43.95366	0.0000
		1844 - 1868 — 25 obs		
C	6.588158	0.072927	90.33942	0.0000
		1869 - 1915 — 47 obs		
C	7.923258	0.091362	86.72337	0.0000
		1916 - 1942 — 27 obs		
C	9.701715	0.261862	37.04891	0.0000
		1943 - 1979 — 37 obs		
C	13.35357	0.297328	44.91191	0.0000
		1980 - 2016 — 37 obs		

Source: Calculated by author

In Figure 5, the structural breaks of money supply of UK have been drawn and pointing out all the breaks.

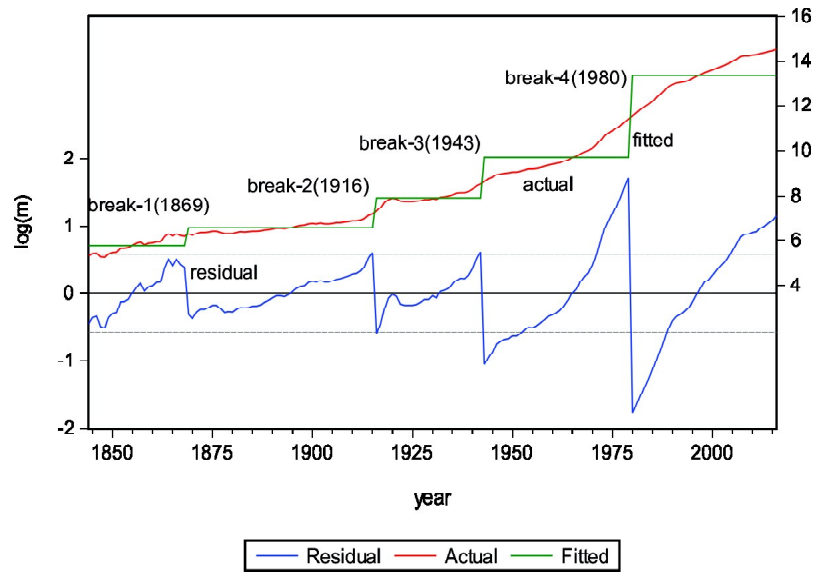


Figure 5: Structural breaks of  $\log(m)$

Source: Plotted by author

Similarly, there are four structural breaks of whole sale price index of UK during 1844-2016 which are significant at 5% level and are shown in the Table 2. The first one is downward and others are upward.

Table 2: Structural breaks of  $\log(p)$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
		1844 - 1883 — 40 obs		
C	0.357063	0.031700	11.26382	0.0000
		1884 - 1914 — 31 obs		
C	0.098992	0.030099	3.288909	0.0012
		1915 - 1945 — 31 obs		
C	0.650048	0.102940	6.314855	0.0000
		1946 - 1976 — 31 obs		
C	2.081331	0.152495	13.64851	0.0000
		1977 - 2016 — 40 obs		
C	4.257524	0.119714	35.56417	0.0000
	R <sup>2</sup> =0.96	F=1266.23	DW=0.48	

Source: Calculated by author

The downward and upward structural breaks of whole sale price index of UK in 1884, 1915, 1946 and 1977 have been indicated in the Figure 6.

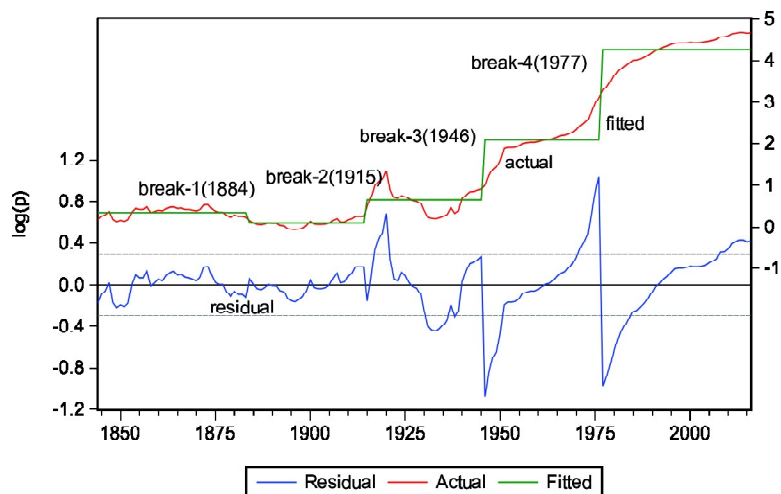
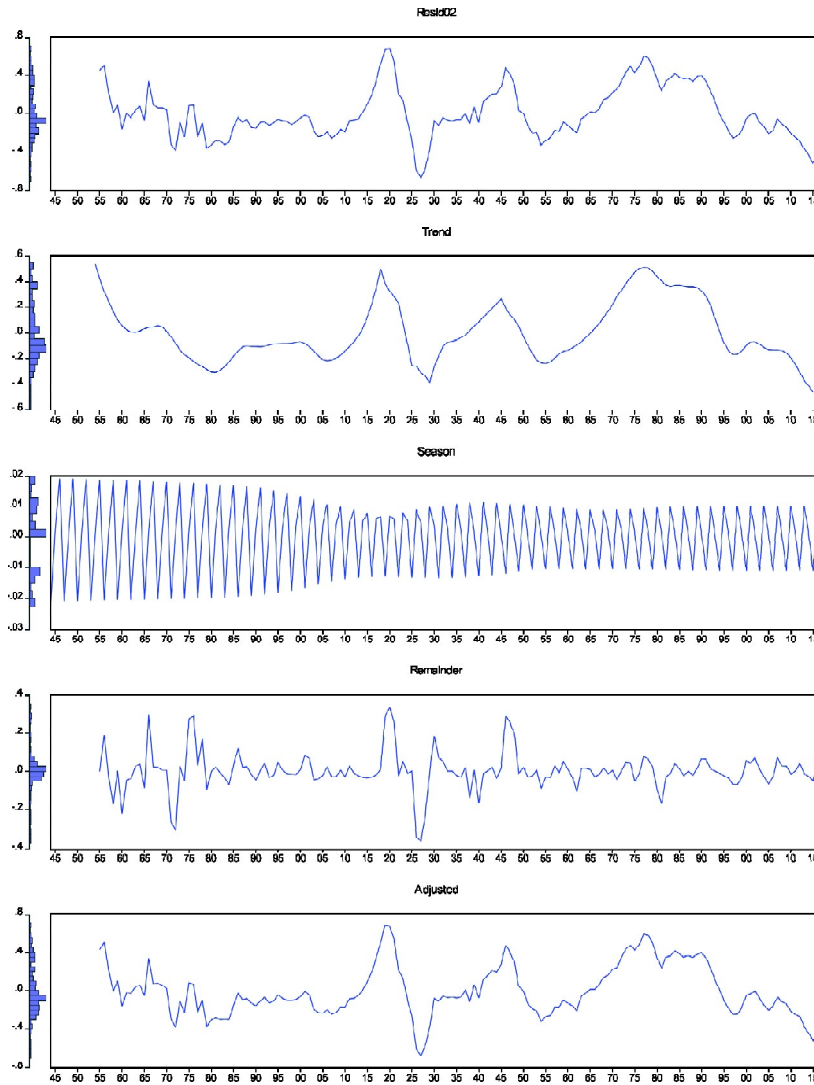


