Liquidity, Risk Premia, and the Financial Transmission of Monetary Policy

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In recent years there has been a resurgence of research on the transmission of monetary policy through the financial system, fueled in part by empirical findings showing that monetary policy affects asset prices and the financial system in ways not explained by the New Keynesian paradigm. In particular, monetary policy appears to impact risk premia in stock and bond prices, and to effectively control the liquidity premium in the economy (the cost of holding liquid assets). We review these findings and recent theories proposed to explain them, and outline a conceptual framework that unifies them. The framework revolves around the central role of liquidity in risk sharing, and how monetary policy governs its production and use within the financial sector.

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I. The Pendulum Swings Back

Until the 1980s standard monetary theory held a key role for the financial system in the transmission of policy. The standard view was that the interest rate is determined by the amount of money created by banks, and that the central bank controls the amount of money banks create through its supply of reserves, which banks were required to hold in proportion to the deposits they issued. Some researchers argued that banks also had a second important role in monetary transmission because their supply of loans was an independent and important determinant of the availability of credit (Bernanke, 1983).

However, by the 1980s these views were losing support (Romer and Romer, 1990). Changes in banking regulation and the availability of new types of savings deposits and payment methods reduced holdings of the most money-like deposits (transaction accounts), for which reserve requirements mattered most. As required reserves became a decreasingly small fraction of bank deposits, and as some countries eliminated reserve requirements altogether, it became increasingly clear that reserve requirements were no longer important to the monetary transmission mechanism. The combination of regulatory and technological changes also made existing measures of monetary aggregates unstable and unreliable for forecasting inflation, and hence caused central banks to shift their focus from targeting monetary aggregates to interest rate targeting.

One of the important developments during this time was the repeal of Regulation Q, which removed the regulatory caps banks had faced on the deposit rates they could pay (Gilbert, 1986). This meant they could raise deposit interest rates as interest rates rose and hence avoid losing large amounts of deposits during these times. The repeal of Regulation Q thus appeared to eliminate a key mechanism through which higher interest rates were understood to cause a contraction in the supply of credit.

These developments shifted attention away from the role of money, and hence also banks, in the transmission of monetary policy. Ultimately, Woodford (1998, 2003) forcefully argued that there is little benefit to tracking conventional monetary aggregates in economies with well-developed financial markets, and showed theortically that when money holdings are small, monetary models need not reference the quantity of money (the "cashless limit"). Without money, the standard new-Keynesian model of monetary transmission contains no role for banks or the financial system more broadly, and hence the vast majority of monetary theory since that time has abstracted completely from financial institutions and frictions.

However, more recently a growing body of research has returned to studying the interaction of monetary policy and the financial system, spurred in large part by three groups of findings. In this article, we review these findings and discuss a framework that explains how they work and how they are connected. The framework is based on the central role of liquidity in the financial system and how monetary policy affects it.

Monetary policy and risk premia. The first group of findings shows that monetary policy shocks impact the prices of large classes of assets in ways that cannot be explained by the new-Keynesian mechanism. Bernanke and Kuttner (2005) is an early and influential paper in this line of work. It uses high-frequency event studies around announcements of interest rate changes to identify monetary policy shocks. It shows that surprise increases in the short interest rate have a strong negative impact on stock returns, and estimates that this effect is due almost entirely to an increase in the equity risk premium. This finding presents an important challenge to monetary theory as the new-Keynesian model is completely silent about the risk premium.

Using a similar high-frequency event study approach, Gertler and Karadi (2015) provides a second important example of an increase in the risk premium, by showing that surprise rate hikes are also associated with a widening of credit spreads on risky bonds.[1] Hanson and Stein (2015) provides yet a third example, and explains why it represents an important challenge to the new-Keynesian paradigm. Using the high-frequency event study approach around

1. The empirical asset pricing literature attributes most of the credit spread and its variation to a default risk premium, because these are too large to be explained by the historical frequency of defaults and average default losses (the "credit spread puzzle").

interest rate announcements, it shows that surprise short rate increases induce substantial increases in long-term (e.g., 10 year) nominal and *real* forward rates. In contrast, monetary theory assumes that the central bank cannot change the real rate in the long run, and in new-Keynesian models this long run is the point at which prices are able to adjust. Thus, the new-Keynsian model cannot account for the observed increases in long-term real forward rates. Hanson and Stein (2015) therefore conclude that these increases reflect increases in the risk premium on forward rates. This finding is especially important for the ability of monetary theory to explain policy-induced fluctuations in investment, because investment decisions depend on changes in the long-term cost of capital.

The common thread of these findings is that monetary policy seems to change risk premia in the economy. Yet the current workhorse monetary theory cannot explain how policy is able to have such an impact. At the same time, it is increasingly clear that variations in the risk premium have a first-order impact on economic activity, a point made abundantly clear by the financial crisis (Gilchrist and Zakrajšek, 2012). For this reason some researchers have added reduced-form risk premium shocks to standard monetary DSGE models, and find that these shocks are very important in explaining fluctuations in real activity (Smets and Wouters, 2003; Gourio, 2012; Christiano, Motto, and Rostagno, 2014). Others seek to generate variation in risk premia by using preferences, such as habit formation, which is commonly used for this purpose in the asset pricing literature (Campbell, Pflueger, and Viceira, 2015).

These findings indicate that there is a monetary transmission mechanism separate from the new-Keynesian channel, one in which monetary policy impacts the risk premium. Since the financial system is at the center of much of the risk taking and risk sharing of modern economies, it is natural to conjecture that this channel runs through the financial system. This conjecture is supported by a second group of recent findings, which show that monetary policy has a large impact on the financial sector.

Monetary policy and bank deposits. Figure I, adapted from Drechsler, Savov, and

Schnabl (2017b, Figure 2), shows the relationship between the interest rate and the flows of deposits by households into the banking system. The figure shows a strong negative correlation: increases in the interest rate are associated with large outflows of deposits from the banking system. This relationship is potentially of great importance, because household deposits are banks' largest and most stable (i.e., least run prone) source of funding. Moreover, since banks are central in funding other parts of the financial system, deposits are in effect an important source of funding for the broader financial system.

Drechsler, Savov, and Schnabl (2017b) show that the relationship between interest rates and deposit flows is causal: interest rate hikes *cause* deposit funding to contract. The reason is that banks have market power over deposit supply, and the extent to which they can exploit this market power depends on the interest rate, because it sets the cost of households' outside option for liquidity, cash. A higher interest rate makes this outside option more expensive and hence allows banks to more profitably exert their market power over deposits. Banks thus optimally respond to an increase in the short rate by widening the interest spread they charge on deposits (the gap between the short rate and the rate the deposits pay). Households respond by withdrawing a fraction of their deposits and substituting towards less liquid assets.

Drechsler, Savov, and Schnabl (2017b) show that this loss of deposit funding causes banks to contract credit supply, and that the resulting decrease in credit causes a slowdown of real activity. Thus, this "deposits channel" is an important mechanism through which monetary policy changes are transmitted through the financial system to the real economy. Section III further discusses this channel.

Deposits are also the main form of safe and liquid assets held directly by households. Together with treasury bonds they represent the economy's main sources of safe and liquid assets. Indeed, as of September 2017 there was $11.3 trillion of total bank deposits, of which $7.75 trillion were savings deposits held by retail accounts. The tremendous magnitude of deposits raises an important and interesting question: do the fluctuations in the amount of retail deposits due to monetary policy change the overall price of liquidity in the economy, the liquidity premium? The third group of recent findings suggests the answer is yes.

