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Abstract

This study analyses the time varying correlation of money and output using the DCC GARCH model for the Euro, India, Poland, the UK and the US. Apart from simple sum money, this model uses Divisia monetary aggregate, which is theoretically shown as the actual measure of monetary services. The inclusion of Divisia money affirms the Friedman-Schwartz hypothesis that money is procyclical. The procyclical nature of association was not robustly observed in recent data when simple sum money was used.

Keywords: DCC GARCH, Divisia, Monetary Aggregates, Real Output

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Abstract

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1. Introduction

A natural method to analyse the link between money and output is to analyse their statistical correlation. Friedman and Schwartz (1963a) established the statistical link between money and business cycles and determined money to be procyclical using historical US data. However, this close association was compromised by the unusual behaviour of monetary aggregates post-1980s and their increased volatility (Friedman and Kuttner, 1992; Estrella and Mishkin, 1997).

Moreover, rampant financial innovations made the measure of money using simple sum unreliable.

After the great financial crisis (GFC) which started in 2008, there was a resurgence of studies that focus on the role of money, particularly Divisia money. This resurgence is due to the loss of credibility of interest rate as a reliable monetary policy instrument when it could no longer be decreased further. The literature on aggregation-theoretical Divisia monetary aggregates has argued that Divisia money places weight on the different components of money on the basis of their relative liquidity accurately determining the liquidity in the economy when new instruments are introduced (Barnett, 1980; Belongia and Binner, 2001).

Belongia and Ireland (2016) used recent US data and determined the procyclical correlations between money and output. The results are significant when Divisia money is used instead of simple sum. Hendrickson (2014) invalidated the redundant role of money as an intermediate target or informational variable by using Divisia to estimate a stable money demand equation. He demonstrated that Divisia money Granger-cause output, whilst simple sum does not.

Engle's (2002) dynamic conditional correlation (DCC) GARCH model is used to determine the time varying role of money. We determine that[1] (1) Divisia money growth rates are generally procyclical, (2) money is countercyclical during recessions, (3) the unconventional monetary policy measures of the US and the UK can explain money's 'transient' countercyclicality during GFC (4) the Euro zone's delay in implementing such measures and the sovereign debt crisis

[1] The results are robust to the use of different types of Divisia money, different types of simple sum money and different combinations of countries.

reflected in Divisia money's 'persistent' countercyclicality post GFC and (5) the inclusion of Divisia money establishes that money remains a reliable business cycle indicator.

2. Data and Methodology

Let $X_t = [M_t, IP_t]'$, where X_t is a 2 × 1 vector, IP_t denotes industrial production (used as a proxy for real output) and M_t denotes money supply (simple sum or Divisia). Table 1A (Appendix) provides the data description. All series are monthly and seasonally adjusted. All variable levels are non-stationary, whilst the annualised month-on-month log differences (growth rate) are stationary (see Appendix Table 2A). Such transformation of variables to their growth rates provides stationary heteroscedastic data so that GARCH analysis can be applied.

The conditional mean equation of the model is as follows:

$$A(L)X_t = \varepsilon_t, \quad \varepsilon_t|I_{t-1} \sim N(0,H_t), \tag{1}$$

where ε_t is the vector of the error terms and I_{t-1} is the information set available until time t−1. H_t is the conditional variance-covariance matrix of the error represented as follows:

$$H_t = D_t R_t D_t, \tag{2}$$

where D_t is a time-varying diagonal matrix obtained from the univariate GARCH (p,q) models, such that $D_t = diag\sqrt{h_{it}}$ and the univariate GARCH (p,q) models are provided as follows:

$$h_{it} = \alpha_i + \sum_{q=1}^{Qi} \alpha_{iq}\varepsilon_{it-q} + \sum_{p=1}^{Pi} \beta_{ip} h_{it-p}. \tag{3}$$

The DCC (M,N) GARCH (p,q) model comprises the following equations:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1}, \tag{4}$$

where

$$Q_t = (1 - \sum_{m=1}^{M} a_m - \sum_{n=1}^{N} b_n)\bar{Q} + \sum_{m=1}^{M} a_m \varepsilon_{t-m}^2 + \sum_{n=1}^{N} b_n Q_{t-n}, \tag{5}$$

in which $\bar{Q}$ is the variance-covariance matrix that is time invariant and Q_t^{*-1} is the diagonal matrix of the square root of the elements of Q_t. Hence, R_t can be represented as $R_t = \frac{q_{ij,t}}{\sqrt{q_{ii,t}q_{jj,t}}}$.

