Information Problems and Deposit Constraints at Banks

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Abstract

Following the investment-cash flow literature, we test whether bank lending is constrained by the availability of insured deposits--a necessary condition for the existence of a bank lending channel of monetary policy. We treat insured deposits as a type of "internal fund," similar to cash flows. We use a simple model to sort out the possible identification issues in interpreting the correlation between lending and deposit growth, including reverse causality and omitted variable bias. To minimize the latter, we split the sample of banks by leverage and also use deposit flows at sister banks within a holding company as an "instrument." The results are consistent with the existence of frictions in capital markets facing banks, and that such frictions force bank lending to be constrained by the availability of insured deposits. However, the frictions seem to matter only at small banks, suggesting that the bank lending channel of monetary policy is small.

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1. Introduction

This paper looks for evidence that bank lending is constrained by the availability of insured deposits because of informational frictions in the market for their *un*insured liabilities. While the presence of such frictions in the market for debt of *non-financial* firms has been thoroughly explored, these problems might be just as big, if not bigger, for banks. The role of banks and other intermediaries, according to theory, is to screen and monitor borrowers (Diamond 1984). If the information they produce about their loans is hard for outsiders to observe, the resulting asymmetry may hamper the ability of banks to fund their lending in capital markets. Regulators certainly seem concerned by that possibility; after all, banks would not have access to the discount window if they had equally good access to market sources of funds.

In testing for deposit constraints on bank lending, we employ the strategy and tactics used in the large literature that tests for cash-flow constraints on investment by non-financial firms. If firms have perfect access to capital markets, non-financial firms should be indifferent between funding their investment with external funds and internal cash flow. The finding that investment and cash-flow are correlated, given investment opportunities, can be taken as evidence of frictions in the market for external funds. Houston et. al. (1996), one of the few studies of liquidity constraints faced by banks, implement such a test to find that bank lending is cash flow constrained.

This paper focuses on deposit constraints. Banks' access to insured deposits is a crucial difference between banks and non-banks. Since deposits are federally insured, they are equivalent to cash flows as a form of "internal funds." In fact, insured deposits are a far more important

source of funds than are cash flows, as seen in Table 1. Even the larger banks, those in top quartile, fund nearly three fourths of their assets using insured deposits. Cash flow, on the other hand, finances no more than four percent of bank assets. This is in sharp contrast to industrial firms, for example, that rely far more on retained earnings.

Our test for deposit constraints also bears on a very basic question about the transmission of monetary policy: can the central bank still reduce the supply of bank loans by draining reserves? In theory, banks could maintain their lending after a loss of reserves by issuing large certificates of deposits (CDs) or other notes that no longer require reserves (Romer and Romer 1990). This basic point seems to rule out the possibility of a significant lending channel in the monetary transmission mechanism.[1] What this point overlooks, however, is that the deposits that still require reserves are also federally insured, whereas a substantial portion of the *nonreservable* liabilities (large CDs, notes, and debentures) are not.[2] Informational frictions in the market for these *uninsured* bank liabilities may prevent banks from completely offsetting a reduction in the supply of insured liabilities, leaving open the possibility of a bank lending channel (Stein 1995).

To determine if frictions in the market for uninsured liabilities lead to deposit constraints on banks' lending, we test whether slower growth in *insured* deposits at a bank is associated with slower growth in lending. We interpret a positive correlation between lending and insured deposit growth as evidence that banks face an inelastic supply of *uninsured* deposits. In essence, we are

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[1] See Kashyap and Stein (1995) for a more thorough discussion of the bank lending channel.

[2] Small CDs do not require reserves, but *are* insured. As long as banks face an inelastic supply of such deposits (say because they are less liquid than large CDs), the impact of a monetary contraction on lending will still depend on the extent of frictions in the market for uninsured, non-reservable liabilities (see Stein 1995).

replacing investment with lending, and cash flow with insured deposits. One potential problem with our strategy is that a bank *chooses* the level of insured deposits, whereas cash flow is essentially exogenous. The endogeneity of deposits creates the potential for reverse causality: growth in loan demand at a bank may cause the bank to issue more *insured* deposits. However, we argue that reverse causality is actually not a problem. Using a simple model of a bank's funding decision, we show that an increase in loan demand will lead banks to issue more *insured* deposits if and only if the supply of insured funds inelastic, due to frictions. Absent frictions, the supply of *uninsured* funds is flat and a bank will fund marginal loan opportunities by issuing only uninsured liabilities. Although the reduced form equation we estimate does not allow us to determine whether deposit growth drives lending or the other way around, the direction of causality is unimportant; what matters is that frictions in capital markets create a link between lending and deposits.

There is another, more important, problem in interpreting a lending-deposit link: lending and deposits may move together simply because faster deposit growth signals growing demand for loans. We call this omitted variable bias because if we could fully control for loan demand, the correlation would disappear. This omitted variable problem is familiar from the investment-cash flow literature, which has the same problem: investment may increase with cash flow because the higher cash flow is a sign of improving investment opportunities.

We confront the omitted variable problem using the same tactics as the liquidity constraints literature. First, we control for loan demand as best as possible using Tobin's *Q*, lagged loan growth, and current loan growth in the state where a bank operates. Second, we split the sample of banks or holding companies by their net worth, or capital. Theory suggests that

agency problems and other frictions in capital markets are decreasing in a borrower's, or in this case a bank's, capital (Bernanke and Gertler 1989). A more recent paper by Holmstrom and Tirole (1997) shows that a savings squeeze, which can be interpreted as a reduction in deposit supply to banks, hits poorly capitalized banks the hardest. Accordingly, we test whether the deposit-lending correlation is higher at more highly leveraged banks. As a third precaution against omitted variable bias, we replace deposit growth at a bank with deposit growth at all the other banks in its holding company. Deposit growth at the sister banks act as an "instrument" for the bank's own deposit growth. It is a source of funds to the bank, provided through internal capital markets, that is not necessarily correlated with the lending opportunities at that bank. This approach--of relying on an instrumental variable--follows Lamont (1996) who exploited the holding company structure at non-financial firms to test for cash-flow constraints and Houston et. al. (1996) who use it to test for cash flow constraints at banks.

