

# The Deposits Channel of Monetary Policy

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## Abstract

We propose and test a new channel for the transmission of monetary policy. We show that when the Fed funds rate increases, banks widen the interest spreads they charge on deposits, and deposits flow out of the banking system. We present a model in which imperfect competition among banks gives rise to these relationships. An increase in the nominal interest rate increases banks' market power, inducing them to increase deposit spreads and hence restrict deposit supply. Households respond to the increase in deposit prices by substituting from deposits into less liquid, but higher-yielding assets. Using branch-level data on the universe of U.S. banks, we show that following an increase in the Fed funds rate, deposit spreads increase by more, and supply falls more, in areas with less deposit competition. We control for changes in banks' lending opportunities by comparing branches of the *same* bank in the *same* state. We control for changes in macroeconomic conditions by showing that deposit spreads widen immediately after a rate change and even if this change is fully *anticipated*. Our results imply that monetary policy has a significant impact on how the financial system is funded, on the quantity of safe and liquid assets it produces, and on its provision of loans to the real economy.

Keywords: Monetary policy, deposits, market power, safe assets, liquidity, private money, real effects

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# I. Introduction

We propose and test a new channel for how monetary policy affects the financial system and the real economy. We show that when the Fed funds rate increases, banks widen the interest spreads they charge on deposits and deposits flow out of the banking system. These relationships are strong and the aggregate effects large, suggesting that monetary policy has a significant impact on how the financial system is funded, and on the quantity of safe and liquid assets it produces. We argue that these relationships are due to imperfect competition among banks, i.e., market power, in the provision of liquid deposits. An increase in the nominal interest rate effectively increases banks' market power, to which banks respond by increasing the spread they charge on deposits. As deposits become more expensive, households reduce their deposit holdings and replace them with imperfect substitutes, higher yielding but lower-liquidity assets. Using branch-level data on geographical variation in competitiveness of local deposit markets, we document this channel and argue that the relationship to monetary policy is indeed causal.

The implications of this channel are significant because deposits are special to both banks and households. Deposits have historically been—and continue to be—far and away the most important single source of funding for the banking system. In 2014, they amount to roughly \$10.2 trillion, or 77% of bank liabilities. As we report below, banks earn large spreads on deposits. Deposits are also much more persistent (“sticky”) than the financial system’s alternative funding sources, mainly short-term wholesale markets, and may therefore confer banks with an advantage in investing in illiquid and risky assets (Hanson, Shleifer, Stein, and Vishny 2014). For households, deposits represent the main source of safe and liquid assets and therefore changes in the price and supply of deposits will affect the price of other major types of safe and liquid assets, including Treasuries. The deposits channel we document can therefore explain how monetary policy can affect the premium on all safe and liquid assets.<sup>1</sup>

Figure 1 plots the time series of the Fed Funds rate and the average rate paid by three deposit products: interest checking, money market saving account, and 12-month certificate of deposits (CD). These three products proxy respectively for the three major classes of

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<sup>1</sup>Krishnamurthy and Vissing-Jorgensen (2012) show that Treasury prices embed a large liquidity premium and document that this premium varies inversely with Treasury supply.

bank deposits: checking deposits, savings deposits, and time deposits, which accounted for \$1.6 trillion, \$6.5 trillion, and \$2.1 trillion in 2014, respectively.

Figure 1 shows two striking regularities. First, the spreads between the Fed funds rate and the deposit rates are often very large, especially for checking and savings deposits. In particular, the spread on savings deposits, which constitutes almost half of all deposits, is greater than 2% on average over this period, and at times exceeds 3%. Checking deposits incur a substantially larger spread still, whereas the spread on time deposits is relatively small. Second, deposit spreads covary strongly positively with the Fed funds rate. When the Fed funds rate increases, banks increase deposit rates, but less than one-for-one, so that spreads widen.<sup>2</sup> In contrast, when the Fed funds rate decreases, deposit spreads shrink. For instance, as the Fed Funds rate dropped from 6.5% in 2000 to 1% in 2004, the spread on savings deposits shrank from 3% to 0.25%. As with average spreads, the pattern in checking deposits is even more pronounced, whereas it is less dramatic for time deposits.

Figure 2 shows the resulting adjustment for the equilibrium quantities of deposits. It plots year-over-year percentage changes in the Fed funds rate against the growth in the aggregate quantity of savings deposits (Panel A), checking deposits (Panel B), time deposits (Panel C), and total deposits (Panel D). The relationships are clear and striking. Panel A shows that changes in the Fed funds rate are strongly negatively related to the growth rate in savings deposits. Hence, as the deposit spread increases, depositors reduce their holdings of savings deposits. Panel B shows a similar relationship for checking deposits. The effects are economically significant in both cases; fluctuations in year-over-year deposits growth range from -14% and +26%, a large amount given the enormous size of total deposits.

Panel C shows that the opposite relationship holds for time deposits: changes in the Fed funds rate are positively related to the growth in time deposits. There appears, therefore, to be an important difference between how depositors treat time deposits relative to checking and savings deposits. Recognizing this difference is important for our theory and empirical analysis. For this reason, which reflects the differences in their demandability and other features as well as their usage, we refer to savings and checking deposits as “liquid deposits” and contrast them with time deposits. Hence, when the Fed funds rate rises, the spreads on

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<sup>2</sup>This gives the impression that deposit rates are “sticky” (Driscoll and Judson 2013).

liquid deposits widen relative to time deposits, and depositors substitute away from liquid deposits and toward less liquid time deposits.

Panel D shows the relationship for total deposits. Changes in the Fed funds rate are strongly negatively related to the growth in total deposits, reflecting the fact that checking and savings deposits account for the majority of total deposits. This shows that the aggregate outflows from liquid deposits exceed the aggregate inflows to time deposits. On net, it follows that when the Fed funds rate increases, total deposits shrink.

We develop a model that explains these relationships and guides our empirical analysis. In the model, banks are monopolistic competitors that have market power over the creation of deposits. Two assets represent imperfect substitutes to deposits; cash (currency or non-interest-bearing accounts), which is completely liquid but pays no interest, and bonds, which provide no (or less) liquidity services but pay a higher, competitive interest rate. As the interest rate increases, cash becomes more expensive to hold and represents a less attractive alternative to deposits as a source of liquidity. Hence, an increase in the nominal interest rate effectively increases banks' market power in liquidity provision. This is especially true in concentrated markets where competition among banks is low. Banks in such markets respond by charging higher deposit spreads, giving rise to the relationship in Figure 1. Households respond to the higher prices by substituting away from liquid deposits to less-liquid deposits and bonds, giving rise to the relationships shown in Figure 2.

Next, we examine empirically whether monetary policy indeed *causes* changes in deposit supply, driving the relationships in Figures 1 and 2. The main identification concern is that monetary policy reacts to macroeconomic conditions, which may directly affect both banks' supply of deposits and households' demand for deposits. For example, monetary policy tends to tighten when inflation rises and higher inflation may also reduce banks' lending opportunities, which in turn lowers banks' funding needs and thus reduces their deposit supply. This could give rise to the observed aggregate relationships between the Fed funds rate and deposits, even in the absence of a deposits channel of monetary policy.

To address this identification challenge, we exploit geographical variation in the degree of competition across U.S. counties. The intuition is that an increase in the Fed funds rate has a larger effect on banks' market power in areas with low competition and thus

leads to higher spreads and larger outflows in those areas. We implement this identification strategy by computing the Herfindahl index based on county-level deposit market shares as a measure of local deposit competition. We then analyze whether an increase in the Fed funds rate raises deposit spreads and outflows more in concentrated markets relative to less concentrated markets.

Importantly, we control for banks' lending opportunities by using information from different branches of the *same* bank. To illustrate our approach, consider a bank with branches in two counties. The bank's lending opportunities may change after a Fed funds rate change because of underlying changes in the economy. We control for such changes by including a full set of bank-time fixed effects in our estimation. This approach adjusts for any unobserved variation in a bank's willingness to supply deposits and identifies the effect of the Fed funds rate on deposits using only *within-bank* variation across counties. The identifying assumption is that a deposit raised at one branch can be used as funding at another branch of the same bank. Under this assumption, changes in a bank's lending opportunities affect all branches equally, allowing us to control for the effect of macroeconomic conditions on deposits.

We implement this strategy using quarterly branch-level data on deposit rates and holdings for the most widely offered savings and time deposit products. Our estimates suggest that after a 100 basis point increase in the Fed funds rate, branches in concentrated markets increase savings deposit spreads by 12 basis points and time deposits spreads by 5 basis point relative to branches located in less concentrated markets. We also find that branches in concentrated markets experience a deposit outflow of 98 basis points relative to branches in less concentrated markets. All results are statistically significant.

These results indicate that monetary policy on net affects the supply of deposits: an increase in the Fed funds rate leads to *higher* deposit spreads and *less* total deposits. We point out that this result is inconsistent with an effect of monetary policy on household demand for deposits. Otherwise one would expect that deposit spreads (price) and total deposits (quantity) move in the same direction. Put differently, the results indicate that monetary policy works through changes in the banks' willingness to supply deposits rather than changes in households' demand for deposits.

To better understand the effect of monetary policy, we examine its timing using weekly data on deposit rates. We find that changes in monetary policy affect deposit rates exactly at the time of the change in the Fed Funds rate. The difference across more and less concentrated deposit markets appears quickly—within a week or two—after Fed funds changes. This result provides further evidence in support of a direct effect of the Fed funds rate on deposits because for other economic variables to explain our results their timing would have to coincide very closely with changes in the Fed funds rate.

Next, we examine the mechanism of how monetary policy affects the supply of deposits. Our theory suggests that monetary policy works through its effect on banks' market power. As an alternative theory, changes in deposit supply may be driven by information that the Federal Reserve releases at the time of rate change announcements. This perspective implies that the Federal Reserve does not control interest rates, but signals information through rate changes.<sup>3</sup> The challenge of distinguishing between the two explanations is a common issue in empirical studies of monetary policy because any rate announcement may reveal private information.

We are able to provide evidence on the mechanism by testing whether deposit spreads respond to *expected* changes in the Fed funds rate, as measured using Fed funds futures prices prior to the rate announcements. Whereas in most financial settings anticipated changes have no effect on prices because prices react to news rather than realizations, in our setting they react to both. The reason is that liquid deposits and the Fed funds rate have zero maturity, and hence the impact of changes is not incorporated until their actual realization, even if these changes are anticipated. This unique feature of our setting allows us to test whether monetary policy works through changes in the interest rate rather than the release of private information. Indeed, we find that our main results are similar if we only use variation in expected changes in monetary policy.

These results also provide additional identification for our main results. If other economic variables affect the supply of deposits, their effect would have to appear exactly at the time of the anticipated rate change. It is hard to think of an alternative transmission channel that allows for economic variables to prompt changes in expectations about monetary policy

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<sup>3</sup>Fama (2013) argues in favor of this viewpoint.

but only affects deposit supply once the changes are implemented.

Finally, as an alternative check on our results, we provide an additional identification test by exploiting a unique feature of our data. Some smaller branches do not set their own deposit rates but rather follow larger branches, some of which are located in other counties. Under the assumption that large banks set rates based on local deposit markets, we can use the deposit competitiveness of rate-setting branches as an instrument for deposit rates at non-rate setting branches and examine its effect on deposit flows. Using branch-level data on the link between rate-setting and non-rate-setting branches, we find that branches that follow rates from less competitive counties experiences larger deposit outflows than those that follow rates from more competitive counties. This finding provides direct evidence on the deposits channel of monetary policy.

We then verify whether our branch-level results aggregate up to the bank-level. This is useful for several reasons. First, it allows us to quantify whether changes in deposits are sufficiently large to affect banks' total funding. Second, we can extend our analysis to the asset side of bank of bank balance sheets and examine its effect on lending. This is important to understand the real effects of the deposits channel. Third, we can verify whether our results are robust to control variables that proxy for alternative channels of monetary policy.

We construct a bank-level measure of deposit competition by aggregating across branches and weighting by deposits. On the liabilities side, we find that the results on deposits are qualitatively and quantitatively similar to the ones at the branch level. A 100 basis point increase in the Fed Funds rate leads to 1.5% larger outflow in deposits in uncompetitive markets relative to competitive markets. On the asset side, we find that after a 100 basis points increase in the Fed funds rate, banks operating in uncompetitive markets reduce assets by 1.0%, and real estate lending by 0.7%, relative to banks operating in competitive markets. The results are robust to controlling for bank fixed effects and time-varying bank characteristics such as leverage and security holdings. These results indicate that monetary policy affects banks' lending through its effect on deposits.

We conduct several robustness test of our main results. First, we find that the results are robust to using alternative measures of market competition such as deposit competition

based on the number of bank branches. Second, we show that the main results are robust to controlling for state-specific, non-parametric time trends, which rules out the effect of confounding state-level factors (e.g., regulatory or political changes). Third, we find that the results are similar and larger, if we estimate the effect using variation across banks.

This paper connects to large theoretical and empirical literatures on the transmission of monetary policy to the real economy, the bank lending channel, and private money creation. Bernanke (1983) documents the importance of bank lending for the propagation of macroeconomic shocks. Bernanke and Gertler (1995) and Kashyap and Stein (1994) formalize the bank lending channel. Kashyap, Stein, and Wilcox (1992) provide evidence based on the behavior of bank lending. Bernanke and Gertler (1989) and Bernanke, Gertler, and Gilchrist (1999) present a broader balance sheet channel that works through limited capital in the financial sector. More recently, He and Krishnamurthy (2013) and Brunnermeier and Sannikov (2014) present fully dynamic macroeconomic models with intermediation frictions.

On the empirical side, Bernanke and Blinder (1992) show that in aggregate time series data an increase in the Fed funds rate is associated with an increase in unemployment and a decline in deposits. Kashyap and Stein (2000) find that small banks with less liquid balance sheets reduce lending more after a rate increase. Jiménez, Ongena, Peydró, and Saurina (2014) and Dell’Ariccia, Laeven, and Suarez (2013) show that monetary policy impacts bank lending decisions by exploiting within bank variation in borrower characteristics. Scharfstein and Sunderam (2014) show that market power in mortgage lending affects the sensitivity of such lending to monetary policy.

Diamond and Dybvig (1983) interpret banks as liquidity providers to households through demand deposits. Kashyap, Rajan, and Stein (2002) study the complementarity between taking deposits and making loans. Consistent with the liquidity provision role of the banking sector, Krishnamurthy and Vissing-Jorgensen (2012, 2013) show that Treasury bill rates incorporate liquidity premia and that bank balance sheets compensate for reductions in the supply of Treasuries. Sunderam (2012) shows that the shadow banking system also responds to liquidity premia. Nagel (2014) links the rates on money market instruments to the cost of liquidity as measured by the Fed funds rate.

The paper also connects to work on deposits. Neumark and Sharpe (1992) and Hannan

and Berger (1991) argue that deposits are downward sticky (and upwards flexible) because of market concentration. Driscoll and Judson (2013) show that average deposit rates adjust asymmetrically to market rates. Acharya and Mora (2014) document a large reallocation of deposits across banks during the financial crisis. Egan, Hortacsu, and Matvos (2015) find that uninsured deposits react strongly to bank risk during the financial crisis. Ben-David, Palvia, and Spatt (2014) and Gilje, Loutskina, and Strahan (2013) show that banks channel deposits across branches to areas with high loan demand. Stein (1998) argues that deposit funding is difficult to replace with wholesale funding and examines the implications for monetary policy transmission. Stein (2012) presents a model that shows how monetary policy can regulate private liquidity creation. Drechsler, Savov, and Schnabl (2014) connect monetary policy and bank risk taking in a dynamic asset pricing framework.

