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MONEY SUPPLY VOLATILITY AND THE MACROECONOMY

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This paper extends the ongoing literature on the macroeconomic effects of money supply volatility. We use monthly data for the USA and a bivariate, Markov switching, structural vector error correction model that is modified to accommodate generalized autoregressive conditional heteroscedasticity-in-mean errors to isolate the effects of money growth volatility on output growth. The model allows us to study how monetary uncertainty affects economic growth across different macroeconomic regimes.

Keywords: CFS Divisia Monetary Aggregates, Markov Regime-Switching, Money Growth Volatility

1. INTRODUCTION

There is a number of recent empirical studies that use state-of-the-art advances in macroeconometrics and financial econometrics to investigate the relationship between money growth volatility and the level of economic activity. For example, Serletis and Shahmoradi (2006) investigate the relationship between the variability of money growth and velocity in the context of a vector autoregressive moving average (VARMA) generalized autoregressive conditional heteroscedasticity (GARCH)-in-mean model of money growth and velocity. They use quarterly data for the USA, over the period from 1959:1 to 2004:3, and simple-sum and an early vintage of the St. Louis Fed's Divisia monetary aggregates, called monetary services indices (MSI) and documented in Anderson et al. (1997a,b), at the M1 and M2 levels of monetary aggregation. They find evidence in support of Friedman (1983, 1984) hypothesis that the variability of money growth helps predict velocity and that the money variability–velocity relationship is robust to alternative methods of aggregating monetary assets.

In extending the work in Serletis and Shahmoradi (2006), Serletis and Rahman (2009) investigate the effects of money growth uncertainty on real economic

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activity in the USA, in the context of a multivariate framework in which a structural vector autoregression (VAR) is modified to accommodate GARCH-in-mean errors, as in Elder (2004) and Elder and Serletis (2010). They use quarterly data over the period from 1959:1 to 2005:4 and provide a comparison among simple-sum, Divisia, and currency equivalent monetary aggregation procedures, using a newer vintage of the MSI documented in Anderson and Buol (2005), at each of the four levels of monetary aggregation—M1, M2, M3, and MZM. They find evidence that money growth volatility has significant negative effects on output growth.

In another paper, Serletis and Rahman (2013) use a more general bivariate VARMA, GARCH-in-mean, asymmetric Baba, Engle, Kraft, and Kroner model to investigate the relationship between money growth volatility and output growth in the USA. They use monthly data from January 1967 to March 2011 for simple-sum monetary aggregates and the latest (and last) vintage of the MSI, documented in Anderson and Jones (2011), at five levels of aggregation—M1, M2, M2M, MZM, and ALL. They show that increased Divisia money growth volatility, irrespective of the level of aggregation, is associated with a lower average growth rate of real economic activity, but find no effects of simple-sum money growth volatility on real economic activity, except with the Sum M1 and perhaps Sum M2M aggregates. They conclude that monetary policies that focus on the Divisia monetary aggregates and target their growth rates will contribute to higher overall economic growth.

More recently, Serletis and Rahman (2015) provide an update regarding the effects of money growth variability on real economic activity in the USA using the new Center for Financial Stability (CFS) Divisia monetary aggregates. The CFS Divisia monetary aggregates are maintained within the CFS program Advances in Monetary and Financial Measurement (AMFM), are documented in detail in Barnett et al. (2013), and are available at www.centerforfinancialstability.org/amfm.php. Serletis and Rahman (2015) use monthly data from January 1967 to January 2014, and completely ignore the simple-sum monetary aggregates. They make comparisons among eight CFS Divisia monetary aggregates: the narrower monetary aggregates, M1, M2M, MZM, M2, and ALL, and the broad monetary aggregates, M4+, M4−, and M3. They also use the same methodology as in Serletis and Rahman (2013) and present evidence that increased uncertainty about the growth rate of the CFS Divisia M1, M2M, and M4+ monetary aggregates is associated with a lower average growth rate of real economic activity, in general consistent with earlier results based on the St. Louis Fed's MSI. They also argue that optimal monetary aggregation, as suggested over 30 years ago by Barnett (1982), will further improve our understanding of how money affects the economy.

