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Abstract

The study analyses the time varying correlation of money and output using DCC GARCH model for Euro, India, Poland, the UK and the USA. In addition to simple sum money, the model uses Divisia monetary aggregate, theoretically shown as the actual measure of money. The inclusion of Divisia money restores the Friedman and Schwartz hypothesis that money is procyclical. Such procyclical nature of association was not robustly observed in the recent data when simple sum money was used.

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

1. Introduction

A natural way to analyse the link between money and output is to examine the statistical correlation between them. The influential paper of Friedman and Schwartz (1963a) established the statistical link between money and business cycles more than 50 years ago. They found money to be procyclical using the historical US data. However, this close association was disregarded due to the unusual behavior of monetary aggregates post 1980s and its increased volatility (Friedman and Kuttner, 1992; Estrella and Mishkin, 1997). Moreover, the rampant financial innovations made the measure of money using simple sum unreliable.

After the great financial crisis (GFC), however, there was a resurgence of studies focusing on role of money, especially Divisia money. This is due to interest rate losing its credibility as the reliable monetary policy instrument when it could not be lowered further. The literature on aggregation-theoretic Divisia monetary aggregates argue that Divisia money puts weights on different components of money based on their relative liquidity capturing the liquidity in the economy accurately when new instruments are introduced (Belongia and Binner, 2001; Barnett, 1980).

Belongia and Ireland (2016), using the recent US data, have found procyclical correlations between money and output as Friedman and Schwartz (1963a). 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 as an informational variable by estimating a stable money demand equation using Divisia. He demonstrated that Divisia money Granger-cause output while simple sum does not.

Engle's (2002) dynamic conditional correlation (DCC) GARCH model is used to capture the time varying role of money. We find that[1] (1) Divisia money growth rates are mostly 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) Euro's

[1] Results are robust to use of different kinds of Divisia money, different kinds of simple sum money and different mix of countries.

delay in implementing such measures and the sovereign debt crisis reflected in Divisia money's persistent countercyclicality post GFC, and (5) the inclusion of Divisia money establishes that money still is a reliable business cycle indicator.

2. Data and Methodology

The monthly data for simple sum M3 and industrial production (used as a proxy for real output) is taken from OECD database. The Divisia data are obtained from respective central bank's website except India and Euro whose Divisia data are taken from Ramachandran et. al. (2010) and Darvas (2015), respectively.

Let $X_t = [M_t, IP_t]'$ where X_t is a 2 x 1 vector where IP_t denotes industrial production and M_t denotes money supply (simple sum or Divisia). Levels of all the variables are non-stationary while the annualized month-on-month log differences (growth rate) are stationary (appendix table 1A). Since GARCH models analyse volatility of a data with zero (constant) mean, such transformation to growth rates gives stationary heteroscedastic data for analysis.

The conditional mean equation of the model is:

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

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

$$H_t = D_t R_t D_t \qquad (2)$$

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

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

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

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1} \quad (4)$$

Where

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

Where $\bar{Q}$ is the variance-covariance matrix which is time invariant and Q_t^{*-1} is the diagonal matrix of square root of 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 Lagrange multiplier tests assumes the series to be homoscedastic. All the variables display heteroscedasticity, deeming them fit for a GARCH analysis.[2] DCC(1,1)-GARCH(1,1) model is estimated using the quasi maximum likelihood estimation (QMLE) technique. The key parameters, dcca1 and dccb1, denoted by the coefficients a_m and b_n in equation (5), are presented in table 3A in appendix for $m = 1, n = 1$.[3] We find significant b_n in all cases validating the use of DCC model. Also, $a_1 + b_1 > 0$ for all the countries with b_1 being closer to 1 implies a high persistence in the correlation. $a_1 + b_1$ closer to 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 individual error terms as well as the cross products of the residuals (Tse and Tsui, 2002)[4]. We find the absence of

[2] See Table 2A (appendix), null is rejected at 1% level of significance.

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

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

heteroscedasticity in all the cases except for the cross products of the residuals for simple sum money for Euro.

Left (right) panel of figure 1 captures the correlation of output with Divisia money growth (simple sum M3 growth) with 95% confidence intervals. Divisia money shows procyclicality in general and countercyclicality during recessions. The simple sum money growth, however, fails to capture the procyclical relation robustly. Correlations with simple sum have largely remained negative post GFC for the UK, and there were frequent countercyclical episodes for both the US starting 1990s and for India for the entire sample.

