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. We use quarterly US data which cover 1971:q1–2011:q4 and implement an instrumental variables Markov regime switching methodology to account for the endogeneity problem. Our investigation shows that monetary policy has a significant impact on output growth during recessions. More interestingly, we find that financial depth plays an important role as it dampens the effects of monetary policy in recessions. The results are robust compared to an alternative financial depth measure and a different sample period.

Keywords: Output growth; asymmetric effects; monetary policy; financial depth; Markov switching; instrumental variables.

JEL classification: E32, E52

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1 Introduction

A vast empirical literature examines the effects of monetary policy on output. Several researchers suggest that monetary policy has an ambiguous or no significant impact on real output, yet several others provide evidence that the impact of monetary policy on the real economy varies over the business cycle.[1] For instance it has been proposed that the asymmetric impact of monetary policy on output over the business cycle may arise from the convexity of the aggregate supply curve. Since output is initially low in the flatter part of the supply curve, when the economy is in a recession, shifts in the aggregate demand due to the changes in monetary policy would result in a larger impact on output than on prices. In contrast, when the economy is in a state of expansion, changes in monetary policy will have a weaker impact on output than on prices as the supply curve becomes steeper.

When we examine the literature on the importance of financial markets, we come across a large and growing body of work which argues that credit market imperfections act as a propagator of shocks and play a significant role in magnifying output fluctuations.[2] This literature suggests that an economy with deeper financial markets can promote investment efficiency and productivity growth as innovative firms continue to raise funds from potential lenders even during economic recessions.[3] Yet, to our knowledge, earlier studies have not considered the role of financial markets in evaluating the asymmetric impact of monetary policy on real output. In this paper, we take a novel approach by examining the of role financial markets to evaluate the asymmetric impact of monetary policy on real output over the business cycle. In particular, we strive to find out whether the extent of financial depth extenuates or amplifies the impact of monetary policy on output growth over the business

[1] For example, Garcia and Schaller (2002), Lo and Piger (2005), Peersman and Smets (2005) and Dolado and María-Dolores (2006) show that monetary policy has an asymmetric effect on output over the business cycle. In contrast, Stock and Watson (2003), Uhlig (2005) and Sims and Zha (2006) suggest that monetary policy has no significant impact.

[2] Levine (2005) and Papaioannou (2007) provide detailed surveys of the literature.

[3] Greenwood et al. (2010) provide an analytical model along these lines.

cycle. Surprisingly, this is an open question and it has not been explored before.

To examine the role of financial markets in determining the impact of monetary policy on real output, we implement an instrumental variables Markov regime switching framework as suggested by Spagnolo et al. (2005). The Markov regime switching framework allows the output growth rate to depend on a latent state variable, which characterizes expansions or recessions, permitting investigation of asymmetries in the data. Moreover, given that the model assigns a larger relative weight to observations that are likely to coincide with recessions in estimating the recession coefficients, this approach can be useful to identify the recessionary periods. Most importantly, using this framework we examine whether the extent of financial depth dampens or amplifies the impact of monetary policy over the business cycle and whether there is any regime dependency in this relation. We achieve this goal through an interaction term between monetary policy and financial depth measures whose coefficient varies over different states. Last but not the least, the instrumental variables approach allows us to overcome endogeneity problems that may exist in our model. To gauge the stance of the monetary policy, we follow the earlier studies and use the first difference of the logarithm of the federal funds rate. The analysis is carried out using quarterly US data over the period 1971:q1–2011:q4.

As we discuss our findings, we ensure that the results are robust by utilizing two separate financial depth measures. Our financial depth measures include i) the value of credits by financial intermediaries to the private sector divided by GDP, and ii) the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks).[4] We also estimate the model over 1971:q1-2008:q3 to exclude the period that followed the collapse of the Lehman Brothers as the framework of monetary policy after this episode changed substantially. Nevertheless, the empirical results obtained for both measures of

[4] The first 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) for more information.

financial depth for either sample periods are similar and can be summarized as follows. i) Monetary policy has a regime dependent impact on output growth: a restrictive monetary policy has a negative and significant impact on output growth during recessions, yet this effect is not significant during expansions; ii) 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; however, deeper financial markets could help firms to raise funds even in hard times.