Our results are consistent with existence of capital market frictions facing banks, although the frictions seem to matter only at small banks. We use a sample of banks between 1992-95 that are affiliated with publicly traded bank holding companies. For the full panel, we find that, on average, reliance on insured funds decreases and issuance of uninsured funds increases as capital increases. We also find that year to year growth in lending is more correlated with growth in insured deposits, the more leveraged the bank. Omitted variable bias might explain why lending and deposit growth are correlated across banks, but it is less obvious why the link should be tighter at more highly leveraged banks. We also find that growth in lending at a bank is also correlated with deposit growth at its sister banks. Taken together, these results are all consistent with frictions, which are necessary for a lending channel. Another result, however, suggests that

the scope of that channel may be small: when we split the sample into small banks and large banks, we find that the lending-deposit relationship depends on leverage only at small banks. Since the small banks are responsible for a relatively small share of lending, this result suggests that the impact of the lending channel may be limited.

2. Related literature

Several theoretical papers explore how informational frictions at the bank level can force banks' lending to be constrained by the supply of insured deposits. Stein (1995) develops an adverse selection model in which investors charge a premium on uninsured bank debt because lenders cannot distinguish "good" banks from "bad" ones. Insured deposits do not carry such an external premium because of the government guarantee attached to such funds. When the supply of insured deposits decreases, the premium on external funds discourages good banks from issuing uninsured liabilities to compensate for the reduction in the supply of insured deposits, forcing them to reduce lending.

Theory has also illustrated how an intermediary's leverage increases its credit constraints. Holmstrom and Tirole (1997) present a moral hazard model of intermediation in which the intermediary's incentive to screen and to reject poor projects is an increasing function of their capital. A key result in their model is that the investment response to a decline in savings is larger at poorly capitalized firms and banks.

An earlier banking model by Bernanke and Gertler (1987) most explicitly captures the interaction between capital structure and lending constraints at banks. In their model, a bank's capital determines the amount of riskless claims it can issue, which in turn determines the relative

amount of loans and securities it can hold.[3] This capital constraint prevents banks from funding all profitable loans, so that in equilibrium, the expected return on the marginal loan exceeds the return on safe securities. Given that wedge, any factor that increases the supply of riskless deposits to banks will also increase their lending. Moreover, lending at poorly capitalized banks will be more sensitive to deposit shocks because the wedge between returns on loans and securities is larger at such banks.

An empirical literature is now emerging that investigates informational frictions and financial constraints at banks. Kashyap and Stein (1995, 1997) have been most ambitious in investigating this issue. Their first paper shows that lending by smaller banks is more sensitive to changes in monetary policy than lending by smaller banks. In their second paper, they show that the impact of monetary policy is significantly stronger at banks with less liquid balance sheets, as measured by the ratio of cash and securities to assets.

Although the basic issues are similar, this paper differs in three key ways. First, our empirical tests follow the strategy of the investment-cashflow literature more closely. For example, we include Tobin's *Q* to control for lending opportunities at a banks' holding company. Second, we use bank capital, rather than size, as the primary proxy for banks' access to capital markets. Given the theoretical link between capital structure and agency problems, cutting by

[3] Banks can only issue riskless claims against loans in their model because the return on loans is observed only by the banker, but not outside investors. This information asymmetry prevents banks from funding their loans with risky claims; investors cannot share the risky returns if they cannot observe them. Banks are forced to finance their loans with riskless deposits that are redeemable at par, regardless of the return on loans. To ensure the deposits are risk free, banks must hold enough capital that to cover even the lowest possible return on loans. Thus, a bank's capital determines the amount of riskless claims it can issue, which in turn determines the amount of lending it can do.

capital seems like a useful test. We think of this as a complementary test, however, since both size and capital may be important determinants of banks' access to uninsured funds. Third, we examine the direct link between lending and deposit growth at banks more generally, while they investigate the link only indirectly, during episodes of tight policy. Our broader focus seems desirable since these deposits constraints should operate at all times, not just during tight policy. Moreover, monetary policy is not the only source of fluctuations in deposit growth. Real shocks, through their affect on savings, will also affect the supply of deposits to banks. Even reallocations of deposits across banks can affect lending when there are frictions in the market for uninsured funds.

While focussing on the deposit lending link in general has advantages, it also opens the door to the types of identification problems discussed in the introduction. In the section below, we lay out the bank analogue to the investment-cashflow regression. We then present a simple model of banks' funding decision to help sort out the identification issues.

3. Empirical Strategy

3.1 The empirical model

The cash flow-investment literature has tested for capital market frictions faced by non-financial firms by seeing if investment by such firms depend on cash flows. That literature interprets a positive correlation between cash flows and investment (after controlling for investment opportunities) as evidence of liquidity constraints. We use a similar approach when testing whether bank lending depends on insured deposits because of credit market frictions. We simply replace investment with loan growth and cash flows with insured deposit growth. The empirical model which is our point of departure, then, is:

$$L_{i,t} = \alpha_0 + \alpha_i + \alpha_t + \alpha_1 D_{i,t} + \alpha_2 W_{i,t-1} + \epsilon_{i,t} \qquad (1)$$

where $L_{i,t}$ is loan growth at bank *i* in year t, α_i and α_t are fixed bank and year effects, $D_{i,t}$ is deposit growth at bank *i* in year t, and $W_{i,t-1}$ is a vector of variables that control for loan demand facing bank *i* (including Tobin's *Q*).

The key issue is interpreting the coefficient on deposit growth, α_1. If capital market frictions in the market for *uninsured* funds cause banks to depend on insured deposits, we should find $\alpha_1 > 0$; reductions in the growth of deposits force banks to slow their lending. However, there are at least two reasons why α_1 may be positive even in the absence of capital market frictions. First, a positive shock to loan demand may lead banks to raise more insured deposits to fund the loans. We call this reverse causality since loan growth is driving deposit growth, rather than the other way around.

The simple model of banks' funding choice in the next section shows that reverse causality is not actually a problem for us in the following sense: reverse causality will not produce a positive α_1 unless banks face frictions in the markets for uninsured funds. Absent such frictions, $\alpha_1 = 0$. The intuition is as follows: if the supply of uninsured funds is perfectly elastic because banks do not face frictions in these markets, and if the marginal loan is funded with such uninsured funds, banks fund additional loans with uninsured funds, not with insured deposits (so that an increase in loan demand will not lead to any increase in deposit intake). However, when the supply of uninsured funds is inelastic due to capital market frictions, banks will fund additional loans with a mix of uninsured funds and insured deposits, generating a positive α_1.

The second reason why α_1 may be positive even in the absence of capital market frictions is that deposit growth may signal changes in loan demand. If we omit variables such as local economic conditions that affect both loan growth and deposit growth, this omitted variable bias may generate a spurious positive correlation between $L_{i,t}$ and $D_{i,t}$ (omitted variable bias). In contrast to reverse causality, which is not actually a problem, omitted variable bias is a serious problem.

