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# The Role of Financial Depth on The Asymmetric Impact of Monetary Policy

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**Abstract**

This paper investigates the role of financial markets in evaluating the asymmetric impact of monetary policy on real output over the business cycle for the US. We show that monetary policy has a significant impact on output growth during recessions. We also show that financial deepening plays an important role by dampening the effects of monetary policy shocks in recessions. The results are robust to the use of alternative financial depth and monetary policy shock measures and a different sample period. We carry out our analysis by implementing an instrumental variable Markov regime switching methodology.

**Keywords:** Output growth; asymmetric effects; monetary policy; financial depth; Markov switching; instrumental variable.
**JEL classification:** E32, E52

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# 1 Introduction

A vast empirical literature examines the effects of monetary policy and the role of financial markets on the real economy. Several researchers suggest that monetary policy has an ambiguous or no significant impact on real output, yet many others provide evidence that the impact of monetary policy on the real economy varies over the business cycle. Researchers also argue that credit market imperfections act as a propagator of shocks and play a significant role in magnifying output fluctuations. In particular, the literature on financial markets suggests that an economy with deeper financial markets promote investment efficiency and productivity growth as innovative firms continue to raise funds from potential lenders even during economic downturns. Yet, to our knowledge, earlier studies have not evaluated the asymmetric impact of monetary policy on real output in conjunction with the role of financial market depth.

In this paper, different from the literature, we specifically examine whether the extent of financial depth extenuates or amplifies the impact of monetary policy on output growth as the economy goes through the business cycle. We achieve this goal by examining how the interaction between monetary policy shocks and financial depth evolves over different states. To carry out our examination, we implement an instrumental variable Markov regime switching framework as suggested by Spagnolo et al. (2005). This framework allows the output growth rate to depend on a latent state variable, which characterizes expansions or recessions, permitting the researchers to investigate the asymmetries in the data. Furthermore, the instrumental variable approach helps us to overcome endogeneity problems that may exist in our model.

Our investigation utilizes two separate financial depth measures. Our first measure is the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks). The second proxy is defined as the ratio of credits by financial intermediaries to the private sector with respect to GDP.[1] To gauge the effects of monetary policy shocks on real output we use three proxies which have been extensively used in the literature. Our first proxy is a conventional measure of monetary policy shocks as captured by the actual changes of the Federal funds rate. However, Romer and Romer (2004) show that the actual changes of Federal fund rates underestimate the impact of monetary policy on output growth because this measure may be contaminated by the endogenous movements of the interest rate and expected actions of the Federal Reserve. To address these difficulties Romer and Romer (2004) derived a new indicator of monetary policy shock by regressing the intended fund rate changes on Fed's internal forecast of inflation and of real economic activity. Rather than directly implementing the model that Romer and Romer (2004) used to generate monetary policy shocks, we modify it such that the model's parameters are time-variant in one case and time-varying with regime switching in the other. This is essential because there is substantial evidence that monetary policy has become more forward-looking and failing to account for structural breaks in the data will lead to biased information regarding the impact of monetary policy shocks on other variables.[2]

The results can be summarized as follows. We first show that monetary policy has a regime dependent impact on output growth. In particular, we show that monetary policy exert a negative and significant impact on output growth during recessions, yet this effect is not significant during expansions. Our analysis also provides evidence that financial depth significantly mitigates the impact of monetary policy in recessions. More concretely, we find that in recessions the total impact of monetary policy on output growth becomes much milder and even diminishes with the deepening of the financial markets. This makes sense because firms mostly suffer from financial frictions during periods of recessions and deeper financial markets could help firms to raise funds even in hard times. The analysis is carried

[1] This measure includes only credits issued by banks and other financial intermediaries to private sector deflating the nominal measures of financial intermediary liabilities and assets. See Levine et al. (2000).

[2] See for instance Barakchian and Crowe (2013).

out using quarterly US data over the period 1971:q1–2011:q4. We also estimate the model over 1971:q1-2008:q2 excluding the period that followed the collapse of the Lehman Brothers as the framework of monetary policy after this episode changed substantially.

The paper is structured as follows. In Section 2, we provide a review of the empirical literature. In section 3, we present the data, the model and the methodology that is utilized in our analysis. Section 4 presents the empirical results. Section 5 concludes the study.

## 2 Brief Literature Review

A substantial literature examines the impact of monetary policy on the real economy. More recently, several researchers have begun to implement stochastic volatility (SV) models to examine the time varying effect of shocks on real variables.[3] The SV model, although attractive, in cases where the underlying process has discrete jumps, will anticipate the changes by showing changes in volatility before they actually happen. This result is due to the fact that estimation methods favor small rather than large changes in the data. To that end Diebold (1986) also shows that ignoring abrupt shifts, SV model may severely bias estimates and invalidate inferences. Hence, in cases where data are subject to regime shifts, one should use other approaches which are designed to capture such changes in the data.

As an alternative, researchers have implemented Markov regime switching models to examine the asymmetric effects of monetary policy. Using this methodology, it has been shown that monetary policy shocks exert asymmetric effects on the real economy over the business cycle. For instance, Garcia and Schaller (2002), provide evidence that monetary policy in the US have larger effects during recessions than expansions. Peersman and Smets (2002, 2005), using data from seven euro-area countries, demonstrate that regional shocks have more profound effects on output during recessions than expansions. Kaufmann (2002),

[3]See for instance Fernández-Villaverde and Rubio-Ramírez (2013), Mumtaz and Theodoridis (2015) and the references therein.

using data from Austria, provides evidence that the impact of monetary policy on output growth is significant and negative during economic recessions while it is insignificant during periods of normal or above average output growth. Implementing a multivariate Markov switching model, Dolado and María-Dolores (2006) show that the effects of monetary policy on real output growth in the euro-area depend on the state of the business cycle.

The observation that monetary policy exert a strong negative impact on economic activity in recessions also receives support from Weise (1999) who models the asymmetries in monetary transmission mechanism with a logistic smooth transition vector autoregressive (LSTVAR) model. Similarly, using UK data and implementing a smooth transition regression (STR) model, Sensier et al. (2002) show that monetary policy is more effective in recessions than in expansions. To that end, Lo and Piger (2005) using an unobserved-component model with regime switching and time varying transition probabilities, argue that changes in monetary policy have stronger real effects in the US during recessions than in expansions. Subsequently, Höppner et al. (2008) applying a time-varying coefficient VAR model confirm the asymmetry of monetary policy over the business cycle of the US.

When we turn to examine the importance of financial markets on growth and productivity, we come across a large and growing body of work. The empirical evidence based on aggregate data suggests that the development and deepening of financial markets allow firms to have easier access to external funds, dampening the impact of negative shocks on the economy. Similar conclusions are provided by researchers who examine industry or firm level data, too. Raddatz (2006) finds that higher financial depth significantly reduces output volatility especially in sectors which need high liquidity. He argues that the results provide strong evidence for the importance of financial development in reducing output fluctuations as financial market depth improves the ability of the financial system to provide liquidity to firms during recessions. Larrain (2006) concludes that the greater the size of bank credit, the less volatile will be the industrial output. His results further show that a well-developed banking system absorbs the shocks to the economy particularly by providing liquidity through short-term debt.

More recently, Beck, Büyükkarabacak, Rioja, and Valev (2012) show that although the share of household credit in total credit increases as countries become more developed and financial sector becomes deeper, it is only bank lending to firms that leads to faster output growth. Beck, Chen, Chen, and Song (2012) find that higher level of financial innovation not only increases the country's growth opportunities, capital and GDP per capita growth but also raises growth rates in industries which depend more on external finance and financial innovation. Cowan and Raddatz (2013) show in countries where firms in sectors with higher external financing contract relatively more following sharp reductions in international capital flows.

