How Monetary Policy Changes Bank Liability Structure and Funding Cost

Mattia Girotti*

December 27, 2014

JOB MARKET PAPER

Abstract

This paper explores the effects of monetary policy shocks on banks' liability structures and funding costs. Banks obtain most of their funding from a combination of demand deposits – i.e. zero-interest deposits – and interest-bearing deposits. Using local demographic variations as instruments for banks' liability structures, I measure the impact of monetary policy shocks on each bank's interest-bearing deposit rate as a function of the bank's before-the-shock liability structure. I find that when monetary policy tightens each bank faces an outflow of demand deposits. It responds by issuing more interest-bearing deposits, but pays on them an interest rate that increases with the quantity of demand deposits being substituted. This finding supports the existence of the bank lending channel of monetary policy transmission. I also provide evidence that larger banks can substitute funding sources more cheaply than smaller banks, and that demand deposits are less sensitive to monetary policy shocks when the local banking market is more concentrated.

JEL Classifications: E44, E50, G21, L16.

Keywords: Banks, Deposits, Lending Channel, Monetary Policy.

---

*Toulouse School of Economics, 21 Allée de Brienne, 31000 Toulouse, France. Email: mn.girotti@gmail.com
I would like to especially thank Augustin Landier and Thierry Magnac for their invaluable guidance and support. For their comments and suggestions, I am also grateful to Piergiorgio Alessandri, Angelo Baglioni, Milo Bianchi, Nina Boyarchenko, Thomas Chaney, Jacques Delpla, Denis Gromb, Alexander Guembel, Christian Hellwig, Margaret Leighton, Dong-Hee Joe, Adrien Matray, Nour Meddahi, Eric Mengus, Jean-Stéphane Mésonnier, Benoît Mojon, Steven Ongena, Guillermo Ordonez, Mario Pietrunti, Guillaume Plantin, Ananya Sen, and seminar participants at the TSE Macro Workshop, the TSE Applied Micro Workshop, the Business PhD Camp at ESCP Europe, the 4th FEBS Conference at the University of Surrey, the 2nd CIdE Workshop at Bank of Italy - SADiBa, the Wolpertinger Conference 2014 at Università Cattolica of Milan, and the 6th LBS-LSE-HEC-INSEAD Workshop at INSEAD. All remaining errors are mine.

1 Introduction

Banks obtain most of their funding from deposits. On average, 80% of a U.S. commercial bank's total assets are funded through deposits.[1] In the U.S., demand deposits (DDs), which essentially include checking accounts, usually pay very little interest.[2] Their opportunity cost is then likely to depend on the profitability of other liquid investments, such as interest-bearing deposits (IBDs) and Treasury Bills. Consider the case in which the Federal Reserve engages in a tight monetary policy. If market interest rates increase, depositors may decide to withdraw their DDs to invest in more appealing investments. The outflow of DDs leads banks to issue more IBDs. However, if the interest rate that they are asked increases with the quantity to borrow, banks may not substitute every dollar lost, and, instead, may decrease their loan supply. Most of the literature that studies the lending channel of monetary policy transmission directly focuses on the effects of monetary policy on bank loan supply.[3] However, in order to fully characterize why monetary policy eventually impacts bank loan supply, it is important to first investigate whether or not monetary policy in fact changes banks' liability structures and funding costs.

In this paper, I empirically explore how monetary policy impacts banks' liability structures and funding costs. I analyze yearly data of every FDIC-insured U.S. commercial and savings bank from June 30, 1994 to June 30, 2010. I take IBDs as the banks' marginal funding source, and assume that each bank's IBD interest rate is the bank's marginal funding rate. I investigate whether or not the IBD interest rate is increasing with the quantity to borrow, and whether or not DDs are sensitive to monetary policy shocks. When these conditions hold true, a contractionary monetary policy has the effect of reducing the supply of DDs to banks, and leads banks to substitute the outflow of DDs by issuing IBDs at increasing interest rates. My identification strategy exploits exogenous variation in each bank's amount of DDs, and quantifies how the reaction of DDs to monetary policy shocks transmits to the bank's IBD interest rate. I also study whether and how the transmission of monetary policy shocks varies with bank size and the local banking market concentration. A priori, due to

[1] Figure 1 plots the evolution over time, and distinguishes between small, medium, and large banks.

[2] In fact, as I discuss later, until July 21, 2011, Regulation Q explicitly prohibited interest payments on these deposits.

[3] See, for example, Kashyap and Stein (2000), Kishan and Opiela (2000), Campello (2002), Gambacorta (2005), Ashcraft (2006), and Jiménez, Ongena, Peydro, and Saurina (2012)).

their greater market power and wider market scope, larger banks should be able to substitute the same amount of DDs more cheaply. Additionally, banks that operate in more concentrated markets may agree not to adjust the IBD interest rate to monetary policy shocks (Hannan and Berger (1991) and Neumark and Sharpe (1992)). If that is the case, depositors may be less willing to modify their allocations of DDs. Therefore, in a more concentrated banking market, DDs may be less sensitive to monetary policy shocks.

In my analysis, I proxy monetary policy shocks by the year changes in the Federal funds rate. The baseline empirical model relates the marginal funding rate that a bank pays when a monetary policy shock is realized to three components: the before-the-shock amount of DDs; its interaction with the monetary policy shock; and the before-the-shock amount of loans. DDs are alternative to IBDs. So, by comparing banks with different before-the-shock amounts of DDs, I can determine if the IBD interest rate is increasing with the quantity being borrowed. The interaction term captures the change in the marginal funding rate due to the shift in the quantity of DDs, as caused by the monetary policy shock, and its substitution with IBDs.[4] This term is significantly different from zero only if the marginal funding rate changes with the quantity to borrow, and if DDs are sensitive to monetary policy shocks. Finally, comparing banks with different before-the-shock amounts of loans is another way to determine if the IBD interest rate is increasing with the quantity being borrowed. In fact, holding constant the amount of DDs, a larger amount of loans implies a greater need to finance with IBDs. Then, because loans are illiquid investments and cannot be liquidated quickly, the larger the before-the-shock amount of loans, the more a bank needs to finance with IBDs whatever monetary policy shock is realized.

The identification challenge is that the before-the-shock amounts of DDs and loans are likely to be endogenous. Both DDs supply and loan demand may depend on elements such as advertising, managerial ability, and effort, which are decided by each bank and are mostly unobservable. These elements also affect the quantity of DDs and loans after the monetary policy shock is realized. Thus, they affect the marginal funding rate, and enter into the unobservable term. This implies that the before-the-shock amounts of DDs and loans are correlated with that term. As a consequence, an OLS

[4]Using this specification, I hypothesize that the shifts in the quantity of DDs are proportional to the level of DDs. In other words, monetary policy shocks cause larger changes in the quantity of DDs in banks with larger amounts of DDs.

estimation is inconsistent and biased. I overcome this issue by making use of instrumental variable techniques. I exploit a novel set of exogenous shifters derived from the demographic and economic shocks that hit the location of each bank. Using data from the Survey of Consumer Finances and the Consumer Expenditure Survey, I provide household-level evidence that demographics influence the supply of DDs and the demand for loans by households and firms. For example, the older is the household the larger are the amounts in his checking accounts, and the larger are his expenditures. In aggregate, therefore, when population age increases, local firms face higher demand for their products and services, and may then increase the demand for bank loans. I obtain a broad set of county-year level demographic and economic characteristics, and I aggregate them to the bank-year level depending on where each bank has its branches. I show that these shifters change each bank's amount of DDs and loans, and the effects are consistent with the household-level analysis. In fact, banks that are located in areas where the mean age of the population increases display upward shifts in the quantities of DDs and loans.

Armed with these exogenous shocks, I assess the effects of the before-the-shock amounts of DDs and loans on the marginal funding rate.[5] The results show that the marginal funding rate decreases with the before-the-shock amount of DDs, and increases with the before-the-shock amount of loans. So, DDs prevent the IBD interest rate from rising, while loans cause it to rise. These results claim that the marginal funding rate increases with the quantity of IBDs to borrow. The other important finding is that the effect of the interaction term between the lagged amount of DDs and the monetary policy shock is strongly significant, and indicates that the amount of DDs decreases in periods of monetary policy tightening, and increases in periods of monetary policy loosening. Overall, the results suggest that when monetary policy tightens, banks substitute the outflow of DDs by issuing IBDs, and this increases the banks' marginal funding rates. The findings are robust to the inclusion of variables that control for each bank's ability and/or necessity to collect IBDs. I consider the bank capitalization (e.g. Kishan and Opiela (2000), Gambacorta and Mistrulli (2004), Gambacorta (2005), and Jiménez et al. (2012)), the participation to a bank holding company (Campello (2002), Gambacorta (2005),

[5]In my specification, I absorb any aggregate component by time fixed effects. Equally, I control for every time-invariant bank-specific components with bank fixed effects. Finally, I control for the contemporaneous demographic shocks, as these shift the supply of DDs and the demand for loans. Indeed, the larger are the exogenous inflows of DDs, and the lower is loan demand, the less a bank is forced to borrow IBDs.

and Ashcraft (2006)), and the international scale of activity (Cetorelli and Goldberg (2012)).

To assess the economic significance of my estimates, I consider the following example. From June 30, 2004 to June 30, 2005, the Federal funds rate increased by 119 basis points. I take two banks that differ for one standard deviation in the amount of DDs as at June 30, 2004. According to my estimates, I aim to determine the effects of such a difference on the IBD interest rates that the two banks pay when the policy shock is realized. Absent the policy shock, the bank that detains one extra standard deviation of DDs has a lower need to finance with IBDs. Its IBD interest rate is 23 basis points lower. However, the policy shock causes an outflow of these deposits, and the bank that has one extra standard deviation faces a larger outflow. The substitution of the extra standard deviation of DDs corresponds to an increase in the marginal funding rate of four basis points. To have a sense of the magnitude of these figures, the standard deviation of the 2005 IBD interest rate, after controlling for time and bank fixed effects, was 63 basis points. This suggests that the substitution of DDs with IBDs has a mild but non-negligible effect on the marginal funding rate. Additionally, it suggests that the cross-sectional heterogeneity in the IBD interest rate depends, to a large extent, on the amount of DDs that banks detain.

Next, I investigate if the dependence of the IBD interest rate on the quantity being borrowed, and the sensitivity of DDs to monetary policy shocks, vary with the bank's size and the local banking market concentration. First, I construct bank-year specific measures of bank size and banking market concentration. Then, I modify the baseline model interacting the constructed measures with the before-the-shock amount of DDs, and with its interaction with the monetary policy shock. I find that the amount of DDs is associated with a smaller decrease in the marginal funding rate when the size of the bank increases. I also find that the change in the IBD interest rate due to the substitution of DDs with IBDs decreases the more the banking market is concentrated. Overall, these results corroborate the hypothesis that due to their greater market power and wider market scope, larger banks are able to substitute the same amount of DDs more cheaply than smaller banks, and that DDs are less sensitive to monetary policy shocks in more concentrated banking markets.

This paper is mainly related to the literature on the bank lending channel of monetary policy transmission (Bernanke and Blinder (1988) and Bernanke and Gertler (1995)). Stein (1998), Kashyap and Stein (2000) and Jayaratne and Morgan (2000) argue that banks' inability to costlessly substitute funding sources can depend on adverse selection.[6] However, while adverse selection can be one reason, Kashyap and Stein (1994) suggest that the lending channel arises, more generally, if banks face an imperfectly elastic supply of alternative liabilities. This paper is, to my knowledge, the first to analyze how monetary policy actually changes banks' liability structures and funding costs. It adds to the literature by providing evidence that the supply of DDs to banks shifts when monetary policy changes stance, and that substituting DDs with IBDs is increasingly costly. In other words, this paper proves that the supply of IBDs, which are taken as the banks' marginal funding source, is imperfectly elastic. So, while the analysis is agnostic on the causes of such imperfect elasticity, it finds support for the bank lending channel.

The magnitude of the lending channel in the cross-section of banks has been extensively studied. Monetary contractions are followed by smaller loan supply decreases in larger banks (e.g. Kashyap and Stein (1995, 2000) and Kishan and Opiela (2000)), and in banks located in more concentrated markets (Adams and Amel (2011)).[7] My findings contribute to this literature suggesting that the reason larger banks cut back lending less is that their marginal funding source is cheaper. At the same time, they indicate that the reason banks operating in more concentrated markets diminish their loan supply less is that banking market concentration limits the sensitivity of DDs to monetary policy shocks.

This paper is also connected to a growing body of literature that looks at how liquidity shocks that hit banks are eventually transmitted to their loan supply (Khwaja and Mian (2008), Paravisini (2008), Iyer and Peydro (2011), and Gilje, Loutskina, and Strahan (2013)).[8] My findings indicate

[6] Their argument is that monetary policy shocks shift the supply of insured deposits, and banks have the ability to adjust their funding needs only by raising uninsured funds. In presence of adverse selection, banks cannot raise any amount of uninsured funds, and are credit rationed at equilibrium. So, a monetary contraction, which reduces the amount of completely insured deposits, decreases the overall amount of bank liabilities, and thus bank loan supply. Maechler and McDill (2006) provide empirical evidence that financially sound banks can raise uninsured deposits by raising the associated interest rate, while weak banks cannot. Maechler and McDill (2006) do not investigate, however, if monetary policy shocks actually shift the supply of insured deposits to banks.

[7] Monetary contractions are also followed by smaller loan supply decreases in banks with a larger buffer of liquid securities (Kashyap and Stein (2000) and Jiménez et al. (2012)), in more capitalized banks (Kishan and Opiela (2000), Gambacorta and Mistrulli (2004), Gambacorta (2005), and Jiménez et al. (2012)), in banks that are part of a multi-bank holding company (Campello (2002), Gambacorta (2005) and Ashcraft (2006)), in banks with international scope (Cetorelli and Goldberg (2012)), and in banks with a higher exposure to interest rate risk (Landier, Sraer, and Thesmar (2013)). Most of these analyses focus on U.S. data. Evidence on the magnitude and cross-sectional heterogeneity of the lending channel in the European Union can be found, more specifically, in De Bondt (1999), Favero, Giavazzi, and Flabbi (1999), Ehrmann, Gambacorta, Martìnez-Pagés, Sevestre, and Worms (2001), Altunbaş, Fazylov, and Molyneux (2002), Angeloni, Kashyap, and Mojon (2003), and Angeloni, Kashyap, Mojon, and Terlizzese (2003).

[8] Similarly, Peek and Rosengren (1997), Chava and Purnanandam (2011), Schnabl (2012), and Cetorelli and Gold-

that substituting funding sources is not costless. Any outflow of DDs, caused not only by a monetary tightening but by any other reason, forces banks to borrow at increasing costs. As a consequence, potential loans that would bring a marginal revenue that is lower than the increased marginal cost are unserved, which is why loan supply decreases.

The remainder of the paper is organized as follows. In Section 2, I describe the different U.S. bank deposit types, the effects of monetary policy shocks on bank liabilities and funding rate, and how to empirically test the mechanism. In Section 3, I display household-level evidence on the effects of demographics on DDs supply and loan demand. I describe the identification strategy in Section 4, and the data in Section 5. In Section 6, I present the results, and in Section 7 I discuss their economic significance. Finally, Section 8 reports different robustness checks, and Section 9 concludes.

2 How monetary policy changes bank liability structure

First, I explore the differences between U.S. bank deposit types. Different deposit types are associated with different interest rates, and react differently to monetary policy shocks. Second, I describe the mechanism through which monetary policy shocks are transmitted to bank liabilities, and how one can test and quantify this mechanism through the analysis of the realized marginal funding rate.

2.1 U.S. bank deposit types and the marginal funding rate

In the U.S., small- and medium-sized banks have, on average, 85% of their total assets backed by domestically raised deposits (Figure 1). The figure is slightly lower for large banks, at around 75%.[9] U.S. bank deposits are not, however, homogenous. Differences in deposit interest rates and reservability are particularly important for understanding the effects of monetary policy shocks on banks' liability structures.

DDs are "*deposits that are payable on demand*", and are used by depositors as a liquid store of value.[10] Until July 21, 2011, Regulation Q explicitly prohibited interest payments on these de-

berg (2012), analyze how liquidity shocks from abroad propagate into the domestic credit market through cross-border ownership of banks.

[9] I define small banks as those below the 50th percentile for total assets nationally in a given period. Medium banks are those between the 50th percentile and the 95th percentile. Large banks are those above the 95th percentile.

[10] FRB Regulations, Part 204, Sec. 2. Definitions.

posits.[11] There were no such restrictions on IBDs. IBDs include savings deposits, money market deposit accounts, and time deposits, raised both in small denomination (< \$100,000) and in large denomination (> \$100,000) accounts.[12] IBDs were allowed to pay a positive interest rate, while being less liquid than DDs and similar to securities such as Treasury Bills.

The Federal Reserve Board's Regulation D requires commercial banks to hold a certain fraction of their reservable liabilities in reserves.[13] Reservable liabilities consist of net transaction accounts, non-personal time deposits, and eurocurrency liabilities. Net transaction accounts, in turn, are composed essentially of DDs.[14] Since December 27, 1990, non-personal time deposits and eurocurrency liabilities have had a reserve ratio of zero.[15] As a consequence, DDs must almost exclusively be backed by reserves.

In the period from June 30, 1994 to June 30, 2010 (which is the focus of my analysis), DDs differ from IBDs as they do not pay any interest and are (almost) the only reservable deposits. DDs and IBDs do not differ with respect to deposit insurance. The coverage limit for both DDs and IBDs was \$100,000 until October 3, 2008, at which point it was raised to \$250,000.[16] In practice, therefore,

[11] FRB Regulations, Part 217, Sec. 3. Interest on demand deposits. The Board of Governors of the Federal Reserve System repealed the prohibition, implementing Section 627 of the Dodd-Frank Wall Street Reform and Consumer Protection Act, with effective date July 21, 2011.

[12] A savings deposit is "*a deposit with respect to which the depositor is required* [...] *to give written notice of an intended withdrawal not less than seven days before withdrawal is made, and that is not payable on a specified date or at the expiration of a specified time after the date of deposit*". A money market deposit account (MMDA) is also a savings deposit "*from which, under the terms of the deposit contract or by practice of the depository institution, the depositor is permitted or authorized to make no more than six transfers and withdrawals* [...] *per calendar month*". Typically, a MMDA requires a average minimum balance over the month. Finally, a time deposit is a "*deposit that the depositor does not have a right and is not permitted to make withdrawals from within six days after the date of deposit unless the deposit is subject to an early withdrawal penalty*" (FRB Regulations, Part 204, Sec. 2. Definitions). Regulation Q used to put caps on savings and time deposits as well. These caps were progressively removed during the 1980's, in particular thanks to the Depository Institutions Deregulation and Monetary Control Act of 1980. Still, the Federal Deposit Insurance Act requires the FDIC to prevent banks that are less than well capitalized from soliciting deposits at interest rates that significantly exceed prevailing rates. The mechanism by which the FDIC sets deposit rate caps for less than well capitalized banks changed in 2009, and started to be effective on January 1, 2010.

[13] These take the form of vault cash and, if vault cash is insufficient, of a deposit maintained with a Federal Reserve Bank.

[14] Total transaction accounts include demand deposits and automatic transfer service (ATS) accounts, NOW accounts, share draft accounts, telephone or preauthorized transfer accounts, ineligible bankers acceptances, and obligations issued by affiliates maturing in seven days or less. To get the net, one has to subtract from total transaction accounts the amounts due from other depository institutions and cash items in the process of collection.

[15] The Garn-St Germain Act of 1982 exempted the first \$2 million of reservable liabilities from reserve requirements. This "exemption amount" is adjusted each year according to a formula specified by the act.

[16] Preliminarly, the Congress approved a temporary increase which was effective through December 31, 2010. On July 21, 2010, President Barack Obama signed the Dodd-Frank Wall Street Reform and Consumer Protection Act into law, which permanently raised the current standard maximum deposit insurance amount to \$250,000. Also, before and after the crisis, particular sub-categories of deposits were given extra coverage. Relevant is the case of noninterest-bearing transaction accounts, which enjoyed full insurance from December 31, 2010, through December

both DDs and IBDs may be only partly insured.

I take IBDs as the banks' marginal funding source. In other words, I assume that when a bank needs to raise additional financing reasonably quickly, it goes on the IBD market. As I detail in the following, this assumption does not mean that banks do not have the ability to target and collect DDs. The assumption says that doing so requires more time. Taking IBDs as the banks' marginal funding source is particularly reasonable for small- and medium-sized banks. These banks finance mainly with retail – i.e. fully insured – deposits, and have limited access to alternative funding sources, such as wholesale markets (Bassett and Brady (2002) and Park and Pennacchi (2009)). The case for large banks is different. Large banks have the ability to finance on wholesale markets. Still, it should be noted that IBDs include large denomination time deposits, which are often considered as wholesale financing (e.g. Song and Thakor (2007) and Huang and Ratnovski (2011)). That is why, even in the case of large banks, taking IBDs as the banks' marginal funding source is not too restrictive.