This omitted variable problem is not uniquely a problem for us, however; the cash flow-investment literature faces the same problem. Investment may be correlated with cash flow because cash flow is a proxy for investment demand. A positive cash flow-investment correlation need not indicate liquidity constraints, but instead it may indicate better investment potential. We try to minimize the potential for omitted variable bias in the same three ways as the cash flow investment literature, as described in the introduction.[4]

3.2 On Reverse Causality and Omitted Variable Biases: A Simple Linear Example and Its Implications for the Empirical Method

Consider the simple single-bank asset case where banks only make loans, L. The marginal revenue from lending is $r^L = l_0 - l_1 L$. We use changes in l_o to stand in for shifts in loan demand. We assume $l_1 > 0$, implying the marginal revenue from lending is decreasing. This is a common assumption, justified by evidence that banks have some pricing power in local markets, due to either geographic or informational considerations.

[4] One solution used by the cash flow-investment literature is to lag the measure of cash flows in the regression. We do not lag insured deposit growth here because we find that in our annual data, insured deposit growth is only weakly correlated over time--hence, it's a weak "instrument" for $D_{i,t}$.

Banks fund their loans with insured deposits, D, and with uninsured funds, U.[5] The marginal cost of deposits and uninsured funds are, respectively, $r^D = d_0 + d_1 D$, and $r^U = u_0 + u_1 U$. We will use variation in the intercept, d_o, to capture shocks to the supply of insured deposits, whether from monetary policy or any other source. We assume $u_0 > d_0 > 0$ to capture the idea that federal deposit insurance is provided at subsidized rates. This subsidy implies that insured deposits are initially less expensive than uninsured funds so banks will fund their first loan with insured funds. We also assume the marginal cost of deposits is increasing, $d_1 > 0$, on the grounds that banks have some market power in local deposit markets.

The key parameter is u_1, which determines whether the marginal cost of *uninsured* funds is flat or increasing. Absent informational problems, we would expect $u_1 = 0$, because the market for large CDs and notes is a large, national market in which individual banks are price takers. Informational problems, however, will lead investors in the market for uninsured bank liabilities to charge a lemon's premium. If the lemon's premium is increasing in the amount of funds sold by the bank, we would expect $u_1 > 0$. The only assumption we will make on this parameter is that $d_1 > u_1 \geq 0$, implying that the marginal cost of insured funds is steeper than the marginal cost of uninsured funds. This assumption ensures that if loan demand is large enough, banks will fund their marginal loan with uninsured funds. The latter assumption is consistent with our sample, in

[5] For the sake of simplicity, we do not consider equity funding of new loans, but we assume that banks hold a stock of loans originated in previous periods that were funded by a mix of equity, insured deposits and uninsured funds.

which all banks, even the smallest, have at least some amount of uninsured funds in their liability mix.[6]

To maximize profits, banks choose the optimal amount of loans and fund them with the cost-minimizing combination of insured deposits and uninsured funds. Optimality requires that the revenue from the marginal loan equals the marginal cost of insured and uninsured funds: $r^L = r^D = r^U$. The bank must also satisfy the balance sheet condition: $L = D + U$. These two condition and the equations above determine the equilibrium quantities of loans, deposits, and uninsured funds: L^*, D^*, U^*. From these solutions, we can determine how shifts in the supply of deposits to banks (d_0) and in the demand for loans (l_0) change the equilibrium quantities of lending and deposits.

<u>Result 1</u>: A reduction in the supply of deposits (that is, an increase in d_0) will reduce bank lending if and only if the marginal cost of uninsured funds is increasing ($u_1 > 0$),:

The proof of this claim stems from the closed form solution for the equilibrium quantity of loans. From the solution for L^*, it can be shown that:

$$\frac{\partial L^*}{\partial d_0} = \frac{-u_1}{u_1(d_1+l_1)+l_1 d_1} \qquad (2)$$

Result 1 is easily derived from equation (2). If the marginal cost of uninsured funds is flat ($u_1 = 0$), reductions in the supply of *insured* funds will not affect lending; banks will maintain their lending by substituting uninsured funds. This is simply the point made by Romer and Romer (1990). Kashyap and Stein (1995) and other have countered that their point assumes that banks

[6] For the full sample, the median ratio of uninsured funds to assets was 11 percent. The ratio for ninety-nine percent of bank-years was above 1.9 percent. Only five bank-years had a ratio of uninsured funds to assets below one percent.

face no frictions in the market for uninsured funds. We propose to test for such frictions by estimated equation (1) and testing whether loan growth and deposit growth are positively correlated (i.e., $\alpha_1>0$ in equation [1]).[7]

Result 1, or the counter result, can also seen with the aid of a simple figure that illustrates the case where the bank operates in a frictionless market for uninsured funds (Figure 1). Shown is the marginal revenue from lending, the marginal cost of insured deposits, and the marginal cost of uninsured liabilities. The latter is drawn flat to reflect the assumption that the bank faces a perfectly elastic supply of such funds if there are no informational frictions in the market. The equilibrium quantity of lending is L^*, where the three margins are equal, and the balance sheet equation is satisfied ($L = D+U$). It is easy to see that in this case, when marginal cost of uninsured funds is constant, changes in the marginal cost of *insured* deposits will have no effect on the lending; the bank will simply adjust its issuance of *uninsured* liabilities. If the marginal cost of uninsured funds is also increasing, however, the bank's effective marginal cost of funds is the envelope of the two marginal cost curves. Our algebraic results show that in that case (which is harder go show graphically), reductions in the supply of insured deposits will lead the bank to reduces its leading.

Recall the concern about reverse causality: perhaps deposits and lending are correlated because shocks to loan demand cause banks to draw in more deposits. While causality in that direction is a distinct possibility, the next result shows that reverse causality will not lead us to misinterpret $\alpha_1>0$ as evidence of capital market frictions.

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[7] Note that in the end, we will be testing whether or not $u_1=0$. While this bears on the *existence* of a credit channel, the *extent* of the channel depends on the magnitude of u_1.

Result 2: Changes in loan demand affect the equilibrium quantity of *insured* deposits if and only if the marginal cost of *uninsured* funds is increasing, $u_1>0$:

$$\frac{\partial D^*}{\partial l_0} = \frac{u_1}{u_1(d_1+l_1)+l_1 d_1} \qquad (3)$$

If $u_1>0$, banks will fund additional loan demand with both insured deposits and uninsured deposits, adjusting the two sources of funds to keep their marginal costs equal. If the marginal cost of uninsured funds is constant, banks will respond to loan demand shocks only by adjusting their issuance of uninsured funds.

