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JEL Code: E420, E520, E580, E64

Money and Output Asymmetry: The unintended consequences of central banks' obsession with inflation

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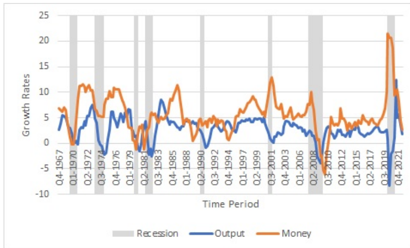
1 Introduction

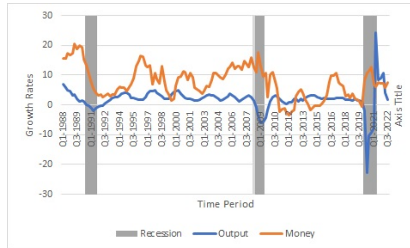
The paper investigates the asymmetric (causal) association between money and output, using a superior measure of money for the US, UK, and the Euro Area. The linear money output relationship is well established since Friedman and Schwartz (1963), Sims et al. (1990), Feldstein and Stock (1993), and more recent literature such as Belongia and Ireland (2016), Hendrickson (2014), Ghosh and Adil (2022), and others. The linear relationship implies that increasing money increases output to the same extent that decreasing money decreases output. However, there is no basis for believing that. The literature has not sufficiently explored the possibility of an asymmetric money output relationship, and it is also unknown what effects such asymmetric relationships might have.

In the recent COVID-19 events, the governments of the major economies resorted to an excessive infusion of liquidity to prevent the economies from entering recessions. While it aided in the creation of output somewhat, it also resulted in abnormal levels of inflation across economies. It is not surprising that modern central banks prioritize controlling inflation, especially in inflation targeting economies where keeping inflation within a target range is legally required. Subsequently the central banks have started adjusting their monetary policy and liquidity in order to control inflation, perhaps without fully comprehending the effects.

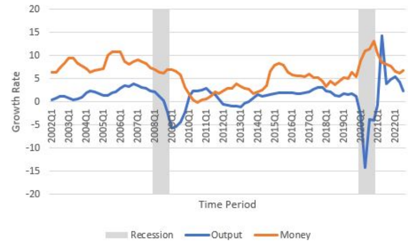
The time series plots for output growth and money growth for the US, the UK, and the Euro Area are shown in Figure 1. The money and output growth are depicted by the orange and blue lines, respectively, and the recessionary periods are highlighted by the grey-shaded areas. For all economies, the graphs generally show significant co-movements between money and output. A closer examination of the graphs, however, reveals that a sharp decline in money is seen before any recession, along with a decline in output. A rise in the money supply coincides with an increase in output, though the relationship appears to be stronger when the money supply is declining rather than rising. Therefore, an initial examination of



(a) US



(b) UK



(c) Euro Area

Figure 1: Growth Rates of Money (Divisia M3) and Output (GDP)

changes in money and output hints at the differential effects of increasing and decreasing the money supply. This motivates us to investigate the asymmetric relationship between money and output.

The Quantity Theory of Money (QTM) holds that after a shock to the quantity of money, incomes and prices change until the sum of the amounts of money that people choose to hold at the new level of income and prices equals the amount of money produced by the banking system. In other words, higher money growth will result in higher inflation and higher overall output. From 2008 onwards until recently, the central banks adopted loose monetary policy and kept infusing money into the economy through a series of quantitative easing measures, but the inflation remained very low. Figure 1(a) shows that the Divisia money growth for the US fell sharply during 2008 for a short period, and did not show much change till the start of the pandemic explaining the low inflation in that period. However, the initial phase of the Covid-19 episode witnessed a huge spike in money growth followed by the uncontrollable inflation as predicted by QTM.

Divisia money, in contrast to their simple-sum counterparts, contains more information and help capture macroeconomic conditions more accurately (Ghosh and Adil (2022)). Belongia (1996) uses the Divisia equivalent of simple sum aggregates to study the relationship between money and output; and holds pitfalls in calculating money aggregates for the differences in its relation to the output. The problem with simple sum aggregates is their inability to internalize the substitution effect completely. Therefore, we test the asymmetric money-output link using Divisia money as a prerequisite, following a similar premise.

While there have been a few studies in the last decade that has looked into asymmetry (Caraiani (2012), Caglayan et al. (2017), and Gefang (2012)), they have primarily focused on the novelty of techniques that they have used such as Spectral analysis, Markow regime-switching, etc. However, we concentrate on traditional Auto Distributed Lag and Granger causality analysis in this paper. Some of them discovered mixed evidence of support for the money-output relationship. The authors like Ghosh and Adil (2022) and Belongia (1996) attribute such poor results to the possible use of faulty money measures. Furthermore, these studies only look at the US, whereas we include the UK and the Euro Area in our sample, allowing us to draw broader conclusions.

