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Sheffield Economic Research Paper Series

SERPS no. 2022003

ISSN 1749-8368

4 March 2022

Monetary Policy and Bank Liquidity Creation: A Multivariate Markov Switching Approach

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March 4, 2022

Abstract

Despite its importance, there is little empirical research on how monetary policy affects bank-liquidity creation. We propose a general Markov switching framework to examine the effects of monetary policy on liquidity creation while accounting for endogenous regime switches and capturing the idea that financial crises could be due to a regime switch from information-insensitive debt to information-sensitive debt. Using total liquidity creation and its components for different bank-size categories, we show that monetary policy has a regime dependent impact. Furthermore, based on the filter probabilities, our analysis also raises the possibility of a future financial turmoil.

Keywords: Liquidity creation; bank size; monetary policy; policy trade-off; asymmetric effects; Markov switching

JEL classification: E32, E52

1 Introduction

It is well accepted that banks play an important role in an economy by providing funds to businesses and consumers. Researchers argue that while bank loans might promote economic growth, excessive lending could as well sow the seeds of a future financial crisis.¹ To date, although the bank lending channel of monetary transmission mechanism has been extensively

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¹See Thakor (2005), Borio and Zhu (2012), Acharya and Naqvi (2012) and Jiménez et al. (2014), along these lines.

studied, despite its importance, the question whether monetary policy can be used as an instrument to control banks' on-balance sheet and off-balance sheet liquidity creation has attracted little attention.

In this study, we propose a novel framework to analyse the impact of monetary policy on the growth rate of liquidity creation. We employ a multivariate Markov regime switching (MRS) model, which treat financial crisis as an endogenous process as highlighted in Gorton and Ordoñez (2014). Our examination offers two key contributions to the literature that a linear framework would be silent on. Firstly, because our empirical framework endogenously determines the states of the economy, we can examine the impact of monetary policy on liquidity creation across normal versus crisis states without imposing any restrictions.² Secondly, our framework allows us to scrutinize the presence of any trade-off between macro-economic and financial stability yielding new insights in relation to the macro-prudential role of monetary policy.

Our investigation provides four novel findings. We first show that the impact of monetary policy on liquidity creation depends both on the type of liquidity creation (total, on- or off-balance sheet liquidity creation) and on the banks' size. Secondly, we observe that the filter probability of the information-insensitive regime (state 2) is high for a large part of our sample, including the period prior to the financial crisis of 2008 and after the financial crises from 2010 up until to the end of the sample, 2016.^{3,4} Thirdly, we find that monetary policy shocks are expansionary for most of the time regardless of the state of economic growth (states 2 or 4) as captured by the estimated filter probabilities summarized in Figure A1.⁵

²See Kaufmann (2002), Garcia and Schaller (2002), Dolado and María-Dolores (2006) and Caglayan et al. (2017) among others who argued that monetary policy effects depend on the state of the economy.

³See Figure A1 in Appendix, which plots the filter probability of State 2 and 4 for total liquidity creation

⁴Gorton and Ordoñez (2014) define information-insensitive regime as the regime during which a lender does not have an incentive to question the quality of the collateral that backs the loan. They show that a credit boom will build up if the persistence of the information-insensitive regime is high. In our model, explained below, the information "insensitive regime" is reflected by the filter probability of state 2.

⁵Monetary policy shocks reflect policy variation (i.e., interest rate changes) that are purged from changes caused by central bank's information: "Information Shocks". The latter are surprises concerning central

Lastly, we observe that monetary policy has an asymmetric impact on the growth rate of liquidity creation. In particular, monetary policy shocks affect the on-balance sheet liquidity creation negatively (and significantly) when the latter is at the high-growth regime and affect the off-balance sheet liquidity creation positively at the low-growth regime.

We carry out our investigation using quarterly US banking data covering the period between 1990:q1 and 2016:q4. Besides total liquidity creation, we also use on-balance sheet and off-balance sheet liquidity creation data, as detailed in Berger and Bouwman (2009). One significant challenge in our investigation is the identification of monetary policy shocks. In our examination, we implemented the monetary policy shock series made available by Jarocinski and Karadi (2020), which did not contain any information shocks. Hence, monetary policy shocks are not subject to the “problem of foresight” where policy shock are not sterilised from private information.⁶

Overall, our results present a striking similarity in liquidity creation growth between the pre and the post great recession periods. Hence, considering the accommodative policies implemented during the Covid19 pandemic, a continuing monetary policy that allows building up of a credit boom can induce a subsequent financial turmoil. Consequently, it is important to examine the data using an Markov regime switching (MRS) model to address the BIS (2015) argument that monetary policy should systematically consider financial stability while accounting for the conventional targets (inflation and output growth).

The paper is structured as follows. Section 2 provides a review of the empirical literature. Section 3 introduces the data, the model and the methodology that we implemented in this investigation. Section 4 presents the empirical results. Section 5 concludes the study.

bank’s assessment of the economic outlook. Therefore, positive shocks are contractionary shocks while negative shocks are expansionary.

⁶Jarocinski and Karadi (2020) use high frequency financial data to separate monetary shocks from information shocks. Also see Ramey (2016) who explain that the use of high frequency data are ideal to account for private information and ensure that a shock is unanticipated.

2 Brief Literature Review and Theoretical Underpinnings

Classical micro-founded models of banking such as Bryant (1980) and Diamond and Dybvig (1983) argue that banks create liquidity through their on-balance sheet activities, by financing business loans with transactions deposits. Subsequently, Holmstrom and Tirole (1998) and Kashyap et al. (2002) have shown that banks can also create liquidity through off-balance sheet commitments and letters of credit. To date, extensive research has shown that monetary policy has a significant impact on banks' lending behavior and subsequently on economic growth.⁷ However, Acharya and Naqvi (2012) argue that when banks experience a surge in deposit flows, credit increases while lending standards are softened. Under these circumstances, if an increase in bank lending is long-lasting, asset prices might increase above sustainable levels and ultimately undermine the financial system.

Surprisingly, despite the extensive literature on monetary transmission mechanism through bank lending channel, research as to whether monetary policy can be used to control liquidity creation is rather limited. To our knowledge, Berger and Bouwman (2017) is the only study that has investigated the impact of monetary policy on liquidity creation across periods of normal times and financial crises. In their examination, they treat the recent financial crisis as an exogenous shock by using a dummy variable to account for regime changes. Although this approach is consistent with models that display persistence, it cannot detect crises unless the size of the impending exogenous shock is big. To that end, Gorton (2012) argue that models with financial frictions, such as Kiyotaki and Moore (1997) and Bernanke and Gertler (1989), cannot produce crisis except through a large shock.

Subsequent research by Dang et al. (2013) and Gorton and Ordoñez (2014) has shown that financial fragility is an endogenous process that exhibits a regime switch from an information-insensitive to information-sensitive debt. Such a switch can be driven by the loss of confidence

⁷See, for instance, Bernanke and Blinder (1988), Boot et al. (1993) and Kashyap and Stein (2000).

due to an exogenous shock, for instance, a gloomy economic forecast. However, Gorton and Ordoñez (2014) have argued that whether a shock would lead to a crisis depends on the duration of the information-insensitive regime; a regime during which agents do not have an incentive to produce information about the quality of the backing collateral of short-term debt. In this environment, a credit boom would occur while low interest rates enhance banks' risk-taking behaviour.⁸ In this framework, a small shock, which would have no effect in the beginning of a credit boom, can shift the economy into the information-sensitive regime if the credit boom has been ongoing for some time. Here, while the shock is exogenous, the emergence of the crisis can be endogenous.

Considering these recent theoretical developments, we argue that the use of Markov-regime switching models (MRS) would be most suitable in examining the impact of monetary policy on liquidity creation. A MRS model captures the observable dynamics of the fundamentals as well as the switches of unobserved state variables that follow an independent Markov process. As Jeanne and Masson (2000) argue, changes in the unobserved state variables reflect market expectations of the economic agents. In our framework, we endogenize regime changes by allowing the unobserved states of the variables included in our model to interact with each other.

3 Data and Econometric Methodology

We conducted the analysis using quarterly US data over the period between 1990:q1 and 2016:q4. We use Bouwman's quarterly liquidity creation data which is detailed in Berger and Bouwman (2009).⁹ The dataset provides information on total and components of liquidity creation on all banks as well as small, medium and large bank size categories. Table 1 presents the basic statistics on the level and growth of liquidity creation. The left hand side entries present the level of liquidity created by all banks and by bank categories. The table

⁸See, for instance, Borio and Zhu (2012), Jiménez et al. (2014) Angeloni et al. (2015).

⁹Data are available from <http://web.mit.edu/cbouwman/www/data.html>

clearly shows that the liquidity creation by large banks exceeds that of by small and medium banks by a considerable amount. The right hand side of the table presents basic statistics on liquidity growth, which we focus in our study.

We see that the average liquidity creation growth rate (both for total liquidity and its components) lie around 1% with a standard deviation of about 2-3% per quarter. This suggests that liquidity creation growth may be quite high or low in some quarters. We see that total liquidity growth can be as high as 4% or as low as -5%, while the spread for off-balance liquidity growth is the highest. When we turn our attention to bank size statistics, we find that the associated spreads are much higher for small banks than that for large banks, while the corresponding average and standard deviations are similar to what we see in panel A for all banks. Different from small and large banks statistics, medium bank average liquidity creation growth figures are much smaller. Inspecting the data closely, we notice that the spread in liquidity growth for medium banks is high. It is this large variation in liquidity growth causes the average values to a lower value than both small and large banks.

We measured output growth (y_t) by the first difference of the logarithm of real GDP (2016=100), IFS line 99b. The average quarterly growth rate is 0.6% with a standard deviation of 0.06%. The maximum quarterly growth rate observed during period of investigation is 1.8% and information-sensitive minimum is -2.2%. In our examination we employed the monetary policy shock series made available by Jarocinski and Karadi (2020). More information is provided in the following section.

3.1 Measuring Monetary Policy Shocks

One of the main challenges of investigating the impact of monetary policy on liquidity creation is the identification of monetary policy shocks. The main vehicle researchers have employed in the literature to identify monetary policy shocks has been the structural Vector

Autoregressive Analysis (SVAR) models. However, SVAR models have been subjected to severe criticism. In particular, Benati and Surico (2009) have shown that there is a disconnect between the structural shock of an underlying DSGE model and the shock identified by the SVAR representation of the same DSGE model.

In response to this criticism, economists identified structural shocks using narrative methods.¹⁰ For example, using this approach Hamilton (1985) identified oil shocks; Romer and Romer (2004) identified monetary policy shocks; and Ramey (2011) identified fiscal policy shock. However, Stock and Watson (2018) and Leeper (1997) among other showed that narrative shocks are not exogenous because they do not control for private information about the future state of the economy: “the foresight problem”. Ramey (2016) explain that high frequency future financial data are ideal to get around the foresight problem and ensure that a shock is unanticipated. Within a similar line of thought, Jarocinski and Karadi (2020) separate monetary policy shock from information shock by examining the high frequency comovement of interest rate and stock prices in a narrow window around the policy announcement.¹¹ We use the monetary policy shocks that were constructed by Jarocinski and Karadi (2020) on a monthly basis from January 1990 to December 2016. We transform the series into quarterly frequency to align the frequency with the remaining variables in our data.

3.2 Methodology and Regime Identification

In this study, we employ a Markov switching framework to estimate the impact of monetary policy on liquidity creation by accounting both for the observed dynamics of fundamentals and the dynamics of their unobserved state variables. The unobserved state variable, denoted by s_t , reflects market expectations. This variable takes values in the finite set $F = \{0, 1\}$

¹⁰Narrative methods construct structural shocks from historical data which can explain a particular change in a variable.