In this paper, in the spirit of Barnett and Chauvet (2016), we build on this literature. We use monthly data for the USA, over the period from January 1967 to October 2016, and (for the first time in this literature) a bivariate, Markov switching, structural vector error correction (VEC) model that is modified to accommodate GARCH-in-mean errors. The purpose of the structural VEC model with GARCH-in-mean errors is to focus on the short-run dynamics between money growth and real output growth while making them consistent with the long-run equilibrium relationship between money and output. It uses a recursive identification scheme, takes into account the possible interaction between conditional means and variances, isolates the effects of money growth volatility on output growth, and allows us to study how monetary uncertainty affects economic growth across different macroeconomic regimes.

The paper distinguishes itself from previous literature by allowing a nonlinear relationship between money growth and real economic activity using the Markov switching model. The Markov switching model, associated with Hamilton (1989), has been widely used in the analysis of economic and financial time series—see, for example, Sims and Zha (2006). The model is very similar with the threshold time series models, except that in the threshold time series models switching is deterministic [see, e.g., Caggiano et al. (2014)], whereas in the Markov switching model switching is stochastic. Another feature of our paper is that it uses the CFS Divisia M4 monetary aggregate, as it has recently been suggested by Jadidzadeh and Serletis (2018), in their study of optimal monetary aggregation in the USA, and Dery and Serletis (2018), in their investigation of the relative information content of narrow and broad Divisia measures of money in explaining key macroeconomic variations. In this regard, Jadidzadeh and Serletis (2018) estimate a disaggregated demand system, encompassing the full range of monetary assets in the USA. They reject the necessary and sufficient conditions for all the money measures published by the Federal Reserve, and conclude that "we have nothing to lose by using the highest level aggregate among those that are in the admissible hierarchy," as Barnett (2015, p. 32) puts it. The CFS Divisia M4 monetary aggregate is the broadest and most theoretically consistent measure of money in the USA today, and this is the monetary aggregate that we use in this paper.

The outline of the paper is as follows: In Section 2 we discuss the data and present the regime-switching structural VEC GARCH-in-mean model. In Section 2 we present and discuss the empirical results. The final section concludes the paper.

2. DATA AND METHODOLOGY

We use monthly data for the USA over the period from January 1967 to October 2016. For the real output series, Y_t, we use the industrial production index (IPI) from the Federal Reserve Economic Database (FRED) maintained by the Federal Reserve Bank of St. Louis. For the money measure, M_t, we use the Divisia M4 monetary aggregate from the Center for Financial Stability (CFS)—see Barnett et al. (2013) for details regarding the construction of the CFS Divisia monetary aggregates. Figures 1 and 2 plot the natural logs of Divisia M4 and IPI, and their growth rates, respectively.

We conduct a series of unit root and stationarity tests in the logarithms of Y_t and M_t, denoted by y_t and m_t, respectively. We find that y_t and m_t are nonstationary. We also test for cointegration using the Johansen (1988) maximum likelihood cointegration approach and find that y_t and m_t are cointegrated with two cointegrating vectors. Based on this evidence, we adopt the VEC model as the basic framework. In particular, our empirical model is a Markov switching structural VEC with GARCH-in-mean. This model allows us to study how monetary uncertainty affects economic growth across different macroeconomic states.

The mean equation of the model is

$$\mathbf{B}_{s_t}\Delta\mathbf{z}_t = \mathbf{C}_{s_t} + \mathbf{\Pi}_{s_t}\mathbf{z}_{t-1} + \sum_{i=1}^{k}\mathbf{\Gamma}_{i,s_t}\Delta\mathbf{z}_{t-i} + \mathbf{\Psi}_{s_t}\sqrt{\mathbf{h}_{t,s_t}} + \boldsymbol{\epsilon}_t$$

with

$$\boldsymbol{\epsilon}_t\,|\Omega_{t-1} \sim (0, \mathbf{H}_{t,s_t}),\ \mathbf{H}_{t,s_t} = \begin{bmatrix} h_{\Delta m,t,s_t} & 0 \\ 0 & h_{\Delta y,s_t} \end{bmatrix},$$

where Ω_{t-1} is the information set available in period $t-1$, $\Delta\mathbf{z}_t$ the first difference of $\mathbf{z}_t$, and