Moreover, the research has concentrated on money and output asymmetry over the course of business cycle. However, modern central banks are mostly inflation targeting and are required to keep inflation under control at all times. Although central banks have consistently used loose monetary policy and injected liquidity into the economy since 2008, a positive shock to money did not always result in an increase in output, due to the increased uncertainty during the 2008 recession. While the economies experienced similar excess liquidity and loose monetary policy at the start of the COVID-19 shock, inflation spiked beyond control and central banks tightened monetary policy despite being in recession. Therefore, the money-output relationship can itself shift during the business cycle and regime. As a result, drawing conclusions from existing findings (such as the strength of the money-output relationship is stronger during recessions as found by Caglayan et al. (2017) and Caraiani (2012)), has become increasingly difficult. Therefore, rather than understanding the effect of money over the business cycle or regime, it is more important to understand the precise effects of positive and negative money shocks on output, which provide important policy implications for the current macroeconomic situation.

We use the non-linear Autoregressive Distributed Lag (NARDL) co-integration techniques and non-linear Granger causality tests to evaluate causation and the overall relationship in a non-linear manner while using Divisia money instead of simple sum aggregates. Given some of the features of our data, the NARDL models have certain advantages over the traditional vector auto regression models and vector error correction models, for example, it accommodates multiple data series of different integration orders and provides best estimates for a small sample size. In addition the ability of the non-linear model to distinguish between short- and long-run asymmetries and capture the response of the output to positive and negative changes in money is very informative. We further perform the non-linear Granger causality tests based on Diks and Panchenko (2005, 2006) to check if money has any causal effect on output.

The study's findings imply that money has an asymmetric effect on output. While the money-output relationship is confirmed by the linear models, the non-linear models offer even more convincing evidence of the link. The NARDL model confirms the presence of non-linear co-integration. The response of the output to positive and negative changes in money in NARDL estimations, allows us to see clearly that the negative effect of money on output overpowers its positive effect. Our results are further confirmed by the non-linear Granger causality tests based on Diks and Panchenko (2005, 2006). The results are consistent across different model specifications, such as the use of different lags, bandwidth, and (Divisia) money measures. Especially we find that, it is the 'growth' rate of Divisia money compared to the levels, which shows consistent effect on output. The relationship is discovered to be consistent in all three areas (the US, UK, and the Euro Area). The findings have implications for the policies implemented during COVID-19. The infusion of liquidity may have aided growth in the short run, but the sharp withdrawal of liquidity occurring now may have a negative impact on growth in the long run. As a result, central banks should not only monitor money growth, but also refrain from implementing policies that cause abrupt changes in money growth.

Section 2 talks about the data and methodology used. The empirical estimation is done for the US, the UK, and the Euro Area. As highlighted by Caglayan et al. (2017), the nature of monetary policy has substantially changed after 2008. Thus, for the US, two models have been estimated: the first is a full sample, and the second is only up to 2008. The empirical findings are discussed in Section 3, and the study's conclusion is presented in Section 4.

2 Data and Methodology

2.1 Data

Table 1 summarises the details about the variables, time periods, and data sources. The study uses quarterly data for the US, the UK, and the Euro Area (Euro 19 countries). The choice of areas is based on the availability of series for Divisia money. We use GDP as a measure of output, Consumer Price Index (CPI) as a measure of the price level, and Divisia M3 as a measure of money. All these variables are transformed using natural logarithms. For the interest rate, the long-term interest rate was considered. The study uses linear Autoregressive Distributed Lag (ARDL), Nonlinear Autoregressive Distributed Lag (NARDL), linear and non-linear Granger causality.

Because the sample spans a very long period that may include a structural break around 2008, the study divides the sample for the United States into two periods: Full sample and

Table 1: Variables

Country	Variables	Data Source	Time Period
US	GDP , CPI, Interest rate	OECD	1966 Q4 to 2022 Q2
	Divisia M3	Centre for Financial Stability	1966 Q4 to 2022 Q2
UK	GDP , CPI, Interest rate	OECD	1987 Q1 to 2022 Q3
	Divisia M3	Bank of England	1987 Q4 to 2022 Q3
Euro Area	GDP , CPI, Interest Rate	OECD	2001 Q1 to 2022 Q3
	Divisia M3	Bruegel	2001 Q1 to 2022 Q3

pre-2008. The US economy was first impacted by the Global Financial Crisis in 2008, then by the central bank's Quantitative Easing measures, and finally by the COVID-19 pandemic. The goal is to determine whether or not the relationship has changed over time. We do not split the samples for the UK and the Euro Area, however, due to the smaller sample sizes.