Result 2 shows that reverse causality will not lead us to misinterpret the empirical model of equation (1): reverse causality produces such a correlation between insured deposits and lending only in the presence of frictions in the markets for uninsured funds (although we cannot identify the direction of causality). Figure 2 helps illustrate this result. Again, we "prove" the result by considering the counter case when the bank faces a flat marginal cost of uninsured liabilities, as in figure 1. Note that if the demand for loans increases in that case, the bank funds all the additional loans by issuing more uninsured liabilities, with no change in the quantity of *insured* deposits. However, if frictions in the market for the bank's uninsured debt cause the marginal cost of such funds to increase, the additional loan demand will be funded with both insured deposits *and* uninsured funds, creating a positive correlation between lending and insured deposits.

Although reverse causality is not a problem with our test of credit market constraints, equation (1) and the test of $\alpha_1 \geq 0$ suffers from a second problem. So far we have assumed that loan demand shocks and deposit supply shocks are not correlated. To the extent that they are positively correlated, we will wrongly infer the presence of credit market constraints from an

observed positive correlation between lending and deposit growth. The next two results, which indicate how the *degree* of correlation is affected by the extent of the frictions, suggest one way to minimize the omitted variable bias.

Result 3: The steeper the marginal cost of uninsured funds (the greater is u_1), the greater is the effect of a loan demand shock on deposits:

$$\frac{\partial^2 D^*}{\partial l_0 \partial u_1} = \frac{l_1 d_1}{\left[u_1(d_1+l_1)+l_1 d_1\right]2} > 0 \qquad (4)$$

Result 4: The steeper the marginal cost of uninsured fund (the greater is u_1), the greater is the effect of a deposit supply shock on lending:

$$\frac{\partial^2 L^*}{\partial d_0 \partial u_1} = \frac{-l_1 d_1}{\left[u_1(d_1+l_1)+l_1 d_1\right]2} > 0 \qquad (5)$$

These two results establish that if banks do face credit constraints, then those banks that face greater frictions should exhibit a stronger correlation between lending and deposit taking. We assume that relatively more leveraged banks face greater frictions, and proceed to test whether they show a greater positive correlation between lending and deposit growth. While omitted variable bias might explain a correlation between lending and deposit taking for the full sample, such a bias should not lead to a *greater* correlation for more leveraged banks.

4. Data and results

4.1 Data

Our sample consists of banks affiliated with U.S.-based bank holding companies (BHCs) whose equity was publicly traded for at least thirty weeks in a calendar year. The BHCs had at

least $150 million in assets.[8] The unbalanced panel of annual data from 1992 to 1995 consists of slightly less than 1500 bank subsidiaries of approximately 300 BHCs each year, yielding a total of 4833 bank-year observations. We chose the 1992-95 period because bank capital regulations were fairly stable during this time (and because we rely on bank capital to identify the extent of credit constraints faced by banks).

We use several variables to control for investment/lending opportunities faced by individual banks or their holding company. Following the cash flow-investment literature, we use Tobin's *Q* (the sum of the market value of equity and book value of debt divided by book value of assets). Since only the equity of the BHC is traded, and not the equity of the individual bank, we use *Q* for the BHC as a proxy for *Q* for the bank. The use of *Q* in the context of financial investment may not be as well motivated as in the literature on physical investment (where adjustment costs stories are easier to tell), buts its inclusion here as a forward looking measure of the bank's earning prospects is still important as a way to try and reduce omitted variable bias. Moreover, its use in the banking context is not unprecedented, as Houston et.al. (1996) used *Q* in their study of cash flow constraints at bank holding companies.

We also use several other variables to control for loan demand at a bank: lagged loan growth, beginning-of-period loan loss provisions (that reflect managers' expectations of future loan losses), change in loan loss provisions over the previous year, and the growth rate of total

[8] We include only the larger BHCs because the Tobin's *Q* is better estimated for these firms (since the markets for their stocks are generally more liquid).

bank lending by all banks in the state (which should reflect loan demand and economic conditions statewide).[9]

We also control for bank size and the amount of securities the bank had at the beginning of the year (scaled by bank loans at the beginning of the year). We include securities because banks may use their stock of securities as a buffer against deposit shocks; if the supply of deposits contract, for example, banks could maintain their lending by selling securities.

Banks' balance sheet data are from year-end Quarterly Reports of Condition and BHC data are from Y9C Reports. Tobin's *Q* data are from the CRSP database.[10] We adjusted for bank mergers by creating *pro forma* banks. For example, if bank A bought bank B during 1992, we measured loan growth at bank A during 1992 by comparing the stock of bank loans at bank A at the end of 1992 with the sum of loans at A and B at the beginning of 1992. Summary statistics are in Table 2.

4.2 Test 1: Are more leveraged banks more deposit constrained?

The simple, linear model of choice of bank funds in Section 2.2 showed that if banks face liquidity constraints, and if such constraints are tighter for more leveraged banks, then these more leveraged banks should demonstrate a stronger correlation between lending and insured deposit flows. We test this implication using the data described in the previous section. We interpret a stronger loan growth-deposit growth correlation for banks with relatively little capital as

[9] We tried using non-performing loans (a measure of current conditions of banks' loan portfolios) as an alternative to loan loss provisions; results did not change.

[10] We thank Marc Saidenberg for the Tobin's *Q* data.

supporting the joint hypothesis that banks face frictions in the market for uninsured funds and that such frictions increase with leverage.

In Table 3, we estimate a regression of loan growth (in logs) on insured deposit growth (also in logs), bank capital (defined as the beginning-of-period book capital divided by beginning-of-period book assets), and an interaction between deposit growth and capital. We control for loan demand conditions, bank size, and beginning-of-period stock of securities. The regression also includes bank and year fixed effects (not shown). We allow capital to affect banks' cost of funds non-linearly by creating several indicator variable to flag "low-capital" banks. The first indicator variable equals one only for those banks that are in the bottom 5 percent of the capital/asset distribution (Column 1). The second indicator variable flags banks that are among the lowest decile of capitalization (Column 2), and the third indicator flags banks that are among the lowest quartile of capitalization (Column 3).

The key result in Table 3 is that, regardless of how we define a low-capital bank, poorly-capitalized banks have significantly stronger positive correlation between their loan growth and insured deposit flows than well-capitalized banks (although the latter too have a significant positive relation between lending and insured deposit flows). For example, the elasticity of bank lending with respect to insured deposit flows for banks in the bottom decile of capitalization is 0.49 percent as compared to an elasticity of 0.37 percent for all other banks. This difference is significant at a 1 percent level.