Figure 6: Structural breaks of price level

Source: Plotted by author

Hamilton regression filter of money supply of UK from 1844 to 2016 is decomposed by STL method into residual, trend, seasonal variation, and seasonally adjusted trend and so on in panels of figure which consists of 5 panels. Panel 1 revealed the filtered residual that represents cyclical patterns with numerous peaks and troughs showing declining trend after 1876 onwards. Panel 2 explains the cyclical trend which is more smoother than H.P. Filter and showed 7 clear peaks and 5 troughs. The duration of downward trends are much longer than the duration of upward trends. Panel 3 expresses the seasonal character which are v shaped showing high volatility with reduced average amplitudes. Panel 5 showed the seasonally adjusted trend which is completely cyclical as like as residual series. (Figure 7).

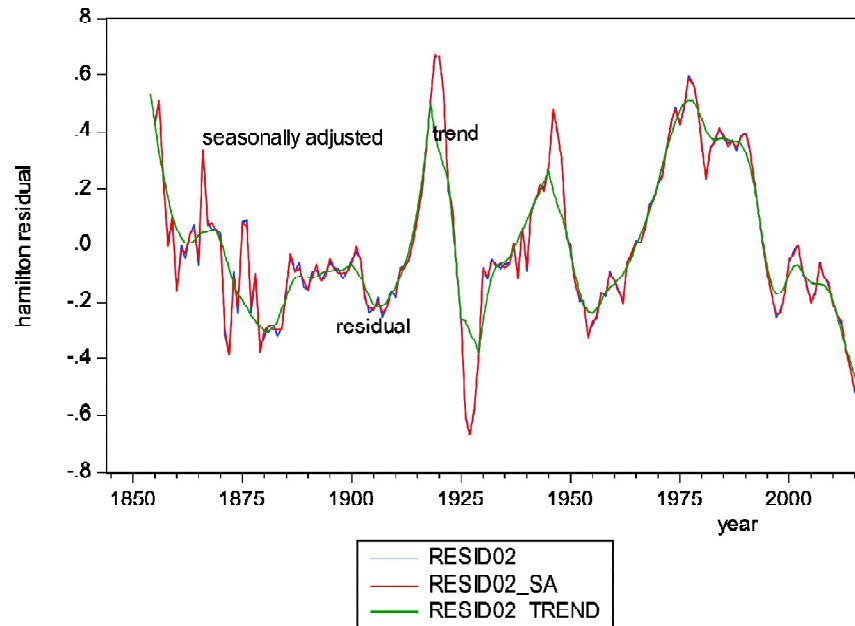
The Hamilton regression filter of money supply series of UK has been shown with trend and seasonally adjusted series in a grouped figure where the residual has been merged with seasonally adjusted series appearing many peaks and troughs in which troughs have been declining since 1876. There is a clear cyclical trend obtained from the filter containing 7 peaks and 5 troughs but speedy decline of troughs were found after 1915 and 1945 in comparison with slowly declining after 1865 and 1875 respectively. (Figure 8).



**Figure 7: Decomposition Hamilton Filter of money supply**

*Source:* Plotted by author

Likewise, the Hamilton regression filter decomposition of the price level of UK from 1844 to 2016 into residual, trend, seasonal variation and seasonally adjusted series by STL method have been done in a figure of five panels of diagrams where residual series of price level is cyclical with big spikes in panel 1 but cyclical trend line has been fluctuated with high amplitudes in panel 2 after 1815 and declined steadily after 1880.



