DISCIPLINE AND LIQUIDITY IN THE INTERBANK MARKET

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ABSTRACT

Using twenty years of panel data, I demonstrate that high-risk banks have consistently paid more than safe banks for interbank loans and have been less likely to use these loans as a source of liquidity. The economic importance of this effect was relatively small until the mid-1990s, when regulatory and institutional changes began to impose more of the costs of bank failure on uninsured creditors. Subsequently, interbank-market price discipline roughly doubled, and risk-based rationing effects increased by a factor of six. In imposing this discipline, lenders seem to care most about credit risk at borrowing institutions.

Depository institutions are subject to a variety of unpredictable liquidity shocks that determine their needs for short-term funding, and these shocks can impose real costs when they result in reserve shortfalls or overdrafts in Federal Reserve accounts. In the face of such shocks, such institutions (hereafter, "banks") typically purchase short-term funds from their peers to avoid these costs. Under perfect competition, banks are price takers in the interbank market—systematic liquidity shocks shift the average price of overnight funding, but idiosyncratic shocks affect it only trivially. This type of behavior, modeled formally by Ho and Saunders (1985), has frequently been invoked to explain cross-sectional differences in net reliance on such funding. Such a framework usually contains, at least implicitly, an assumption that there is a single rate that applies to all borrowers and, thus, that sellers of funds in the interbank market do not consider the possibility that their loans will not be repaid.[1]

Yet a large empirical literature now supports the proposition that the holders of uninsured liabilities at financial institutions demand higher rates of return in response to higher probabilities of default.[2] Indeed, the idea of using bank-liability prices in supervision has received considerable attention recently, in the wake of the Basle Accord's entreaty to employ market discipline as one of the "three pillars" of supervision. The Financial Modernization Act (FMA) of 1999 included the latest effort in this direction by experimenting with mandatory subordinated-debt issuance for certain large institutions. However, requiring banks to issue such instruments can impose costs on those institutions that would not voluntarily do so based solely on considerations of profit maximization. Before extending such policies, it is worth investigating the extent to which the market has sufficient information to price these claims efficiently.

This paper provides a picture of how interbank lenders respond to default risk among interbank borrowers—in both price and quantity dimensions—and how this response has changed over time. Using the quarterly financial statements of a large sample of banks over the period 1986 – 2005, I confirm Furfine's (2001) result of a statistically significant yield response to risk, particularly credit risk, and I show that the magnitude of this response has increased in recent years, consistent with the intent of regulatory reforms in the mid-1990s. I also find that the importance of quantity rationing, and its response to the institutional changes, appears to be at least as great as the pricing effects.

The market for interbank lending is fertile ground for market-discipline tests in several respects. First, interbank loans are uninsured and often uncollateralized, and interbank defaults have occasionally had severe consequences for lenders. For example, the 1989 failure of MCorp led to the demise of 14 affiliated institutions, and the 1991 failure of the Bank of New England directly triggered the failure of Connecticut Bank and Trust through losses on federal funds sold.[3] Second, given the comparative advantage of banks in understanding the business of banking, it would seem reasonable that they are in a better position than other liability holders to monitor borrowing institutions. Indeed, if banks are better able than other lenders to assess bank quality, then the level of discipline in the interbank market constitutes a sort of upper bound on the potential for discipline among other liabilities. Third, the interbank market presents an opportunity to examine the effectiveness of market discipline at smaller banks, which do not routinely issue subordinated debt or enjoy thick markets for their CDs. Finally, because interbank loans are typically overnight contracts, examining this market avoids the difficult problem of adjusting for the term structure of liabilities using imperfect data on remaining maturities and embedded options.