Each bank's marginal funding rate is, therefore, the interest rate that the bank faces in the IBD market. Unless the supply of IBDs is perfectly elastic, banks are not able to finance an arbitrary amount of IBDs at a constant interest rate. The interest rate required by investors may be increasing with respect to the quantity to finance: the larger the amount to borrow, the higher the interest rate to pay. As I detail in the following, the interest rate elasticity of the supply of IBDs will mediate the effect of monetary policy shocks on the banks' marginal funding rate.

2.2 The effects of monetary policy shocks on bank liabilities

The price at which banks trade their reserves is the Federal funds rate. When the Federal Reserve changes its monetary policy stance, it targets a new Federal funds rate, and may conduct open market operations to reach it.[17] In open market operations the central bank trades with commercial banks and exchanges securities, such as Treasury Bills, against money (reserves). For example, when the Federal Reserve aims for a contractionary policy, it announces a higher target for the Federal

31, 2012.

[17]Guthrie and Wright (2000) suggest that "open mouth" operations are actually enough for the coordination on the new target rate. The central bank has the ability to move rates simply by announcing its intentions. The threat to adjust liquidity as needed to achieve the target rate makes, in fact, the market coordinate on the new rate.

funds rate. Unless the effective Federal funds rate automatically adjusts, the Federal Reserve sells securities and withdraws money held in banks' reserves until the target is reached. In the process, the price of securities decreases, and their implied return increases.

Monetary policy affects the amount of DDs that each bank detains. The literature identifies two mechanisms. In the traditional mechanism (e.g. Bernanke and Blinder (1988) and Kashyap and Stein 1995)), the Federal Reserve, in the conduct of monetary policy, directly manipulates the amount of reserves, and thereby the amount of DDs. Because reservable liabilities – i.e. DDs – are a fixed multiple of reserves, when the Federal Reserve sets the amount of reserves, it automatically sets the amount of DDs. In the alternative mechanism (e.g. Disyatat (2008, 2011)), monetary policy affects DDs by changing their opportunity cost. Because DDs may not pay interest, their opportunity cost depends on the profitability of alternative investments (e.g. IBDs, Treasury Bills). When monetary policy alters such profitability, it also affects the amount of DDs.

To the extent that a contractionary monetary policy implies both a reduction in reserves and an increase in market rates, both mechanisms lead to the same outcome. Both the drain of reserves and the increased attractiveness of alternative investments lead to a decrease in the supply of DDs. The opposite holds for an expansionary monetary policy.

Monetary policy affects IBDs as well. When the stance of monetary policy changes, market interest rates adjust. This changes the opportunity cost of IBDs, and investors shift their supply. For example, an increase in market rates during a contractionary phase increases the opportunity cost of IBDs. This pushes IBD investors to demand a higher interest rate.

2.3 How to test and quantify the mechanism

In order to explore the effects of monetary policy on bank liability structure and funding cost, I build a stylized theoretical model in which a monopolistic bank operates over two periods (the details of the model can be found in the appendix). In both periods, the bank invests in loans and has access to DDs and IBDs. In the second period, a stochastic monetary policy shock hits the economy, and the supplies of DDs and IBDs are modified in response.

In the first period, the bank can choose both the amount of loans and the liability structure. Even though DDs cannot be directly remunerated, the model posits that the bank can attract

DDs providing greater "service quality". Service quality can be an extensive branch and/or ATM network, but also any other non-interest feature that depositors may value, such as advertising and marketing. Empirical studies, reviewed by VanHoose (2010), find that service quality affects depositors' choices. In these analyses, service quality takes the form of weekly office hours/24h ATM service (Heggestad and Mingo (1976)), branch density (Kim and Vale (2001) and Cerasi et al. (2002)), and IT/advertising outlays (Martín-Oliver and Salas-Fumás (2008)).

In the second period, the bank can only optimize over the quantity of loans. The service quality that the bank installed in period 1 may still attract new DDs, but cannot be adjusted in period 2. Such would be the case, for example, of an advertising campaign that took place in period 1, and still triggers effects in period 2.

The model shows that the impact of the monetary policy shock on period 2 IBD interest rate depends on the amounts of DDs and loans that the bank has before the shock is realized. These amounts matter as long as the supply of IBDs is not perfectly elastic.

In order to compare how different asset and liability structures (as at period 1) affect the period 2 IBD interest rate, I consider two scenarios. Relative to the first, in the second scenario, the bank has a larger amount of DDs and loans at the end of period 1. In both cases, the supply of IBDs is imperfectly elastic, and the IBD interest rate is increasing with the quantity of IBDs to finance. In period 2, a contractionary monetary policy shock hits the economy. When the bank displays a larger amount of DDs at the end of period 1, it still has, after the shock, a lower need to finance with IBDs. The period 2 IBD interest rate is then lower than the one paid in the other scenario. However, the monetary policy shock causes the withdrawal of a proportion of the DDs that the bank has. Abstracting from changes in loan demand, in both scenarios the bank substitutes the outflowed DDs by issuing more IBDs. Because the IBD interest rate increases with the amount being borrowed, substituting DDs with IBDs requires the bank to offer a higher interest rate. When the bank begins period 2 with a larger amount of DDs, it has a larger amount to substitute, and so its IBD interest rate increases more. Finally, holding constant the amount of DDs, a larger stock of loans implies a greater need to issue IBDs. Then, because loans cannot be liquidated quickly, when the bank begins period 2 with a larger amount of loans, it has to finance more with IBDs also when the shock is realized. This means that the larger the amount of loans at the end of period 1, the higher is period

2 IBD interest rate (whatever monetary policy shock is realized).

The equation that describes the relationship between period 2 IBD interest rate and period 1 amount of DDs and loans (see equation (11) in the appendix) can be directly brought to the data. It directly allows us to test if the supply of IBDs is perfectly elastic, and if the sensitivity of DDs to monetary policy shocks is null. The key is to understand if there is any change in the IBD interest rate due to the substitution of DDs with IBDs. The quantitative change depends on the elasticity of the IBD supply and on the sensitivity of DDs to monetary policy shocks. In fact, substituting DDs with IBDs is more expensive when the supply of IBDs is more inelastic, and when the quantitative changes of DDs are larger. When the elasticity is very low, a marginal increase in the quantity of IBDs requires a large increase in the interest rate. Similarly, a massive outflow of DDs implies a large sum of IBDs to finance, and therefore a large increase in the IBD interest rate.

The imperfect elasticity of the supply of IBDs, and the sensitivity of DDs to monetary policy shocks, are tightly linked to the magnitude of the lending channel of monetary policy. In accordance with Kashyap and Stein (1994), the model in the appendix reveals that if banks are not able to borrow any amount of IBDs at a constant interest rate, the outflows of DDs decrease their loan supply. The existing large body of empirical literature that shows the existence of the lending channel suggests, therefore, that the interest rate elasticity of the supply of IBDs is not null.

Still, the model shows that the magnitude of the lending channel is decreasing with the elasticity of the IBD supply, and increasing with the sensitivity of DDs to monetary policy shocks. It is not clear, in practice, which of these two components is more important. The sensitivity of DDs to monetary policy shocks is, in fact, hard to quantify a priori. As Disyatat (2008, 2011) and Borio and Disyatat (2010) argue, neither of the mechanisms through which monetary policy affects DDs is likely to be very effective. First, the role of central banks in manipulating reserves, and consequently DDs, has been greatly de-emphasized in recent years. Banks hold reserves to meet reserve requirements, but also to have a cushion against uncertainty related to payments flows. Second, since depositors hold DDs mainly for transaction purposes, their opportunity cost is not likely to be very responsive to market rates, and so their sensitivity to monetary policy shocks will be low.

The empirical model can be modified to investigate whether or not the elasticity of the IBD supply and the sensitivity of DDs to monetary policy shocks change with regard to the bank's size and the banking market concentration. A priori, because larger banks have greater market power and wider market scope, they are likely to pay IBDs more cheaply. In other words, the elasticity of the supply of IBDs may be increasing with bank size. Moreover, the more a banking market is concentrated, the more banks may agree not to adjust their IBD interest rate when the monetary policy stance changes (Hannan and Berger (1991) and Neumark and Sharpe (1992)). In such a case, demand depositors would be less incentivized to modify their allocations of DDs to invest in IBDs. Therefore, DDs may be less sensitive to monetary policy shocks the more the banking market is concentrated.

Finally, note that the theoretical equation raises concerns about the endogeneity of period 1 DDs. Service quality chosen in period 1 affects DDs supply in period 2, and as service quality cannot be measured, it falls into the unobservable term. As period 1 service quality clearly affects period 1 DDs, the unobserved error term will be correlated with one of the regressors. While not modelled, it is likely that loan demand also depends on service quality, in which case, the same reasoning applies, and the period 1 amount of loans is also endogenous. The empirical analysis must account for this.

3 Demographics as shifters for DDs supply and loan demand

The identification strategy requires us to find instrumental variables (IVs) for each bank's endogenous amounts of DDs and loans. These variables need to be uncorrelated with the unobservable term in the main equation, but also need to affect the asset and liability structures that each bank has before the monetary policy shock is realized. In this section, I concentrate on the latter of these conditions. I describe how demographic shocks affect DDs supply and loan demand.

The Flow of Funds of the U.S. indicates that in 1994 households held 51% and nonfinancial businesses held 25% of the $1240.2bn aggregate amount of checkable deposits and currency. In 2010, of the total amount of $2359.8bn, households held 18% and non-financial businesses held 32%. That suggests that DDs supply essentially depends on these two players and shocks hitting them or their preferences should be ultimately experienced by banks. The effect of households' demographic characteristics on deposit supply is not new. Becker (2007) looks at U.S. metropolitan statistical areas (MSAs) and draws a causal relationship between each MSA's fraction of seniors (people aged 65 or more), the amount of deposits (not distinguishing by type of deposits) collected by banks, and the number of firms operating in the MSA. In addition, however, demographics may also have a direct effect on firms' loan demand to the extent that they affect households' spending and consumption.

To understand the effects of households' demographic characteristics on the supply of DDs and loan demand in a given geographical region, two margins need to be considered. The first is how households' demographics affect households' direct holdings of DDs. The second is how households' demographics affect consumption and spending and, as a consequence, firms' holdings of DDs and loan demand. The second margin, which relates to the macroeconomic effects of demographics, merits an example. At the aggregate level, if household spending increases, so do firms' money holdings. Firms, in fact, exchange with households, and receive cash against goods and services. To meet the increased demand, firms may place greater orders for their inputs, and may do so upstream firms as well. So, the increase in households' spending may stimulate firms' willingness to invest, and firms' loan demand may also increase.

I first analyze households' holdings of DDs as a function of their demographic characteristics. The Survey of Consumer Finances collects household-level information on checking account holdings together with demographic characteristics, such as age, race, level of education, income, and number of people in the household. I obtain data for the years 1995, 1998, 2001, 2004, 2007, and 2010. Then, I explain the probability that a household has a checking account by its demographic characteristics using the Probit model:

$$\Pr\left[Own\,check\,acct_{ht} = 1|X_{ht}\right] = \Phi\left(X_{ht}\alpha\right)$$

where subscripts h and t denote, respectively, households and time. $Own\,check\,acct_{ht}$ takes the value of one when h has a checking account at t, and $\Phi(.)$ is the cumulative normal distribution function. X is a matrix of households' demographic characteristics. It includes the age of the head (Age), the log of the number of people in the household ($\log(HHsize)$), controls for race and education, the household (log) total income ($\log(inc)$), and year dummies. The controls for race are $Black$, $Hispanic$, and $Other$, and take the value of one if the head is, respectively, black/African-American, hispanic, or either Asian, American Indian/Alaska Native or Native Hawaiian/Pacific Islander. The controls for education are $College$ and PhD, which equal to one if the head has taken any college-level, respectively PhD-level, classes.

Next, conditionally on the household having at least one checking account, I explain the (log) dollar amount that it detains ($Check\,acct_{ht}$) by the usual demographic characteristics (X_{ht}) using the model:

$$\log\left(1 + Check\,acct_{ht}\right) = X_{ht}\beta + u_{ht}$$

where u_{ht} denotes the error term.

Table 1 displays the results. Demographics do affect both the probability of having a checking account and the amounts stored therein, and in the same direction. The relationship is positive with income, education level and age. It is negative with the household being non-white, with a particularly strong magnitude in the case of black/African-American. The result on age is consistent with that of Becker (2007). Similarly, the effect of belonging to a minority is coherent with the analysis conducted by the Federal Deposit Insurance Corporation in January 2009 (FDIC (2009)). Using data from a special supplement to the U.S. Census Bureau's Current Population Survey that study finds that a large fraction of U.S. households do not have a bank account, and that participation is particularly low amongst minorities. Table 1 also reveals that the more numerous the household – i.e. the larger $\log(HHsize)$ – the lower is the amount held in the checking account(s). Arguably, the reason is that larger households spend more and this depletes the holdings of cash and DDs.

I then analyze households' expenditures as a function of their demographic characteristics. I obtain micro data on households' quarterly expenditures from the 2003 Quarterly Interview Survey, included in the Consumer Expenditure Survey (CEX). I explain the (log) dollar amount of a household's expenditures (Exp) by its demographic characteristics X following the model:

$$\log\left(1 + Exp_h\right) = X_h\beta + u_h$$

where h indicates the household, and u_h the error term. I consider different types of expenditures Exp: total expenditures ($Total$), total food expenditures ($Food$), total expenditures for food consumed at home ($Home\,food$), total expenditures for shelter, utilities, fuels, public services, household operations, housefurnishings and equipment ($House$), total expenditures for housefurnishings and equipment ($Furnish$), and total apparel expenditures ($Apparel$). Similarly to the analysis of households' holdings of DDs, X includes the age of the head (Age), the log of the number of people in the household ($\log(HHsize)$), the same controls for race and education, the household (log) total income ($\log(inc)$), but also a control for whether h resides in a urban area ($Urban$), and region dummies.

Results appear in Table 2, and show that expenditures increase with income, education level, and age of the head. Conversely, they decrease when the household belongs to a minority. Consistent with the hypothesis advanced, more numerous households appear to have larger expenditures. Importantly, all demographic characteristics influence all types of expenditures in the same direction.[18]

The analysis of households' holdings of DDs and households' expenditures can be combined. Household income and age of the head are positively related to the probability of having a checking account, the amount of money stored therein, and the level of expenditures. An increase in per capita income and average age in a given region should then be associated with an increase in the supply of DDs, and firms' demand for loans. Minorities have, all other things being equal, a lower probability of having a checking account, lower amounts in their checking accounts, and lower expenditures. As a consequence, the higher their presence, the lower the DDs supply and firms' loan demand is expected to be. Finally, household size relates negatively to the amounts deposited in the checking accounts, but positively to expenditures. The effect of household size on the regional DDs supply depends on which effect is actually dominating. Nevertheless, the effect of household size on firms' loan demand is clear and expected to be positive.

Because banks are located in different areas, they face different demographic shocks, and therefore different shocks in DDs supply and loan demand. In the data section, I describe how bank-specific shifters for DDs supply and loan demand can be constructed from county-year level demographic data. Data on income, race, and age are retrievable at such levels. From these data, I construct measures of the demographic dynamics that each bank faces in the areas where it operates. Data on household size are, instead, not available at the county-year level. However, as larger households are normally

[18] The only exception is the age of the head. This is positively related to most types of expenditures (including total expenditure) but negatively to expenditures for housefurnishings and equipment, and for total apparel.

those where the number of children is higher, the proportion of children in the population may be used as a proxy for the average household size in the area. To be certain, I test this relationship using the data from the Survey of Consumer Finances and the Consumer Expenditure Survey. I explain the (log) household size ($HHsize$) by the usual demographic characteristics, plus the proportion of people in the household aged less than 18 ($Prop\,young$), and the proportion of people aged over 64 ($Prop\,old$). Results reveal that household size is strongly and positively related to the proportion of people in the household aged less than 18 (Table 3). The correlation is negative with the proportion of people aged over 64, suggesting that when the number of elderly people increases, the household shrinks in size. All parameter estimates are consistent across the two datasets. In the following, I proxy each region's average household size by the proportions of children and elderly people.

4 Identification strategy

The objective is to study how monetary policy shocks affect each bank's marginal funding rate as a function of the asset and liability structures that the bank has before the monetary policy shocks realize. I present the baseline model, which enables us to test (1) if the marginal funding rate depends on the quantity to finance, and (2) if DDs are sensitive to monetary policy shocks. The endogeneity of the asset and liability structures is the identification challenge of the analysis. I discuss under which conditions a set of IVs is valid. Then, I present additional econometric models which investigate whether or not the elasticity of the IBD supply and the sensitivity of DDs to monetary policy shocks change with bank size and banking market concentration.

4.1 Baseline model

The baseline econometric model can be directly derived from the theoretical model in the appendix. I observe an unbalanced panel of J banks operating over T periods. At any period t, the IBD interest rate paid by a bank j is r^b_{jt} (I detail how I measure it in the data section). Consistent with the theoretical model, I define d_{jt-1} as the amount of DDs that j has at $t-1$ normalized by j's total assets at $t-2$. Similarly, l_{jt-1} is the amount of total loans and leases that j has at $t-1$ normalized by j's total assets at $t-2$. Also, d_{jt-2} (l_{jt-2}) is the amount of DDs (loans and leases) that j has at

$t-2$ normalized by $t-2$ total assets.[19]

The change in monetary policy stance that happens in period t is proxied by the change in the Federal funds rate, ΔFF_t.[20] This is in line with Bernanke and Blinder (1992) and Kashyap and Stein (2000). Both ΔFF_t and r^b_{jt} are expressed in hundreds of basis points (bp).

I model r^b_{jt} as:

$$r^b_{jt} = \gamma d_{jt-1} + \gamma^{\Delta FF}\left(d_{jt-1} \times \Delta FF_t\right) + \delta l_{jt-1} + \beta_1 demogr_{jt} + \beta_2 \triangle demogr_{jt} + \eta_t + \eta_j + \eta_{jt} \qquad (1)$$

where $demogr_{jt}$ are the demographic levels that each bank faces in the areas in which it is set, and $\triangle demogr_{jt}$ are the innovations with respect to $t-1$. η_t and η_j are time and bank fixed effects and η_{jt} is the idiosyncratic error.

Model (1) enables us to test if the supply of IBDs is not perfectly elastic. If r^b_{jt} is a function of the quantity of IBDs that j borrows, then the supply of IBDs is not perfectly elastic. So, because DDs are alternative to IBDs, testing if γ is equal to zero corresponds to testing if the supply of IBDs is perfectly elastic. The sign of γ indicates if the IBD interest rate is increasing or decreasing with the amount of IBDs to borrow. In particular, the sign of γ is the opposite of the sign of the relationship between r^b_{jt} and the amount of IBDs. γ is negative, for example, when j has to offer a greater interest rate the more it has to borrow.

Next, if the supply of IBDs is not perfectly elastic, r^b_{jt} incorporates the substitution of DDs with IBDs as caused by period t monetary policy shock. Period t monetary policy shock, ΔFF_t, modifies the amount of DDs, d_{jt-1}, and bank j responds by changing the quantity of IBDs borrowed. If the supply of IBDs is not perfectly elastic, such change alters the IBD interest rate. $\gamma^{\triangle FF}$ traces the impact on r^b_{jt} of a 100bp change in the Federal funds rate per unit of DDs held at $t-1$. It is important

[19] The normalizing factor of period $t-1$ and period $t-2$ DDs and loans is arbitrary. One alternative could be to normalize by the total assets of each period. The reason I use period $t-2$ total assets as normalizing factor is that it allows me to isolate the effects of the demographic shocks on DDs and loans. For example, when I regress d_{jt-1} over d_{jt-2}, and the demographic shocks, demographic shocks are meant to explain the normalized change in DDs. If I used, instead, the normalization by each period's total assets, and regressed the normalized amount of DDs over the demographic shocks, I would not be able to say if demographics impact DDs, or total assets, or both.

[20] I obtain historical data on the Federal funds rate from the website of the Federal Reserve Bank of New York. I take the geometric average of the effective daily Federal funds rate over period t, and over period $t-1$. Then, I take the difference between the two and obtain ΔFF_t.

to note that while monetary policy shocks are aggregate shocks, they do not affect all banks the same way. They impact banks proportionally to the amount of DDs that they hold. Testing if $\gamma^{\triangle FF}$ is equal to zero is the same as testing if the supply of IBDs is not perfectly elastic, and if DDs are sensitive to monetary policy shocks.