¹¹Monetary policy shocks are identified by negative comovement between interest rate and stock prices while information shock are identified by positive comovement of interest rate and stock prices.

and follows a Markov process with transition probability $p = [p]_{ij}$, with $i, j \in F$. Probability $p_{ij} = P(s_t = j | s_{t-1} = i)$ denotes the transition probability that regime i is followed by regime j . If transition probabilities are time-invariant then the regime shifts from a normal to a crisis period would be driven by an exogenous shock unrelated to fundamentals.

In our empirical examination, we allow for endogeneity by assuming that the behaviour of the unobserved states is not common across the included variables in the model. In particular, we adopt a framework suggested by Phillips (1991) that the unobserved states can be independent, perfectly correlated, or lead/lag each other.¹² Consequently, by considering the interactions between the unobserved states of the growth rate of liquidity creation, GDP growth and monetary policy, we can endogenize the switch between the normal and crisis times. In that sense, our empirical model relates to Gorton and Ordoñez (2014) who argue that changes in the perceived quality of collateral resulting from an external shock can endogenously push the economy into a period of crisis.

To examine the linkages between liquidity creation, output growth and monetary policy we consider a 3×1 vector $x_t = [\Delta LC_t, y_t, mp_t]'$ such that

$$x_t = \mu_{s_t} + \sum_{i=1}^{p_1} \Phi(s_t)_i x_{t-i} + \Sigma(s_t) v_t \quad (1)$$

where $v_t = [u_t^{\Delta LC}, u_t^y, u_t^{mp}]'$ is a Gaussian process with mean zero and positive definite variance covariance matrix $\Sigma(s_t)$. Equation (1) embodies two components: the first component describes the observed dynamics of the fundamentals and the (unobserved) second component, s_t^x , reflects the market expectations. We assumed that the unobserved components of x , denoted by $s_t^{\Delta LC}$, s_t^{gr} and s_t^{mp} , follow a two-state Markov process independent of each other. Therefore, s_t^x is modeled as a linear homogenous eight-state Markov process:

¹²Although we assume that the unobserved state variables are independent of each other, it is possible to introduce restrictions such that the unobserved states would lead/lag each other (see Caglayan et al., 2017).

$$\begin{aligned}
s_t^x &= 1 \text{ if } s_t^{mp} = 1 \text{ and } s_t^{gr} = 1 \text{ and } s_t^{\Delta LC} = 1 \\
s_t^x &= 2 \text{ if } s_t^{mp} = 0 \text{ and } s_t^{gr} = 1 \text{ and } s_t^{\Delta LC} = 1 \\
s_t^x &= 3 \text{ if } s_t^{mp} = 1 \text{ and } s_t^{gr} = 0 \text{ and } s_t^{\Delta LC} = 1 \\
s_t^x &= 4 \text{ if } s_t^{mp} = 0 \text{ and } s_t^{gr} = 0 \text{ and } s_t^{\Delta LC} = 1 \\
s_t^x &= 5 \text{ if } s_t^{mp} = 1 \text{ and } s_t^{gr} = 1 \text{ and } s_t^{\Delta LC} = 0 \\
s_t^x &= 6 \text{ if } s_t^{mp} = 0 \text{ and } s_t^{gr} = 1 \text{ and } s_t^{\Delta LC} = 0 \\
s_t^x &= 7 \text{ if } s_t^{mp} = 1 \text{ and } s_t^{gr} = 0 \text{ and } s_t^{\Delta LC} = 0 \\
s_t^x &= 8 \text{ if } s_t^{mp} = 0 \text{ and } s_t^{gr} = 0 \text{ and } s_t^{\Delta LC} = 0
\end{aligned} \tag{2}$$

In constructing the model, we aim to provide a general framework, which can be used to address policy questions such as the nature of the financial crisis and the trade-off between macroeconomic and financial stability. We do so by assuming that the unobserved states of liquidity creation, output growth and monetary policy shocks are driven by factors that are independent of each other. Therefore, the transition probability matrix of s_t^x is given by $P = P^{mp} \otimes P^{gr} \otimes P^{\Delta LC}$ where P^{mp} , P^{gr} and $P^{\Delta LC}$ are the transition probability matrices of monetary policy, GDP growth and liquidity creation growth, respectively. We call this generalized framework as Model A.

In Model A, we identify the regimes based on the *state-dependent* unconditional mean of the fundamental variables. For all variables, we assign state 1 to denote the high-growth regime and state 0 to reflect the low-growth regime. For example, GDP is in an expansionary phase in state 1 while it is in a recessionary phase in state 0 (i.e., high- *versus* low-growth phase). The crisis regime is depicted by state 8 ($s_t^x = 8$) where the growth rates of both GDP and liquidity creation are low (or even negative) while monetary policy is expansion-

ary. In particular, the transition probabilities at state 8 imply that in a gloomy economic environment (p_{00}^{gr} is high) banks will restrain loans for a prolonged period ($p_{00}^{\Delta LC}$ is high) and monetary policy will remain expansionary (p_{00}^{mp} is high), aiming to boost aggregate demand.¹³ In contrast, state 2 ($s_t^x = 2$, both economic and liquidity creation growth rates are high while the monetary policy is expansionary: $s_t^{gr} = s_t^{\Delta LC} = 1$ and $s_t^{mp} = 0$) is consistent with Gorton and Ordoñez (2014): during a regime of high economic growth and expansionary monetary policy, banks would have no incentive to monitor the quality of collateral (information-insensitive regime) and would maintain a high liquidity creation rate.¹⁴ If the duration of regime 2 is long then an exogenous negative shock such as a forecast of an imminent recession can lead to a crisis. However, unlike in state 2 where monetary policy fuels the risk-taking behaviour of banks, in state 1 ($s_t^x = 1$) monetary policy is contractionary to control both output growth and financial stability.

Using equation 2, we can further identify the potential trade-off between economic growth and financial stability. This tradeoff emerges when GDP and liquidity creation states are in different regimes. In such cases a policy tradeoff can be identified by observing whether the unobserved state of monetary policy shock is in the same regime as the unobserved state of any of the target variables. For example, assume a period during which liquidity creation is in the high growth regime while GDP is going through a period of recession. Monetary policy could either be expansionary to enhance the economic growth or it could be contractionary to bring credit to a sustainable path. In state 3 ($s_t^x = 3$), monetary policy shocks are in the same phase as the growth rate of liquidity creation. Therefore, we can argue that policymakers opt for controlling liquidity creation rather than boosting economic activity. The reverse is true in state 4 ($s_t^x = 4$) where monetary policy focuses on achieving higher economic growth overlooking financial stability. In state 5 ($s_t^x = 5$) monetary policy also

¹³High transition probabilities (p_{ii}) implies the high duration of regime i . The duration of regime i is computed by $P(D = i) = 1/(1 - p_{ii})$.

¹⁴Expansionary monetary policy in high growth regime encourages bank's risk-taking behaviour.

aims to achieve macroeconomic stability by restraining the inflationary pressures that would result from high economic growth. However, availability of limited credit supply in state 5 in conjunction with a contractionary monetary policy might undermine both macroeconomic and financial stability. It is also important to indicate that in state 6 monetary policy is geared to enhance liquidity creation while output growth is already in the high-growth phase. Under such circumstances, monetary policy can undermine both the stability of output and the financial system. In particular, during the high GDP growth phase, low interest rate can increase the risk tolerance and risk-taking behaviour of banks. In short, when there is a trade-off between macroeconomic and financial stability (states 3 to 6) monetary policy might undermine both targets. State 7 is rather unlikely to occur because monetary policy aims to restrict an already suffering economy and a financial sector.

We must emphasize that without considering the transition probabilities one can be misled by the information drawn from the estimates of state-dependent unconditional means and the corresponding filter probabilities. For example, although the unconditional means imply that all unobserved states are in the same phase (i.e., $s_t^x = 8$ or $s_t^x = 1$), the filter probabilities may indicate that there is a trade-off between macroeconomic and financial stability. From this perspective, liquidity creation and GDP growth appear to be in different phases such that s_t^x can be in any of the states 3, 4, 5 or 6. If the filter probability is in state 4 while the estimated state-dependent unconditional means imply that the unobserved state s_t^x is in state 8, then expectations about a future regime-change will impose a significant effect on the current regime. As a consequence, any expectation at the end of time $t - 1$ that the unobserved state s_t^x might switch to state 8 can affect both agent's behaviour and the coefficient estimates at the current state 4.¹⁵

Therefore, we argue that the impact of monetary policy depends on the persistence

¹⁵This is because estimates of state-dependent unconditional means are functions of both filter and transition probabilities.

of economic agents' expectations on the future regime.¹⁶ In other words, the estimated coefficients will be affected not only by the probability that the model will switch to another state but also by the expectation that it will stay in that regime for a long period. It is worth recalling that although regime switching of individual states is exogenous, the switch of the state vector s_t^x is endogenous. This is because the switch for the unobserved state vector s_t^x depends on the interaction of individual states as reflected by the transition probabilities.

4 Empirical Analysis

This section presents our results concerning the impact of monetary policy on liquidity creation and its components: on-balance and off-balance liquidity creation. We assume that the unobserved states of liquidity creation, monetary policy and GDP growth are independent of each other.¹⁷

4.1 Summary of Findings

Unlike Berger and Bouwman (2017) who argued that most of the effects of monetary policy on bank liquidity creation relate to small banks, our investigation yields four novel results. Table A1 presents a summary of results. We first show that the impact of monetary policy on liquidity creation depends both on the type of liquidity creation (total, on- or off-balance sheet) and on the banks' size. When we consider aggregate data, we find that while monetary policy mostly affects on-balance sheet liquidity creation, it affects off-balance sheet liquidity creation positively. When inspect the results across bank size groups, we consistently find that monetary policy has a negative and significant effect on small banks' liquidity creation. In the case of medium banks, with the exception of the on-balance sheet liquidity creation,

¹⁶Davig and Leeper (2007) explain that the lower is the transition probabilities (i.e., low persistence of current regime) the smaller is the impact of expected regime change.

¹⁷We also tested whether the unobserved states are perfectly correlated or lead each other. Our investigation showed that, based on likelihood values, the model with independent states outperformed any other alternatives. The details are available upon request.

the effects of monetary policy is positive and significant. We also provide evidence that monetary policy has a positive and significant impact on large banks' on-balance sheet liquidity creation. Results on liquidity creation by all banks show that, except for the on-balance sheet liquidity creation, the impact of monetary policy on liquidity creation is positive and significant.

Secondly, we observe that the filter probability of the information-insensitive regime (state 2) is high for a large part of our sample, including the post great recession period.¹⁸ In fact, our estimates show that state 2 was the dominant regime prior to the 2008 financial crisis.¹⁹ This observation suggests that the monetary policy authorities could in fact be sowing the seeds of the next financial crisis.²⁰ Thirdly, although the estimated conditional means do not necessarily identify a trade-off between macroeconomic versus financial stability, examining the estimated filter probabilities, we observe that the model also subsists for long periods in state 4 (monetary policy is expansionary at low GDP growth while liquidity creation is at high growth regime) for all liquidity types and bank size groups. Considering the observation that the economy stays in state 2 or state 4 for long periods of time as captured by the filter probabilities shown in Figure A1, monetary policy could contribute to a building-up of a credit boom that might potentially lead to a future financial turmoil.²¹ Fourthly, we show that monetary policy effects on liquidity creation is not symmetric. We observe that monetary policy has a negative impact on the on-balance sheet liquidity creation when the later is in the high growth regime. However, monetary policy effects on the off-balance sheet

¹⁸Recall that in state 2, both economic growth and liquidity creation are high while monetary policy is expansionary.

¹⁹Recall that a prolonged period of low interest rate has lead to a credit boom and a financial crisis in 2008.