3. Results

The null hypothesis for the Lagrange multiplier tests assumes the series to be homoscedastic. All variables display heteroscedasticity, thereby deeming them fit for GARCH analysis.[2] The DCC (1,1)-GARCH (1,1) model is estimated using the quasi maximum likelihood estimation technique. The key parameters, dcca1 and dccb1, denoted by the coefficients a_m and b_n in Equation (5), respectively, are presented in the Appendix Table 4A for $m = 1$, $n = 1$.[3] We determine significant b_n in all cases, thereby validating the use of the DCC model. Additionally, $a_1 + b_1 > 0$ for all countries with b_1 approximating 1 implies a high persistence in the correlation. Meanwhile, $a_1 + b_1$ approximating 1 shows that the conditional variances are highly persistent and mean reverting in nature. We run post-estimation diagnostics using weighted Portmanteau test (Li and Mak, 1994) on the individual error terms and cross products of the residuals (Tse and Tsui, 2002)[4]. We determine the absence of heteroscedasticity in all cases except for the cross products of the residuals for simple sum money for Euro.

The left (right) panel of Figure 1 illustrates the correlation of the output with Divisia money growth (simple sum M3 growth) with 95% confidence intervals. Divisia money generally shows

[2] See Table 3A (Appendix); null is rejected at the 1% significance level.

[3] Table 4A presents the conditional mean and conditional variance equations.

[4] Table 5A presents the results for lags 10. The results are robust to the use of different lags.

procyclicality and countercyclicality during recessions. However, the simple sum money growth fails to robustly determine the procyclical relation. Correlations with simple sum have generally remained negative post-GFC for the UK. Moreover, frequent countercyclical episodes were observed for the US starting in the 1990s and India for the entire sample.

The graphs show a systematic and predictable behaviour of money and output correlation, specifically before, during and after any major recession. A sharp decline occurs in the correlation during GFC and becomes countercyclical in many cases. Post-GFC, the correlation with Divisia money becomes positive and even reaches the pre-recession level for all countries[5]. Euro showed the persistent countercyclicality of Divisia during GFC and in its aftermath, whereas the UK and the US showed transient countercyclicality. Interestingly, the US and the UK began pursuing quantitative easing immediately following the onset of GFC, whereas Euro delayed it for several years.

Consistent with Belongia and Ireland (2016), the US Divisia remained procyclical with the exception of GFC, the energy crisis of the late 1970s and early 1980s recessions. The UK Divisia became countercyclical in 2002 when Euro was formed and in 2016 when the UK voted to leave the European Union (Brexit). Although, Euro's correlation between Divisia money and output fell during the Brexit movement, it did not become countercyclical. Brexit did not have an adverse impact on the correlations of Euro, although GFC and the ensuing period did. Generally, Divisia money was highly procyclical for Poland and India.

[INSERT FIGURE 1 HERE]

4. Conclusion

[5] With the exception of India, the Divisia data of which are available only until June 2008.

We evaluate the shifts in money and output correlation for Euro, India, Poland, the UK and the US by estimating a bivariate DCC-GARCH model. Divisia money growth generally remains procyclical. The majority of the simple sum money results are obscured by money's frequent countercyclical behaviour. Money's countercyclicality during recessions hints at the shifting preference behaviour of individuals for demand for liquid assets. The quantitative easing adopted by the US and the UK during GFC was deemed effective because it helped money become procyclical considerably faster compared with Euro, which failed to immediately adopt the measure.

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Appendix:

Table 1A: Data Description

Country	Variable	Database	Time period
US	M3, IP	OECD	Feb 1967 – June 2018
	Divisia M4 Including Treasuries	Center for Financial Stability	
UK	M3, IP	OECD	Feb 1999 – June 2018
	Monetary financial institutions' sterling divisia (total)	Bank of England	
Euro Area	M3, IP	OECD	Feb 2001 – June 2018
	M3 Divisia changing composition	Bruegel[6]	
India	M3, IP	OECD	April 1994 – June 2018
	M3 Divisia	Ramachandran et. al. (2010)	April 1994 – June 2008
Poland	M3, IP	OECD	Jan 1997 – June 2018
	Div3	Narodowy Bank Polski	