A branch of the empirical literature on monetary policy and asset prices uses the event study methodology. Bernanke and Kuttner (2005), Hanson and Stein (2015), and Gertler and Karadi (2014) show that nominal rates have large effects on risky assets such as stocks, long-term bonds, and credit spreads.

The broad contribution of our paper is two fold: to show that deposit taking transmits monetary policy to the real economy via the banking system, and to demonstrate how this channel works through imperfect competition in private liquidity provision.

The rest of this paper is organized as follows: Section II presents our model, Section III summarizes our data, Section IV presents our results, and Section V concludes.

## II. Model

We present a simple model that captures the relationships between bank competition, deposits, and the nominal interest rate. For simplicity, the economy lasts for one period and there is no risk. We think of this economy as corresponding to a well-defined regional market, or county, in the context of our empirical analysis.<sup>4</sup>

The county's representative household maximizes utility, defined over final wealth,  $W$ ,

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<sup>4</sup>For theoretical models of deposit pricing with market power see Hutchison (1995) and Rosen (2002).

and liquidity services,  $v$ , according to the following CES aggregator:

$$U(W_0) = \max_{M,D} u(W, v) \quad (1)$$

$$u(W, v) = \left[ W^{\frac{\rho-1}{\rho}} + \alpha v^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}, \quad (2)$$

where  $\alpha$  is a share parameter, and  $\rho$  is the elasticity of substitution between wealth and liquidity. Such a preference for liquidity arises in many models. For example, it arises in many monetary models as a consequence of a cash-in-advance constraint (see Galí 2009). In other models it arises as a preference for extreme safety (e.g., Stein 2012). In both cases, it is natural to think of wealth and liquidity as complementary, so that  $\rho < 1$ .

Liquidity services are in turn derived from holding cash  $M$  and deposits  $D$  according to a CES aggregator:

$$v(M, D) = \left[ M^{\frac{\epsilon-1}{\epsilon}} + \delta D^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}, \quad (3)$$

where  $\epsilon$  is the elasticity of substitution and  $0 \leq \delta < 1$  measures the relative contribution of deposits to liquidity. We interpret cash as consisting of currency and zero-interest checking accounts. In contrast, deposits pay a rate of interest, determined in equilibrium. We interpret deposits as consisting of savings deposits and small time deposits offered to households.<sup>5</sup> Because they both provide liquidity, it is most natural to view cash and deposits as substitutes, so that  $\epsilon > 1$ .

The county's deposits are themselves a composite good produced by the  $N$  banks in the county,

$$D = \left( \frac{1}{N} \sum_{i=1}^N D_i^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}, \quad (4)$$

where  $\eta$  is the elasticity of substitution between banks. Each bank has mass  $1/N$  and produces deposits at the intensity  $D_i$ , resulting in an amount  $D_i/N$ . If all the intensities are identical, then  $D_i = D$ . When  $N \rightarrow \infty$ , the aggregator becomes the usual Dixit-Stiglitz

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<sup>5</sup>For simplicity, we only have a single type of deposit. One could extend the model to allow for deposits of varying degree of liquidity.

aggregator. Because deposits at different banks are substitutes,  $\eta > 1$ . The imperfect substitutability ( $\eta < \infty$ ) between deposits creates monopolistic competition, giving banks market power and allowing them to sustain nonzero profit margins. Although we model a representative county household, the aggregator can be interpreted as representing a county populated by individual households. Each household has a preference for keeping deposits at the most convenient bank, but can substitute (imperfectly) to other banks. Hence, households aggregate into a representative household that substitutes deposits imperfectly across banks and prefers to distribute deposits evenly.

Each bank charges a deposit spread  $s_i$  and so pays a deposit rate  $f - s_i$ , where  $f$  is the Fed funds rate set by the central bank and is equal to the rate of return on bonds. Let  $W_0$  be the initial wealth of the household. Terminal wealth is then given by

$$W = \left( W_0 - M - \frac{1}{N} \sum_{i=1}^N D_i \right) (1 + f) + M + \frac{1}{N} \sum_{i=1}^N D_i (1 + f - s_i) \quad (5)$$

$$= W_0 (1 + f) - Mf - \frac{1}{N} \sum_{i=1}^N D_i s_i. \quad (6)$$

If we define the weighted average spread on deposits as  $s = \frac{1}{N} \sum_{i=1}^N \frac{D_i}{D} s_i$ , then this equation can be written as

$$W = W_0 (1 + f) - Mf - Ds. \quad (7)$$

In words, households earn the bond interest rate on their initial wealth while foregoing all interest on their cash holdings and the deposit spread on their deposits.

The household's optimality choices can be summarized by three conditions. The first condition is the interbank substitution margin,

$$\frac{D_i}{D} = \left( \frac{s_i}{s} \right)^{-\eta}. \quad (8)$$

In words, as a bank increases its deposit spread (relative to other banks), the household reduces deposits at the bank at the rate  $\eta$ , the elasticity of substitution across banks. The

second condition is the cash-deposits substitution margin,

$$\frac{D}{M} = \delta^\epsilon \left( \frac{s}{f} \right)^{-\epsilon}. \quad (9)$$

It says that when deposits spreads are high, households substitute away from deposits and into cash at the rate  $\epsilon$ , the cash-deposits elasticity. Finally, the cash-bonds substitution margin is

$$\frac{M}{W} = \alpha^\rho f^{-\rho} \left[ 1 + \delta^\epsilon \left( \frac{f}{s} \right)^{\epsilon-1} \right]^{\frac{\rho-\epsilon}{\epsilon-1}}. \quad (10)$$

When the fed funds rate is high, and therefore cash is expensive, households hold less cash and more bonds. However, just how much depends also on the relative cost of deposits ( $f/s$ ).

Banks raise deposits and invest in bonds, which yield a higher rate. More generally we can think of banks investing in a portfolio of risky loans with the same risk-adjusted return as safe bonds. Banks set their deposit spreads to maximize profits:

$$\max_{s_i} s_i D_i. \quad (11)$$

The profit-maximizing condition is

$$\frac{\partial D_i/D_i}{\partial s_i/s_i} = -1. \quad (12)$$

In words, at the optimal deposit spread the elasticity of deposits with respect to the spread is precisely -1, and hence further adjustment of the spread cannot increase the bank's profits.

We can use the interbank margin (8) to calculate the elasticity in (12):

$$\frac{\partial D_i/D_i}{\partial s_i/s_i} = \left( \frac{\partial D/D}{\partial s/s} \right) \left( \frac{1}{N} \frac{D_i}{D} \frac{s_i}{s} \right) - \eta \left( 1 - \frac{1}{N} \frac{D_i}{D} \frac{s_i}{s} \right). \quad (13)$$

In a symmetric equilibrium ( $D_i = D$  and  $s_i = s$ ) this becomes

$$\frac{\partial D_i/D_i}{\partial s_i/s_i} = \frac{1}{N} \left( \frac{\partial D/D}{\partial s/s} \right) - \eta \left( 1 - \frac{1}{N} \right). \quad (14)$$

As bank  $i$  increases its spread  $s_i$ , it faces outflows from two sources. The first is an aggregate effect: the increase raises the average deposit spread, making deposits more expensive. This leads to outflows from deposits as an asset class. This effect diminishes as banks become more numerous because each individual bank is less important. The second source of outflows is due to competition among banks and is bank-specific: raising  $s_i$  increases the deposit spread of bank  $i$  relative to the average deposit spread. When bank  $i$  raises its spread by one percent, the average spread goes up by  $1/N$  percent, and hence the relative spread of bank  $i$  increases by  $1 - 1/N$ . This induces an outflow of deposits at a rate  $\eta$ , the elasticity of substitution across banks.

Substituting (14) into (12), we get the equilibrium condition

$$\frac{1}{N} \left( \frac{\partial D/D}{\partial s/s} \right) - \eta \left( 1 - \frac{1}{N} \right) = -1. \quad (15)$$

Whereas the interbank effect (second term) does not depend on monetary policy  $f$ , the aggregate effect, which is due to the competition of deposits with other asset classes (the first term), does. Specifically, (7), (9) and (10) give

$$-\frac{\partial D/D}{\partial s/s} = \left[ \frac{1}{1 + \delta^\epsilon \left( \frac{f}{s} \right)^{\epsilon-1}} \right] \epsilon + \left[ \frac{\delta^\epsilon \left( \frac{f}{s} \right)^{\epsilon-1}}{1 + \delta^\epsilon \left( \frac{f}{s} \right)^{\epsilon-1}} \right] \left\{ \rho + (1 - \rho) \left( \frac{f \left( \frac{\alpha}{f} \right)^\rho \left[ 1 + \delta^\epsilon \left( \frac{f}{s} \right)^{\epsilon-1} \right]^{\frac{\rho-1}{\epsilon-1}}}{1 + f \left( \frac{\alpha}{f} \right)^\rho \left[ 1 + \delta^\epsilon \left( \frac{f}{s} \right)^{\epsilon-1} \right]^{\frac{\rho-1}{\epsilon-1}}} \right) \right\}. \quad (16)$$

Households can substitute deposits with either cash or bonds and hence both represent a source of competition for deposit dollars. When the fed funds rate is low, cash is cheap and is an attractive source of liquidity. For a given average spread  $s$ , the elasticity of deposit demand is then close to  $\epsilon$ , the elasticity of substitution between deposits and cash, which is high. Hence, banks face strong competition from cash for deposit dollars. Conversely, when the fed funds rate is high, cash is expensive and is relatively unattractive as a source of liquidity. It provides little competition for deposit dollars and banks' competition comes mostly from bonds, which are not as good a substitute for deposits ( $\rho \leq \epsilon$ ). For a given average spread  $s$ , deposit demand elasticity is then close to a value between  $\rho$  and 1 (the

term in brackets), which is less than  $\epsilon$ . Thus, when rates are high banks face a less elastic demand curve. Hence, banks face less competitive pressure when the fed funds rate is high.

We can obtain a closed-form solution for spreads in the case when liquidity demand is arbitrarily small.<sup>6</sup>

**Proposition 1.** *Let  $\rho < 1 < \epsilon$  and  $\eta > 1$ . Denote by  $\mathcal{M}$  the quantity  $1 - (\eta - 1)(N - 1)$ , which captures the effective market power of the banking sector. Consider the limiting case  $\alpha \rightarrow 0$ . If  $\mathcal{M} < \rho$  then the deposit spread is zero. Otherwise the deposit spread is*

$$s = \delta^{\frac{\epsilon}{\epsilon-1}} \left( \frac{\mathcal{M} - \rho}{\epsilon - \mathcal{M}} \right)^{\frac{1}{\epsilon-1}} f, \quad (17)$$

*The deposit spread:*

- (i) *increases in banks' market power  $\mathcal{M}$ , which is itself decreasing in the number of banks  $N$  and elasticity of substitution across banks  $\eta$*
- (ii) *increases with the fed funds rate  $f$*
- (iii) *increases more with the fed funds rate when the banking sector's market power is higher*

*Proof of Proposition 1.* It follows from (15) that when banks' equilibrium choice is internal, the aggregate deposit elasticity satisfies  $-\frac{\partial D/D}{\partial s/s} = 1 - (\eta - 1)(N - 1) = \mathcal{M}$ . Equation (17) follows by substituting (16) into this expression and letting  $\alpha \rightarrow 0$ . The relationship between  $s$  and  $\mathcal{M}$  is  $\frac{\partial s}{\partial \mathcal{M}} = s(\epsilon - 1)^{-1} (\epsilon - \mathcal{M})^{-2}$ . Thus  $s$  increases in  $\mathcal{M}$  provided that  $\epsilon > 1$ . Moreover,  $\mathcal{M}$  decreases in  $N$  and  $\eta$  provided  $N, \eta > 1$ . Using  $\frac{\partial^2 s}{\partial \mathcal{M} \partial f} = \frac{1}{s} \frac{\partial s}{\partial f} \frac{\partial s}{\partial \mathcal{M}}$  and  $\frac{\partial s}{\partial f} > 0$  gives (iii).  $\square$

Competition among banks leads to the banking sector as a whole having an effective market power given by the endogenous quantity  $\mathcal{M}$ . This market power decreases when there is more competition, either because there are more banks ( $N$  is higher), or because bank deposits are more easily substituted across banks ( $\eta$  is larger). One way to interpret the result of the proposition is to replace the banking sector with an hypothetical representative bank with this level of market power. The equilibrium deposit spread is the one that maximizes

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<sup>6</sup>This can also be done in the case  $\rho = 1$ .

this representative bank’s profits, and is given precisely by the spread at which the elasticity of aggregate deposit demand,  $-\frac{\partial D/D}{\partial s/s}$ , equals the representative bank’s market power  $\mathcal{M}$ . When there is only one bank, or bank deposits are relatively hard to substitute ( $\eta \rightarrow 1$ ),  $\mathcal{M} = 1$  (its largest possible value), the banking sector acts like a pure monopolist, and the deposit spread is large. In contrast, when  $N$  is large or bank deposits are good substitutes ( $\eta$  is large),  $\mathcal{M}$  is small and the equilibrium deposit spread is small.

The proposition further shows that the equilibrium spread rises with the fed funds rate. When the fed funds rate is high, cash is an expensive source of liquidity and hence an expensive substitute for bank deposits. The representative bank’s competition comes mostly from bonds, a relatively poor substitute for deposits ( $\rho < \epsilon$ ). Hence, the representative bank faces a relatively inelastic demand curve and so charges more for deposits. In contrast, when the fed funds rate is low the representative bank faces more competition from cash, which has a high elasticity ( $\epsilon > 1$ ) with deposits. It therefore faces a relatively elastic demand curve and hence charges less for deposits. In this way monetary policy affects the level of external competition faced by the banking sector.

Finally, proposition 1 shows that the effect of the fed funds rate on the deposit spread is larger where there is less competition. Where competition is intense, spreads are low regardless of the fed funds rate and the opportunity cost of holding cash. In contrast, where competition is weak, cash is a more important alternative to bank deposits, and hence the effect of the fed funds rate on deposit spreads is stronger. This effect is captured by the cross-partial in part (iii) of Proposition 1 and corresponds empirically to the coefficient on the interaction of market power and changes in the fed funds rate that we estimate in the deposit rate regressions below.

### III. Data and Summary Statistics

We build a novel data set at the bank-branch level that includes information on deposits rates (by product), deposit holdings, branch ownership, bank characteristics, and county characteristics.

The data on deposit holdings is from the Federal Deposit Insurance Corporation (FDIC).

The FDIC provides annual branch-level data on total deposits outstanding from June 1994 to June 2014. The data set has information on branch characteristics such as the branch ownership, the branch address, and the branch’s geographic coordinates (latitude and longitude). The data covers the universe of bank branches in the U.S. and contains a unique branch identifier, bank identifier, and county identifier. We use these identifiers to match the data with other data sets.

The data on deposit rates is from the private data provider Ratewatch. Ratewatch collects weekly branch-level data on deposit rates by branch and product. The data is a representative sample of U.S. branches with a coverage of 54% in 2008. We merge the Ratewatch data with the FDIC data using the unique FDIC branch identifier. We are able to match 85.4% of the data collected by Ratewatch.