²⁰Only in the beginning of 2022, the FED announced that the bank rate will be increased due to the strength of the economy and heightened inflation rates compared to the last 40 years.

²¹During the pre-2008 financial crisis, we experienced a prolonged period of low interest rate and credit boom. After the great recession, all central banks reduced the policy rates to around the zero bound and injected billions of dollars worth of funds into the financial sector to avoid a complete meltdown. Relaxed policies continued until 2022 to accommodate the adverse effects of Covid19 pandemic on the economy.

liquidity creation is negative when liquidity creation is at the low-growth regime.

4.2 Empirical Results

We carry out the estimations for a sample from 1990Q1 to 2016Q4. Table 2 provides the estimates of equation (1) for all banks. Tables 3-5 give the results for small, medium and large banks, respectively. Each table displays three sets of results for Model A. The first set displays the results for total liquidity creation. The following two sets are for on-balance and off-balance liquidity creation, respectively. Furthermore, each table contains four Panels. Panel A lays out the estimated transition probabilities. Panel D presents the estimates of all parameters for liquidity creation including its state-dependent unconditional mean and standard deviation estimates, while Panels B and C provide the estimates of the state-dependent unconditional mean and standard deviation for both monetary policy and output growth.²²

The phase (high- *versus* low-growth) of each unobserved state variable in the tables is determined by the state-dependent unconditional mean of the observed variable denoted by μ_i (and μ_{1-i}) where $i \in \{0, 1\}$. As noted in our discussion of equation 2, high (low) unconditional mean of a variable is assigned to state 1 (0). It is also important to recall that high-growth phase of monetary policy stands for a contraction (negative policy shock), while high-growth phase of output growth or liquidity creation growth captures an expansionary phase. Given these reminders, we can now inspect the tables and scrutinize the impact of monetary policy on liquidity creation.

4.2.1 Liquidity Creation: All Banks

Table 2 presents the effects of monetary policy on total liquidity, and its components. Inspecting Column 1, Panel D, we find that monetary policy has a positive and significant

²²The unreported coefficient estimates for monetary policy and output growth are available upon request from the authors.

impact (at the 10% level) on total liquidity creation ($\beta_1 = 0.272$) when the latter is in the high-growth phase ($\mu_1^{\Delta LC} = 0.005$). Given that the unconditional mean of monetary policy is negative (an expansionary policy shock) and significant (at the 10% level), one would expect total liquidity creation by all banks to be increasing.

Column 3, Panel D, shows that monetary policy has a negative and significant effect (at the 5% level) on the on-balance sheet liquidity creation ($\beta_1 = -0.688$) when it is in the high growth regime. Although the estimated state-dependent unconditional means imply that the model is either in state 4 or 5 (equation 2), their insignificance makes it difficult to argue for a trade-off between macroeconomic and financial stability.²³ Referring to Figure 1, we see that the filter probabilities of state 4 and 5 are indeed low for most of the sample. The figure also conveys that the estimated filter probabilities of state 1 or state 8 (all three variables are in the same state) are high for long periods of time. The filter probability of state 1 was high for most of the period up to 2008.²⁴ There is also evidence that the filter probability of state 6 is high from 2009 to 2010, and after 2014.²⁵ Under such circumstances monetary policy can push the economy into a period of credit boom (state 2) which could lead into a financial crisis. Hence, although the monetary policy before the financial crisis seemed to be consistent with both macroeconomic and financial stability, the fact that the economy experienced a financial crisis raises the question as to whether imperfect information and other frictions in credit markets were at work (e.g., see Bernanke and Gertler, 1995 and Bernanke et al., 1996), or whether, as BIS (2015) pointed out, the reason was due to focusing *predominantly* on the conventional target of low inflation and sustainable output growth while overlooking the stability of the financial sector.

²³When the model is in states 4 and 5, the macroeconomic environment embodies a trade-off in conducting monetary policy between macroeconomic stability versus financial stability.

²⁴State 1 can be referred as the safe regime in the sense that the implemented monetary policy controls both output and liquidity growth—monetary policy is contractionary to limit high economic growth and high liquidity creation.

²⁵In state 6 expansionary monetary policy is implemented to boost liquidity creation, which is in the low growth regime. In state 6 GDP is in high growth regime.

The penultimate column of Table 2 shows that monetary policy exerts a positive and significant impact on the off-balance sheet liquidity creation ($\beta_0 = 0.248$) when the latter is in the low growth phase. Although the estimates of unconditional means suggest that the model could be in state 3 or 6, Figure 2 shows that the filter probabilities associated with these two states are low for most of the sample. In contrast, we observe that the filter probability of the information-insensitive regime (state 2) is high over the periods 1994-1999, 2003-2007, 2009, and 2012-2016. We also see that the filter probability of state 4 is high between 2010 and 2013. This observation reflects that the monetary policy has been expansionary for an extensive period and it might have given rise to an expectation that the policy will remain expansionary inducing bank managers to create further off-balance sheet liquidity.²⁶ This is consistent with the empirical regularities that the economy experienced substantial credit boom prior to the 2008, and eventually collapsed as the financial sector experienced a melt down. But interestingly, our empirical evidence shows that there is a new round of credit boom since the FED has started to inject substantial amounts of liquidity in the financial system to lift the economy following the 2008 financial crisis.

The results we have discussed so far were based on the full sample from 1990Q1 to 2016Q4. For comparison purposes, we also estimated the model using the data from 1990Q1 up to the 2008 financial crisis. The results, which we report in Table A2, Appendix are very similar to those presented in Table 2. In particular, we find that monetary policy affects on-balance sheet liquidity creation negatively while it affects off-balance sheet liquidity creation positively. Different from the full data, the results based on the shorter sample did not provide evidence that monetary policy had a significant impact on total liquidity creation by all banks.

²⁶Note that the expectation formation effect dependent on the persistence of regime 2: $P(s_t^x = 2 | s_{t-1}^x = 2) = p_{00}^{mp} p_{11}^{gr} p_{11}^{\Delta LC}$.

4.2.2 Observations Accounting for Bank-Size categories

We proceed with our investigation concerning the effects of monetary policy shocks on banks liquidity creation by accounting for the bank-size categories. The results show that monetary policy shocks have significant effects on all size groups.

Results for Small Banks

The first column of Table 3 lays out that monetary policy has a negative and significant impact on total liquidity creation ($\beta_0 = -0.171$) when the latter is at the low growth regime ($\mu_0^{\Delta LC} = -0.010$). Estimates of the unconditional means show that the model is either in state 2 or state 7 — the growth rate of liquidity creation and GDP are in the same phase while monetary policy is at a different phase. Figure 3 shows that the filter probability of state 2 is high for a large part of our sample including the periods between 1992 and 1995; 1999 and 2008 and 2011 and 2016. In state 2, monetary policy shocks are expansionary while both liquidity and output are in the high growth regime; a combination that may have led to the 2008 financial crisis. This result is consistent with the view that financial crises have been preceded by an information-insensitive (credit boom) regime. It is also important to notice that the filter probability of state 2 increases soon after the financial crisis and stays consistently high from 2011 to the end of the sample (2016Q4). Indeed, the monetary policy has been expansionary following the great recession and throughout the Covid19 pandemic. These observations consequently raise concern about the sustainability of the current state of the economy during which the interest rates are kept around the zero bound to support the businesses after the 2008 breakdown and also to avert the adverse effects of the pandemic.

The third column of the table shows that monetary policy affects the on-balance sheet liquidity creation generated by small banks negatively ($\beta_1 = -0.337$) at the 1% level. The negative impact could be a result of reduced demand for credit in the spot market due to contractionary monetary policy (state 1). Interestingly, Figure 4 shows that the model

resides in state 4 for most of the sample and that monetary policy shocks are generally expansionary. Further, there is considerable evidence that prior to the 2008 financial crisis, the economy was in the information-insensitive regime (state 2). Hence, the negative effect of monetary policy on small banks' on-balance sheet liquidity creation could have been mostly dictated by the availability of capital and the volatility in the economic environment.²⁷

The last two columns of Table 3 provide evidence that monetary policy has negative effects on small banks' off-balance sheet liquidity creation during the low growth phase. Consistent with the estimated filter probabilities and based on the unconditional means, we see that output growth, monetary policy shocks and liquidity creation growth variables are all in the same phase: either state 1 or 8. Looking at Figure 5, we see that the probability of state 8 is high for most of the period of our sample: 1990-1995; 1998-2000; 2001-2008; and 2011-2013. However, although the conditional mean of monetary policy is negative (expansionary in nature), its immediate impact on small banks' off-balance sheet liquidity creation is negative. This negative effect could simply be a reflection small bank managers' preference to increase banks' capital buffer while the policy is expansionary.²⁸

Results for Medium Banks

Column 1 of Table 4 shows that monetary policy has a positive impact on total liquidity creation of medium banks ($\beta_1 = 0.161$). This observation could be driven by the strong positive impact of monetary policy on medium banks' off-balance sheet liquidity creation (column 5) which outweigh the negative impact of monetary policy on the on-balance sheet liquidity creation (column 3). From column 1, we also observe that the GDP growth rate and liquidity creation are in the same phase while monetary policy is in a different phase ($\mu_1^{\Delta LC} > \mu_0^{\Delta LC}$; $\mu_1^{gr} > \mu_0^{gr}$ and $\mu_1^{mp} < \mu_0^{mp}$). Overall, as expected, an expansionary monetary policy, in the low growth phase, accommodates both output and liquidity creation.

²⁷Small banks react different from large banks to changes in monetary policy due to capital requirements (Kashyap and Stein, 2000) and uncertainty in the economic environment (Baum et al., 2013).

²⁸See for instance Kashyap and Stein (1995)

A closer examination shows that the model is either in the information-insensitive regime (state 2) during which credit boom is building up or in state state 7, which is rather unlikely to occur.²⁹ Figure 6 shows that the filter probability of state 2 is high throughout the sample, except for early 2000s, and from 2007 to 2008. It is also worth noting that the filter probability of crisis regime (state 8) is high during the 2008-financial crisis period. Furthermore, the probability of being the credit boom regime (in state 2) is high after 2010. Expansion of credit growth by medium banks, which was also observed for all bank data, is of importance as it is suggestive that the economy can slide into another crisis unless steps are taken to deflate this possibility.³⁰

The middle two columns of the table show that monetary policy negatively affects the medium banks on-balance sheet liquidity creation ($\beta_1 = -0.694$). Based on the estimates of unconditional means the model appears to be in state 6 and state 3. Yet, the state-dependent unconditional means of liquidity creation is not significantly different from zero in either regime. When we examine Figure 7, we see that the estimated filter probabilities for state 2 is high for a large part of the sample covering the periods 2001 to 2003; 2005 to 2007; and 2010 to 2016. We also observe that the filter probability of state 4 where monetary policy is expansionary is very high for most of the period in our sample. In particular, state 4 is high in the first half of the sample from 1992 to 2000; before the financial crisis from 2003 to 2005; and from 2008 to 2010. The negative impact of monetary policy on medium banks' on-balance sheet liquidity creation might be driven by expectation that GDP growth will switch to the low growth regime.³¹

The last two columns of the table show that monetary policy has a positive and signif-

²⁹As raised earlier, in state 7 monetary policy undermines both output growth and the growth rate of liquidity creation. This is a highly unlikely occurrence.

³⁰High credit growth and risk taking attributes played an important role on the 2008 financial crisis.