In what follows below, we present our empirical framework which we use to examine the role of financial markets in evaluating the asymmetric impact of monetary policy on real output over the business cycle. To pursue our goal, we implement an instrumental variable Markov regime switching framework. The use of an instrumental variable approach is essential in a study such as ours as the endogeneity problem may affect the results due to the potential correlation between the explanatory variables and the disturbance term.

# 3 Data and Methodology

## 3.1 Data

We carry out the analysis using quarterly US data over the period 1971:q1-2011:q4. Data are obtained from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). We measure output growth ($y_t$) in period $t$, by the first difference of the logarithm of the real GDP index (2005=100), IFS line 99b.

#### 3.1.1 Measuring Financial Depth

We use two different proxies to gauge financial depth, $(fd_t)$. Our first measure is the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks).[4] This measure, originally proposed by King and Levine (1993), is used by several researchers.[5] Credit to private sector is a critical key variable which reflects the "depth" of the financial market. This proxy provides information on the percentage of credit allocated to private firms in the economy. Thus, it measures the extent to which credit is allocated to the private rather than the public sector.

Our second financial depth measure is proposed by Levine et al. (2000) as the ratio of credits by financial intermediaries to the private sector with respect to GDP.[6] This measure is constructed as $0.5 * \left[\frac{F(t)}{P_{end}(t)} + \frac{F(t-1)}{P_{end}(t-1)}\right] / \frac{GDP(t)}{P_{ave}(t)}$. In this measure $F$ is quarterly credit by deposit money banks and other financial institutions to the private sector (IFS lines 22d+42d), $P_{end}$ is end-of period quarterly CPI (IFS line 64), $P_{ave}$ is the average CPI for the quarter (IFS line 64) and GDP is seasonally adjusted nominal quarterly gross domestic product (IFS line 99b). Specifically, this depth measure includes only credits issued by banks and other financial intermediaries. Similar to Levine et al. (2000), we measure the items in financial intermediary balance sheets at the end of the period but GDP is measured over the period. Thus, the end-of-period items in financial intermediary balance sheets are deflated by the end of period consumer price indices (CPI) while the GDP series is deflated by the average CPI for the period.

[4]Total domestic credit (excluding credit to money banks) is composed of claims on central government, claims on state and local governments, claims on public nonfinancial corporations and claims on the nonfinancial private sector. Claims on the nonfinancial private sector is extracted from IFS line 32d and domestic credit (excluding credit to money banks) is taken from IFS lines 32a through 32f excluding 32e.

[5]See, for instance Denizer et al. (2002).

[6]For instance Hasan et al. (2009) and Lins et al. (2010) use this variable as a measure of financial depth.

#### 3.1.2 Measuring of Monetary Policy Shocks

A quick survey of the literature shows that researchers heavily use VAR methodology to examine the effects of monetary policy. However, given that the policy makers have become more forward-looking over the years as Barakchian and Crowe (2013) demonstrate, identification of structural shocks in VAR models has become a more difficult task.[7] This is because when agents react to expected variables, which are not observed by the econometricians, non-fundamentalness emerges.[8] Benati and Surico (2009) also argue that there is a fundamental disconnect between what is structural within a dynamic stochastic general equilibrium (DSGE) model and that from a structural VAR representation implied by the same DSGE model. At the very least recent research has shown that comparison of structural VAR (SVAR) estimates with DSGE model is not straightforward and caution must be exercised in comparing the two models.[9]

Given these concerns, we employ three different proxies to gauge the stance of the monetary policy. As commonly used in the literature, we use the first difference of the logarithm of the Federal Funds rate ($mp_t$), IFS line 60b, as our first measure. This is a simple yet conventional approach taken by many researchers to gauge monetary policy shocks.[10] However, this measure is subject to two main shortcomings. First, Federal fund rates often moves endogenously with changes in economic conditions. Such endogenous movements will lead to biased estimates of the impact of monetary policy on the target variables. For instance, an endogenous response of the fund rate to economic activities might lead one to underestimate the impact that monetary policy has on real economic variables.[11] Furthermore, to analyze the effects of monetary policy on economic growth and on inflation one needs to extract

[7] For further discussion see Leeper et al. (1996), Christiano et al. (1999).

[8] A model is non-fundamental when structural shocks cannot be recovered by current and past observations (see Hansen and Sargent (1991)).

[9] For further discussion see Kilian (2012).

[10] See for instance Sims (1992), Bernanke and Mihov (1998) and Garcia and Schaller (2002).

[11] See Romer and Romer (2004).

variations in the policy rates that is orthogonal to the Fed's forecast of future output and inflation. If the forward-looking elements of monetary policy framework is not taken into account appropriately then a perverse positive relationship between the Federal fund rate and target variables such as output growth and inflation is likely to emerge.

Next, we generate two additional monetary policy shocks in the sprit of Romer and Romer (2004) by modifying their model to allow for time-varying parameters and regime shifts. This is essential because there is ever increasing evidence that monetary policy has become more forward-looking and failing to account for the structural breaks in the data will lead to biased information regarding the impact of monetary policy shocks on other variables. Romer and Romer (2004) measure monetary policy shocks using a reaction function where the desired Fed Funds target rate is the dependent variable and the right-hand side variables include the level of the desired Fed Funds target prior to the FOMC meeting, and 17 forecast variables (the current quarter of unemployment, eight forecasts for the real GDP growth and that for the GDP deflator) taken from the Greenbook.[12] To obtain our second proxy to gauge monetary policy shocks we allow the parameters associated with all 18 variables in the Romer and Romer (2004) model to vary over time. The third monetary policy shock proxy is obtained by implementing a time varying with regime switching model allowing the variance and the parameters of the four significant variables from the original model to vary over time as it was not possible to estimate the model with the full set of variables.

## 3.2 Methodology

To examine the role of financial markets in evaluating the asymmetric impact of monetary policy on real output we implement a Markov switching framework. The complication that may arise from this approach is the potential endogeneity of the monetary policy and the financial depth measures which we use as explanatory variables in the output growth equa-

[12] The appendix provides further details concerning their specification.

tion. In this case, the use of standard maximum likelihood approach in estimating a regime switching model would yield inconsistent parameter estimates as a result of the within-regime correlation between the regressors and the disturbance term.[13] Here, we follow an approach suggested by Spagnolo et al. (2005) and estimate the following system of equations for output growth and the instrumenting equations for monetary policy and for financial depth:

$$y_t = \mu_{s_t} + \sum_{s_t=0}^{1}\sum_{i=1}^{k}\gamma_{s_t}^{i}y_{t-i} + \beta_{s_t}\widehat{mp}_{t-1} + \varphi_{s_t}\widehat{fd}_t + \eta_{s_t}\widehat{mp}_{t-1}\times\widehat{fd}_{t-1} + \sigma_{s_t}\varepsilon_t \qquad (1)$$

where

$$\begin{aligned}
\mu_{s_t} &= \left[\mu_0\left(1-s_t\right)+\mu_1 s_t\right],\ \gamma_{s_t}^{i} = \left[\gamma_0^{(i)}\left(1-s_t\right)+\gamma_1^{(i)}s_t\right],\\
\beta_{s_t} &= \left[\beta_0\left(1-s_t\right)+\beta_1 s_t\right],\ \varphi_{s_t} = \left[\varphi_0\left(1-s_t\right)+\varphi_1 s_t\right],\\
\eta_{s_t} &= \left[\eta_0\left(1-s_t\right)+\eta_1 s_t\right],\ \text{and } \sigma_{s_t} = \left[\sigma_0\left(1-s_t\right)+\sigma_1 s_t\right]
\end{aligned}$$

$$mp_{t-1} = \kappa_{s_t} + \sum_{s_t=0}^{1}\sum_{i=1}^{k}\delta_{s_t}^{i}y_{t-i-1} + \sum_{s_t=0}^{1}\sum_{i=1}^{l}\phi_{s_t}^{i}mp_{t-i-1} + \theta_{s_t}\xi_t \qquad (2)$$

where

$$\begin{aligned}
\kappa_{s_t} &= \kappa_0\left(1-s_t\right)+\kappa_1 s_t,\ \delta_{s_t}^{i} = \delta_0^{(i)}\left(1-s_t\right)+\delta_1^{(i)}s_t,\\
\phi_{s_t}^{i} &= \phi_0^{(i)}\left(1-s_t\right)+\phi_1^{(i)}s_t \text{ and } \theta_{s_t} = \theta_0\left(1-s_t\right)+\theta_1 s_t
\end{aligned}$$

$$fd_t = \alpha_{s_t} + \sum_{s_t=0}^{1}\sum_{i=1}^{k}\lambda_{s_t}^{i}fd_{t-i} + \chi_{s_t}\varsigma_t \qquad (3)$$