Almost all other control variables appear as expected. Surprisingly, however, bank capital does not appear to directly associated with loan growth. This may be because the "within"

variation of the low-capital indicators is very small; a bank that is classified as being a low-capital bank in a given year is also likely to be a low-capital bank the next year.

We interpret the results in Table 3--that poorly-capitalized banks have relatively stronger correlation between lending and insured deposit flows--as evidence of frictions in the uninsured funds markets. As a result of these frictions the supply of such funds is not perfectly elastic, forcing bank lending to depend on the supply of insured deposits.

Note that bank capital may reflect not just the degree of credit market frictions but also loan demand conditions; banks facing strong loan demand may be better capitalized because they enjoy higher profits, some of which is retained. However, it is not clear how this alternative interpretation of bank capital explains the results in Table 3; there is no apparent reason why banks facing poor loan demand (banks with little capital) should finance more loans with insured deposits than banks facing robust loan demand.

A natural question is whether these capital/deposit constraints are tighter at smaller banks. To answer that, we split the sample into "Large Banks" and "Small Banks,"where the former consists of all banks with assets greater than the median (equal to $239 million in 1995 dollars), and the latter all have assets less than the median. We estimate the model in Table 3 separately for the two samples. Low-capital banks were defined as in Table 3. Only the coefficients on insured deposits and capital indicators are discussed here.

Table 4 shows that only *small* banks' leverage affects their lending-insured deposit flow correlation, implying that large banks may not face significant capital market frictions.[11] Although

[11] Although leverage affects the lending-insured deposits relation only for small banks, the coefficients on insured deposits is slightly bigger for large banks (although the difference is not statistically significant at the 10 percent level). However, this does not contradict our conclusion

not shown here, we also tried a finer size partition of banks to verify the results in Table 4 and to better gauge which banks are affected by leverage. Specifically, we estimated the regression model in Table 3 separately on each size *quartile* (instead of splitting the sample at the median as in Table 4). We found that leverage affects the lending- deposit relation for only the smallest quartile of banks (those with assets less than $98 million).

This result--that only *small* banks' leverage affects their lending-insured deposit flow correlation--is consistent with several studies of non-financial industries that have found little or no evidence that large firms are liquidity constrained (for example, Oliner and Rudebusch 1997). Larger banks may be less liquidity constrained for the same reasons that large, non-financial firms are unconstrained. For example, big banks may be older firms that have a long history known to capital markets. Diamond (1989) shows that older firms are subject to smaller agency problems under certain circumstances. Moreover, big banks may have more transparent assets because they make fewer monitoring-intensive loans such as small business loans.

4.3 Test 2: "Instrumenting" for insured deposits with BHC deposit growth

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that large banks face few liquidity constraints. If BHCs have internal markets for insured deposits (as we will argue later) the same way that they appear to have internal capital markets (as Houston, James, and Marcus [1996] have shown), then the lending-insured deposit flow relation will be weaker for small banks. If a small bank can tap into a large pool of insured deposits within a BHC whenever that bank has a lending opportunity, then we will see a weak relation between that bank's lending and its own insured deposit flows. In the opposite extreme case of a "large bank" where the bank is also the BHC, there is no internal market and its lending will be correlated with insured deposit flows even if it is otherwise identical to the small bank considered before.

Our basic test of banks' liquidity constraints in equation (1) suffers from the problem that a positive association between lending and insured deposit flows (i.e., $\alpha_1>0$ in equation [1]) need not imply that banks are constrained. We may observe such a positive association even in the absence of frictions in the market for uninsured funds because we may not have controlled for factors that produce a positive correlation between lending and deposits (such as local economic conditions). We minimized this omitted-variable bias in the previous section by splitting the sample by bank leverage and by assuming that the omitted variable bias is the same for well-capitalized and poorly-capitalized banks.

In this section, we pursue a different solution to the omitted-variable bias. If we can find an "instrument" for insured deposits (such that the instrument is not correlated with the omitted variables that drive a bank's lending opportunities but is correlated with insured deposit flows), then a solution offers itself. A positive correlation between this instrument and bank lending implies that banks are liquidity constrained, and that they depend on insured deposits.

Suppose BHCs have internal markets whereby they allocate insured deposits across bank subsidiaries in pursuit of higher returns. In the presence of such internal markets, insured deposit inflows at *other* banks within the same holding company increases a given bank's financial slack. Then, affiliated banks' insured deposit flows could act as an "instrument" in the sense defined before (assuming that lending opportunities at a given bank are not correlated with insured deposit flows at other banks in the same BHC).

Table 5 tests the joint hypothesis that banks face significant credit market frictions, and that they mitigate these costs by creating internal markets within BHCs that allocate insured

deposits across bank subsidiaries. This hypothesis predicts that a bank's lending should be positively correlated with insured deposit flows at other banks affiliated with the same BHC.

Table 5 confirms this prediction. We find that insured deposit growth at the BHC level (the change in the stock of insured deposits at the BHC less deposit growth at the subsidiary bank) is positively correlated with loan growth at the average subsidiary bank. Moreover, BHC-level deposit growth has a larger effect on loan growth at the subsidiary banks than that subsidiary bank's own insured deposit growth (an elasticity of 0.65 versus 0.37), implying that the within-BHC deposit market is an important source of funds.

Of course, a bank's loan growth may be positively correlated with insured deposit flows at affiliated banks in the same BHC because lending and deposit flows at all subsidiaries of the average BHC are driven by the same factors that we have controlled for poorly. For example, the banks within a BHC are often in the same general geographic area (contiguous states, for example), and local economic conditions that produce a positive association between a given bank's lending and deposit growth may also produce a similar relation between that bank's lending and affiliated banks' deposit growth. We control for this problem by including the BHC's loan growth in the regression. The negative coefficient on this variable suggests that the above objection is not a serious problem here. The sign on this variable is hard to explain, except in terms of the existence of an internal BHC capital market that attempts to mitigate credit market frictions faced by banks.

Houston et. al. (1996) find that BHCs have internal markets for capital that help mitigate credit market frictions. Similarly, Lamont (1997) finds evidence of internal capital markets in corporations with oil subsidiaries. The finding here that BHCs appear to have an internal market

for *insured deposits* supports and extends these results. The multi-firm setting of BHCs allow them to not only allocate cash flows across their subsidiaries but also a more important type of internal funds (for banks), insured deposits.[12] [13]

5. Conclusion

This paper investigates a very basic question about banks: is bank lending constrained by the availability of insured deposits? If banks operated in the Miller-Modigliani world with perfect information, the answer would be no; banks would simply issue uninsured debt (or equity) to offset a loss of deposits. But then, in a world with perfect information, banks and other financial intermediaries would not exist in the first place.