**Figure 8: Hamilton regression filter of money supply**

*Source:* Plotted by author

The seasonal variation with increasing volatility occurred till 1840 and then volatility gradually diminished which was clearly visible in panel 3. The seasonally adjusted series of price level is similar to the residual series which was shown in panel 5. This decomposition of Hamilton filter in price level is more accurate than the H.P. Filter model (1997). (Figure 9).

In the composite figure the Hamilton filter of the price level of UK during 1844-2016 was depicted where residual series of price level after filter and the seasonally adjusted line have shown marginal difference so that both of the lines were merged with each other. The exception is the cyclical trend line of price level after filter which is showing 11 clear peaks and 9 troughs although 3 spikes are mostly mentionable during 1920, 1955 and 1980 respectively where the durations of downward trends are shorter than the duration of declining after 1860 and 1980. (Figure 10).

### **[ii] Estimated relation between money supply and price level**

The double log regression model states that one per cent increase in money supply per year led to increase in price level by 0.5739% per year in UK from 1844 to 2016 significantly at 5% level.

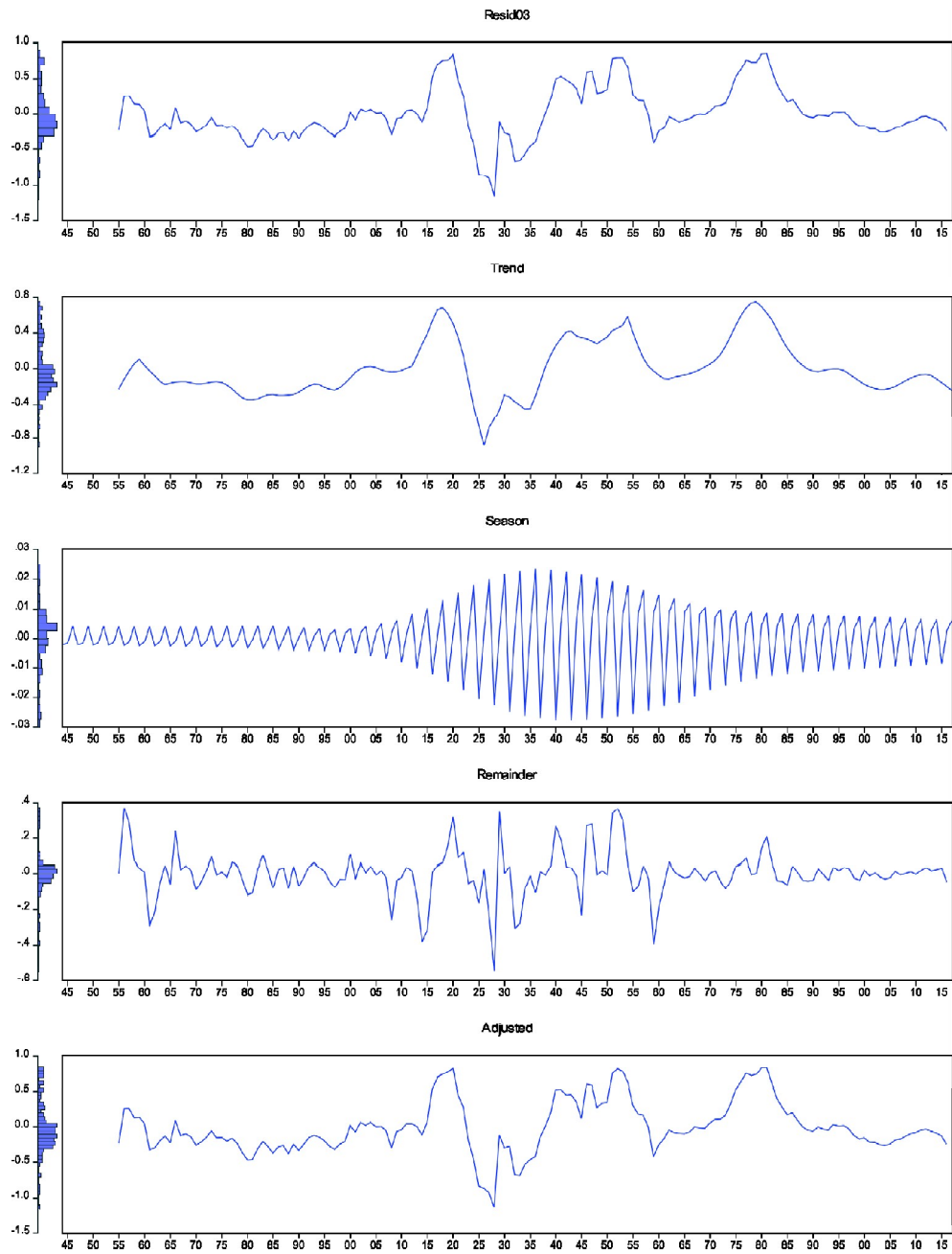


Figure 9: Decomposition of Hamilton filter in price level

Source: Plotted by author

Empirical Evidence of Quantity theory of Money in U.K.