[13] A standard Taylor rule suggests that the short term interest rate reacts to contemporaneous values of inflation and output-gap. In this case a growth equation where one of the regressors is the change in the short term interest rate is subject to endogeneity problem due to the simultaneity bias. Thus, the short term interest rate will be correlated with the error term of the model.

where

$$
\begin{aligned}
\alpha_{s_t} &= \alpha_0(1-s_t)+\alpha_1 s_t,\ \lambda^i_{s_t}=\lambda^i_0(1-s_t)+\lambda^i_1 s_t \text{ and} \\
\chi_{s_t} &= \chi_0(1-s_t)+\chi_1 s_t
\end{aligned}
$$

The state variable, $s_t$, is a homogenous first order Markov chain on $\{0,1\}$ with transition probabilities:

$$
\begin{aligned}
q &= P\left[s_t=0 \mid s_{t-1}=0\right], \\
p &= P\left[s_t=1 \mid s_{t-1}=1\right].
\end{aligned}
\tag{4}
$$

In this system, the first equation models the real output growth ($y_t$), the second equation models the monetary policy ($mp_{t-1}$) and the third equation models the financial depth ($fd_t$) while all explanatory variables have state dependent coefficients. The disturbance terms in equations (1-3) are captured by $\epsilon_t$, $\xi_t$ and $\varsigma_t$, respectively. This equation includes the lags of the dependent variable, a measure of expected financial depth ($fd_t$), and the first lag of expected monetary policy ($mp_{t-1}$) to capture the observation that output growth reacts to changes in monetary policy with a lag. Output growth equation also includes an interaction term between the first lagged financial depth and monetary policy measure, $(\widehat{mp}_{t-1}\times\widehat{fd}_{t-1})$. The interaction term is of key importance to us for it allows us to examine whether financial depth mitigates or intensifies the impact of monetary policy on real output over the business cycle. The fitted value of the monetary policy, $\widehat{mp}_{t-1}=E\left[mp_{t-1}\mid s_{t-1},\Omega_{t-1}\right]$, is obtained from equation (2) where $s$ denotes the unobserved state variable and $\Omega_{t-1}$ denotes the information set available at time $t-1$. In the same spirit, the fitted value of the financial depth, $\widehat{fd}_t=E\left[fd_t\mid s_t,\Omega_t\right]$, is obtained from instrumenting equation (3).

Equation (2) is a reduced-form model for the endogenous regressor, $mp_{t-1}$, which is assumed to respond asymmetrically to lagged output and lagged dependent variable. Here, we assume that there is simultaneity bias between the first lagged interest rate changes and the output growth, reflecting the delayed impact of monetary policy on output.[14] Equation (3) models the financial depth variable as an autoregressive process where the associated parameters depend on the state of the economy. Thus, the fitted value of financial depth ($\widehat{fd_t}$) obtained from (3) is exogenous to output growth in (1). Prior to using the second lag of monetary policy as well as the first lag of the financial depth measures as instruments in estimating the model, we carry out exogeneity tests suggested by Kim (2004). This procedure shows that both lags of the aforementioned variables are exogeneous.[15]

To estimate this model we use a recursive algorithm explained in Hamilton (1994).[16] This process yields a sample likelihood function which can be maximized numerically with respect to $\nu = (\mu_0, \mu_1, \gamma_0^{(1)}, \gamma_1^{(1)}, \gamma_0^{(2)}, \gamma_1^{(2)}, \cdots, \gamma_0^{(j)}, \gamma_1^{(j)}, \delta_0^{(1)}, \delta_1^{(1)}, \delta_0^{(2)}, \delta_1^{(2)}, \cdots, \delta_0^{(j)}, \delta_1^{(j)}, \phi_0^{(1)}, \phi_1^{(1)}, \phi_0^{(2)}, \phi_1^{(2)}, \cdots, \phi_0^{(j)}, \phi_1^{(j)}, \beta_0, \beta_1, \eta_0, \eta_1, \sigma_0, \sigma_1, \varphi_0, \varphi_1, \kappa_0, \kappa_1, \theta_0, \theta_1, \alpha_0, \alpha_1, \lambda_0^i, \lambda_1^i, \chi_0, \chi_1)$, subject to the constraint that $p$ and $q$ lie in the open unit interval. As a consequence, we can write the conditional probability density function of the data $w_t = (y_t, mp_t, fd_t)$ given the state $s_t$

[14] For instance Svensson (1997) argues that monetary policy will affect output with a one year delay.

[15] These results are available from the authors upon request.

[16] See Spagnolo et al. (2005) for more details on estimation.

and the history of the system:

$$
\begin{aligned}
pdf(w_t \mid w_{t-1},...,w_1;\nu) = & \frac{1}{\sqrt{2\pi}\sigma_{s_t}} exp \\
& \left[ -\frac{1}{2} \left( \frac{y_t - \mu_{s_t} - \sum_{j=1}^{J} \gamma_{s_t}^{(j)} y_{t-j} - \beta_{s_t} \widehat{mp}_{t-1} - \varphi_{s_t} \widehat{fd}_t - \eta_{s_t} \widehat{mp}_{t-1} \times \widehat{fd}_{t-1}}{\sigma_{s_t}} \right)^2 \right] \\
& \times \frac{1}{\sqrt{2\pi}\theta_{s_t}} exp \\
& \left[ -\frac{1}{2} \left( \frac{mp_{t-1} - \kappa_{s_t} - \sum_{k=1}^{K} \delta_{s_t}^{(k)} y_{t-k-1} - \sum_{l=1}^{L} \phi_{s_t}^{(l)} mp_{t-l-1}}{\theta_{s_t}} \right)^2 \right] \\
& \times \frac{1}{\sqrt{2\pi}\chi_{s_t}} exp \\
& \left[ -\frac{1}{2} \left( \frac{fd_t - \alpha_{st} - \sum_{s_t=0}^{1} \sum_{i=1}^{k} \lambda_{s_t}^{i} fd_{t-i}}{\chi_{s_t}} \right)^2 \right]
\end{aligned}
\tag{5}
$$

Here $\widehat{mp}_{t-1} = \widehat{\kappa}_{s_t} + \sum_{s_t=0}^{1} \sum_{k=1}^{K} \widehat{\delta}_{s_t}^{(k)} y_{t-k-1} + \sum_{l=1}^{L} \widehat{\phi}_{s_t}^{(l)} mp_{t-l-1}$ and $\widehat{fd}_t = \widehat{\alpha}_{s_t} + \sum_{s_t=0}^{1} \sum_{i=1}^{k} \widehat{\lambda}_{s_t}^{i} fd_{t-i}$ are obtained from the state-dependent instrumenting equations for $mp_{t-1}$ and $fd_t$ as shown in (2) and (3).