Monetary policy and the liquidity premium. Figure II, adapted from Drechsler, Savov, and Schnabl (2017c, Figure 1), plots the Fed funds rate against the spread of the Fed funds rate over the yield on three-month treasury bills, a standard measure of the liquidity premium in government bond prices, for the period 1955 to 2017. The very tight, positive relationship between the interest rate and liquidity premium is readily apparent. Nagel (2016) finds a similarly strong relationship between the interest rate and the liquidity premium on a variety of liquid assets. Since deposits account for a large share of total liquidity supply, it seems very plausible that their strong negative relationship with the interest rate–per the deposits channel–is central to explaining how the short rate governs the liquidity premium. Section III.B discusses this further.

Changes in the liquidity premium have potentially substantial effects on the investment decisions of financial institutions and hence on asset prices and the cost of capital in the economy. Holmström and Tirole (1998, 2011) highlight the importance of liquid asset holdings in mitigating contracting frictions between firms and outside investors, thus allowing firms to maximize the amount of outside financing they can raise. They show that when there are aggregate shocks to liquidity, firms want liquid claims on entities outside the corporate sector, namely government bonds. This implies that by changing the liquidity premium monetary policy impacts firms' investment decisions.

Drechsler, Savov, and Schnabl (2017c) construct a model in which monetary policy's influence on the liquidity premium causes it to impact the risk premium in the economy. In the model, financial institutions issue short-term debt to make levered investments in risky assets. Short-term debt is subject to runs, however, which are episodes in which investors lose faith in the soundness of financial institutions and refuse to roll-over their liabilities. To guard against these runs, financial institutions hold buffer stocks of liquid assets. By influencing the liquidity premium, monetary policy controls the cost of holding this buffer and hence the cost of taking leverage. A higher liquidity premium makes taking leverage more costly, which leads to less risk taking, higher risk premia, lower asset prices, and less investment. Risk premia are also higher in the bond market, consistent with the evidence in Hanson and Stein (2015).

Banks that rely on insured retail deposits have less to fear from runs but must instead invest in a deposit franchise. This imposes large operating costs, which banks recoup by gaining market power and paying low rates. Drechsler, Savov, and Schnabl (2017a) show that this explains why commercial banks engage in maturity transformation, investing in long-term (fixed-rate) assets while issuing (floating-rate) deposits. The standard view is that maturity transformation allows banks to earn the term premium but exposes them to interest rate risk (Bolvin, Kiley, and Mishkin, 2011). Specifically, when rates rise, expenses rise but income does not, leading to large losses.

Drechsler, Savov, and Schnabl (2017a) show that this is not what we see: banks' interest income and expenses move together so that the difference, their net interest margin, is almost completely flat. Moreover, bank equity prices are no more exposed to interest rate changes than non-financial firms or the stock market as a whole. Drechsler, Savov, and Schnabl (2017a) show that market power over deposits explains these results. When rates rise, interest expenses rise only a little, which keeps net interest margins from falling even if banks only hold a small amount of short-term assets. On the other hand, to guard against a drop in interest rates, banks must hold a substantial amount of long-term (fixed-rate) assets. Otherwise, they would not be able to meet their operating expenses and lose their deposit franchise. Maturity transformation is therefore necessary for banks and goes hand-in-hand with deposit taking.

From all these findings, a central theme emerges. Financial institutions are in the business of providing liquidity. On the liabilities side, they provide liquidity to their depositors and earn the deposit spread. On the asset side, they provide liquidity to their borrowers and earn the term premium. Banks' market power over deposits gives monetary policy traction over deposit supply and, given the enormous size of deposits, over liquidity provision more broadly. As rates rise and deposits contract, the price of liquidity rises for everyone. Bank borrowers receive less credit, risk taking by financial institutions falls, and firms see a higher cost of capital. This is the financial transmission of monetary policy.

II. Framework

Before proceeding with a further discussion of these topics, we sketch a novel conceptual framework that unifies many of the results linking monetary policy, liquidity, and risk premia. Our framework centers on liquidity, how it is produced and consumed by the financial sector, and the influence that the nominal rate exerts on these processes.

We say that an asset is liquid in a given state if having to sell or redeem it quickly (liquidating it) has little negative impact on the price attainable. In contrast, if an asset is illiquid in that state, then a substantially better price can be attained by selling it gradually or with a delay. A principal source of illiquidity is asymmetric information (Akerlof, 1970), whose redistributive effects can overwhelm the gains from trade. Gorton and Pennacchi (1990) show that this problem can be mitigated by creating assets whose payoffs are insensitive to information.

The predominant private-sector source of liquid assets in the economy are the liabilities of the financial sector. The most prominent of these is bank deposits, which are the banking system's largest source of funding. Other important examples of liquid assets created by the financial sector are commercial paper, asset-backed securities, and shares of money market mutual funds. The other major source of liquid assets in the economy are the liabilities of the government, in particular currency, reserves, and treasury bonds. Krishnamurthy and Vissing-Jorgensen (2015) show that government liabilities are partial substitutes for the liabilities of banks. Sunderam (2015) extends this to shadow banks.

The distinction between government (public) liabilities and financial-sector (private) liabilities is central to our framework, and to the mechanism by which monetary policy is transmitted through the financial system. The important difference between these liabilities is in what happens to them in case of a financial crisis or run. This is an event in which households lose faith in the value of claims on the financial sector and refuse to roll them over or to buy new ones, except perhaps at a steep discount. This type of liquidity crunch was a defining feature of the 2008 financial crisis (Brunnermeier, 2009).[2] In contrast, households do not usually lose faith in the value of government liabilities during this time. This characteristic took centuries to evolve (Gorton, 2017), and is implicitly due to the government's unique ability to repay by levying taxes (Caballero and Farhi, 2017).[3]

Because public liabilities are liquid in a crisis, their prices command a liquidity premium over those of private liabilities even in normal times. Krishnamurthy and Vissing-Jorgensen (2012) measure the liquidity premium on public liabilities and show that it is negatively related to their supply. This liquidity premium is at the heart of the financial transmission of monetary policy.

Due to the catastrophic consequences of financial runs, the government guarantees some of the financial sector's liabilities, in particular those sold primarily to retail buyers. The most important example is retail bank deposits. The financial liabilities that are given such public backing are also immune to runs, and therefore command a liquidity premium over non-guaranteed private liabilities. Yet despite the fact that these liabilities receive government guarantees, the financial sector retains control over how many of them are produced. This dichotomy is key to the mechanism through which monetary policy influences the financial system. To emphasize it, and to distinguish these liabilities from liabilities that are purely public or private, we refer to them as *public-private* liabilities.[4]

As discussed above and in Section III, banks have substantial market power over the

2. Moreira and Savov (2017) analyzes the macroeconomic impact of a liquidity crunch.

3. This, too, has limits. Bailing out a highly-distressed financial sector can strain the government's taxation capacity and thus expose it to default risk, as in the European sovereign debt crisis (Acharya, Drechsler, and Schnabl, 2014). In this case the financial crisis can spill over into a sovereign debt crisis.

4. In practice, the distinction can be difficult. Asset-backed commercial does not have a public guarantee. However, before the financial crisis issuers of asset-backed commercial paper usually had a liquidity or credit guarantees from a commercial bank that issued private-public liabilities. Acharya, Suarez, and Schnabl (2013) argue that banks engaged in regulatory arbitrage by effectively guaranteeing asset-backed commercial paper.

supply of deposits, which are the main form of public-private liquidity. Crucially, the nominal rate determines banks ability to exploit this power, by setting the opportunity cost of households' alternative option for liquidity, cash. A higher nominal rate raises the cost of this outside option and thus increases banks' ability to raise deposit spreads. Banks respond to this by increasing the interest spreads they charge on deposits, but avoid raising them to the point where households find it attractive to substitute towards cash. Nevertheless, deposits (and cash) become more expensive to hold, so households substitute away from liquid holdings to less liquid claims (see Section III for more details). In this way the nominal rate controls the price (premium) and total supply of public-quality (public + public-private) liquidity in the economy.