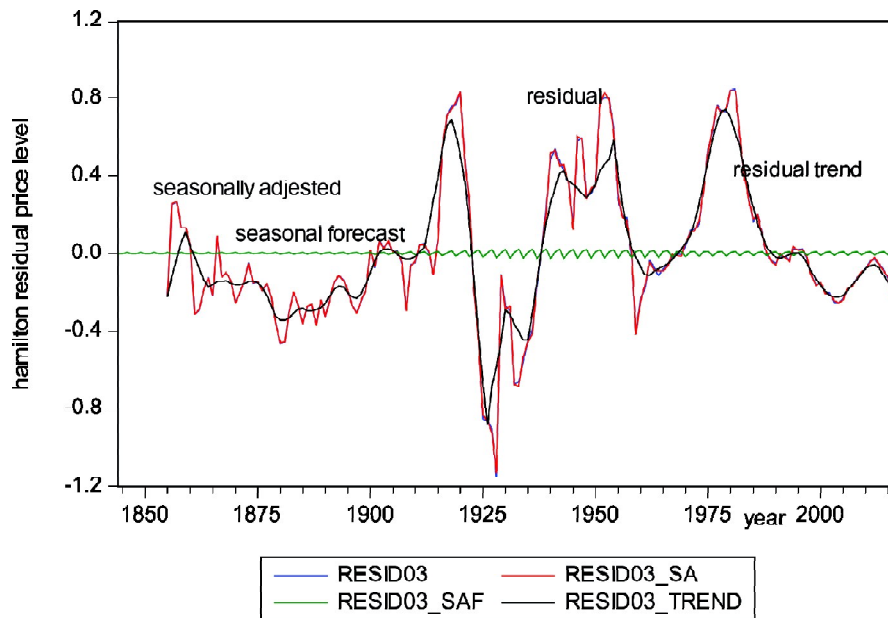


Figure 10: Hamilton filter of price level

Source: Plotted by author

$$\text{Log}(p) = -3.471 + 0.5739 \log(m)$$

(-36.169) (55.13)\*

$R^2 = 0.94$ ,  $F = 3039.59^*$ ,  $DW = 0.041$ , \*=significant at 5% level.

This model suffers from autocorrelation problem. Thus, if we wipe out the problem by estimating the following regression model.

$$\text{Log}(p) = -0.1045 + 0.0191 \log(m) + 0.975 \log(p(-1))$$

(-1.68) (1.94)\* (57.88)\*

$R^2 = 0.99$ ,  $F = 33311.28^*$ ,  $DW = 1.145$ , \*=significant at 5% level.

After removing autocorrelation, the estimate states that one per cent increase in money supply led to 1.91% increase in price level in UK during 1844-2016. It is significant.

CUSUM square stability test assures that it is more stable after removal of autocorrelation problem which is shown below in Figure 11.

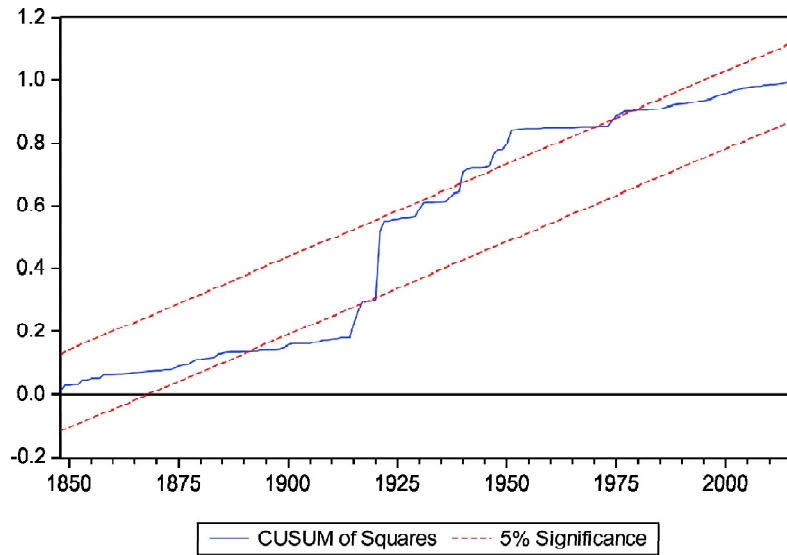


Figure 11: Stability test after removal of autocorrelation

Source: Plotted by author

The Stability test before the removal of autocorrelation problem is shown below.

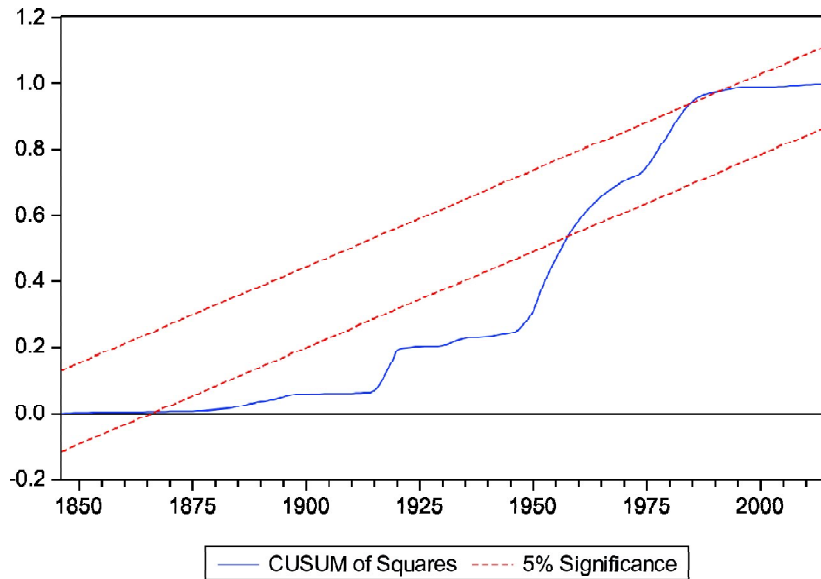


Figure 12: Stability test when autocorrelation exists

Source: Plotted by author.