2.2 Autoregressive Distributed Lag (ARDL)

The long-term linear relationship between money and output is first studied using the ARDL approach by Pesaran et al. (2001). It allows using I(1) and I(0) variables in the model while estimating the variables' short-run and long-run impact. The model specification is given by equation 1:

$$\begin{aligned} \triangle Y_t = \theta_0 + \theta_1 Y_{t-1} + \theta_2 M_{t-1} + \theta_3 R_{t-1} + \theta_4 CPI_{t-1} \\ + \sum_{j=1}^{p} \phi_{1j} \triangle Y_{t-j} + \sum_{j=0}^{q_1} \phi_{2j} \triangle M_{t-j} + \sum_{j=0}^{q_2} \phi_{3j} \triangle R_{t-j} + \sum_{j=0}^{q_3} \phi_{4j} \triangle CPI_{t-j} + \epsilon_t \end{aligned} \tag{1}$$

The $\theta's$ are the long-term coefficients while the $\phi_{ij}s$ are the short-run coefficients. Here, Y represents output measured as the logarithmic value of GDP , M is the logarithmic value of Divisia M3, R represents the long-term interest rate in the economy and CPI is the logarithmic value of CPI index of the country. Here, p and q_i's are the lag orders which are selected based on the AIC criterion, and the bounds test is evaluated using the F-statistics.

The literature highlights a non-linear relationship between money and output Baek and Brock (1992); Berger and Österholm (2009); Gefang (2012). Thus, using NARDL instead of ARDL would help evaluate money's asymmetric effect on output. It distinguishes between the impact of an increase in money and a decrease in money while capturing the asymmetric effect both in the short run and the long run.

2.3 NARDL

Like ARDL models, NARDL models allow the simultaneous study of short-run and long-run effects, but in addition, it separately captures the impact of positive and negative change in the independent variables. It also allows multiple orders of integration. This study uses Shin et al. (2014) to study the asymmetric effects of variables in the long run and short run.

Equation 2 below explains the specification used for the NARDL estimation. If X_t is the independent variable, then X_t^+ is the positive component, and X_t^- is the negative component. Here, $X_t = X_0 + X_t^+ + X_t^-$; X_0 is the arbitrary initial value, X_t^+ is the cumulative sum of positive changes, and X_t^- is the cumulative sum of negative changes.

$$\begin{aligned}\triangle Y_t = \theta_0 + \theta_1 Y_{t-1} + \theta_2 M_{t-1}^+ + \theta_3 M_{t-1}^- + \theta_4 R_{t-1}^+ + \theta_5 R_{t-1}^- + \theta_6 CPI_{t-1}^+ + \theta_7 CPI_{t-1}^- \\ + \sum_{j=1}^{p} \phi_{1j} \triangle Y_{t-j} + \sum_{j=0}^{q_1} \phi_{2j} \triangle M_{t-j}^+ + \sum_{j=0}^{q_2} \phi_{3j} \triangle M_{t-j}^- + \sum_{j=0}^{q_3} \phi_{4j} \triangle R_{t-j}^+ + \sum_{j=0}^{q_4} \phi_{5j} \triangle R_{t-j}^- \\ + \sum_{j=0}^{q_5} \phi_{6j} \triangle CPI_{t-j}^+ + \sum_{j=0}^{q_6} \phi_{6j} \triangle CPI_{t-j}^-\end{aligned} \tag{2}$$

Here, θ_i's are the long-run coefficients, and ϕ_{ij} are the short-run coefficients. The asymmetric effect of each case is given as the ratio of the long-run coefficient of the variable (θ_i^+ or θ_i^- for i=2,3,4) to the long-run coefficient of output (i.e. θ_1). Here, p and q_i's are the lag lengths and the optimal model is selected based on the AIC criterion and the Bounds test is evaluated using the F-statistics.

2.4 Non-Linear Granger Causality

Baek and Brock (1992) suggest a non-linear Granger causality test based on the assumptions of the errors of the VAR model. The assumption is that the errors of the VAR model are mutually independent and are *independent and identically distributed.* Hiemstra and Jones (1994) modified the test and showed that the casuality would hold even in the case when the errors are weakly dependent and not completely independent. Diks and Panchenko (2005) suggests that the test does not perform well in case of more observations and has an upward bias, thus rejecting the null of no causality more often. Thus, Diks and Panchenko (2006) suggested a further modified test that is given below.