Model (1) also relates r^b_{jt} to the lagged normalized amount of loans and leases, l_{jt-1}. Holding the amount of DDs constant, a larger stock of loans equates to a larger amount of IBDs to finance. When the monetary policy shock hits the economy, loans and leases cannot immediately be liquidated. As a consequence, banks that start the period with a larger amount of loans and leases still have greater need to finance with IBDs when the monetary policy shock is realized. The argument about the liquidity of the bank balance sheet is related to prior evidence on the bank lending channel. Among others, Kashyap and Stein (2000) and Jiménez et al. (2012) suggest that liquid securities enable banks to decrease their loan supply less when contractionary monetary policy shocks realize. The reason is that banks can respond to the withdrawal of DDs by liquidating the securities that they have, without the need to decrease their loan supply. Here the reasoning is regarding the necessity to keep the amount of liabilities unaltered. Controlling for the amount of loans and leases is, essentially, controlling for the opposite of liquid assets. So, the larger is a bank's holdings of loans and leases, the larger the quantity of IBDs the bank needs to borrow whatever monetary policy shock is realized. Therefore, δ captures whether the IBD interest rate changes with the quantity of IBDs being borrowed.

The model controls for the exogenous shifts in loan demand and DDs supply. The reason for doing that is that if r^b_{jt} is a function of the quantity of IBDs that j borrows, changes in loan demand and DDs supply affect the quantity of IBDs demanded by the bank, and in turn the interest rate paid. Aggregate components, such as GDP growth, are captured by the time fixed effect η_t, while bank-specific components are captured by the vector of demographic shocks $\triangle demogr_{jt}$. Model (1) also controls for the level of the demographics $demogr_{jt}$. Consider the case in which demographics affect the level of risk of the bank, and this is incorporated in r^b_{jt}. $demogr_{jt}$ absorbs such effect.

The baseline model can be extended to include variables that may affect each bank's funding possibilities. I select a few controls following the literature on the lending channel of monetary policy. These are intended to either soften the necessity to raise IBDs and/or to ease its collection.

The Tier1 ratio is a measure of capitalization. $Tier\,1\,ratio_{jt-1}$ is defined as the ratio of period $t-1$ amount of Tier 1 (core) capital to period $t-2$ total assets. The more a bank is capitalized, the less it needs to finance with IBDs and, at the same time, the better it signals to IBD investors about the quality of its assets (Holmstrom and Tirole (1997), Kishan and Opiela (2000), Gambacorta and Mistrulli (2004), Gambacorta (2005), and Jiménez et al. (2012)). In this sense, $Tier\,1\,ratio_{jt-1}$ also captures bank j's risk. Then, I include two dummy variables, BHC_{jt-1} and $International_{jt-1}$, which capture whether bank j belongs to a bank holding company (BHC) at $t-1$, or, respectively, operates in other countries at $t-1$. They are proxies for the ability to finance through internal capital markets, so to avoid financing on the domestic IBD market. In one case, such a possibility comes from getting funds from other banks in the BHC (Campello (2002), Gambacorta (2005), and Ashcraft (2006)). In the other case, the possibility comes from foreign branches of the bank (Cetorelli and Goldberg (2012)).

4.2 Endogeneity of d_{jt-1} and l_{jt-1}

As discussed in Section 2, banks can attract DDs providing greater service quality. A few examples of service quality are a large branch network, advertising, and managerial effort and ability. The amount of DDs that a bank displays at $t-1$, d_{jt-1}, depends on the service quality provided at $t-1$. Similarly, while not specifically modelled, it is likely that period $t-1$ loan demand, and thereby l_{jt-1}, are also a function of period $t-1$ service quality. Investments in service quality are typically not measurable and may have effects for more than one period. In that case, the amount of loans and DDs at t are also a function of period $t-1$ service quality. The amount of IBDs to borrow at t is a function of the amount of loans and DDs. So, if the IBD interest rate depends on the quantity of IBDs to borrow, r^b_{jt} is also a function of period $t-1$ service quality. Because service quality cannot be measured, it enters in (1) as the unobservable η_{jt}. However, as d_{jt-1} and l_{jt-1} are a function of period $t-1$ service quality, they correlate with η_{jt}, and are endogenous in (1).

When banks have the ability to provide service quality, so as to affect DDs supply and loan demand, estimating (1) by OLS leads to inconsistent and biased estimates. IV techniques, however, can apply. The (excluded) IVs need to correlate with the endogenous variables d_{jt-1} and l_{jt-1}, but need to have zero correlation with η_{jt}. I look for variables that affect the amount of DDs and loans that a bank has, but that do not depend on the service quality that the bank provides. I consider as potential IVs the past normalized amounts d_{jt-2} and l_{jt-2}, and period $t-1$ demographic shocks $\triangle demogr_{jt-1}$.

To be valid instruments, these variables need not to have any direct effect on period t variables. In particular, that means that period $t-1$ amounts of DDs and loans have to immediately adjust for the demographic shocks $\triangle demogr_{jt-1}$. If that was not the case, $\triangle demogr_{jt-1}$ would directly affect period t amounts of DDs and loans, and should be included in the main model. This restriction can be rephrased as follows. Imagine that to a higher mean age of the population correspond larger amounts of DDs and loans. Period $t-1$ change in the mean age of the population is a valid instrument for d_{jt-1} and l_{jt-1} as soon as its effect on these two amounts is immediate. DDs and loans fully adjust for this shock in period $t-1$, and the shock does not have any direct effect in subsequent periods.

Because d_{jt-1} is endogenous in (1), so is the interaction term $d_{jt-1} \times \Delta FF_t$. Let $\hat{d}_{jt-1}$ be the fitted value resulting from the first-stage regression of d_{jt-1} on d_{jt-2}, l_{jt-2}, $\triangle demogr_{jt-1}$, $\triangle demogr_{jt}$, $demogr_{jt}$, time and bank fixed effects. I follow Wooldridge (2001), and define as (excluded) IVs for $\{d_{jt-1};\ l_{jt-1};\ d_{jt-1} \times \Delta FF_t\}$ the set $\left\{d_{jt-2};\ l_{jt-2};\ \triangle demogr_{jt-1};\ \hat{d}_{jt-1} \times \Delta FF_t\right\}$.

4.3 Extended models

The second step to take is to understand whether or not banks differ in the elasticity of the supply of IBDs that they face, and/or in the sensitivity of their DDs to monetary policy shocks. I analyze if these elements change as a function of bank size and banking market concentration.

I capture bank size by two dummy variables, $Top\,50_{jt}$, and $Top\,5_{jt}$. They indicate if bank j is in period t in the top 50th, respectively fifth, percentile for total assets at the national level. In terms of market concentration, I compute the Herfindahl–Hirschman Indices in terms of number of branches and amount of deposits of the markets in which bank j operates. These two measures, respectively $HHI\,NBR_{-jt}$ and $HHI\,Deps_{-jt}$, are computed without considering bank j's market shares, which is why the subscript is $-j$.

In order to understand how the elasticity of the IBD supply and the sensitivity of DDs to monetary policy shocks change with bank size and market concentration, I modify the baseline model (1) by simply interacting d_{jt-1} and $d_{jt-1} \times \Delta FF_t$ with the different measures created.

Finally, as d_{jt} is endogenous in the model, so are its interaction terms. Let the interacted characteristic of bank j at t be $char_{jt}$. The set of endogenous variables is $\{d_{jt-1};\ l_{jt-1}; d_{jt-1} \times char_{jt}; d_{jt-1} \times \Delta FF_t; d_{jt-1} \times \Delta FF_t \times char_{jt}\}$. I consider as set of (excluded) IVs $\{d_{jt-2};\ l_{jt-2}; \triangle demogr_{jt-1}; \hat{d}_{jt-1} \times char_{jt}; \hat{d}_{jt-1} \times \Delta FF_t; \hat{d}_{jt-1} \times \Delta FF_t \times char_{jt}\Big\}$.

5 Data

5.1 Banking data

I obtain data on U.S. commercial and savings banks from the Federal Deposit Insurance Corporation (FDIC), the U.S. agency responsible for providing deposit insurance to account holders. All FDIC-insured banks, filers of either the Reports of Condition and Income (Call Reports), or Thrift Financial Reports, are accounted for. I employ two datasets: the Statistics on Depository Institutions (SDI); and the Summary of Deposits (SOD). The first includes balance sheets and income statements on a quarterly basis. The second displays every branch location for each bank, and the amounts of deposits collected therein, as at June 30 of every year. The period under consideration is from June 30, 1994 to June 30, 2010.

Unfortunately, the demographic and economic information that I merge with the bank level data is released only as at July 1 of every year. In this study, therefore, periods are one year long and run from July 1 to the following June 30. Stock banking data – i.e. balance sheet variables – are taken as at June 30. Instead, quarterly flow banking data – i.e. income statement variables – need to be manipulated in order to obtain yearly figures.

The IBD interest rate is the main variable to be constructed from the flow banking data. It is defined as follows. First, I obtain quarterly interest rates dividing the domestic deposit interest payments realized during a quarter by the amount of IBDs outstanding at the end of the previous quarter. I compound the gross quarterly interest rates realized in the four quarters that compose the period of interest. Then, I subtract one. So, for example, the 1996 IBD interest rate paid by a given bank is the product of the gross quarterly interest rates realized during the third and fourth quarters of 1995, and first and second quarters of 1996, minus one.

As argued, for example, by Adams (2012), the consolidation process experienced by the U.S.

banking industry in the last twenty year includes many mergers and acquisitions. It is not clear what the effects on my analysis would be of including observations from banks involved in such activities. Thus, I isolate mergers and acquisitions in two ways. First, I obtain the list of mergers from the website of the Chicago Federal Reserve Bank. I exclude observations of banks engaging in such activities in that particular year. Second, I compute the year-specific distribution of banks' total assets growth, and I exclude observations below the first percentile or above the 99th.

5.2 Demographic and economic data

The Population Estimates Program (PEP) of the U.S. Census Bureau utilizes current data on births, deaths, and migration, in order to calculate on July 1 every year, the county-level estimates of population, demographic components of change, and housing units. The data sources considered and confronted are many, and include the Internal Revenue Service (IRS), the Social Security Administration (SSA), the National Center for Health Statistics, and other state and federal agencies. These estimates are often termed "postcensal estimates", and are used for Federal funding allocations and in setting the levels of national surveys. When two consecutive decennial censuses take place, both the beginning and ending populations are known. "Intercensal estimates" are then produced adjusting the existing time series of postcensal estimates for the entire decade to smooth the transition from one decennial census count to the next.[21]

I retrieve intercensal estimates for every county in the U.S. from 1994 to 2010. The variables include the number of people disaggregated by gender, five-year age group, race and ethnicity.[22] I manipulate the data to obtain for each county-year the mean age of the population ($Mean\,age$), the proportion of young ($\leq$ 19 years old, $Prop\,Young$) and elderly people ($\geq$65 years old, $Prop\,Old$), the proportion of blacks/African-Americans ($Prop\,Black$), hispanics ($Prop\,Hisp$) and American Indians/Alaska Native, together with Asian/Pacific Islander ($Prop\,Other$).

I also collect county-year per-capita income (after taking the log, $\log(Inc\,pc)$), and number of

[21] More specifically, intercensal estimates differ from the postcensal estimates because they rely on a mathematical formula that redistributes the difference between the April 1 postcensal estimate and the April 1 census count at the end of the decade.

[22] The categories of race used by the U.S. Census Bureau come from the Office of Management and Budget Directive No. 15. Race categories are white, black/African-American, American Indian/Alaska Native, Asian/Pacific Islander. The hispanic origin is captured by ethnicity and is not considered an additional category of race. Therefore, there can be overlappings between any race and the hispanic origin.

jobs per-capita ($Jobs\,pc$) from the Bureau of Economic Analysis (BEA), Regional Economic Accounts. Finally, I obtain counties' land area in square miles from the U.S. Census of 2010 and compute the population density dividing the total resident population by that area and taking the log ($Pop\,density$).

As stressed, both demographic and economic data are obtained at the county-year level. Because, in general, banks are located in more than one county, it is necessary to find a way to aggregate this information to the bank-year level. The SOD data displays the precise location of each bank branch. I obtain the total number of branches that a given bank j has at t, and compute the proportion of branches that j has in county c. This ratio is then used to compute a weighted average of the demographic and economic conditions that the bank faces. In formula, x_{ct} being the county-year demographic or economic variable, and NBR_{jct} the number of branches that bank j has in c at time t, the bank-year demographic variable x_{jt} is

$$x_{jt} = \sum_{c} \frac{NBR_{jct}}{NBR_{jt}} x_{ct}$$

The figures obtained are the demographic levels $demogr_{jt}$. Demographic shocks, $\triangle demogr_{jt}$, are obtained taking the year changes. I present the summary statistics of the demographic levels and shocks in Table 4. The table presents means and standard deviations comparing the years 1996 and 2010. It is interesting to notice that, over this period, banks have been exposed, on average, to an increase in the proportion of children, mean age, proportion of minorities (especially hispanics), and population density. The other significant point to note is that demographic shocks are very heterogeneous in the cross-section of banks. Their standard deviations are, in fact, much larger than their mean values.

5.3 Market structure data

The SOD data displays the precise location of each bank branch and the amount of deposits collected therein. I use this data to compute the two proxies for market concentration.

The measure of market concentration in terms of the number of branches is constructed as follows. I obtain the total number of bank branches present in a county-year. I compute each bank's market share. I take the square, and sum over all banks. I remove the squared market share of the bank to which the measure refers. In this way, I obtain a measure of concentration of the market to which each bank is exposed, independently of the bank's actions. Finally, I aggregate these bank-county-year measures to the bank-year level using the strategy adopted for demographics, and obtain $HHI\,NBR_{-jt}$.

I repeat this procedure using the outstanding amount of deposits that each bank holds in a given county-year instead of the number of branches, and obtain $HHI\,Deps_{-jt}$.

6 Results

6.1 First-stage regressions: the effect of demographics on DDs and loans

Section 3 presents household-level evidence on the relationship between demographics and DDs and loans. Here, I present the bank-level evidence. Banks are located in different areas, and are exposed to different demographic dynamics. If the household-level analysis is confirmed, the consequence is that banks display different amounts of DDs and loans.

In the first-stage regressions, the two endogenous variables d_{jt-1} and l_{jt-1} are a function of their past normalized amounts d_{jt-2}, and l_{j-2}, period $t-1$ and period t demographic shocks, period t demographic levels, on top of time and bank fixed effects. If demographic shocks actually shape banks' amounts of DDs and loans, the parameters' estimates of period $t-1$ shocks should be significantly different from zero. Table 5 presents the results. All standard errors are clustered by bank and year following Thompson (2011).

In the first column, the dependent variable is the amount of DDs, d_{jt-1}, while in the second column the dependent variable is the amount of loans, l_{jt-1}. Overall, demographic shocks change the amounts of DDs and loans in the same direction, however, the same shock alters the amounts of DDs and loans with different magnitudes. The proportion of children, and elderly, which stand as proxies for household size, are strongly significant in explaining the amount of DDs. Only the proportion of children, however, is significant in explaining the amount of loans. The household-level analysis highlights that large households tend to have a smaller amounts of funds in their checking accounts, but have larger expenditures. The results of Table 5 suggest that the effect on expenditures dominates in the aggregate. The more households spend, the more they exchange with firms. The result is that larger amounts of cash and DDs circulate in the system and loan demand increases.

Increases in mean age positively affects both d_{jt-1} and l_{jt-1}. Statistical significance is strong in explaining DDs, and mild in explaining loans. This is consistent with older households detaining larger amounts of DDs, and spending more for consumption. This, in turn, fosters loan demand. The changes in the proportions of minorities have the expected negative sign, but most of these shocks display low statistical significance. Only $\triangle PropOther_{jt-1}$ appears with positive sign in explaining DDs.

The change in income per capita positively affects the amount of DDs, but its effect is negligible on loans. Instead, contrary to the expectations, a positive change in the number of jobs per capita negatively affects both DDs and loans. This effect is puzzling, and for which there is no clear explanation. Finally, increases in population density positively affect both DDs and loans, and are strongly significant. The more numerous a community, the more it holds DDs, and the more it demands loans.

The series of both DDs and loans are very persistent, and the initial levels, d_{jt-2} and l_{jt-2}, appear strongly significant. Period t demographic shocks, and period t demographic levels are not significant (and not reported).

6.2 Baseline model

Table 6 presents parameters' estimates of the baseline model (1). While not reported, I control for period t demographic shocks and levels. Standard errors are again clustered by bank and year. The first column presents OLS estimates, the second column presents IV estimates, and the third column presents IV estimates controlling for the variables that may affect the collection of IBDs.

I start with the IV estimates. The IBD interest rate is negatively related to the lagged normalized amount of DDs. As DDs are alternative to IBDs, this indicates that the IBD interest rate increases with the quantity of IBDs to borrow. Indeed, the more a bank holds DDs, the less it needs to borrow on the IBD market and the lower the interest rate it appears that the bank pays. The estimate is strongly significant. This is the first main finding. The supply of IBDs is not perfectly elastic, and IBD investors require a given bank to pay an interest rate that is increasing with the quantity of

IBDs to borrow.

In line with this, I find that the IBD interest rate is positively related to the before-the-shock normalized amount of loans. Holding constant the amount of DDs, a larger stock of loans pairs with a larger amount of IBDs to finance. Moreover, as loans cannot be liquidated quickly, such a quantity still appears on the bank balance sheet when the policy shock is realized. As a consequence, banks that start the period with a larger amount of loans have greater need to keep financing with a larger amount of IBDs when the monetary policy shock is realized. The positive effect of the stock of loans on the IBD interest rate, therefore, provides additional evidence that the IBD interest rate increases with the quantity of IBDs to borrow.

The other important finding is that the IBD interest rate relates positively to the interaction term of the lagged normalized amount of DDs with the Federal funds rate change. This suggests that, for example, when monetary policy contracts, and $\triangle FF_t > 0$, there is an outflow of DDs. This pushes banks to issue more IBDs. And, as the IBD interest rate increases with the quantity to borrow, the substitution of DDs with IBDs implies an increase in the IBD interest rate to pay. The estimate is strongly significant. To summarize, this finding suggests that DDs are sensitive to monetary policy shocks, and their substitution with IBDs leads to an increase in the marginal funding rate.

As a term of comparison, the first column of Table 6 displays OLS estimates. As long as the unobservable term includes any factor that influences the supply of DDs and loan demand both at t and $t-1$, the parameters are both biased and inconsistent. Relative to the IV estimates, the signs and significances are conserved. What changes are the magnitudes, which in fact diminish.

The third column displays IV estimates controlling for the Tier1 ratio, the dummy variables for the participation to a BHC, and for operating in other countries. The previous IV estimates are conserved. The Tier1 ratio affects negatively r^b_{jt} and its effect is strongly significant. The reason is that a higher Tier1 ratio indicates that a bank has a lower need to borrow on the IBD market, and at the same time, is less risky. Belonging to a bank-holding company does not have a significant effect. Having branches outside of the U.S. is negatively related to r^b_{jt}, but the effect is not significant at usual confidence levels.

Because the number of IVs is greater than the number of endogenous variables, it is possible to perform the Sargan test. This is a test of over-identifying restrictions. The joint null hypothesis is that the instruments are valid instruments, thus uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation. The p-values are reported at the bottom of the table. In both cases they are above usual confidence levels, and this suggests that the instruments used are valid.

6.3 Extended models

The extended models explore how the interest rate elasticity of the supply of IBDs, and the sensitivity of DDs to monetary policy shocks, change with bank size and banking market concentration. I present the IV estimates in Table 7. While not reported, all regressions include period t demographic shocks and levels, period $t-1$ Tier1 ratio, and the dummy variables for belonging to a BHC, and for the presence in other countries, as at $t-1$. Standard errors are clustered by bank and year.

The first column shows the effect of bank size. Bank size is captured by $Top\,50_{jt}$, and $Top\,5_{jt}$, which indicate if bank j is in period t in the top 50th, respectively fifth, percentile for total assets at the national level. The parameter attached to d_{jt-1} captures the extent to which having DDs prevents the IBD interest rate from rising. Therefore, it measures whether or not the IBD interest rate increases with the quantity of IBDs to borrow. The parameter attached to d_{jt-1} decreases the larger the bank, and in fact becomes positive in the case of the top five percentile banks. This means that the IBD interest rate is less increasing with the quantity to borrow, the larger is the bank. IBDs are, therefore, a cheaper funding source for larger banks. Additionally, if a bank is in the top five percentile for total assets, the IBD interest rate is actually decreasing with the quantity to borrow. To summarize, this result suggests that the interest rate that larger banks pay on IBDs is less sensitive to the amount they borrow. Thus, the interest rate elasticity of the supply of IBDs is increasing with bank size.

The sensitivity of DDs to monetary policy shocks also depends on bank size. The effect on the IBD interest rate of substituting DDs with IBDs is captured by the parameter attached to $d_{jt-1} \times \triangle FF_t$. Table 7 shows that the same monetary policy shock causes the same change in the IBD interest rate in small, medium, and large banks. However, because the interest rate elasticity of the supply of IBDs increases with bank size, this is compatible with DDs in larger banks being more sensitive to monetary policy shocks. Consider the usual example of a monetary contraction. Banks face an outflow of DDs that they substitute with IBDs. Because the IBD interest rate increases with the quantity to borrow, this implies an increase in the IBD interest rate. According to the earlier finding, financing one unit of IBDs is cheaper in larger banks. Therefore, to have that the same monetary policy shock is associated with the same change in the IBD interest rate in all classes of bank size, it must be that DDs are more sensitive to monetary policy shocks in larger banks.