³¹This is consistent with evidence that the filter probability of state 4 is high when the filter probability of state 2 is low. Thus, while the model is in state 2, during which GDP growth is in high mean growth, there are expectations that the model will switch to state 4 as GDP growth attains a low-mean growth.

icant effect on the off-balance sheet liquidity creation ($\beta_0 = 1.671$). The positive impact of monetary policy on off-balance sheet liquidity creation might be related to the demand side effects of monetary policy. Estimates of the unconditional means suggest that both GDP growth and off-balance sheet liquidity creation growth are in the same phase while monetary policy is not.³² Figure 8 justifies that the model stays mostly in state 2.³³ The filter probability for state 2 is high for the first half of the sample from 1992 to 1998, before the financial crisis between 2003 and 2006 and after the financial crisis from 2010 to 2012. Furthermore, there is evidence that the filter probability of state 4 is high several periods before the financial crisis and from 2011 to the end of the sample.³⁴

Results for Large Banks

Finally, Table 5 shows the coefficient estimates for large banks. We find that monetary policy positively and significantly affects the large banks' on-balance sheet liquidity creation ($\beta_1 = 0.733$) when liquidity creation is in the high growth phase.³⁵ Estimates of the unconditional means imply that the model is either in state 1 or 8. In contrast, Figure 9 shows that while the filter probabilities of state 1 and 8 are low, the filter probability of state 2 stays high several periods including from 1992 to 1995, 2004 to 2008, and 2011 to 2014. Further, the filter probability of state 4 is high for a large part of our sample especially after 2014. Recall that during states 4 and 2, the monetary policy is expansionary. Hence, it is unsurprising to find that large banks' on-balance sheet liquidity creation is positively affected.

The findings regarding the differences between the states implied by the unconditional means and the filter probabilities are mainly driven by expectation formation effects, which depend on the persistence of states 1 or 8. In particular, when the economy is in state 2,

³²Hence, the model is either in state 2 (credit boom regime) or state 7

³³An unlikely possibility is that the model could be in state 7 during which monetary policy undermines *both* financial and macroeconomic stability. As expected, the filter probability of this state is confirmed to be close to zero thorough the sample.

³⁴In regime 4, monetary policy is expansionary to uplift GDP growth.

³⁵Berger and Bouwman (2017) find no significant effects of monetary policy on large banks' liquidity creation.

economic agents would expect that it will switch to state 1 (or state 8): $P(s_t^x = 1 | s_{t-1}^x = 2) = p_{01}^{mp} p_{11}^{gr} p_{11}^{\Delta LC}$. This is because, while the economy experiences a credit and output growth boom, bank managers expect that monetary policy will eventually become contractionary to restrict both output and liquidity creation growth.³⁶ Alternatively, economic agents might believe that the economy is in the credit and output boom regime (state 2), and that a crisis is building up: $P(s_t^x = 8 | s_{t-1}^x = 2) = p_{00}^{mp} p_{10}^{gr} p_{10}^{\Delta LC}$. The expectation formation effects of the crisis regime (state 8) is stronger than the expectation formation effects of state 1. This is because the persistence of state 8 is high $P(s_t^x = 8 | s_{t-1}^x = 8) = p_{00}^{mp} p_{00}^{gr} p_{00}^{\Delta LC} = 0.79 \times 0.856 \times 0.83$, while the persistence of state 1 is rather low.³⁷ Therefore, our result suggest that although the economy was in a credit boom regime —state 2— economic agents are most likely to consider that the economy will move to a crisis regime rather than monetary policy will become contractionary to prevent a possible financial crisis. Indeed, this is just what happened pre financial crises.

5 Conclusion

It is well documented that banks play an important role by creating liquidity in support of economic growth. However, research has also shown that excessive liquidity creation can undermine both the stability of the financial system and the economic activities. Surprisingly, despite its significant influence on the stability of both the macro-economy and financial sector, there is little empirical research concerning the extent to which monetary policy can be used to control liquidity creation.

In this study, we propose a general Markov regime-switching model to examine the interrelations between liquidity growth and monetary policy shocks for the US from 1990:q1 to 2016:q4. In doing so, we account for endogenous regime switches while we capture the

³⁶A similar observation is expected when the economy is in state 4.

³⁷The persistence of regime 1 is low because the transition probability of the growth rate of liquidity creation to remain in the high growth regime is very low: $P(s_t^x = 1 | s_{t-1}^x = 1) = p_{11}^{mp} p_{11}^{gr} p_{11}^{\Delta LC} = 0.967 \times 0.873 \times 0.379$

idea proposed by Gorton and Ordoñez (2014) that financial crises are the result of a regime switch from information-insensitive debt to information-sensitive debt. Consequently, we contribute to the literature on two key aspects that a linear framework would be silent on. Firstly, because our empirical framework endogenously determines the states of the economy, we can examine the impact of monetary policy on liquidity creation across normal versus crisis states without imposing any restrictions. Secondly, our model can provide evidence of any trade-off between macro-economic and financial stability, a contentious problem. Overall, our investigation allows us to provide valuable insights on the macro-prudential role of monetary policy.

Our examination offers four novel observations. We first show that the impact of monetary policy on banks' liquidity creation depends on both the type (total, off-balance sheet and on-balance sheet liquidity creation) and the bank size. Secondly, we observe that the economy resides in the information-insensitive regime (state 2) for a long period of time, including the period prior to the financial crisis of 2008 and from 2010 until the end of the sample, 2016. Thirdly, we find that monetary policy was mostly expansionary regardless the state of liquidity creation (either state 2 or state 4). Lastly, we show that monetary policy has an asymmetric impact on the growth rate of liquidity creation.

The evidence that the economy resides, for a large part of our sample covering the pre and the post great recession periods, in the information-insensitive regime —state 2— is most disconcerting. The model also subsists for long periods in state 4 during which monetary policy is expansionary. We also need to be mindful that both the fiscal and monetary policies were accommodative during the Covid19 pandemic to keep the economy going. Looking into the future, as the inflation picks up and Covid19 is no longer a major thread to humanity, the policy authorities should be prepared to implement restrictive policies. These observations relates with the Gorton and Ordoñez (2014) view that if an economy resides in the information-insensitive regime for prolonged periods, then a small shock can push the

economy into another crisis cycle.

For future research, it would be useful to investigate the interrelations between monetary policy, liquidity growth and output growth for other large OECD economies using a similar framework as proposed here. Our findings may become more meaningful in consideration of the earlier evidence presented by researchers (Jiménez et al., 2014, Angeloni et al., 2015) that risk-taking behaviour in Europe has reached substantial levels. An investigation as such can also reveal the potential trade off between macroeconomic and financial stability that the monetary policy authorities are confronted with.

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Figure 1: The Filter Probabilities of On-Balance Sheet Liquidity Creation for All Banks

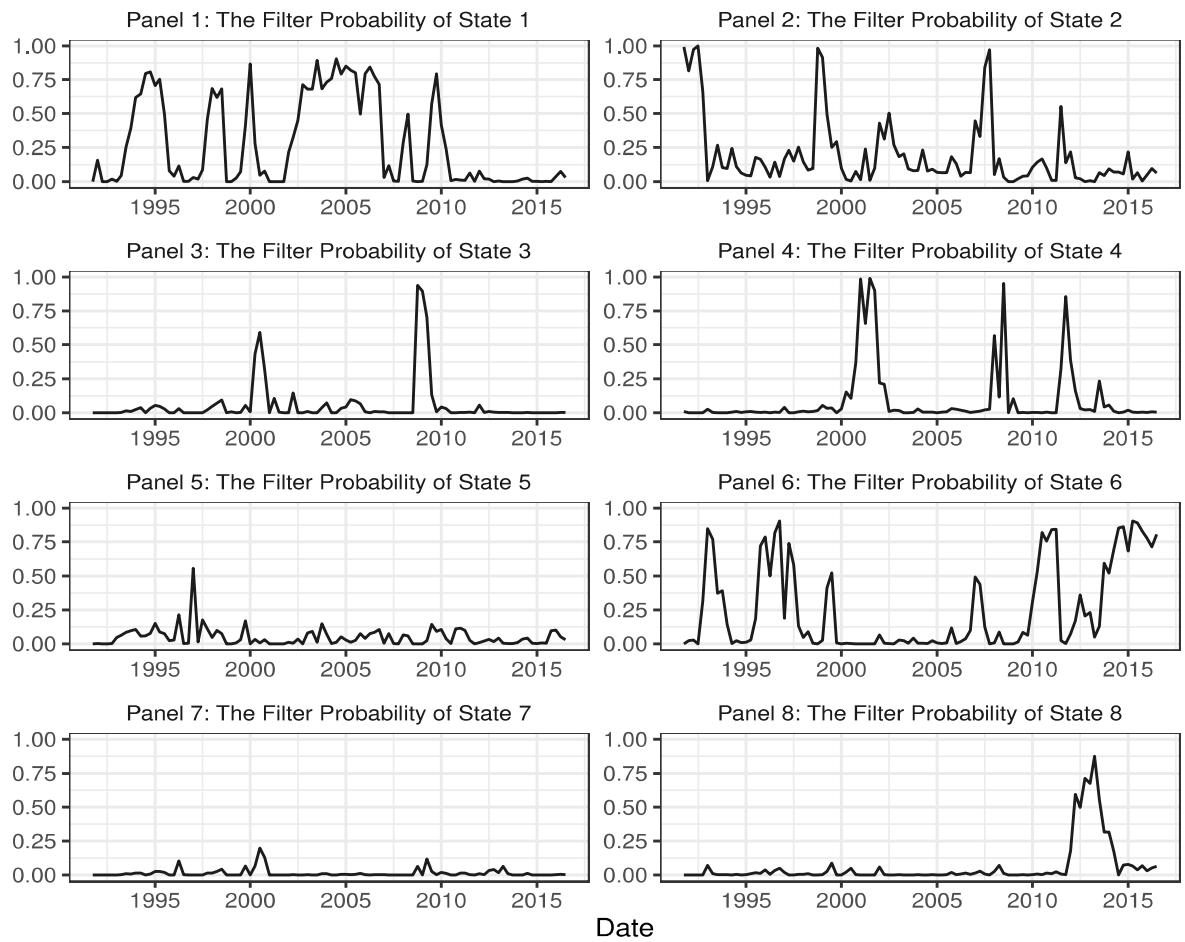


Figure 2: The Filter Probabilities of Off-Balance Sheet Liquidity Creation for All Banks