Let X_t and Y_t be two stationary time series. X_t is said to cause Y_t if its past and current values could significantly impact the future values of Y_t. Let I_{X_t} and I_{Y_t}, known as the information sets, contain the past and current information of X and Y. Then X_t Granger causes Y_t if for s$\geq$ 1, $(\mathrm{Y}_{t+1}, Y_{t+2}, ..., Y_{t+s})|(I_{X_t}, I_{Y_t})$ is superior to $(Y_{t+1}, Y_{t+2}, ..., Y_{t+s})|(I_{Y_t})$.

Let, $X_t^{l_x} = (X_{t-l_x-1}, ..., X_t)$ and $Y_t^{l_y} = (Y_{t-l_y-1}, ..., Y_t)$ for $l_x, l_y \geq 1$. Then the null hypothesis (H_0) for non-linear Granger causality is that the additional information on X_t does not help in predicting the future values of Y_t better i.e., $H_0 : Y_{t+1}|(Y_t^{l_y}; X_t^{l_x})\ Y_{t+1}|(Y_t^{l_y})$.

Under the null hypothesis, for simplicity, assume $l_x = l_y = 1$ and ignore the time index, the joint and marginal probability density function must satisfy the following relation,

$$\frac{f_{X,Y,Z}(X,Y,Z)}{f_Y(Y)} = \frac{f_{X,Y}(X,Y)}{f_Y(Y)} \frac{f_{Y,Z}(Y,Z)}{f_Y(Y)} \tag{3}$$

where $Z_t = Y_{t+1}$. Therefore, the null could be expressed as,

$$E[f_{X,Y,Z}(X,Y,Z) f_Y(Y) - f_{X,Y}(X,Y) f_{Y,Z}(Y,Z)] = 0 \tag{4}$$

Table 2: Stationarity Results using the Phillips–Perron test

Country	Variable	Levels	First Difference	Inference
US	Output	-1.29	-15.18 ***	I(1)
	Divisia M3	-2.21	-9.93 ***	I(1)
	CPI	-1.27	-7.39 ***	I(1)
	Interest Rate	-2.68	-11.39 ***	I(1)
UK	Output	-3.02	-15.92 ***	I(1)
	Divisia M3	-1.77	-9.88 ***	I(1)
	CPI	-3.39*	-8.89 ***	I(1)
	Interest Rate	-2.29	-10.77 ***	I(1)
Euro Area	Output	-3.74**	-11.90 ***	I(1)
	Divisia M3	-2.27	-7.81 ***	I(1)
	CPI	-1.48	-9.54 ***	I(1)
	Interest Rate	-1.78	-6.46 ***	I(1)

***-1% level of Significance, **-5% level of Significance, *-10% level of Significance

The test statistic is,

$$T_n(\epsilon) = \frac{n-1}{n(n-2)} \sum i[\hat{f}_{X,Y,Z}(X_i, Y_i, Z_i)\hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i, Y_i)\hat{f}_{Y,Z}(Y_i, Z_i)] \tag{5}$$

According to Diks and Panchenko (2006), the statistic must satisfy $\sqrt{n}\frac{T_n(\epsilon)-q}{S_n} \xrightarrow{D} N(0,1)$, where q and S_n are estimators of asymptotic expectation and standard error, respectively. Here, the null hypothesis is that money does not cause output in a non-linear way.

3 Results

3.1 Stationarity

The unit root test results are presented in Table 2. The Phillips–Perron test is used to evaluate the stationarity of all the variables. The test results suggest that all the variables are stationary at first difference i.e., are I(1) at 1 percent level of significance. This looks perfect for ARDL and NARDL modeling as they require data to be I(1), or a mixture of I(1) and I(0), with the dependent variable to be always I(1).

3.2 ARDL

Table 3 presents the results of the linear ARDL model. First, the presence of a co-integrating relationship between the dependent and independent variables is evaluated using the Bounds test. The Bounds test is satisfied in all cases, except for the UK, suggesting a long-run relationship exists between output and the independent variables. The Bounds test is inconclusive for the UK as it lies within the uncertainty interval. Following Ghosh and Parab (2021), which suggests estimating the long-run relationship and then drawing conclusions based on the long-term coefficient of GDP. In this case, a negative and significant long-term coefficient of GDP suggests a stable long-term relationship. In other cases as well, the coefficient is found to be negative and significant. The DW Statistic and the LM test suggests no auto-correlation in the data.