Note that the system of equations in (1-4) assumes that the unobserved state variables of GDP growth, monetary policy and financial depth measures are synchronized. Prior to estimating the model, as discussed in the next subsection, we show that this assumption holds in our case.

## 3.3 Modeling the Unobserved States

Although our empirical model accounts for the potential endogeneity between the state variables and the policy instrument, using a common unobserved state variable for all three equations might be problematic. To be able to properly examine the impact of monetary policy on output growth over different regimes within the context of a Markov regime framework, we must examine the interrelations of the unobserved state variables of output growth, policy shocks and financial depth. More concretely, we must find out whether these unobserved state variables are in the same phase or lead each other.

To illustrate the interaction between the unobserved states of $y_t$ and $mp_t$ consider a $2 \times 1$ vector $z_t = [y_t, mp_t]'$ such that

$$z_t = \mu_{st} + \sum_{i=1}^{p} \Phi_i v_{t-i} \tag{6}$$

where $v_t = [u_t^y, u_t^{mp}]'$ is a Gaussian process with mean zero and positive-definite variance covariance matrix $\Sigma$; $\{s_t\}$ the unobserved state of $z$ is modeled by the unobserved states of $s_t^y$ and $s_t^{mp}$ as a linear homogenous four-state Markov process with[17]

$$\begin{aligned} s_t^z &= 1 \text{ if } s_t^{mp} = 1 \text{ and } s_t^y = 1 \\ s_t^z &= 2 \text{ if } s_t^{mp} = 2 \text{ and } s_t^y = 1 \\ s_t^z &= 3 \text{ if } s_t^{mp} = 1 \text{ and } s_t^y = 2 \\ s_t^z &= 4 \text{ if } s_t^{mp} = 2 \text{ and } s_t^y = 2 \end{aligned} \tag{7}$$

If the unobserved states $s_t^y$ and $s_t^{mp}$ are independent, then the transition probability matrix of $s_t^z$ is given by

$$P_{ymp}^A = P^y \otimes P^{mp} = \begin{bmatrix} p_{11}^y p_{11}^{mp} & p_{11}^y p_{21}^{mp} & p_{21}^y p_{11}^{mp} & p_{21}^y p_{21}^{mp} \\ p_{11}^y p_{12}^{mp} & p_{11}^y p_{22}^{mp} & p_{21}^y p_{12}^{mp} & p_{21}^y p_{22}^{mp} \\ p_{12}^y p_{11}^{mp} & p_{12}^y p_{21}^{mp} & p_{22}^y p_{11}^{mp} & p_{22}^y p_{21}^{mp} \\ p_{12}^y p_{12}^{mp} & p_{12}^y p_{22}^{mp} & p_{22}^y p_{12}^{mp} & p_{22}^y p_{22}^{mp} \end{bmatrix} \tag{8}$$

We call this model $A$. A second model, model $B$, suggested by Schwert (1989) and Campbell

[17]For more details see Phillips (1991), Hamilton and Lin (1996) and Sola et al. (2007).

et al. (1998), considers the case of a perfect synchronization between $s_t^y$ and $s_t^{mp}$ ($s_t^y = s_t^{mp}$). In model $B$ the unobserved state variable $s_t^z$ follows a two-state Markov process with the transition probability matrix:

$$P_{ymp}^B = \begin{bmatrix} p_{11}^y p_{11}^{mp} & 0 & 0 & p_{21}^y p_{21}^{mp} \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ p_{12}^y p_{12}^{mp} & 0 & 0 & p_{22}^y p_{22}^{mp} \end{bmatrix} \tag{9}$$

In contrast, when the unobserved state of monetary policy measure leads the unobserved state of output growth (i.e. $s_t^y = s_{t-1}^{mp}$) the transition probability matrix of $s_t^z$ is given by

$$P_{ymp}^C = \begin{bmatrix} p_{11}^y p_{11}^{mp} & 0 & p_{21}^y p_{11}^{mp} & 0 \\ p_{11}^y p_{12}^{mp} & 0 & p_{21}^y p_{12}^{mp} & 0 \\ 0 & p_{12}^y p_{21}^{mp} & 0 & p_{22}^y p_{21}^{mp} \\ 0 & p_{12}^y p_{22}^{mp} & 0 & p_{22}^y p_{22}^{mp} \end{bmatrix} \tag{10}$$

This alternative model is denoted as $C$. In Model $C$, the expectation about the future state of output will affect the current policy decisions. Here, the unobserved state of the monetary policy measure will lead the unobserved state of output.

Finally, if monetary policy reacts to expectations concerning the state variables other than output such as inflation then the unobserved state of output might lead the unobserved state of monetary policy measure ($s_t^{mp} = s_{t-1}^y$). Hence, in model $D$, the transition probability matrix of $s_t^z$ will be:

$$
P_{ymp}^{D} = \begin{bmatrix} p_{11}^{y} p_{11}^{mp} & p_{11}^{y} p_{21}^{mp} & 0 & 0 \\ 0 & 0 & p_{21}^{y} p_{12}^{mp} & p_{21}^{y} p_{22}^{mp} \\ p_{12}^{y} p_{11}^{mp} & p_{12}^{y} p_{21}^{mp} & 0 & 0 \\ 0 & 0 & p_{22}^{y} p_{12}^{mp} & p_{22}^{y} p_{22}^{mp} \end{bmatrix} \tag{11}
$$

We use Models $A, B, C$ and $D$ to investigate the interactions among the unobserved states of the output growth, monetary policy and financial depth measures. In other words, using these models we examine the interrelations between the unobserved states of output and monetary policy, between output and financial depth and between monetary policy and financial depth. Our examination shows that model $B$ characterizes the interrelation of the unobserved states: the unobserved states are perfectly correlated.

### 3.4 Other Econometric Issues

To implement the Markov regime switching framework, the series must exhibit regime shifts. We follow Hansen (1992a, 1996) to test for regime switching. Note that the null hypothesis of linearity against the alternative of a Markov regime switching cannot be tested directly using a standard likelihood ratio (LR) test. This is because under the null of linearity the parameters of transition probabilities are unidentified and the scores with respect to parameters of interest are identically zero. Under such circumstances the information matrix is singular. Therefore, we apply Hansen's standardized likelihood ratio test, which requires an evaluation of the likelihood function across a grid of different values for the transition probabilities.

# 4 Empirical Analysis

Given that the level impact of financial depth in equation (1) did not receive a significant coefficient in our first attempts, we excluded it from our final model. Our final equation employs two lags of the dependent variable, once lagged expected monetary policy and an interaction term between expected financial depth and monetary policy. We first estimate this framework for two separate financial depth measures. Next, we estimate the model for the period before the collapse of Lehman Brothers as the FED changed its approach in stimulating the economy following this event. Last, we estimate the model for two additional monetary policy shock measures which allow the parameters of the model that we generated these proxies to be time-varying in the first case and time-varying with regime shifts in the other. The results are similar across each case and can be summarized as follows.

We first show that monetary policy has a regime dependent impact on output growth. In particular, we show that monetary policy shocks exert a negative and significant impact on output growth during recessions, yet this effect is not significant during expansions. Our analysis also provides evidence that financial depth significantly mitigates the impact of monetary policy in recessions. More concretely, we find that in recessions the total impact of monetary policy on output growth becomes much milder and even diminishes with deepening of the financial markets. This makes sense because firms mostly suffer from financial frictions during recessions and deeper financial markets could facilitate firms to raise funds even in hard times.