While the financial sector is the major producer of public-private and private liquidity, it is also a large consumer of (purely) public liquidity. Since government guarantees extend only to some of the financial sector's borrowing, mainly retail bank deposits, it remains exposed to runs on its private liabilities. Therefore, to limit losses in the event of a crisis the financial sector holds large buffers of public liquidity alongside its holdings of risky and illiquid assets. It can then liquidate these buffers in the event of a crisis to reduce the need to (fire) sell its risky and illiquid assets, whose prices drop precipitously during a crisis as a result of the sharp decline in the financial sector's ability to borrow and take risk.[5]

By controlling the liquidity premium, the nominal rate controls the cost of carrying liquidity buffers. An increase in the nominal rate raises the liquidity premium, making it more expensive to hold these buffers. Thus, it decreases the financial sector's demand for risky and illiquid assets and hence raises their risk premium in equilibrium. In other words, an increase in the nominal rate decreases the willingness of the financial sector to

5. To partially offset this decrease in banks' risk-taking capacity during a crisis, the central bank can act as a lender-of-last-resort and allow banks to borrow against risky collateral at below-market haircuts. This describes the European Central Bank's main unconventional monetary policy intervention during the European sovereign debt crisis (Drechsler, Drechsel, Marques-Ibanez, and Schnabl, 2016). Alternatively, it can also increase risk-taking capacity by recapitalizing the financial sector though equity injections, asset purchases, and debt guarantees. This describes the main policy intervention in the immediate aftermath of the Lehman bankruptcy in September 2008 (Philippon and Schnabl, 2013).

take risk and thus increases the risk premium in the economy. Since the risk premium is a big component of the total cost of capital for most investments, an increase in the risk premium reduces total investment (especially for riskier projects) and ultimately growth in the economy.

Because an interest rate increase induces the financial sector to supply fewer public-private liabilities (in order to charge higher spreads), it affects the composition of the financial sector's liabilities. This, in turn, further affects the financial sector's assets. Public-private liabilities are effectively guaranteed to be the financial sector's most stable, run-free source of funding, and it is therefore expensive to replace them. Hence, the decrease in their supply forces the financial sector to contract lending, especially to illiquid borrowers. This is an unavoidable tradeoff banks face in exploiting their market power over this source of funds.

As discussed above and in Section IV.A, the strong relationship between the interest rate and the liquidity premium also means that the prices of longer-maturity bonds covary more negatively with the liquidity premium. Thus, liquidity-constrained investors, such as the financial sector, incur larger losses on long-term bonds when interest rates rise and liquidity contracts, making them less useful as a source of liquidity—in this sense, less liquid. Investors therefore demand additional compensation—the term premium—to hold long-term bonds.[6]

Lastly, as discussed above and in Section V, banks' market power over liquidity supply makes them natural providers of long-term loans. In other words, deposit-taking and maturity transformation are natural counterparts. Interpreted within our framework, banks can earn the liquidity premium on long-term bonds because they have an offsetting, positive exposure to the liquidity premium through their market power over deposits. Thus, our framework shows how the financial transmission of monetary policy is intertwined with both banks' liabilities and assets.

While we focus mostly on conventional monetary policy, our framework also applies to

6. This changes when the liquidity contraction is induced by a crisis rather than monetary policy. Flight to safety tends to push up the prices of long-term *safe* bonds (e.g., Treasuries), making them endogenously *more* liquid, see Moreira and Savov (2017). This explains why Treasury term premia collapse during crises.

unconventional monetary policy, which is policy conducted through means other than the nominal interest. Examples include quantitative easing, lender-of-last-resort interventions, and bank recapitalization. Quantitative easing works in our framework by using the central bank's balance sheet to increase overall risk taking, thus decreasing the economy's effective risk aversion. Lender-of-last resort interventions work because they allow banks to keep risky assets on their balance sheets, which prevents fire sales. And bank recapitalization works because it raises the financial sector's capacity to take on risk and thus increases the supply of credit. To sum up, we offer a new framework of how monetary policy—conventional and unconventional—affects the financial sector and the broader economy.

III. The Deposits Channel

Even as the study of monetary economics turned its attention away from liquidity supply in the 1980s, monetary policy continued to exert a powerful influence over it. Figure I, adapted from Drechsler, Savov, and Schnabl (2017b, Figure 2), shows this. It plots the annual growth rates of savings deposits (top panel) and total core deposits (bottom panel) against the contemporaneous change in the Fed funds rate, since 1986. Savings deposits growth is strongly negatively related to changes in the Fed funds rate; their correlation is -60%. Moreover, the sensitivity of deposits growth to Fed fund changes is economically large: annual savings deposits growth declines by 2.76% per 100 bps increase in the Fed funds rate. The enormous size of savings deposits–\$7.75 trillion as of September 2017–suggests that this has important implications. The relationship for total core bank deposits is similar: the correlation of its growth with Fed funds rate changes is -50%, and its sensitivity is -1.11% per 100 bps. The smaller sensitivity is due to a partially offsetting inflow of small time deposits, a type of deposit that imposes restrictions on withdrawals and is therefore substantially less liquid. Thus, the panels highlight two related results: (1) higher interest rates are associated with a substantial decline in total deposits, and (2) within deposits, households substitute from more to less liquid forms of deposits. Since deposits are by far the largest class of liquid assets held by households, their contraction suggests a contraction in the overall supply of liquidity.

Figure III, also adapted from Drechsler, Savov, and Schnabl (2017b, Figure 1), reveals the proximate cause for this contraction. The figure plots the rates paid on representative products from the three main types of core deposits: checking, savings, and small time deposits. It shows that banks raise deposit rates far less than one-for-one with the Fed funds rate. This is especially true for the more liquid types of deposits, checking deposits and savings deposits, whose rates go up by only 19 bps and 47 bps, respectively, per 100 bps Feds funds rate increase. The rate on time deposits rises by 76 bps (see also Hannan and Berger, 1989, 1991; Diebold and Sharpe, 1990; Neumark and Sharpe, 1992; Driscoll and Judson, 2013; Yankov, 2014). The spread between the Fed funds rate and the rate paid by a deposit, the deposit spread, represents the opportunity cost of holding the deposit due to foregone interest. Hence, the figure shows that when the Fed funds rate increases, deposits become much more expensive to hold, particularly the more liquid deposits.

Together, Figures I and III show that higher interest rates are associated with a lower quantity and higher price of deposits. Thus, monetary policy appears to shift banks' supply curve of deposits to households. This is precisely what one used to see under the required reserves and rate ceiling mechanisms (Friedman and Kuttner, 2010; Gilbert, 1986), yet neither has been operative in the U.S. for decades. Thus, there must be a different mechanism at work, one that has remained intact despite the profound regulatory and technological changes that have occurred during this time.

Drechsler, Savov, and Schnabl (2017b) argue that this mechanism centers on banks' market power over retail deposits. They present a model of how it works. In the model, households have a preference for liquid assets, of which there are two: cash, which pays no interest, and deposits, which pay an endogenous interest rate set by banks. Households can choose among several banks in their local area, but they view each bank as somewhat differentiated from the others. For example, they may prefer a bank whose branches are more convenient for their daily routines. Differentiation could also result from relationship or branding effects, or from households not paying full attention to the rates offered at all other banks.[7]

Differentiation gives banks market power, allowing them to charge depositors a spread by setting the deposit rate below the (risk-adjusted) rate they earn on other assets–the Fed funds rate. Moreover, banks are able to charge a higher spread when the Fed funds rate increases because this makes households' outside liquidity option, cash, more expensive. Since the most liquid deposits, such as checking and savings accounts, are the closest substitutes for cash, the model further implies that their deposit spreads go up the most. Thus, the model matches the behavior of deposit spreads in Figure III, both overall and by product.