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 we implement to carry out our analysis. Section 4 presents the empirical results. Section 5 concludes the study.

2 Brief Literature Review

A substantial literature examines the asymmetric impact of monetary policy on the real economy. To that end several researchers have considered the asymmetric effects of monetary policy on the economy with respect to the type of shocks (positive *versus* negative) and the size of shocks (small *versus* large).[5] In this section, we provide a brief review of those studies which implement nonlinear methods to capture the asymmetric impact of monetary policy on output growth. We also review the literature that examines the role financial depth on output growth.

Several researchers have used the Markov regime switching methodology to examine the asymmetric impact of monetary policy on output. For instance, Garcia and Schaller (2002),

[5] Among others see Cover (1992), and Thoma (1994).

show that monetary policy in the US have larger effects during recessions than expansions. Peersman and Smets (2002, 2005) asses whether euro-area monetary policy have asymmetric effects across the business cycle in seven euro-area countries. They show that area-wide shocks have more profound effects on output during recessions than expansions. Kaufmann (2002), 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. Using 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. This line of literature argues that credit market imperfections act as a propagator of shocks and play a significant role in magnifying output fluctuations.[6] In this context empirical researchers point out that countries with developed financial systems experience a higher and a more stable output growth. For

[6]Levine (2005) and Papaioannou (2007) provide detailed surveys of the literature. Kiyotaki and Moore (1997), Bernanke et al. (1999) and Mendoza (2010) present analytical foundations to explain the importance of financial markets on output fluctuations.

instance, Easterly et al. (2001) suggest that better access to credit in a deeper financial system leads to less output volatility in the economy. Denizer et al. (2002) provide evidence that countries with well-developed financial markets have less volatility in real per capita output, consumption and investment growth. Bekaert et al. (2005) show that financial liberalization leads to lower volatility in consumption growth and output growth. Subsequently, Beck et al. (2006) provide evidence that financial development may reduce the impact of macroeconomic shocks on growth volatility. Dynan et al. (2006) conclude that financial innovation contribute to the stabilization of economic activity.

Overall, 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 when they wish to carry out investment expenditures, dampening the impact of aggregate 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 needs 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 variables 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). As commonly used in the literature, we proxy for monetary policy by the first difference of the logarithm of the Federal Funds rate (mp_t), IFS line 60b.[7] 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. We use two different proxies to measure financial depth, (fd_t).

Our first financial depth proxy, proposed by Levine et al. (2000), is the ratio of credits by financial intermediaries to the private sector divided by GDP which is defined as: $0.5 * \left[\frac{F(t)}{P_{end}(t)} + \frac{F(t-1)}{P_{end}(t-1)}\right] / \frac{GDP(t)}{P_{ave}(t)}$. 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).

[7] Among others see Sims (1992), Bernanke and Mihov (1998).

Specifically, this depth measure includes only credits issued by banks and other financial intermediaries. Moreover, this definition improves upon the previous measures of financial depth by correctly deflating the nominal measures of financial intermediary liabilities and assets. As pointed out by Levine et al. (2000) the items in financial intermediary balance sheets are measured at the end of the period but GDP is measured over the period. Thus, Levine et al. (2000) deflate the end-of-period items in financial intermediary balance sheets by the end of period consumer price indices (CPI) while deflate the GDP series by the average CPI for the period. Then, they compute the average of the item in period t and $t-1$ and divide it by the real GDP measured in period t.[8]

To check for the robustness of our findings, we use an additional measure of financial depth. The second measure, is the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks).[9] This measure, originally proposed by King and Levine (1993), is used by several researchers.[10] 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.

3.2 Methodology

To examine whether the impact of monetary policy on real output growth differs over the business cycle we implement a Markov switching framework. The complication that may arise from this approach is due to the potential endogeneity of the monetary policy and the financial depth measures which we use as explanatory variables in the output growth

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

[9]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.