## 4.1 Preliminary Tests

Table 1 shows that the Hansen test rejects the null of linearity for the monetary policy and the first measure of financial development. However, the null of linearity for GDP growth and the second measure of financial depth cannot be rejected. This might be due to the low power of the test when the model accounts for autoregressive dynamics. To further investigate for the presence of regime switching we implement structural break tests proposed by Hansen (1992b), Andrews (1993), and Andrews and Ploberger (1994) for output growth equation in (1) (using both financial depth measures). We apply the same tests for the instrumenting equation for our financial depth measures in (3) as well. The null hypothesis for these tests is that parameters are stable while the alternative is that there is an evidence of one-time change at the break point. The Hansen (1992b) tests, see Table 2, confirm the evidence of parameter instability in the output growth equation and the instrumenting equation for financial depth.

Table 1 about here

Table 2 about here

Table 3 presents results concerning the synchronicity of the unobserved states of output growth, monetary policy instrument and financial depth measure. This exercise provides evidence that the states are in the same phase at each point of time supporting the validity of model $B$. Equipped with this information, we estimate the system of equations (1-4).

Table 3 about here

## 4.2 Results for the Full Sample

Table 4 presents the results for the output growth equation. The estimates for the instrumenting equation, which are available upon request from the authors, are suppressed for parsimony. The first two columns of the table give the parameter estimates and the standard errors when financial depth measure is constructed as the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks). The next two columns present our results when we use our alternative financial depth measure (the ratio of credit by financial intermediaries to the private sector to GDP). We observe for both sets of results that the state dependent growth rate $\mu_0$ is greater than $\mu_1$. Hence, we assume that state 0 captures the high growth regime and state 1 captures the low growth regime.

Table 4 about here

To scrutinize the impact of monetary policy on output growth we examine the coefficients associated with $\widehat{mp}_{t-1}$: $\beta_0$ and $\beta_1$. Observing the table we see that for both measures of financial depth, the monetary policy coefficient is negative and significant only in recessions ($\beta_1 < 0$). This finding suggest that monetary policy has asymmetric impact on output growth over the business cycle. These results are in line with the theoretical models and empirical findings which provide evidence in favor of asymmetric impact of monetary policy as discussed in the literature review section.

Next we asses whether the real effects of monetary policy vary over the business cycle with the level of financial depth. We expect to find that the impact of monetary policy should be dampened with the deepening of financial markets. This is because the availability of credit lines in times of economic bottlenecks can help to smooth output fluctuations as firms would have easier access to credit and they do not have to cut back employment or investment expenditures as severely. Observing the estimated coefficients associated with the interaction term between our financial depth measures and monetary policy, we see that our expectations receive support: the coefficient estimate that captures the role of financial depth in low growth regime, $\eta_1$, is positive and strongly significant. This observation provides evidence that financial depth plays a significant role during recessions in monetary transmission mechanism. Yet, the coefficient that captures the role of financial depth in high growth state, $\eta_0$, is insignificant. The insignificance of $\eta_0$ can be explained by the fact that firms have access to a wider variety of sources of finance in periods of expansion.

It is also useful to look at Figures 1 and 2 which provide the filter probabilities of State 1 (low growth state) for both sets of financial depth measures. The shaded areas in these figures capture recessions which are also acknowledged by the NBER. In this context, the filter probabilities provide evidence that the model successfully captures the major recessions as announced by the NBER (see Table 5). In fact the model captures the NBER dates slightly better when we use the ratio of claims on the nonfinancial private sector to total domestic credit as a measure of financial depth.[18] It should be noted that the persistence of recessions is stronger in the model than in the data. However, the business cycle turning points captured by the model presents a good match with respect to the NBER dates.

Figure 1 about here

Figure 2 about here

Table 5 about here

### 4.3 Results for the pre-Financial Crises Period: 1971:q1-2008:q2

In this subsection, to see whether the results are robust to the exclusion of the data that followed the collapse of the Lehman Brothers, we examine the pre-financial crises period between 1971:q1-2008:q2.[19] Results given in Table 6 are similar to our earlier observations. The impact of monetary policy on output growth is negative and significant in the low growth state while it is insignificant in the high growth state. When we turn to asses the role of financial depth in the transmission of monetary policy, we see that the interaction term is positive in both regimes but it is significant only in the low growth state, mitigating the adverse impact of monetary policy during recessions as we discussed earlier.

[18]The model when we use the second measure of financial depth fails to capture the recession in 1990 (see, Figure 2). This might be due to the fact that this recession was relatively moderate and lasted only two quarters.

[19]After the collapse of the Lehman Brothers, FED changed its approach in stimulating the economy as it was clear that the use of conventional monetary policy tools were not effective anymore.

Table 6 about here

Overall, the results based on the full sample and the pre-crises period for which we allow two different financial depth measures provide support for our claim that i) monetary policy affects output growth asymmetrically over the business cycle and ii) financial depth plays a significant role in mitigating the adverse impact of monetary policy during recessions.

#### 4.3.1 Additional Robustness Checks Based on Alternative Proxies of Monetary Policy Shocks

We provide two additional sets of results as we estimate the model for two different measures of monetary policy shocks. Note that both measures are based on the narrative approach of Romer and Romer (2004) but allow for time-variation. In particular, the first measure is generated by a model that allows for time varying parameters and the other from a model that allows for time varying parameters with regime shifts. We follow this approach to overcome the possibility that the change in fed funds rate could have underestimated the true impact of monetary policy on output growth and inflation as noted by Romer and Romer (2004). Table 7 presents the results.

The first two columns of the table presents the coefficient estimates and their standard variations when we use the second monetary policy shock measure driven from a time-varying parameter model. The last two columns are obtained for the third monetary policy shock measure which is obtained from a model where the parameters are time-varying and the volatility is regime dependent. In both cases we see that monetary policy has a negative and significant effect in the low growth state. As in the previous cases, we find that the effect of monetary policy becomes insignificant during high growth states verifying the asymmetric impact of monetary policy shocks on output growth. When we turn to examine the role of financial depth, we see that the interaction coefficient is positive and significant suggesting that financial depth mitigates the impact of monetary policy shocks during low growth regimes. The interaction coefficient is insignificant during the high growth state as we have found in our earlier tables.

Table 7 about here

### 4.4 The Full Impact of Monetary Policy

So far we have shown that monetary policy exerts a significant negative impact on real output growth during log growth states and that financial depth mitigates the adverse effects of monetary policy. These results accord with the intuition and point out at the significant role financial markets play in the transmission of monetary policy. However, the evidence we have presented so far does not provide us the full impact of monetary policy on output growth over the business cycle. To gauge its full impact we must evaluate the total derivative of output growth with respect to monetary policy for each state

$$\partial y_t/\partial \widehat{mp}_{t-1} = \left[\widehat{\beta_0}\left(1-s_t\right)+\widehat{\beta_1}s_t\right]+\left[\widehat{\eta_0}\left(1-s_t\right)+\widehat{\eta_1}s_t\right]\widehat{fd}^*_{t-1} \tag{12}$$

at various levels of financial depth, $\widehat{fd}^*_{t-1}$. To compute the total impact of monetary policy on output growth, we use the point estimates for $\widehat{\beta}_i$ and $\widehat{\eta}_i$ shown in Table (4). The estimates $\widehat{\beta}_i$ and $\widehat{\eta}_i$ capture the direct and indirect impact of monetary policy on output growth, respectively. The index $s_t = 0, 1$ denotes the states of the economy where 0 represents the low growth regime and 1 represents the high growth regime. $\widehat{fd}^*_{t-1}$ refers to a particular level of financial market depth at which we compute the derivative including the $10th$, $25th$, $50th$, $75th$, and $90th$ percentiles. For each state of the economy, we present in Table (8) the full impact of monetary policy on output growth along with the associated standard errors. In Figure 3, we plot these point estimates along with the corresponding 95% confidence interval.

Table 8 about here

Figure 3 about here

Panel A in Table (8), (also see State 0, Figure (3)), provides information on the total impact of an adverse monetary policy on output growth in expansions. Panel A shows that the total impact of monetary policy on output growth is almost always positive. But in all cases this impact is insignificant.