**[iii] Cointegration test and Vector Error Correction Model**

Unit root test was applied to both log series of money supply and price level of UK during 1884-2016. The log series of money supply of UK from 1844 to 1916 has a unit root which was justified by the Augmented Dicky-Fuller test assuming intercept and linear trend with application of automatic SIC and maximum 13 lags where t statistic is observed as -0.914813 which is accepted at 1% significant level (critical value=-4.012944) at  $H_0 = \log(m)$  has a unit root because  $prob = 0.9510$ . The log series of price level of UK from 1844 to 1916 has a unit root which was verified by Augmented Dickey-Fuller test assuming intercept and linear trend with automatic SIC and maximum 13 lags where observed t statistic = -1.606019 which is accepted as 1% significant level with  $prob = 0.7869$  and  $H_0 = \log(p)$  has unit root.

In order to justify long run association between log of money supply and log of price level in UK during 1844-2016, Johansen unrestricted rank cointegration test between change of money and change of price level with one to one lag was applied and found that there is one cointegrating equation between them in both Trace statistic and Max Eigen Statistic which are shown in Table 3.

**Table 3: Johansen cointegration test**

<i>Hypothesized No. of CE(s)</i>	<i>Eigen value</i>	<i>Trace Statistic</i>	<i>0.05 critical value</i>	<i>probability</i>
None	0.061996	14.93671	15.49471	0.0605
At most 1 *	0.023077	3.992445	3.841466	0.0457
		Max Eigen Statistic		
None	0.061996	10.94427	14.26460	0.1570
At most 1 *	0.023077	3.992445	3.841466	0.0457

\* denotes rejection of the hypothesis at the 0.05 level, \*\*MacKinnon-Haug-Michelis (1999) p-values  
*Source:* Calculated by author.

It was found from the Granger Causality test assuming lag=2 that there is unidirectional causality from money supply to price level during 1844-2016 in UK which was significant at 5% level.

**Table 4: Granger Causality**

<i>Null Hypothesis:</i>	<i>Obs</i>	<i>F-Statistic</i>	<i>Prob.</i>
log(m) does not Granger Cause log(p)	171	10.6834	4.E-05
log(p) does not Granger Cause log(m)		2.44515	0.0898

*Source:* Calculated by Author.

Since, there is long run association between money supply and price level in UK, then it is necessary to estimate vector error correction model between them during the said period 1844-2016.

$$[i] \Delta \log p_t = -0.01607EC + 0.3438\Delta \log p_{t-1} - 0.0503\Delta \log p_{t-2} + 0.4667\Delta \log m_{t-1} - 0.01307\Delta \log m_{t-2} - 0.0059$$

(-1.42)      (4.34)\*      (-0.65)      (4.22)\*      (-0.11)      (-0.71)

$R^2=0.27, F=12.46, AIC=-2.35, SC=-2.24$

$$[ii] \Delta \log m_t = 0.0155EC + 0.663\Delta \log p_{t-1} + 0.0753\Delta \log p_{t-2} + 0.3474\Delta \log m_{t-1} + 0.068\Delta \log m_{t-2} + 0.0275$$

(1.93)\*      (1.17)      (1.36)      (4.41)\*      (0.83)      (4.60)\*

$R^2=0.308, F=14.62, AIC=-3.03, SC=-2.92, *$ =significant at 5% level.

Both the estimated VECM equations are not good fit yet the first equation asserts that  $\Delta \log p_t$  and  $\Delta \log m_{t-1}$  are positively and significantly related and error correction is also moving towards equilibrium although it is not significant at 5% level. The low speed of adjustment is found as 1.6% per annum only during 1844-2016. The unidirectional causality is also justified by two equations.

The estimated first equation  $\Delta \log p_t$  has been depicted in Figure 13 in which the fitted line moves towards equilibrium that is visible in the diagram.