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

equation. In this case, using the 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.[11] To overcome the endogeneity problem some researchers have used innovations derived from structural VAR models. However this approach requires the researcher to impose (uncontroversial) restrictions to render the model identified.[12] Here, we follow an approach suggested by Spagnolo et al. (2005) to overcome the endogeneity problem, and estimate the following system of equations for output growth and the instrumenting equations for monetary policy and for financial depth:

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

where

$$\begin{aligned}
\alpha_{s_t} &= \left[\alpha_0\left(1-s_t\right)+\alpha_1 s_t\right],\ \gamma_{st}^{i} = \left[\gamma_0^{(i)}\left(1-s_t\right)+\gamma_1^{(i)} s_t\right], \\
\beta_{s_t} &= \left[\beta_0\left(1-s_t\right)+\beta_1 s_t\right],\ \varphi_{s_t} = \left[\varphi_0\left(1-s_t\right)+\varphi_1 s_t\right], \\
\eta_{s_t} &= \left[\eta_0\left(1-s_t\right)+\eta_1 s_t\right],\ \text{and } \sigma_{s_t} = \left[\sigma_0\left(1-s_t\right)+\sigma_1 s_t\right]
\end{aligned}$$

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

[11] 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.

[12] Benati and Surico (2009) point out that for a certain class of DSGE models, VARs are unable to unveil both the true dynamics of the state variables and the true shocks even if the appropriate identification restrictions were used.

where

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

$$
fd_t = \mu_{s_t} + \sum_{s_t=0}^{1} \sum_{i=1}^{k} \lambda_{s_t}^i fd_{t-i} + \chi_{s_t} \varsigma_t \tag{3}
$$

where

$$
\begin{aligned}
\mu_{s_t} &= \mu_0(1 - s_t) + \mu_1 s_t,\ \lambda_{s_t}^i = \lambda_0^i(1 - s_t) + \lambda_1^i s_t \text{ and} \\
\chi_{s_t} &= \chi_0(1 - s_t) + \chi_1 s_t
\end{aligned}
$$

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 coeffcients. The disturbance terms in equations (1-3) are captured by ϵ_t, ξ_t and ς_t, respectively. Output growth 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 Ω_{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.[13] 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.[14]

To estimate this model we use a recursive algorithm explained in Hamilton (1994).[15] This process yields a sample likelihood function which can be maximized numerically with respect to $\nu = (\alpha_0, \alpha_1, \gamma_0^{(1)}, \gamma_1^{(1)}, \gamma_0^{(2)}, \gamma_1^{(2)}, \cdots, \gamma_0^{(j)}, \gamma_1^{(j)}, \delta_0^{(1)}, \delta_1^{(1)}, \delta_0^{(2)}, \delta_1^{(2)}, \cdots, \delta_0^{(j)}, \delta_1^{(j)}, \phi_0^{(1)}, \phi_1^{(1)},$ $\phi_0^{(2)}, \phi_1^{(2)}, \cdots, \phi_0^{(j)}, \phi_1^{(j)}, \beta_0, \beta_1, \eta_0, \eta_1, \sigma_0, \sigma_1, \varphi_0, \varphi_1, \kappa_0, \kappa_1, \theta_0, \theta_1, \mu_{0t}, \mu_{1t}, \lambda_{0t}^i, \lambda_{1t}^i, \sigma_{w_{0t}}, \sigma_{w_{1t}})$, 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

[13]For instance Svensson (1997) argues that monetary policy will affect output with a one year delay.
[14]These results are available from the authors upon request.
[15]See Spagnolo et al. (2005) for more details on estimation.

state s_t and the history of the system:

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

Here $\widehat{mp}_{t-1} = \kappa_{s_t} + \sum_{s_t=0}^{1} \sum_{k=1}^{K} \delta_{s_t}^{(k)} y_{t-k-1} + \sum_{l=1}^{L} \phi_{s_t}^{(l)} mp_{t-l-1}$ and $\widehat{fd}_t = \mu_{s_t} + \sum_{s_t=0}^{1} \sum_{i=1}^{k} \lambda_{s_t}^{i} fd_{t-i}$ 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 2×1 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 Σ; $\{s_t\}$ 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[16]