Inspecting Panel B in Table (8), (also see State 1, Figure (3)), we observe that an adverse monetary policy has a significant negative impact on output growth in low growth regimes but this impact weakens as financial depth increases. To put it differently, the adverse impact of monetary policy would have been stronger in recessions if the economy were to experience tight credit market conditions. In fact when financial deepening were to exceed slightly above its third quartile level, the effect of monetary policy on output growth becomes insignificant. This suggests that during periods of low growth regimes, as liquidity dries up, the economy suffers considerably because businesses and firms cannot keep operating in an environment where borrowing is compromised due to frictions in the financial markets. Our findings in this context are particularly relevant in the light of events that followed the 2008/09 financial crises with businesses shedding employment and delaying capital investment expenditures as the credit dried up despite the fact that the central banks injected billions of dollars of funds into the system to keep the financial markets afloat.

Our results may be of interest to researchers and policy makers who examine the impact of monetary policy on output growth. Several papers in the literature argue that monetary policy does not significantly affect the real economy. In particular, several researchers conclude that the impact of monetary policy on the real economy is ambiguous. We show here that monetary policy affects output growth asymmetrically (more so in recessions but not in expansions) while financial depth plays an important role on the full impact of monetary policy. Hence, any suggestion that the impact of monetary policy on output growth is ambiguous may be a consequence of ignoring the presence of asymmetries in the data. In such cases it is quite possible to argue that the role of monetary policy on output is limited, whereas the true answer might depend on the state of the business cycle. Furthermore, our findings show that the impact of monetary policy also depends on whether financial markets operate properly providing liquidity and depth, or not.

# 5 Conclusion

In this study we empirically examine the of role financial markets in evaluating the asymmetric impact of monetary policy on real output over the business cycle. In particular we ask whether monetary policy have an asymmetric impact on real output growth and whether this impact depends on the depth of the financial markets as the economy evolves over high and low growth states. The investigation is carried out using quarterly US data over 1971:q1–2011:q4.

We examine the presence of asymmetric effects of monetary policy and financial market depth on output growth by implementing a Markov regime switching model which allows all coefficients to vary over the business cycle.[20] Furthermore, our model includes an interaction term between a measure of financial depth and monetary policy indicator allowing us to examine whether financial depth influences the impact of monetary policy on output growth across different phases of the business cycle or not. We estimate our model applying an instrumental variable approach as suggested by Spagnolo et al. (2005) to avoid problems that may arise due to endogeneity of the right hand side variables.

Our findings can be summarized as follows. We first show that monetary policy has an asymmetric impact on output growth: a restrictive monetary policy leads to a significant drop in output growth during low growth states, while such a policy does not have any significant impact on output during high growth states. When we examine the role of financial markets,

[20] Prior to estimating our model we verify that the unobserved states of the variables in our model are synchronized.

we see that financial depth plays a significant role in mitigating the adverse effects of tight monetary policy in bad states. In fact, we find that as financial depth increases, the adverse impact of restrictive monetary policy is nullified. Overall, our results provide evidence that although tight monetary policy might have adverse effects on output growth during low growth regimes, such effects diminish or even nullify when the financial markets are deeper. Last but not the least, we show that our results are robust compared to alternative financial depth and monetary policy shock proxies and different sample periods.

The evidence we present here have important policy implications as they point out the importance of financial deepening in the transmission of monetary policy, especially in low growth states. Given the difficulties that most of the developed and emerging countries have been experiencing due to the 2008/09 financial crises, we argue that authorities should devise a regulatory framework which will help and stimulate the financial institutions to provide the markets with much needed depth and liquidity especially during recessions. In this context, we suggest that it would be fruitful to scrutinize data from other countries and examine to what extent cash injections into the financial system have helped economies on either side of the Atlantic and whether financial deepening has been achieved. Such an investigation can help us to understand and to develop the tools in monitoring the health of the financial markets and how quickly liquidity and financial depth can pull the economies out of recessions. More research on the interactions between financial markets and monetary policy would help us to answer several related questions.

**Appendix: The Romer and Romer (2004) (RR) Approach**

Romer and Romer (2004) estimate the following model to derive a proxy for monetary policy shocks:

$$\begin{aligned}\Delta ff_m &= \alpha + \beta ffb_m + \Sigma_{i=-1}^{2}\gamma_i \Delta y_{mi} + \Sigma_{i=-1}^{2}\lambda_i(\Delta y_{mi} - \Delta y_{m-1,i}) \\ &\quad + \Sigma_{i=-1}^{2}\varphi_i \pi_{mi} + \Sigma_{i=-1}^{2}\theta_i(\pi_{mi} - \pi_{m-1,i}) + \rho u_m + \varepsilon_m\end{aligned} \tag{13}$$

where $\Delta ff_t$ is the change in the desired funds rate around the FOMC meeting at date $m$. The level of the desired fund rate before any change related to meeting is denoted by $ffb_m$. The forecast of inflation, real GDP growth and the unemployment rate are depicted as $\pi$, $\Delta y$ and $u$. The subscript $i$ refers to the forecast horizon: $-1$ is the previous quarter, 0 is the current quarter, 1 is the next quarter and 2 is two quarters ahead. We extent the RR approach by allowing the estimated parameters in (13) to be time-varying.[21] In particular, we write (13) in a state-space form as follows:

$$y_t = X_t' \xi_t + e_t, \; e_t \sim N(0, \sigma_e^2) \tag{14}$$

$$\xi_t = F\xi_{t-1} + v_t, \; v_t \sim N(0, Q_t) \tag{15}$$

where $y_t = \Delta ff_t$, $X_t' = [ffb_m, \Delta y_{mi}, (\Delta y_{mi} - \Delta y_{m-1,i}), \pi_{mi}, (\pi_{mi} - \pi_{m-1,i}), u_m]$, and $\xi = [\alpha, \beta, \gamma_i, \lambda_i, \varphi_i, \theta_i, \rho]$ for $i = -1, 0, 1, 2$. Equations (14) and (15) are the measurement and transition equation of (13). The Kalman filter is then applied to make inferences on the changing regression coefficients $\xi_t$. The Kalman filter gives insights into how a rational agent updated his estimates of the coefficients in a Bayesian context with the arrival of new information in a world of uncertainty, especially under changing policy.

Note that the conditional variance of (14) consists of filter uncertainty and uncertainty

[21] Kim and Nelson (1989), based on stability test results on the regression coefficients, consider a time-varying parameter model for the U.S. monetary growth function.

concerning the future shocks:

$$f_{t|t-1} = X_t P_{t|t-1} X_t^{'} + \sigma_e^2 \tag{16}$$

where $P_{t|t-1}$ represents filter uncertainty conditional on information up to time $t-1$ and $\sigma_e^2$ represents uncertainty concerning the future exogenous shocks. To account for potential heteroscedasticity of the exogenous uncertainty we estimate a model where $e_t$ follows a Markov process. Therefore, the version of model (14) and (15) with switching effects takes the following form:

$$e_t \sim N(0, \sigma_{e,S_t}^2) \tag{17}$$

$$\sigma_{e,S_t}^2 = \sigma_0^2 + (\sigma_1^2 - \sigma_0^2) S_t,\ \ \sigma_1^2 > \sigma_0^2 \tag{18}$$

To estimate the new model given by (14)-(18) we employ Kim's (1994) algorithm.