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

US Divisia, consistent with Belongia and Ireland (2016) remained procyclical, with exceptions of the GFC, the energy crisis of late 1970s and the early 1980s recessions. UK Divisia became countercyclical around 2002 when Euro was formed and around 2016 when England voted to exit out of Euro (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 correlations of Euro, although the GFC and the period ensuing that, did. For Poland and India, the Divisia money was mostly highly procyclical.

[5] With the exception of India whose Divisia data is available only till June, 2008.

[INSERT FIGURE 1 HERE]

4. Conclusion

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 largely remains procyclical. Most of the simple sum money results are obscured by money's frequent countercyclical behavior. Money's countercyclicality during recessions hints at shifting preference behavior of individuals for demand for liquid assets. The quantitative easing adopted by the US and the UK during GFC was deemed effective as it helped money become procyclical much faster compared to Euro which did not adopt the measure sooner.

References:

Barnett, W.A., 1980, "Economic Monetary Aggregate: An Application of Index Number and Aggregation Theory". *Journal of Econometrics*, September, 1980.

Belongia, M. and Binner, J., 2001, *Divisia Monetary Aggregates: Theory and Practice*, Palgrave Macmillan, UK.

Belongia, M.T. and Ireland, P.N., 2016, "Money and Output: Friedman and Schwartz Revisited", *Journal of Money, Credit and Banking,* Vol. 48, No. 6.

Darvas, Z., 2015, "Does Money Matter in the euro Area? Evidence from a New Divisia Index", *Economics Letters,* Elsevier, vol. 133(C), pages 123-126.

Engle, R., 2002, "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models", Journal of Business & Economic Statistics, Vol. 20, No. 3, DOI 10.1198/073500102288618487.

Estrella, A. and Mishkin, F. S., 1997, "Is there a role for monetary aggregates in the conduct of monetary policy?" Journal of Monetary Economics, Vol. 40, p. 279 304.

Friedman, B. M. and Kuttner, K. N., 1992, "Money, Income, Prices, and Interest Rates." American Economic Review, Vol. 82, No. 3, p. 472 - 492.

Friedman, M., and Schwartz., A. J., 1963a, "Money and Business Cycles.'' *Review of Economics and Statistics*, 45, 32–64.

Hendrickson, J. R., 2014, "Redundancy and 'Mismeasurement'? A Reappraisal of Money", *Macroeconomic Dynamics*, Volume 18, pp. 1437–65.

Li, W. K. and Mak, T. K., 1994. On the squared residual autocorrelations in nonlinear time series with conditional heteroskedasticity, Journal of Time Series Analysis, 15(6), 627 – 636.

Ramachandran, M., Das, R., and Bhoi, B., 2010, "The Divisia Monetary Indices as Leading Indicators of Inflation", RBI Development Research Group Study No. 36, Mumbai.

Tse, Y. K., and Tsui, A. K. C., 2002, "A Multivariate GARCH Model with Time-Varying Correlations", Journal of Business and Economic Statistics, 20, 351–362.

Appendix:

Table 1A- Augmented Dickey Fuller Tests

Null: Variable has a unit root

	US (1967 Feb - 2018 June)		**UK (1999 Feb - 2018 June)**		**Euro Area (2001 Feb - 2018 June)**	
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 (1997 Jan- 2018 June)		**India (1994 Apr - 2008 June)**			
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 2A- 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 3A- Conditional Mean and Conditional Variance Equations

		US				UK				EURO			
		Divisia(t)	**IP (t)**	**M3(t)**	**IP (t)**	**Divisia(t)**	**IP (t)**	**M3(t)**	**IP (t)**	**Divisia(t)**	**IP (t)**	**M3(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*	6.78*	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**	0.98*	-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	-0.82*	-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*	1.41*	102.71*
	α (1)	0.19*	0.31*	0.63*	0.31*	0.06***	0.48*	0.001	0.38*	0.03	0.32**	0.07	0.32**
	β(1)	0.84*	0.34**	0.16	0.33**	0.93*	0.16	0.94*	0.15	0.94*	0.00	0.86*	0.00
	dcca1	0.006		0.006		0.008		0.03		0.05		0.03	
	dccb1	0.84*		0.85*		0.82*		0.81*		0.84*		0.83*	
		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*					