The Ratewatch data reports a deposit rate if a specific product is offered by a branch. We focus our analysis on the two deposit products that are most widely offered across all branches, 10K money market account and 12-month 10K certificates of deposit. These two products are representative of the two main types of deposits (savings and time). We confirm in robustness tests that our results also hold for other deposit products.

The Ratewatch data reports whether a branch actively sets deposit rates (“rate setter”) or whether a branch uses rates that are set by another branch (“non-rate setter”). The data provides a link between non-ratesetting and ratesetting branches. Each non-rate setter is linked to a single rate setter, while rate setters can be linked to more than one non-rate setter. Most of our analysis focuses on the active setting of deposit rates and we therefore focus on the sample of rate setters. We use the sample of non-rate setters for a separate empirical test.

We collect data on county characteristics from several sources. The data on the annual number of establishments, employment, and annual payroll are from the County Business Patterns survey, the data on quarterly wages are from the Bureau of Labor Statistics, and the data on annual population and county size are from the Census Bureau. We also collect data on annual gross county tax revenues from the Internal Revenue Services and data on annual median household income, the unemployment rate, and the poverty rate from the Census Bureau. We merge the county-level data with the deposit data using the FDIC

county identifier. The data covers all counties with at least one bank branch.

We collect the data on bank characteristics from the U.S. Call Reports, obtained from the Federal Reserve Bank of Chicago. U.S. Call Reports include quarterly bank-level data on income statements and balance sheets data for all U.S commercial banks. To ensure robustness against outliers, we drop observations if total assets, total deposits, or total liabilities are less than \$1 million or if they are missing. We match the bank-level data to the branch-level data using the FDIC bank identifier.

Our analysis focuses on the effect of monetary policy on deposits rates and holdings. We measure the stance of monetary policy using the Fed funds rate. We collect the quarterly Fed funds rate (as of the end of the quarter) from the St. Louis Federal Reserve Economic Database. For some of our analysis, we distinguish between expected and unexpected changes in the Fed funds rate over a quarter. Following Kuttner (2001), we compute the expected change in the Fed funds rate as the difference between the Fed funds rate and the Fed funds future rate, both at the beginning of the quarter. The unexpected change in the monetary policy is the actual change during a quarter minus the expected change.

Our main measure of bank competition is the deposit Herfindahl index at the county level. We compute the deposit Herfindahl for a given county in a given year in the standard way, i.e. by summing the squared deposit shares of all banks with branches within that county and in that year. A Herfindahl of one indicates an extreme of complete concentration of county deposits within a single bank, whereas lower values indicate greater competitiveness.

Figure 3 plots the variation in bank competition across counties. For each county, we plot the average deposit Herfindahl from June 1994 to June 2008. As shown in the figure, there is significant variation across counties ranging from highly competitive counties with a minimum Herfindahl of 0.06 to uncompetitive counties with a maximum Herfindahl of 1. The figure does not reveal any obvious regional clustering of bank competition. As we show in the robustness section, our results are robust to computing the Herfindahl index based on a number of bank branches operating in a county.

Panel A of Table 1 provides summary statistics at the county level. The data is at the annual level from 1996 to 2008 covering all U.S. counties with at least one bank branch, which yields a total of 46,674 observations. We focus on the period before 2008 because we are

interested in the conduct of monetary policy during regular (non-crisis) times. The average Herfindahl index during this period is 0.354 with a standard deviation of 0.290. We provide a breakdown of county characteristics split at the median Herfindahl index within each year. Low-Herfindahl counties (high competition) are larger than high-Herfindahl counties (low competition) with a median population of 49,889 versus 13,496. They also have a higher median household income, \$38,815 versus \$33,212, and a lower poverty rate, 13.1% versus 16.2%.

Panel B of Table 1 provides summary statistics at the branch level. The data is annual from 1996 to 2008 for all U.S. commercial banks with at least two ratesetting branches, which yields a total of 97,751 observations. The average bank has total deposits of \$122 million with an average deposit growth of 6.2%. The average deposit Herfindahl index is 0.239 with a standard deviation of 0.203. The median spread (Fed funds rate minus deposit rate) is 1.91% for interest checking accounts, 1.66% for money market accounts, and 0.01% for 12-month CDs. We also provide a breakdown by the median Herfindahl of 0.203 and find that spreads are similar across high- and low-Herfindahl counties.<sup>7</sup>

Panel C of Table 1 provides summary statistics at the bank level. The data is annual from 1996 to 2008 for the sample of all U.S. commercial banks, which yields a total of 122,821 observations. We compute a bank's deposit Herfindahl index as the weighted average of its branch-level Herfindahl indices using deposits as weights. The average bank has \$765 million in assets and grows at a median rate of 6.43%. The main funding source is deposits, which account for 83.0% of the balance sheet. Demand deposits, which include checking deposits, account for 12.8%, savings deposits account for 19.9%, and time deposits account for 39.1%. The other funding sources are equity with an 11.1% share and non-deposit debt with a 5.9% share.

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<sup>7</sup>This finding is somewhat surprising given that the earlier literature on deposits found that deposit rates are lower in less competitive areas. We find that this result holds *after* controlling for county-level income. This result reflects the fact that higher income counties are both more competitive and have higher spreads. This may be caused by the higher cost of operating branches in high-income areas (e.g. because of higher wages and higher rentals costs).

## IV. The Effect of Monetary Policy on Deposits

### A. *Across-branch empirical strategy*

Our empirical strategy is designed to estimate the effect of monetary policy on deposits. As shown in Figure 1, the spread between deposit rates and the Fed funds rate widens as the Fed funds rate increases. At the same time, as shown in Figure 2, there is an outflow from checking and savings deposits (Panels A and B) and an inflow to time deposits (Panel C). The net effect is an aggregate outflows of deposits from the banking system (Panel D). Hence, when the Fed funds rate increase, total deposits shrink and the composition of deposits becomes less liquid. This evidence is suggestive of a direct link between monetary policy and deposit flows.

However, it is possible that omitted variables such as time-varying economic conditions drive both monetary policy and deposit flows. For example, the Federal Reserve tends to tighten monetary policy when inflation rises. If higher inflation also reduces banks' lending opportunities, then banks may supply fewer deposits when the Fed funds rate increases. Hence, omitted variables can generate the observed aggregate relationships even in the absence of a direct effect of monetary policy on deposits.

We use several strategies to address this concern. As a first step, we exploit differences in market power across banks. Our model predicts that an increase in the Fed funds rate leads to higher deposit spreads in areas where competition is low (see Proposition 1). Hence, we can test the deposit channel by comparing banks in concentrated (uncompetitive) areas with banks in less concentrated (competitive) areas. This approach controls for the average effect of aggregate economic conditions on bank lending opportunities.

We start by analyzing the sensitivity of deposit rates and flows to changes in monetary policy. Specifically, for each bank branch we estimate the following regression:

$$\Delta y_{ijct} = \alpha_{ij} + \beta_{ij} \Delta FF_t + \varepsilon_{ijct} , \tag{18}$$

where  $y_{ijct}$  is either the change in the deposit spread (price) or the log change in total deposits (quantity) of branch  $i$  of bank  $j$  in county  $c$  from time  $t$  to  $t + 1$  and  $\Delta FF_t$  is the change

in the Fed funds rate from time  $t$  to  $t + 1$ . We refer to the coefficient  $\beta$  as the deposit beta because it captures the average change in deposit rate and flow associated with a change in the Fed funds rate (“deposit beta”). We then average the deposit betas by county, sort counties into twenty buckets by Herfindahl index, and report average county deposit betas by bucket. This yields a total of 20 point estimates, each representing the average deposit beta for about 161 counties.

We conduct this estimation for deposit spreads on 10K money market accounts and 10K 12-month CDs because they are the most widely offered deposit products across branches. The frequency is quarterly. We conduct the estimation for total deposits using branch-level deposit growth, which is available at an annual frequency. We include all branches that report deposit rates in the Ratewatch data and total deposits in the FDIC data through June 2008.

Panel A of Figure 4 shows the results for 10K money market accounts (savings deposits). The figure shows that the deposit beta is larger for less competitive markets. The average deposit beta is around 0.64 in low-Herfindahl counties (below 10th percentile) relative to about 0.71 in high-Herfindahl counties (above 90th percentile). This means that a 100 basis points increase in the Fed funds rate leads to a 7 basis point increase in uncompetitive markets relative to competitive markets. The result is robust in that other markets line up in between with a roughly linear increase in deposit beta in the Herfindahl index. Differences in county Herfindahl thus account for 11% of the average increase in deposit spreads after an increase in the Fed funds rate.

Panel B shows the result for time 12-month certificate of deposits (time deposits). We find again that the deposit beta is larger for less competitive markets. The average deposit beta is around 0.24 in low-Herfindahl counties (below 10th percentile) relative to about 0.28 in high-Herfindahl counties (above 90th percentile). This effect accounts for 15% of the average difference increase in deposit spread after an increase in the Fed funds rate.

Panel C shows the result for deposit growth. In contrast to the result on prices, we find that the deposit beta is larger in competitive markets. The average deposit beta decreases by about 0.6 going from low-Herfindahl to high-Herfindahl counties (below 10th to above 90th percentile). This difference accounts for 22% of the average deposit outflow after an

increase in the Fed funds rate.

Importantly, these results show that an increase in the Fed funds rate leads to an increase in deposit spreads (price) and a decline in outstanding deposits (quantity). This indicates that monetary policy works through shifting the supply curve rather than shifting the demand curve. This rules out alternative explanations that rely on shifting the demand curve for deposits, which would predict that price and quantity move in the same direction.

While using variation in deposit competition across markets controls for changes in aggregate economic conditions, it does not control for differential changes in local economic conditions. Such differential changes might affect banks' lending opportunities, which in turn might affect local deposit supply. If these changes are also correlated with deposit competition, then this may bias our estimation. For instance, if banks in more concentrated markets face a larger decline in lending opportunities after a Fed funds increase relative to banks in less concentrated markets, then they may raise fewer deposits to finance their lower loan growth. In this case, loan demand rather than market power would be responsible for the observed changes in deposit prices and quantities.

We address this concern by exploiting geographical variation in deposit competition across branches of the *same* bank. This strategy is best illustrated by an example. Consider a bank that is operating two branches, one in a more concentrated area and one in a less concentrated area. Because the bank can move deposits from one branch to the other, the decision of how many loans to make at a given branch becomes independent of how many deposits to raise at that specific branch. We can therefore control for the effect of banks' lending opportunities on branch-level deposit supply by comparing branches of the same bank.

The identifying assumption is that banks equalize the marginal return to lending across branches by lending to projects with the highest expected value. This assumption is satisfied if banks use internal capital markets to allocate resources efficiently. Even if there are frictions in banks' internal capital market, this strategy identifies the effect of competition on deposits as long as the frictions are uncorrelated with deposit competition. This assumption is supported by evidence that banks channel deposits to areas with high loan demand (e.g., Gilje, Loutskina, and Strahan (2013)).

We implement this identification strategy using an ordinary least square (OLS) regression:

$$\Delta y_{ijct} = \alpha_i + \delta_{jt} + \lambda_{st} + \beta HHI_{ct} + \gamma \Delta FF_t \times HHI_{ct} + \varepsilon_{ijct}, \quad (19)$$

where  $y_{ijct}$  is either the change in the deposit spread (price) or the log change in total deposits (quantity) of branch  $i$  of bank  $j$  in county  $c$  from time  $t$  to  $t + 1$ ,  $\Delta FF_t$  is the change in the Fed funds rate from time  $t$  to  $t + 1$ ,  $HHI_{ct}$  is the deposit Herfindahl in county  $c$  at time  $t$ ,  $\alpha_i$  are branch fixed effects,  $\delta_{jt}$  are bank-time fixed effects and  $\lambda_{st}$  are state-time fixed effects. We cluster standard errors at the county level.<sup>8</sup>

We estimate the model for the sample of banks with at least two branches because the coefficient on the interaction between the change in the Fed funds rate and the Herfindahl index is not identified for single-branch banks. We analyze the period from January 1996 to June 2008 because we are primarily interested in the effect of monetary policy on deposits during regular (non-crisis) times. We estimate the regression at the quarterly level to allow branches some time to adjust spreads after a Fed funds rate change. We focus on money market accounts and 12-month CDs because they are most widely offered deposit products across all branches. We focus on the most common account size of \$10,000.

Panel A of Table 2 presents the results for savings deposits (10K money market accounts). Column 1 shows the benchmark specification with controls for county and time fixed effects. We find a statically significant coefficient of 0.095 on the interaction of the change in the Fed Funds rate and the Herfindahl index. This results shows that branches in more concentrated markets increase deposit spreads relative to branches in less concentrated markets. Column 2 add state-time fixed effects to the specification. State-time fixed effects control for state-level, non-parametric time trends, such as political changes or regulatory reforms, that may affect all branches in the same state. We find that the coefficient is slightly larger, which shows that the result holds comparing branches within the *same* state.

Column 3 adds bank-time fixed effects. As discussed above, bank-time fixed effects control for any bank-level variation in the willingness to supply deposits. We find that the

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<sup>8</sup>We use deposit spread as one of the main outcome variable. We do so because the spread is the price of deposits in our model. Alternatively, one can estimate the regressions using deposit rates as the outcome variable (i.e, without deducting the Fed funds target rate). This estimation yields identical coefficients (but with opposite sign) because of the inclusion of time fixed effects.

coefficient is almost unchanged. This shows that the results hold by comparing branches of the same bank in the same state. Hence, our results are not driven by bank-level variation in lending opportunities. Indeed, the coefficients in Columns 2 and 3 are almost identical, which suggest that changes in lending opportunities are unlikely to materially affect our estimation.

Column 4 adds branch fixed effects to control for variation in branch-level trends. This is our preferred specification with the full set of branch, bank-time, and state-time fixed effects. We find a statistically significant coefficient of 0.122. This means that a 100 basis points increase in the Fed funds rate raises deposit spreads of branches in concentrated areas by 12 basis points relative to branches in less concentrated areas. This is economically significant as it accounts for 19% of the average increase in deposit spreads.

Panel B of Table 2 presents the results for time deposits using the same specifications as for savings deposits. As shown in Column 1, we find a statistically significant coefficient of 0.061 on the interaction of Fed funds rate changes and Herfindahl index. As shown in Columns 2 and 3, the effect is robust to controlling for state-time and bank-time fixed effects, respectively. As shown in our preferred specification in Column 4, we find a statistically significant coefficient of 0.050. This means that a 100 basis points increase in the Fed funds rate, raises deposit spreads in concentrated areas by an additional 5 basis points relative to less concentrated areas. This accounts for 20% of the average increase in deposit spreads.

Next, we analyze the effect of monetary policy on branch-level deposit growth. This is important for several reasons. First, we are testing whether the effect of monetary policy on spreads (prices) also affects the quantity of deposits. Second, the directional effect on deposit growth allow us to assess whether changes in the Fed funds rate represent a supply shock or demand shock. Third, the magnitude of this relationship allows us to quantify the response of deposit flows to differences in competition.

We estimate the model for all branches that report deposit holdings to the FDIC. We start the analysis in June 1994 because the FDIC data becomes available prior to the spreads data. Because the FDIC only reports total deposits, we do not have a breakdown by product type. We thus interpret our estimates as the effect of monetary policy on total deposits. We estimate the regressions at the annual level because the FDIC data is only available annually.