$$\mathbf{z}_t = \begin{bmatrix} m_t \\ y_t \end{bmatrix}; \qquad \boldsymbol{\epsilon}_t = \begin{bmatrix} \epsilon_{\Delta m,t} \\ \epsilon_{\Delta y,t} \end{bmatrix}; \qquad \mathbf{h}_t = \begin{bmatrix} h_{\Delta m,t,s_t} \\ h_{\Delta y,s_t} \end{bmatrix}; \qquad \mathbf{B}_{s_t} = \begin{bmatrix} 1 & 0 \\ b_{s_t} & 1 \end{bmatrix},$$

$$\mathbf{\Pi}_{s_t} = \begin{bmatrix} \pi_{s_t,11} & \pi_{s_t,12} \\ \pi_{s_t,21} & \pi_{s_t,22} \end{bmatrix}; \qquad \mathbf{\Gamma}_{i,s_t} = \begin{bmatrix} \gamma_{i,s_t,11} & \gamma_{i,s_t,12} \\ \gamma_{i,s_t,21} & \gamma_{i,s_t,22} \end{bmatrix}; \qquad \mathbf{\Psi}_{\mathbf{s_t}} = \begin{bmatrix} 0 & 0 \\ \psi_{s_t} & 0 \end{bmatrix}.$$

Above, s_t denotes the unobserved economic regime and is assumed to follow a first-order, homogeneous, two-state Markov chain governed by the transition matrix

$$\mathbf{P} = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix},$$

where $p_{ij} = P\,(s_t = i\,|s_{t-1} = j)$, $i, j = 1, 2$ and $p_{11} = 1 - p_{21}$ and $p_{12} = 1 - p_{22}$. All the parameters in the $\mathbf{B}_{s_t}$, $\mathbf{C}_{s_t}$, $\mathbf{\Gamma}_{s_t}$, and $\mathbf{\Pi}_{s_t}$ matrices are regime dependent, taking different values across the two regimes (i and j can only take two values). The two assumed regimes will sufficiently describe the dynamic interactions between money and output growth; as suggested by Hamilton (1988, 1989) the two-regime model is sufficient for modeling recessions and expansions observed in many macroeconomic time series.

We use a GARCH(1, 1) specification to model the conditional variance of money growth, $h_{\Delta m,t,s_t}$, as follows:

$$h_{\Delta m,t,s_t} = d_{1,s_t} + d_{2,s_t}\bar{\epsilon}_{\Delta m,t-1} + d_{3,s_t}\bar{h}_{\Delta m,t-1},$$

where $\bar{\epsilon}_{\Delta m,t-1}$ and $\bar{h}_{\Delta m,t-1}$ denote the regime-independent shock and variance, respectively, as in Gray (1996) who solved the path-dependence problem in the estimation of Markov switching GARCH models. Finally, because of computational difficulties, in order to obtain a simplified version of the model we assume that the variance of output growth is constant within each regime, but different across regimes, thus allowing homoscedasticity within each regime, but heteroscedasticity across regimes.

We identify the model by assuming that the matrix of contemporaneous coefficients, $\mathbf{B}_{s_t}$, is lower triangular. The purpose of our Markov switching, identified structural VEC model with GARCH-in-mean effects is to focus on the short-run dynamics between real output and the money supply while making them consistent with the long-run equilibrium relationship between them across different macroeconomic regimes. The coefficients of the $\mathbf{\Pi}_{s_t}$ matrix are interpreted as speed of adjustment parameters; they capture how real output growth and money growth respond to deviations from the long-run equilibrium across different stages of the business cycle. Following Balcilar et al. (2015), we can decompose $\mathbf{\Pi}_{s_t}$ in three different ways, as $\mathbf{\Pi}_{s_t} = \boldsymbol{\alpha}_{s_t}\boldsymbol{\beta}^{'}$, $\mathbf{\Pi}_{s_t} = \boldsymbol{\alpha}\boldsymbol{\beta}^{'}_{s_t}$, or $\mathbf{\Pi}_{s_t} = \boldsymbol{\alpha}_{s_t}\boldsymbol{\beta}^{'}_{s_t}$, where $\boldsymbol{\alpha}$ is the weight matrix and $\boldsymbol{\beta}$ denotes the cointegrating vectors. The first decomposition assumes that the responses of money growth and output growth to deviations from the long-run equilibrium relationship between the money supply and real output are regime dependent, the second that the long-run equilibrium relationship between money and output is regime dependent, and the third that the responses of money and output growth to deviations from the long-run equilibrium between money and output and the long-run equilibrium relationship are both regime dependent. In this paper, we assume $\mathbf{\Pi}_{s_t} = \boldsymbol{\alpha}_{s_t}\boldsymbol{\beta}^{'}$ (i.e., the responses of money and output growth to deviations from the long-run equilibrium relationship between the money supply and real output are regime dependent).