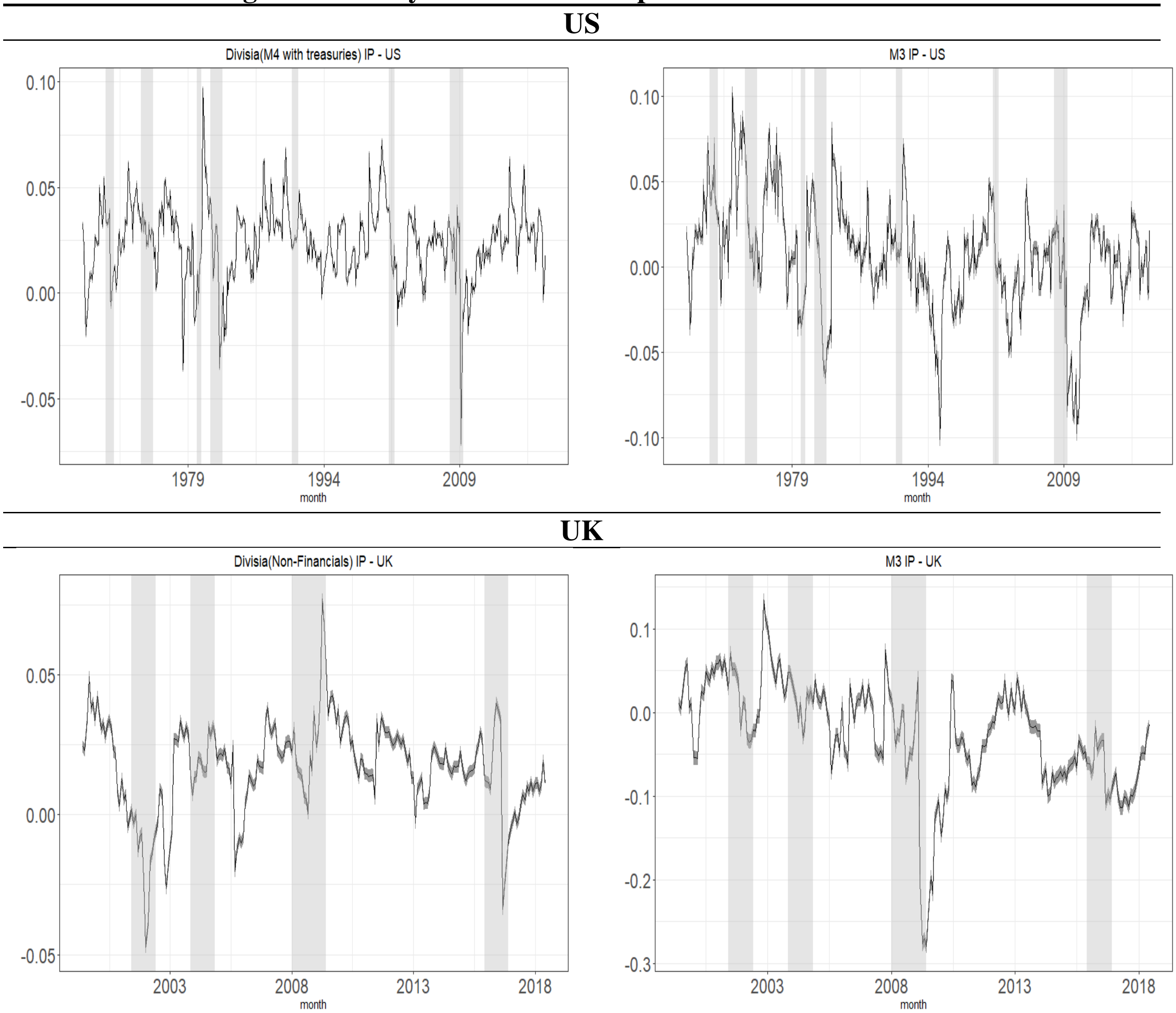
Level of Significance: ‘*’-1%, ‘**’-5%, ‘***’- 10%

Table 4A- Li-Mak Test for Heteroscedasticity

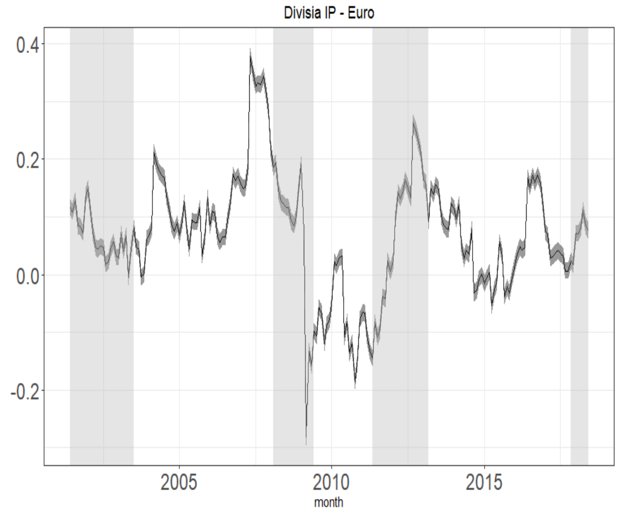
Null Hypothesis: Series is homoscedastic