Despite these advantages—and in contrast to the voluminous literature examining the responses to risk among other bank liabilities—surprisingly little research has examined the prevalence of market discipline between banks. Indeed, the only study to test specifically for risk pricing in the modern fed-funds market is Furfine (2001), which examined FedWire data in the first quarter of 1998.[4] One reason that previous researchers have neglected this market may be the fact that, due to the extremely short maturity of interbank arrangements, sellers of fed funds have the ability to "get out in time" when they see the borrowing bank having problems. Thus, we may never observe risk premia for the riskiest banks because they are simply unable to borrow in the market. Yet quantity rationing of this type constitutes its own sort of discipline, albeit one that has traditionally received less emphasis than the price dimension. Broker-dealers and correspondents frequently adopt minimum credit standards and borrowing-frequency guidelines that could have a rationing effect, and we also have anecdotal evidence of fed-funds rationing in certain high-profile cases.[5] Rationing, therefore, can potentially apply pressure to management and provide market signals that may be missed by focusing solely on interest-rate spreads. Emphasis on the quantity dimension has grown in the recent market-discipline literature, as in Park and Peristiani (1998) and Goldberg and Hudgins (2002).

Another reason for the lack of attention to the interbank market may be a perception that losses on fed funds are rare and that lenders thus have little incentive to engage in effective monitoring and pricing. Indeed, in the most recent round of wide-spread bank failures, this was largely the case. During the late 1980s and early 1990s, sellers of fed funds to insolvent institutions were often protected from losses through either purchase-and-assumption resolution or the FDIC's "too big to fail" policy. Even those banks that did suffer losses on fed funds typically recovered a relatively high percentage of their principal, based on the structure of the payoff hierarchy at the time.

However, regulatory reforms in the early 1990s—including the FDIC Improvement Act, National Depositor Preference legislation, and Federal Reserve Regulation F—shifted more of the costs of failure to fed-funds sellers, thus raising the expected costs of fed-funds defaults and providing lenders stronger incentives for caution. Studies of the discipline imposed on banks by other types of liability markets have demonstrated that the risk-elasticity of liability prices (i.e., the coefficients in a regression of yields on risk variables) can vary over time, depending on aggregate economic conditions and institutional considerations (e.g., Flannery and Sorescu, 1996; Martinez Peria and Schmukler, 2001; Flannery et al., 2004). Thus, the interbank market of the early 1990s presents an opportunity to test the potential effectiveness of institutional arrangements in providing incentives for market discipline. It is this test—in both the price and quantity dimensions—that constitutes the heart of the paper.

After a brief description of the data, Section 1 motivates the paper by demonstrating, through simple difference-of-means tests, that failing banks have historically paid more for and relied less on interbank funding than contemporaneous safe banks, although the difference is relatively small economically. However, because the observable failure data come overwhelmingly from the late 1980s and early 1990s, it is not clear whether these results still apply in the more recent environment. Section 2 sets up a Heckman (1976)-

type model to examine the risk-pricing and rationing more thoroughly in the early and late subsamples of the data, as well as in year-by-year regressions. Section 3 investigates the particular types of risk that fed-funds lenders responded to over the sample, with credit risk emerging as the most important. Section 4 concludes the paper.

1. SOME MOTIVATING OBSERVATIONS

1.1 Data on Interbank Activity

The bank-level data used in this study are taken from the Consolidated Reports of Condition and Income (Call Reports) filed quarterly by all commercial banks with the federal regulatory agencies. Although the bulk of the balance-sheet data included in the Call Reports is reported as of the end of each quarter, several series—including interbank borrowing—are also reported as quarterly averages of daily values (on Schedule RC-K). Dividing the quarterly interest expense on interbank borrowings (from Schedule RI) by this average outstanding balance yields the average rate paid by each bank in each quarter.