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**Table 1: Hansen Test Results**

| | **y** | **mp** | **fd1** | **fd2** |
|---|---|---|---|---|
| Standardized LR | 0.699 | 6.344 | 2.163 | 0.839 |
| M=0 | 0.581 | 0.000 | 0.080 | 0.468 |
| M=1 | 0.560 | 0.000 | 0.059 | 0.459 |
| M=2 | 0.553 | 0.000 | 0.055 | 0.446 |
| M=3 | 0.549 | 0.000 | 0.050 | 0.436 |
| M=4 | 0.542 | 0.000 | 0.053 | 0.423 |

Notes: Financial depth 1 (fd1) is the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks). Financial depth 2 (fd2) is measured by the ratio of credits by financial intermediaries to the private sector with respect to GDP and defined as: $0.5 * \left[\frac{F(t)}{P_{end}(t)} + \frac{F(t-1)}{P_{end}(t-1)}\right] / \frac{GDP(t)}{P_{ave}(t)}$

**Table 2: Stability Tests for Output Growth and Financial Depth Variables**

| Panel A: Stability Tests for Output Growth Equation | |
|---|---|
| **Using financial depth measure fd1** | |
| Hansen (1992) | 1.912** |
| Andrews (1993) | 11.546 |
| Andrews, Ploberger (1994) | 3.314 |
| **Using financial depth measure fd2** | |
| Hansen (1992) | 1.596* |
| Andrews (1993) | 6.898 |
| Andrews, Ploberger (1994) | 1.616 |
| **Panel B: Stability Tests for Financial Depth; Instrumenting Equation** | |
| **Financial depth measure:** | **fd1** |
| Hansen (1992) | 0.863** |
| Andrews (1993) | 3.679 |
| Andrews, Ploberger (1994) | 0.369 |
| **Financial depth measure:** | **fd2** |
| Hansen (1992) | 0.674* |
| Andrews (1993) | 5.587 |
| Andrews, Ploberger (1994) | 1.108 |

Notes: *, **, *** denote significance at the 10%, 5% and 1% levels. Each entry depicts the the estimated test statistics associated with the listed reference. Financial depth 1 (fd1) is the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks). Financial depth 2 (fd2) is measured by the ratio of credits by financial intermediaries to the private sector with respect to GDP and defined as: $0.5 * \left[\frac{F(t)}{P_{end}(t)} + \frac{F(t-1)}{P_{end}(t-1)}\right] / \frac{GDP(t)}{P_{ave}(t)}$.

**Table 3: Testing the Interrelations of Unobserved States**

| | Model A | Model B | Model C | Model D |
|---|---|---|---|---|
| y vs mp | -939.219 | -919.871 | -948.043 | -941.162 |
| y vs fd1 | -1180.134 | -1180.209 | -1180.222 | -1182.026 |
| mp vs fd1 | -699.504 | -671.535 | -681.064 | -698.013 |
| y vs fd2 | -1150.733 | -1149.709 | -1151.360 | -1146.630 |
| mp vs fd2 | -665.110 | -654.512 | -665.479 | -682.473 |

Notes: Each entry presents the maximum likelihood values associated with the corresponding MRS model. Financial depth 1 (fd1) is the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks). Financial depth (fd2) is measured by the ratio of credits by financial intermediaries to the private sector with respect to GDP and defined as: $0.5 * \left[\frac{F(t)}{P_{end}(t)} + \frac{F(t-1)}{P_{end}(t-1)}\right] / \frac{GDP(t)}{P_{ave}(t)}$.

**Table 4: Asymmetric Effect of Monetary Policy on Output Growth: Full Sample (1971:q1-2011:q4)**

| | Financial Depth 1 | | Financial Depth 2 | |
|---|---|---|---|---|
| | Estimates | Std Errors | Estimates | Std Errors |
| $\mu_0$ | 0.005*** | 0.001 | 0.004*** | 0.001 |
| $\gamma_{11}$ | 0.121 | 0.099 | 0.297* | 0.124 |
| $\gamma_{12}$ | 0.328*** | 0.111 | 0.250 | 0.128 |
| $\beta_0$ | -0.081 | 0.149 | 0.012 | 0.031 |
| $\eta_0$ | 0.088 | 0.174 | -0.009 | 0.016 |
| $\sigma_0$ | 0.005*** | 0.001 | 0.004*** | 0.000 |
| $\mu_1$ | -0.007 | 0.009 | -0.001 | 0.003 |
| $\gamma_{21}$ | 0.352*** | 0.133 | 0.307*** | 0.114 |
| $\gamma_{22}$ | 0.507 | 0.562 | 0.557* | 0.303 |
| $\beta_1$ | -1.473** | 0.585 | -0.250*** | 0.091 |
| $\eta_1$ | 1.680*** | 0.643 | 0.130*** | 0.047 |
| $\sigma_1$ | 0.009*** | 0.001 | 0.009*** | 0.001 |
| $p$ | 0.864*** | 0.064 | 0.918*** | 0.046 |
| $q$ | 0.873*** | 0.047 | 0.910*** | 0.042 |
| log likelihood | | 1024.6 | | 1266.1 |

Notes: *, **, *** denote significance at the 10%, 5% and 1% levels. Financial depth measure 1 is constructed as the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks). Financial depth measure 2 is the ratio of credit by financial intermediaries to the private sector with respect to GDP.

**Table 5: NBER Dates of Expansions and Contractions**

| **Business Cycles Reference Dates** | | **Duration in Months** | |
|---|---|---|---|
| Peak | Trough | Contraction | Expansion |
| April 1960(II) | February 1961(I) | 10 | 24 |
| December 1969(IV) | November 1970(IV) | 11 | 106 |
| November 1973(IV) | March1975(I) | 16 | 36 |
| January 1980(I) | July 1980(III) | 6 | 58 |
| July 1981(III) | November 1982(IV) | 16 | 12 |
| July 1990(III) | March 1991(I) | 8 | 92 |
| March 2001(I) | November 2001(IV) | 8 | 120 |
| December 2007(IV) | June 2009(II) | 18 | 73 |

Source: National Bureau of Economic Research (NBER), Quarterly dates are in parentheses.

**Table 6: Asymmetric Effect of Monetary Policy on Output Growth for the pre-Financial Crises Period: 1971:q1-2008:q2**

| | Financial Depth 1 | | Financial Depth 2 | |
|---|---|---|---|---|
| | Estimates | Std Errors | Estimates | Std Errors |
| $\mu_0$ | 0.005** | 0.002 | 0.004*** | 0.001 |
| $\gamma_{11}$ | 0.090 | 0.107 | 0.297** | 0.119 |
| $\gamma_{12}$ | 0.315*** | 0.101 | 0.265* | 0.138 |
| $\beta_0$ | 0.064 | 0.106 | 0.020 | 0.034 |
| $\eta_0$ | -0.090 | 0.133 | -0.016 | 0.022 |
| $\sigma_0$ | 0.004*** | 0.000 | 0.004*** | 0.000 |
| $\mu_1$ | -0.110 | 0.664 | -0.001 | 0.004 |
| $\gamma_{21}$ | 0.245* | 0.128 | 0.227** | 0.112 |
| $\gamma_{22}$ | 6.375*** | 35.870 | 0.631* | 0.343 |
| $\beta_1$ | -3.276*** | 8.699 | -0.212** | 0.096 |
| $\eta_1$ | 2.432* | 1.278 | 0.106* | 0.057 |
| $\sigma_1$ | 0.009*** | 0.001 | 0.009*** | 0.001 |
| $p$ | 0.89012*** | 0.056179 | 0.942*** | 0.042 |
| $q$ | 0.89508*** | 0.045747 | 0.935*** | 0.037 |
| log likelihood | 1199.3 | | 962.09 | |

Notes: *, **, *** denote significance at the 10%, 5% and 1% levels. Financial depth measure 1 is constructed as the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks). Financial depth measure 2 is the ratio of credit by financial intermediaries to the private sector with respect to GDP.