Money has a significant long-term impact only in Model 1 and not in any other model. This gives a false impression that money does not impact output. Further results discussed in the upcoming section suggest that money impacts output when considering the asymmetric (non-linear) effect. Therefore, when we consider the impact of money change on output to be symmetric (linear), the relevance of money is lost. Also, the results suggest that money can have a significant short-run impact on output when we consider lagged values of Divisia M3. Moreover, interest rate has a significant negative long-term impact on output. With an increase in the interest rate, the cost of borrowing increases, and thus, it has a negative impact on output through the investment channel.

3.3 NARDL

The results of the NARDL model are presented in Table 4. The Bounds test F-statistic is significant, suggesting an asymmetric long-run relationship exists for all the models. In case of the Euro Area, the Bounds test is in the inconclusive range. However, the negative significant long term coefficient of dependent variable suggests that the model is stable

Table 3: Results of ARDL

Country	**Model 1** US (pre-2008)	**Model 2** US (full sample)	**Model 3** UK	**Model 4** Euro Area
Long Run Coefficients				
GDP_{t-1}	-0.071***	-0.056***	-0.168 ***	-0.345***
$DivisiaM3_{t-1}$	0.388***	0.152	0.138	0.004
R_{t-1}	-0.007	-0.018*	-0.047***	-0.023*
CPI_{t-1}	0.138	0.398***	-0.288	0.254*
Short Run Coefficients				
$\triangle\text{GDP}_{t-1}$	0.089	-0.026	-0.204**	
$\triangle\text{GDP}_{t-2}$	0.119	0.184***		
$\triangle\text{GDP}_{t-3}$	0.019	-0.080		
$\triangle$Divisia M3_t	-0.033	0.042	-0.088	-0.020***
$\triangle$Divisia M3_{t-1}		-0.422***	-0.311 ***	-0.034 ***
$\triangle$Divisia M3_{t-2}		0.263***	0.199*	
$\triangle$Divisia M3_{t-3}		0.207***		
$\triangle\text{R}_t$	0.004 ***	0.002*	0.011 *	0.0041287
$\triangle\text{R}_{t-1}$			0.009	0.027***
$\triangle\text{R}_{t-2}$			0.0037	-0.002
$\triangle\text{R}_{t-3}$			0.012**	0.023***
$\triangle\text{CPI}_t$	0.066	0.051		0.136
$\triangle\text{CPI}_{t-1}$	-0.312**	-0.186		0.650**
$\triangle\text{CPI}_{t-2}$	-.246 *	-0.192*		
$\triangle\text{CPI}_{t-3}$	-.125			
Constant	1.831078	1.458	4.106	9.406
Adj. R Squared	0.29	0.32	0.17	0.31
Bound Test	6.541***	4.64**	3.642	5.588**
DW Statistic.	2.019	1.988	2.077	2.232
LM Test	3.450	1.609	3.620	5.112
White test (Homoscedasticity)	121.82**	211.48***	134.97***	83

***-1% level of Significance, **-5% level of Significance, *-10% level of Significance

and has a long term relationship (Ghosh and Parab (2021)). In fact, the long-run output coefficient is negative and significant for all the models, indicating their stability.

The broad understanding from the empirical exercise is that there exists asymmetry in the impact of money on output. In the case of the US for the full sample model, the results suggest that an increase in money by 1 percent increases output by 4 percent, while a decrease in money by 1 percent decreases output by 10 percent, although the latter result is not significant. An asymmetric effect exists in the short run but not in the long run, as shown by the long-run asymmetry and short-run asymmetry tests. In comparison, in the pre-2008 sample, an increase in money by 1 percent increases output by 3 percent, while a decrease in money by 1 percent decreases output by 51 percent, a much larger amount, and both the results are significant. The pre-2008 sample results indicate that the output decreases significantly in case of a decrease in the money, and the magnitude is greater than it would be in the case of increase in money. The asymmetry test confirms the presence of a long run asymmetric effect of money on output.

For the UK and the Euro Area, the results suggest that the long-run effects of increase in money on output are insignificant. The long-run effect of a decrease in money is negative and significant as captured by the long-run coefficients of Table 4. For a 1 percent increase in money measured by Divisia M3, UK's output reduces by 21 percent while the Euro areas output reduces by 2 percent. Thus, this suggests that withdrawing liquidity could harm the economy's growth prospects, but just an infusion of liquidity in the economy does not mean long-term growth. In light of COVID, much attention was given to the infusion of liquidity, which impacts the output level in the short-run but does not have a long-term impact.

The evaluation of long-term and short-term asymmetric effects suggests that in the Euro area money has both long-term and short-term asymmetric effects, statistically significant at 1 percent and 10 percent levels of significance. For the UK, the results suggest that there exists long-term asymmetric impact of money on output, but in the short-run, there is no asymmetry.