Table 3 reports the results for deposit flows. Column 1 presents the specification with branch and time fixed effects. We find that a statistically significant coefficient of  $-2.47$  on the interaction of changes in the Fed funds rate and the Herfindahl index. This means that branches in more concentrated areas experience larger deposit outflows after an increase in the Fed funds rate. Columns 2 and 3 add state-time and bank-time fixed effect, respectively. The coefficients slightly decrease but remain statistically significant. This shows that the results hold for branches in the same state and branches of the same bank.

Column 4 presents our preferred specification with the full set of branch, bank-time, and state-time fixed effects. We find a coefficient of  $-0.98$ . This means that that a 100 basis point increase in the Fed funds rate raises deposit outflows in concentrated areas by 98 basis points relative to less concentrated areas. The effect is economically significant as it accounts for 30% of the median deposit flow.

Our results on deposit spreads and deposit flows provide strong support for our model. As suggested by Proposition 1 of our model, we find that after an increase in the Fed funds rate deposit spreads increase more, and deposits supply falls more, for branches located in concentrated areas relative to branches located in less concentrated areas. This result holds even when comparing deposit rates and flows across branches of the same bank and in the same state, thus controlling for any factors at the bank or state level that might influence banks' supply of deposits. Thus, the results show that banks experience a supply shock, as spreads (prices) increase while quantities fall.

The fact that prices and quantities change in opposite directions—i.e., banks experience a supply shock—rules out alternative explanations of our results based on demand shocks. To illustrate, a potential alternative might be that, following a Fed funds rate increase, household demand for deposits remains stronger in more concentrated areas than in less concentrated areas. In this case one would expect deposit prices to be higher in more concentrated areas, but deposit quantities to be higher as well. In contrast, we find that prices and quantities move in opposite directions. Hence, such changes in deposit demand cannot explain our results.

## *B. Event study response to monetary policy*

We next study the timing of the deposits channel of monetary policy. The timing is important because it helps to identify whether the Fed funds rate has an independent effect on deposit spreads and flows. The leading alternative explanation is that it does not have an independent effect and that both the Fed funds rate and deposit supply simply respond to changing economic conditions. In this case the Fed funds rate is just an indicator of economic conditions but does not have a causal effect on the economy. Under this explanation, deposit supply still varies as a function of banks' market power, but the change in deposit supply is caused by changes in economic conditions, not changes in the Fed funds rate.<sup>9</sup>

To be clear, it is hard to think of specific economic variables that may generate the branch-level results. As discussed above, our main analysis controls for bank lending opportunities by including bank-time fixed effects. Also, our results show that branches reduce the supply of deposits after Fed funds rate rise, ruling out explanations that work through the influence of economic conditions on deposit demand. In any case, if we find sharp changes in deposits at the time of Fed funds rate changes, it provides further evidence of a direct effect of the Fed funds rate on deposits.

Our analysis of the timing focuses on deposit spreads because the analysis requires high-frequency data and only the spreads data is available at a high frequency (weekly). We include all rate-setting branches. We focus on the same time period as in our main analysis (January 1996 to June 2008) and the main savings deposit product (10K money market accounts). We examine the effect in a five-week window around Fed funds rate changes. We choose this window because scheduled Fed meetings occur in a six week interval. This estimation window allows us to focus on the effect of a single meeting.

The test examines at the weekly level whether changes in deposit spreads occur at the same time as changes in the Fed funds rate. We implement this test by estimating the OLS

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<sup>9</sup>We believe that our result that deposit supply varies with local competition is important and novel in its own right. The analysis of the timing helps us to identify whether this effect is caused by the Fed funds rate or aggregate changes in the economy that correlate with the Fed funds rate.

regression

$$\Delta y_{ijct} = \alpha_t + \beta \text{HHI}_c + \sum_{\tau=-5}^5 \gamma_\tau \text{HHI}_c \times \Delta \text{FF}_{t-\tau} + \varepsilon_{ijct} \quad (20)$$

where  $\Delta y_{ijct}$  is the change in the deposit spread of branch  $i$  of bank  $j$  in county  $c$  from week  $t$  to  $t + 1$ ,  $\Delta \text{FF}_{t-\tau}$  is the change in the Fed funds rate from week  $t - \tau$  to  $t - \tau + 1$ ,  $\text{HHI}_c$  is the deposit Herfindahl in county  $c$ , and  $\alpha_t$  are time fixed effects. We cluster standard errors at the county level.

Panel A of Figure 5 shows the effect of Fed funds rate changes on deposit spreads at the weekly frequency. We plot the running sum of the interaction coefficients  $\gamma_\tau$  and its 95% confidence interval to show the cumulative effect over time.<sup>10</sup> We find no effect in the weeks before Fed funds rate changes with a tight confidence interval around zero. In the week of Fed funds rate changes, we find that deposit spreads in concentrated areas increase by about 6 basis points relative to deposit spreads in less concentrated areas. The effect increases to about 9 basis points in the 2 weeks after Fed funds rate changes and remains constant thereafter. The effect is statistically significant at the 1%-level.

These findings show that changes in the pricing of deposits occur closely around changes in the Fed funds rate. Given that the change in deposit spreads coincides so closely with Fed funds changes, it is unlikely that these changes are caused by changes in (slow-moving) economic conditions. Instead, the results indicate that changes in monetary policy directly affect deposit spreads.

### *C. Expected changes in monetary policy*

Our results so far show that changes in the Fed funds rate are associated with changes in deposit spreads and flows, and that their timing is precisely aligned. Next, we examine whether it is the change in the Fed funds rate itself that affects deposit supply. Alternatively, it could be that the effects are induced by a simultaneous release of private information about the economy by the Federal Reserve. This private information may come from the Fed's

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<sup>10</sup>The computation of the 95% confidence interval takes into account the covariance between the individual coefficients.

superior ability to process publicly available information or from its access to proprietary information through its role as a regulator. It may be released through press releases or other forms of communication, or it could be embedded as a signal in the Fed Funds rate itself. Under this explanation, the Federal Reserve only affects the economy through the release of private information. As a result, the Fed still has an effect on deposits but it works through the release of information rather than the rate change itself.

In general, it is difficult to distinguish between the direct effect of rate changes and the effect of private information. Indeed, this is an unavoidable concern in empirical studies of monetary policy.

We are uniquely able to address this issue by examining the effect of *anticipated* changes in the Fed funds rate. If monetary policy affects the economy through actual rate changes, as suggested by our model, then anticipated changes in monetary policy should affect deposit rates at the time of the rate change because rate changes affect a bank's effective market power. In contrast, under the information release explanation, anticipated changes in monetary policy should have no effect because by construction they do not convey new information.

The strength of the effect of anticipated rate changes on deposit spreads depends on the maturity of the deposit. For deposits with zero maturity such as savings deposits, the impact of a rate change on the deposit spread should occur precisely at the time of that change, even if it is anticipated. As the maturity of the deposit (or any asset more generally) increases, its spread should reflect anticipated rate changes in advance of when they actually occur. This is because the spread is fixed over the life of the deposit. The strength of the effect of anticipated rate changes thus depends on the maturity of the deposit relative to the date when the anticipated rate change is set to occur.

The results of this test have a bearing on a large literature that studies the effect of monetary policy, as reflected by Fed funds rate changes, on asset prices. To identify this effect, this literature relies on the correlation between asset prices and unanticipated rate changes, typically on the day of the announcement (e.g. Kuttner 2001, Bernanke and Kuttner 2005). Yet, these tests cannot rule out the possibility that the observed changes in asset prices are due to a release of private information by the Fed rather than the actual rate change.

Our setting allows us to solve this problem by examining anticipated rate changes, thereby holding information sets fixed. Our paper is the first to our knowledge to use anticipated rate changes for identifying the effects of monetary policy.<sup>11</sup>

We test for the effect of anticipated changes in monetary policy by decomposing the change in the Fed funds rate into the unexpected and expected part. We compute the expected change as the difference between the actual Fed funds rate and the 3-month Fed funds futures rate at the beginning of the quarter. We compute the unexpected change in the Fed funds rate as the actual change over a quarter minus the expected change in the Fed funds rate. This decomposition follows the event study literature. We implement this test by estimating the same regressions as in Table 2 after replacing the actual change in the Fed funds rate with the expected change in the Fed funds rate.

Panel A of Table 4 presents the result for savings deposits (money market accounts). We find that across all specifications the coefficients are similar to the ones in Panel A of Table 2. In the preferred specification in Column 4 with the full set of branch, bank-time and state-time fixed effects, we find a statistically significant coefficient of 0.182. The coefficient implies that a 100 basis points expected increase in the Fed funds rate raises deposit spreads in uncompetitive areas by 18 basis points relative to competitive areas. This estimate is similar to the one for actual rate change.

Panel B of Table 4 presents the results for time deposits (12-month certificate of deposits). As discussed above, we expect weaker results because anticipated changes should be partially priced in advance for assets with a non-zero maturity. In Columns 1 and 2, we find no statistically significant effect. In Columns 3 and 4, after controlling for bank-year and state-time fixed effect, we find positive coefficients. In the benchmark specification in Column 4, we find a statistically significant coefficient of 0.056. The coefficient implies that a 100 basis points anticipated increase in the Fed funds rate, raises deposit spreads in uncompetitive areas by 6 basis points relative to competitive areas.

We also examine the timing of the effect of expected and unexpected rate changes. We estimate the same event study regression (20) used to produce Panel A of Figure 5, but

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<sup>11</sup>To be clear, Kuttner (2001) does examine the effect of expected Fed funds changes on long-maturity bond prices and finds no effect, as one would expect.

replacing the actual change in the Fed funds rate with the expected change (Panel B) and the unexpected change (Panel C). We estimate the expected change in the Fed funds rate as in Kuttner (2001).<sup>12</sup>

Panel B of Figure 5 plots the effect for anticipated rate changes. Anticipated rate changes have no effect on deposit spreads prior to the actual rate change. At the time of rate change, the deposit spread in concentrated areas increases by about 6 basis points relative to less concentrated areas. The effect grows to about 8 basis points in the following week and remains constant thereafter. This result is strong evidence in favor of the deposits channel. As discussed above, the effect for zero-maturity deposits should occur at the actual time of the rate change and this is indeed what we find.

Panel C of Figure 5 plots the effect for surprise rate changes. We find that deposits spreads increase by about 15 basis points in the week of a surprise rate change. The spread increases by another 5 basis points in the following two weeks and remains constant thereafter.

In short, we find that anticipated changes in monetary policy affect deposit spreads. Hence, it is not just information release, but the actual change in the Fed funds rate that causes the price of deposits to change.

Finally, we note that these results provide further identification for our main channel. If our results reflect the impact of changes in underlying economic conditions, then the timing of these changes would have to coincide precisely with both anticipated and unanticipated Fed funds changes. We view this as highly implausible.

#### *D. Effect of monetary policy on non-rate setters*

Our analysis has already shown that the Fed funds rate has a direct effect on deposits spreads and flows. Nevertheless, we provide an additional identification test that provides complementary evidence to our main analysis.

As discussed above, smaller branches often do not set their own rates but instead have their rates set by other branches of the same bank. Our data allows us to link these non-rate-setting branches to their respective rate setters. Our test focuses on non-rate-setting

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<sup>12</sup>We use the spreadsheet available on Kenneth N. Kuttner's website as of August 18, 2014.

branches that are located in a different county than their rate setters. This gives us variation in deposit spreads within a county induced by differences in competition faced by their rate setters that are located in different counties.

The identification is best illustrated with an example. Consider two non-ratesetting branches located in county A. Suppose the rate-setting branch for the first branch is located in county B, while the rate-setting branch for the second branch is located in county C. We can examine whether differences in bank competition between County B and C affects the deposits of the two non-rate setting branches in County A. The identifying assumption is that the effect of bank competition in Counties B and C only affects branches in county A through the rate-setting process.

Importantly, this identification strategy allows us to control for county-specific, non-parametric trends in local economic conditions by using county-time fixed effects. To implement this strategy, we estimate the following OLS regression:

$$\Delta y_{ijct} = \alpha_i + \delta_{ct} + \gamma \Delta FF_t * HHI_r + \varepsilon_{ijct} , \quad (21)$$

where  $y_{ijct}$  is the log change in total deposits of non-ratesetting branch  $i$  of bank  $j$  in county  $c$  from time  $t$  to  $t + 1$ ,  $\Delta FF_t$  is the change in the Fed funds rate from time  $t$  to  $t + 1$ ,  $HHI_r$  is the deposit Herfindahl of the ratesetting branch in county  $r$ ,  $\alpha_i$  are branch fixed effects and  $\delta_{ct}$  are county-time fixed effects.<sup>13</sup> We cluster standard errors at the county level.

Table 5 present the results. Column 1 presents the specification with bank-time fixed effects. We find a statically significant coefficient of  $-0.98$  on the interaction of the change in the Fed Funds rate and the Herfindahl index of the rate-setting branch. Column 2 examines whether the result is robust to controlling for branch fixed effects. Branch fixed effects control for differences in average deposit flows across branches, possibly due to differences in economic conditions across branches. We find that the coefficient is even larger. Column 3 examines robustness to controlling for county-time fixed effects. As discussed above, county-time fixed effects control for any trends in local economic conditions. We find that the coefficient is almost unchanged.

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<sup>13</sup>We look at deposit flows and not spreads because by construction the deposit spread of a non-rate setting branch is the same as the deposit spread of its rate setter.

Column 4 is our preferred specification with both branch and county-time fixed effects. We find a statistically significant coefficient of  $-1.71$ . This means that a 100 basis points increase in the Fed funds rate raises deposit outflows in of branch with rate-setters in concentrated areas by 171 basis points relative to branches with rate-setters in less concentrated areas. This results provides direct evidence in support of our economic model.

In short, we find additional evidence that the Fed funds rate affects deposit flows. We exploit the structure of rate-setting to identify a new source of variation - namely, variation in bank competition across rate-setting branches. This approach allow us to compare deposit flows of branches located in the same county *after* controlling for any variation in local economic conditions. The result are qualitatively and quantitatively similar to the ones in our main analysis.

### *E. Across-bank empirical strategy*

We analyze whether the branch-level results are robust to aggregation at the bank level. This is important because it allows us to assess the magnitude of the effect of the bank-level. Moreover, it also allows us to examine the impact of monetary policy on the asset side of bank balance sheets.<sup>14</sup> Even though the identification is weaker at the bank level relative to the branch level, this estimation has been used widely in the literature. Hence, it also allows use to cross-check our results with results from prior studies (e.g., Kashyap and Stein (2000)). In particular, we can further test the deposit channel by examining whether the variation in deposits also coincides with variation in lending.

To implement this test, we construct a bank-level measure of deposit competition using the weighted average of county-level Herfindahl indices using branch deposits as weights. This bank-level Herfindahl proxies for the average level of competition in the markets in which a bank is active. We estimate the bank-level analog to the branch-level results using the following OLS regression:

$$\Delta y_{ijct} = \alpha_i + \delta_t + \beta HHI_{it} + \gamma \Delta FF_t * HHI_{it} + \varepsilon_{ijct} , \quad (22)$$

---

<sup>14</sup>There is no meaningful way to examine bank assets at the branch-level since it would require assigning assets to specific branches.

where  $y_{ijct}$  is the change in a bank-level outcome (e.g., log growth of assets, deposits, loans, interest spread) of bank  $i$  from time  $t$  to  $t + 1$ ,  $\Delta FF_t$  is the change in the Fed funds rate from time  $t$  to  $t + 1$ ,  $HHI_{it}$  is the average deposit Herfindahl of bank  $i$  at time  $t$ ,  $\alpha_i$  are bank fixed effects and  $\delta_t$  are time fixed effects. We cluster standard errors at the bank level.