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

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

[16]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

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

We denote this alternative model as C. In Model C, the expectation about the future state of output will affect the current policy decisions. Here, the unobserved state of 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 ($s_t^{mp} = s_{t-1}^y$). In this model D the transition probability matrix of s_t^z will be:

$$P^D_{ymp} = \begin{bmatrix} p^y_{11}p^{mp}_{11} & p^y_{11}p^{mp}_{21} & 0 & 0 \\ 0 & 0 & p^y_{21}p^{mp}_{12} & p^y_{21}p^{mp}_{22} \\ p^y_{12}p^{mp}_{11} & p^y_{12}p^{mp}_{21} & 0 & 0 \\ 0 & 0 & p^y_{22}p^{mp}_{12} & p^y_{22}p^{mp}_{22} \end{bmatrix} \tag{11}$$

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 attempts, we exclude this variable from our final model.[17] 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 estimate this framework for two separate financial depth measures to confirm the robustness of our results. The results for each measure are similar and can be summarized as follows.

- Monetary policy exert a regime dependent impact on output growth. We find that a restrictive monetary policy have a significant negative impact on output growth during recessions. Monetary policy has no significant impact on output growth during expansions.

- The interaction term between financial depth and monetary policy takes a positive and significant coefficient during recessions. This observation suggests that financial depth mitigates (and even nullifies) the adverse effects of monetary policy in recessionars. In expansionary states, this effect becomes insignificant.

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 the structural break tests proposed by Hansen (1992b), Andrews (1993), and Andrews and Ploberger (1994) for the

[17]Results for a more general model including the financial depth measure are available from the authors.

output growth equation in (1) using both financial depth measures. We apply the same tests for the instrumenting equation for our financial depth measures as given 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 results in Table 2 show that the Hansen (1992b) tests confirms 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 in all cases model B, where the unobserved states are perfectly correlated (i.e., the states are in the same phase at each point of time), receive support from the data. Equipped with this information, we estimate the system of equations (1-4).

Table 3 about here

4.2 Estimation Results

Table 4 presents the results for the output growth equation. The results for the instrumenting equation, which are available upon request from the authors, are suppressed for parsimony. The first two columns of Table 4 give the results when we use the ratio of credit by financial intermediaries to the private sector divided by GDP as a measure of financial depth. To check for the robustness of our findings, the fourth and fifth columns of the table provide the results 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). Observe for both sets of results that the state dependent growth rate α_0 is positive and α_1 is negative. Based on these estimates we assume that state 0 captures expansions and state 1 captures recessions.

Table 4 about here

To scrutinize the impact of monetary policy on output growth we examine the coefficients associated with $\widehat{mp}_{t-1}$: β_0 and β_1. The monetary policy coefficient is negative and significant only in recessions ($\beta_1 < 0$). This implies that the impact of monetary policy on output is asymmetric over the business cycle. Considering the absolute value of the point estimates, the negative impact of a tightening monetary policy on output growth in a recession is about twenty fold more than that in an expansion. Furthermore, based on the point estimates our model suggests that a one percentage point increase in interest rates during a recession leads to a reduction of 0.25 percentage point in output growth. These results are in line with the theoretical models and empirical findings which provide evidence in favor of asymmetric impact of monetary policy.[18]

Next we asses whether the real effects of monetary policy vary over the business cycle with the level of financial depth. Given the results in the literature, we expect to find that the impact of monetary policy should be dampened with the deepening of financial markets. Firms that operate in an economy with deeper financial markets have generally easier access to credit. The existence of credit lines in times of economic bottlenecks can help to smooth output fluctuations as firms 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 recessions, η_1, is positive and significant. This observation provides evidence that financial depth plays a significant role during recessions in the transmission of monetary policy. Yet, the coefficient that captures the role of financial depth in expansions, η_0, is insignificant. The insignificance of η_0 can be explained by the fact that firms have access to a wider variety of sources of finance in periods of expansion.