For small and infrequent borrowers, the quarterly rates computed in this manner can be somewhat noisy (for example, some are in excess of 100%). Some restrictions on admissible observations are thus necessary to screen out data-entry errors and clearly impossible values. I use two screens. First, I remove from the sample all banks with computed rates that lie either below zero or outside a 200-basis-point band around the contemporaneous "effective" fed-funds rate, as reported by the Federal Reserve.[6] Second, I remove all observations for which quarterly average interbank interest expense is less than $10,000. Because Call Report entries are rounded to the nearest $1,000, this restriction ensures two digits of precision in the numerator and thus reduces rounding errors. The advantages of these screens must, of course, be weighed against the risks of eliminating potentially informative heterogeneity in the data and introducing selection bias. In the Appendix, I demonstrate that the central results reported below are not qualitatively sensitive to the restrictions I impose on the data. Furthermore, note that these two restrictions are only necessary to obtain a reliable sample of yields; when looking at borrowing *levels* (measured here by the ratio of interbank borrowing to total liabilities) there is no need to impose them.

Another concern is that the Call Report data do not distinguish between federal funds purchased and repurchase agreements ("repos") when reporting interbank borrowing. Repos are short-term loans between financial institutions that are collateralized with government securities. They thus carry little default risk, and we might not expect repo participants to exert much market discipline. On the other hand, repos are still subject to the risk that the collateral may not be collectable, which, as described by Ringsmuth (1985), Lumpkin (1993), and Muelendyke (1998, p. 102), has historically been a problem in some failure situations. Still, if repo behavior is relatively insensitive to risk, this would work against a finding of significant market discipline. As will be seen, the tests produce significant results in spite of this handicap.

The time series of the average of the Call Report-based interbank rates is shown in Figure 1, and corresponding distributional statistics are reported in Table 1. The effective federal-funds rate reported by the Federal Reserve is given for comparison. In general, the effective rate is close to the average of the rates computed from the Call Report data, although these rates also exhibit substantial cross-sectional variation.[7] Larger banks (those with total assets of over $500 million in 1996 dollars) pay slightly lower rates on average and exhibit somewhat less cross-sectional variability in these rates. However, even among these institutions, the within-quarter standard deviation is 29 basis points higher than that of the effective rate on average—i.e., considerable heterogeneity remains. Finally, although the average level and time-series volatility of rates is lower in the second half of the sample period, the cross-sectional dispersion of the rates is roughly constant over time.

1.2 The Pattern of Failures

Table 2 compares the interbank-borrowing activity of banks that failed and those that did not between 1986 and 2005. The sample includes 1,182 failing institutions, although not all institutions purchased interbank funds in all quarters prior to failure. In Panel A, I report a comparison of the spreads paid over the effective fed funds rate by the two groups of banks. Over the two years prior to failure, the failing banks for which rates could be computed numbered between 240 and 293 and paid an average of about 21 basis points more for interbank funding than their peers. This difference in pricing is consistently statistically significant at the 1% level. This suggests that lending institutions were able, at least to some extent, to observe the risk of borrowing banks and price this risk into the terms of the contracts.

Although the spreads in Panel A display an upward trend as failure approaches, it is modest. One possible explanation for this is that borrowing banks tend to exit the market as they become more risky. Panel B of the table, which shows interbank borrowing as a percentage of liabilities for failing and non-failing banks, provides evidence of this possibility. Over the period, failing banks relied less on interbank loans than safe banks, and this difference became more pronounced and statistically significant as failure approached. These latter results illustrate the importance of examining the quantity dimension of market discipline in addition to the pricing dimension. Indeed, Panel C shows that troubled institutions systematically dropped out of the market—by the quarter prior to failure, the proportion of surviving banks doing any interbank borrowing at all was over a third greater than the same proportion for failing banks.

The results in Table 2 are consistent with the presence of market discipline, but they also raise several questions. First, the magnitude of the discipline appears rather weak—a bank on the verge of failure paid only about 24 basis points more than a perfectly safe bank, on average, during the sample period. Although this spread combined with quantity effects to force some banks out of the market, 35.6% of failing institutions continued to borrow on the eve of their demise. Second, the table does not allow us to distinguish between two separate effects that may be driving the changes in reliance—a reaction to the higher prices (i.e., a movement along the demand curve) and rationing by interbank lenders. Third, these simple difference-of-means tests cannot control for other factors (such as bank size) that are likely to be correlated with both failure and fed-funds behavior, nor can they tell us the extent of any discipline in cases less severe than outright failure. All of these points will be addressed in the regression analysis of Section 2.