The second and third columns report the effects of market concentration. Market concentration is captured by the two measures $HHI\,NBR_{-jt}$ and $HHI\,Deps_{-jt}$. These are the Herfindahl–Hirschman Indices in terms of number of branches and amount of deposits of the markets in which bank j operates. The interaction term $d_{jt-1} \times HHI\,NBR_{-jt}$ suggests that the more concentrated the market, the more expensive are IBDs. This effect disappears once I consider the alternative measure of market concentration, or I include the measures of bank size. More importantly, both columns suggest that the sensitivity of DDs to monetary policy shocks decreases with the banking market concentration. This confirms the prior result that the more the banking market is concentrated, the more banks are able to agree not to adjust the IBD interest rate to monetary policy shocks (Hannan and Berger (1991) and Neumark and Sharpe (1992)). In this way, demand depositors are not stimulated to withdraw DDs and invest in IBDs when, for example, monetary policy tightens. DDs are then less sensitive to monetary policy shocks.

The fourth and fifth columns of Table 7 include the interactions with both bank size and market concentration. The main results are confirmed. The interest rate elasticity of the IBD supply is higher in larger banks, and the sensitivity of DDs to monetary policy shocks increases with bank size and decreases the more the market is concentrated.

All columns report the p-value of the Sargan test, and in all cases, it is above usual confidence levels. Once again, this suggests that the instruments used are valid.

The existing evidence on the lending channel suggests that monetary contractions are followed by smaller loan supply decreases in larger banks (Kashyap and Stein (1995, 2000) and Kishan and Opiela (2000)), and in more concentrated markets (Adams and Amel (2011)). Overall, my findings suggest that the reason larger banks cut back lending less during monetary contractions is that their marginal funding source is more expensive. At the same time, the reason banks operating in more concentrated markets diminish less their loan supply is that market concentration limits the sensitivity of DDs to policy shocks.

6.4 Direct evidence of the sensitivity of DDs to monetary policy shocks

The results presented indicate that DDs are sensitive to monetary policy shocks. Moreover, this sensitivity increases with bank size and decreases with banking market concentration. These findings are derived from the analysis of the realized IBD interest rate. My strategy has the objective to gauge if monetary policy shifts the supply of DDs to banks, and if their substitution with IBDs eventually modifies the marginal funding rate paid. In my strategy, I first investigate whether or not the supply of IBDs is imperfectly elastic. In fact, in such a case, any substitution of DDs with IBDs alters the IBD interest rate. So, by analyzing the realized IBD interest rate, I am able to infer whether or not DDs are sensitive to monetary policy shocks. If one disregards the effects on the marginal funding rate paid, a more direct strategy can be used to study if DDs are sensitive to monetary policy shocks.

In order to check if my results on the sensitivity of DDs to monetary policy shocks are robust, I structure a simple dynamic panel data model which does not require us to normalize the variables, and is more standard in the literature (see e.g. Kashyap and Stein (1995)). It says:

$$\begin{aligned}\log\left(demand\,deposits_{jt}\right) &= \rho\log\left(demand\,deposits_{jt-1}\right)+\alpha Fed\,funds\,rate_{t}\\ &+ \beta_1 demogr_{jt}+\beta_2\triangle demogr_{jt}+\eta_j+\eta_{jt}\end{aligned}$$

The log of the quantity of DDs of bank j in period t, $\log\left(demand\,deposits_{jt}\right)$, is a function of its lagged value, period t Federal funds rate $Fed\,funds\,rate_t$, period t demographic shocks and levels, and bank fixed effects η_j. The unobservable term is η_{jt}. Additionally, in order to capture differences in the sensitivity of DDs to monetary policy shock, I interact $Fed\,funds\,rate_t$ with the measures of bank size and banking market concentration.

I estimate the model using Blundell and Bond's (1998) GMM two-step estimator.[23] Parameters' estimates, together with Windmeijer's (2005) robust standard errors, appear in Table 8. Again,

[23] Flannery and Hankins (2013) suggest that Blundell and Bond's (1998) system GMM is among the most accurate methodologies to estimate dynamic panel data models in the context of corporate finance datasets.

while included in the regression, I do not report parameters' estimates of period t demographic shocks and levels. The first column presents the estimates of the effect of the policy shock without interactions. $Fed\,funds\,rate_t$ negatively relates to the log of DDs, and its parameter's estimate is strongly significant. These results are consistent with prior evidence. A monetary tightening decreases the amount of DDs that a bank has, while a monetary loosening increases it. The estimate suggests that a 100bp increase in the Federal funds rate decreases the amount of DDs by 1.6%.

The other columns present the effects of the policy shock interacting with the measures of bank size and market concentration. The same monetary policy shock shifts the amount of DDs more in larger banks, i.e. those above the 50th percentile. Conversely, its effect is smaller the more concentrated the market in which a bank operates.

Overall, these results are consistent with the evidence presented earlier. DDs are sensitive to monetary policy shocks, and their sensitivity increases with bank size, and decrease with banking market concentration.

7 Economic significance

The estimations presented show that the IBD interest rate generally increases with the quantity to borrow, thus the supply of IBDs is not perfectly elastic. The results also show that DDs are sensitive to monetary policy shocks. In this section, I discuss the implications of these findings, in particular I argue that they explain the cross-sectional heterogeneity of the IBD interest rate, and help understand banks' strategies when they choose their optimal liability structure.

Related to the first point, I aim to measure how a larger before-the-shock amount of DDs transmits to the IBD interest rate paid when the shock is realized. I do so following model (1). Absent monetary policy shocks, a larger before-the-shock amount of DDs implies a lower need to finance with IBDs, and so a lower IBD interest rate. This effect is captured by parameter γ. With monetary policy shocks, however, a larger amount of DDs implies a larger amount to substitute with IBDs, and therefore a higher IBD interest rate to pay. This effect is captured by parameter $\gamma^{\triangle FF}$.

Consider the following example. On June 30, 2004, the target level of the Federal funds rate is 125bp. One year later, after eight upward revisions, it is 325bp. In annualized terms, this monetary policy shock corresponds to an increase of 119bp. Before this shock, banks display very heterogeneous liability compositions. On June 30, 2004, the mean of the normalized amount of DDs is .11 and the standard deviation is .08. At the first percentile, DDs are zero, and at the 99st, DDs are .41.

I first look at two banks differing for one standard deviation in the amount of DDs as at June 30, 2004. I measure the effect of such extra standard deviation on the IBD interest rate paid in 2005 using the IV estimates of Table 6, second column. Absent the policy shock, the bank that has more DDs pays an IBD interest rate that is 23bp lower. However, because of the policy shock, the extra standard deviation of DDs needs to be partly substituted with IBDs. This leads to an increase in the IBD interest rate of 4bp. Netting the two effects, the bank that has more DDs pays an IBD interest rate that is 19bp lower.

Similarly, I compare the bank that is at the first percentile for the before-the-shock amount of DDs with the one that is at the 99th percentile. Absent the policy shock, the bank at the 99th percentile pays an IBD interest rate that is 119bp lower. With the monetary policy shock, the same bank has a larger amount of DDs to substitute. This implies an increase in the IBD interest rate of 20bp. Therefore, the difference between the IBD interest rates that the two banks pay is 99bp.

To have a sense of whether or not these numbers may account for a sizeable portion of the marginal funding rate variability, the standard deviation of the 2005 IBD interest rate (after controlling for time and bank fixed effects) is 63bp. One standard deviation of the before-the-shock DDs amount may account, therefore, for almost one third of the part of 2005 funding rate standard deviation that is not explained by time and bank fixed effects. This figure is remarkably large.

Essentially, the numbers show that the cross-sectional heterogeneity in the IBD interest rate depends on banks' heterogeneous liability structures. The question is now why banks display such heterogeneous liability structures. A priori, banks' liability structures are endogenous and chosen by banks in order to maximize their profit. The theoretical model presented in the appendix shows that the optimal amount of DDs depends on the elasticity of the supply of IBDs. Under some conditions, the relationship is negative. Intuitively, if the elasticity of the IBD supply is low, financing with IBDs is expensive, and banks have an incentive to invest more to attract DDs.

Parameters' estimates of the extended model (Table 7) show that smaller banks face a less elastic supply of IBDs. If the earlier intuition is right, they should invest more in service quality, and as a consequence, they should display larger amounts of DDs. I consider two measures of service quality: First, the advertising rate, which is the annualized expenses for advertising and marketing per unit of asset; and second, the number of branches per unit of assets. I compute the median of these two measures within small, medium, and large banks. Figures 2 and 3 show how the medians evolve in the period under analysis. Large banks have the largest expenditures for advertising until the first years of the 2000's. After that time, they attain the lowest levels. Instead, small banks keep their advertising rate at a more constant level throughout the period, and always greater than medium banks. Figure 3 shows that smaller banks always have the largest number of branches per unit of assets, followed by medium banks.

At the beginning of my sample period, it is not clear which class of banks has the greatest service quality, and therefore, it is not clear which should display the largest amount of DDs. Instead, it is clear that after the early 2000's, smaller banks should display the largest amounts of DDs, followed by medium banks. Figure 4 plots the median normalized amount of DDs within small, medium, and large banks. At the beginning of the sample period all classes of banks have the same normalized amount of DDs. In more recent years, however, small banks display the largest amounts, followed by medium banks. In fact, from 1994, medium and large banks observe a drastic decline. These differences in the evolution of the amount of DDs seem, therefore, to match the evolution of service quality in the different classes of banks. Moreover, they also confirm the finding that medium and large banks face a much more elastic supply of IBDs. Again, because they can raise funding with IBDs without incurring too high premia, larger banks have no need to stimulate the supply of DDs providing service quality, and have an incentive to compose their liability structure with more IBDs.

8 Robustness checks

In this section, I present several robustness checks which assess the validity and strength of the instrumental variables used in the baseline model.

8.1 Demographic shocks taken further in the past

As stressed in the identification strategy, in order to be valid instruments, the demographic shocks $\triangle demogr_{jt-1}$ need to affect DDs and loans only at the moment in which they realize and not in subsequent periods. Otherwise, if they directly affected period t DDs and loans, they should be included in the main equation. The Sargan test seems to exclude that their effect actually propagates to subsequent periods. Nevertheless, I consider here two robustness checks that minimize even more the concern that the instruments used are not valid.

Instead of considering demographic shocks that happen in $t-1$, I consider those that happen in earlier periods. The idea is that the further in the past these shocks happen, the more negligible, if any, is their direct effect on period t DDs and loans. Take for example a shock in population density that realizes in period $t-2$. Such shock directly affects period $t-2$ DDs and loans. Potentially, period $t-2$ DDs and loans do not fully adjust. As a consequence, the period $t-2$ population density shock also has a direct effect on period $t-1$ DDs and loans. In period $t-1$, however, DDs and loans are likely to have fully incorporated the shock. Thus the period $t-2$ population density shock does not trigger any further direct effect on DDs and loans in period t.

I first consider demographic shocks that happen in period $t-2$. I re-normalize period $t-1$ amount of DDs and loans with respect to period $t-3$ total assets. I obtain d_{jt-1} and l_{jt-1}. I also define d_{jt-3} (l_{jt-3}) as the amount of DDs (loans and leases) held by j at $t-3$ normalized by period $t-3$ total assets.[24] The change of normalization enables me to measure the effect of period $t-2$ demographic shocks on period $t-1$ DDs and loans. I first regress d_{jt-1} on d_{jt-3}, l_{jt-3}, $\triangle demogr_{jt-2}$, $\triangle demogr_{jt}$, $demogr_{jt}$, time and bank fixed effects. Similar to what previously defined, $\hat{\hat{d}}_{jt-1}$ is the vector of fitted values, and the set of (excluded) IVs for $\{d_{jt-1};\ l_{jt-1};\ d_{jt-1} \times \Delta FF_t\}$ is now $\{d_{jt-3};$ $l_{jt-3};\ \triangle demogr_{jt-2};\ \hat{\hat{d}}_{jt-1} \times \Delta FF_t\Big\}$. Table 9 presents parameters' estimates of the baseline model (1) with the new set of IVs. The qualitative effects of d_{jt-1}, $d_{jt-1} \times \Delta FF_t$, and l_{jt-1}, on r^b_{jt} is corroborated. Relative to the estimates of the baseline model of Table 6, parameters' estimates change, possibly due to the change of normalization. The significance of the parameters is, however, confirmed.

[24] Similarly, I re-define the Tier1 ratio, $Tier1\,ratio_{jt-1}$, as period $t-1$ Tier1 (core) capital normalized by period $t-3$ total assets.

I then consider demographic shocks that realize in period $t-3$. I repeat the procedure detailed above, and present the results of the baseline model in Table 10. Again, the significance and sign of Table 6 parameters' estimates is confirmed. Also in this case, the magnitude changes. Finally, it should be noted that taking shocks that happen further in the past comes at the cost of reducing the length of the panel.

8.2 Reduced form model

In this subsection, I further relax the exclusion restriction employed in the baseline model. Specifically, I allow period $t-1$ demographic shocks to have a direct effect on period t normalized amounts of DDs and loans. I re-write the original model (1) as:

$$\begin{aligned} r_{jt}^{b} &= \sigma_1 d_{jt-2} + \gamma^{\Delta FF}\left(d_{jt-1} \times \Delta FF_t\right) + \sigma_2 l_{jt-2} \\ &+ \beta_1 demogr_{jt} + \beta_2 \triangle demogr_{jt} + \sigma_3 \triangle demogr_{jt-1} + \eta_t + \eta_j + \eta_{jt} \end{aligned}$$

where regressors now directly include d_{jt-2}, l_{jt-2} and $\triangle demogr_{jt-1}$.

This reduced form model allows previously excluded instruments to have a direct effect on r_{jt}^{b}. Here, the only endogenous covariate is $d_{jt-1} \times \Delta FF_t$, and is instrumented by $\hat{d}_{jt-1} \times \Delta FF_t$. As above, $\hat{d}_{jt-1}$ is the fitted value resulting from the regression of d_{jt-1} on d_{jt-2}, l_{jt-2}, $\triangle demogr_{jt-1}$, $\triangle demogr_{jt}$, $demogr_{jt}$, time and bank fixed effects. The exclusion restriction is that period $t-1$ demographic shocks do not have direct effects joint with the monetary policy shock ΔFF_t. In other words, a period $t-1$ increase in the mean age of the population does not trigger effects on r_{jt}^{b} depending on the monetary policy shock that is realized in t. Clearly, this exclusion restriction is milder than the one used so far.

Results appear in Table 11. The estimate and statistical significance of $\gamma^{\Delta FF}$ are very close to the ones presented in Table 6.

8.3 Demographic variables weighted using amount of deposits collected

The demographic shocks are defined as the year changes in the demographic levels that each bank faces in the areas where it is set. One potential concern refers to how the county-year demographics are aggregated to the bank-year level. In the data section, I detail that when banks operate in more than one county, I compute a weighted average of the county demographics. Each county is weighted by the proportion of branches that a bank has there. It may be, however, that this weighting does not measure the exact demographic dynamics to which each bank is exposed. For instance, some branches may not be used to collect DDs or lend loans, thus the weighting by number of branches may over-weight the counties that host these branches.

I address this issue by changing the weights. I weight each county-year demographic variable by the proportion of deposits that a bank collects there. After I aggregate the county-year demographics to the bank-year level, I compute the year changes in the demographics. I repeat the procedure to obtain a set of IVs, and I use them in the estimation of the baseline model. Table 12 presents the results. There does not appear to be any appreciable change relative to the estimates of Table 6. All results are conserved.

8.4 Demographic variables weighted using the 1994 branch network

Another concern is that banks may set their branch network forecasting demographic dynamics. If a bank has the ability to forecast that a particular area will boom, it may set new branches there, so to benefit when the boom realizes. In that case, the observed branch networks, and the weighting used to aggregate county demographics to the bank level, are endogenous. As a consequence, the constructed bank level demographics are endogenous, and their year changes are no longer valid instruments.

I address this issue noting that, until 1994, regulation significantly limited the ability of banks to open new branches. As detailed by Kane (1996) and Johnson and Rice (2008), until at least the 1980's, regulation on commercial banks' geographic expansion was heavy and pointed to both *intra*-state and *inter*-state *banking* and *branching*.[25] The picture changed with the Riegle-Neal Interstate

[25] Intra-state operations are those happening within the bank's home state borders, while inter-state ones those across. With banking it is meant the establishment or acquisition of a separate charter. With branching, the estab-

Banking and Branching Efficiency Act (IBBEA) of 1994. The act permitted the consolidation of existing out-of-state subsidiaries, which would have become branches of the lead bank (of an existing multi-bank holding company), and also allowed banks to set up new out-of-state branches (the so-called "*de novo* branching").[26] Indeed, between 1994 and 2005, states gradually moved towards a relaxation of the constraints, and the number of entries of out-of-state banks largely increased (Johnson and Rice (2008)).

This brief discussion suggests that the ability of banks to adjust their branch network forecasting demographic dynamics is a legitimate concern, especially for the latter years of the sample period. Instead, 1994 is the last year during which banks are limited to adjust their branch network by regulation. I exploit this limitation, and construct bank level demographics using the weights derived from the 1994 branch network only. The resulting bank level variables capture the demographic dynamics to which each bank is exposed, but exclude from it the part due to the (endogenous) creation of new branches. I compute the year changes, and repeat the same procedure to construct a set of IVs. Table 13 reports the results for the baseline model using this new set of IVs. Again, parameters' estimates and significance confirm the earlier results of Table 6.

8.5 Clustering by bank-holding company and year

As discussed earlier, Campello (2002), Gambacorta (2005), and Ashcraft (2006) suggest that banks belonging to a bank-holding company can take advantage of the internal capital markets and are insulated from monetary policy shocks. The models presented control for each bank's participation to a BHC, but cluster standard errors by bank and year. Clustering by bank and year excludes the possibility that the correlation of the regression residuals of banks belonging to the same BHC is not zero. If that is not the case, standard errors are inconsistent, and t-statistics are over-estimated (Petersen (2009) and Thompson (2011)). I address this issue clustering by BHC and year. The results of the baseline model are presented in Table 14. The significance of the parameters of d_{jt-1}, $d_{jt-1} \times \Delta FF_t$, and l_{jt-1}, is still large and not different from that obtained in Table 6.

lishment or acquisition of a branch office which is not separately chartered or capitalized.

[26] In fact, the act left to each state the possibility to "opt out" or put restrictions on inter-state branching operations (see Johnson and Rice (2008) and Rice and Strahan (2010)).

9 Conclusion

What are the effects of monetary policy shocks on banks' liability structures and funding costs? In this paper, I detail the mechanism by which monetary policy affects the composition of banks' liabilities and, through that channel, banks' funding costs. When monetary policy changes stance, the quantity of demand deposits that banks detain may modify. Banks respond by changing the quantity of interest-bearing deposits issued. If, however, the interest rate to pay on IBDs depends on the quantity to borrow, this will in turn affect the IBD interest rate.

I analyze the universe of FDIC-insured U.S. commercial and savings banks from 1994 to 2010. Exploiting exogenous variation in individual banks' DDs, I trace how the reaction of DDs to monetary policy shocks is transmitted to the IBD interest rate. My findings indicate that the IBD interest rate increases with the quantity to borrow, and that monetary policy shocks significantly affect the quantity of DDs. In particular, I show that a monetary contraction decreases the amount of DDs, and that this leads banks to substitute the outflow of DDs with IBDs; their IBD interest rate rises as a result. I also investigate whether and how bank size and banking market concentration alter the transmission of the monetary policy shock. I find that substituting DDs with IBDs is cheaper for larger banks, and that DDs are less sensitive to monetary policy shocks in more concentrated banking markets.

I find support for the bank lending channel of monetary policy. Because substituting DDs is costly, banks may not substitute every dollar of lost DDs. A monetary contraction therefore leads to a decrease in loan supply. The results suggest that substituting DDs is cheaper for larger banks, which may account for the earlier finding that monetary contractions are followed by smaller loan supply decreases in large banks (Kashyap and Stein (1995, 2000) and Kishan and Opiela (2000)). Similarly, banking market concentration limits the sensitivity of DDs to policy shocks. This is consistent with Adams and Amel (2011) who find that banks operating in more concentrated markets diminish their loan supply to a lesser extent.

In my empirical strategy, the liability structure that banks display before the monetary policy shock is considered endogenous. I posit that banks target an optimal liability structure, and have the possibility to attract DDs. Banks are expected to choose their optimal amount of DDs considering the costs of raising IBDs, and the sensitivity of DDs to monetary policy shocks. The estimation shows that the same unit of IBDs is more expensive for smaller banks than for larger banks; smaller banks' DDs are also less sensitive to monetary policy shocks. Both findings suggest that DDs are a valuable source of funding, especially for smaller banks. I consistently observe that in recent years small banks have had, relative to large banks, a greater part of their balance sheet financed through DDs. DDs seem therefore to be used by small banks as a hedge against shocks hitting the IBD market. For future research, I leave the analysis of whether or not DDs are (or can be) used for such risk-management purposes.