The model also matches the behavior of deposit quantities, shown in Figure I. When the Fed funds rate rises and banks increase their deposit spreads, households respond by withdrawing some of their deposits and investing in less liquid assets, such as time deposits and money market funds (they could also consume or pay down debt). Thus, banks experience a net reduction in deposits, but make higher profits overall because of the ones that stay. Thus, when the Fed funds rate rises, banks act as (partial) monopolists, charging higher prices and restricting quantities.

Drechsler, Savov, and Schnabl (2017b) test the market power mechanism using geographic variation in local market power. They use geographic variation for empirical identification because of the endogeneity of monetary policy. Monetary policy is tightened when aggregate economic conditions are improving or are expected to improve, which leads to a pro-cyclical nominal interest rate in the aggregate time series. Therefore, they need to control for aggregate economic conditions, which they do by comparing the impact of monetary policy across different geographic regions.

Market power depends jointly on the amount of differentiation across banks as well as the

7. Hortaçsu and Syverson (2004) show that there is substantial differentiation in the market for S&P 500 index funds, a financial service that is *a priori* highly homogeneous. Gabaix, Laibson, Li, Li, Resnick, and de Vries (2016) provide a model of how high markups can persist in such a market even with a large number of firms.

concentration of banks in a local area. Local concentration is readily observable, making it a useful source of geographic variation. To control for banks' lending opportunities, Drechsler, Savov, and Schnabl (2017b) compare the deposit spreads of different branches of the same bank across local markets with high and low concentration.[8] The identifying assumption is that banks are able to raise deposits at one branch and lend them at another, thereby decoupling the local deposit-taking and lending decisions (this assumption is supported by the literature, see Gilje, Loutskina, and Strahan, 2013). Consistent with the market power mechanism, Drechsler, Savov, and Schnabl (2017b) find that when the Fed funds rate rises, banks raise deposit spreads by more and experience greater deposit outflows at branches located in more concentrated areas.

These results show that monetary policy changes the supply of deposits through banks' market power in deposit markets. Drechsler, Savov, and Schnabl (2017b) call this transmission mechanism the *deposits channel of monetary policy.*

III.A. The Deposits Channel and Bank Lending

The deposits channel has important implications for bank lending. This is because deposits are by far the largest source of bank funding, representing 81% of aggregate bank liabilities as of September, 2017.[9] Deposits are also a special source of bank funding due to their stability and reliability (Kashyap, Rajan, and Stein, 2002; Hanson, Shleifer, Stein, and Vishny, 2015). This is especially true of banks' core (i.e., retail) deposits (Federal Deposit Insurance Corporation, 2011), which drive the deposits channel. In contrast, wholesale (i.e., non-deposit) funding is far more price-sensitive and run-prone because the market for it is competitive and it is not protected by government guarantees. Consequently, wholesale funding charges a rate that is higher and, due to adverse selection concerns, is sensitive to

8. This is akin to the within-borrower estimator used by Khwaja and Mian (2008), Schnabl (2012), Jiménez, Ongena, Peydró, and Saurina (2014) and Paravisini, Rappoport, Schnabl, and Wolfenzon (2015) but with depositors as lenders and banks as borrowers.

9. The numbers are from the Federal Reserve Board's H.8 release.

the amount borrowed (Stein, 1998). Thus, wholesale funding is an expensive and imperfect substitute for deposit funding, so that banks' deposit supply decisions impacts their lending. As a result, banks face a tradeoff: contracting deposit supply in order to raise deposit prices (after an increase in the Fed funds rate)forces them to reduce lending growth.

Thus, the deposits channel generates a bank lending channel of monetary policy (Bernanke, 1983; Bernanke and Blinder, 1988; Kashyap and Stein, 1994). This is an important result because the literature on the bank lending channel has lacked a plausible driving mechanism for a long time. Early works relied on the cost of required reserves and the deposit rate ceiling mechanism, but these been essentially irrelevant in the U.S. for decades (Romer and Romer, 1990).[10] At the same time, the empirical literature has continued to find strong evidence that monetary policy impacts bank lending (Bernanke and Blinder, 1992; Kashyap, Stein, and Wilcox, 1993; Kashyap and Stein, 2000; Jiménez, Ongena, Peydró, and Saurina, 2014). Thus, the deposits channel fills a large gap in this literature by providing a plausible mechanism for these findings.

Drechsler, Savov, and Schnabl (2017b) test this implication of the deposits channel directly. They compare lending within a given county by banks who raise deposits in markets with different levels of concentration. By comparing lending within the same county, this methodology holds local lending opportunities constant and hence isolates the impact of differences in banks' market power over deposit supply on banks' lending. The results show that banks that raise deposits in more concentrated markets contract their lending by more than other banks when the Fed funds rate increases, as predicted by the deposits channel. This decrease in lending adds up to an aggregate effect: the paper shows that counties served by banks with greater average market power over their deposit supply experience a greater contraction in total lending when the Fed funds rate increases. Moreover, and consistent with the deposits channel, it shows that the response of lending in a given county to a

10. The bank lending channel also relies on the assumption that bank lending is "special", i.e., firms face significant costs in substituting to other sources of funding (Bernanke and Blinder, 1988; de Fiore and Uhlig, 2011, 2015)

Fed funds rate change depends only on the average concentration of the markets where the lending banks raise deposits, but not on the concentration of the county itself.

Drechsler, Savov, and Schnabl (2017b) further find that banks only substitute a fraction of the deposit funding they lose due to the deposits channel with wholesale funding, consistent with deposit funding being especially important. As a result, when the Fed funds rate increases banks shrink their balance sheets, causing a contraction of all of the main categories of assets, and especially of securities. As securities are banks' largest source of long-duration assets (Drechsler, Savov, and Schnabl (2017a)), their sales shorten the duration of banks' balance sheets.

III.B. The Deposits Channel and the Liquidity Premium

Since deposits are by far the largest source of liquid assets for households ($11.3 trillion as of September 2017), the deposits channel impacts the total supply of liquidity in the economy. As banks increase the price and decrease the quantity of deposits, the prices of other liquid assets are likely to rise, while the prices of more illiquid assets are likely to fall (see Section IV). These changes affect the cost of capital of firms in the economy and the consumption-savings decisions of households.

An example of how this works in practice is provided by money market funds. Money market funds hold government and highly-rated private debt instruments with very short maturities. They also allow their investors to trade in and out on a daily basis. This makes money market funds a potential substitute for bank deposits.[11] At the same time, they are an imperfect substitute because they are not insured by the government, so they are purely private liquidity.[12]

Consistent with some degree of substitutability with bank deposits, money market funds

11. Indeed, the money market fund industry got its start as a higher-yielding alternative to bank deposits in the era of deposit rate ceilings under Regulation Q (Kacperczyk and Schnabl, 2010, 2013).