Perhaps most importantly, the failures used in this exercise overwhelming come from the banking crisis of the late 1980s and early 1990s, with 97% of them occurring prior to 1996. The lack of failures since that time makes it difficult to use the above type of analysis to determine whether the patterns in Table 2 have remained stable. This question is potentially of considerable interest for learning about the effects of different market structures on the efficacy of discipline. Indeed, I discuss below some institutional reasons that discipline in the interbank market may well have improved over the last ten to fifteen years.

1.3 Institutional Changes in the 1990s

Since the early 1990s, the banking sector has undergone dramatic changes in structure and technology. King et al. (2006) argue that these shifts in the financial environment may have fundamentally altered the patterns that lead to bank distress. It is also plausible that the improved flow of information and increased participation in capital markets enhanced the ability of market participants to monitor and respond to changing risk at borrowing institutions. Indeed, many authors have argued recently for the efficiency-enhancing effects of the increased competition brought about by improved information flows and branching deregulation (e.g., Jayaratne and Strahan, 1996; Petersen and Rajan, 2002; Dick, 2006).

In addition to the general deepening and development of funding markets in the 1990s, three specific regulatory changes are likely to have had substantial effects on the interbank market. Perhaps the most important of these was the FDIC Improvement Act (FDICIA) of 1991, which, among other provisions, mandated least-cost failure resolution. Prior to FDICIA, the FDIC resolved most bank failures through purchase and assumption, under which method even uninsured liability holders were often protected. The numbers suggest that the FDIC is indeed serious about least-cost resolution: as shown in Benston and Kaufman (1998), uninsured depositors were protected in 81% of the bank failures in the six years preceding FDICIA; in the six years following, the figure was just 37%. FDICIA also included provisions intended to retreat from the Too Big to Fail policy, which may have previously led lenders of federal funds to large banks to believe that their loans were insured *de facto*.[8]

Second, National Depositor Preference (NDP) legislation, which went into effect in January of 1994, rearranged the failure-resolution hierarchy, subordinating fed funds to all domestic deposit liabilities and thus increasing the expected loss to fed-funds sellers in the event of bankruptcy. (See Marino and Bennett, 1999, for details on NDP.) In particular, prior to this legislation, the *pro rata* share of a failed bank's assets that was recovered by federal funds lenders was the same as that received by other general creditors. NDP decreased this share (in an expected value sense) by subordinating fed-funds claims to those of uninsured depositors.

Finally, Federal Reserve Regulation F, which itself was the implementation of a FDICIA provision, became effective in June of 1993. This regulation effectively requires interbank lenders to monitor their borrowing banks—as, for example, in the following language:

> "A bank shall establish and maintain written policies and procedures to prevent excessive exposure to any individual correspondent in relation to the condition of the correspondent…. [and] take into account credit and liquidity risks, including operational risks, in selecting correspondents and terminating those relationships…. Factors bearing on the financial condition of the correspondent include the capital level of the correspondent, level of nonaccrual and past due loans and leases, level of earnings, and other factors affecting the financial condition of the correspondent." [Reg. F, §206.3(a) – (b)]

In addition, the regulation sets specific guidelines and exposure limits for lending to undercapitalized institutions. Thus, in practice, Reg F restricts the supply of fed funds to weak banks and raises the expected costs to fed-funds sellers of lending to such banks by raising the probability of supervisory penalties.

The following section demonstrates econometrically that the interbank-market response to risk was significantly larger in the 1996-2005 period than in the 1986-1995 period. The break is chosen somewhat arbitrarily as the midpoint of the sample, but I will also show that the most dramatic changes in year-by-year regressions do indeed occur around this time. Of course, the timing of these changes does not conclusively tells us their source. However, their rather sudden and dramatic nature is strongly suggestive of a link to the institutional innovations just described.