Table 6 presents the results for bank liabilities. Columns 1 and 2 present the results for total deposit growth (comparable to Table 3). Column 1 finds a negative and statistically significant effect: a 100 increase in the Fed funds rate raises deposit outflows by 1.5% for banks in uncompetitive deposit markets relative to banks in competitive deposit markets. The coefficient is robust to controlling for time-varying bank characteristics such as the equity ratio, securities as a share of total assets, and their interactions with the Fed funds rate (Column 2).

Columns 3 to 8 examine the effect by type of deposits. As shown in Columns 3 to 8, the effect is negative and statistically significant for all types of deposits and across all specifications. Columns 9 and 10 show that the effect on the average deposit rate is negative and statistically significant, consistent with the branch-level results in Table 2. Hence, the bank-level results on deposits are qualitatively and quantitatively similar to the ones at the branch level.

Next, we turn to the asset side of bank balance sheets. Table 7 presents the results. As shown in Columns 1, we find a statistically significant coefficient of  $-1.026$  on the interaction of the change in the Fed funds rate and the Herfindahl index. This effect is also economically significant: a 100 increase in the Fed funds rate reduces assets by 1.0% for banks in uncompetitive deposit markets relative to banks in competitive deposit markets. The effect is robust to controlling for bank characteristics and their interactions with the Fed funds rate (Columns 2). We find similar results for real estate loans (Columns 3 and 4), C&I loans (Columns 5 and 6), and securities (Columns 7 and 8).

In short, these results suggest that banks cannot easily replace deposit financing and that increases in the Fed funds rate affects banks' supply of loans to the real economy. They are consistent with the central mechanism of our model, which is that the Fed funds rate affects the tradeoff banks face between limiting deposit supply in order to maximize the rents from market power and financing a large balance sheet to maximize revenues. It also

consistent with the large literature on the bank lending channel, which argues that banks amplify changes in monetary policy through changing the supply of credit to firms.

### *F. Robustness*

Our preferred measure of bank competition is the deposit-based Herfindahl index. As an alternative, we also compute branch-based Herfindahl index. The branch-based Herfindahl index is based on the share of a county's branches that belong to a given bank in a given year. We examine whether our main results are robust to using this alternative measure.

Table 8 presents the results for deposit spreads. The top panel presents the results when the outcome variable is the change in the rate on money market accounts. The effect is negative across all four specifications. In the main specification in Column 4, a 100 basis point increase in the Fed funds rate raises the spread in competitive counties by 8 basis points relative to uncompetitive counties. The bottom panel presents the results when the outcome variable is the change in the interest rate on CDs. Again, the effect is negative across all four specifications. In the main specification in Column 4, a 100 basis point increase in the Fed funds rate raises the spread in uncompetitive counties by 5 basis points relative to competitive counties.

Table 9 presents the result when the outcome variable is deposit growth. Similar to Table 3, we find that the effect is negative and statistically significant across all four specifications. In the main specification in Column 4, a 100 basis point increase in the Fed funds rate, raises increases the deposit outflow by 1.5% in uncompetitive areas relative to competitive areas.

In short, our results are qualitatively and quantitatively robust to using an alternative measure of bank competition.

## **V. Conclusion**

Deposits remain far and away the largest funding source for banks. Households are willing to pay a high price for holding liquid deposits as reflected in their rates, which are substantially below market interest rates. We document that the cost of deposits, as measured by the

spread between the Fed funds rate and deposit rates, is strongly positively related to the level of interest rates. This makes deposits expensive to hold when interest rates are high. Consistent with a supply effect, the higher cost is associated with large outflows.

We argue that the positive relationship between market interest rates, deposit spreads, and deposit flows can be explained by imperfect competition among banks in deposit taking. When rates are low, banks face competition from cash and must charge low spreads, whereas when they are high competition is mainly from other banks. This allows banks in concentrated markets to increase their spreads. The implication of doing so, however, is that by limiting the deposit supply banks also limit the size of their balance sheets. Hence, banks face a tradeoff between maximizing the rents they earn on deposits and financing a large balance sheet to maximize revenue from lending. We call this mechanism the deposits channel of monetary policy.

We provide evidence on the deposits channel by looking at the cross section of deposit rates and flows. Importantly, we compare branches of the same bank located in markets with varying levels of competitiveness. This allows us to control for any heterogeneity of lending opportunities or capital position across banks. We find that branches located in less competitive markets raise their deposit spreads more when the Fed funds rate rises. Moreover, they experience lower deposit growth. We also show that the differential rate adjustment happens within a week or two of the Fed funds rate changing, and that it occurs even when the change is expected, which helps to rule out alternative explanations.

Because deposits are the primary source of funding for banks and are well-suited to funding risky and illiquid assets due to their stability, the deposits channel has important implications for credit supply, the prices of risky assets, and the macroeconomy. Moreover, because deposits represent the main source of liquidity and safety for households, the deposits channel also implies that monetary policy drives the supply of safe and liquid securities produced by the financial system and the price of liquidity in the economy.

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Figure 1: **Deposit rates and monetary policy**

This figure plots deposit rates by product, as well as the Fed funds rate target. The data is weekly from RateWatch. The sample is from January 1997 to June 2008.

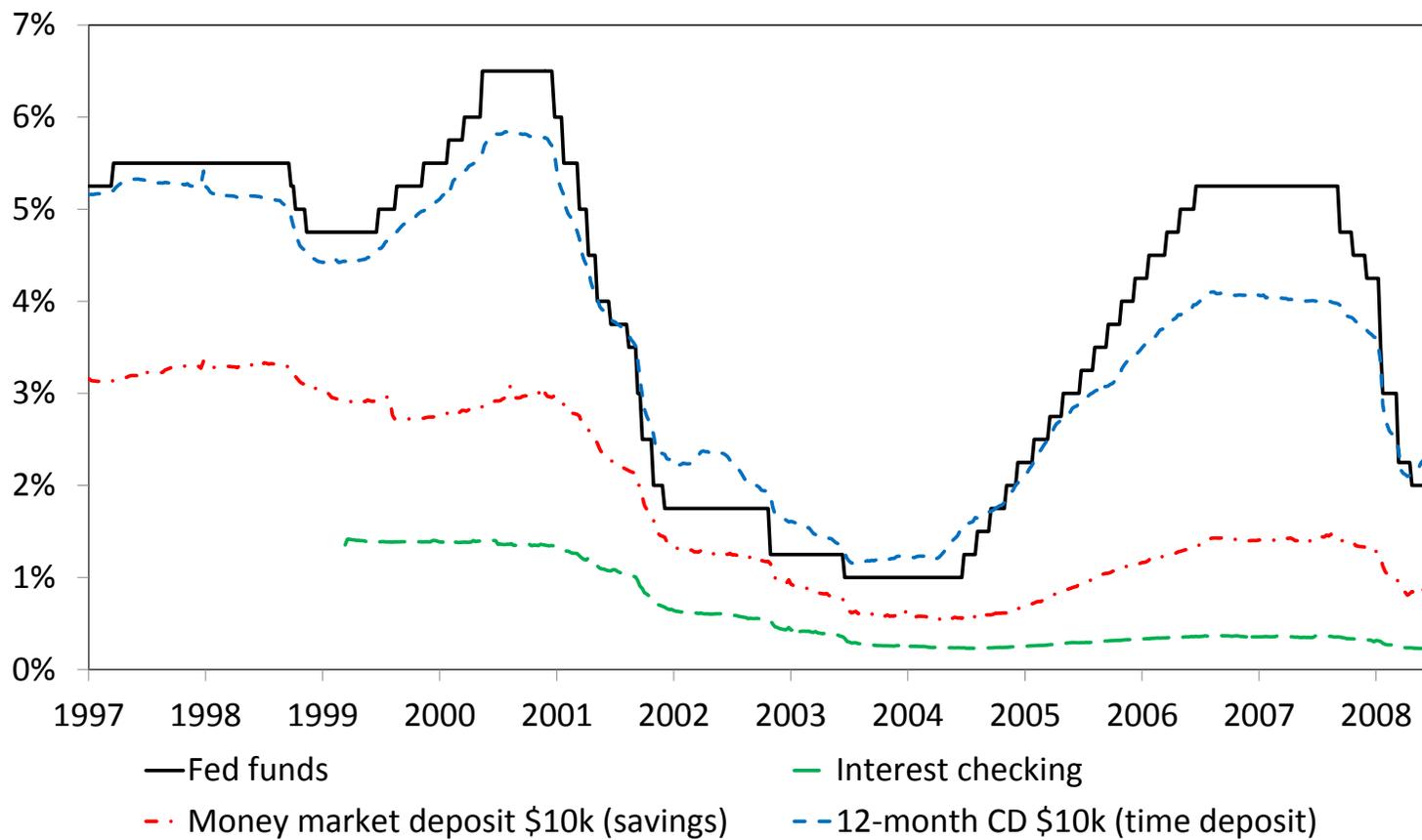
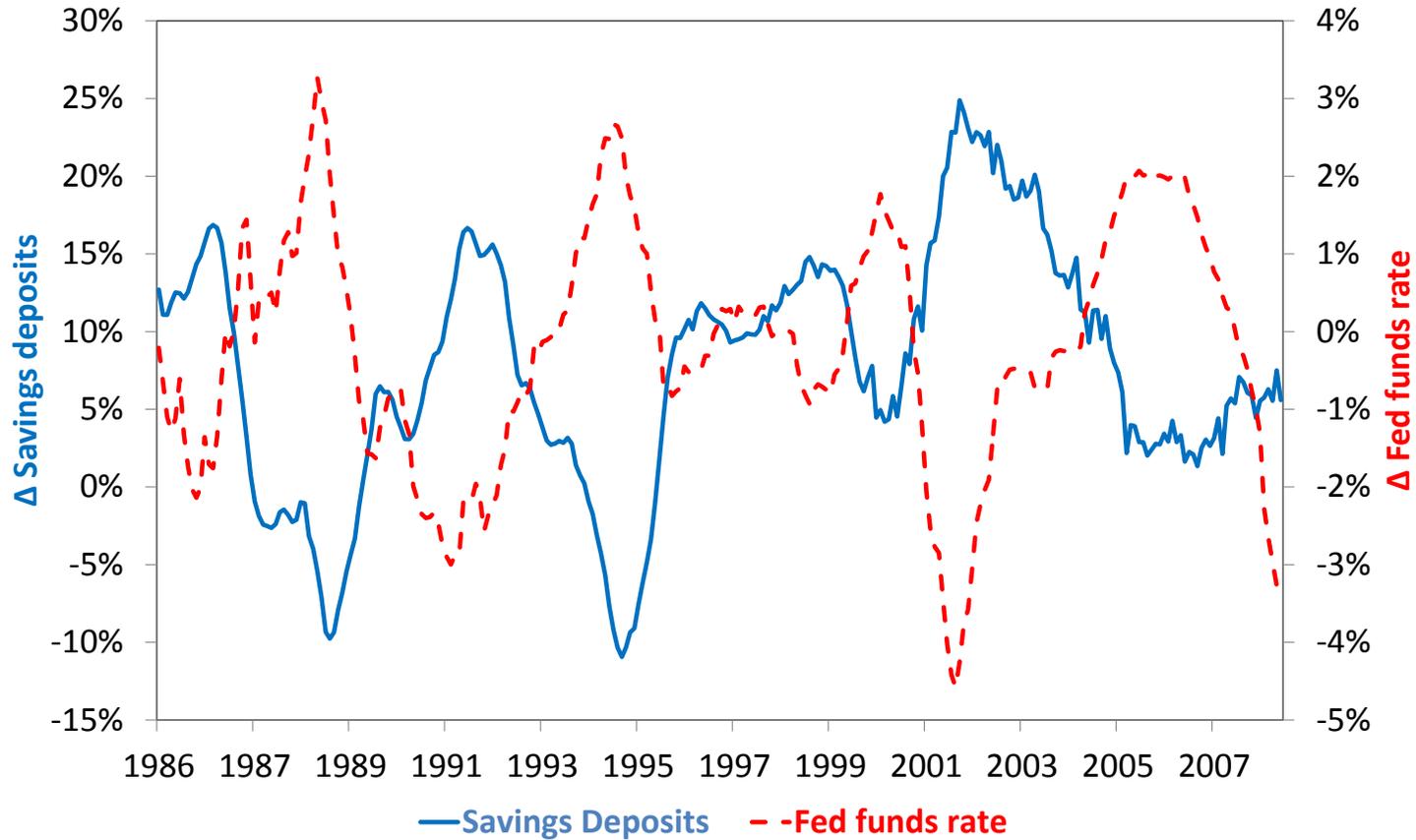


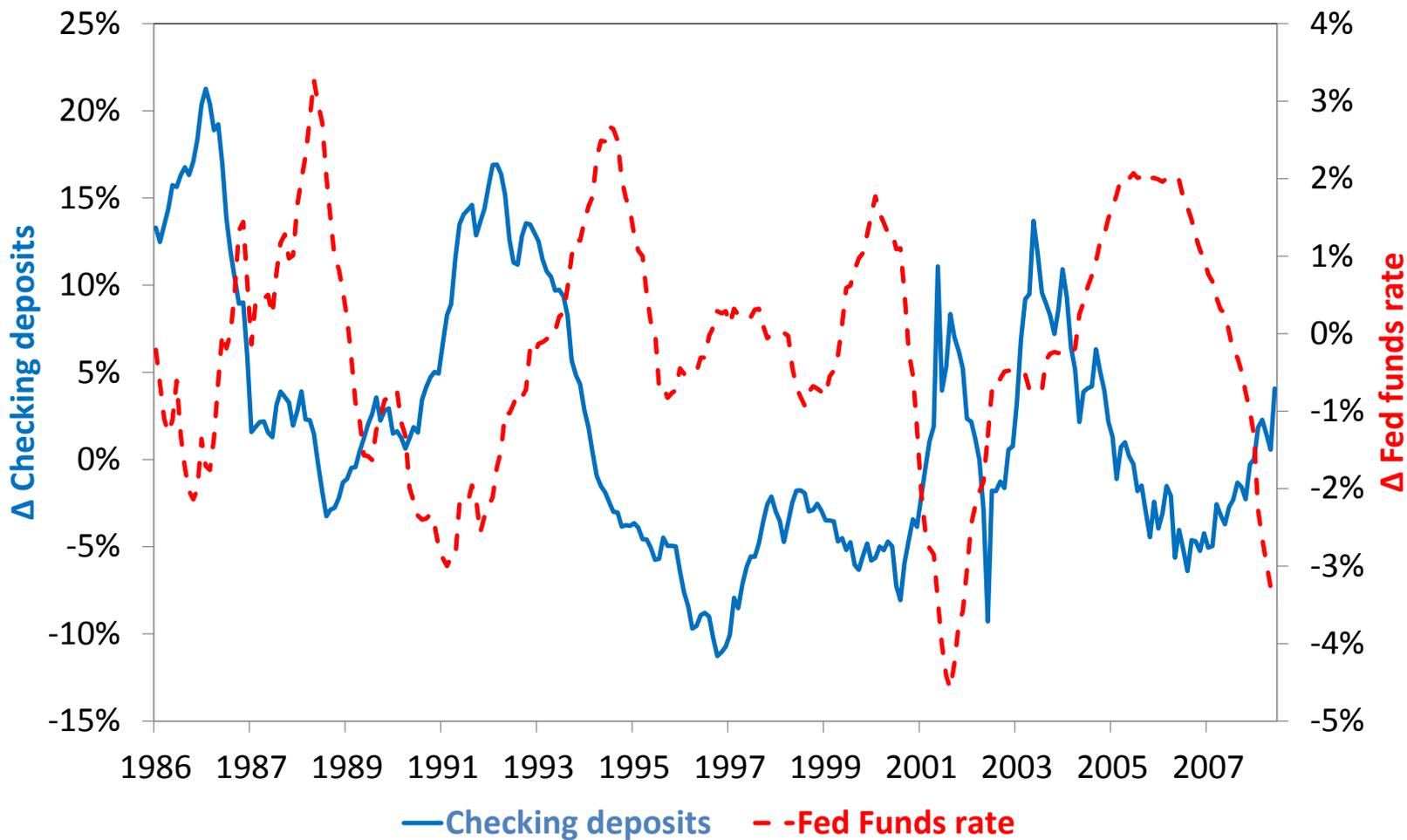
Figure 2: **Deposit flows and monetary policy**

This figure plots year-over-year changes in savings deposits (Panel A), checking deposits (Panel B), time deposits (Panel C), and total deposits (Panel D) and year-over-changes in the Fed funds rate. The data are from the Federal Reserve Economic Database (FRED) and the Flow of Funds. The sample is from January 1986 to June 2008.