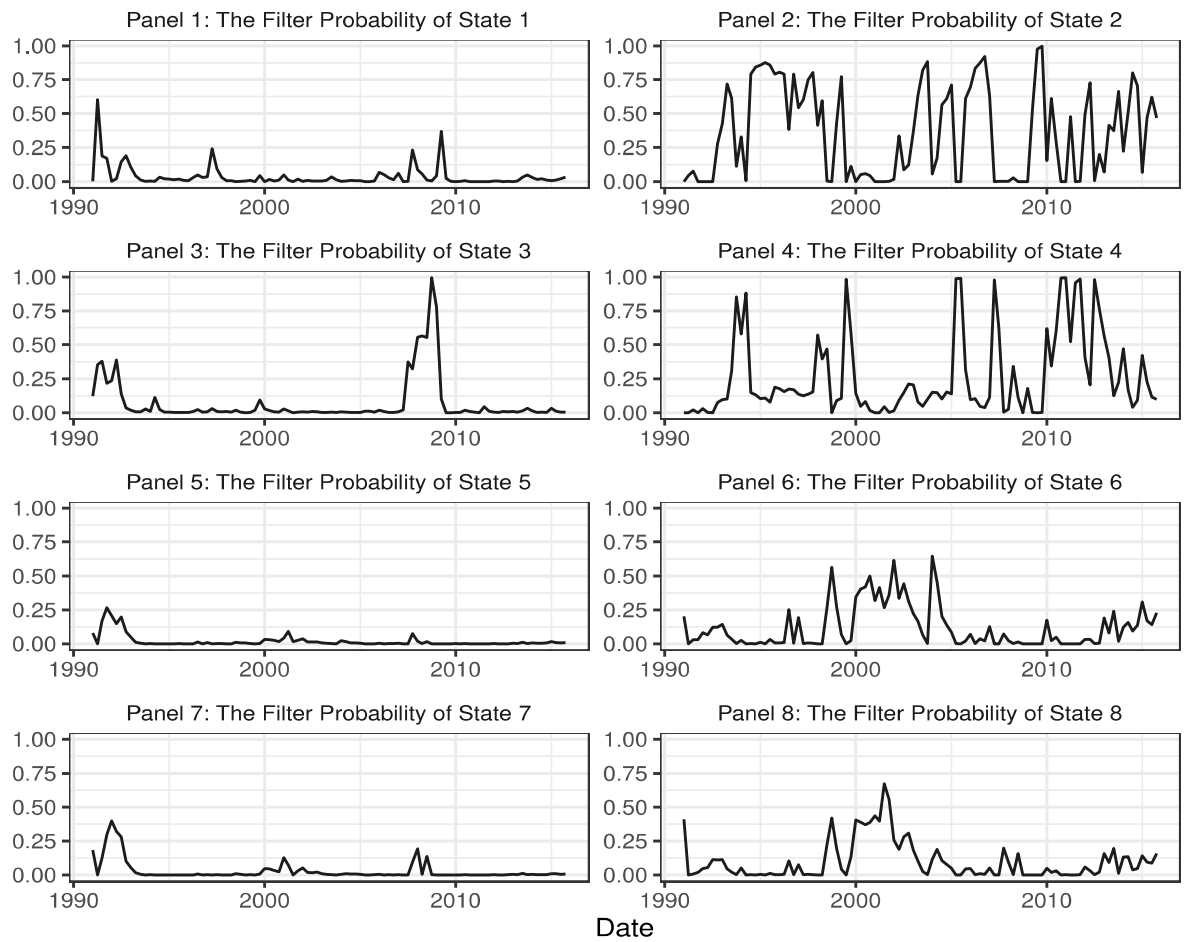


Figure 3: The Filter Probabilities of Aggregate Liquidity Creation for Small Banks

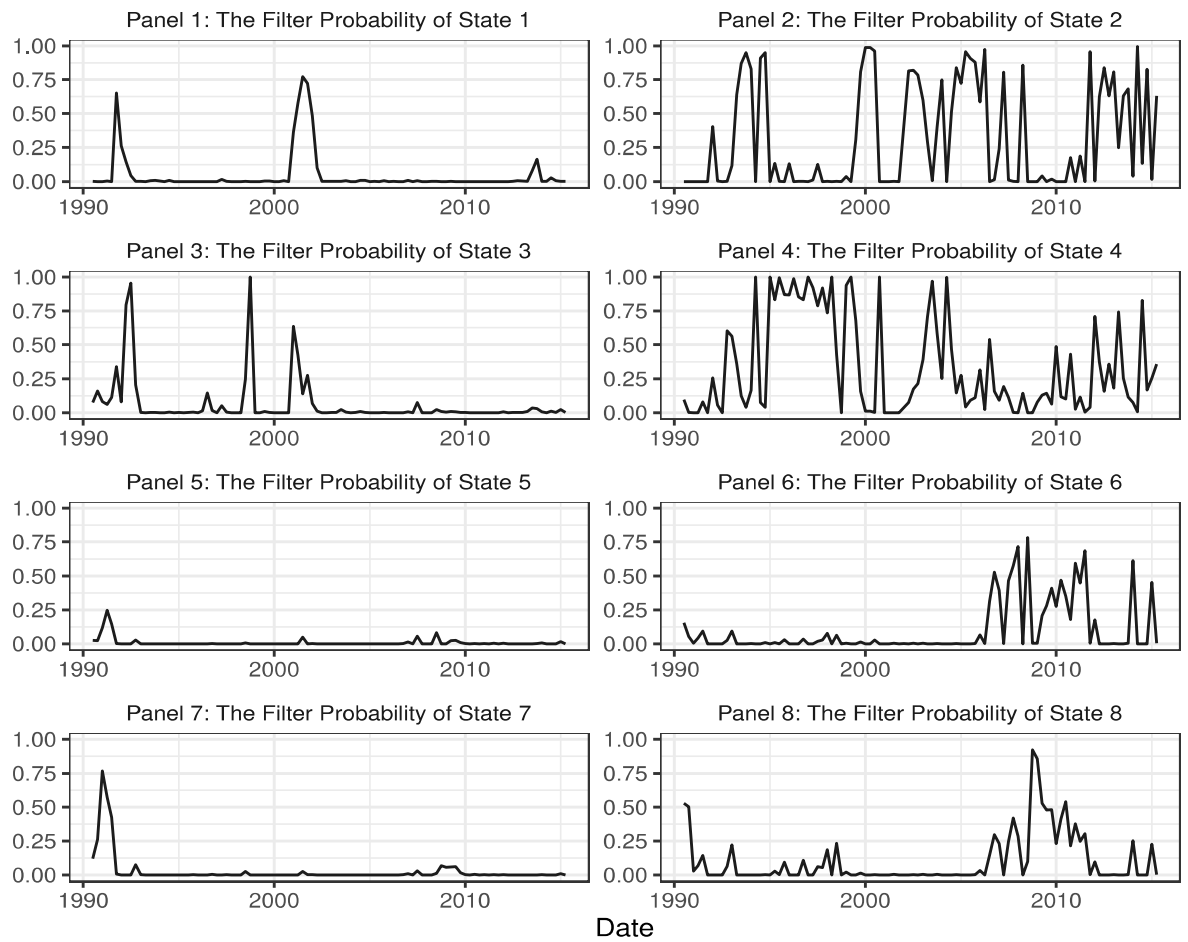


Figure 4: The Filter Probabilities of On-Balance Sheet Liquidity Creation for Small Banks

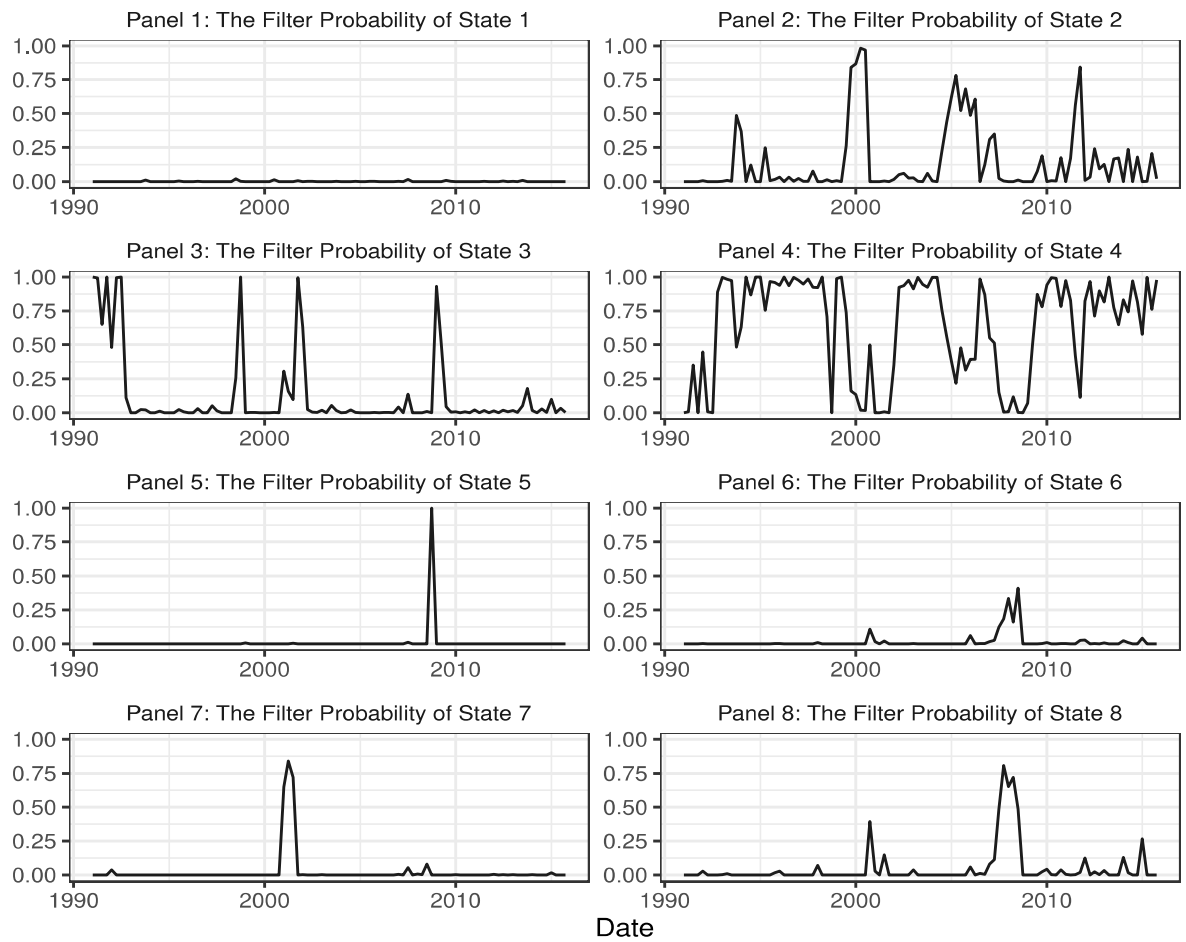


Figure 5: The Filter Probabilities of Off-Balance Sheet Liquidity Creation for Small Banks

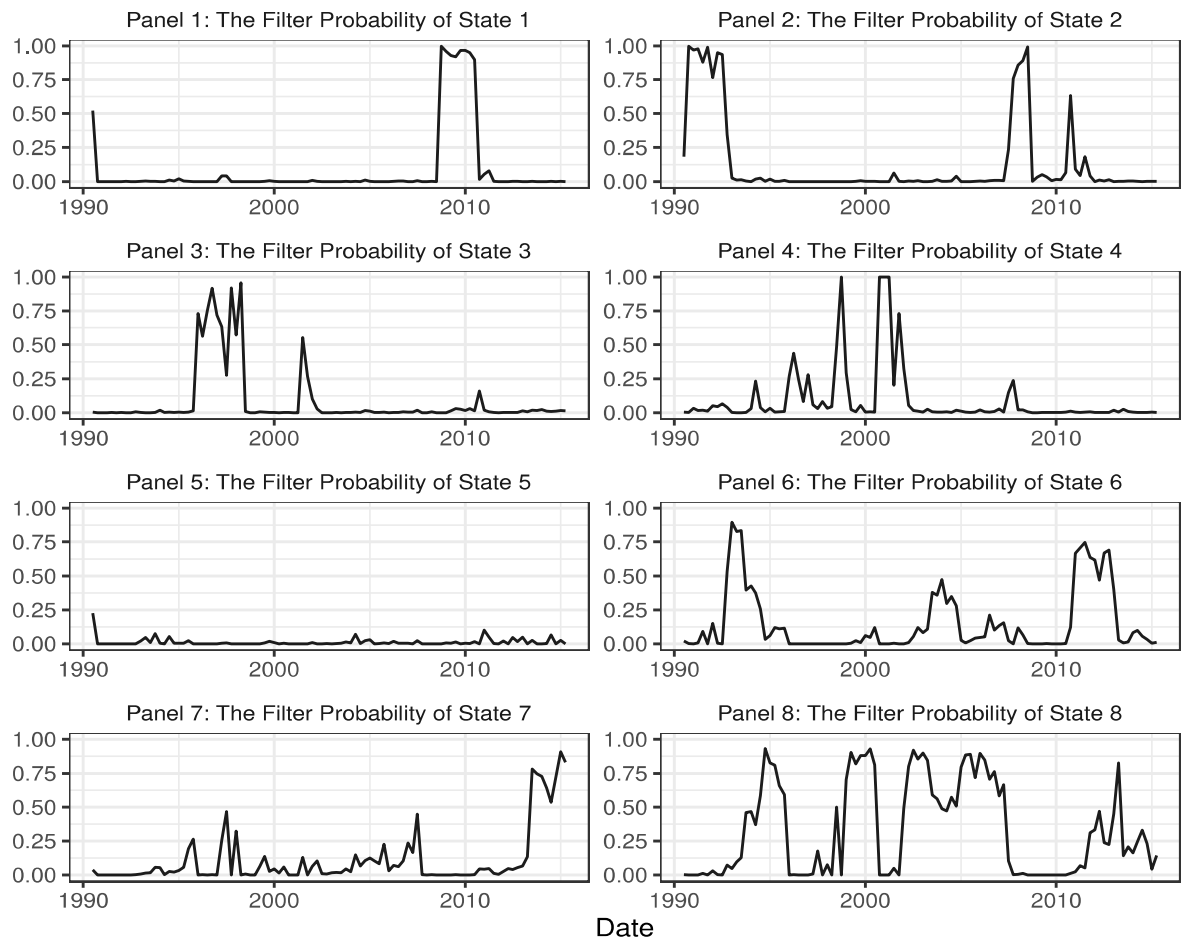


Figure 6: The Filter Probabilities of Aggregate Liquidity Creation for Medium Banks