[18] See amongst others, Garcia and Schaller (2002) and Lo and Piger (2005).

The results based on the second measure of financial depth are consistent with the previous set. Here, we observe that the impact of monetary policy on economic growth is negative in both regimes but it is significant only in recession. When we turn to asses the role of financial depth in the transmission of monetary policy, we see that the interaction term has a positive impact in both regimes but it is significant only in recessions, mitigating the adverse impact of monetary policy during recessions as we discussed earlier.

It is also useful to look at Figures 1 and 2 which provide the filter probabilities of State 1 (recessionary regime) 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 6). In fact the results are better for the second financial depth measure (the ratio of claims on the nonfinancial private sector to total domestic credit).[19] It should be noted that the persistence of recession is stronger in the model than in the data. However, the business cycle turning points captured by model presents a good match to those announced by the NBER.

Figure 1 about here

Figure 2 about here

Table 6 about here

Last but not the least, we estimate the model over 1971:q1-2008:q3 to see if the results are robust to the exclusion of the data that followed the collapse of the Lehman Brothers.[20]. Results given in Table 5 are similar our earlier observations. The impact of monetary policy on economic growth is negative and significant in recessions while it is insignificant in

[19]The model when we use the first measure of financial depth fails to capture the recession in 1990 (see, Figure 1). This might be due to the fact that this recession was relatively moderate and lasted only two quarters.

[20]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.

expansions. 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 recessions, mitigating the adverse impact of monetary policy during recessions as we discussed earlier.

Table 5 about here

Overall, the results based on two sample periods and two separate 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 The Full Impact of Monetary Policy

So far we have shown that monetary policy exert a significant negative impact on real output growth during recessions 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

$$\partial y_t/\partial \widehat{mp}_{t-1} = \left[\widehat{\beta}_0\,(1-s_t)+\widehat{\beta}_1 s_t\right]+\left[\widehat{\eta}_0\,(1-s_t)+\widehat{\eta}_1 s_t\right]\widehat{fd}^{*}_{t-1} \tag{12}$$

at various levels of financial depth. To compute the total impact of monetary policy on output growth, we use the point estimates for $\widehat{\beta}_i$ and $\widehat{\eta}_i$ in Table (4). The estimates $\widehat{\beta}_i$ and $\widehat{\eta}_i$ capture the impact of monetary policy on output growth and that arises from the interaction between monetary policy and financial markets, respectively. The index $s_t = 0, 1$ denotes the states of the economy where 0 represents recessions and 1 represents expansions. $\widehat{fd}^*_{t-1}$ 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 (7) the full impact of monetary policy on output growth along with the associated standard errors.[21] In Figure 3, we plot these point estimates along with the corresponding 95% confidence interval.

Table 7 about here

Figure 3 about here

Panel A in Table (7), (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 (7), (also see State 1, Figure (3)), we observe that an adverse monetary policy has a significant negative impact on output growth in recessions 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 recession, as liquidity dries up, the economy suffers considerably. This is 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

[21] Note that financial depth is defined as the ratio of credits by financial intermediaries to the private sector divided by GDP.

central banks inject 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 in the transmission 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 between recessions and expansions. The investigation is carried out using quarterly US data over 1971:q1–2011:q4.

We consider 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 expansions and contractions.[22] 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 variables 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 have an asymmetric impact on output growth: a restrictive monetary policy leads to a significant drop in output growth during recessions, while such a policy does not have any significant impact on output during expansions. When we examine the role of financial markets, we see that financial depth plays a significant role in mitigating the adverse effects of tight monetary policy in recessions. 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 recessions, such effects diminishes or even nullifies when the financial markets are deeper. Last but not the least, we show that our results are robust compared to alternative financial depth measures and different sample periods.