Our research question is answered by testing whether money growth volatility affects real output growth. This is a test of restrictions on ψ_{s_t}, the element of the $\mathbf{\Psi}_{s_t}$ matrix that relates the conditional standard deviation of money growth, given by the appropriate element of $\sqrt{h_{t,s_t}}$, to the conditional mean of Δy_t. If the volatility of money growth has negatively affected output growth, then we would expect to find a negative and statistically significant $\hat{\psi}_{s_t}$.

3. ESTIMATION RESULTS

We multiply the growth rates of the two series by 1000 and estimate the model with three lags based on the Bayesian information criteria. The estimation results are reported in Table 1. As can be seen, the structural parameter, b_{s_t}, is not statistically significant across different stages of the cycle, $\hat{b}_{s_t=1} = 0.110$ with a p-value of 0.294 and $\hat{b}_{s_t=2} = 0.020$ with a p-value of 0.704. According to the estimates of the $\boldsymbol{\alpha}_{s_t}$ matrix, we find that money growth and real output growth respond to deviations from the long-run equilibrium relationship between money and real output differently across regimes. In particular, a shock that leads to a deviation of the money supply from its long-run equilibrium relationship with real output leads to a decline in the real output growth rate in regime 1 ($\hat{\alpha}_{s_t=1,21} = -1.019$ with a p-value of 0.000), but to a positive response with statistical significance in regime 2 ($\hat{\alpha}_{s_t=2,21} = 0.380$ with a p-value of 0.000).

TABLE 1. Parameter estimates of the Markov switching structural GARCH in mean VEC model

(A) Conditional mean equation

$$\boldsymbol{B}_{s_t=1}=\begin{bmatrix} 1 & 0 \\ 0.110\ (0.294) & 1 \end{bmatrix};\ \boldsymbol{C}_{s_t=1}=\begin{bmatrix} 2.862\ (0.046) \\ 37.348\ (0.000) \end{bmatrix};\ \boldsymbol{\alpha}_{s_t=1}=\begin{bmatrix} 0.162\ (0.015) & -0.182\ (0.002) \\ -1.019\ (0.000) & -0.827\ (0.003) \end{bmatrix};\ \boldsymbol{\Psi}_{s_t=1}=\begin{bmatrix} 0 & 0 \\ -0.716\ (0.020) & 0 \end{bmatrix};$$

$$\boldsymbol{B}_{s_t=2}=\begin{bmatrix} 1 & 0 \\ 0.020\ (0.704) & 1 \end{bmatrix};\ \boldsymbol{C}_{s_t=2}=\begin{bmatrix} -5.125\ (0.000) \\ 17.196\ (0.000) \end{bmatrix};\ \boldsymbol{\alpha}_{s_t=2}=\begin{bmatrix} 1.446\ (0.000) & -0.849\ (0.000) \\ 0.380\ (0.000) & -1.069\ (0.000) \end{bmatrix};\ \boldsymbol{\Psi}_{s_t=2}=\begin{bmatrix} 0 & 0 \\ 0.140\ (0.432) & 0 \end{bmatrix};$$

$$\boldsymbol{\Gamma}_{1,s_t=1}=\begin{bmatrix} 0.444\ (0.000) & 0.070\ (0.000) \\ 0.515\ (0.000) & -0.182\ (0.002) \end{bmatrix};\ \boldsymbol{\Gamma}_{2,s_t=1}=\begin{bmatrix} 0.101\ (0.132) & -0.021\ (0.302) \\ -0.120\ (0.331) & 0.095\ (0.082) \end{bmatrix};\ \boldsymbol{\Gamma}_{3,s_t=1}=\begin{bmatrix} -0.017\ (0.776) & -0.026\ (0.201) \\ 0.112\ (0.314) & 0.149\ (0.005) \end{bmatrix};$$

$$\boldsymbol{\Gamma}_{1,s_t=2}=\begin{bmatrix} 0.113\ (0.024) & -0.193\ (0.000) \\ -0.104\ (0.054) & -0.016\ (0.763) \end{bmatrix};\ \boldsymbol{\Gamma}_{2,s_t=2}=\begin{bmatrix} -0.028\ (0.571) & -0.157\ (0.000) \\ -0.019\ (0.709) & 0.084\ (0.108) \end{bmatrix};\ \boldsymbol{\Gamma}_{3,s_t=2}=\begin{bmatrix} 0.145\ (0.001) & -0.191\ (0.000) \\ -0.104\ (0.051) & 0.112\ (0.042) \end{bmatrix};$$