3. EMPIRICAL TESTS

3.1 Model Details

To set up the regressions, I assume that the interbank funding market is competitive (so that the rate a bank pays on its borrowing is independent of the quantity borrowed) and that the individual rate paid is approximately linear in risk and other factors:

$$r_{it}^{*} = a_1 + a_2 \pi_{it} + \mathbf{a}\mathbf{x}_{it} + e_{it} , \tag{1}$$

where π_{it} is the default probability of bank i in quarter t and $\mathbf{x}_{it}$ is a vector of control variables. The quantity of funding that a bank demands depends upon the rate r_{it} that it must pay and its idiosyncratic liquidity characteristics $\mathbf{L}_{it}$:

$$q_{it}^{D} = b_1 + b_2 r_{it}^{*} + \mathbf{b}\mathbf{L}_{it} + u_{it}$$

where q^D_{it} is interbank borrowing demand as a percentage of liabilities, and $\mathbf{L}_{it}$ is a vector of bank-specific liquidity proxies.

The quantity of funds supplied to a given bank q^S_{it} is perfectly elastic in r_{it}, but I allow for risk-based quantity rationing so that the supply of lending may depend on π_{it}. I assume this takes the form

$$q_{it}^S = q_{it}^D + c\pi_{it} + v_{it} \, ,$$

where v_{it} is an error term and credit rationing exists if $c < 0$. Note that risk is a precondition for rationing in the sense that, if $\pi_{it} = 0$, supply equals demand in expectation.

In general, the equilibrium quantity q^* is equal to supply, giving

$$q_{it}^* = b_1 + b_2 r_{it}^* + c\pi_{it} + \mathbf{bL}_{it} + \eta_{it} \quad , \tag{2}$$

where $\eta_{it} = u_{it} + v_{it}$. However, in practice, q^* and r^* are only observed when $q^* > 0$. Letting q and r be the observed quantity of borrowing and rate paid,

$$q_{it} = \max\left[q_{it}^*, 0 \right] \tag{3}$$

$$r_{it} = \begin{cases} r_{it}^* & \text{if } \; q_{it}^* > 0 \\ \mathit{undefined} & \text{if } \; q_{it}^* \le 0 \end{cases} \tag{4}$$

Under the assumption that e_{it} and η_{it} are jointly normal, the system defined by equations (1) – (4) can be rewritten as

$$r_{it} = a_1 + a_2\pi_{it} + a_3\lambda_{it} + \mathbf{ax}_{it} + e_{it} \tag{5}$$

$$q_{it} = b_1 + b_2 r_{it} + b_3\lambda_{it} + c\pi_{it} + \mathbf{bL}_{it} + \eta_{it} \tag{6}$$

for $q_{it} > 0$, where λ is the inverse Mill's ratio:

$$\lambda_{it} = \phi\left(q_{it}^*\right) \big/ \Phi\left(q_{it}^*\right)$$

with ϕ and Φ indicating the standard normal PDF and CDF, respectively.

The marginal effect of each independent variable—most notably, of π—on r and q is given by the sum of the direct effect and the indirect effect operating through probability of participation. For example, for bank i in time t,

$$\begin{aligned} \frac{\partial r}{\partial \pi_{it}} &= a_2 + a_3 \frac{\partial \lambda_{it}}{\partial \pi_{it}} = a_2 - a_3 \frac{c}{\sigma_\eta}\left(\lambda_{it}^2 + \lambda_{it} q_{it}^*\right) \\ \frac{\partial q}{\partial \pi_{it}} &= c + b_3 \frac{\partial \lambda_{it}}{\partial \pi_{it}} = c - b_3 \frac{c}{\sigma_\eta}\left(\lambda_{it}^2 + \lambda_{it} q_{it}^*\right) \end{aligned} \tag{7}$$