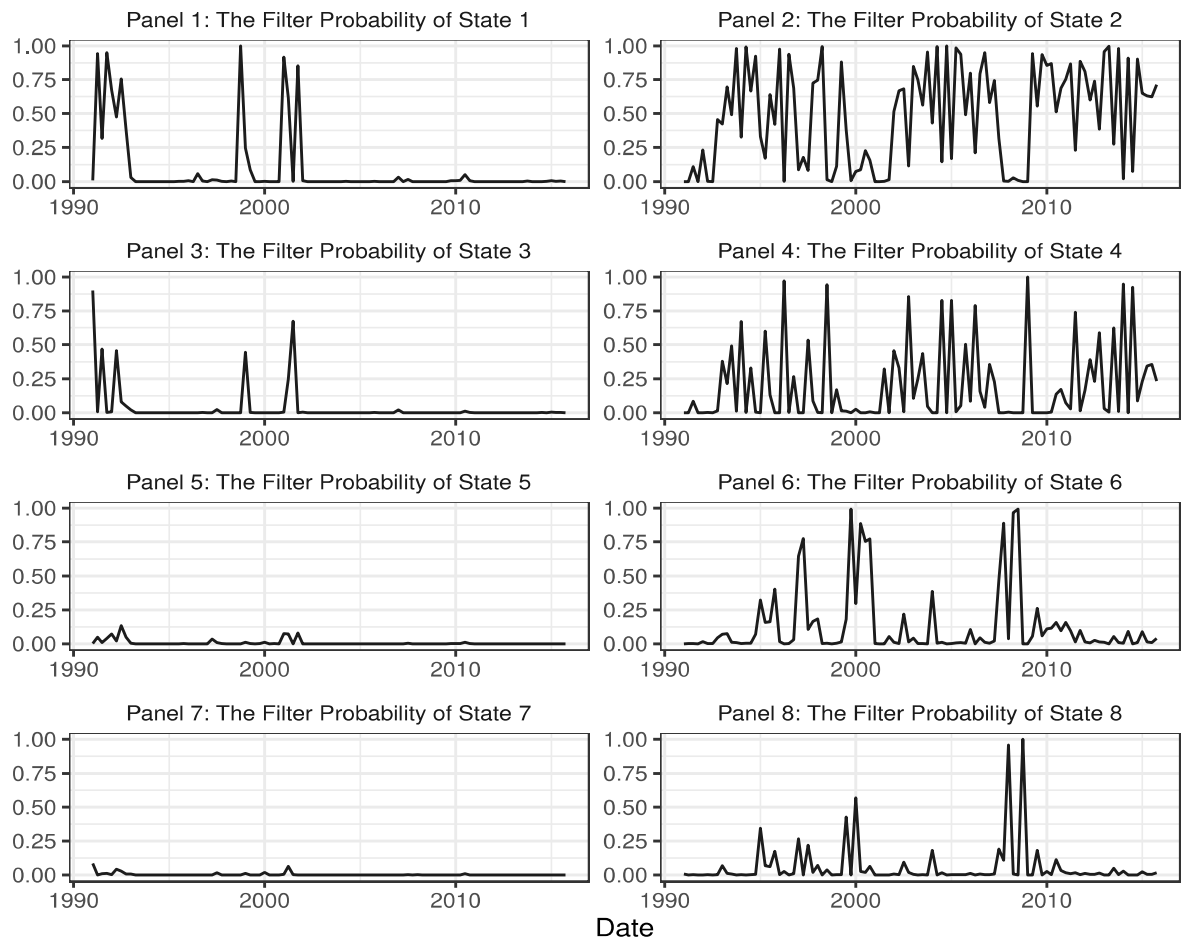


Figure 7: The Filter Probabilities of On-Balance Sheet Liquidity Creation for Medium Banks

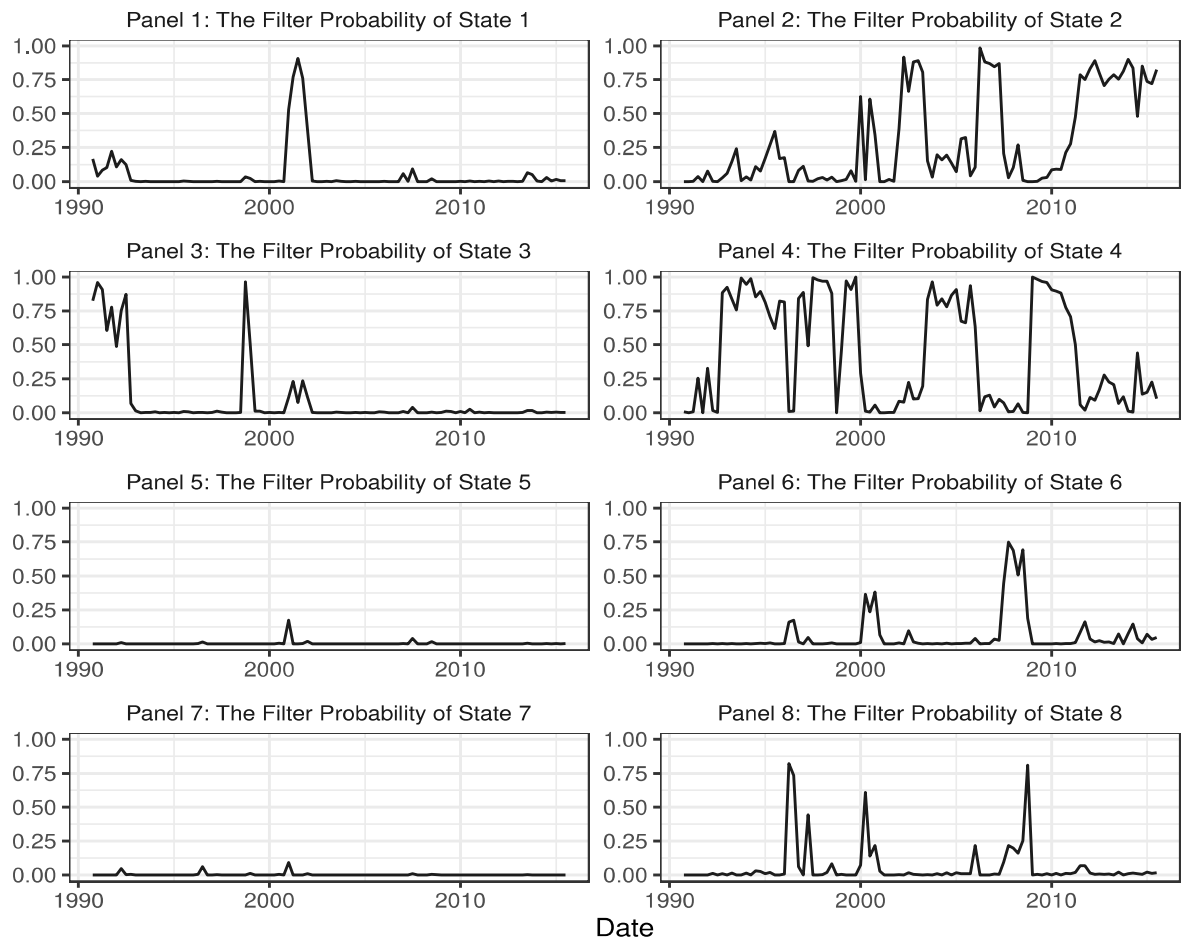


Figure 8: The Filter Probabilities of Off-Balance Sheet Liquidity Creation for Medium Banks

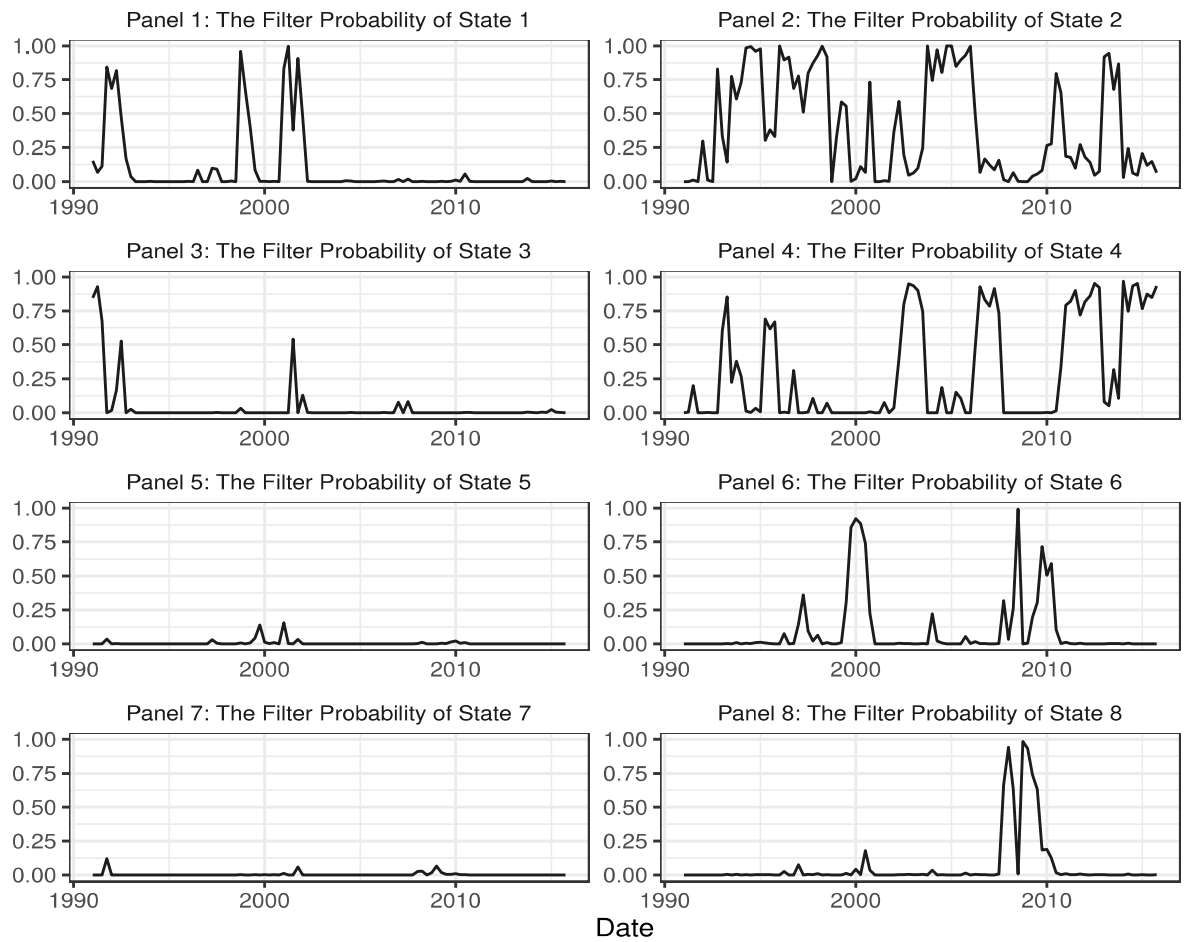


Figure 9: The Filter Probabilities of On-Balance Sheet Liquidity Creation for Large Banks