3.4 Asymmetric Effect

This section complements our findings of the long-run asymmetric effect. In Figure 2 the black (black dotted) line tells about the impact of positive (negative) changes in the Divisia M3 on output. The dark red dotted line suggests the asymmetric effect of positive and negative effects with the given confidence interval, i.e., the difference between the impact of increase or decrease in Divisia M3. The confidence interval present here is the 95 percent band. If the 0 line falls between the confidence interval, it suggests an insignificant asymmetric effect.

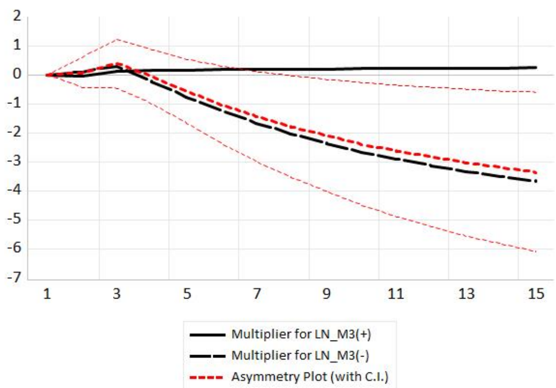
In the case of the US (Figure 2 (b)), the magnitude of the negative shock is much larger than the positive shock. Although there is no asymmetric effect of positive or negative shocks over a longer time horizon, but an asymmetric effect exists in a short horizon. This is in line with the results which were discussed earlier. For the pre-2008 for the US (Figure 2(a)), money does have an asymmetric impact on output in the long-run. For the UK (Figure 2 (c)), the impact of a negative shock is more than a positive shock. Also, the asymmetric effect suggests that in the immediate time horizon, there is no asymmetry, but over a longer time horizon, there exists an asymmetric effect of change in money. And in the case of the Euro Area (Figure 2 (d)), the results suggest an asymmetric effect in both the short- and the long-run.

This aligns with the results presented earlier and suggests an asymmetric impact of money on output. The impact of a decrease in the money is more than an increase in the money and is sustained over time.

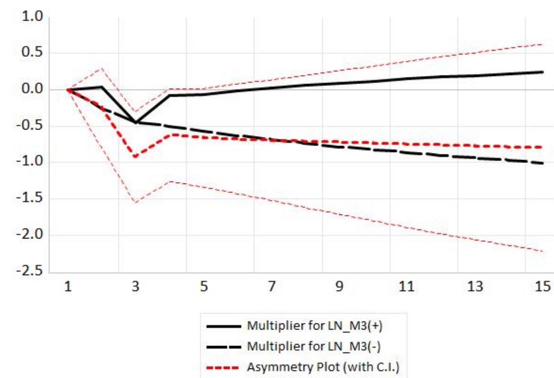
Table 4: Results of NARDL

Country	**Model 1** US (pre-2008)	**Model 2** US (full sample)	**Model 3** UK	**Model 4** Euro Area
Long Run Coefficients				
GDP_{t-1}	-0.102 ***	-0.079 ***	-0.275 ***	-0.50***
$DivisiaM3_{t-1}+$	0.031 ***	0.040 ***	0.010	-0.010
$DivisiaM3_{t-1}-$	0.516***	0.103	0.214 *	0.023 ***
$R_{t-1}+$	0.002	-0.001	0.013	0.008
$R_{t-1}-$	-0.001	-0.0002	-0.016 ***	-0.014 *
$CPI_{t-1}+$	0.009	0.012	-0.437 ***	0.597
$CPI_{t-1}-$	0.645 *	0.033	.227	-0.862
Short Run Coefficients				
△GDP$_{t-1}$	0.120	-0.054	-0.184 **	-0.070
△Divisia M3$_t$ +	-0.042	0.033	-0.046 *	-0.018 *
△Divisia M3$_{t-1}$ +	0.121	-0.528 ***	-0.393 ***	-0.034 ***
△Divisia M3$_{t-2}$ +		0.279 ***		
△Divisia M3$_t$ -	-0.082	0.258	0.045	0.011
△Divisia M3$_{t-1}$ -	-0.684 *	0.112	.156	-0.011
△Divisia M3$_{t-2}$ -		.015		
△R$_t$ +	0.005 **	0.001	0.005	0.016
△R$_{t-1}$ +	0.003	0.001	-0.008	0.017
△R$_{t-2}$ +		0.001		
△R$_t$ -	0.003	0.005 **	0.006	-0.006
△R$_{t-1}$ -	0.002	-0.0002	0.010	0.015
△R$_{t-2}$ -		0.001		
△CPI$_t$ +	-0.131	-0.298 **	0.261	0.462
△CPI$_{t-1}$ +	-0.466***	-0.182	0.382	0.086
△CPI$_{t-2}$ +		-0.344 **		
△CPI$_t$ -	0.846 **	1.158 ***	-1.885	0.516
△CPI$_{t-1}$ -	0.342	0.397	0.195	2.521*
△CPI$_{t-2}$ -		0.496		
Long Run Asymmetry				
Divisia M3	4.458 **	0.407	2.734 *	14.33 ***
R	5.452 **	0.207	11.77 ***	2.248
CPI	2.787 **	.018	.325	3.378*
Short Run Asymmetry				
Divisia M3	2.405	2.648 *	.719	3.615*
R	0.275	.258	.554	0.417
CPI	3.265 *	21.45 ***	.237	1.136
Adj. R Squared	0.32	0.38	0.15	0.31
Bound Test	4.1022**	4.0959**	3.28*	3.21*
Portmanteau test	44.91	46.37	16.12	24.42
BPG test	0.3261	80.41***	106.8***	34.52***