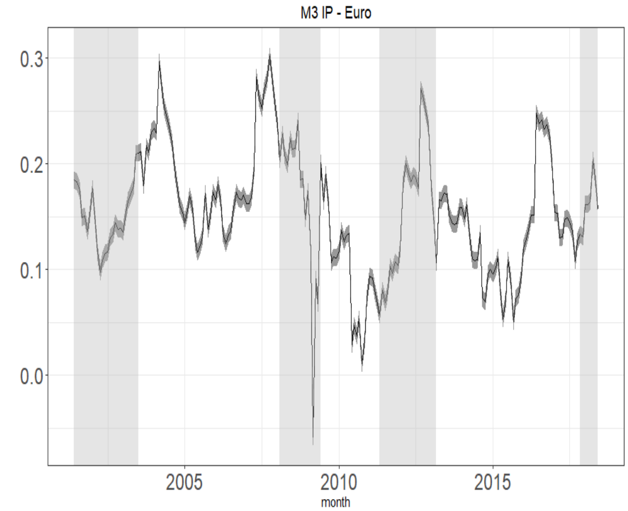
	US		UK		EURO		POLAND		INDIA	
	Divisia	**Simple Sum**	**Divisia**	**Simple Sum**	**Divisia**	**Simple Sum**	**Divisia**	**Simple Sum**	**Divisia**	**Simple Sum**
Money residual	0.99	0.99	0.99	0.27	0.22	0.51	0.99	0.43	0.99	0.91
IP residual	0.99	0.99	0.99	0.49	0.15	0.94	0.82	0.99	0.88	0.99
Cross-product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

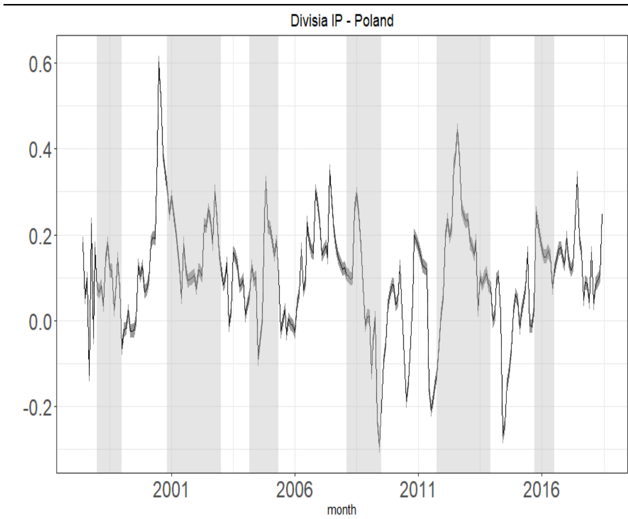


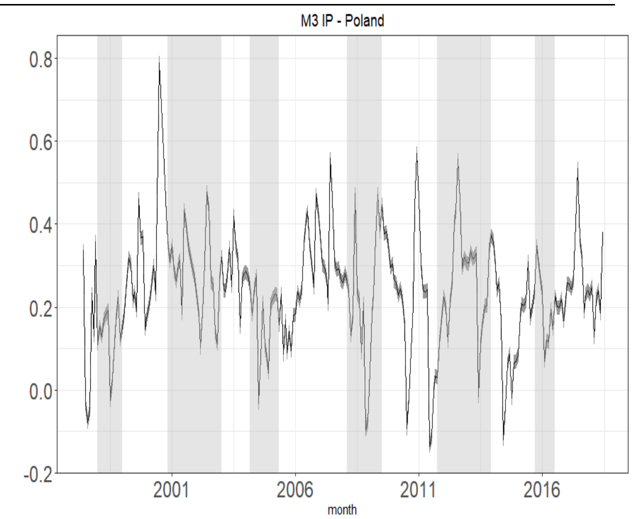
EURO





POLAND





INDIA