12. They also do not offer the convenience of bank branches, which households appear to value, and may require greater financial knowledge and sophistication. These differences help explain why retail money market funds remain comparatively small despite offering higher rates than bank deposits.

experience inflows when the Fed funds rate rises, and outflows when it falls. This is shown in Figure IV, which plots the annual growth rate of retail money market funds (those offered to households) against the contemporaneous change in the Fed funds rate. The relationship is very strong, though with a lag of a little over a year. The semi-elasticity is 5.2%, which is larger than that for deposits, but since this asset class is much smaller ($700 billion as of September 2017), money market funds absorb only a fraction of deposit outflows following a Fed funds rate increase.[13]

Money market funds absorb the inflows they receive from households by investing in short-term instruments such as T-Bills. We therefore expect to see the yields of T-Bills fall relative to less liquid assets. This is indeed the case, as shown in Figure II, adapted from Drechsler, Savov, and Schnabl (2017c, Figure 1). The figure plots the Fed funds-T-Bill spread, a proxy for the liquidity premium on T-Bills, against the Fed funds rate itself. Consistent with the implications of the deposits channel, the liquidity premium on T-Bills rises with the Fed funds rate.[14] The higher liquidity premium confirms a contraction in liquidity throughout the financial system.

IV. Monetary Policy and the Risk Premium

Recent work shows that increases in the interest rate are associated with an increase in the risk premium in several large classes of risky assets, including equities, corporate bonds, mortgage-backed securities, and long-maturity treasuries. Drechsler, Savov, and Schnabl (2017c) provides a model that can explain these findings. In the model, the interest rate influences the financial sector's willingness to take risk by changing the opportunity cost of holding liquidity buffers, which the financial sector requires in proportion to its level of risk taking.

An important assumption underlying this model is that the opportunity cost of holding

13. Savings deposits alone are eleven times larger at $7.7 trillion. Their semi-elasticity is 2.76%, which implies that money market funds absorb about 17% of the savings deposits outflows.

14. Nagel (2016) finds a similar result using a different measure of the liquidity premium in T-Bills.

liquid assets increases with the nominal interest rate. Hence, this model fits naturally with the deposits channel, although other economic mechanisms underlying this relationship could work as well. The essential ingredient is a close link between the opportunity cost of money (i.e., the nominal interest rate) and the liquidity premium on near-money assets. And, as shown in Nagel (2016) and Drechsler, Savov, and Schnabl (2017c), there is strong empirical support for a tight and economically large relationship between the level of the nominal rate and the liquidity premium.

The model has two types of agents, who differ (only) in their risk aversion (γ). Agents of type A are less risk-averse than those of type B, $\gamma^A < \gamma^B$. This heterogeneity creates a demand for risk-sharing between the two agents. Thus, in equilibrium type A agents sell risk-free claims ("deposits") to type B agents and use this borrowing to increase their holdings of the risky asset (take leverage). The model interprets type A agents as pooling their net worth together to provide the equity capital of financial intermediaries. It refers to financial intermediaries as "banks", but interprets this term broadly as encompassing not only commercial banks but also broker-dealers, hedge funds, and off-balance-sheet vehicles. The key common trait of these institutions from the point of view of the model is that they take leverage using short-term debt. Even more broadly, the model applies to any intermediaries that finance holdings of risky assets using liabilities that are exposed to funding shocks, i.e., are runnable.[15] In the baseline version of the model, aggregate output is given by an endowment process Y_t and the only state variable is the wealth share of the type-A agents, $\omega_t = \frac{W_t^A}{W_t^A + W_t^B}$. All agents can buy claims on the aggregate endowment, which is the risky asset. The price of this claim is given by P_t and its return process, which is determined in equilibrium as a function of ω_t, is $dR_t = \mu_t(\omega_t)dt + \sigma_t(\omega_t)dB_t$. Agents also trade instantaneous risk-free bonds that pay the competitive, equilibrium real interest rate

15. For example, it applies also to open-end mutual funds, which issue shares that are redeemable daily at net asset value. This creates funding risk that can lead to fire sales (Coval and Stafford, 2007). Indeed, long-term equity and bond funds hold 5% of total assets as cash on average, ranging from 1% for government bond funds to 15% for global bond funds (Investment Company Institute, 2014).

$r_t(\omega_t)$.[16]

The risky asset completes the market, so there would be full risk sharing in the absence of any financial frictions. However, borrowing is subject to a friction: there is a risk that depositors (type-B agents) lose faith in the financial sector and refuse to roll over or accept its liabilities, causing a run/financial crisis. This forces the financial sector to de-leverage rapidly. The difficulty is that in this scenario risky assets can only be liquidated quickly at a steep fire-sale discount, similar to Allen and Gale (1994). To limit fire-sale losses in such an event, the financial sector continuously holds buffers of liquid assets, which can be liquidated rapidly at full value.[17]

Policymakers have indeed embraced the idea of holding liquid asset buffers as insurance against funding risk (Stein, 2013). Recent regulations requiring liquid asset buffers include the liquidity coverage and net stable funding ratios adopted by Basel III and US regulators (Basel Committee on Banking Supervision, 2013, 2014). These rules are precisely meant to ensure that banks avoid fire-sale liquidations. While the financial sector in the model self-insures voluntarily, the implications are unchanged if they do so to comply with regulation.

Note that the financial sector's liquidity buffer must consist of *public* liquidity. Claims on other financial intermediaries, such as interbank loans, cannot act as a buffer for systematic (financial crisis) shocks. To see this, note that in a crisis the financial sector must shrink it's external borrowing since households shrink their holdings of private financial sector claims. Thus, the financial sector must also shrink its claims on entities outside the financial sector. Clearly, holding intra-financial-sector claims does not help to achieve since they are a liability of the financial sector (as well as an asset). Thus, they cannot serve as liquidity buffers. Rather, liquidity buffers must consist of safe claims on entities outside the financial system ("outside liquidity" in the language of Holmström and Tirole, 1998). In practice these

16. Since the rate is competitive, the bonds represent wholesale funding rather than retail deposits.

17. Although the model does not microfound the occurrence of fire sales during a crisis, it suggests the reason for them: in a crisis the financial sector needs to de-lever and thus unloads a large quantity of assets to the more risk-averse depositors. This causes the risk aversion of the marginal buyer in the economy to increase sharply compared to normal times and thus causes a sharp drop in the prices of risky assets.

are mostly bonds that are explicitly or implicitly guaranteed by the government, including treasury and agency bonds, and agency mortgage-backed securities.

The nominal interest rate in the model is denoted by n_t. Based on the tight relationship in Figure II and the mechanism discussed in section III.B, the model assumes that the liquidity premium on government bonds is n_t/m, i.e., it is proportional to n_t. The model derives conditions under which banks hold a fraction λ of public liquidity (government bonds) against each dollar of leverage, to avoid fire sale losses in case of a crisis/run. Then, provided that the demand for risk sharing is sufficiently large ($\gamma^b - \gamma^a$ exceeds a cutoff), banks take leverage in equilibrium. Their portfolio weight in the risky asset (w_S^A) is given by

$$w_S^A = \frac{1}{\gamma^A} \frac{(\mu - r) - \lambda(n/m)}{\sigma^2} + \text{hedging terms.} \tag{1}$$

The difference between this expression and the standard portfolio-choice expression is the presence of the term $\lambda(n/m)$. This term reflects the marginal cost of the liquidity buffer the bank needs to hold against its leveraged position, and shows the direct impact of the interest rate on its risk/leverage choice. For each additional dollar of bank leverage, the bank must increase its liquid holdings to avoid fire sales. Doing so is costly liquid assets command a liquidity premium n/m. Since this premium is increasing in n_t, a higher nominal rate raises the cost of risk-taking/leverage. Indeed, an increase in the nominal rate works like an increase in banks' effective risk aversion. This decreases the overall demand for risky assets in the economy and thus raises the equilibrium risk premium.

Drechsler, Savov, and Schnabl (2017c) compare equilibrium prices and quantities under various interest-rate rules. They set the risk versions of the type-A and -B agents to 1.5 and 15, respectively, to get a substantial demand for risk sharing, and the population share of type-A agents to be 10%. Since the risky asset is the endowment claim, they set its average growth rate and volatility to 2%, consistent with standard estimates for aggregate U.S. consumption.