[6] http://bruegel.org/publications/datasets/divisia-monetary-aggregates-for-the-euro-area/

Table 2A- Augmented Dickey Fuller Tests

Null: Variable has a unit root

	US		**UK**		**Euro Area**	
Variables	Level	First Difference	Level	First Difference	Level	First Difference
Divisia	-0.51	-12.69*	1.83	-11.79*	-0.34	-6.70*
M3	5.36	-10.09*	-1.48	-8.84*	-0.94	-5.18*
IP	-1.57	-11.89*	-1.55	-12.19*	-1.52	-8.51*
	Poland		**India**			
Divisia	2.22	-10.27*	2.63	-9.51*		
M3	-0.22	-14.26*	4.82	-10.93*		
IP	-2.19	-13.85*	1.78	-11.09*		

'*' represents rejection of null at 1% significance level.

Table 3A- Lagrange Multiplier Test

Null: Series is homoscedastic (p-values are reported)

Variables	**US**	**UK**	**Euro**	**Poland**	**India**
Divisia	0.00	0.00	0.00	0.00	0.00
M3	0.00	0.00	0.00	0.00	0.00
IP	0.00	0.00	0.00	0.00	0.00

Table 4A- Conditional Mean and Conditional Variance Equations

		US				UK				EU	
		Divisia(t)	**IP(t)**	**M3(t)**	**IP(t)**	**Divisia(t)**	**IP(t)**	**M3(t)**	**IP(t)**	**Divisia(t)**	**IP(t)**
Conditional Mean	**Constant**	5.79*	2.99*	6.03*	3.02*	9.17	-0.12	5.79*	-0.12	5.16*	1.63*
	Divisia(t-1)	0.41*	-0.57*	0.78*	0.78*	0.73*	0.15*	0.09	0.19	0.96*	-0.24**
	IP(t-1)	-0.69*	0.72*	-0.22**	-0.60*	-0.18*	-0.22	0.92*	-0.46***	0.80*	-0.09
Conditional Variance	**Constant**	0.84*	23.44*	5.85*	23.83*	0.76	49.91	2.26	58.27	0.42	102.71*
	α(1)	0.19*	0.31*	0.63*	0.31*	0.06***	0.48*	0.001	0.38*	0.03	0.32**
	β(1)	0.84*	0.34**	0.16	0.33**	0.93*	0.16	0.94*	0.15	0.94*	0.00
	dcca1	0.006		0.006		0.008		0.03		0.05	
	dccb1	0.84*		0.85*		0.82*		0.81*		0.84*	
		POLAND				**INDIA**					
Conditional Mean	**Constant**	9.52*	4.92*	11.67*	5.02*	14.59*	7.70*	15.94*	7.45*		
	Divisia(t-1)	-0.48*	0.20	0.06	-0.28**	0.30*	0.23**	0.45*	-0.50*		
	IP(t-1)	0.26*	0.76*	-0.34**	-0.12	-0.26**	-0.08	-0.35*	-0.02*		
Conditional Variance	**Constant**	0.00	0.00	0.00	0.00	6.48	4.36*	2.37*	6.25*		
	α(1)	0.02	0.03	0.02	0.03	0.05	0.1***	0.08	0.07***		
	β(1)	0.97*	0.97*	0.97*	0.96*	0.91*	0.89**	0.85*	0.91*		
	dcca1	0.09**		0.12*		0.04		0.03			
	dccb1	0.66*		0.53*		0.83*		0.85*			