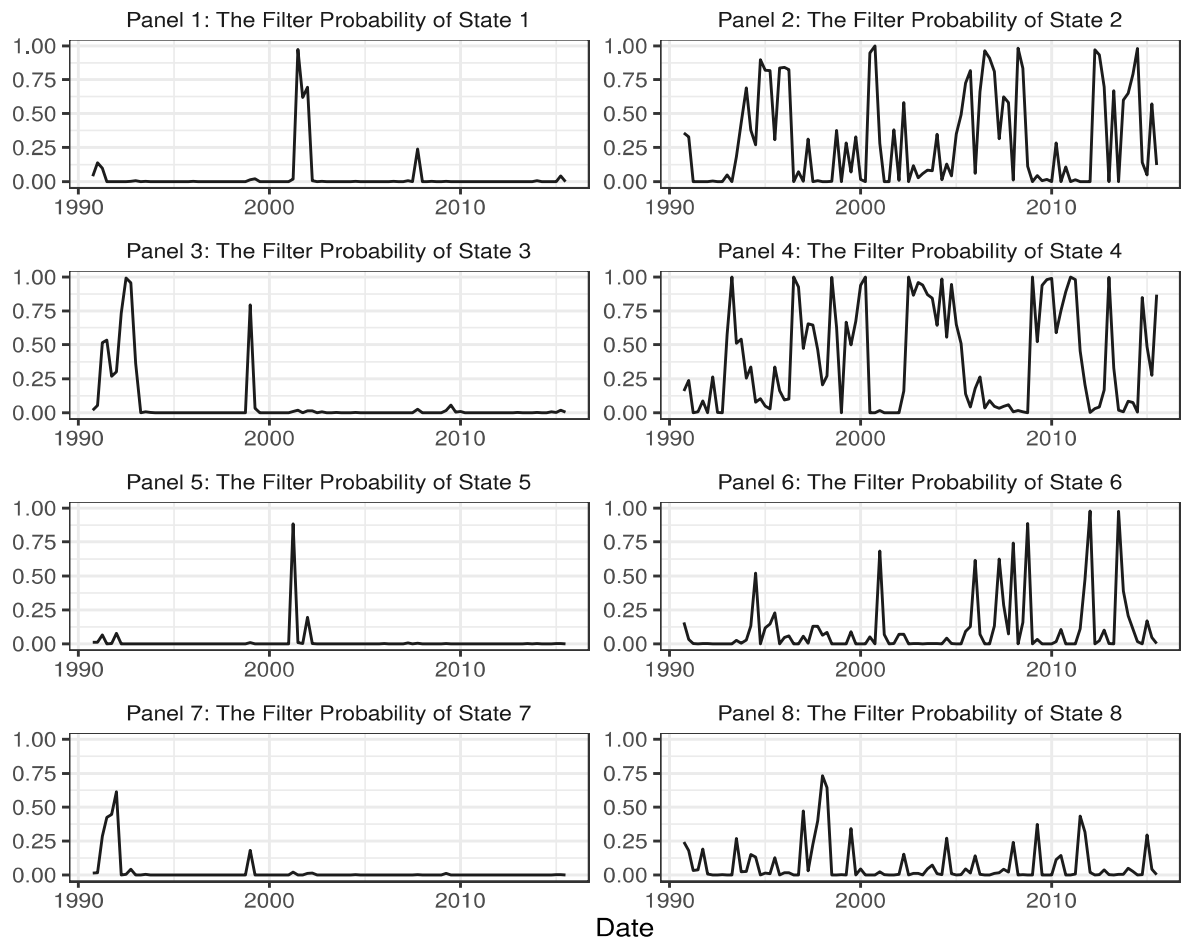


Table 1: Basic Descriptive Statistics

Panel A: Level and growth of Liquidity creation for All banks

	Level of Liquidity Creation			Growth of Liquidity creation		
	Total	On-Balance	Off-Balance	Total	On-Balance	Off-Balance
Mean	4.412E+09	1.891E+09	2.521E+09	0.01122	0.010688	0.011874
SD	1.551E+09	6.947E+08	9.526E+08	0.0200	0.022094	0.030254
Max	7.003E+09	3.747E+09	4.277E+09	0.0488	0.071593	0.131943
Min	2.041E+09	1.022E+09	9.030E+08	-0.05426	-0.0481	-0.09166

Panel B: Level and growth of Liquidity creation for Small banks

	Level of Liquidity Creation			Growth of Liquidity creation		
	Total	On-Balance	Off-Balance	Total	On-Balance	Off-Balance
Mean	58348.8	46476	11872.7	0.013359	0.01372	0.011601
SD	21977	19616.3	2918.58	0.025527	0.024253	0.062501
Max	102752	86879.8	16255.6	0.103673	0.08863	0.338909
Min	25165.5	18722.1	6194.15	-0.06398	-0.07645	-0.19598

Panel C: Level and growth of Liquidity creation for Medium banks

	Level of Liquidity Creation			Growth of Liquidity creation		
	Total	On-Balance	Off-Balance	Total	On-Balance	Off-Balance
Mean	627089	429011	198078	0.004026	0.004908	0.000689
SD	80000.9	96403	35381.2	0.027262	0.024507	0.071931
Max	812384	602647	257468	0.138814	0.065975	0.512888
Min	533210	321003	112934	-0.05767	-0.046	-0.19662

Panel D: Level and growth of Liquidity creation for Large banks

	Level of Liquidity Creation			Growth of Liquidity creation		
	Total	On-Balance	Off-Balance	Total	On-Balance	Off-Balance
Mean	1.616E+07	5.604E+06	1.055E+07	0.012646	0.012389	0.012912
SD	6.972E+06	1.826E+06	5.177E+06	0.030176	0.03193	0.037922
Max	2.764E+07	8.441E+06	1.967E+07	0.115022	0.104601	0.131397
Min	6.573E+06	2.943E+06	3.495E+06	-0.06212	-0.08602	-0.08921

Table 2: The Impact of Monetary Policy on Liquidity Creation: All Banks

1990Q1-2016Q4	Total		On-balance		Off-balance	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
Panel A: Transition probability estimates						
p_{11}^{mp}	0.951	4.890	0.836	11.413	0.976	6.951
p_{00}^{mp}	0.672	38.714	0.907	17.618	0.898	51.536
p_{11}^{gr}	0.910	13.019	0.953	32.444	0.798	6.438
p_{00}^{gr}	0.887	10.836	0.823	8.609	0.737	3.962
$p_{11}^{\Delta LC}$	0.770	29.998	0.918	18.060	0.728	12.146
$p_{00}^{\Delta LC}$	0.953	5.353	0.866	11.740	0.915	5.148
Panel B: Unconditional monetary policy (mean and variance estimates)						
μ_i^{mp}	-0.049	-3.439	-0.004	-1.065	-0.026	-2.318
$\sigma_{1-i}^{2,mp}$	0.028	5.462	0.011	8.352	0.035	5.808
μ_{1-i}^{mp}	-0.005	-1.779	-0.011	-1.657	-0.005	-1.721
$\sigma_{1-i}^{2,mp}$	0.014	11.670	0.040	6.312	0.013	9.513
Panel C: Unconditional output growth (mean and variance estimates)						
μ_i^{gr}	0.006	5.500	0.005	5.475	0.005	4.247
$\sigma_{1-i}^{2,gr}$	0.007	6.152	0.004	10.302	0.006	6.321
μ_{1-i}^{gr}	0.000	0.242	-0.002	-1.664	0.001	0.382
$\sigma_{1-i}^{2,gr}$	0.004	11.045	0.004	5.257	0.004	9.997
Panel D: Liquidity creation (all) coefficient estimates						
$\mu_i^{\Delta LC}$	-0.001	-0.645	0.005	1.025	-0.008	-2.880
α_{i1}	0.139	1.512	0.108	0.826	0.212	2.150
α_{i2}	0.306	3.408	-0.184	-1.335	0.240	2.727
γ_{i1}	0.521	1.905	0.169	0.303	1.317	3.090
γ_{i2}	1.081	3.980	0.914	1.695	1.277	3.377
β_i	0.024	0.502	0.117	1.198	0.248	2.926
$\sigma_{1-i}^{2,\Delta LC}$	0.009	6.869	0.017	11.593	0.009	4.342
$\mu_{1-i}^{\Delta LC}$	0.005	0.889	0.006	0.677	0.005	1.053
α_{1-i1}	0.791	3.863	-0.124	-0.740	0.133	0.748
α_{1-i2}	-0.515	-2.534	0.500	3.845	-0.073	-0.655
γ_{1-i1}	0.310	0.571	-0.748	-0.936	0.241	0.535
γ_{1-i2}	0.150	0.296	0.540	0.901	0.244	0.528
β_{1-i}	0.272	1.893	-0.688	-2.257	-0.012	-0.154
$\sigma_{1-i}^{2,\Delta LC}$	0.020	7.047	0.025	4.770	0.032	6.123
log likelihood	980.29		900.51		931.93	

Notes: Panel A provides the Transition probability estimates. Panels B and C provide the state-dependent unconditional mean and standard deviation for both monetary policy and output growth for parsimony. Panel D provides the coefficient estimates for model $\Delta LC_t = \mu_{s_t} + \sum_{i=1}^j \alpha_{i,s_t} \Delta LC_{t-i} + \sum_{i=1}^j \gamma_{i,s_t} y_{t-i} + \beta_{s_t} mp_{t-1} + \sigma_{s_t} \varepsilon_t$, where ΔLC_t , mp_t , and y_t denote growth of liquidity creation, monetary policy shock and output growth, respectively. ε_t is the error term. The model is estimated as a linear homogenous eight-state Markov process where $i \in \{0, 1\}$. State 1 indicates the high-growth phase.