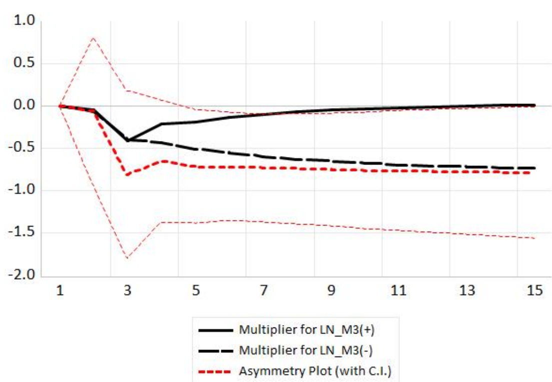
***-1% level of Significance, **-5% level of Significance, *-10% level of Significance



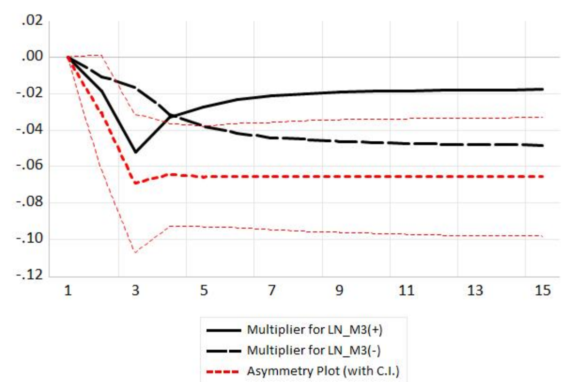
(a) US (upto 2008)



(b) US



(c) UK



(d) Euro Area

Figure 2: Asymmetric Effects of Money on Output

As discussed earlier, the asymmetric impact of monetary policy has been evaluated earlier, and Morgan (1993) dates it back to the times of the Great Depression. The asymmetric impact is mainly attributed to credit constraints and economic outlook. In the case of an expansionary monetary policy, the mere availability of more money does not mean that credit or investment would pick up, thereby affecting output. But in the case of a contractionary monetary policy, the credit is constrained, which impacts investment decisions. This also depends on agents' outlook, and during recessions, it is pessimistic. Because of lower confidence, easy credit does not always result in output. As a result, the expansionary policy is rendered ineffective, and monetary policy has an asymmetric impact.

3.5 Causality

After establishing co-integration, we now proceed to check whether a stronger association between money and output exists. We test for causality in a bi-variate setting, where only output and money are considered, and then extend the analysis to a multi-variate setting to ensure the robustness of the money-output relationship. Interest rates and prices are added in the multi-variate setting. This is necessary because, for example, if interest rates have a significant impact on output, the money-output bi-variate model will attribute the effect to money. In addition, three model specifications are taken into account. Model 1 includes all variables in growth rates, Model 2 includes only money in growth rates and all other variables in log levels, and Model 3 includes all variables in log levels.

We first present the results for the linear Granger causality in Table 5. A VAR model is estimated where the lag length is decided based on the AIC criterion. In Model 1 and Model 2, where the growth rates of money is considered, the null is rejected suggesting that Divisia Money does Granger cause output, and the relationship holds for all areas and also in the case of a multivariate model. Thus, we see that the predictive power of money does not decrease when more variables are added. The relationship holds across Model 3 as well. Having discussed the results of the linear model, next the results for the non-linear Granger

Table 5: Linear Granger Causality Tests

Country	US (pre-2008)	US (full sample)	UK	Euro Area
	Model 1: All Variables in Growth Rates			
Bi-Variate	6.54***	4.63***	4.36**	14.52***
Multi-Variate	2.04**	3.32**	2.63**	5.61***
	Model 2 : Money in Growth Rate and Other Variables in Log Levels			
Bi-Variate	5.42***	4.88***	3.26**	13.02***
Multi-Variate	3.28***	3.5***	2.24**	5.51***
	Model 3 : All Variables in Log Levels			
Bi-Variate	4.99**	3.98***	1.18	3.35**
Multi-Variate	2.42**	2.96***	3.36**	2.01*

***-1% level of Significance, **-5% level of Significance, *-10% level of Significance

causality are discussed.