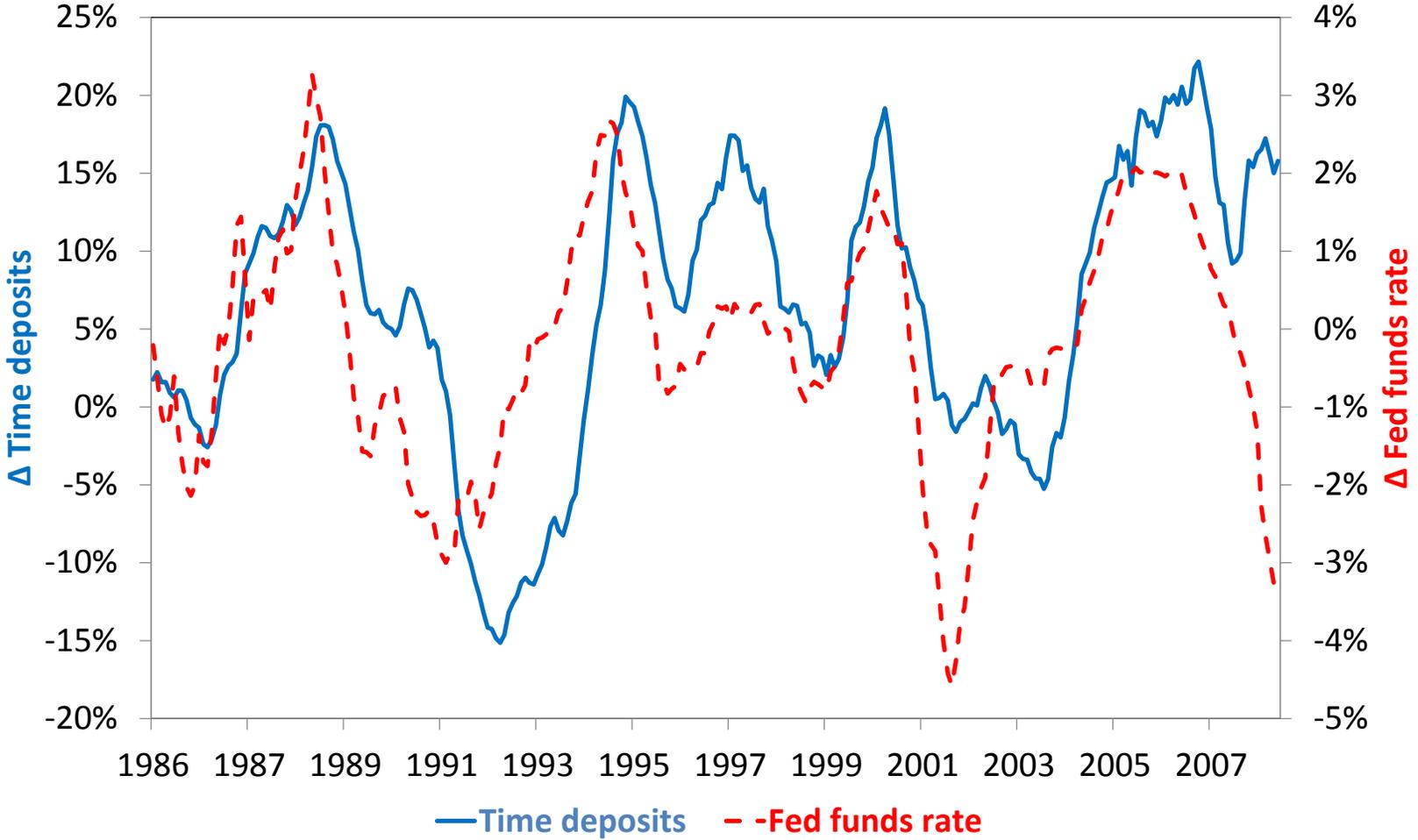
Panel A: Savings Deposits



Panel B: Checkable Deposits



Panel C: Time Deposits



40

Panel D: Total Deposits

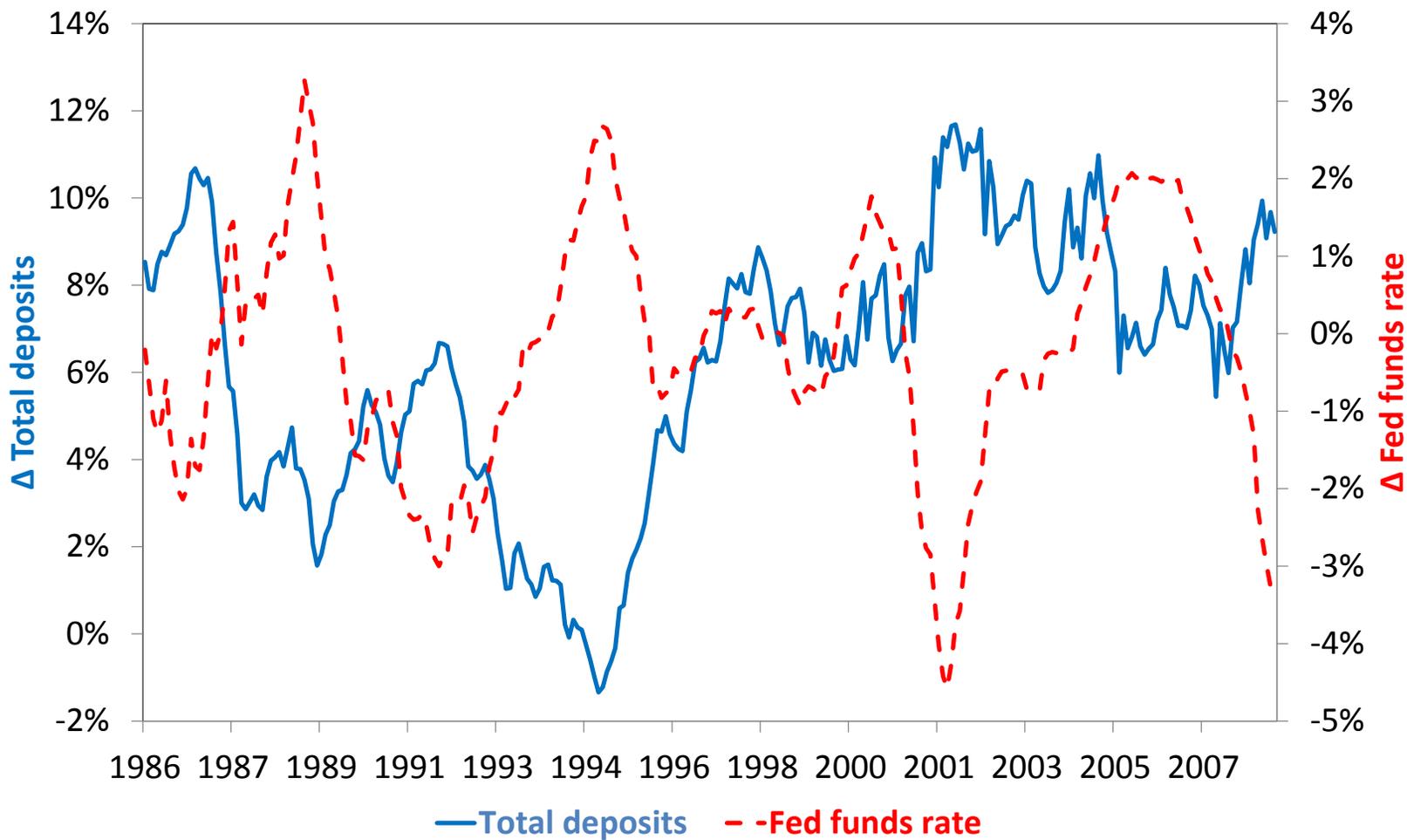


Figure 3: **Deposit competition**

This map shows the average Herfindahl index for each county. The Herfindahl is calculated annually using deposit market share by bank and county and averaged from 1994 to 2008. The data are from the FDIC.

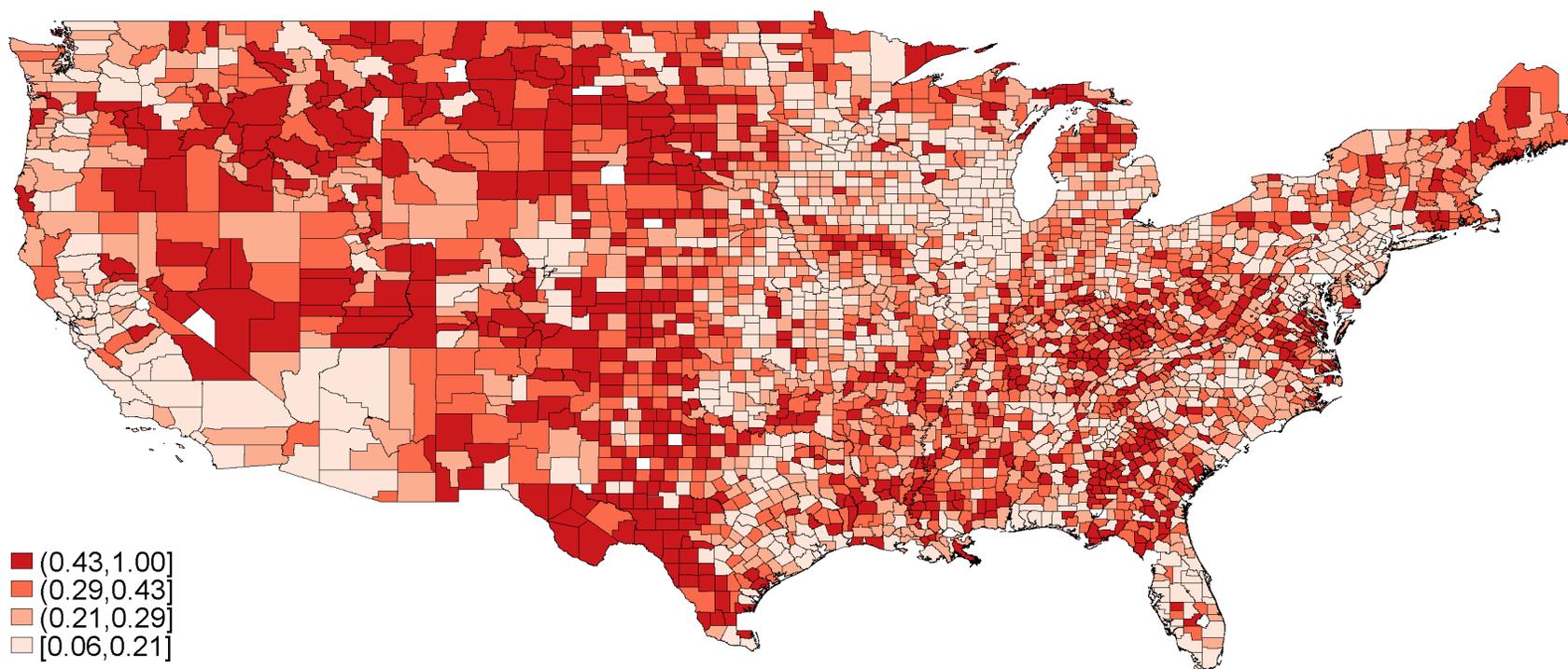


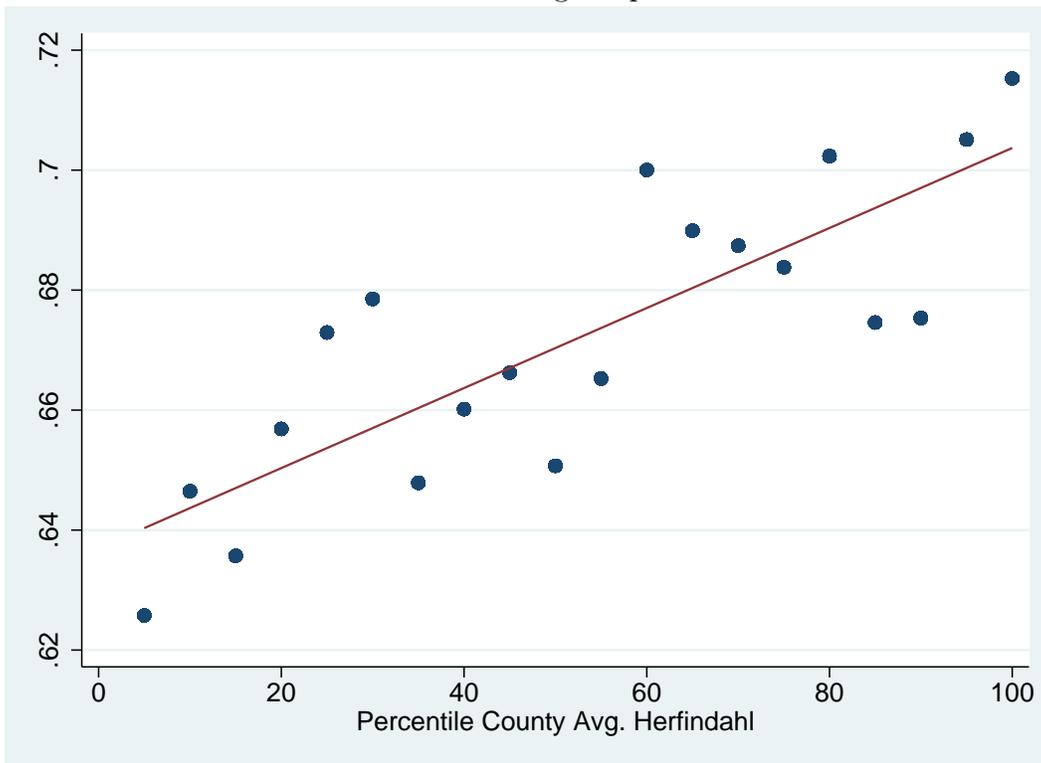
Figure 4: **Deposit beta and market power**