Table 3: The Impact of Monetary Policy on Liquidity Creation: Small Banks

1990Q1-2016Q4	Total		On-balance		Off-balance	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
Panel A: Transition probability estimates						
p_{11}^{mp}	0.964	6.674	0.951	6.290	0.945	10.336
p_{00}^{mp}	0.811	44.901	0.761	38.631	0.882	24.894
p_{11}^{gr}	0.748	6.560	0.684	2.998	0.970	24.163
p_{00}^{gr}	0.741	7.972	0.932	19.065	0.951	41.933
$p_{11}^{\Delta LC}$	0.929	21.937	0.797	54.434	0.936	17.696
$p_{00}^{\Delta LC}$	0.766	5.692	0.977	6.075	0.902	28.760
Panel B: Unconditional monetary policy (mean and variance estimates)						
μ_i^{mp}	-0.045	-3.604	-0.040	-4.122	-0.013	-3.638
$\sigma_1^{2,mp}$	0.023	7.771	0.023	6.335	0.012	11.691
μ_{1-i}^{mp}	-0.005	-1.732	-0.004	-1.136	-0.003	-0.625
$\sigma_{1-i}^{2,mp}$	0.013	10.891	0.013	11.916	0.050	6.228
Panel C: Unconditional output growth (mean and variance estimates)						
μ_i^{gr}	0.005	3.501	0.005	0.823	0.002	2.240
$\sigma_1^{2,gr}$	0.007	7.135	0.005	4.437	0.004	12.103
μ_{1-i}^{gr}	0.003	2.227	0.004	4.618	0.005	3.967
$\sigma_{1-i}^{2,gr}$	0.004	8.529	0.004	10.416	0.005	5.278
Panel D: Liquidity creation (all) coefficient estimates						
$\mu_i^{\Delta LC}$	0.022	5.855	0.007	1.594	-0.023	-3.374
α_{i1}	0.005	0.128	0.202	2.248	0.068	0.406
α_{i2}	-0.189	-2.647	0.113	1.393	-0.002	-0.051
γ_{i1}	-0.075	-0.446	-0.558	-1.233	0.663	0.963
γ_{i2}	0.116	0.281	1.042	2.336	0.941	1.318
β_i	-0.103	-1.581	-0.077	-0.617	-0.490	-2.653
$\sigma_1^{2,\Delta LC}$	0.008	6.786	0.007	4.624	0.022	12.687
$\mu_{1-i}^{\Delta LC}$	-0.010	-4.524	0.022	5.292	0.016	2.641
α_{1-i1}	-0.092	-0.617	-0.487	-3.265	-0.195	-2.145
α_{1-i2}	0.069	0.555	-0.559	-3.602	-0.072	-0.961
γ_{1-i1}	0.801	2.111	-2.612	-4.424	0.415	0.681
γ_{1-i2}	-0.640	-1.722	-0.341	-0.606	-0.105	-0.216
β_{1-i}	-0.171	-1.947	-0.337	-5.588	0.096	0.557
$\sigma_{1-i}^{2,\Delta LC}$	0.033	7.811	0.026	11.519	0.121	5.632
log likelihood	947.330		908.820		884.710	

See Notes to table 2.

Table 4: The Impact of Monetary Policy on Liquidity Creation: Medium Banks

1990Q1-2016Q3	Total		On-balance		Off-balance	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
Panel A: Transition probability estimates						
p_{11}^{mp}	0.968	6.363	0.967	7.250	0.966	6.645
p_{00}^{mp}	0.812	51.950	0.816	50.437	0.807	48.089
p_{11}^{gr}	0.603	4.318	0.923	17.790	0.869	14.923
p_{00}^{gr}	0.000	0.000	0.940	23.006	0.825	10.222
$p_{11}^{\Delta LC}$	0.928	13.930	0.956	34.212	0.975	52.304
$p_{00}^{\Delta LC}$	0.681	4.082	0.653	3.819	0.836	8.097
Panel B: Unconditional monetary policy (mean and variance estimates)						
μ_i^{mp}	-0.083	-6.917	-0.059	-3.985	-0.071	-7.648
$\sigma_1^{2,mp}$	0.021	5.062	0.026	6.655	0.017	6.203
μ_{1-i}^{mp}	-0.005	-1.792	-0.005	-2.038	-0.005	-1.780
$\sigma_{1-i}^{2,mp}$	0.013	8.827	0.013	11.669	0.014	10.985
Panel C: Unconditional output growth (mean and variance estimates)						
μ_i^{gr}	0.005	6.559	0.006	3.680	0.006	3.205
$\sigma_1^{2,gr}$	0.004	5.127	0.008	6.453	0.005	4.653
μ_{1-i}^{gr}	0.001	0.972	0.004	4.193	0.004	3.495
$\sigma_{1-i}^{2,gr}$	0.004	9.895	0.004	10.401	0.004	10.125
Panel D: Liquidity creation (all) coefficient estimates						
$\mu_i^{\Delta LC}$	0.006	2.287	0.004	1.063	0.010	2.035
α_{i1}	0.079	0.750	0.017	0.185	-0.316	-3.314
α_{i2}	0.205	2.160	0.336	3.294	-0.102	-1.214
γ_{i1}	0.433	1.190	-0.066	-0.369	0.224	0.366
γ_{i2}	-0.071	-0.224	0.257	0.625	-0.022	-0.070
β_i	0.161	2.518	0.015	0.192	0.184	1.540
$\sigma_1^{2,\Delta LC}$	0.021	8.635	0.016	6.369	0.050	10.039
$\mu_{1-i}^{\Delta LC}$	-0.020	-2.142	0.005	0.579	-0.083	-2.941
α_{1-i1}	0.019	0.073	-0.280	-0.750	0.006	0.038
α_{1-i2}	-0.624	-2.952	-1.293	-4.324	-0.564	-2.513
γ_{1-i1}	-2.139	-2.348	-1.599	-0.970	-1.914	-1.009
γ_{1-i2}	2.480	2.044	2.540	2.079	0.786	0.415
β_{1-i}	-0.060	-0.125	-0.694	-2.737	1.671	2.150
$\sigma_{1-i}^{2,\Delta LC}$	0.009	4.012	0.023	9.154	0.014	6.312
log likelihood	938.690		929.830		874.210	

See Notes to table 2.

Table 5: The Impact of Monetary Policy on Liquidity Creation: Large Banks

1990Q1-2016Q3	Total		On-balance		Off-balance	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
Panel A: Transition probability estimates						
p_{11}^{mp}	0.966	7.441	0.767	5.361	0.968	5.794
p_{00}^{mp}	0.822	49.797	0.790	50.543	0.787	53.101
p_{11}^{gr}	0.864	12.224	0.873	13.979	0.567	7.997
p_{00}^{gr}	0.919	17.292	0.856	14.185	0.818	3.328
$p_{11}^{\Delta LC}$	0.960	27.556	0.379	11.247	0.569	12.534
$p_{00}^{\Delta LC}$	0.674	3.549	0.830	1.839	0.857	4.152
Panel B: Unconditional monetary policy (mean and variance estimates)						
μ_i^{mp}	-0.059	-4.382	-0.067	-5.175	-0.076	-6.165
$\sigma_1^{2,mp}$	0.027	6.513	0.023	6.688	0.022	7.358
μ_{1-i}^{mp}	-0.004	-1.734	-0.006	-2.090	-0.005	-1.993
$\sigma_{1-i}^{2,mp}$	0.013	11.467	0.013	9.289	0.013	9.503
Panel C: Unconditional output growth (mean and variance estimates)						
μ_i^{gr}	0.005	2.844	0.001	0.466	0.003	3.843
$\sigma_1^{2,gr}$	0.008	5.797	0.004	4.866	0.007	6.847
μ_{1-i}^{gr}	0.004	4.491	0.003	2.603	0.008	1.805
$\sigma_{1-i}^{2,gr}$	0.004	10.338	0.005	9.881	0.003	9.064
Panel D: Liquidity creation (all) coefficient estimates						
$\mu_i^{\Delta LC}$	-0.002	-0.449	0.002	0.371	-0.004	-0.937
α_{i1}	0.209	2.071	-0.173	-2.295	0.363	3.372
α_{i2}	-0.002	-0.037	-0.141	-1.516	0.162	1.813
γ_{i1}	0.678	1.402	0.410	0.782	-0.161	-0.296
γ_{i2}	1.216	2.386	0.791	1.439	1.706	3.148
β_i	0.010	0.327	-0.070	-0.929	0.039	0.361
$\sigma_1^{2,\Delta LC}$	0.022	6.128	0.012	4.796	0.016	8.073
$\mu_{1-i}^{\Delta LC}$	-0.008	-0.730	0.019	3.303	0.002	0.354
α_{1-11}	-0.451	-0.882	0.317	1.876	-0.031	-0.333
α_{1-i2}	1.164	2.785	0.585	4.384	0.036	0.340
γ_{1-i1}	1.296	0.735	0.860	1.209	4.072	7.345
γ_{1-i2}	1.004	0.406	-1.557	-2.737	-2.640	-2.399
β_{1-i}	0.078	0.308	0.733	4.051	0.108	0.707
$\sigma_{1-i}^{2,\Delta LC}$	0.026	8.125	0.039	8.753	0.048	6.297
log likelihood	894.120		898.950		908.540	

See Notes to table 2.

Appendices

A Summary Results

Table A1: The impact of Monetary Policy on Liquidity Creation

	Total	On-Balance	Off-Balance
All Banks	High Growth (+)*	High Growth (−)**	Low Growth (+)***
Small Banks	Low Growth (−)*	High Growth (−)***	Low Growth (−)***
Medium Banks	High Growth (+)**	High Growth (−)***	Low Growth (+)**
Large Banks	—	High Growth (+)***	—

The table shows summary impact of monetary policy on liquidity creation when liquidity creation exhibits high-growth or low-growth phase. The results are driven from an eight state MRS model. *, **, *** denote significance at the 10%, 5% and 1% levels.

Table A2: The Impact of Monetary Policy on Liquidity Creation:
All Banks (Pre-Financial Crisis)

1990Q1-2008Q4	Total		On-balance		Off-balance	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
Panel A: Transition probability estimates						
p_{11}^{mp}	0.663	6.291	0.769	4.254	0.883	15.411
p_{00}^{mp}	0.678	6.460	0.851	8.012	0.739	7.606
p_{11}^{gr}	0.904	12.220	0.768	7.925	0.813	10.607
p_{00}^{gr}	0.946	29.192	0.794	9.487	0.741	6.530
$p_{11}^{\Delta LC}$	0.840	12.003	0.801	11.389	0.937	21.349
$p_{00}^{\Delta LC}$	0.678	5.914	0.559	2.995	0.766	3.935
Panel B: Unconditional monetary policy (mean and variance estimates)						
μ_i^{mp}	0.009	2.307	0.006	1.766	-0.003	-0.750
$\sigma_{1-i}^{2,mp}$	0.007	7.562	0.008	2.546	0.011	7.796
μ_{1-i}^{mp}	-0.048	-6.713	-0.046	-6.823	-0.059	-6.236
$\sigma_{1-i}^{2,mp}$	0.032	6.292	0.038	5.216	0.040	5.156
Panel C: Unconditional output growth (mean and variance estimates)						
μ_i^{gr}	-0.005	-4.435	-0.003	-2.423	0.005	3.578
$\sigma_{1-i}^{2,gr}$	0.004	9.061	0.004	6.206	0.005	8.999
μ_{1-i}^{gr}	0.005	8.964	0.007	6.778	-0.003	-2.506
$\sigma_{1-i}^{2,gr}$	0.001	5.273	0.003	3.072	0.002	3.817
Panel D: Liquidity creation (all) coefficient estimates						
$\mu_i^{\Delta LC}$	0.000	0.008	-0.003	-0.988	0.010	2.258
α_{i1}	0.463	3.493	-0.105	-1.040	0.235	2.516
α_{i2}	-0.159	-1.393	-0.569	-5.637	0.143	1.704
γ_{i1}	0.444	1.663	1.834	6.417	0.248	0.615
γ_{i2}	0.359	1.178	1.241	4.371	0.275	0.843
β_i	0.066	1.539	0.049	0.984	0.037	0.547
$\sigma_{1-i}^{2,\Delta LC}$	0.006	7.491	0.005	8.163	0.009	6.509
$\mu_{1-i}^{\Delta LC}$	0.027	4.627	-0.003	-1.041	-0.011	-2.552
α_{1-i1}	-0.265	-2.381	0.069	0.549	-0.825	-3.524
α_{1-i2}	-0.346	-2.827	0.672	8.420	0.115	1.185
γ_{1-i1}	-0.484	-1.170	-0.234	-0.674	1.200	2.521
γ_{1-i2}	2.048	5.387	1.735	4.193	0.895	1.345
β_{1-i}	0.084	1.113	-0.524	-7.285	0.267	2.197
$\sigma_{1-i}^{2,\Delta LC}$	0.014	7.559	0.030	6.812	0.027	5.926
log likelihood	695.85		675.32		670.57	

See Notes to table 2.

Figure A1: The Filter Probabilities of State 2 and State 4 of Total Liquidity Creation