References

[1] Adams, Robert M., 2012. "Consolidation and Merger Activity in the United States Banking Industry from 2000 through 2010," Finance and Economics Discussion Series. Divisions of Research & Statistics and Monetary Affairs, Federal Reserve Board.

[2] Adams, Robert M., & Amel, Dean F., 2011. "Market structure and the pass-through of the federal funds rate," Journal of Banking and Finance, Vol. 35, Pages 1087-1096.

[3] Altunbaş, Yener, Fazylov, Otabek, & Molyneux, Philip, 2002. "Evidence on the bank lending channel in Europe", Journal of Banking & Finance, Vol. 26(11), Pages 2093-2110.

[4] Angeloni, Ignazio, Kashyap, Anil K., & Mojon, Benoît, 2003. "Monetary transmission in the Euro Area", Cambridge University Press.

[5] Angeloni, Ignazio, Kashyap, Anil K., Mojon, Benoît, & Terlizzese, Daniele, 2003. "Monetary transmission in the Euro area: Does the interest rate channel explain all?", NBER Working Paper No. 9984.

[6] Ashcraft, Adam B., 2006. "New Evidence on the Lending Channel," Journal of Money, Credit and Banking, Vol. 38(3), Pages 751-775.

[7] Bassett, Bill, & Brady, Tom, 2002. "What Drives the Persistent Competitiveness of Small Banks?", Finance and Economics Discussion Series Working Paper 2002-28, Board of Governors of the Federal Reserve System.

[8] Becker, Bo, 2007. "Geographical segmentation of U.S. capital markets", Journal of Financial Economics, Vol. (85), Pages 151-178.

[9] Bernanke, Ben S., & Blinder, Alan S., 1988. "Credit, Money, and Aggregate Demand," American Economic Review, (Papers and Proceedings), Vol. 78(2), Pages 435-439, May.

[10] Bernanke, Ben S., & Blinder, Alan S., 1992. "The Federal Funds Rate and the Channels of Monetary Transmission", American Economic Review, Vol. 82(4), Pages 901-921.

[11] Bernanke, Ben S., & Gertler, Mark., 1995. "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," Journal of Economic Perspectives, Vol. 9(4), Pages 27-48, Fall.

[12] Black, Lamont K., Hancock, Diana, & Passmore, Wayne, 2010. "The Bank Lending Channel of Monetary Policy and Its Effect on Mortgage Lending", Finance and Economics Discussion Series, Board of Governors of the Federal Reserve System.

[13] Blundell, Richard, & Bond, Steve, 1998. "Initial conditions and moment restrictions in dynamic panel data models", Journal of Econometrics, Vol. 87, Pages 115-143.

[14] Borio, Claudio E. V., & Disyatat, Piti, 2010. "Unconventional Monetary Policies: An Appraisal", The Manchester School, Pages 53-89.

[15] Campello, Murillo, 2002. "Internal Capital Markets in Financial Conglomerates: Evidence from Small Bank Responses to Monetary Policy," The Journal of Finance, Vol. 57(6), Pages 2773-2805.

[16] Cerasi, Vittoria, Chizzolini, Barbara, & Ivaldi Marc, 2002. "Branching and competition in the European Banking Industry," Applied Economics, Vol. 34.

[17] Cetorelli, Nicola, & Goldberg, Linda, 2012. "Bank Globalization and Monetary Policy", Journal of Finance, Vol. 67(5), Pages 1811-1843.

[18] Chava, Sudheer, & Purnanandam, Amiyatosh, 2011. "The effect of banking crisis on bank-dependent borrowers", Journal of Financial Economics, Vol. 99(1), Pages 116-135.

[19] De Bondt, Gabe J., 1999. "Banks and Monetary Transmission in Europe: Empirical Evidence", BNL Quarterly Review 209, Pages 149-168.

[20] Dick, Astrid A., 2007. "Market Size, Service Quality, and Competition in Banking", Journal of Money, Credit and Banking, Vol. 39(1), Pages 49-81.

[21] Disyatat, Piti, 2008. "Monetary Policy Implementation: Misconceptions and Their Consequences", BIS Working Papers No. 269.

[22] Disyatat, Piti, 2011. "The Bank Lending Channel Revisited", Journal of Money, Credit and Banking, Vol. 43(4), Pages 711-734.

[23] Ehrmann, Michael, Gambacorta, Leonardo, Martìnez-Pagés, Jorge, Sevestre, Patrick, & Worms, Andreas, 2001. "Financial Systems and the Role of Banks in Monetary Policy Transmission in the Euro Area", ECB Working Paper No. 105.

[24] Favero, Carlo A., Giavazzi, Francesco, & Flabbi, Luca, 1999. "The Transmission Mechanism of Monetary Policy in Europe: Evidence from Banks Balance Sheets", NBER WP 7231.

[25] Flannery, Mark J., & Hankins, Kristine W., 2013. "Estimating dynamic panel models in corporate finance", Journal of Corporate Finance, Vol. 19, Pages 1-19.

[26] FDIC, 2009. "National Survey of Unbanked and Underbanked Households," (full report).

[27] Gambacorta, Leonardo, & Mistrulli, Paolo E., 2004. "Does bank capital affect lending behavior?," Journal of Financial Intermediation, Vol. 13, Pages 436-57.

[28] Gambacorta, Leonardo, 2005. "Inside the bank lending channel", European Economic Review, Vol. 49(7), Pages 1737-1759.

[29] Gilje, Erik, Loutskina, Elena, & Strahan, Philip E., 2013, "Exporting liquidity: Branch banking and financial integration", NBER Working Paper #19403.

[30] Guthrie, Graeme, & Wright, Julian, 2000. "Open Mouth Operations", Journal of Monetary Economics, Vol. 46, Pages 489-516.

[31] Hannan, Timothy H., & Berger, Allen N., 1991. "The rigidity of prices: Evidence from the banking industry", American Economic Review Vol. 81, Pages 938-945.

[32] Heggestad, Arnold A., & Mingo, John J., 1976. "Prices, Nonprices, and Concentration in Commercial Banking," Journal of Money, Credit, and Banking, Vol. 8(1), Pages 107-117.

[33] Holmstrom, Bengt, & Tirole, Jean, 1997. "Financial Intermediation, Loanable Funds, and the Real Sector." Quarterly Journal of Economics, Vol. 112(3), Pages 663-91.

[34] Huang, Rocco, & Ratnovski, Lev, 2011. "The Dark Side of Bank Wholesale Funding", Journal of Financial Intermediation, Vol. 20, Pages 248-63.

[35] Iyer, Rajkamal, & Peydro, José-Luis, 2011. "Interbank Contagion at Work: Evidence from a Natural Experiment", Review of Financial Studies, Vol. 24, Pages 1337-1377.

[36] Jayaratne, Jith, & Morgan, Donald P., 2000. "Capital Market Frictions and Deposit Constraints at Banks." Journal of Money, Credit, and Banking, Vol. 32(1), Pages 74-92.

[37] Johnson, Christian A., & Rice, Tara, 2008. "Assessing a Decade of Interstate Bank Branching", Wash. & Lee L. Review, Vol. 65(1), Pages 73-127.

[38] Jiménez, Gabriel, Ongena, Steven, Peydro, José-Luis, & Saurina, Jesús, 2012. "Credit supply and monetary policy: identifying the bank balance-sheet channel with loan applications", American Economic Review, Vol. 102, Pages 2301-2326.

[39] Kane, Edward J., 1996. "De Jure Interstate Banking: Why Only Now?", Journal of Money, Credit and Banking, Vol. 28(2), Pages 141-161.

[40] Kashyap, Anil K., & Stein, Jeremy C., 1994. "Monetary Policy and Bank Lending," N. Gregory Mankiw, ed., Monetary policy. Chicago: University of Chicago Press, Pages 221-56.

[41] Kashyap, Anil K., & Stein, Jeremy C., 1995. "The impact of monetary policy on bank balance sheet," Carnegie-Rochester Conference Series on Public Policy, Vol. 42, Pages 151-195.

[42] Kashyap, Anil K., & Stein, Jeremy C., 2000. "What do a million observation of banks say about the transmission of monetary policy," American Economic Review, Vol. 90, Pages 407-428.

[43] Kim, Moshe, & Vale, Bent, 2001. "Non-price strategic behavior: the case of bank branches," International Journal of Industrial Organization, Vol. 19, Pages 1583-1602.

[44] Kinneckell, Arthur B., 2000. "Wealth measurement in the survey of consumer finances: methodology and directions for future research," Working paper, Federal Reserve Board of Governors.

[45] Kishan, Ruby P., & Opiela, Timothy P., 2000. "Bank size, bank capital, and the bank lending channel," Journal of Money Credit and Banking, Vol. 32, Pages 121-141.

[46] Khwaja, Asim I., & Mian, Atif, 2008. "Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market", American Economic Review, Vol. 98, Pages 1413-1442.

[47] Landier, Augustin, Sraer, David, & Thesmar, David, 2013. "Banks' Exposure to Interest Rate Risk and The Transmission of Monetary Policy", NBER Working Paper #18857.

[48] Little, Roderick J. A., & Rubin, Donald B., 1987. "Statistical Analysis with Missing Data," 1st ed. Wiley Series in Probability and Statistics.

[49] Maechler, Andrea M., & McDill, Kathleen M., 2006. "Dynamic depositor discipline in U.S. banks", Journal of Banking and Finance, Vol. 30, Pages 1871-1898.

[50] Martín-Oliver, Alfredo, & Salas-Fumás, Vicente, 2008. "The output and profit contribution of information technology and advertising investments in banks," Journal of Financial Intermediation, Vol. 17, Pages 229-255.

[51] Montalto, Catherine P., & Sung, Jaimie, 1996. “Multiple imputation in the 1992 survey of consumer finances,” Financial Counseling and Planning, Vol. (7), Pages 133-146.

[52] Neumark, David, & Sharpe, Steven A., 1992. “Market structure and the nature of price rigidity: Evidence from the market for consumer deposits”, Quarterly Journal of Economics, Vol. 107, Pages 657-680.

[53] Paravisini, Daniel, 2008. “Local Bank Financial Constraints and Firm Access to External Finance”, Journal of Finance, Vol. 63, Pages 2161-2193.

[54] Park, Kwangwoo, & Pennacchi, George, 2009. “Harming Depositors and Helping Borrowers: The Disparate Impact of Bank Consolidation”, Review of Financial Studies, Vol. 22(1), Pages 1-40.

[55] Peek, Joe, & Rosengren, Eric S. (1997). “The International Transmission of Financial Shocks: The Case of Japan”, American Economic Review, Vol. 87, Pages 495-505.

[56] Petersen, Mitchell A., 2009. “Estimating standard errors in finance panel datasets: comparing approaches”, Review of Financial Studies, Vol. 22, Pages 435-480.

[57] Puri, Manju, & Robinson, David T., 2007. “Optimism and economic choice,” Journal of Financial Economics, Vol. (86), Pages 71-99.

[58] Rice, Tara, & Strahan, Philip E., 2010. “Does Credit Competition Affect Small-Firm Finance?” 2010, Journal of Finance 65(3).

[59] Schnabl, Philipp, 2012. “The International Transmission of Bank Liquidity Shocks: Evidence from an Emerging Market”, Journal of Finance, Vol. 67, Pages 897-932.

[60] Song, Fenghua & Thakor Anjan V., 2007. “Relationship Banking, Fragility, and the Asset-Liability Matching Problem”, Review Financial Studies, Vol. 20(6), Pages 2129-2177.

[61] Stein, Jeremy C., 1998. “An Adverse-Selection Model of Bank Asset and Liability Management with Implications for the Transmission of Monetary Policy”, The RAND Journal of Economics, Vol. 29 (3), Pages 466-486.

[62] Sutton, John., 1991. “Sunk Cost and Market Structure: Price Competition, Advertising, and the Evolution of Concentration”, The MIT Press.

[63] Thompson, Samuel B., 2011. “Simple formulas for standard errors that cluster by both firm and time”, Journal of Financial Economics, Vol. (99), Pages 1-10.

[64] Van Hoose, David, 2010. “The Industrial Organization of Banking”, Springer.

[65] Windmeijer, Frank, 2005. “A finite sample correction for the variance of linear efficient two-step GMM estimators”, Journal of Econometrics, Vol. 126, Pages 25-51.

[66] Wooldridge, Jeffrey M., 2001. “Econometric Analysis of Cross Section and Panel Data”, The MIT Press.

Figures

Figure 1: Domestic deposits to total assets. Median by class of bank size

This figure plots the quarterly evolution of the median ratio of domestic deposits to total assets, computed within class of bank size. I compute the ratio of domestic deposits to total assets for each bank-quarter, from 1994q2 to 2010q2. I define small banks as those below the 50th percentile for total assets nationally in a given quarter. Medium banks are those between the 50th percentile and the 95th percentile. Large banks are those above the 95th percentile. I then take the median of banks' ratios of domestic deposits to total assets within each group-quarter. The data are from the FDIC, Statistics on Depository Institutions.

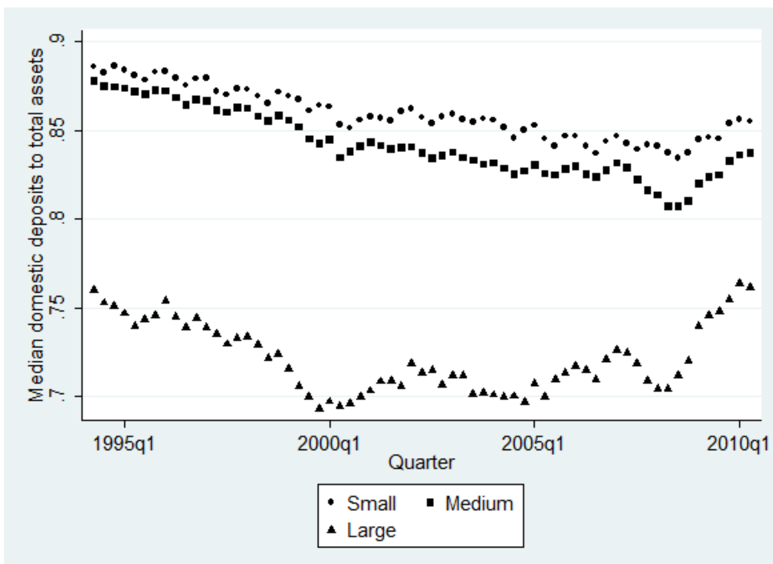


Figure 2: Advertising rate. Median by class of bank size

This figure plots the quarterly evolution of the advertising rate, computed within class of bank size. The quarterly advertising rate is defined as the ratio of advertising and marketing expenses of a given bank in a quarter to the amount of the bank's total assets outstanding at the end of the previous quarter. I annualize this figure compounding it over the quarter and the previous three quarters, from 1994q2 to 2010q2. I define small banks as those below the 50th percentile for total assets nationally in a given quarter. Medium banks are those between the 50th percentile and the 95th percentile. Large banks are those above the 95th percentile. I then take the median of banks' annualized adveritising rates within each group-quarter. The data are from the FDIC, Statistics on Depository Institutions.

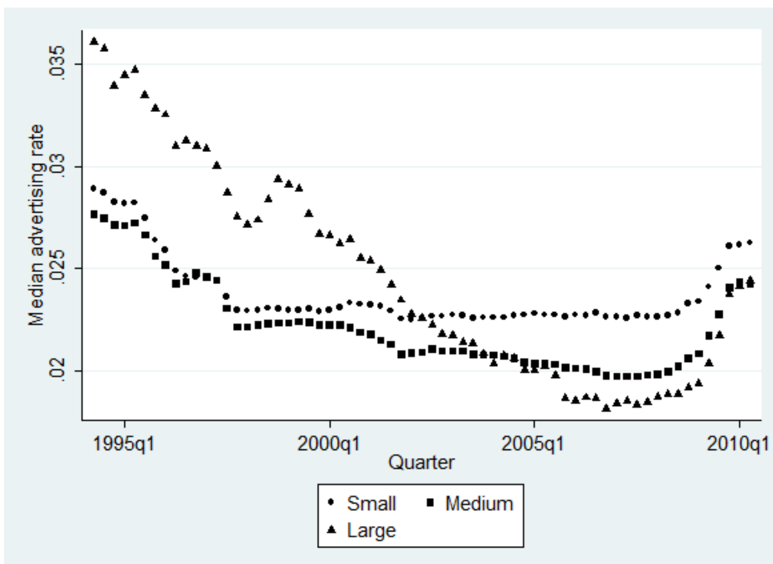


Figure 3: Number of branches per unit of total assets. Median by class of bank size

This figure plots the quarterly evolution of the median ratio of number of branches to total assets, computed within class of bank size. I compute the ratio of number of branches to total assets for each bank-quarter, from 1994q2 to 2010q2. I define small banks as those below the 50th percentile for total assets nationally in a given quarter. Medium banks are those between the 50th percentile and the 95th percentile. Large banks are those above the 95th percentile. I then take the median of banks' ratios of number of branches to total assets within each group-quarter. The data are from the FDIC, Statistics on Depository Institutions.

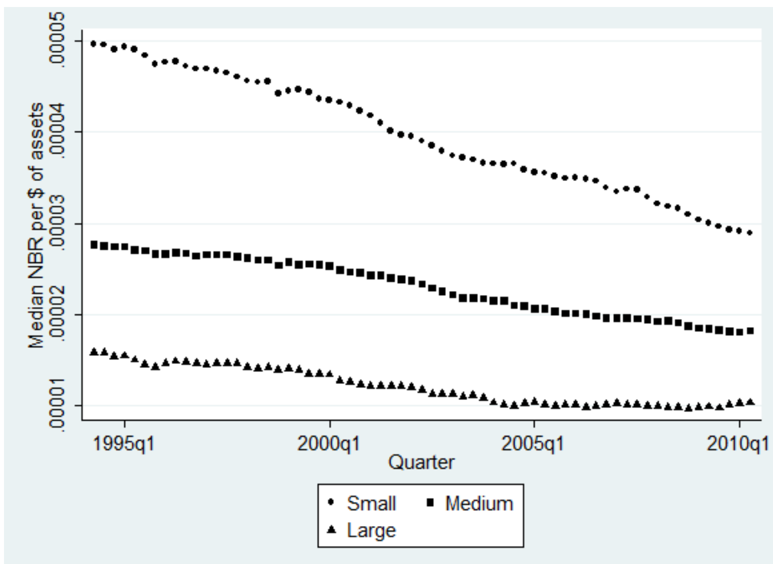
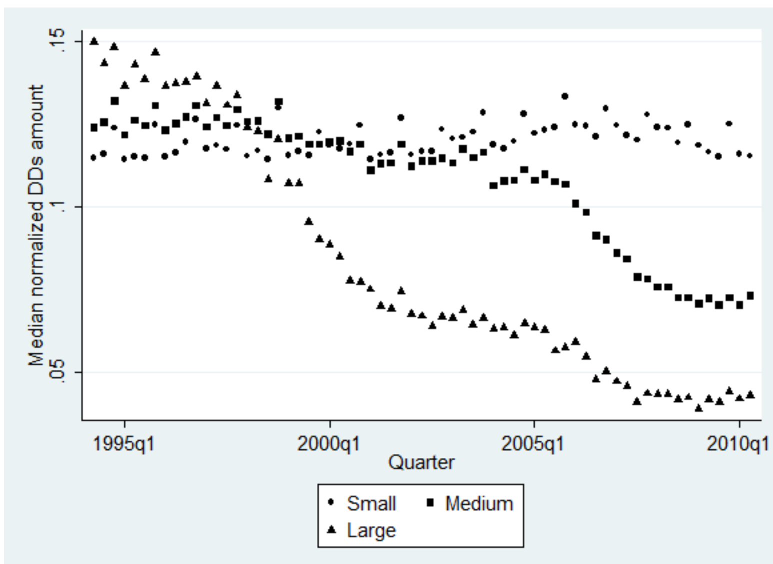


Figure 4: Normalized amount of demand deposits. Median by class of bank size

This figure plots the quarterly evolution of the median normalized demand deposits amount, computed within class of bank size. A bank's normalized demand deposits amount is the amount of demand deposits that the bank has at the end of a quarter divided by the total assets outstanding one year earlier. I compute this figure for each bank-quarter, from 1994q2 to 2010q2. I define small banks as those below 50th percentile for total assets nationally in a given quarter. Medium banks are those between the 50th percentile and the 95th percentile. Large banks are those above the 95th percentile. I then take the median of banks' normalized demand deposits amounts within each group-quarter. The data are from the FDIC, Statistics on Depository Institutions.