Two important parameters are λ and $1/m$, which set the size of the liquidity buffer and government bond liquidity premium, respectively. The paper sets $1/m = 0.25$ based on the time series in Figure II and $\lambda = 29\%$ based on the ratio of banks' liquid securities to deposits (Brunnermeier, Gorton, and Krishnamurthy (2012) and Bai, Krishnamurthy, and Weymuller (2016) undertake comprehensive analyses of banks' funding risk.)

As an example of the impact of the interest rate, the paper compares risk-taking and the risk premium across two constant interest-rate rules: $n_t = 0\%$ and $n_t = 5\%$. These values also depend on the state variable, so the paper plots these values for all values of ω. Under the 0% rule, liquidity is costless, so the model is equivalent to one with no funding risk, whereas under the 5% rule liquidity is costly and leverage is constrained. This is clear in the results: under the 5% rule banks' take significantly less leverage, and the risk premium and Sharpe ratio of the risky asset increase substantially. One way to think about this increase is to calculate the difference in the risk aversion of the economy's implied rep agent: it increases from 4 to 14 for common values of ω. The increase in the risk premium translates into an increase in the total discount rate and hence a compression in the valuation of the endowment claim (P/Y) for all ω.[18]

The paper also shows that the interest rate policy can have strong effects on the volatility of returns. In the constant-rate scenarios, there is more volatility under the lower rate because leverage is higher and hence the wealth share is more volatile. However, under dynamic interest-rate rules with feedback, such as a rule that captures the notion of the "Greenspan put", the relationship of volatility and the interest rate is more complicated and involves a tradeoff between short-term stability and long-term instability.

Drechsler, Savov, and Schnabl (2017c) further expand the model to incorporate monetary policy shocks (unexpected deviations from the expected interest rate rule) and a real side to

18. The real rate in the model moves opposite to the risk premium, because increased risk aversion increases the demand for precautionary savings. A useful extension of the model would incorporate nominal price rigidities, as in the new Keynesian model, so that the real rate moves in tandem with the nominal rate. In this case, the risk premium and real rate would move in the same direction, causing an even larger impact on the total discount rate.

the economy, to demonstrate the effect of these on production and investment. The model shows how a shock increase to the nominal rate reduces investment and economic growth by raising the risk premium and causing risky asset prices to fall.

IV.A. Term Structure

As Drechsler, Savov, and Schnabl (2017c) explain, the model makes an important prediction about the slope of the yield curve, and it's response to rate shocks: it generates a substantial term premium and hence a yield curve that is significantly upward sloping on average. The reason is the basic mechanism; a higher nominal rate implies a higher cost of liquidity, decreased risk-sharing, and hence a higher risk premia. Thus, a positive nominal rate shock increases marginal utilities, and since nominal bond prices fall in these states, agents demand a risk premium to hold them. Since long-term bond are more sensitive to such shocks, they are riskier, and there is a term premium.

Thus, the impact of the nominal rate on the liquidity premium allows the model to explain the term premium. Indeed, the term premium can be interpreted as the term structure of liquidity premia. Under this interpretation investors treat long-term bonds as less liquid than short-term bonds because their returns co-vary more negatively with the liquidity premium. In other words, they suffer larger losses when liquidity constraints tighten in the economy, making them a less useful source of liquidity, i.e., effectively less liquid. Because a positive rate shock increase risk premia, it increases the risk premium in forward rates (the forward premia), including far out on the yield curve. Hence, the model explains Hanson and Stein (2015)'s finding that monetary policy shocks move long-term forward real rates, which cannot be explained by the new-Keynesian paradigm.

V. Deposits and Maturity Transformation

One of the main functions of banks is maturity transformation, whereby banks borrow using short-term debt but lend long-term. In so doing, they increase the supply of long-term credit to the economy. The substantial yield premium paid by long-term credit (the term premium) shows that such credit is in high demand; the additional yield it pays compensates banks for providing it. The risk involved in providing maturity transformation is that it creates a mismatch between the short duration of the liabilities and the long duration of the assets. This implies that when the short rate increases unexpectedly, the interest rate paid by the short-term funding will rise faster than the rate earned by the long-term assets, causing the bank's net interest income to fall (Bolvin, Kiley, and Mishkin, 2011). In present value terms, the value of the bank's assets falls more than the value of its liabilities, and the banks suffers a loss of equity capital. According to the bank capital channel, the loss of capital should induce the bank to shrink its balance sheet and contract lending (Peek and Rosengren, 2010).

Drechsler, Savov, and Schnabl (2017a) document that the duration mismatch of the aggregate banking sector is around 4 years. By a standard duration calculation this implies that an accumulated surprise increase in the short rate of 100 basis (over any period of time) causes banks' assets to decline by 4% more than their liabilities. Equivalently, banks' net interest margin (NIM) decreases by 100 bps for 4 years running, resulting in a cumulative 4% loss. Given banks 10-to-1 leverage, this translates into a 40% loss of bank equity.

It is therefore quite surprising that no such episode of any comparable magnitude has ever occurred.[19] This is certainly *not* because of a lack of interest rate surprises; the short rate rose nearly 20% from the 1950s to 1980/81, and then steadily decreased for the subsequent

19. The closest is the savings and loan (S&L) crisis that began in the mid-1980s. An unprecedented rise in interest rates in the early 1980s inflicted significant losses on these institutions, which were subsequently compounded by risk shifting White (1991). However, unlike the S&L sector, the commercial banking sector saw no decline in NIM during this period. As White (1991) points out, the rise in interest rates occurred right after deposit rates were deregulated, making it difficult S&Ls to anticipate the effect of such a large shock on their funding costs. In this sense the S&L crisis was the exception that proves the rule.

three decades. Both the run-up and decline were largely unanticipated at the outset and hence generated cumulative surprises far larger than 100bps (as evidenced by comparably large changes in long-term rates over these periods).

The reason why these accumulated surprises have not led to a banking crisis is that banks' exposure to interest rates is far lower than implied by their duration mismatch. Using an event-study approach around Federal Open Market Committee (FOMC) meetings, Drechsler, Savov, and Schnabl (2017a) find that a 100 bps increase in interest rates only reduces bank equity by 2.4% (not 40%), about the same as for the market as a whole.

To understand this, Drechsler, Savov, and Schnabl (2017a) analyze the stream of banks' incomes and expenses. The short duration of banks' liabilities implies that their stream of interest expenses should be sensitive to the short rate, in contrast to the stream of interest income from their fixed-rate, long-duration assets. However, Drechsler, Savov, and Schnabl (2017a) find that *both* banks' interest income *and* expenses are insensitive to the short rate. As a result, there is very little fluctuation in banks' net interest margin or return on assets over the period 1955 to 2015, and no correlation between these profitability measures and the short rate.[20]

Drechsler, Savov, and Schnabl (2017a) construct a simple model that explains this result. The key assumption is that banks have a deposit franchise that gives them market power over deposit provision, as shown in Drechsler, Savov, and Schnabl (2017b). The deposit franchise allows banks to charge high spreads on deposits, but servicing it imposes large, recurring operating costs (e.g., branch network, marketing, customer service). The evidence shows that these costs are about 2% to 3% of assets.