Our results have important policy implications as they point out the importance of financial deepening in the transmission of monetary policy, especially in recessions. 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 provide a regulatory framework which will help and stimulate the financial institutions to provide the markets with much needed depth and liquidity especially during periods of recessions. In this context, we suggest that it would be fruitful to scrutinize data from other countries and examine to what

[22]Note that prior to estimating our model we test whether the unobserved states of the variables in our model are synchronized or not. Verifying that this is the case, we estimate the model.

extent cash injections into the financial system have helped economies on either side of the ocean 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.

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

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

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

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

	Financial Depth 1		Financial Depth 2	
Parameter	Estimate	Std. Error	Estimate	Std. Error
α_0	0.004***	0.001	0.005***	0.001
γ_0^1	0.297**	0.124	0.121	0.099
γ_0^2	0.250*	0.128	0.328***	0.111
β_0	0.012	0.031	-0.081	0.149
η_0	-0.009	0.016	0.088	0.174
σ_0	0.004***	0.000	0.005***	0.001
α_1	-0.001	0.003	-0.007	0.009
γ_1^1	0.307***	0.114	0.352***	0.133
γ_1^2	0.557*	0.303	0.507	0.562
β_1	-0.250***	0.091	-1.473**	0.585
η_1	0.130***	0.047	1.680**	0.643
σ_1	0.009***	0.001	0.009***	0.001
p	0.918***	0.046	0.864***	0.064
q	0.910***	0.042	0.873***	0.047
Log likelihood	1024.600		1266.100	

Notes: *, **, *** denote significance at the 10%, 5% and 1% levels. State 0 and State 1 capture expansion and recession, respectively. Financial depth 1 (fd1) is measured by the ratio of credits by financial intermediaries to the private sector divided by GDP and defined as: $0.5 * \left[\frac{F(t)}{P_{end}(t)} + \frac{F(t-1)}{P_{end}(t-1)}\right] / \frac{GDP(t)}{P_{ave}(t)}$. Financial depth 2 (fd2) is the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks).

Table 5: Asymmetric Effects of Monetary Policy on Output Growth: Pre-Lehman Brothers Collapse Period (1971:q1-2008:q3)

	Financial Depth 1		Financial Depth 2	
Parameter	Estimate	Std. Error	Estimate	Std. Error
α_0	0.004***	0.001	0.005***	0.002
γ_0^1	0.298**	0.118	0.090	0.107
γ_0^2	0.263*	0.143	0.315***	0.101
β_0	0.020	0.039	0.064	0.106
η_0	-0.016	0.026	-0.090	0.133
σ_0	0.004***	0.000	0.004***	0.000
α_1	0.000	0.004	-0.110	0.664
γ_1^1	0.225***	0.111	0.245*	0.128
γ_1^2	0.618**	0.307	6.375	35.870
β_1	-0.203***	0.077	-3.276	8.699
η_1	0.109**	0.044	2.432*	1.278
σ_1	0.009***	0.001	0.009***	0.001
p	0.942***	0.042	0.890***	0.056
q	0.935***	0.037	0.895***	0.046
Log likelihood	962.090		1199.300	

Notes: *, **, *** denote significance at the 10%, 5% and 1% levels. State 0 and State 1 capture expansion and recession, respectively. Financial depth 1 (fd1) is measured by the ratio of credits by financial intermediaries to the private sector divided by GDP and defined as: $0.5 * \left[\frac{F(t)}{P_{end}(t)} + \frac{F(t-1)}{P_{end}(t-1)}\right] / \frac{GDP(t)}{P_{ave}(t)}$. Financial depth 2 (fd2) is the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks).

Table 6: 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 7: 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 State 1 (Recession Regime), Financial depth variable: the ratio of credits by financial intermediaries to the private sector divided by GDP