**Table 7: Asymmetric Effect of Monetary Policy on Output Growth: RR Approach**

| | RR-TVP | | RR-TVP MRS | |
|---|---|---|---|---|
| | Estimates | Std Errors | Estimates | Std Errors |
| $\mu_0$ | 0.006*** | 0.001 | 0.005*** | 0.002 |
| $\gamma_{11}$ | 0.608*** | 0.128 | 0.308** | 0.143 |
| $\gamma_{12}$ | -0.227* | 0.135 | 0.015 | 0.072 |
| $\beta_0$ | -0.061 | 0.072 | -0.034 | 0.102 |
| $\eta_0$ | 0.089 | 0.091 | 0.043 | 0.129 |
| $\sigma_0$ | 0.007*** | 0.001 | 0.011*** | 0.001 |
| $\mu_1$ | 0.003*** | 0.001 | 0.003*** | 0.001 |
| $\gamma_{21}$ | 0.115 | 0.080 | 0.185** | 0.094 |
| $\gamma_{22}$ | 0.379*** | 0.083 | 0.366*** | 0.092 |
| $\beta_1$ | -0.179** | 0.074 | -0.167** | 0.078 |
| $\eta_1$ | 0.218** | 0.092 | 0.215** | 0.098 |
| $\sigma_1$ | 0.005*** | 0.000 | 0.004*** | 0.000 |
| $p$ | 0.869*** | 0.065 | 0.993*** | 0.008 |
| $q$ | 0.842*** | 0.067 | 0.990*** | 0.014 |
| likelihood | 1090.2 | | 1082.7 | |

Notes: *, **, *** denote significance at the 10%, 5% and 1% levels. RR-TVP denotes the time-varying monetary policy shock measure derived using for 18 indicators as noted in Romer and Romer (2004). RR-TVP MRS denotes regime dependent monetary policy shock indicator accounting for Markov switching heteroscedasticity.

**Table 8: Total Effects of Monetary Policy**

**Panel A: State 0**

| | **P10** | **P25** | **P50** | **P75** | **P90** |
|---|---|---|---|---|---|
| Financial depth | 0.886 | 0.932 | 1.184 | 1.654 | 1.899 |
| $\frac{\partial y}{\partial_{mp}}$ | 0.004 | 0.004 | 0.001 | -0.003 | -0.005 |
| Std. Err. | 0.017 | 0.017 | 0.013 | 0.007 | 0.007 |
| t statistic | 0.235 | 0.219 | 0.102 | -0.405 | -0.786 |

**Panel B: State 1**

| | **P10** | **P25** | **P50** | **P75** | **P90** |
|---|---|---|---|---|---|
| Financial depth | 0.886 | 0.932 | 1.184 | 1.654 | 1.899 |
| $\frac{\partial y}{\partial_{mp}}$ | -0.135 | -0.129 | -0.096 | -0.036 | -0.004 |
| Std. Err. | 0.054 | 0.052 | 0.044 | 0.034 | 0.034 |
| t statistic | -2.507 | -2.474 | -2.210 | -1.054 | -0.116 |

Notes: Total effects are calculated for Financial depth 1 (fd1) which is measured by the ratio of credits by financial intermediaries to the private sector divided by GDP and defined as: $0.5 * \left[\frac{F(t)}{P_{end}(t)} + \frac{F(t-1)}{P_{end}(t-1)}\right] / \frac{GDP(t)}{P_{ave}(t)}$.

**Figure 1: Filter Probabilities for the Low Growth State, Financial depth variable: the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks)**

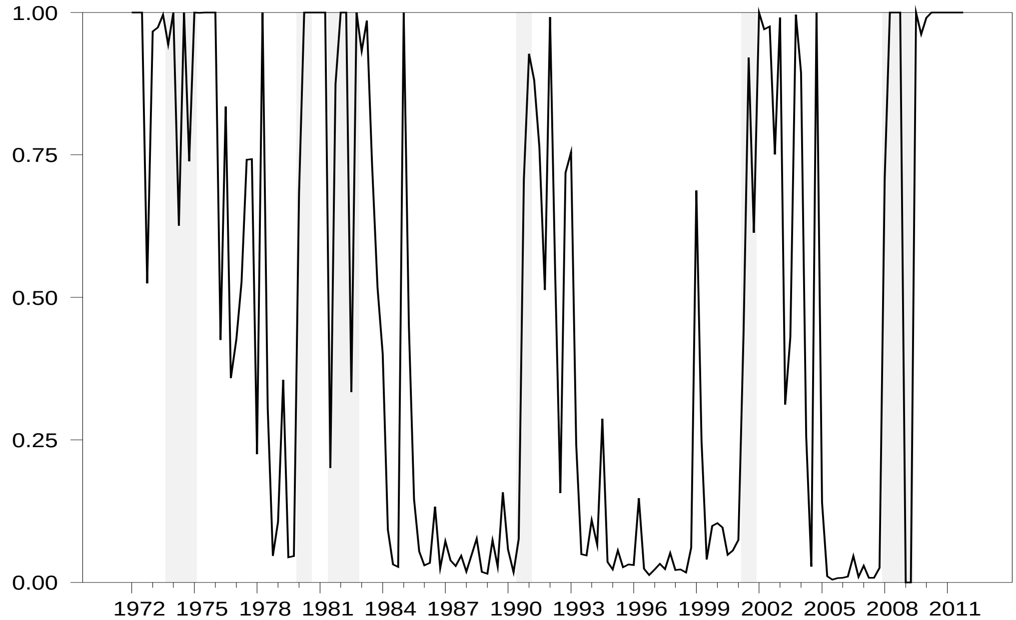

**Figure 2: Filter Probabilities for the Low Growth State, Financial depth variable: the ratio of private sector credits by financial intermediaries to GDP**

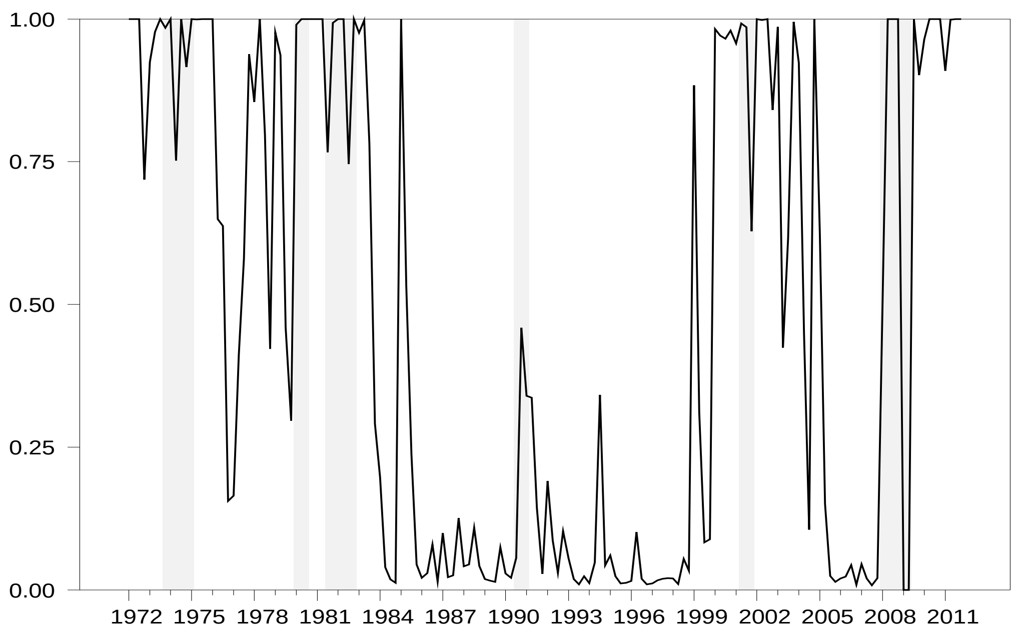

**Figure 3: Total Effects of Monetary Policy**