To estimate these effects, I apply Heckman's (1976) two-stage procedure to the system described above. Specifically, in the first stage, I estimate each bank's probability of borrowing in the interbank market in each quarter, using a probit model with a default probability (π) and controls (**x** and **L**) as the explanatory variables. As observed above, banks do appear to drop out of the market as they become riskier, so that this equation is of some interest in its own right. In the second stage, I use OLS to estimate equations (5) and (6) for banks with positive interbank borrowing, using each bank's inverse Mill's ratio computed from the first-stage probit as an estimate of λ_{it} in both equations.[9] These can then be used to infer the marginal effects of bank risk from equations (7).

3.2 Regression Data

In running the regressions, I impose a few additional data screens to eliminate outliers. First, I exclude banks that have acquired other banks within the previous two years because of the balance-sheet noise introduced by these transactions. For similar reasons I exclude *de novo* banks and those whose reported volume of loans or core deposits changed by more than 50% in a given quarter. Finally, in order to eliminate fed-funds brokers and other unusual institutions, I exclude any observation for which interbank borrowing constitutes more than 20% of liabilities. Again, the Appendix demonstrates that the central results are not sensitive to these restrictions.

I adopt a univariate approach to measuring the default probability π, which allows for a straightforward assessment of joint economic and statistical significance, following Hannan and Hanweck (1988), Park and Peristiani (1998), and Hall et al. (2002). Section 3 considers alternative tests that use a vector of individual financial ratios. As the summary measure of risk here, I use the failure probability (or "risk rank") generated by the Federal Reserve's System to Estimate Examination Ratings (SEER). SEER (formerly known as FIMS—see Cole et al., 1995) is a probit model estimated on bank-failure events. As the Fed's primary off-site surveillance model during most of the sample period, it was verified annually by economists at the Board of Governors and consistently performed well relative to other "early-warning" models of bank risk (see Gilbert et al., 1999).[10] Technically, a bank's SEER score is interpretable as the probability that it will fail over the coming eight quarters.[11] More informally, it can be thought of as an index for a bank's overall risk position. Because it was based on a thorough specification search and was subject to repeated testing and review, we can be confident that it reflected the most important determinants of bank failure (and thus default) over the sample period.

The variables in the $\mathbf{x}_{it}$ vector control for general market conditions and supply-side considerations. Specifically, I include a vector of time dummies to sweep out levels of and changes in interest rates, market liquidity, and systemic risk. I also include the log of total assets, as a control for bank opacity. Bank size may also proxy for market power and access, as argued by Allen et al. (1989) and Carpenter and Klee (2006). The control variables in the $\mathbf{L}_{it}$ vector proxy for individual liquidity needs, which affect a bank's demand for funding. Specifically, for each bank, I include non-pledged securities holdings as a percentage of assets, annualized quarterly loan and deposit growth, a dummy variable for Federal Home Loan Bank membership, and the log of real assets. The loan- and deposit-growth variables are intended to capture (with opposite signs) a bank's demand for short-term funding; non-pledged securities and FHLB access represent alternative, non-interbank sources of funding supply.[12] I also include the time dummies in this equation, to capture the general availability and cost of alternative sources of funding (e.g., Discount Window loans). Table 3 displays summary statistics for the variables used in the regressions.

3.3 Results

The two panels of Table 4 report the results for the 1986-1995 and 1996-2005 subsamples. The first column in each panel shows the coefficients in the probit regression. The second and third sets of columns show the marginal effects of the independent variables on yields and quantities borrowed, evaluated at the full-sample mean of the estimated inverse Mill's ratio. I obtain standard errors for these marginal effects using the delta method.[13] For robustness, I also report OLS estimates for the yield and quantity equations.