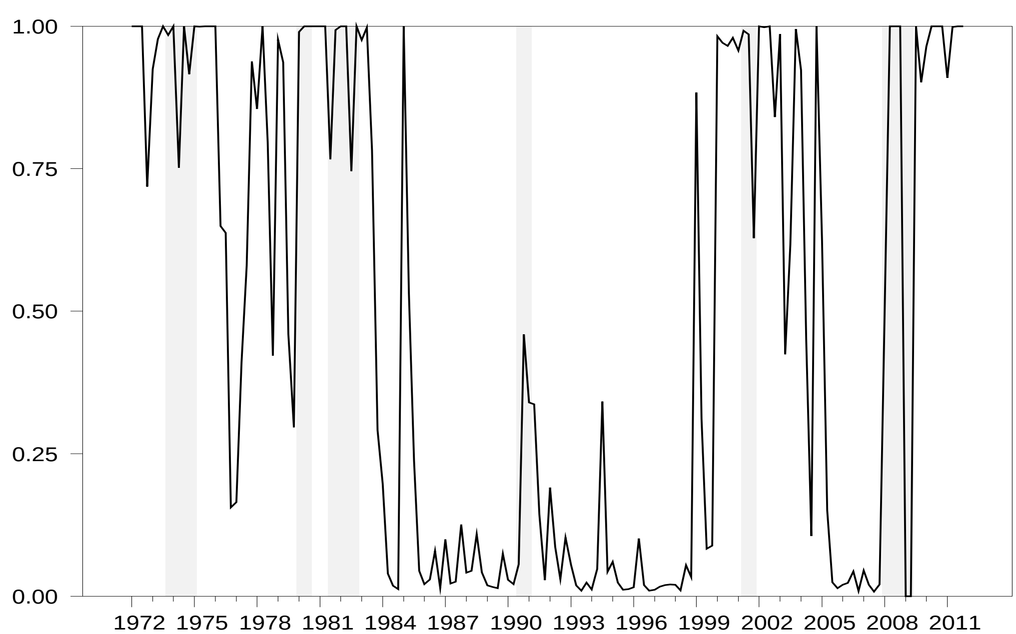

Figure 2: Filter Probabilities for State 1 (Recession Regime), Financial depth variable: the ratio of claims on the nonfinancial private sector to total domestic credit (excluding credit to money banks

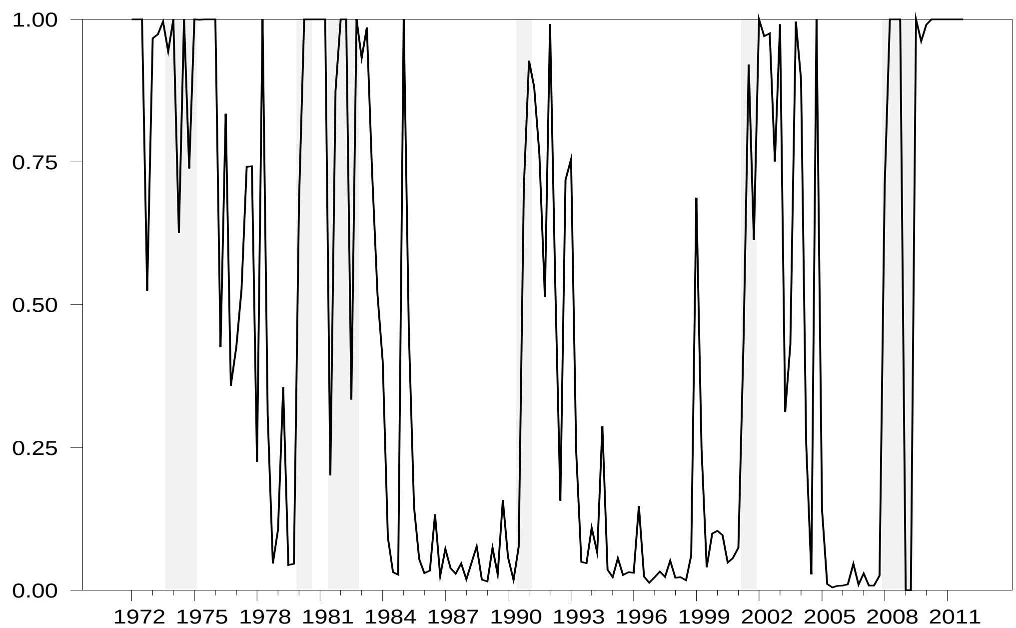

Figure 3: Total Effects of Monetary Policy