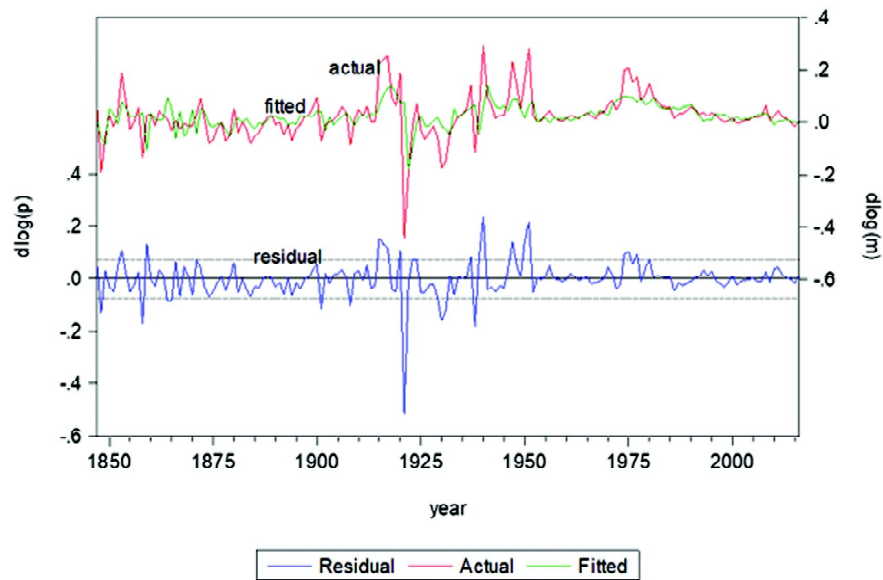


Figure 13: Estimated  $\Delta \log p_t$

Source: Plotted by author

The causality from price level to money supply was found from the second equation where error correction coefficient is positive and significant which indicates that it is divergent from equilibrium which is clearly shown in the Figure 14.

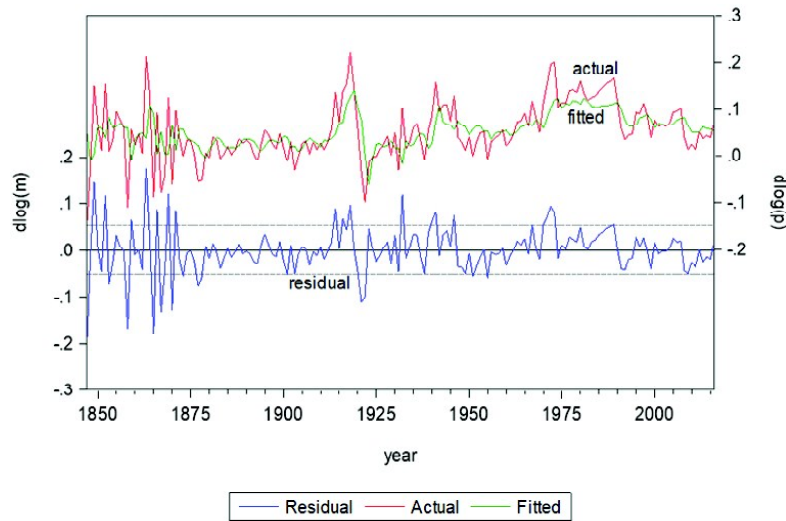


Figure 14: Estimated  $\Delta \log m_t$

Source: Plotted by author

Thence, the cointegrating equation is estimated from VECM using system equation technique and is given below.

$$\text{Cointegrating equation} = -0.01607 \log p_{t-1} - 0.430508 \log m_{t-1} + 2.2155$$

$$(-1.427) \quad (-5.864)^*$$

The cointegrating equation states that it tends to equilibrium because the coefficient of  $\log p_{t-1}$  is negative and it is not significant at 5% level but it is 15%. It also implies that there is long run causality from money supply to price level but not vice versa. It is depicted in Figure 15 below.

Moreover, the VECM is stable because all the roots (1, 0.98, 0.65,  $0.0506 \pm 0.023i$ , -0.067) lie on or inside the unit circle which is shown in the figure below. Since it has one unit root, then the model is nonstationary.

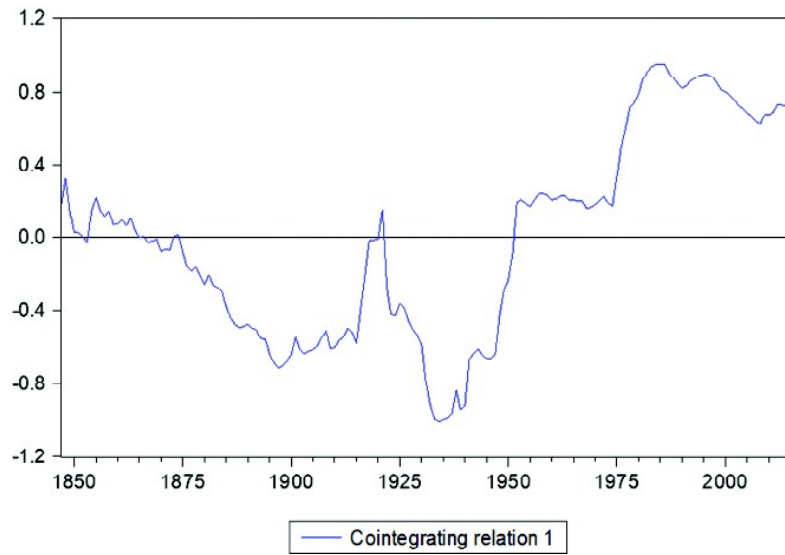


Figure 15: Cointegrating equation

Source: Plotted by author.