(B) Conditional variance equation

$d_{1,s_t=1}=0.162\ (0.501)$ $d_{2,s_t=1}=0.228\ (0.000)$ $d_{3,s_t=1}=0.721\ (0.000)$ $h_{\Delta y,s_t=1}=61.420\ (0.000)$

$d_{1,s_t=2}=0.504\ (0.088)$ $d_{2,s_t=2}=0.000\ (0.999)$ $d_{3,s_t=2}=0.932\ (0.000)$ $h_{\Delta y,s_t=2}=16.448\ (0.000)$

(C) Transition matrix

$$\boldsymbol{P}=\begin{bmatrix} 0.979\ (0.000) & 0.025\ (0.002) \\ 0.021\ (0.009) & 0.975\ (0.000) \end{bmatrix}$$

Note: Numbers in parentheses are p-values.

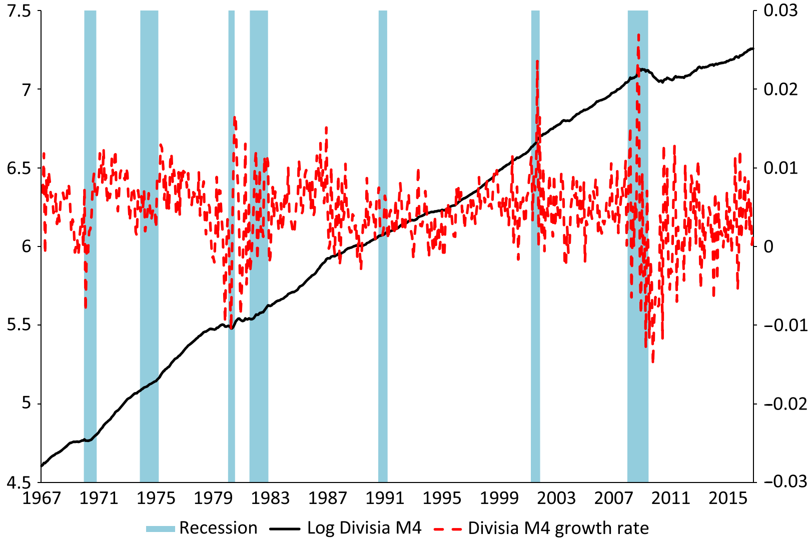

FIGURE 1. Log Divisia M4 and its growth rate.

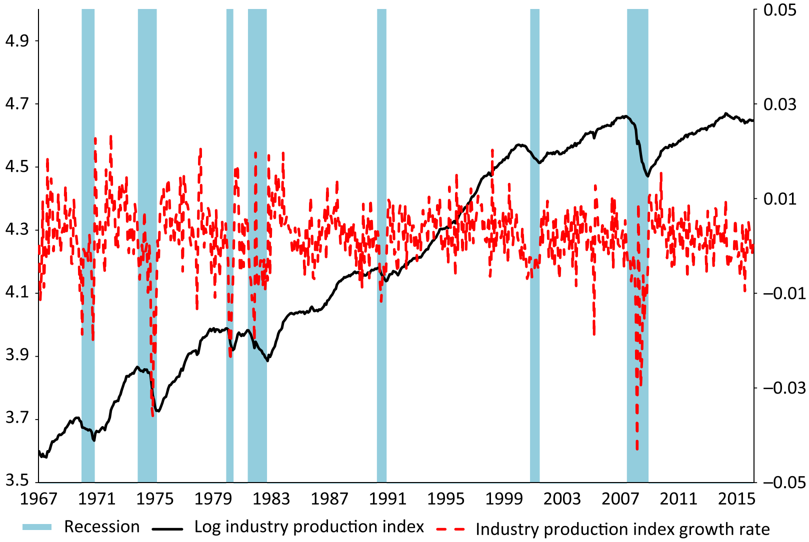

FIGURE 2. Log IPI and its growth rate.