The key insight is that, due to their ability to increase deposit spreads when the interest rate goes up, banks pay low and insensitive rates on their deposits and hence their interest expenses have low sensitivity to the short rate. At the same time, their other large expenses,

20. During the zero-lower-bound period after 2008, there was a mild decline in net interest margins as long-term assets rolled off only to be replaced by new assets paying significantly lower rates. A more severe compression occurred in Europe where policy rates turned negative. Brunnermeier and Koby (2016) analyze the implications of such a compression for the effectiveness of monetary policy.

their operating costs, are also largely invariant to the interest rate and hence resemble a fixed-rate liability. Hence, the importance of the deposit franchise effectively makes banks stream of total expenses, composed of interest and operating expenses, akin to a fixed-rate liability. Given this, banks need to hold long-maturity fixed-rate assets, so that they remain solvent even if interest rates decrease and compress the spreads they earn from their deposit franchise. In other words, banks match the level of interest rate (in)sensitivity of their liabilities and assets. Thus, banks with a bigger deposit franchise and more market power have lower interest sensitivity of their liabilities and should therefore hold a greater proportion of interest-insensitive assets, such as long-term bonds.

Drechsler, Savov, and Schnabl (2017a) find strong support for this matching prediction in the cross-section of US banks. For each bank they estimate the sensitivity (beta) of its interest expenses and interest income to changes in the Fed funds rate. They show that there is strong matching of interest expense and income betas, both on average and bank-by-bank. The average expense and income betas are relatively low, 0.360 and 0.379 respectively, reflecting banks' high level of market power. Yet, there is also substantial variation in the cross section and yet a close to one-for-one matching of income and expense betas at the bank level. This leaves profitability effectively unexposed to interest rates across the whole distribution of banks, and hence shows that banks provide maturity transformation without taking interest-rate risk.

These results have important implications for monetary policy and financial stability. Banks' large maturity mismatch is a common source of concern about financial stability, leading to calls for narrow banking. Yet, these results show that if banks have market power then they are efficient providers of long-term credit. This suggests that forcing them to be narrow would increase the term premium and decrease their stability. More broadly, these results explain why deposit-taking and maturity transformation coexist and are the foundation for the business of banking.

VI. Conclusion

We discuss recent findings on the role of the financial sector in the transmission of monetary policy. A key focus of this work is the role of liquidity in risk sharing and how monetary policy governs its production. This research proposes a new framework that is based on banks market power over deposits, which allows monetary policy to affect the deposit supply and, given the enormous size of deposits, to affect liquidity provision more broadly. In this framework, monetary policy controls the liquidity premium in the economy and affects the risk premium on bond and stocks. Monetary policy has real effect leading to changes in the supply of credit, risk taking by financial institutions, and aggregate investment. Overall, these findings suggest that there is a monetary transmission mechanism separate from the new-Keynesian channel, which deserves to be studied further.

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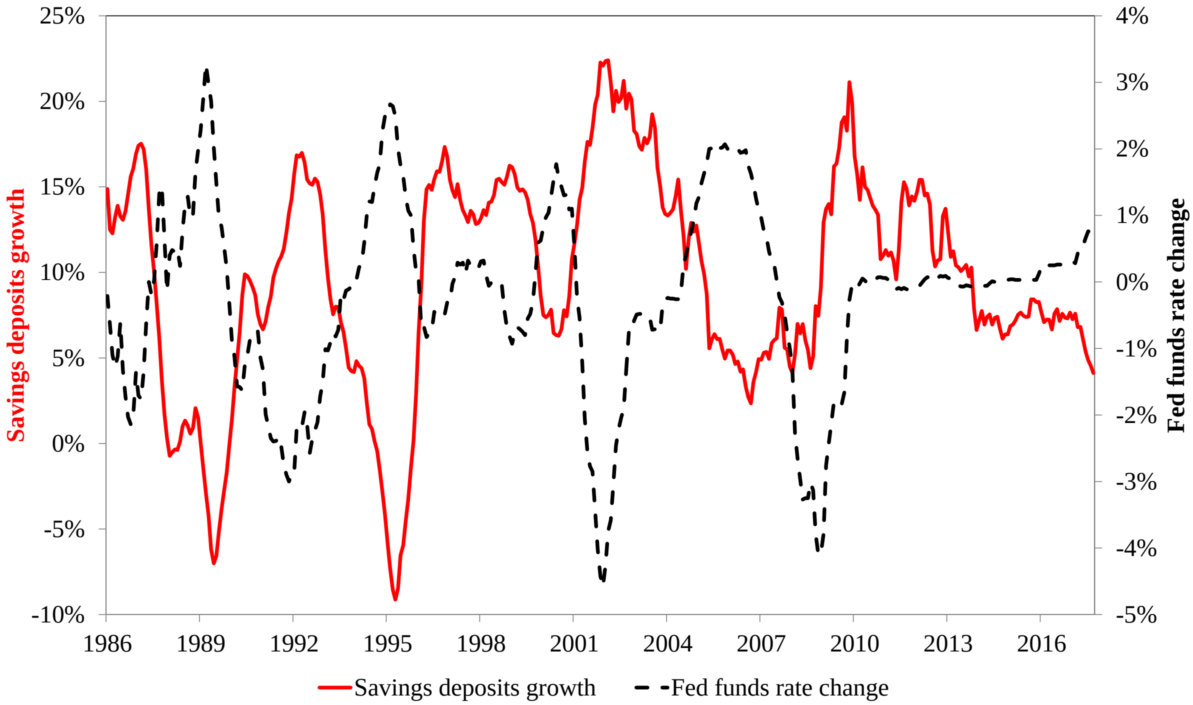
Figure I
Monetary policy and deposit growth

The figure is adapted from Drechsler, Savov, and Schnabl (2017b, Figure 2). It plots year-over-year changes in savings deposits (Panel A) and total core deposits (Panel B) against year-over-changes in the Fed funds rate. Total core deposits are the sum of checking, savings, and small time deposits. The data are from the Federal Reserve Board's H.6 release. The sample is January 1986 to September 2017.