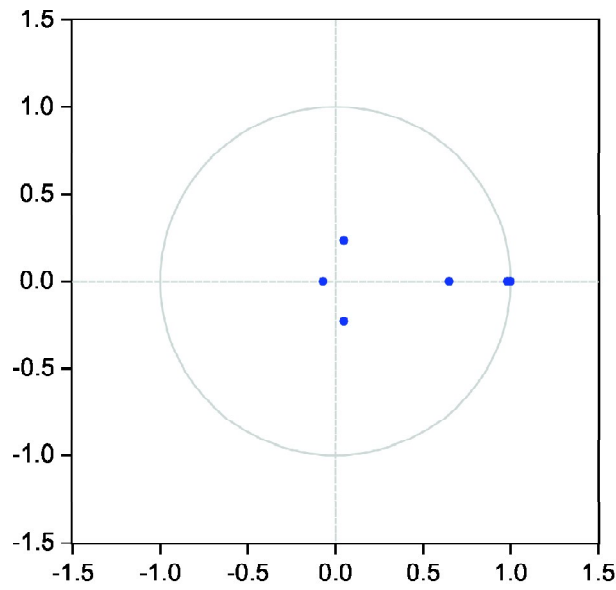


Figure 16: Unit circle

Source: Plotted by author.

The nonstationary and responsiveness can also be verified from the impulse response functions where the response of money supply from price level or response of price level from money supply turn diverging which have been measured by response of Cholesky one standard deviation innovation and is shown in Figure 17.

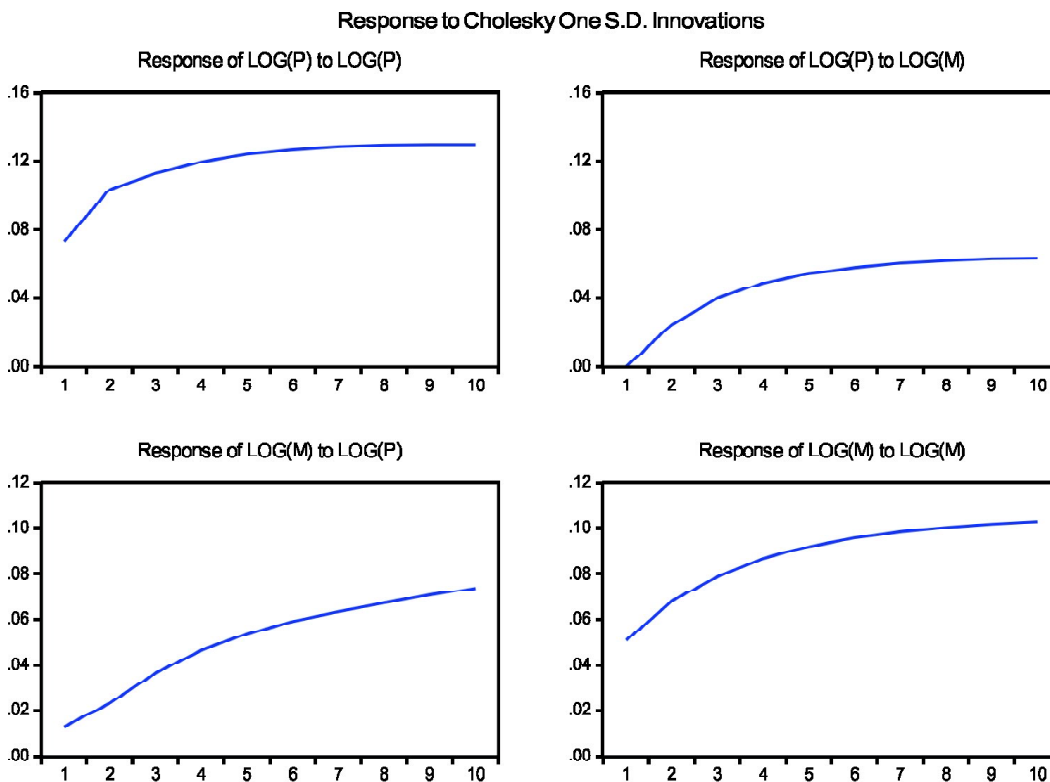


Figure 17: Impulse response functions

Source: Plotted by author.

## V. LIMITATIONS

The paper has some limitations too. It did not include consumer price index as the other measurement of price level. Besides, the paper can be extended by adding output, employment and inflation expectation as the other independent variables so as to explain neutrality of money and expected price inflation. Even, it perhaps could identify the factors of autocorrelation in the specified time series data of UK.

## VI. CONCLUSION

The paper concludes that money supply of UK from 1844 to 2016 had increased by 5.3% per annum significantly whose ARIMA (3, 1, 3) was stable, nonstationary and convergent and it had four upward structural breaks in 1969, 1916, 1943 and 1980. On the other hand, price level of UK measured by whole sale price index had risen by 2.91% per annum whose ARIMA (1, 1, 3) is stable, stationary and convergent and it consists of four structural breaks in 1884, 1915, 1946 and 1977 respectively in which 1884 is downward and the rests are upward. Double log regression model suggested that one per cent increase in money supply revealed 0.57% increase in price level in UK during 1844-2016 which is significant at 5% level but after removing autocorrelation problem the rate became 1.91% per annum both of which satisfied CUSUM square stability test. Granger causality assured that there is unidirectional causality from money supply to price level with lag 2. Johansen cointegration test showed one cointegrating equation in Trace and Max Eigen statistic and unidirectional causality was verified by VECM which showed that there is long run causality from money supply to price level which was supported by cointegrating equation that tends to equilibrium insignificantly whose speed of adjustment was found as 1.60% per annum where VECM is stable but nonstationary.