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[12] The presence of internal markets within the holding companies raises the possibility that the capital of the holding company--rather than the capital of the individual bank--determines the extent of the constraint on the bank. This, in turn, suggests that we should estimate the regressions in Table 3 using BHC-level data and not bank-level data (although Table 5 must rely in bank-level data). When we estimated the regressions in Table 3 using BHC-level data, we found that BHC-level capital does not affect the correlation between loan growth and insured deposit growth. This is explained by the fact that we find that bank capital does not affect the loan growth-deposit growth relation for large banks (Table 4), and the BHC-level data used in the BHC-level regressions constitute a weighted average of bank-level data, with bigger banks receiving greater weight.

[13] A natural extension of the results in Table 5 is to compare large banks with small banks and see whether large banks' lending is relatively less correlated with affiliated banks' deposit flows. We would expect a smaller correlation if large banks are less credit constrained than small banks. Although not shown, we re-estimated the model in Table 5, having added an interaction term between LOG of INSURED DEPOSIT GROWTH (BHC) and BANK ASSETS. If large banks rely less on affiliated banks' insured deposits, this interaction should have a negative coefficient. Instead, we find that the interaction has a positive coefficient (significant at the 5 percent level). However, this does not necessarily contradict our conjecture that large banks are less credit constrained than small banks. Large banks are typically affiliated with larger BHCs, which probably have deeper internal markets for insured deposits. Consequently, larger banks' lending may have a stronger positive correlation with affiliated banks' deposit flows than small banks--but only because big banks can tap into more liquid internal markets.

Our evidence suggests that real-world frictions in the market for bank debt lead to deposits constraints on banks. Loan growth at banks is strongly, positively correlated with their deposit growth, even after controlling for lending opportunties. We recognize the pitfalls in interpreting the deposit-lending correlation, and the simple model in the paper helps us steer clear of the potential identification problems. Reverse causality (loan demand driving deposits) is not a real problem here; absent information problems in the uninsured debt market, lending and insured deposit growth will not be causaly related in either direction. The potential for omitted variable bias (deposits proxying for loan demand), is mitigated by our treatment of the data: we proxy for loan demand with several variables, we instrument for a bank's own deposit growth using its sister bank's deposit growth, and we split the sample by bank leverage. The lending-deposit correlation survives all those cuts. Moreover, the correlation is most pronounced at poorly capitalized banks, where theory suggests the informational frictions should be most severe.

Our notion and evidence of deposit constraints on banks extends the large literature that tests for cash-flow constraints on non-financial firms. Houston et. al. (1996) have already made progress on that front with their finding that banks appear to be cash-flow constrained. Our broader notion of deposit constraints is an important extension of his work, since insured deposits are far more important than cash flow as a source of funds to banks.

Our evidence also helps to establish the possibility of a bank lending channel. Absent deposit constraints, a monetary tightening that reduces the supply of insured deposits will not affect the supply of bank loans. Our results imply that the bank lending channel of monetary policy works primarily through small, poorly-capitalized banks. This prediction is supported in Kashyap and Stein (1995) who find that small banks reduce lending more than large banks in

response to a monetary policy tightening, in Kashyap and Stein (1996) who find that small banks with less liquid assets respond more to a policy tightening, and in Kishan and Opiela (1997) who find that small, poorly-capitalized banks reduce lending more following a tightening.

The magnitude of the lending channel is still open to question, however. We find that the deposits constraints operate only on poorly capitalized banks that are also relatively small, those with assets less than $100 million, while the larger banks appear to be unconstrained. Since these larger banks are also responsible for the vast majority of lending (93 percent in 1995), this secondary finding suggest the extent of lending channel may be limited. Future efforts in this line of research should be directed toward trying to determine the magnitude of the lending channel.

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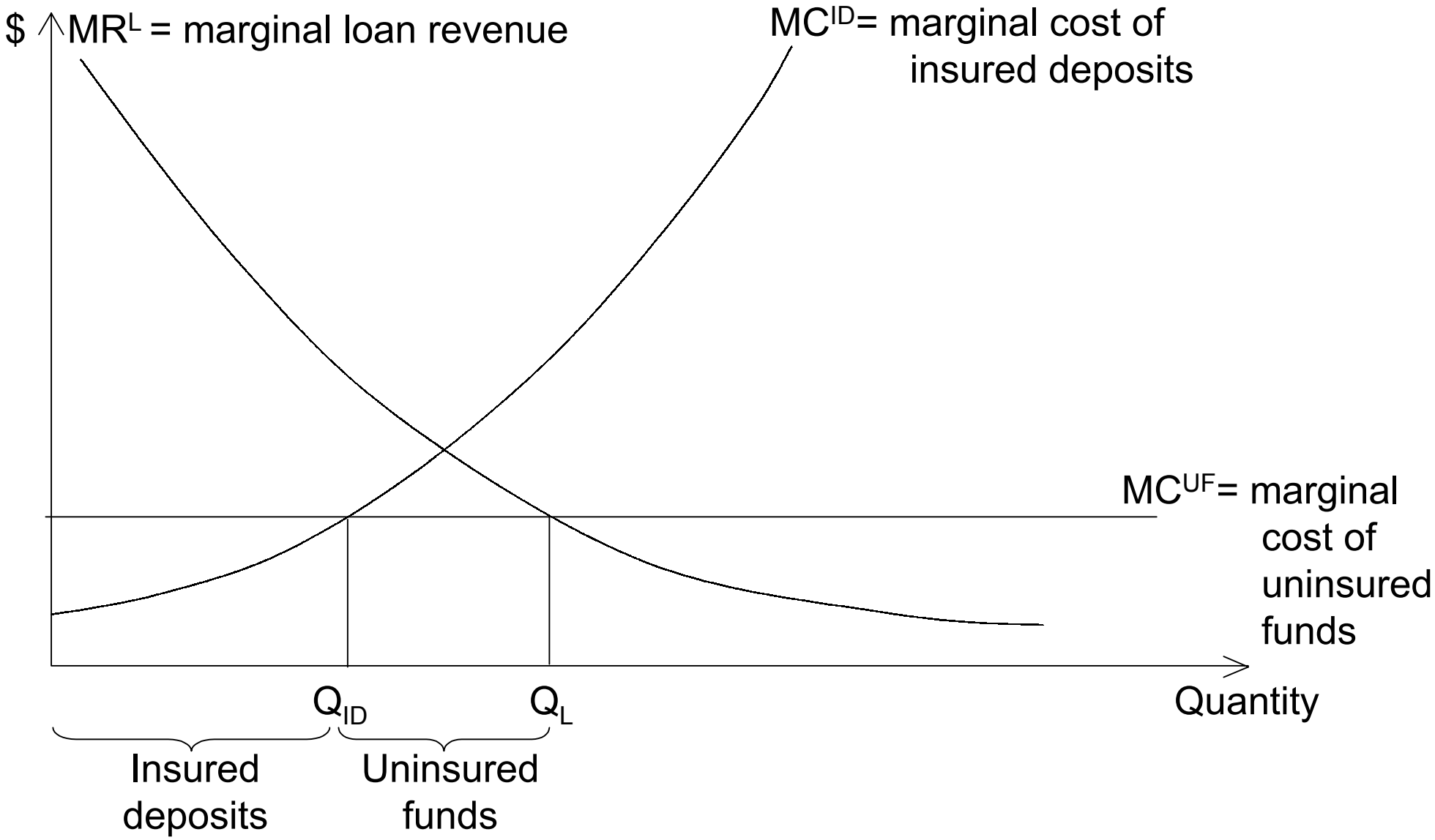
<u>Figure 1</u>: Equilibrium with frictionless uninsured funds markets