A test given by Diks and Panchenko (2005, 2006) is used to evaluate the non-linear causal relationship. A standard VAR model is first estimated, and the errors obtained from the VAR models for money and output are normalized to have mean 0 and variance 1. The normalized error terms are used to perform the Diks and Panchenko (2006) test. For this empirical exercise, the same lag length is considered for the dependent and independent variables while fixing the bandwidth parameter at 1.5 ($\epsilon = 1.5$) for the test statistic values reported in Table 6. The results are consistent for varying values of bandwidth.

Just like linear Granger causality case, the same three model specifications are estimated and the errors of the estimated VAR models are used for the Diks and Panchenko (2006) test. The results suggests that for most of the cases, we reject the null that money does not Granger cause output in a non-linear fashion. The results are consistent for different lag lengths, different bandwidth parameters and across all areas under consideration. The relationship holds in both bi-variate and multi-variate models. The results are consistent even for different model specifications (e.g., Models 1, 2 and 3), with growth rate of money providing the strongest evidence for the role of money in output. Thus, we conclude that money does Granger cause output in a non-linear fashion.

4 Conclusion

Studies like Ghosh and Adil (2022) have already addressed the reason behind lack of consensus in the literature on the relationship between money and output. This study aims to understand further if money has any asymmetric effect on output and concludes that money impacts output level in the long run and the impact it has is asymmetric. A decrease in the money supply has a significant negative impact on output in the long run, but simply increasing the money supply does not guarantee long-term growth. The results are consistent across different lag orders, further strengthening the claims. The Diks and Panchenko (2006) test also suggests that money does Granger cause output in a non-linear fashion. Our findings not only support the New Monetarist position that the role of money in the economy is not redundant and that monetary authorities must consider money, but we also warn monetary authorities about the ability of money to cause havoc if not handled prudently.

At the outbreak of COVID-19, globally, there was massive infusion of liquidity into the economies. It may have short-term implications for output, but in the long run, there may not be any significant impact of the same as indicated by our results. Short-term goals may drive it, but in a scenario like now, where the liquidity is being withdrawn drastically across countries to combat abnormal inflation created due to excess liquidity, the negative impact on long-run output may be even more damaging. Thus, it calls for careful evaluation of the trade-off that exists.

Table 6: Non-Linear Granger Causality tests

			Lag Order		
Model	Country	Time Period	2	3	4
Model 1: All Variables in Growth Rates					
Bi-Variate	US (pre 2008)	1.493*	1.09	0.845	
	US (full sample)	1.21	1.73**	1.68**	
	UK	1.477*	1.978**	2.115**	
	Euro Area	3.03***	2.715***	2.401***	
Multi-Variate	US (pre 2008)	0.906	1.643*	1.645*	
	US (full sample)	1.571*	1.853**	1.607*	
	UK	1.943**	1.368*	1.834**	
	Euro Area	2.485***	2.293**	1.846**	
Model 2: Money in Growth Rate and Other Variables in Log Levels					
Bi-Variate	US (pre 2008)	1.485*	1.524*	0.731	
	US (full sample)	1.992**	1.582*	1.426*	
	UK	1.604*	2.043**	2**	
	Euro Area	2.964**	3.452***	3.023***	
Multi-Variate	US (pre 2008)	1.254*	1.4*	1.952**	
	US (full sample)	2.394***	2.183**	1.951**	
	UK	2.237**	2.086**	2.024**	
	Euro Area	2.964***	3.452***	3.023***	
Model 3 : All Variables in Log Levels					
Bi-Variate	US (pre 2008)	0.941	1.248*	1.755**	
	US (full sample)	4.256***	3.598***	3.398***	
	UK	2.041***	2.182***	2.189***	
	Euro Area	1.413*	1.703**	1.586*	
Multi-Variate	US (pre 2008)	0.687	1.213		
	US (full sample)	4.882***	4.301***	3.423***	
	UK	1987 Q1 to 2022 Q3	2.81***	2.547***	2.347***
	Euro Area	2001 Q1 to 2022 Q3	0.331	0.424	0.383

***-1% level of Significance, **-5% level of Significance, *-10% level of Significance

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