Level of Significance: ‘*’-1%, ‘**’-5%, ‘***’- 10%

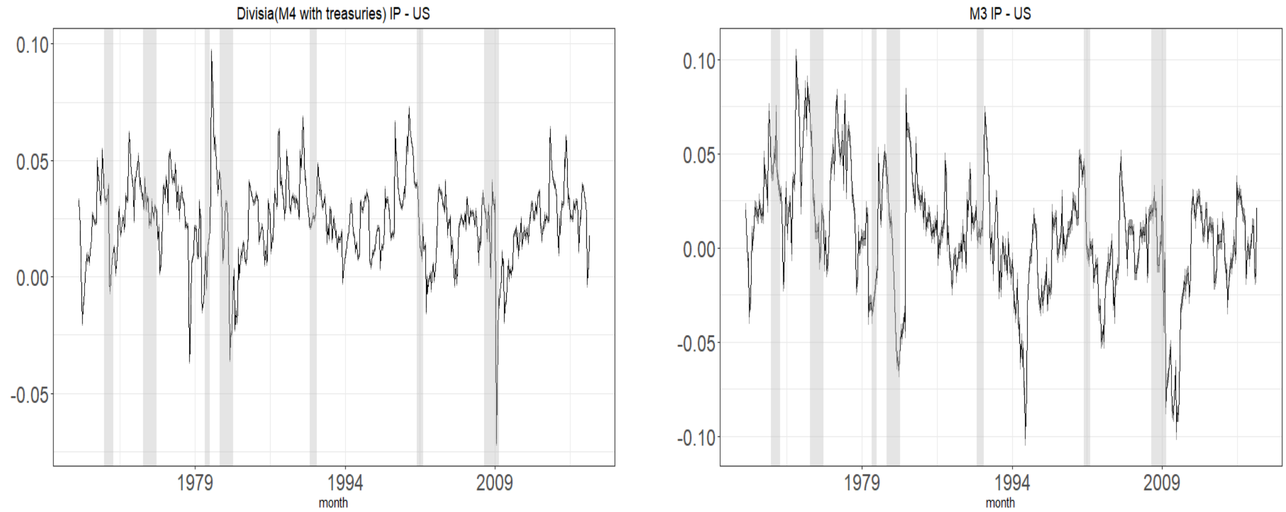
Table 5A- Li-Mak Test for Heteroscedasticity

Null Hypothesis: Series is homoscedastic

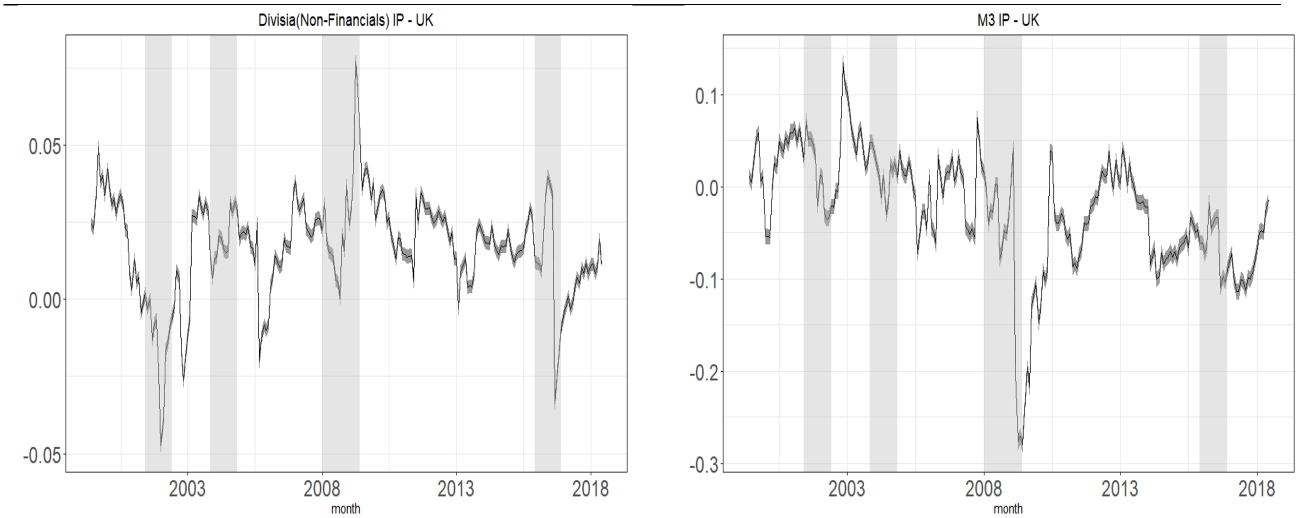
	US		UK		EURO		POLAND		INDIA	
	Divisia	**M3**	**Divisia**	**M3**	**Divisia**	**M3**	**Divisia**	**M3**	**Divisia**	**M3**
Money residual	0.99	0.99	0.99	0.27	0.22	0.51	0.99	0.43	0.99	0.91
IP residual	0.99	0.99	0.99	0.49	0.15	0.94	0.82	0.99	0.88	0.99
Cross-product residual	0.99	0.99	0.99	0.19	0.88	0.01*	0.99	0.99	0.99	0.99