<u>Figure 2</u>: Absent frictions, loan demand shocks don't affect insured deposits

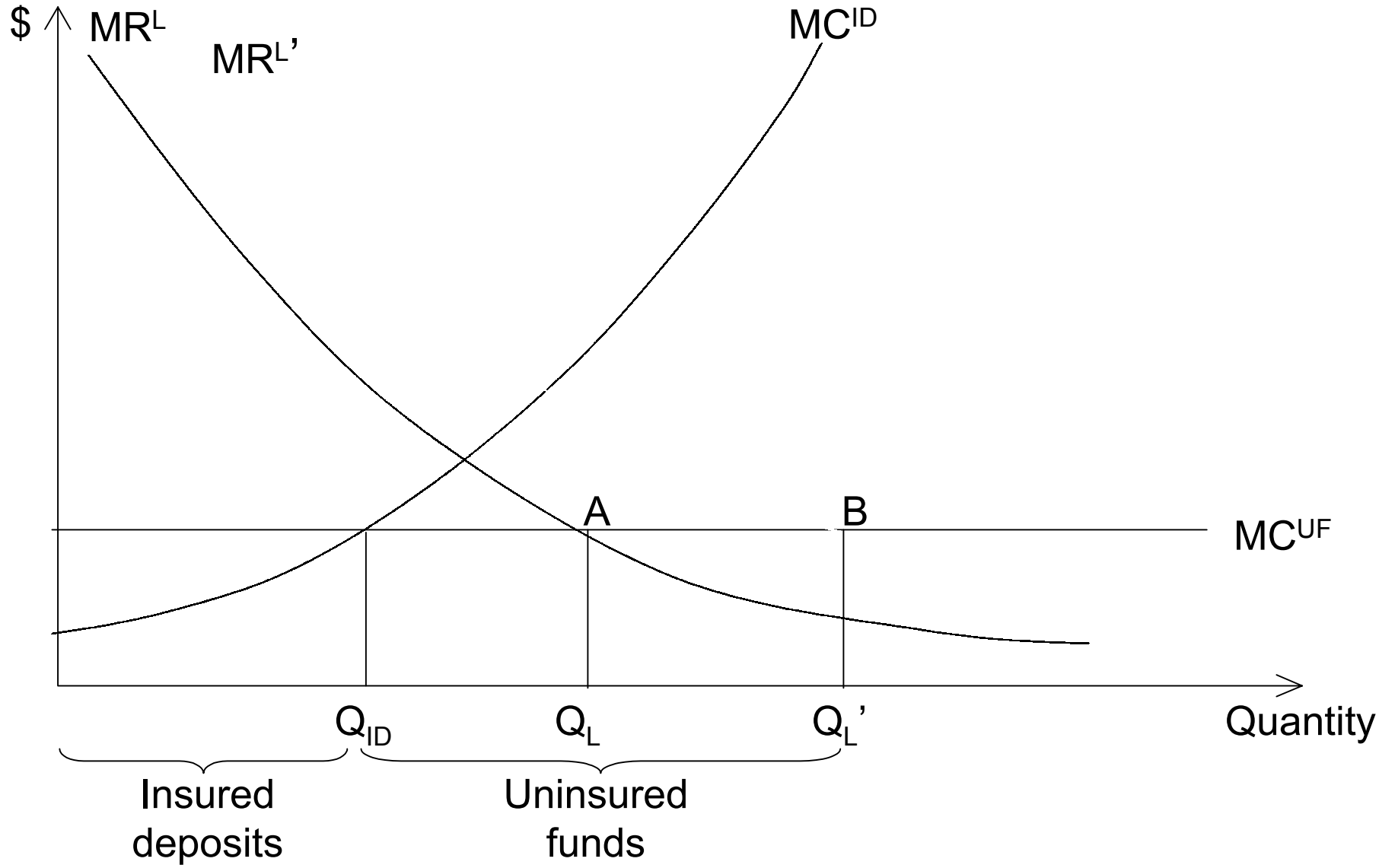


Table 1: Sources of funds, banks affiliated with publicly-traded bank holding companies, 1992-95

Bank size (Assets in 1995 dollars)	Sources of funds (percent of total assets for median bank)			Number of bank-years
	Retained earnings	Insured deposits	Uninsured funds	
First quartile (25th percentile=$98 million)	3.3	83	8.3	1209
Second quartile (Median=$239 million)	4	82	9.2	1208
Third quartile (75th percentile=$754 million)	4.2	80	11	1208
Fourth quartile	3.9	72	19	1208

Source: End-of-year Quarterly Reports of Condition, 1992-95

Table 2: Summary Statistics for Banks

Variable	Mean	Median	Standard deviation	N
Rate of loan growth (annual)	0.07	0.06	0.17	4834
Rate of insured deposit growth (annual)	0.04	0.02	0.15	4834
Capital/ Assets	0.083	0.08	0.026	4834
Tobin's Q	1.04	1.035	0.038	4834
Loan Loss Provisions	0.006	0.0036	0.02	4834
Change in Loan Loss Provisions	-0.0022	-0.00065	0.023	4834
Rate of Loan Growth in State (annual)	0.066	0.07	0.076	4834
Bank Assets ($ '000)	1,951,587	238, 921	9,427,596	4834
Securities/Assets	0.27	0.26	0.14	4834

Source: End-of-year Quarterly Reports of Condition, 1992-95.