The figures show the relation between market power and the sensitivity of deposit spreads and flows to changes in monetary policy (“deposit beta”) The figures are constructed in two steps. The first step is to estimate the following regression for each bank branch:

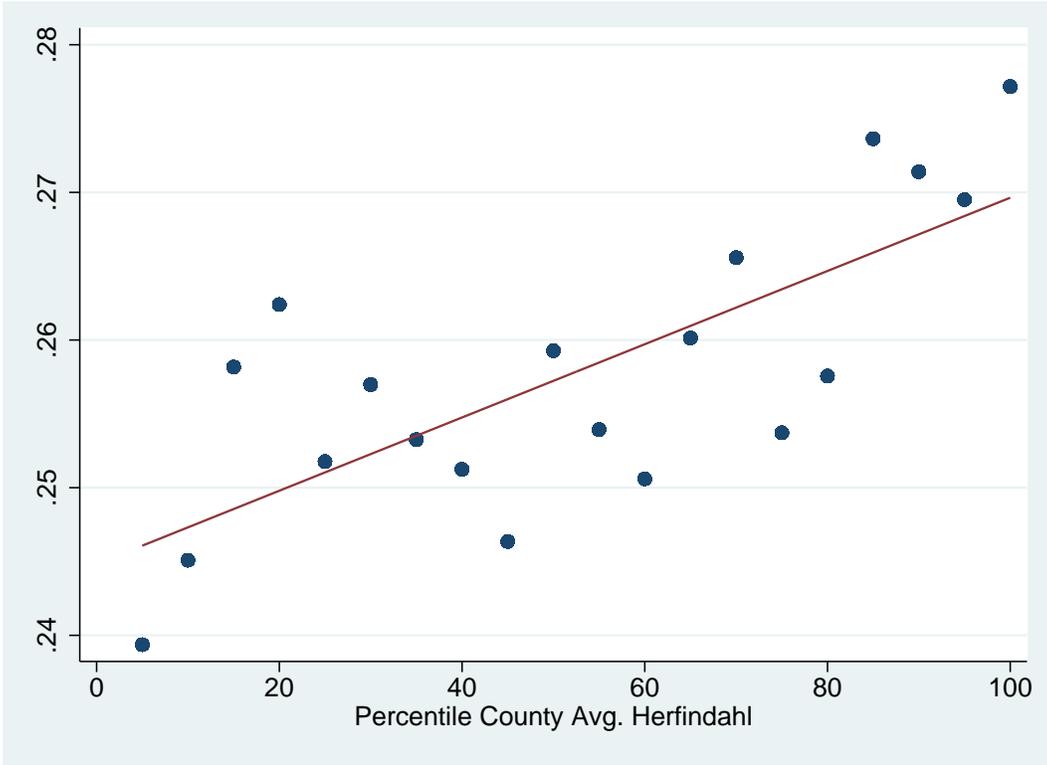
$$\Delta y_{ijct} = \alpha_{ij} + \beta_{ij} \Delta FF_t + \varepsilon_{ijct}.$$

where  $y_{ijct}$  is either the change in the deposit spread or deposit growth for branch  $i$  of bank  $j$  in county  $c$  at time  $t$ . This yields the deposit beta,  $\hat{\beta}_{ij}$ , for each bank branch. The second step is to relate deposit betas to market power. We then average deposit beta by county, sort counties into twenty buckets by Herfindahl index, and report average county deposit betas by bucket. Panel A shows the result for 10K money market accounts. Panel B shows the result for 12-month certificate of deposits. Panel C shows the result for deposit growth.

Panel A: Savings Deposits



Panel B: Time Deposits



Panel C: Deposit Flows

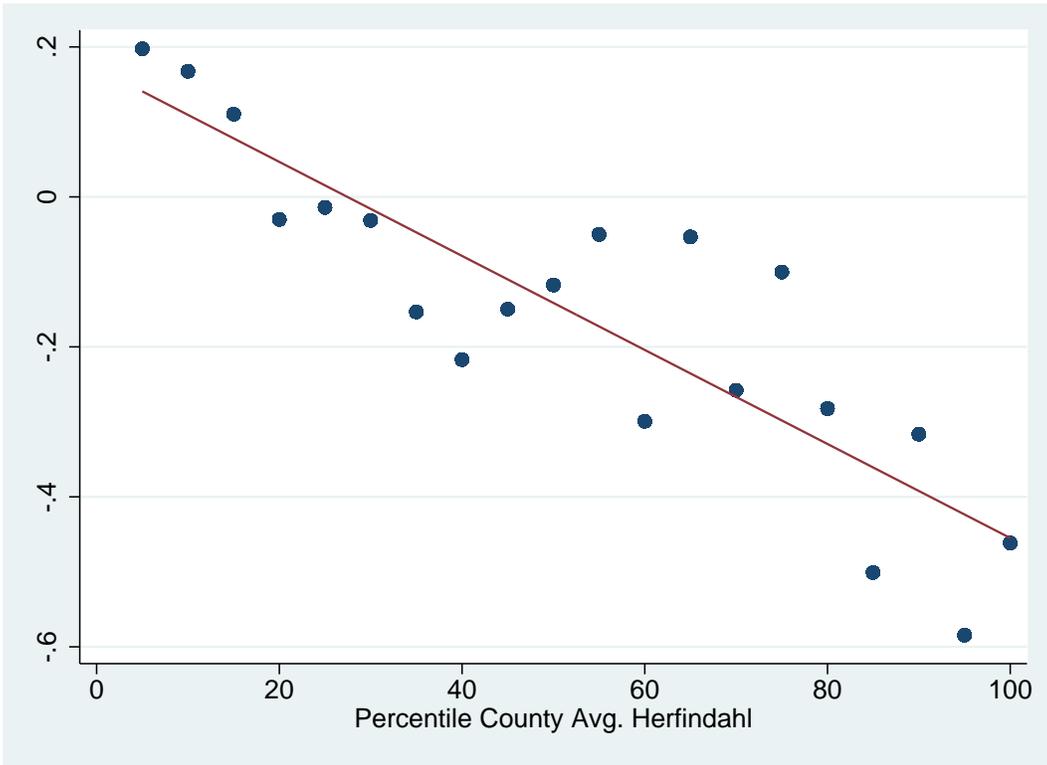
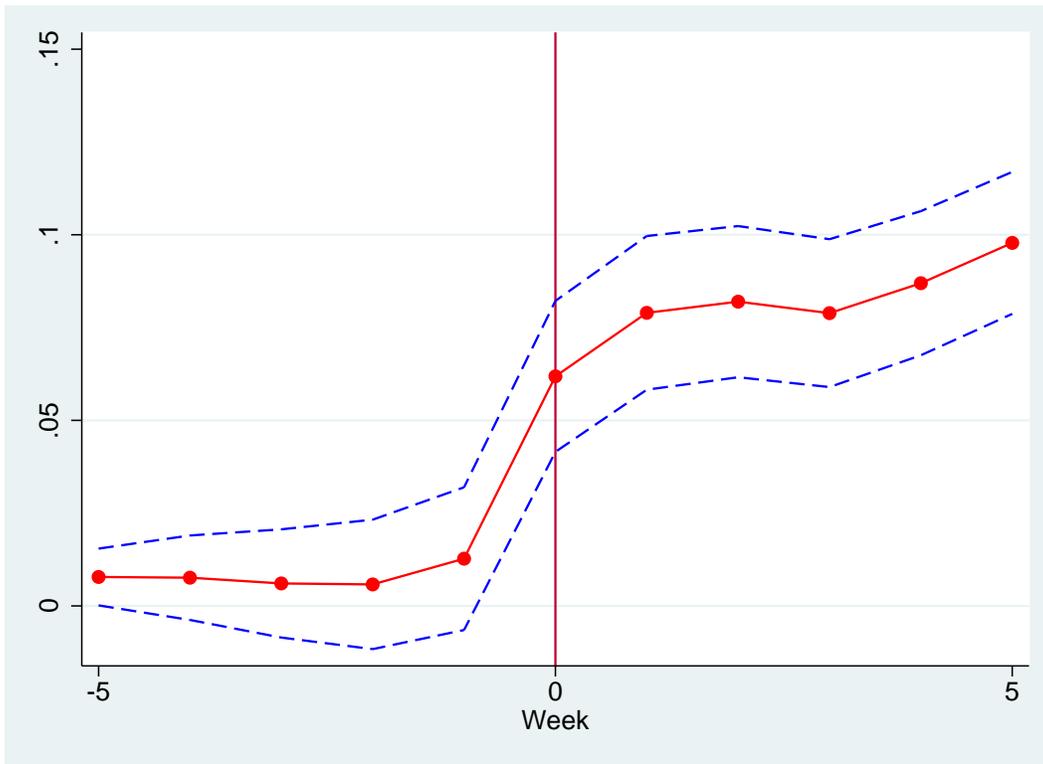


Figure 5: **The price of deposits and market power, event study**  
 The figure plots the coefficient sum  $\sum_{\tau=-5}^t \gamma_{\tau}$  for  $t = -5, \dots, 5$  weeks, and 95%-confidence interval, estimated from the regression

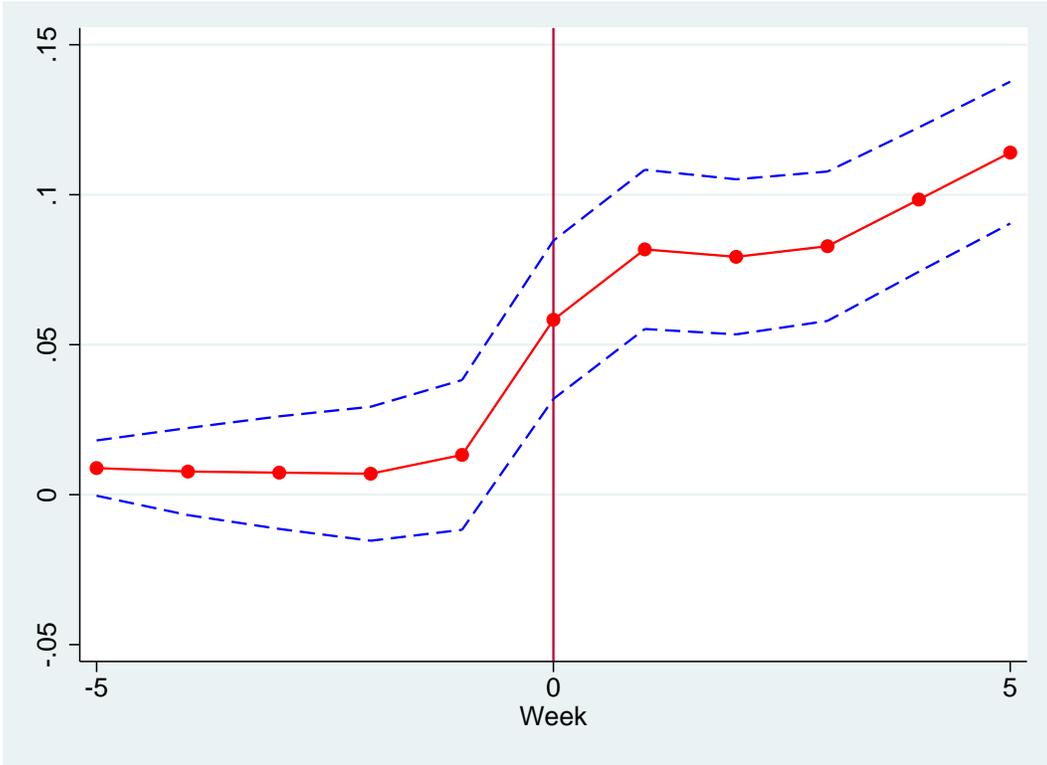
$$\Delta \text{Spread}_{ijct} = \alpha_t + \beta \text{Herfindahl}_c + \sum_{\tau=-5}^5 \gamma_{\tau} \text{Herfindahl}_c \times \Delta \text{FF}_{t-\tau} + \varepsilon_{ijct}.$$

where  $\Delta \text{Spread}_{ijct}$  is the change in the Fed funds rate minus the change in the deposit rate on 10K money market accounts over a week. Herfindahl is the average county-level Herfindahl index calculated based on deposit market shares by bank.  $\Delta \text{FF}$  is the change in the Fed funds target rate over a week. The sample are all branches in the Ratewatch data from January 1, 1997 to June 30, 2008. Panel A uses the actual change in the Fed funds target rate; Panel B uses the anticipated change; and Panel C uses the surprise change. These are from Kuttner (2001) and are constructed from Fed funds futures.

Panel A: Total  $\Delta \text{FF}$



Panel B: Anticipated  $\Delta FF$



Panel C: Surprise  $\Delta FF$

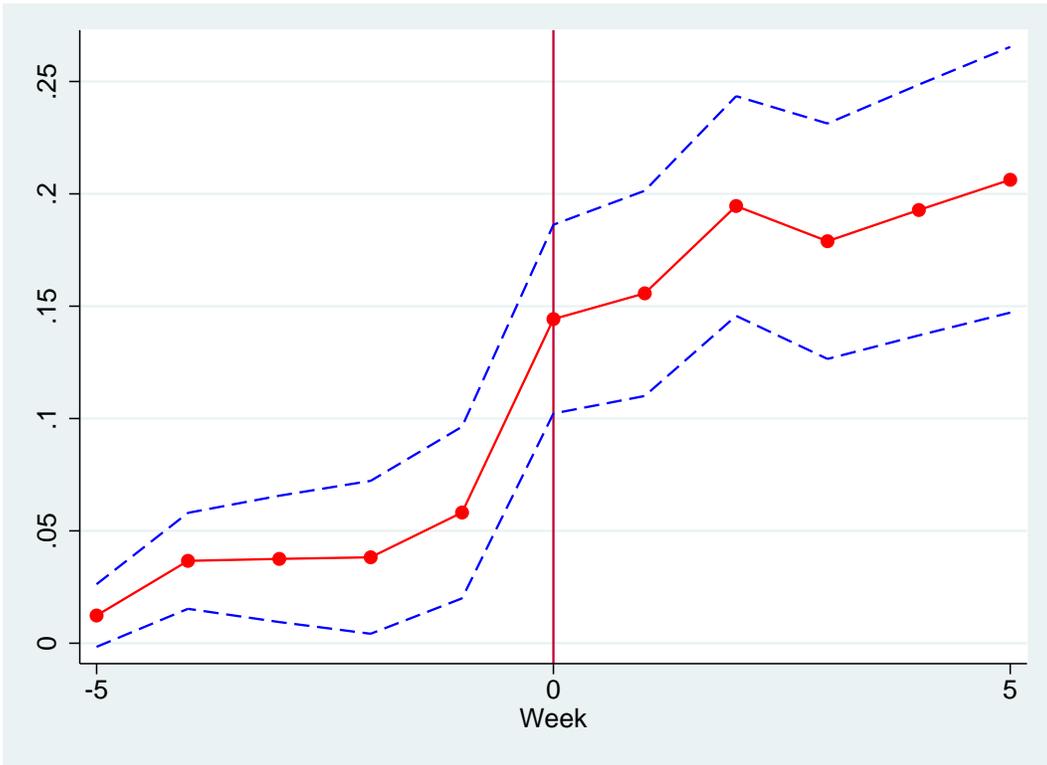


Table 1: **Descriptive statistics**

Table 1 provides annual summary statistics at the branch, bank, and county level. Panel A covers county-level data for all U.S. counties with at least one branch. The data are from the Census Bureau, Call reports, and the FDIC. Panel B covers branch-level data for the rate-setting branches. The data are from the FDIC and Ratewatch. Panel C covers bank-level data for all U.S. commercial banks. The data are from Call Reports.