Panel A: Savings deposits



Panel B: Total core deposits

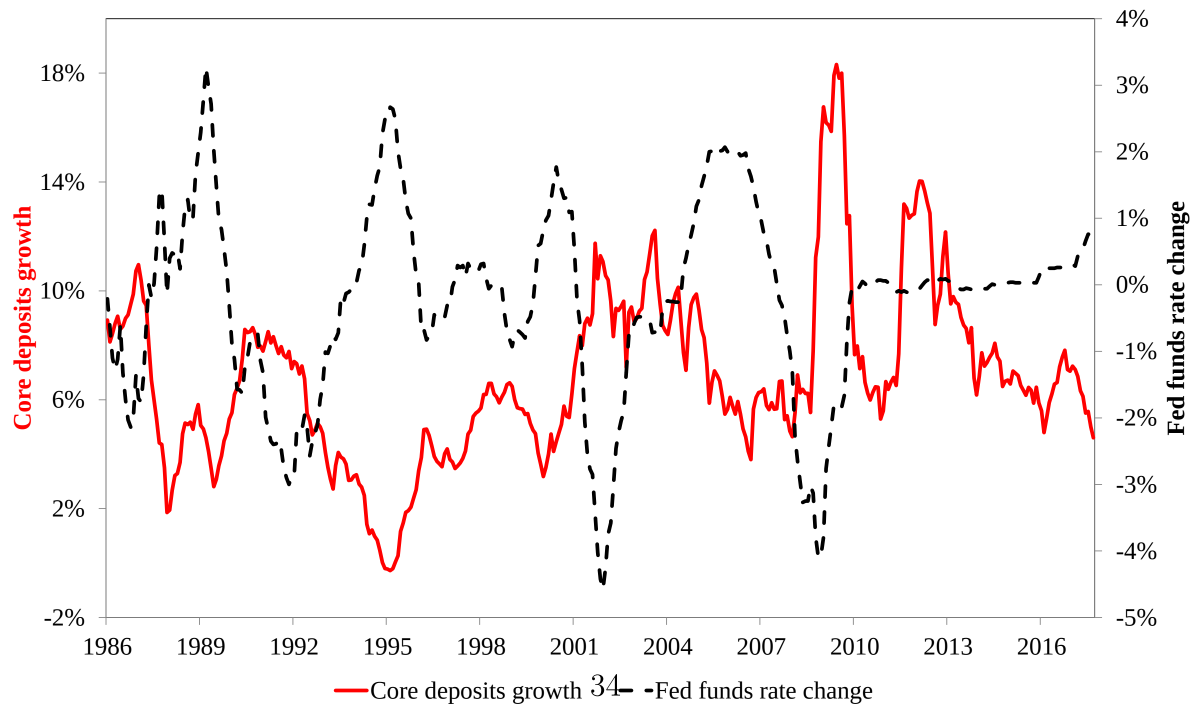


Figure II
The Fed funds-T-Bill spread

The figure is adapted from Drechsler, Savov, and Schnabl (2017c, Figure 1). It plots the Fed funds-T-Bill spread against the Fed funds rate. The Fed funds-T-Bill spread is the difference in yields between the Fed funds rate and the three-month T-Bill. The data is from the Federal Reserve Board's H.15 release. The sample is 1954 to 2017.

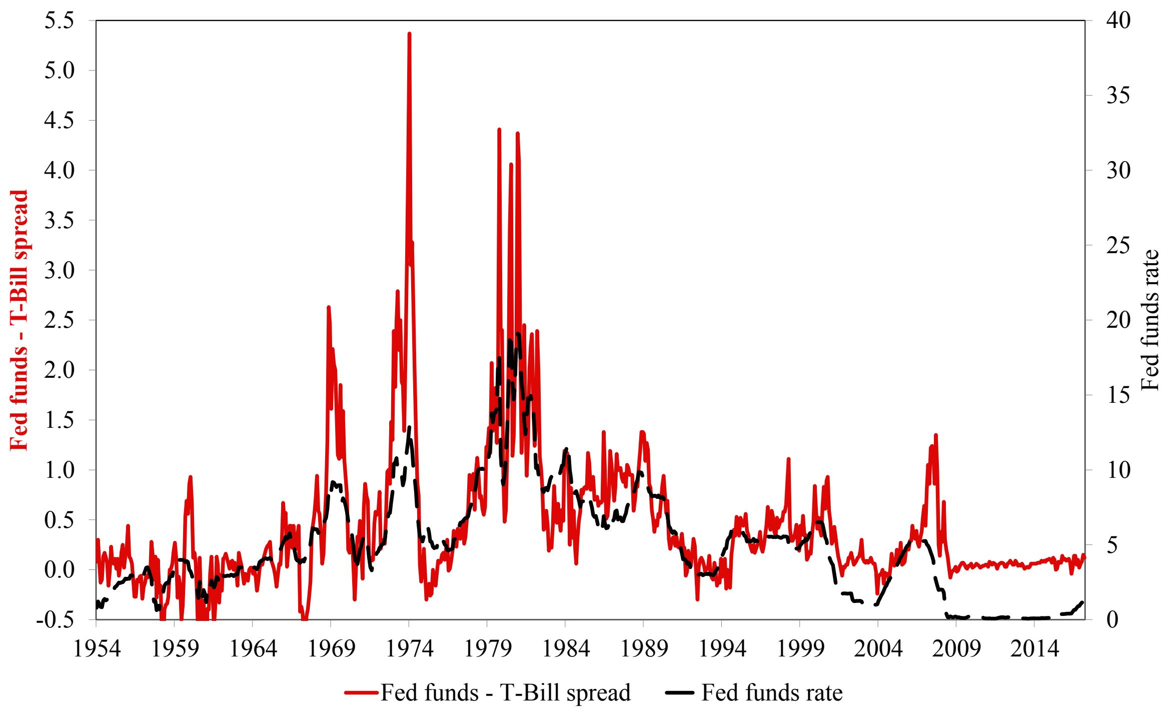


Figure III
Monetary policy and deposit rates

The figure is adapted from Drechsler, Savov, and Schnabl (2017b, Figure 1). The figure plots the Fed funds rate and the average interest rates paid on representative core deposit products. The data is from Ratewatch, 1997 to 2013. The deposit products are interest checking, money market deposit accounts with balances of $25,000 (a savings deposit product), and one-year certificates of deposit with balances of $10,000 (a time deposit). These are the most common products within their respective class (checking, savings, and time deposits) in the Ratewatch data.

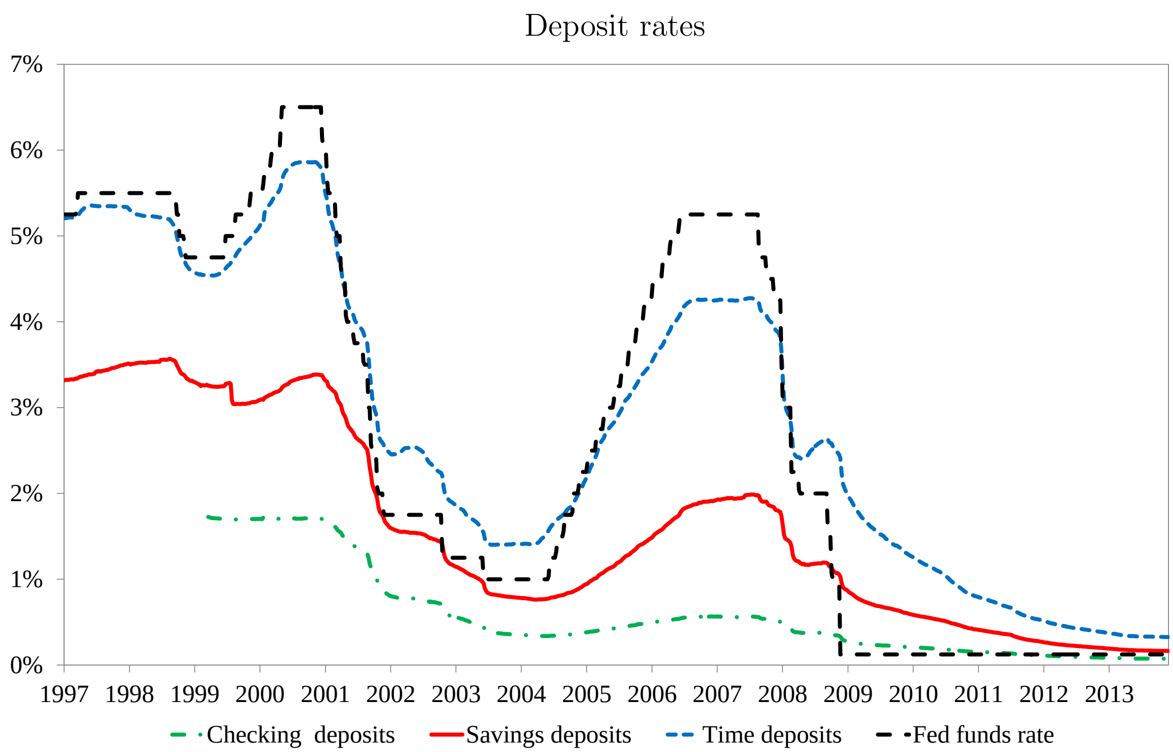


Figure IV
Monetary policy and money market funds growth

This figure plots year-over-year changes in the total net assets of retail money market funds against year-over-changes in the Fed funds rate. The data are from the Federal Reserve Board's H.6 release, Table L.121. The sample is January 1986 to September 2017.