Tables

Table 1: Household DDs holdings as a function of the HH demographic characteristics

This table presents the estimates of the effects of household demographics on the probability that the household has a checking account (left column), and, if the household has at least one, on the amount that it detains there (right column). In the column on the left, I structure a Probit model, and $Own\,check\,acct_{ht}$ takes the value of one when household h has a checking account in year t. In the column on the right, the dependent variable is the log of one plus the amount detained by the household in its checking account(s) ($Check\,acct_{ht}$). The independent variables are household level demographics (X) and year dummies. X include the age of the head (Age), the log of the number of people in the household ($\log(HHsize)$), controls for race and education, and household (log) total income ($\log(inc)$). The controls for race are $Black$, $Hispanic$, and $Other$, and take the value of one if the head is, respectively, black/African-American, hispanic, or either Asian, American Indian/Alaska Native or Native Hawaiian/Pacific Islander. The controls for education are $College$ and PhD, which equal to one if the head has taken any college-level, respectively PhD-level, classes. In the column on the left, I report marginal effects. They are obtained setting independent continuous variables to median levels, and independent dummy variables to 0. The data are from the Survey of Consumer Finances (SCF), and the years considered are 1995, 1998, 2001, 2004, 2007 and 2010. Both estimations use population weights. The SCF uses multiple imputation to correct for missing and sensitive data. Every respondent is accounted five times in the public dataset (Kinneckell (2000)). Because not all observations are independent, neglecting multiple imputation in a regression analysis would result in artificially high t-values. I follow the approach described in Puri and Robinson (2007) and use for my estimations the package *rii* developed for Stata by Dan Blanchette and David Robinson. Standard errors are adjusted averaging the standard errors from each imputation, plus adding on a term that accounts for the variation across implicates. This technique is derived from Montalto and Sung (1996) and Little and Rubin (1987). As explained in Puri and Robinson (2007), the "multiple imputation-corrected standard error may be smaller than that obtained from a randomly chosen implicate (if the imputation of the data chosen produces large standard errors relative to the average across implicates, and the across-imputation variance were not too large). But it will always be larger than the standard error obtained by averaging the covariates across the imputations of the data before analysis (because doing so ignores across-imputation variance and may shrink within-imputation variance)". Resulting standard errors are in parenthesis. Significance levels: ***1%, **5%, *10%.

	$\Pr[Own\,check\,acct_{ht} = 1 \mid X_{ht}]$	$\log(1 + Check\,acct_{ht})$
Age_{ht}	.0016***	0.0217***
	(.0002)	(0.0008)
$\log(HHsize_{ht})$	.0084	-0.1750***
	(.0055)	(0.0288)
$Black_{ht}$	-.1647***	-0.4920***
	(.0111)	(0.0487)
$Other_{ht}$	-.0774***	0.0969
	(.0187)	(0.0694)
$Hispanic_{ht}$	-.1652***	-0.1850***
	(.0131)	(0.0598)
$College_{ht}$	.0954***	0.4450***
	(.0061)	(0.0345)
PhD_{ht}	.0868***	0.8770***
	(.0078)	(0.0463)
$\log(inc_{ht})$	.0443***	0.6010***
	(.0028)	(0.0283)
Time FE	Yes	Yes
N° Obs	141,590	117,448

Table 2: Household expenditures as a function of the HH demographic characteristics

This table presents the estimates of the effects of household demographics on the household expenditures. The dependent variables are the log of one plus one of the following household expenditures: total expenditures ($Total$), total food expenditures ($Food$), total expenditures for food consumed at home ($Home\,food$), total expenditures for shelter, utilities, fuels, public services, household operations, housefurnishings and equipment ($House$), total expenditures for housefurnishings and equipment ($Furnish$), and total apparel expenditures ($Apparel$). The independent variables are household demographics (X) and region dummies. X include the age of the head (Age), the log of the number of people in the household ($\log(HHsize)$), controls for race and education, the household (log) total income ($\log(inc)$), and a dummy that equals to one if the household resides in a urban area ($Urban$). The controls for race are $Black$, $Hispanic$, and $Other$, and take the value of one if the head is, respectively, black/African-American, hispanic, or either Asian, American Indian/Alaska Native or Native Hawaiian/Pacific Islander. The controls for education are $College$ and PhD, which equal to one if the head has taken any college-level, respectively PhD-level, classes. The data are from the 2003 Quarterly Interview Survey, included in the Consumer Expenditure Survey (CEX). Standard errors are in parenthesis. Significance levels: ***1%, **5%, *10%.

	$\log(1+\ldots)$					
	$Total_h$	$Food_h$	$Home\,food_h$	$House_h$	$Furnish_h$	$Apparel_h$
Age_h	0.0016***	0.0024***	0.0072***	0.0040***	-0.0044***	-0.0201***
	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0008)	(0.0007)
$\log(HHsize_h)$	0.5460***	0.6970***	0.8430***	0.5650***	0.6430***	0.8070***
	(0.0057)	(0.0066)	(0.0078)	(0.0079)	(0.0239)	(0.0201)
$Black_h$	-0.2640***	-0.2200***	-0.1110***	-0.0613***	-0.7530***	-0.1010***
	(0.0103)	(0.0121)	(0.0143)	(0.0144)	(0.0435)	(0.0367)
$Other_h$	-0.1530***	-0.1110***	-0.1140***	-0.0968***	-0.4500***	-0.2930***
	(0.0137)	(0.0161)	(0.0189)	(0.0191)	(0.0578)	(0.0488)
$Hispanic_h$	-0.2450***	-0.1110***	-0.0333**	-0.1010***	-0.5520***	-0.1210***
	(0.0120)	(0.0141)	(0.0166)	(0.0168)	(0.0507)	(0.0428)
$College_h$	0.3610***	0.1920***	0.1100***	0.3430***	0.8150***	0.7020***
	(0.0071)	(0.0084)	(0.0098)	(0.0099)	(0.0300)	(0.0254)
PhD_h	0.7350***	0.4380***	0.3070***	0.7360***	1.4480***	1.2900***
	(0.0105)	(0.0124)	(0.0146)	(0.0147)	(0.0445)	(0.0376)
$\log(inc_h)$	0.0498***	0.0205***	0.0127***	0.0339***	0.1310***	0.1160***
	(0.0009)	(0.0011)	(0.0013)	(0.0013)	(0.0039)	(0.0033)
$Urban_h$	0.1320***	0.1030***	0.0597***	0.2800***	0.1650***	0.3650***
	(0.0111)	(0.0130)	(0.0153)	(0.0155)	(0.0468)	(0.0395)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
N° Obs.	40,073	40,073	40,073	40,073	40,073	40,073

Table 3: HH size as a function of the proportions of children and elderly people in the HH and other demographics

This table presents the estimates of the effects of household demographics and the proportions of children and elderly people on the size of the household. The dependent variable is the log of the number of people in the household h ($\log(HHsize_h)$). The independent variables are the age of the head (Age), the proportion of people in the household aged less than 18 ($Prop\,young$), the proportion of those aged more than 64 ($Prop\,old$), controls for race and education, and household (log) total income ($\log(inc)$). The controls for race are $Black$, $Hispanic$, and $Other$, and take the value of one if the head is, respectively, black/African-American, hispanic, or either Asian, American Indian/Alaska Native or Native Hawaiian/Pacific Islander. The controls for education are $College$ and PhD, which equal to one if the head has taken any college-level, respectively PhD-level, classes. In the column on the left, I use the data from the Survey of Consumer Finances (SCF), for the years 1995, 1998, 2001, 2004, 2007 and 2010. I include as additional independent variables year dummies. The estimation uses population weights. In the column on the right, I use data from the 2003 Quarterly Interview Survey, included in the Consumer Expenditure Survey (CEX). I include as additional independent variables a dummy that equals to one if the household resides in a urban area ($Urban$), and region dummies. Standard errors are in parenthesis. The standard errors reported in the column on the left consider multiple imputation and are computed following Puri and Robinson (2007). Significance levels: ***1%, **5%, *10%.

	$\log(HHsize_h)$	
	SCF	CEX
Age_h	0.0045***	0.0070***
	(0.0003)	(0.0002)
$Prop\,young_h$	1.6010***	1.7490***
	(0.0144)	(0.0090)
$Prop\,old_h$	-0.2000***	-0.3530***
	(0.0110)	(0.0081)
$Black_h$	-0.0551***	-0.0996***
	(0.0085)	(0.0064)
$Other_h$	0.0494***	0.0831***
	(0.0143)	(0.0085)
$Hispanic_h$	0.1100***	0.1460***
	(0.0102)	(0.0074)
$College_h$	0.0200***	0.0139***
	(0.0064)	(0.0044)
PhD_h	0.0171*	0.0696***
	(0.0091)	(0.0066)
$\log(income_h)$	0.1060***	0.0094***
	(0.0044)	(0.0006)
$Urban_h$		-0.0269***
		(0.0069)
Region FE	–	Yes
Time FE	Yes	–
N° Obs.	141,112	40,073

Table 4: Summary statistics of the bank level demographic variables

This table presents summary statistics of the bank level demographic variables. Demographic variables are based on the conditions of the areas in which each bank operates. $Prop\,Young$ and $Prop\,Old$ are the proportions of young (≤ 19 years old) and elderly (≥ 65 years old) people. $Mean\,age$ is the mean age of the population. $Prop\,Black$, $Prop\,Hisp$, and $Prop\,Other$ are the proportions of blacks/African-Americans, hispanics, and American Indians/Alaska Native together with Asian/Pacific Islander. $\log(Inc\,pc)$ is the (log) per-capita income. $Jobs\,pc$ is the number of jobs per-capita. $Pop\,density$ is the log of the population density. Year changes in these demographic variables are indicated by a $\triangle$ in front. Bank-year level demographic variables are weighted averages of county-year level data. The weights depend on the proportion of branches that a bank has in a county-year. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. Bank branches data is from the FDIC, Summary of Deposits.

	All sample			Year: 1996			Year: 2010		
Variable	*N° Obs.*	*Mean*	*St. Dev.*	*N° Obs.*	*Mean*	*St. Dev.*	*N° Obs.*	*Mean*	*St. Dev.*
$Prop\,Young_{jt}$	117,602	0.2780	0.0272	9,343	0.2885	0.0274	7,164	0.2645	0.0259
$Prop\,Old_{jt}$	117,602	0.1440	0.0379	9,343	0.1454	0.0403	7,164	0.1483	0.0356
$Mean\,age_{jt}$	117,602	37.4505	2.6886	9,343	36.5256	2.6543	7,164	38.5247	2.5775
$Prop\,Black_{jt}$	117,602	0.0872	0.1190	9,343	0.0847	0.1224	7,164	0.0926	0.1168
$Prop\,Hisp_{jt}$	117,602	0.0817	0.1222	9,343	0.0638	0.1162	7,164	0.1016	0.1287
$Prop\,Other_{jt}$	117,602	0.0420	0.0563	9,343	0.0269	0.0521	7,164	0.0574	0.0615
$\log(Inc\,pc_{jt})$	117,602	3.3406	0.2903	9,343	3.0569	0.2259	7,164	3.5902	0.2123
$Jobs\,pc_{jt}$	117,602	0.4310	0.1323	9,343	0.4204	0.1374	7,164	0.4172	0.1218
$Pop\,density_{jt}$	117,602	4.8080	1.8520	9,343	4.6411	1.8483	7,164	5.0312	1.8556
$\Delta Prop\,Young_{jt}$	117,602	-0.0016	0.0032	9,343	-0.0004	0.0032	7,164	-0.0025	0.0024
$\Delta Prop\,Old_{jt}$	117,602	0.0002	0.0039	9,343	-0.0005	0.0039	7,164	0.0015	0.0027
$\Delta Mean\,age_{jt}$	117,602	0.1413	0.2656	9,343	0.1038	0.2520	7,164	0.1813	0.1983
$\Delta Prop\,Black_{jt}$	117,602	0.0004	0.0088	9,343	0.0006	0.0093	7,164	0.0004	0.0066
$\Delta Prop\,Hisp_{jt}$	117,602	0.0027	0.0074	9,343	0.0024	0.0063	7,164	0.0018	0.0059
$\Delta Prop\,Other_{jt}$	117,602	0.0020	0.0045	9,343	0.0009	0.0025	7,164	0.0016	0.0034
$\Delta\log(Inc\,pc_{jt})$	117,602	0.0399	0.0489	9,343	0.0650	0.0489	7,164	0.0316	0.0310
$\Delta Jobs\,pc_{jt}$	117,602	-0.0001	0.0208	9,343	0.0034	0.0205	7,164	-0.0041	0.0125
$\Delta Pop\,density_{jt}$	117,602	0.0194	0.1746	9,343	0.0216	0.1641	7,164	0.0109	0.1213

Table 5: First-stage regressions

This table presents the estimates of the effects of the instrumental variables on the endogenous covariates in the main model. In the column on the left, the dependent variable d_{jt-1} is the amount of demand deposits that j has at $t-1$ normalized by the amount of total assets at $t-2$. In the column on the right, the dependent variable l_{jt-1} is the amount of total loans and leases that j has at $t-1$ normalized by the amount of total assets at $t-2$. In both columns, the independent variables include period $t-2$ normalized amounts of demand deposits d_{jt-2} and loans l_{jt-2}, period $t-1$ demographic shocks, period t demographic shocks $\triangle demogr_{jt}$, period t demographic levels $demogr_{jt}$, bank and time fixed effects. d_{jt-2} (l_{jt-2}) is defined as period $t-2$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. Demographic variables are the proportion of young ($\leq$ 19 years old, $Prop\,Young$) and elderly ($\geq$ 65 years old, $Prop\,Old$) people, mean age of the population ($Mean\,age$), proportion of blacks/African-Americans ($Prop\,Black$), hispanics ($Prop\,Hisp$) and American Indians/Alaska Native together with Asian/Pacific Islander ($Prop\,Other$), (log) per-capita income ($\log(Inc\,pc)$), number of jobs per-capita ($Jobs\,pc$), log of the population density ($Pop\,density$). Year changes in these demographic variables are indicated by a $\triangle$ in front. Bank-year level demographic and economic variables are weighted averages of county-year level data. The weights depend on the proportion of branches that a bank has in a county-year. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. The source of banking data is the FDIC, Statistics on Depository Institutions and Summary of Deposits. Parameters' estimates of period t demographic shocks and period t demographic levels are not reported. The standard errors are in parenthesis and are clustered by bank and year following Thompson (2011). Significance levels: ***1%, **5%, *10%.

	d_{jt-1}	l_{jt-1}
d_{jt-2}	0.7471***	0.1128***
	(0.0307)	(0.0235)
l_{jt-2}	-0.0249***	0.6527***
	(0.0061)	(0.0438)
$\Delta Prop\,Young_{jt-1}$	0.5782***	1.5335***
	(0.1248)	(0.4205)
$\Delta Prop\,Old_{jt-1}$	-0.3982***	-0.1692
	(0.1360)	(0.4992)
$\Delta Mean\,age_{jt-1}$	0.0107***	0.0168*
	(0.0027)	(0.0095)
$\Delta Prop\,Black_{jt-1}$	-0.0039	-0.2008*
	(0.0248)	(0.1078)
$\Delta Prop\,Hisp_{jt-1}$	-0.0156	-0.1668*
	(0.0284)	(0.0898)
$\Delta Prop\,Other_{jt-1}$	0.0742**	-0.1542
	(0.0370)	(0.2028)
$\Delta\log(Inc\,pc_{jt-1})$	0.0270**	-0.0291
	(0.0107)	(0.0207)
$\Delta Jobs\,pc_{jt-1}$	-0.0268***	-0.1337**
	(0.0094)	(0.0547)
$\Delta Pop\,density_{jt-1}$	0.0095***	0.0548***
	(0.0010)	(0.0043)
$\triangle demogr_{jt}$	Yes	Yes
$demogr_{jt}$	Yes	Yes
Time FE	Yes	Yes
Bank FE	Yes	Yes
N° Obs.	117,602	117,602
R^2	0.3879	0.2080
Time period	1994 – 2010	

Table 6: Baseline model

This table presents the estimates of the effects of period $t-1$ liability and asset structures on period t marginal funding rate. The dependent variable r^b_{jt} is the interest rate paid by bank j in period t on interest-bearing deposits. The independent variables include period $t-1$ normalized amount of demand deposits d_{jt-1}, its interaction with period t monetary policy shock (ΔFF_t), period $t-1$ normalized amount of total loans and leases l_{jt-1}, period t demographic shocks $\triangle demogr_{jt}$, period t demographic levels $demogr_{jt}$, bank and time fixed effects. d_{jt-1} (l_{jt-1}) is defined as period $t-1$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. ΔFF_t is the year change in the effective Federal funds rate. The column on the left presents OLS estimates. The central column considers d_{jt-1}, $d_{jt-1} \times \Delta FF_t$, and l_{jt-1} endogenous. The set of excluded IVs is composed by d_{jt-2}, l_{jt-2}, period $t-1$ demographic shocks, and $\hat{d}_{jt-1} \times \Delta FF_t$. d_{jt-2} (l_{jt-2}) is defined as period $t-2$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. $\hat{d}_{jt-1}$ is the fitted value of the normalized amount of demand deposits computed from the first-stage regression of table 5. The column on the right also considers d_{jt-1}, $d_{jt-1} \times \Delta FF_t$, and l_{jt-1} endogenous, and uses the same set of IVs. But it also adds different control variables. $Tier\,1\,ratio_{jt-1}$ is the amount of period $t-1$ Tier 1 (core) capital to period $t-2$ total assets. BHC_{jt-1} and $International_{jt-1}$ are dummy variables that equal to one if the bank belongs to a bank holding company, or, respectively, operates in other countries, as at $t-1$. Bank-year level demographic and economic variables are weighted averages of county-year level data. The weights depend on the proportion of branches that a bank has in a county-year. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. The source of banking data is the FDIC, Statistics on Depository Institutions and Summary of Deposits. Parameters' estimates of period t demographic shocks and period t demographic levels are not reported. The standard errors are in parenthesis and are clustered by bank and year following Thompson (2011). Significance levels: ***1%, **5%, *10%.

	r^b_{jt}		
	OLS	IV	
d_{jt-1}	-1.6920***	-2.8906***	-2.7224***
	(0.2364)	(0.4387)	(0.4413)
$d_{jt-1} \times \Delta FF_t$	0.3109***	0.4058***	0.4060***
	(0.0900)	(0.1055)	(0.1005)
l_{jt-1}	0.8673***	2.3577***	1.9530***
	(0.1171)	(0.2204)	(0.1793)
$Tier\,1\,ratio_{jt-1}$			-4.3243***
			(0.4450)
BHC_{jt-1}			0.0002
			(0.0330)
$International_{jt-1}$			-0.2575
			(0.2167)
$\triangle demogr_{jt}$	Yes	Yes	Yes
$demogr_{jt}$	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Sargan test (d.f.)	-	9	9
p-value	-	0.1652	0.1813
N° Obs.	117,602	117,602	117,602
R^2	0.9152	0.9112	0.9147
Time period		1994 – 2010	

Table 7: Extended model. Bank size and banking market concentration

This table presents the estimates of the effects of period $t-1$ liability and asset structures, and different interaction terms with measures of bank size and market concentration, on period t marginal funding rate. The dependent variable r_{jt}^{b} is the interest rate paid by bank j in period t on interest-bearing deposits. In every column, the independent variables include period $t-1$ normalized amount of demand deposits d_{jt-1}, its interaction with period t monetary policy shock (ΔFF_t), period $t-1$ normalized amount of total loans and leases l_{jt-1}, period t demographic shocks $\triangle demogr_{jt}$, period t demographic levels $demogr_{jt}$, control variables $controls_{jt-1}$, bank and time fixed effects. d_{jt-1} (l_{jt-1}) is defined as period $t-1$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. ΔFF_t is the year change in the effective Federal funds rate. $controls_{jt-1}$ include: $Tier\,1\,ratio_{jt-1}$, which is the amount of period $t-1$ Tier 1 (core) capital to period $t-2$ total assets; BHC_{jt-1} and $International_{jt-1}$, which are dummy variables that equal to one if the bank belongs to a bank holding company, or, respectively, operates in other countries, as at $t-1$. In the different columns, I interact d_{jt-1} and $d_{jt-1} \times \Delta FF_t$ with measures of bank size and market concentration. I capture bank size by two dummy variables, $Top\,50_{jt}$, and $Top\,5_{jt}$. They indicate if bank j is in period t in the top 50, respectively five, percentile for total assets at the national level. As for market concentration, I compute the Herfindahl–Hirschman Indices in terms of number of branches and amount of deposits of the banking markets in which bank j is involved. The two measures, respectively $HHI\,NBR_{-jt}$ and $HHI\,Deps_{-jt}$, are computed without considering bank j's market shares. In every column, d_{jt-1}, $d_{jt-1} \times \Delta FF_t$, their interactions with any characteristic $char_{jt}$, and l_{jt-1}, are considered endogenous. The set of excluded IVs is composed by d_{jt-2}, l_{jt-2} period $t-1$ demographic shocks, $\hat{d}_{jt-1} \times char_{jt}$, $\hat{d}_{jt-1} \times \Delta FF_t$, and $\hat{d}_{jt-1} \times \Delta FF_t \times char_{jt}$. d_{jt-2} (l_{jt-2}) is defined as period $t-2$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. $\hat{d}_{jt-1}$ is the fitted value of the normalized amount of demand deposits computed from the first-stage regression of table 5. Bank-year level demographic and economic variables are weighted averages of county-year level data. The weights depend on the proportion of branches that a bank has in a county-year. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. The source of banking data is the FDIC, Statistics on Depository Institutions and Summary of Deposits. Parameters' estimates of period t demographic shocks, period t demographic levels, control variables $controls_{jt-1}$, and negligible interaction terms are not reported. The standard errors are in parenthesis and are clustered by bank and year following Thompson (2011). Significance levels: ***1%, **5%, *10%.