According to the parameter estimates of the variance equation for money growth, we find that money growth volatility reacts more intensely to money growth movements in regime 1 ($\hat{d}_{2,s_t=1} = 0.228$ with a p-value of 0.000) than in regime 2 ($\hat{d}_{2,s_t=2} = 0.000$ with a p-value of 0.999). However, money growth volatility is more persistent in regime 2 ($\hat{d}_{3,s_t=2} = 0.932$ with a p-value of 0.000)

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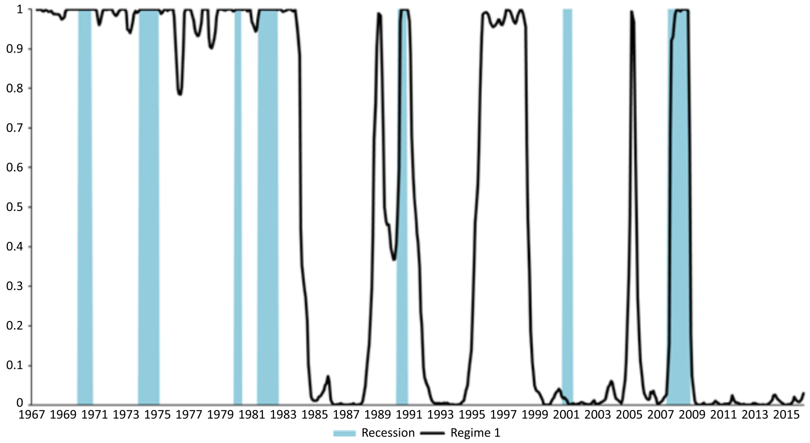

FIGURE 3. Smoothed probabilities of regime 1.

than in regime 1 ($\hat{d}_{3,s_t=1} = 0.721$ with a p-value of 0.000). Overall, money growth volatility is more spiky in regime 1, since $\hat{d}_2$ is relatively high and $\hat{d}_3$ is relatively low in regime 1. We also find that output growth is more volatile in regime 1 ($h_{\Delta y,s_t=1} = 61.420$ with a p-value of 0.000) relative to regime 2 ($h_{\Delta y,s_t=2} = 16.448$ with a p-value of 0.000).

According to the ψ_{s_t} estimates across the two regimes, we find that the volatility of money growth has a negative and statistically significant effect on output growth in regime 1 ($\hat{\psi}_{s_t=1} = -0.716$ with a p-value of 0.020), but this effect is insignificant in regime 2 ($\hat{\psi}_{s_t=2} = 0.140$ with a p-value of 0.432). This is evidence of a nonlinear relation between money growth volatility and output growth. To better understand the macroeconomic regimes, we plot the smoothed probabilities of regime 1, $p(s_t = 1|\Omega)$, where Ω is the full sample information, in Figure 3. As can be seen, regime 1 is generally consistent with contractions in the business cycle and exactly captures the recent global financial crisis. Thus, we conclude that money growth volatility exerts asymmetric effects on output growth over expansions and contractions in economic activity.

To get an idea of the economic significance of the effect of money growth volatility on real output growth, we calculate that effect based on a money growth shock equal to the unconditional standard deviation of the change in the money growth rate. We find that money growth volatility reduces current real output growth by 0.003. That is, money growth volatility reduces the real output growth rate by 0.3% at a monthly frequency if the economy is in regime 1 and everything else is held constant. We also report the estimated money growth volatility in Figure 4, with the shaded bars indicating the economic regimes calculated with a 95% confidence level. We find that the estimated money growth volatility is generally high in regime 1. The volatility peak around 1970 is attributed to the fact that monetary policy was procyclical during that period, with the Federal