Figure 1: Money Growth and Output Growth Correlations

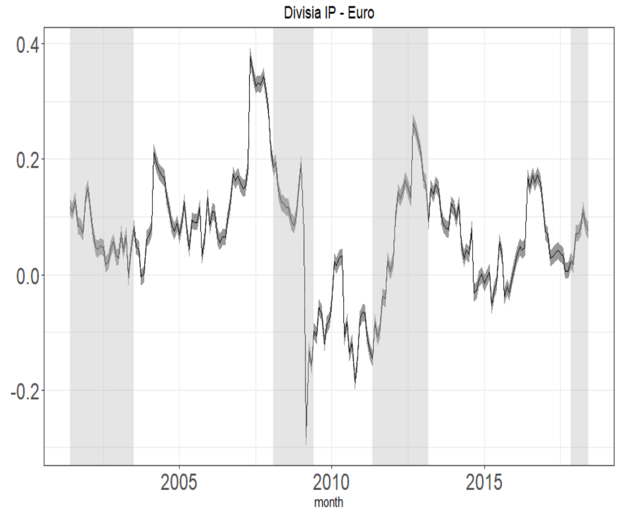
US

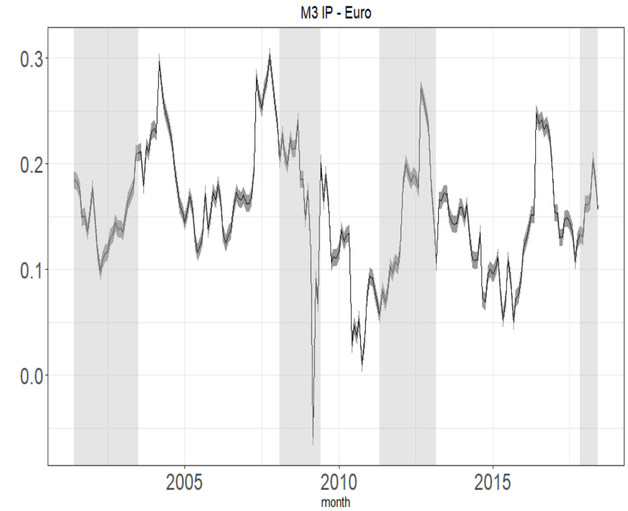


UK

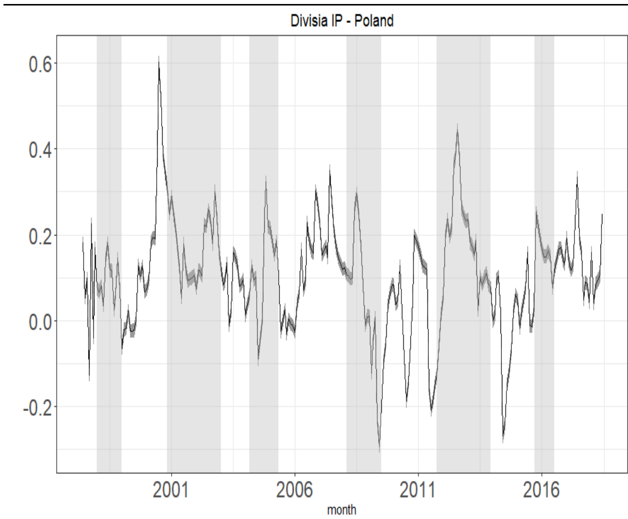


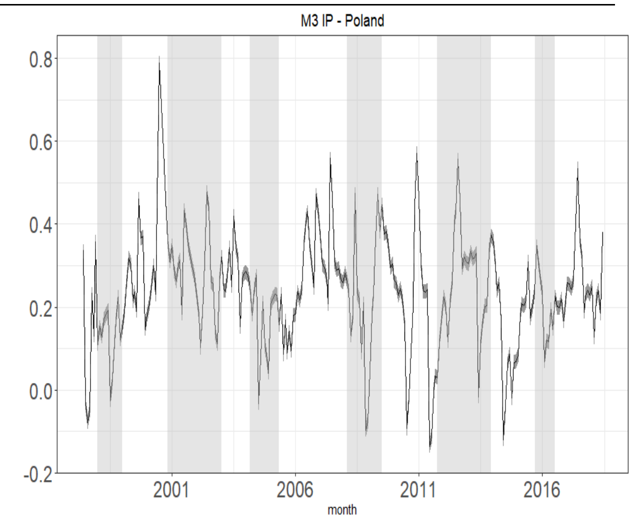
EURO





POLAND





INDIA