	r^b_{jt}				
d_{jt-1}	-4.9145***	-1.8680***	-2.4984***	-4.6217***	-4.8792***
	(0.4535)	(0.5952)	(0.5741)	(0.6915)	(0.5946)
$d_{jt-1} \times Top\,50_{jt}$	2.9165***			2.8738***	2.9072***
	(0.4581)			(0.4750)	(0.4640)
$d_{jt-1} \times Top\,5_{jt}$	2.5725**			2.5658**	2.5463**
	(1.1809)			(1.1784)	(1.1757)
$d_{jt-1} \times HHI\,NBR_{-jt}$		-8.5506**		-2.6428	
		(3.3658)		(3.5736)	
$d_{jt-1} \times HHI\,Deps_{-jt}$			-1.4546		-0.0775
			(1.9578)		(1.8560)
$d_{jt-1} \times \Delta FF_t$	0.5068***	0.5759***	0.6099***	0.7564***	0.7546***
	(0.1118)	(0.0913)	(0.1431)	(0.1329)	(0.1926)
$d_{jt-1} \times Top\,50_{jt} \times \Delta FF_t$	0.0320			-0.0217	-0.0116
	(0.1215)			(0.1221)	(0.1326)
$d_{jt-1} \times Top\,5_{jt} \times \Delta FF_t$	0.1416			0.1173	0.1165
	(0.2903)			(0.2953)	(0.2899)
$d_{jt-1} \times HHI\,NBR_{-jt} \times \Delta FF_t$		-1.6315**		-2.0965**	
		(0.7098)		(0.8949)	
$d_{jt-1} \times HHI\,Deps_{-jt} \times \Delta FF_t$			-1.1735**		-1.3588**
			(0.5284)		(0.6239)
l_{jt-1}	1.8306***	1.9611***	1.9524***	1.8344***	1.8289***
	(0.1676)	(0.1791)	(0.1781)	(0.1677)	(0.1669)
$Top\,50_{jt}$	-0.1702**			-0.1681**	-0.1754**
	(0.0700)			(0.0701)	(0.0696)
$Top\,5_{jt}$	-0.3224*			-0.3213*	-0.3179*
	(0.1891)			(0.1878)	(0.1867)
$HHI\,NBR_{-jt}$		0.5575		-0.0559	
		(0.5684)		(0.5861)	
$HHI\,Deps_{-jt}$			-0.6195*		-0.7031**
			(0.3440)		(0.3247)
$\triangle demogr_{jt}$	Yes	Yes	Yes	Yes	Yes
$demogr_{jt}$	Yes	Yes	Yes	Yes	Yes
$controls_{jt-1}$	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Sargan test (d.f.)	9	9	9	9	9
p-value	0.1865	0.1801	0.1855	0.1869	0.1913
N° Obs.	117,602	117,602	117,602	117,602	117,602
R^2	0.9166	0.9149	0.9149	0.9167	0.9168
Time period			1994 – 2010		

Table 8: Dynamic panel data analysis. Effect of Federal funds rate on (log) demand deposits

This table presents the dynamic panel data estimates of the effects of period t Federal funds rate, and different interaction terms with measures of bank size and market concentration, on period t (log) demand deposits. The dependent variable $\log(demand\,deposits_{jt})$ is the log of the demand deposits of bank j in period t. In every column, the independent variables include periods $t-1$ (log) amounts of demand deposits of bank j, period t Federal funds rate ($Fed\,funds\,rate_{jt}$), period t demographic shocks $\triangle demogr_{jt}$, period t demographic levels $demogr_{jt}$, and bank fixed effects. In the different columns, I interact period t Federal funds rate with measures of bank size and market concentration. I capture bank size by two dummy variables, $Top\,50_{jt}$, and $Top\,5_{jt}$. They indicate if bank j is in period t in the top 50, respectively 5, percentile for total assets at the national level. As for market concentration, I compute the Herfindahl–Hirschman Indices in terms of number of branches and amount of deposits of the banking markets in which bank j is involved. The two measures, respectively $HHI\,NBR_{-jt}$ and $HHI\,Deps_{-jt}$, are computed without considering bank j's market shares. The estimates are obtained using Blundell and Bond's (1998) GMM two-step estimator. Bank-year level demographic and economic variables are weighted averages of county-year level data. The weights depend on the proportion of branches that a bank has in a county-year. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. The source of banking data is the FDIC, Statistics on Depository Institutions and Summary of Deposits. Parameters' estimates of period t demographic shocks and period t demographic levels are not reported. Windmeijer's (2005) robust standard errors are in parenthesis. Significance levels: ***1%, **5%, *10%.

	$\log(demand\,deposits_{jt})$					
$\log(demand\,deposits_{jt-1})$	0.7119***	0.7059***	0.7118***	0.7138***	0.7056***	0.7073***
	(0.0216)	(0.0222)	(0.0216)	(0.0216)	(0.0222)	(0.0222)
$Fed\,funds\,rate_{jt}$	-0.0160***	-0.0118***	-0.0222***	-0.0206***	-0.0163***	-0.0153***
	(0.0008)	(0.0009)	(0.0018)	(0.0023)	(0.0020)	(0.0026)
$Fed\,funds\,rate_{jt} \times Top\,50_{jt}$		-0.0081***			-0.0072***	-0.0074***
		(0.0016)			(0.0016)	(0.0016)
$Fed\,funds\,rate_{jt} \times Top\,5_{jt}$		-0.0076			-0.0074	-0.0075
		(0.0073)			(0.0074)	(0.0074)
$Fed\,funds\,rate_{jt} \times HHI\,NBR_{-jt}$			0.0492***		0.0323***	
			(0.0118)		(0.0119)	
$Fed\,funds\,rate_{jt} \times HHI\,Deps_{-jt}$				0.0281**		0.0196
				(0.0130)		(0.0134)
$Top\,50_{jt}$		0.0916***			0.0886***	0.0887***
		(0.0099)			(0.0100)	(0.0101)
$Top\,5_{jt}$		0.1147**			0.1143**	0.1147**
		(0.0531)			(0.0532)	(0.0533)
$HHI\,NBR_{-jt}$			-0.1450		-0.0666	
			(0.0965)		(0.0969)	
$HHI\,Deps_{-jt}$				-0.1855*		-0.1460
				(0.0981)		(0.0996)
$\triangle demogr_{jt}$	Yes	Yes	Yes	Yes	Yes	Yes
$demogr_{jt}$	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Arellano-Bond stat. (2nd order)	.3678	.5035	.37461	.3856	.49801	.51531
p-value	0.7130	0.6146	0.7080	0.6998	0.6185	0.6063
N° Obs.	117,602	117,602	117,602	117,602	117,602	117,602
Time period	1994 – 2010					

Table 9: Robustness. IVs: demographic shocks taken two years far. Baseline model

This table presents the estimates of the effects of period $t-1$ liability and asset structures on period t marginal funding rate. The dependent variable r^b_{jt} is the interest rate paid by bank j in period t on interest-bearing deposits. The independent variables include period $t-1$ normalized amount of demand deposits d_{jt-1}, its interaction with period t monetary policy shock (ΔFF_t), period $t-1$ normalized amount of total loans and leases l_{jt-1}, period t demographic shocks $\triangle demogr_{jt}$, period t demographic levels $demogr_{jt}$, bank and time fixed effects. d_{jt-1} (l_{jt-1}) is defined as period $t-1$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-3$. ΔFF_t is the year change in the effective Federal funds rate. In both columns, d_{jt-1}, $d_{jt-1} \times \Delta FF_t$ and l_{jt-1} are considered endogenous. The set of excluded IVs is composed by d_{jt-3}, l_{jt-3}, period $t-2$ demographic shocks, and $\hat{d}_{jt-1} \times \Delta FF_t$. d_{jt-3} (l_{jt-3}) is defined as period $t-3$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-3$. $\hat{d}_{jt-1}$ is the fitted value of the normalized amount of demand deposits computed from the first-stage regression. The column on the right adds different control variables. $Tier\,1\,ratio_{jt-1}$ is the amount of period $t-1$ Tier 1 (core) capital to period $t-3$ total assets. BHC_{jt-1} and $International_{jt-1}$ are dummy variables that equal to one if the bank belongs to a bank holding company, or, respectively, operates in other countries, as at $t-1$. Bank-year level demographic and economic variables are weighted averages of county-year level data. The weights depend on the proportion of branches that a bank has in a county-year. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. The source of banking data is the FDIC, Statistics on Depository Institutions and Summary of Deposits. Parameters' estimates of period t demographic shocks and period t demographic levels are not reported. The standard errors are in parenthesis and are clustered by bank and year following Thompson (2011). Significance levels: ***1%, **5%, *10%.

	r^b_{jt}	
d_{jt-1}	-4.2725***	-3.0563***
	(0.9164)	(0.7071)
$d_{jt-1} \times \Delta FF_t$	0.4314***	0.4282***
	(0.1092)	(0.0981)
l_{jt-1}	3.7610***	2.8309***
	(0.6608)	(0.3306)
$Tier\,1\,ratio_{jt-1}$		-9.0668***
		(1.3249)
BHC_{jt-1}		-0.0780***
		(0.0301)
$International_{jt-1}$		-0.0756
		(0.1960)
$\triangle demogr_{jt}$	Yes	Yes
$demogr_{jt}$	Yes	Yes
Time FE	Yes	Yes
Bank FE	Yes	Yes
Sargan test (d.f.)	9	9
p-value	0.2807	0.2282
N° Obs.	105,340	105,340
R^2	0.8842	0.9112
Time period	1994 – 2010	

Table 10: Robustness. IVs: demographic shocks taken three years far. Baseline model

This table presents the estimates of the effects of period $t-1$ liability and asset structures on period t marginal funding rate. The dependent variable r^b_{jt} is the interest rate paid by bank j in period t on interest-bearing deposits. The independent variables include period $t-1$ normalized amount of demand deposits d_{jt-1}, its interaction with period t monetary policy shock (ΔFF_t), period $t-1$ normalized amount of total loans and leases l_{jt-1}, period t demographic shocks $\triangle demogr_{jt}$, period t demographic levels $demogr_{jt}$, bank and time fixed effects. d_{jt-1} (l_{jt-1}) is defined as period $t-1$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-4$. ΔFF_t is the year change in the effective Federal funds rate. In both columns, d_{jt-1}, $d_{jt-1} \times \Delta FF_t$ and l_{jt-1} are considered endogenous. The set of excluded IVs is composed by d_{jt-4}, l_{jt-4}, period $t-3$ demographic shocks, and $\hat{d}_{jt-1} \times \Delta FF_t$. d_{jt-4} (l_{jt-4}) is defined as period $t-4$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-4$. $\hat{d}_{jt-1}$ is the fitted value of the normalized amount of demand deposits computed from the first-stage regression. The column on the right adds different control variables. $Tier\,1\,ratio_{jt-1}$ is the amount of period $t-1$ Tier 1 (core) capital to period $t-4$ total assets. BHC_{jt-1} and $International_{jt-1}$ are dummy variables that equal to one if the bank belongs to a bank holding company, or, respectively, operates in other countries, as at $t-1$. Bank-year level demographic and economic variables are weighted averages of county-year level data. The weights depend on the proportion of branches that a bank has in a county-year. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. The source of banking data is the FDIC, Statistics on Depository Institutions and Summary of Deposits. Parameters' estimates of period t demographic shocks and period t demographic levels are not reported. The standard errors are in parenthesis and are clustered by bank and year following Thompson (2011). Significance levels: ***1%, **5%, *10%.

	r^b_{jt}	
d_{jt-1}	-8.3509***	-5.1843***
	(2.7806)	(1.7972)
$d_{jt-1} \times \Delta FF_t$	0.4644***	0.4186***
	(0.0818)	(0.0910)
l_{jt-1}	3.6291***	4.1297***
	(0.9295)	(0.9899)
$Tier\,1\,ratio_{jt-1}$		-16.7870***
		(4.5927)
BHC_{jt-1}		-0.2449***
		(0.0829)
$International_{jt-1}$		-0.0715
		(0.2362)
$\triangle demogr_{jt}$	Yes	Yes
$demogr_{jt}$	Yes	Yes
Time FE	Yes	Yes
Bank FE	Yes	Yes
Sargan test (d.f.)	9	9
p-value	0.2823	0.3777
N° Obs.	93,787	93,787
R^2	0.8598	0.8789
Time period	1994 – 2010	

Table 11: Robustness. Reduced form estimates of the baseline model

This table presents the estimates of the response of period t marginal funding rate to period t monetary policy shock depending on period $t-1$ quantity of demand deposits. The dependent variable r^b_{jt} is the interest rate paid by bank j in period t on interest-bearing deposits. The independent variables include period $t-2$ normalized amount of demand deposits d_{jt-2}, the interaction of period $t-1$ normalized amount of demand deposits d_{jt-1} with period t monetary policy shock ΔFF_t, period $t-2$ normalized amount of total loans and leases l_{jt-2}, period $t-1$ and t demographic shocks $\triangle demogr_{jt-1}$ and $\triangle demogr_{jt}$, period t demographic levels $demogr_{jt}$, bank and time fixed effects. d_{jt-2} (l_{jt-2}) is defined as period $t-2$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. d_{jt-1} is period $t-1$ amount of demand deposits divided by the amount of total assets at $t-2$. ΔFF_t is the year change in the effective Federal funds rate. In both columns, only $d_{jt-1} \times \Delta FF_t$ is considered endogenous. The excluded instrument is $\hat{d}_{jt-1} \times \Delta FF_t$, where $\hat{d}_{jt-1}$ is the fitted value from the regression of d_{jt-1} on d_{jt-2}, l_{jt-2}, $\triangle demogr_{jt-1}$, $\triangle demogr_{jt}$, $demogr_{jt}$, bank and time fixed effects. The column on the right adds different control variables. $Tier\,1\,ratio_{jt-1}$ is the amount of period $t-1$ Tier 1 (core) capital to period $t-2$ total assets. BHC_{jt-1} and $International_{jt-1}$ are dummy variables that equal to one if the bank belongs to a bank holding company, or, respectively, operates in other countries, as at $t-1$. Bank-year level demographic and economic variables are weighted averages of county-year level data. The weights depend on the proportion of branches that a bank has in a county-year. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. The source of banking data is the FDIC, Statistics on Depository Institutions and Summary of Deposits. Parameters' estimates of period $t-1$ and t demographic shocks and period t demographic levels are not reported. The standard errors are in parenthesis and are clustered by bank and year following Thompson (2011). Significance levels: ***1%, **5%, *10%.

	r^b_{jt}	
d_{jt-2}	-1.7769***	-1.7756***
	(0.2879)	(0.2874)
$d_{jt-1} \times \Delta FF_t$	0.3576***	0.3594***
	(0.1135)	(0.1119)
l_{jt-2}	1.6693***	1.6071***
	(0.1503)	(0.1543)
$Tier\,1\,ratio_{jt-1}$		-0.7772**
		(0.3619)
BHC_{jt-1}		0.0446
		(0.0360)
$International_{jt-1}$		-0.2639
		(0.2157)
$\triangle demogr_{jt-1}$	Yes	Yes
$\triangle demogr_{jt}$	Yes	Yes
$demogr_{jt}$	Yes	Yes
Time FE	Yes	Yes
Bank FE	Yes	Yes
N˚ Obs.	117,602	117,602
R^2	0.9162	0.9163
Time period	1994 – 2010	

Table 12: Robustness. IVs: demographics weighted using amount of deposits raised. Baseline model

This table presents the estimates of the effects of period $t-1$ liability and asset structures on period t marginal funding rate. The dependent variable r^b_{jt} is the interest rate paid by bank j in period t on interest-bearing deposits. The independent variables include period $t-1$ normalized amount of demand deposits d_{jt-1}, its interaction with period t monetary policy shock (ΔFF_t), period $t-1$ normalized amount of total loans and leases l_{jt-1}, period t demographic shocks $\triangle demogr_{jt}$, period t demographic levels $demogr_{jt}$, bank and time fixed effects. d_{jt-1} (l_{jt-1}) is defined as period $t-1$ normalized amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. ΔFF_t is the year change in the effective Federal funds rate. In both columns, d_{jt-1}, $d_{jt-1} \times \Delta FF_t$ and l_{jt-1} are considered endogenous. The set of excluded IVs is composed by d_{jt-2}, l_{jt-2}, period $t-1$ demographic shocks, and $\hat{d}_{jt-1} \times \Delta FF_t$. d_{jt-2} (l_{jt-2}) is defined as period $t-2$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. $\hat{d}_{jt-1}$ is the fitted value of the normalized amount of demand deposits computed from the first-stage regression. The column on the right adds different control variables. $Tier\,1\,ratio_{jt-1}$ is the amount of period $t-1$ Tier 1 (core) capital to period $t-2$ total assets. BHC_{jt-1} and $International_{jt-1}$ are dummy variables that equal to one if the bank belongs to a bank holding company, or, respectively, operates in other countries, as at $t-1$. Bank-year level demographic and economic variables are weighted averages of county-year level data. The weights depend on the proportion of deposits that a bank has outstanding in a county-year. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. The source of banking data is the FDIC, Statistics on Depository Institutions and Summary of Deposits. Parameters' estimates of period t demographic shocks and period t demographic levels are not reported. The standard errors are in parenthesis and are clustered by bank and year following Thompson (2011). Significance levels: ***1%, **5%, *10%.

	r^b_{jt}	
d_{jt-1}	-2.9171***	-2.7248***
	(0.4316)	(0.4352)
$d_{jt-1} \times \Delta FF_t$	0.4069***	0.4067***
	(0.1029)	(0.0982)
l_{jt-1}	2.2605***	1.9042***
	(0.2079)	(0.1742)
$Tier\,1\,ratio_{jt-1}$		-4.2219***
		(0.4330)
BHC_{jt-1}		-0.0007
		(0.0329)
$International_{jt-1}$		-0.2676
		(0.2147)
$\triangle demogr_{jt}$	Yes	Yes
$demogr_{jt}$	Yes	Yes
Time FE	Yes	Yes
Bank FE	Yes	Yes
Sargan test (d.f.)	9	9
p-value	0.1754	0.2010
N° Obs.	117,597	117,597
R^2	0.9118	0.9149
Time period	1994 – 2010	

Table 13: Robustness. Demographics weighted using 1994 branch network. Baseline model

This table presents the estimates of the effects of period $t-1$ liability and asset structures on period t marginal funding rate. The dependent variable r^b_{jt} is the interest rate paid by bank j in period t on interest-bearing deposits. The independent variables include period $t-1$ normalized amount of demand deposits d_{jt-1}, its interaction with period t monetary policy shock (ΔFF_t), period $t-1$ normalized amount of total loans and leases l_{jt-1}, period t demographic shocks $\triangle demogr_{jt}$, period t demographic levels $demogr_{jt}$, bank and time fixed effects. d_{jt-1} (l_{jt-1}) is defined as period $t-1$ normalized amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. ΔFF_t is the year change in the effective Federal funds rate. In both columns, d_{jt-1}, $d_{jt-1} \times \Delta FF_t$ and l_{jt-1} are considered endogenous. The set of excluded IVs is composed by d_{jt-2}, l_{jt-2}, period $t-1$ demographic shocks, and $\hat{d}_{jt-1} \times \Delta FF_t$. d_{jt-2} (l_{jt-2}) is defined as period $t-2$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. $\hat{d}_{jt-1}$ is the fitted value of the normalized amount of demand deposits computed from the first-stage regression. The column on the right adds different control variables. $Tier\,1\,ratio_{jt-1}$ is the amount of period $t-1$ Tier 1 (core) capital to period $t-2$ total assets. BHC_{jt-1} and $International_{jt-1}$ are dummy variables that equal to one if the bank belongs to a bank holding company, or, respectively, operates in other countries, as at $t-1$. Bank-year level demographic and economic variables are weighted averages of county-year level data. The weights depend on the proportion of branches that a bank has in a county in 1994. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. The source of banking data is the FDIC, Statistics on Depository Institutions and Summary of Deposits. Parameters' estimates of period t demographic shocks and period t demographic levels are not reported. The standard errors are in parenthesis and are clustered by bank and year following Thompson (2011). Significance levels: ***1%, **5%, *10%.