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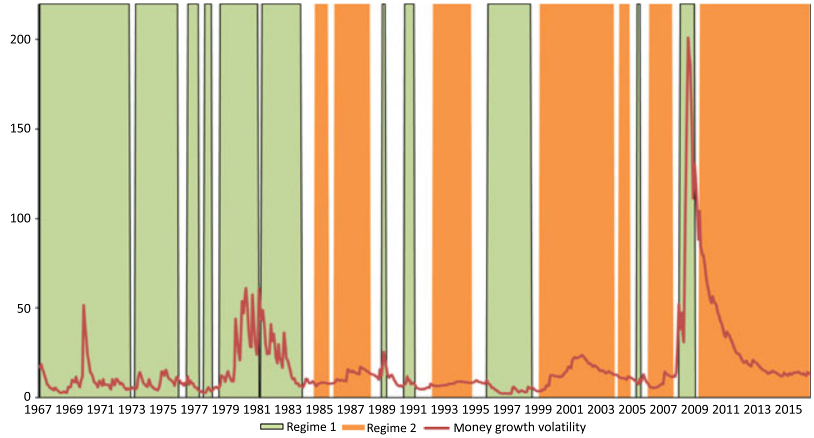

FIGURE 4. Estimated money growth volatility.

Reserve using the federal funds rate as its operating instrument and monetary aggregates as intermediate targets. The next peak from 1979 to 1985 corresponds to the period when the Fed de-emphasized the federal funds rate as an operating instrument and used nonborrowed reserves as the primary operating instrument. Finally, the most recent increase in money growth volatility corresponds to the global financial crisis when the federal funds rate reached the zero lower bound and the Fed resorted to unconventional monetary policy.

4. CONCLUSION

In the context of a bivariate, Markov switching, identified structural VEC model with GARCH-in-mean errors, we investigate the effects of money growth volatility on real output growth in the USA, using monthly data over the period from 1967 to 2016, and the new CFS Divisia monetary data documented in Barnett et al. (2013). We find that money growth volatility exerts asymmetric effects on output over expansions and contractions in the business cycle. In particular, we present evidence that increased uncertainty about the growth rate of the CFS Divisia M4 monetary aggregate is associated with a lower average growth rate of real output over contractions in the business cycle, but has no statistically significant effect on the real output growth rate over expansions in the business cycle.

The idea that real economic activity reacts asymmetrically to money is not new. Florio (2004) surveys a number of empirical studies on the asymmetric effects of monetary policy and also reviews its possible theoretical explanations. As Florio (2004, p. 409) puts it, “it is widely recognized that monetary policy has real effects on the economy over short horizons. The idea that these real effects are asymmetric is, by contrast, less well established in the literature. In particular, the reduction in output following a negative monetary policy shock appears larger than the expansion induced by a positive shock of similar size." In this regard, Cover (1992) found that positive money supply shocks do not have an effect on output while negative money supply shocks do have an effect on output. Cover's (1992) finding was further confirmed by a number of other authors, including DeLong and Summers (1988) and Thoma (1994), among others. However, this evidence of asymmetric effects of positive and negative money supply shocks also generated considerable controversy—see, for example, Weise (1999).

The contribution of our paper is the use of recent state-of-the-art advance in macroeconometrics and financial econometrics to show that money growth volatility exerts asymmetric effects on output growth over expansions and contractions in economic activity. Our results are consistent with recent empirical evidence that shows that money growth uncertainty has a negative and statistically significant effect on output growth—see Serletis and Shahmoradi (2006) and Serletis and Rahman (2009, 2013, 2015). More importantly, our evidence in this paper shows that real output growth reacts asymmetrically to money growth volatility over different stages of the business cycle. This is in line with the recent evidence by Santono et al. (2014) who embed prospect theory into a dynamic general equilibrium model and show that the optimal Ramsey policy is state dependent.

Finally, our evidence suggests that the CFS Divisia M4 monetary aggregate could potentially be relevant either as an intermediate target with nominal GDP being the final target of monetary policy, as suggested by Belongia and Ireland (2014), or as an indicator in the real-time nowcasting of nominal GDP as required in implementation of any nominal GDP targeting policy, as suggested by Barnett et al. (2016).

REFERENCES

Anderson, R. G. and J. Buol (2005) Revisions to user costs for the Federal Reserve Bank of St. Louis Monetary Services Indices. *Review* 87, 735–749.

Anderson, R. G. and B. E. Jones (2011) A comprehensive revision of the U.S. Monetary Services (Divisia) Indexes. *Review* 93, 325–359.

Anderson, R. G., B. E. Jones and T. D. Nesmith (1997a) Monetary aggregation theory and statistical index numbers. *Review* 79, 31–51.

Anderson, R. G., B. E. Jones and T. D. Nesmith (1997b) Building new monetary services indexes: Concepts, data and methods. *Review* 79, 53–82.