## REFERENCES

- Alimi, Santos R. (2012, June). The Quantity Theory of Money and Its Long run Implications: Empirical Evidence from Nigeria. *MPR Paper*, 49598.
- Amin, Sakib-Bin. (2011, September). Quantity Theory of Money and Its Applicability: The Case of Bangladesh. *World Review of Business Research*, 1(4), 33-43.
- Ashra, S., Chattopadhyaya, S., & Choudhury, K. (2004, April). Deficit, Money and Price: The Indian Experience. *Journal of Policy Modeling*, 26(3), 289-299. <https://doi.org/10.1016/j.jpoland.2004.03.03.010>
- Bai, Jushan., & Perron, Pierre. (2003). Critical values for multiple structural change Tests, *Econometrics Journal*, 6, 72-78.
- Bodin, Jean. (1566). Response to the Paradoxes of Malestroit. Translated by Henry Tudor. Bristol: Thoemmes Continuum (1997).
- Bowen, F. (1856). *Principles of Political Economy*. London.
- Bhowmik. Debesh. (2019). *Studies on Econometric Applications*. NewDelhi: Synergy Books India.
- Briscoe, J. (1694). *Discourse on the Late Funds*. London.
- Fisher, I. (1911, June). The Purchasing Power of Money: Its Determination and Relation to Credit. *European Scientific Journal*, 8(12).
- Friedman, M. (1956). The Quantity Theory of Money-A Restatement. In Friedman, M.(Ed.), *Studies in the Quantity Theory of Money*. Chicago: University of Chicago.

- Granger, C.W.J. (1969). Investigating Causal Relations by Econometric Models and Cross -Spectral Methods. *Econometrica*, 37(3), 424-438.
- Hamilton, J. D. (2018). Why you should never use the Hodrick Prescott Filter. *Review of Economics and Statistics*, 100(5), 831-843.
- Hammond, J. David. (1999, September). Labels and Substance: Friedman's Restatement of the Quantity Theory. *History of Political Economy*, 449-471. <https://www.doi.org/10.1215/00182702-31-3-449>
- Hetzel, Robert L. (1987). Henry Thornton: Seminal Monetary Theorist and Father of the Modern Central Bank. *Economic Review*, July/August, 1-14.
- Hillinger, C., Sussmuth, B., & Sunder, M. (2012, March). The Quantity Theory of Money and Friedmanian Monetary Policy: An Empirical Investigation. *CESifo Working Paper No-3754*. [https://ifo.de/DocDL/cesifo1\\_wp3754.pdf](https://ifo.de/DocDL/cesifo1_wp3754.pdf)
- Hodrick, Robert., & Prescott, Edward C. (1997). Post War US Business Cycles: An Empirical Investigation. *Journal of Money, Credit and Banking*, 29(1), 1-16.
- Hume, David. (1752). *Political Discourses*. Edinburgh: A Kincaid and A. Donalson.
- Humphrey, Thomas M. (1984, February). Algebraic Quantity Theory of Equations before Fisher and Pigou. *Economic Review*, September/October, 13-22.
- Humphrey, Thomas M. (1974). The Quantity Theory of Money: Its Historical Evolution and Role in policy Debates. *Economic Review*, May/June, 1-17.
- Humphrey, Thomas M. (1997). Fisher and Wicksell on the Quantity Theory. *Economic Quarterly*, 83(4), Fall, 71-9. <http://ssrn.com/abstract=2129819>
- Humphrey, Thomas M. (2004, December). Alfred Marshall and the Quantity Theory of Money. Working Paper No-04-10. Federal Reserve Bank of Richmond.
- Jerome, Howard Jr. (2016). Study of the Quantity Theory of Money. [https://opensiuc.lib.siu.edu/gs\\_rp](https://opensiuc.lib.siu.edu/gs_rp).
- Johansen, S. (1988). Statistical Analysis of Cointegrating vectors. *Journal of Economic Dynamics and Control*, 12, 231-254.
- Keynes, J. M. (1923). *A Tract on Monetary Reform*. London.
- Keynes, J. M. (1936). *General Theory of Employment, Interest and Money*. London.
- Mishra, P. K. (2010, January). Money, Price and Output: A Causality Test for India. *International Research Journal of Finance and Economics*, 53, 26-36.
- Newcomb, S. (1855). *Principles of Political Economy*. New York
- Ozgun, Aslan., & Levant, Korap. (2007). Testing Quantity theory of money for the Turkish economy. MRPA Paper No 21704. <https://mpa.ub.uni-muenchen.de/21704>
- Pigou, A.C. (1917). The Value of Money. *Quarterly Journal of Economics*, 32(1), 38-65.
- Teles, P., Uhlig, H., & Azevedo, J.V. (2015, March). Is Quantity Theory Still Alive? *The Economic Journal*, 126, 442-464.

- Thornton, Henry. (1802). *An Enquiry into the Nature and Effects of the Paper Credit of Great Britain*. New York.
- Wen, Yi. (2006). The Quantity Theory of Money. *Economic Synopses*. No-25. <https://files.stlouisfed.org/files/hdocs/publications/es/06/ES0625.pdf>
- Wicksell, Knut. (1906). Lectures on Political Economy, Vol. 2, *Money*. Translated by E. Classen. Edited by Lionel Robbins. London: Routledge and Kagan Paul (1935).

**To cite this article:**

Debesh Bhowmik. Empirical Evidence of Quantity theory of Money in U.L. *Journal of International Money, Banking and Finance*, Vol. 1, No. 1, 2020, pp. 31-54