Panel A: County characteristics

	All			Low Herfindahl			High Herfindahl		
	Mean	Median	St. Dev.	Mean	Median	St. Dev.	Mean	Median	St. Dev.
Population	91,359	25,113	295,027	151,156	49,889	395,672	31,515	13,496	101,502
Area (sq. mi.)	1,055	613	2,483	918	620	1,317	1,193	602	3,252
Median h'hold income	36,012	34,349	10,214	38,815	36,953	10,662	33,212	31,889	8,905
Poverty rate	14.61	13.60	6.14	13.07	12.40	5.17	16.15	14.90	6.63
Unemployment rate	5.44	5.00	2.42	5.15	4.80	2.07	5.74	5.20	2.68
Herfindahl	0.354	0.290	0.214	0.204	0.206	0.051	0.503	0.434	0.210
Obs. (county×year)	46,674			23,335			23,329		

Panel B: Branch characteristics

	All			Low Herfindahl			High Herfindahl		
	Mean	Median	St. Dev.	Mean	Median	St. Dev.	Mean	Median	St. Dev.
Deposits (mill.)	122	51	830	108	53	402	137	49	1,103
Deposit growth	6.19	3.74	18.16	7.06	4.17	19.69	5.33	3.38	16.46
Herfindahl	0.239	0.203	0.139	0.146	0.149	0.036	0.332	0.285	0.141
MMA 10k spread	1.65	1.66	1.53	1.63	1.64	1.52	1.68	1.68	1.53
12-month CD 10k spread	-0.07	0.01	0.97	-0.08	0.00	0.97	-0.07	0.02	0.97
Obs. (branch×year)	97,751			48,911			48,840		

Panel C: Bank characteristics

	All			Low Herfindahl			High Herfindahl		
	Mean	Median	St. Dev.	Mean	Median	St. Dev.	Mean	Median	St. Dev.
Assets (mill.)	765	79	13,817	704	91	9,167	947	81	18,317
Herfindahl	0.244	0.212	0.137	0.152	0.157	0.041	0.336	0.291	0.137
Deposits spread	1.05	1.24	1.48	1.00	1.19	1.51	1.04	1.24	1.42
Assets growth	9.92	6.43	15.70	11.37	7.34	16.77	8.54	5.74	14.04
Deposit growth	9.93	5.93	18.17	11.44	6.80	19.51	8.40	5.29	15.93
Loan growth	11.81	8.28	19.83	13.47	9.31	21.15	10.14	7.45	17.52
Total Deposits/Assets	0.830	0.860	0.113	0.837	0.861	0.095	0.837	0.860	0.091
Demand deposits/Assets	0.128	0.117	0.065	0.132	0.119	0.068	0.125	0.117	0.058
Savings deposits/Assets	0.199	0.179	0.107	0.217	0.197	0.110	0.186	0.167	0.099
Time deposits/Assets	0.391	0.403	0.133	0.383	0.393	0.133	0.405	0.415	0.121
Equity/Assets	11.113	9.514	5.945	10.440	9.264	4.568	10.699	9.624	4.310
Securities/Assets	25.614	23.910	14.827	24.787	22.972	14.697	26.490	24.806	14.359
Loans/Assets	0.602	0.623	0.161	0.617	0.636	0.155	0.603	0.621	0.152
Real estate loans/Assets	0.361	0.359	0.170	0.390	0.387	0.168	0.352	0.349	0.162
C&I loans/Assets	0.099	0.083	0.071	0.105	0.089	0.073	0.093	0.079	0.065
Obs. (bank×year)	122,821			55,773			55,756		

Table 2: **The price of deposits and market power**

This table examines the effect of monetary policy on the price of deposits (deposit spreads). The sample are banks with two or more rate-setting branches from January 1, 1997 to June 30, 2008.  $\Delta$  Spread is the change in the deposit spread, which is computed as the change in the Fed funds target rate minus the change in the deposit rate over a quarter. Herfindahl is the average county-level Herfindahl index computed from deposit market shares by bank.  $\Delta$  FF is the change in the Fed funds target rate over a quarter. Panel A reports the results for savings deposits (10K money market accounts). Panel B reports the results for time deposits (12-month certificate of deposits). Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

Panel A: Savings Deposits				
	$\Delta$ Spread			
	(1)	(2)	(3)	(4)
$\Delta$ FF * Herfindahl	0.095** (0.040)	0.144*** (0.044)	0.125*** (0.034)	0.122*** (0.036)
Quarter f.e.	Y	N	N	N
County f.e.	Y	Y	Y	N
State x quarter f.e.	N	Y	Y	Y
Bank x quarter f.e.	N	N	Y	Y
Branch f.e.	N	N	N	Y
$R^2$	0.540	0.567	0.804	0.810
Observations	87,186	87,186	87,186	87,186
Panel B: Time Deposits				
	$\Delta$ Spread			
	(1)	(2)	(3)	(4)
$\Delta$ FF * Herfindahl	0.061** (0.025)	0.086*** (0.023)	0.049** (0.019)	0.050** (0.021)
Quarter f.e.	Y	N	N	N
County f.e.	Y	Y	Y	N
State x quarter f.e.	N	Y	Y	Y
Bank x quarter f.e.	N	N	Y	Y
Branch f.e.	N	N	N	Y
$R^2$	0.357	0.410	0.770	0.776
Observations	93,225	93,225	93,225	93,225

Table 3: **Deposit flows and market power**

This table examines the effect of monetary policy on deposit flows. The sample are all commercial banks in the FDIC data from June 30, 1994 to June 30, 2008. Deposit growth is the log growth in branch-level deposits over a year. Herfindahl is the average county-level Herfindahl index computed from deposit market shares by bank.  $\Delta$  FF is the change in the Fed funds target rate over a quarter. Fixed effects are denoted at the bottom of the table. Standard errors are clustered by county.

	Deposit growth			
	(1)	(2)	(3)	(4)
$\Delta$ FF * Herfindahl	-2.468*** (0.246)	-2.360*** (0.214)	-1.413*** (0.334)	-0.984*** (0.279)
Year f.e.	Y	N	N	N
Branch f.e.	Y	Y	Y	Y
State x year f.e.	N	Y	N	Y
Bank x year f.e.	N	N	Y	Y
$R^2$	0.31	0.32	0.45	0.46
Observations	906,122	906,122	906,122	906,122

Table 4: **The price of deposits and market power, expected Fed funds changes**  
This table examines the effect of expected changes in monetary policy on the price of deposits (deposit spreads). The sample are banks with two or more rate-setting branches from January 1, 1997 to June 30, 2008.  $\Delta$  Spread is the change in the deposit spread, which is computed as the change in the Fed funds target rate minus the change in the deposit rate over a quarter. Herfindahl is the average county-level Herfindahl index computed from deposit market shares by bank.  $\Delta$  Exp. FF is the expected change in the Fed funds target, which is computed as the difference between the Fed Funds target rate minus the Fed funds Futures rate three months ahead at the start of a quarter. Panel A reports the results for savings deposits (10K money market accounts). Panel B reports the results for time deposits (12-month certificate of deposits). Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

Panel A: Savings Deposits				
	$\Delta$ Spread			
	(1)	(2)	(3)	(4)
$\Delta$ Exp. FF * Herfindahl	0.152** (0.059)	0.219*** (0.064)	0.183*** (0.054)	0.182*** (0.058)
Quarter f.e.	Y	N	N	N
County f.e.	Y	Y	Y	N
State x quarter f.e.	N	Y	Y	Y
Bank x quarter f.e.	N	N	Y	Y
Branch f.e.	N	N	N	Y
$R^2$	0.540	0.567	0.804	0.811
Observations	87,186	87,186	87,186	87,186
Panel B: Time Deposits				
	$\Delta$ Spread			
	(1)	(2)	(3)	(4)
$\Delta$ Exp. FF * Herfindahl	-0.054 (0.037)	-0.023 (0.032)	0.057** (0.026)	0.056** (0.028)
Quarter f.e.	Y	N	N	N
County f.e.	Y	Y	Y	N
State x quarter f.e.	N	Y	Y	Y
Bank x quarter f.e.	N	N	Y	Y
Branch f.e.	N	N	N	Y
$R^2$	0.357	0.409	0.770	0.776
Observations	93,225	93,225	93,225	93,225

Table 5: **Deposit flows and rate setter's market power**

This table examines the effect of changes in monetary policy on deposit flows. The sample are non-rate setting branches that are not located in the same county as their rate setting branch from June 30, 1994 to June 30, 2008. R.s. Herfindahl is the average county-level Herfindahl index computed from deposit market shares by bank for the county where the rate-setting branch is located. Deposit growth is the log growth rate in branch-level deposits over the year. Fixed effects are denoted at the bottom of the table. Standard errors are clustered by county.

	Deposit growth			
	(1)	(2)	(3)	(4)
$\Delta \text{FF} \times \text{R.s. Herfindahl}$	-0.980*** (0.354)	-1.731*** (0.361)	-1.751*** (0.537)	-1.707*** (0.507)
Year f.e.	Y	Y	N	N
Branch f.e.	N	Y	N	Y
County $\times$ year f.e.	N	N	Y	Y
$R^2$	0.006	0.367	0.156	0.473
Observations	218,975	218,975	218,975	218,975

Table 6: **Bank liabilities and market power**

This table examines the effect of monetary policy on bank liabilities. The sample consists of commercial banks from the Call Reports from January 1, 1994 to June 30, 2008. The bank-level Herfindahl is calculated as the weighted average of county-level Herfindahl indices using branch-level deposits lagged by one quarter as weights. The quantity-based dependent variables are calculated as log growth over a quarter. The deposit spread is the change in the Fed funds rate minus the change in the deposit rate over a quarter. The main effects (Herfindahl, Equity/Assets, Securities/Assets) are included as control variables in the regressions (coefficients not shown). All regressions include bank and quarter fixed effects. Standard errors are clustered by bank.

	Total deposits		Demand deposit		Savings deposit		Time deposit		$\Delta$ Spread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\Delta$ FF x Herfindahl	-1.498*** (0.170)	-1.098*** (0.162)	-0.665** (0.272)	-0.453* (0.271)	-1.061*** (0.280)	-0.831*** (0.276)	-2.843*** (0.253)	-2.250*** (0.243)	0.023*** (0.004)	0.024*** (0.004)
$\Delta$ FF x Sec./Assets		-0.020*** (0.002)		-0.009*** (0.003)		-0.009*** (0.003)		-0.031*** (0.003)		0.000*** (0.000)
$\Delta$ FF x Equ./Assets		-0.011 (0.010)		0.028* (0.017)		0.058*** (0.015)		-0.055*** (0.012)		0.000 (0.000)
Quarter f.e.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bank f.e.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
$R^2$	0.168	0.231	0.089	0.099	0.082	0.101	0.16	0.206	0.81	0.81
Observations	443,591	443,591	441,761	441,761	439,551	439,551	441,282	441,282	443,612	443,612

Table 7: **Bank lending and market power**

This table examines the effect of monetary policy on bank lending. The sample consists of commercial banks from the Call Reports from January 1, 1994 to June 30, 2008. The bank-level Herfindahl is calculated as the weighted average of county-level Herfindahl indices using branch-level deposits lagged by one quarter as weights. The quantity-based dependent variables are calculated as log growth over a quarter. The main effects (Herfindahl, Equity/Assets, Securities/Assets) are included as control variables in the regressions (coefficients not shown). All regressions include bank and quarter fixed effects. Standard errors are clustered by bank.

	Assets		Real Estate Loans		C&I Loans		Securities	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta$ FF x Herfindahl	-1.026*** (0.136)	-0.694*** (0.128)	-0.711*** (0.229)	-0.599*** (0.219)	-0.878** (0.378)	-0.717* (0.374)	-0.903** (0.356)	-0.477 (0.358)
$\Delta$ FF x Securities/Assets		-0.019*** (0.001)		0.000 (0.002)		-0.008** (0.004)		-0.014*** (0.004)
$\Delta$ FF x Equity/Assets		-0.01 (0.007)		0.017 (0.012)		0.039** (0.018)		0.037** (0.016)
Quarter f.e.	Y	Y	Y	Y	Y	Y	Y	Y
Bank f.e.	Y	Y	Y	Y	Y	Y	Y	Y
$R^2$	0.174	0.218	0.168	0.211	0.054	0.069	0.057	0.088
Observations	443,748	443,748	439,803	439,803	438,467	438,467	439,322	439,322

Table 8: **The price of deposits and market power, branch concentration**

This table examines the effect of monetary policy on the price of deposits (deposit spreads). The sample are banks with two or more rate-setting branches from January 1, 1997 to June 30, 2008.  $\Delta$  Spread is the change in the deposit spread, which is computed as the change in the Fed funds target rate minus the change in the deposit rate over a quarter. Branch herfindahl is the average county-level Herfindahl index computed from deposit market shares by branch.  $\Delta$  FF is the change in the Fed funds target rate over a quarter. Panel A reports the results for savings deposits (10K money market accounts). Panel B reports the results for time deposits (12-month certificate of deposits). Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

Panel A: Saving Deposits				
$\Delta$ Spread				
	(1)	(2)	(3)	(4)
$\Delta$ FF $\times$ Herfindahl	0.052*	0.057*	0.073***	0.081**
	(0.028)	(0.033)	(0.027)	(0.031)
Branch f.e.	N	Y	N	Y
Bank $\times$ quarter f.e.	Y	Y	Y	Y
State $\times$ quarter f.e.	N	N	Y	Y
$R^2$	0.632	0.648	0.652	0.668
Observations	88,481	88,481	88,481	88,481
Panel B: Time Deposits				
$\Delta$ Spread				
	(1)	(2)	(3)	(4)
$\Delta$ FF $\times$ Herfindahl	0.050***	0.065***	0.037**	0.051**
	(0.019)	(0.022)	(0.019)	(0.022)
Branch f.e.	N	Y	N	Y
Bank $\times$ quarter f.e.	Y	Y	Y	Y
State $\times$ quarter f.e.	N	N	Y	Y
$R^2$	0.855	0.860	0.863	0.868
Observations	91,548	91,548	91,548	91,548

Table 9: **Deposit flows and market power, branch concentration**

This table examines the effect of monetary policy on deposit flows. The sample are all commercial banks in the FDIC data from June 30, 1994 to June 30, 2008. Deposit growth is the log growth in branch-level deposits over a year. Herfindahl is the average county-level Herfindahl index computed from deposit market shares by branch.  $\Delta$  FF is the change in the Fed funds target rate over a quarter. Fixed effects are denoted at the bottom of the table. Standard errors are clustered by county.

	Deposit growth			
	(1)	(2)	(3)	(4)
$\Delta$ FF $\times$ Herfindahl	-1.549*** (0.211)	-3.166*** (0.224)	-2.008*** (0.268)	-1.519*** (0.238)
Year f.e.	Y	Y	N	N
Branch f.e.	N	Y	Y	Y
Bank $\times$ year f.e.	N	N	Y	Y
State $\times$ year f.e.	N	N	N	Y
$R^2$	0.005	0.310	0.428	0.435
Observations	873,686	873,686	873,686	873,686