Balcilar, M., R. Gupta and S. M. Miller (2015) Regime switching model of US crude oil and stock market prices: 1859 to 2013. *Energy Economics* 49, 317–327.

Barnett, W. A. (1982) The optimal level of monetary aggregation. *Journal of Money, Credit, and Banking* 14, 687–710.

Barnett, W. A. (2015) Friedman and Divisia monetary measures. In: R. Cord and D. Hammond (eds.), *Milton Friedman: Contributions to Economics and Public Policy*. Oxford: Oxford University Press.

Barnett, W. A. and M. Chauvet (2016) How better monetary statistics could have signaled the financial crisis. *Journal of Econometrics* 161, 6–23.

Barnett, W. A., M. Chauvet and D. Leiva-Leon (2016) Real-time nowcasting of nominal GDP with structural breaks. *Journal of Econometrics* 191, 312–324.

Barnett, W. A., J. Liu, R. S. Mattson and J. van den Noort (2013) The new CFS Divisia monetary aggregates: Design, construction, and data sources. *Open Economies Review* 24, 101–124.

Belongia, M. T. and P. N. Ireland (2014) The Barnett critique after three decades: A new Keynesian analysis. *Journal of Econometrics* 183, 5–21.

Caggiano, G., E. Castelnuovo and N. Groshenny (2014) Uncertainty shocks and unemployment dynamics in U.S. recessions. *Journal of Monetary Economics* 67, 78–92.

Cover, J. P. (1992) Asymmetric effects of positive and negative money-supply shocks. *Quarterly Journal of Economics* 107, 1261–1282.

DeLong, J. B. and L. H. Summers (1988) How does macroeconomic policy affect output? *Brookings Papers on Economic Activity* 2, 433–494.

Dery, C. and A. Serletis (2018) Interest Rates, Money, and Economic Activity. Mimeo, Department of Economics, University of Calgary.

Elder, J. (2004) Another perspective on the effects of inflation uncertainty. *Journal of Money, Credit, and Banking* 36, 911–28.

Elder, J. and A. Serletis (2010) Oil price uncertainty. *Journal of Money, Credit, and Banking* 42, 1137–1159.

Florio, A. (2004) The asymmetric effects of monetary policy. *Journal of Economic Surveys* 18, 409–426.

Friedman, M. (1983) Monetary variability: The United States and Japan. *Journal of Money, Credit and Banking* 15, 339–343.

Friedman, M. (1984) Lessons from the 1979–1982 monetary policy experiment. *American Economic Review Papers and Proceedings* 74, 397–400.

Gray, S. F. (1996) Modeling the conditional distribution of interest rates as a regime-switching process. *Journal of Financial Economics* 42, 27–62.

Hamilton, J. D. (1988) Neoclassical model of unemployment and the business cycle. *Journal of Political Economics* 96, 593–617.

Hamilton, J. D. (1989) A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica* 57, 357–384.

Jadidzadeh, A. and A. Serletis (2018) The demand for assets and optimal monetary aggregation. *Journal of Money, Credit and Banking*.

Johansen, S. (1988) Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control* 12, 231–254.

Santono, E., I. Petrella, D. Pfajfar and E. Gaffeo (2014) Loss aversion and the asymmetric transmission of monetary policy. *Journal of Monetary Economics* 68, 19–36.

Serletis, A. and S. Rahman (2009) The output effects of money growth uncertainty: Evidence from a multivariate GARCH-in-mean VAR. *Open Economies Review* 20, 607–630.

Serletis, A. and S. Rahman (2013) The case for Divisia money targeting. *Macroeconomic Dynamics* 17, 1638–1658.

Serletis, A. and S. Rahman (2015) On the output effects of monetary variability. *Open Economies Review* 26, 225–236.

Serletis, A. and A. Shahmoradi (2006) Velocity and the variability of money growth: Evidence from a VARMA, GARCH-M model. *Macroeconomic Dynamics* 10, 652–666.

Sims, C. A. and T. Zha (2006) Were there regime switches in US monetary policy? *American Economic Review* 96, 54–81.

Thoma, M. A. (1994) Subsample instability and asymmetries in money-income causality. *Journal of Econometrics* 64, 279–306.

Weise, C. L. (1999) The asymmetric effects of monetary policy: A nonlinear vector autoregression approach. *Journal of Money, Credit and Banking* 31, 85–108.