	r^b_{jt}	
d_{jt-1}	-2.4158***	-2.1996***
	(0.4876)	(0.4813)
$d_{jt-1} \times \Delta FF_t$	0.3581***	0.3447***
	(0.1224)	(0.1210)
l_{jt-1}	2.1480***	2.1078***
	(0.1816)	(0.1782)
$Tier\,1\,ratio_{jt-1}$		-5.8091***
		(0.5001)
BHC_{jt-1}		-0.0407
		(0.0279)
$International_{jt-1}$		-0.2104
		(0.2036)
$\triangle demogr_{jt}$	Yes	Yes
$demogr_{jt}$	Yes	Yes
Time FE	Yes	Yes
Bank FE	Yes	Yes
Sargan test (d.f.)	9	9
p-value	0.2723	0.2666
N° Obs.	105,000	105,000
R^2	0.9230	0.9245
Time period	1994 – 2010	

Table 14: Robustness. Standard errors clustered by BHC and year. Baseline model

This table presents the estimates of the effects of period $t-1$ liability and asset structures on period t marginal funding rate. The dependent variable r^b_{jt} is the interest rate paid by bank j in period t on interest-bearing deposits. The independent variables include period $t-1$ normalized amount of demand deposits d_{jt-1}, its interaction with period t monetary policy shock (ΔFF_t), period $t-1$ normalized amount of total loans and leases l_{jt-1}, period t demographic shocks $\triangle demogr_{jt}$, period t demographic levels $demogr_{jt}$, bank and time fixed effects. d_{jt-1} (l_{jt-1}) is defined as period $t-1$ normalized amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. ΔFF_t is the year change in the effective Federal funds rate. In both columns, d_{jt-1}, $d_{jt-1} \times \Delta FF_t$ and l_{jt-1} are considered endogenous. The set of excluded IVs is composed by d_{jt-2}, l_{jt-2}, period $t-1$ demographic shocks, and $\hat{d}_{jt-1} \times \Delta FF_t$. d_{jt-2} (l_{jt-2}) is defined as period $t-2$ amount of demand deposits (total loans and leases) divided by the amount of total assets at $t-2$. $\hat{d}_{jt-1}$ is the fitted value of the normalized amount of demand deposits computed from the first-stage regression. The column on the right adds different control variables. $Tier\,1\,ratio_{jt-1}$ is the amount of period $t-1$ Tier 1 (core) capital to period $t-2$ total assets. BHC_{jt-1} and $International_{jt-1}$ are dummy variables that equal to one if the bank belongs to a bank holding company, or, respectively, operates in other countries, as at $t-1$. Bank-year level demographic and economic variables are weighted averages of county-year level data. The weights depend on the proportion of branches that a bank has in a county-year. County-year level demographic data are from the intercensal estimates of the U.S. Census Bureau. County-year level economic data are from the Regional Economic Accounts, Bureau of Economic Analysis. The source of banking data is the FDIC, Statistics on Depository Institutions and Summary of Deposits. Parameters' estimates of period t demographic shocks and period t demographic levels are not reported. The standard errors are in parenthesis and are clustered by bank-holding company and year following Thompson (2011). Significance levels: ***1%, **5%, *10%.

	r^b_{jt}	
d_{jt-1}	-2.8906***	-2.7224***
	(0.4479)	(0.4563)
$d_{jt-1} \times \Delta FF_t$	0.4058***	0.4060***
	(0.1222)	(0.1206)
l_{jt-1}	2.3577***	1.9530***
	(0.2425)	(0.2059)
$Tier\,1\,ratio_{jt-1}$		-4.3243***
		(0.5056)
BHC_{jt-1}		0.0002
		(0.0345)
$International_{jt-1}$		-0.2575
		(0.2256)
$\triangle demogr_{jt}$	Yes	Yes
$demogr_{jt}$	Yes	Yes
Time FE	Yes	Yes
Bank FE	Yes	Yes
Sargan test (d.f.)	9	9
p-value	0.1473	0.1760
N° Obs.	117,602	117,602
R^2	0.9112	0.9147
Time period	1994 – 2010	

Appendix: Theoretical Model

I consider a monopolistic bank that operates over two periods, $t = 1, 2$. It invests in loans L and get financing through two sources, demand deposits D, and interest-bearing deposits B. There is no equity, and at any period t, the bank is subject to the budget constraint $L_t = D_t + B_t$. The bank starts period 1 with an exogenous amount of loans L_0, which is the initial dimension of the balance sheet. This is used to normalize all other amounts, which then take the lowercase.

Demand deposits (DDs) and interest-bearing deposits (IBDs) display one key difference. Contrary to IBDs, DDs are prohibited to pay a positive interest rate. Monetary policy is not implemented modifying the level of reserves as both funding sources do not entail any reserve requirement. Monetary policy shocks shift the supplies of DDs and IBDs by altering their opportunity cost.

At the beginning of period 1, the bank maximizes period 1 profit together with the expectation of that of period 2. At that time, the main sources of uncertainty over period 2 are the monetary policy stance, and its effects on loan demand, and on the two deposit supplies. In period 1, the bank sets the optimal amount of loans and the optimal liability structure. In period 2, when uncertainty dissolves, the bank optimizes only over the quantity of loans.

In period 1, the (inverse) loan demand writes

$$r_1^l = \bar{r}^l - \alpha^l l_1 \tag{2}$$

where r_1^l is the loan interest rate, $\bar{r}^l$ is the interest rate corresponding to zero-loan demand, l_1 is the normalized amount of loans, and α^l is the sensitivity of the interest rate to l_1 and is assumed positive. In the second period, loan demand shifts by a stochastic amount $\tilde{\Lambda}$ and writes:

$$r_2^l = \bar{r}^l - \alpha^l l_2 + \tilde{\Lambda} \tag{3}$$

Lacking of the ability to pay a positive interest rate, the bank can attract DDs offering "service quality". Service quality is linked to the provision of liquidity to depositors, in which case it takes the form of an extensive branch and/or ATM network. However, it also includes any other non-interest feature that depositors may value such as advertising and marketing. The investment in service quality is long-lasting, and triggers (stochastic) effects in period 2.

Period 1 supply of DDs writes:

$$d_1 = \alpha^q q \tag{4}$$

where the normalized amount of DDs, d_1, depends on depositors' sensitivity to service quality, α^q, and on the service quality q provided by the bank.

While withdrawable at demand, DDs have an infinite maturity. So, period 2 supply depends on the amount collected in period 1. But it also depends on three stochastic factors. The first is the monetary policy shock, and the extent to which it affects the DDs collected in period 1. The second is how much the installed service quality is still valuable, and enables to collect new DDs. The third is any other exogenous stochastic shift. Period 2 supply of DDs can be written as:

$$d_2 \;\; = \;\; (1-\tilde{\rho})\, d_1 + \tilde{\xi}\alpha^q q + \tilde{\Theta} \tag{5}$$

$\tilde{\rho}$ is the fraction of period 1 DDs which is withdrawn (or added) as a function of the monetary policy shock. $\tilde{\xi}$ is the shock affecting the sensitivity to service quality. $\tilde{\Theta}$ is the exogenous shift. To be noted is that I assume that in period 2 the bank does not have the ability to offer additional service quality.

When the bank provides service quality in period 1, it sustains a cost. Following Sutton (1991), I model the investment in service quality as a sunk cost,[27] and take it to be equal to q. This is the only cost linked to the collection of DDs. In particular, I assume that the marginal cost of servicing DDs is nil.

IBDs are the alternative funding source. They have one-period maturity and need to be renewed every period. Their supply is not perfectly elastic and the interest rate depends on the quantity to

[27] Sutton (1991) suggests that by incurring sunk costs, which are valuable to consumers, firms are able to deter entry of competitors. Dick (2007) tests the theory in the banking industry and observes that, while they display great heterogeneity in terms of potential consumers, U.S. geographical markets all display a similar degree of concentration. Coherently with the theory, dominant players are shown to have higher values of advertising and branch density. In my modelling, I do not explicitly consider strategic interactions between banks. The endogenous sunk cost is only the instrument used to attract DDs.

finance. In the first period, the supply of IBDs writes:

$$r_1^b = \varepsilon b_1 \tag{6}$$

where r_1^b is the interest rate, b_1 is the amount of funds to supply, and ε is the responsiveness of the interest rate to the quantity to supply. Clearly, the interest rate elasticity of the supply of IBDs increases the closer to zero is ε. The formulation of (6) is similar to the one of Kashyap and Stein (1995) and Khwaja and Mian (2008), and is silent on which precise mechanism lies behind ε.

In the second period, the supply of IBDs shifts by a stochastic factor $\tilde{\varepsilon}$. Such shift incorporates the change in the opportunity cost of IBDs as a function of the monetary policy shock. Period 2 supply writes then:

$$r_2^b = \tilde{\varepsilon} + \varepsilon b_2 \tag{7}$$

Maximization program

In period 1, the bank maximizes the profit of period 1, Π_1, together with the expectation of that of period 2, $\mathbb{E}[\Pi_2]$, under the budget constraint $l_1 = d_1 + b_1$. Because $b_1 = l_1 - d_1$, and d_1 is a function of the service quality q, period 1 strategic variables are l_1 and q. All other variables are a consequence of the choice of the dimension of the balance sheet, and the service quality used to attract DDs. To be noted is that the role of IBDs is to provide residual financing, once the optimal amount of loans exceeds the reached amount of DDs.

The maximization program of period 1 is:

$$\begin{aligned}
arg \max_{l_1, q_1} \quad & \{ \quad \Pi_1 (l_1; q) + \mathbb{E}[\Pi_2 (q)] \} = \\
arg \max_{l_1, q_1} \quad & \{ \quad r_1^l (l_1) l_1 - r_1^b (l_1; q) [l_{j1} - d_1 (q)] - C [d_1 (q)] \\
& + \quad \mathbb{E}\left[r_2^l l_2 - r_2^b (q) [l_2 - d_2 (q)] \right] \}
\end{aligned}$$

where all variables are written as a function of the choice variables l_1 and q. Clearly, the dynamics of the problem enters through DDs. Contrary to IBDs, DDs have an infinite maturity and are passed to period 2. That implies that the endogenous sunk cost q has a direct effect on Π_2.

The model can be solved backwards from period 2. In period 1, the bank knows that in period 2 it maximizes the profit Π_2 over l_2. The optimal value of l_2 is a function of the realized exogenous shocks. Period 2 first order condition in l_2 leads to the optimal value

$$l_2^* = \frac{\bar{r}^l + \tilde{\Lambda} - \tilde{\varepsilon}}{2\left(\alpha^l + \varepsilon\right)} + \frac{\varepsilon}{\alpha^l + \varepsilon}\left[\left(1 - \tilde{\rho}\right) d_1 + \tilde{\xi}\alpha^q q + \tilde{\Theta}\right] \tag{8}$$

Substituting such expression in period 1 maximization problem, the first-order conditions with respect to l_1 and q lead to the optimal values of l_1 and d_1:

$$l_1^* = \frac{\bar{r}^l}{2\left(\alpha^l + \varepsilon\right)} + \frac{\varepsilon}{\left(\alpha^l + \varepsilon\right)} d_1 \tag{9}$$

$$\begin{aligned} d_1^* \quad = \quad & \frac{\left(2 + \mathbb{E}\left[\tilde{\lambda}\right]\right)\bar{r}^l + \text{cov}\left(\tilde{\lambda}, \tilde{\Lambda}\right) + \mathbb{E}\left[1 + \tilde{\lambda}\right]\mathbb{E}\left[\tilde{\Lambda}\right] - \frac{1}{\alpha^q} + \frac{\alpha^l}{\varepsilon}\left(\text{cov}\left(\tilde{\lambda}, \tilde{\varepsilon}\right) + \mathbb{E}\left[1 + \tilde{\lambda}\right]\mathbb{E}\left[\tilde{\varepsilon}\right] - \frac{1}{\alpha^q}\right)}{2\alpha^l\left(\text{var}\left(\tilde{\lambda}\right) + \left(\mathbb{E}\left[\tilde{\lambda}\right] + 2\right)\mathbb{E}\left[\tilde{\lambda}\right] + 2\right)} \\ - \quad & \frac{\text{cov}\left(\tilde{\lambda}, \tilde{\Theta}\right) + \mathbb{E}\left[1 + \tilde{\lambda}\right]\mathbb{E}\left[\tilde{\Theta}\right]}{\text{var}\left(\tilde{\lambda}\right) + \left(\mathbb{E}\left[\tilde{\lambda}\right] + 2\right)\mathbb{E}\left[\tilde{\lambda}\right] + 2} \end{aligned} \tag{10}$$

where $\tilde{\lambda} = \tilde{\xi} - \tilde{\rho}$.

Interpretation

Expression (10) highlights different links between d_1^* and exogenous variables and parameters. Most importantly, the amount of DDs raised in period 1 depends on period 2 supply of IBDs.

The relationship is positive with the expected shift $\mathbb{E}\left[\tilde{\varepsilon}\right]$. The more the bank expects that the cost to raise IBDs is higher in the future, the more it increases DDs ex ante.

Period 1 amount of DDs also depends on the covariance between $\tilde{\lambda}$ and $\tilde{\varepsilon}$. $\text{cov}\left(\tilde{\lambda}, \tilde{\varepsilon}\right)$ is equal to $\text{cov}\left(\tilde{\xi}, \tilde{\varepsilon}\right) - \text{cov}\left(\tilde{\rho}, \tilde{\varepsilon}\right)$. Consider a contractionary policy. When monetary policy tightens, market rates increase, and the effect on bank liabilities is twofold. First, DDs are withdrawn in proportion $\tilde{\rho}$. Second, IBDs become more expensive, and $\tilde{\varepsilon}$ is positive. As $\tilde{\varepsilon}$ and $\tilde{\rho}$ increase together, $\text{cov}\left(\tilde{\rho}, \tilde{\varepsilon}\right)$

is positive. At the same time, the shock that affects depositors' sensitivity to service quality, $\tilde{\xi}$, can be taken as independent from $\tilde{\varepsilon}$, and $\text{cov}\left(\tilde{\xi},\tilde{\varepsilon}\right)=0$.[28] The sign of $\text{cov}\left(\tilde{\lambda},\tilde{\varepsilon}\right)$ is, therefore, negative. (10) suggests that the larger is such covariance, the larger is the amount of DDs that the bank raises ex ante. Because $\text{cov}\left(\tilde{\lambda},\tilde{\varepsilon}\right)$ is in general negative, d_1^* increases the more $\text{cov}\left(\tilde{\lambda},\tilde{\varepsilon}\right)$ approaches zero. The reason is that when $\text{cov}\left(\tilde{\lambda},\tilde{\varepsilon}\right)=0$, the stochastic components of the two funding sources are unrelated, and DDs represent a hedge against the increase in the cost of IBDs. It is therefore good for the bank to hoard DDs ex ante.

The effect of an increase in the slope of the supply of IBDs, ε, depends on the sign of $\text{cov}\left(\tilde{\lambda},\tilde{\varepsilon}\right)+\mathbb{E}\left[1+\tilde{\lambda}\right]\mathbb{E}\left[\tilde{\varepsilon}\right]-\frac{1}{\alpha^q}$. This is negative when either $\mathbb{E}\left[\tilde{\varepsilon}\right]$, or the sensitivity of DDs to service quality α^q, are relatively small, or $\text{cov}\left(\tilde{\rho},\tilde{\varepsilon}\right)$ is relatively large. In that case, the optimal amount of DDs increases with ε. If a bank knows that the interest rate on IBDs increases rapidly with the amount to borrow, it hoards DDs in advance.

The optimal amount of DDs also depends on loan demand. The greater is the expected loan takers' willingness to borrow $\tilde{\Lambda}$, the greater is the amount of DDs raised in period 1. Conversely, the more the bank expects that there is going to be an exogenous inflow of demand deposits – i.e. $\mathbb{E}\left[\tilde{\Theta}\right]>0$ – the less it spends in service quality to collect them ex ante.

Finally, the denominator of (10) includes $\text{var}\left(\tilde{\lambda}\right)$. This is equal to $\text{var}\left(\tilde{\xi}\right)+\text{var}\left(\tilde{\rho}\right)-2\text{cov}\left(\tilde{\xi},\tilde{\rho}\right)$. The variance can be taken as a measure of uncertainty. So, (10) suggests that the higher is the uncertainty over the future monetary policy stance and over the future effects of the current investment in service quality, the less the bank spends to attract DDs ex ante.

The effect of monetary policy shocks on lending

The expressions of l_1^* and l_2^* are useful to analyze the effect of a monetary policy shock on bank lending. The change in the outstanding loan amount is in general:

$$\triangle l_2=l_2^*-l_1^*=\frac{\tilde{\Lambda}-\tilde{\varepsilon}}{2\left(\alpha^l+\varepsilon\right)}-\frac{\varepsilon}{\left(\alpha^l+\varepsilon\right)}\tilde{\rho}d_1+\frac{\varepsilon}{\left(\alpha^l+\varepsilon\right)}\left[\tilde{\xi}\alpha^q q+\tilde{\Theta}\right]$$

Consider, again, a contractionary monetary policy.

[28] In fact, allowing for $\text{cov}\left(\tilde{\xi},\tilde{\varepsilon}\right)\neq 0$ would not change the sign of $\text{cov}\left(\tilde{\lambda},\tilde{\varepsilon}\right)$ and would actually increase the magnitude.

First, $\triangle l_2$ is a function of the change in loan demand. If loan takers' willingness to borrow decreases, i.e. $\tilde{\Lambda} < 0$, the outstanding loan amount decreases.

Second, $\triangle l_2$ depends on the bank's borrowing cost. A contractionary monetary policy shock comes with a positive fraction of DDs withdrawn, $\tilde{\rho} > 0$, and a positive shift in the IBD interest rate, $\tilde{\varepsilon} > 0$. Both have the effect of decreasing loan supply. The effect of $\tilde{\rho}$ is amplified the larger is ε, and so the less elastic is the supply of IBDs. In that case, the shift $\tilde{\varepsilon}$ loses weight and the change in outstanding loan amount is mainly due to $\frac{\varepsilon}{(\alpha^l+\varepsilon)}\tilde{\rho}d_1$.

Third, the more service quality still brings new DDs, $\tilde{\xi} > 0$, and/or the larger are the exogenous inflows of DDs, $\tilde{\Theta} > 0$, the larger is loan supply.

What can be extracted from period 2 IBD interest rate

Period 2 IBD interest rate is defined in equation (7). I define $\triangle d_2 = d_2^* - d_1^*$. Making use of the budget constraint ($b_2 = l_2 - d_2$), r_2^b can be written as:

$$r_2^b = \tilde{\varepsilon} + \varepsilon\left(l_2 - d_2\right) = \tilde{\varepsilon} + \varepsilon\left(l_1 - d_1 + \triangle l_2 - \triangle d_2\right)$$

Then, following equation (5), r_2^b can be re-expressed as:

$$r_2^b = -\varepsilon d_1 + \frac{\alpha^l \varepsilon}{\alpha^l + \varepsilon}\tilde{\rho} d_1 + \varepsilon l_1 + \frac{\varepsilon\left(\tilde{\Lambda} - 2\alpha^l\tilde{\Theta}\right)}{2\left(\alpha^l + \varepsilon\right)} + \frac{\left(2\alpha^l + \varepsilon\right)\tilde{\varepsilon}}{2\left(\alpha^l + \varepsilon\right)} - \frac{\alpha^q\alpha^l\varepsilon}{\alpha^l + \varepsilon}\tilde{\xi} q \tag{11}$$

Equation (11) shows that if the supply of IBDs is not perfectly elastic, and $\varepsilon \neq 0$, period 2 funding rate is a function of period 1 amount of DDs and period 1 amount of loans.

When DDs have an infinite maturity, and there is no monetary policy shock, the stock of DDs that the bank has at the beginning of period 2 indicates its needs to borrow on the IBD market along the period. The larger is such amount, the less the bank needs to borrow. When the IBD interest rate increases with the quantity to borrow, and $\varepsilon > 0$, the relationship between r_2^b and d_1 in (11) is, in fact, negative. The relationship between r_2^b and l_1 in (11) is, instead, positive. In my modelling, loans have one period maturity. However, holding fixed the amount of DDs, a larger amount of loans indicates a larger need to finance with IBDs. In case $\varepsilon > 0$, this leads to a higher IBD interest rate.

The effect of period 2 monetary policy shock is to shift the supply of DDs. The bank is led to adjust its liability structure issuing more (or less) IBDs. If the loan demand and the supply of IBDs are not perfectly elastic, and $\alpha^l, \varepsilon \neq 0$, r_2^b is then a function of the fraction of DDs $\tilde{\rho}$ which is withdrawn (or added) due to period 2 monetary policy shock. The lower is the elasticity of the supply of IBDs, and/or the more DDs are sensitive to monetary policy shocks, the larger is the effect on r_2^b.

Equation (11) can be directly brought to the data. It enables us to test (1) if the supply of IBDs is not perfectly elastic, and (2) if DDs are sensitive to monetary policy shocks. An econometric model based on (11), however, raises the issue of measuring and including service quality q. If this is not possible, $\frac{\alpha^q \alpha^l \varepsilon}{\alpha^l + \varepsilon} \tilde{\xi} q$ falls in the error term, causing the endogeneity of d_1 and l_1.