Table 3: Low-capital banks are more dependent on insured deposits
Dependent variable: Log of loan growth, 1992-95

	Low Capital Indicator=1 if a bank is in the bottom 5% of capital/assets	Low Capital Indicator=1 if a bank is in the bottom 10% of capital/assets	Low Capital Indicator=1 if a bank is in the bottom 25% of capital/assets
	(1)	(2)	(3)
Log of Insured Deposit Growth	0.39	0.37	0.35
	(12.7)***	(12)***	(10.4)***
Log of Insured Deposit Growth * Low Capital Indicator	0.08	0.12	0.09
	(2.2)**	(4.04)***	(3.2)***
Low Capital Indicator	-0.02	-0.002	0.0001
	(-1.64)*	(-0.2)	(0.02)
Tobin's Q	0.38	0.39	0.4
	(3.8)***	(3.9)***	(3.9)***
Lagged Loan Growth	-0.29	-0.29	-0.29
	(-12)***	(-12.1)***	(-12)***
Loan Loss Provisions	-1.53	-1.57	-1.6
	(-3.12)***	(-3.2)***	(-3.4)***
Change in Loan Loss Provisions	0.38	0.39	0.4
	(1.5)	(1.5)	(1.6)
Loan Growth in State	0.2	0.2	0.2
	(5.7)***	(5.6)***	(5.7)***
Bank Assets	-1.38E-09	-1.37E-09	-1.38E-09
	(-1.76)*	(-1.73)*	(-1.82)*
Securities	0.7	0.69	0.69
	(12.5)***	(12.5)***	(12.7)***
N	4243	4243	4243
R-squared	0.35	0.36	0.36

1. T-statistics are reported within parentheses. * indicates significance at a 10 percent level, ** at 5 percent, and *** at 1 percent. The t-statistics are based on heteroskedasticity-consistent standard errors (White 1980).
2. All independent variable values are as of the beginning of the period (except Insured Deposit Growth and Loan Growth in State which are contemporaneous).
3. The regressions were estimated with year fixed effects and bank fixed effects (not reported).
4. The regressions are estimated over the 1992-95 period.

Table 4: Low-capital banks are more dependent on internal funds (cash flows and insured deposits)
...but only when they are small

Dependent variable: Log of loan growth, 1992-95

	Low Capital Indicator=1 if a bank is in the bottom 5% of capital/assets		Low Capital Indicator=1 if a bank is in the bottom 10% of capital/assets		Low Capital Indicator=1 if a bank is in the bottom 25% of capital/assets	
Panel A: Large Banks						
Log of Insured Deposit Growth	0.43	-----	0.42	-----	0.4	-----
	(10.8)***		(10.1)***		(8.5)***	
Log of Insured Deposit Growth * Low Capital Indicator	-0.001	-----	0.06	-----	0.06	-----
	(-0.02)		(1.2)		(1.3)	
Cash Flows	-----	2.1	-----	1.9	-----	2.1
		(3.4)***		(3.2)***		(3.4)***
Cash Flows * Low Capital Indicator	-----	-0.48	-----	0.8	-----	-0.18
		(-0.49)		(0.7)		(-0.2)
Low Capital Indicator	-0.02	-0.02	-0.006	-0.03	-0.005	-0.01
	(-1.3)	(-0.8)	(-0.6)	(-0.97)	(-0.7)	(-0.34)
N	2121	2122	2121	2122	2121	2122
R-squared	0.4	0.26	0.4	0.25	0.41	0.25
Panel B: Small Banks						
Log of Insured Deposit Growth	0.3	-------	0.3	-------	0.29	-------
	(6.2)****		(6.0)****		(5.5)****	
Log of Insured Deposit Growth * Low Capital Indicator	0.11	-------	0.17	-------	0.11	-------
	(2.9)***		(4.5)***		(2.9)***	
Cash Flows	-------	0.32	-------	0.34	-------	0.37
		(0.6)		(0.6)		(0.7)
Cash Flows * Low Capital Indicator	--------	1.3	--------	1.4	--------	0.87
		(2.1)**		(2.2)**		(1.3)
Low Capital Indicator	-0.02	-0.055	0.01	-0.011	0.01	0.87
	(-0.7)	(-2.2)**	(1.02)	(-0.5)	(1.08)	(1.3)
N	2122	2122	2122	2122	2122	2122
R-squared	0.32	0.25	0.32	0.25	0.32	0.25

1. These results were produced by the regression model described in Table 3. "Small Banks" are those smaller than the median.
2. T-statistics are reported within parentheses. * indicates significance at a 10 percent level, ** at 5 percent, and *** at 1 percent. The t-statistics are based on heteroskedasticity-consistent standard errors (White 1980).
3." Cash flows" is defined to be (profits before extraordinary items + loan loss provisions + amortization of intangible items)/(Total loans).
4. All independent variable values are as of the beginning of the period (except Insured Deposit Growth and Loan Growth in State which are contemporaneous).
5. The regressions were estimated with year fixed effects and BHC fixed effects (not reported).
6. The regressions are estimated over the 1992-95 period (1991 drops out when we first-difference the data).

Table 5: Bank lending depends on affiliated banks' insured deposits
Dependent variable: Log of loan growth, 1992-95

Log of Insured Deposit Growth (Bank)	0.37
	(11.4) ***
Log of Insured Deposit Growth (BHC)	0.65
	(4.2) ***
Log of Loan Growth (BHC)	-2.1
	(-14.7) ***
Capital (Bank)	-0.41
	(-0.9)
Tobin's Q	0.44
	(4.6) ***
Lagged Loan Growth (Bank)	-0.26
	(-11.4) ***
Loan Loss Provisions	-1.43
	(-3.1) ***
Change in Loan Loss Provisions	0.39
	(1.6)
Loan Growth in State	0.18
	(5.4) ***
Bank Assets	-1.32E-09
	(-1.73) *
Securities	0.62
	(11.9) ***
N	4243
R-squared	0.42

1. Insured Deposit Growth (BHC) is the change in the stock of insured deposits in all banks affiliated with the bank. Likewise, Loan Growth (BHC) is the change in the stock of loans in all affiliated banks.
2. T-statistics are reported within parentheses. * indicates significance at a 10 percent level, ** at 5 percent, and *** at 1 percent. The t-statistics are based on heteroskedasticity-consistent standard errors (White 1980).
3. All independent variable values are as of the beginning of the period (except Insured Deposit Growth [Bank and BHC], Loan Growth [BHC] and Loan Growth in State, which are contemporaneous).
4. The regressions were estimated with year fixed effects and bank fixed effects (not reported).
5. The regressions are estimated over the 1992-95 period.