Looking first at the pre-1996 results in Panel A, the positive and statistically significant coefficient on failure probability indicates that riskier banks are indeed being charged more for interbank loans. However, the magnitude of the failure-probability coefficient is economically small: on average, a ten-percentage-point increase in failure probability leads to a fed-funds rate that is just 4.5 basis points higher.[14] Similarly, the failure-probability effects in the participation and quantity equations are negative and significant, indicating the presence of rationing. Yet, again, the magnitude of these effects appears modest—a ten-percentage-point increase in failure probability leads to a drop of just 20 basis points in the ratio of interbank borrowing to liabilities among borrowing banks.

Panel B shows the results for the more recent subsample, after the institutional changes discussed above had gone into effect. Notably, the effect of failure probability increases in magnitude in all of the equations, and in all cases this increase is statistically significant at the 1% level. The estimated marginal effect nearly doubles in the yield equation and rises by a factor of six in the borrowing equation.[15]

These changes can also be seen in Figure 2, which plots the marginal effects of failure probability in the yield equation (Panel A) and quantity equation (Panel B), when the system is instead estimated year-by-year. Although both series are somewhat volatile, the increase in magnitude in the mid-1990s is pronounced. For 1986 through 1995, the yield effect averages 0.003, and the quantity effect averages -0.027; for 1996 through 2005, the averages are 0.016 and -0.147.

It is also worth noting that the estimated effects of the control variables in these regressions are generally in agreement with theoretical intuition. An increase in bank size is associated with lower rates paid and a greater probability of borrowing. This reflects differences in reserve requirements and perhaps, as Allen et al. (1989) argue, differences across size in risk aversion and deposit-market concentration. FHLB membership is associated with a higher probability of participating in the interbank market in both periods, which is consistent with the hypothesis that liquidity-constrained institutions would be more likely both to join the FHLB and to borrow frequently from other banks. However, given that they participate, FHLB members borrow less than nonmembers, all else equal, in the more recent period. In both subsamples, increases in non-pledged securities and deposits and decreases in loan growth significantly lower the probability that a bank will borrow funds. Higher rates of loan growth do raise the probability of borrowing, as we expect. However, one puzzling result is that, conditional on this participation, reliance tends to be lower for banks with more rapid loan growth in the second period.

Finally, the Heckit regressions show that interbank borrowing demand was statistically insensitive to interest rates in the pre-1996 period but that the price elasticity became significantly negative in the second half of the sample. In particular, since 1996, a 100-basis-point increase in funding costs has been associated with a decrease in interbank reliance of 47 basis points. As reported in Table III, average interbank reliance was 4.88% of total liabilities during this time, so this magnitude would seem to be marginally significant economically.

In principle, the increase in the marginal effect of risk on interbank pricing could result from a shift away from repo-based funding into fed funds, which are presumably more risk-sensitive. Yet, to the extent that there has been a secular trend in this direction, it does not appear to be large or sudden enough to account for the pattern observed in Figure 2. Although consistent data on the relative reliance on fed funds and repos are unavailable, the Call Report did include quarter-end balances in each category during the years 1988 – 96. The proportion of interbank borrowing consisting of fed funds is depicted in Figure 3, along with the estimated marginal effect of default probability on rates (the same series shown in Figure 2). The two series do not generally move together. In particular, the increase in fed-funds reliance in 1996 appears far too modest to account for the large increase in the estimated risk pricing in that year.

4. THE COMPONENTS OF DISCIPLINE

This section decomposes default risk into its various components and tests which of these components are responsible for the significant coefficients found above. In theory, fed-funds sellers should demand a risk premium in response to any financial variable that increases the probability of loss, a list that is likely to include measures of capital, credit risk, earnings, asset mix, and liquidity risk. Studies of market discipline in other markets typically include proxies for most of these factors. To maintain consistency with the analysis above, I use the specific proxies that appear as regressors in the SEER model. Again, these were originally chosen based on their correlation with future financial distress. They also largely overlap with variables used in previous market discipline studies.

Table V shows the marginal effects of these variables when they are used in place of failure probability in the system of equations estimated previously. (All of the previous control variables are also included but are not reported in the table.) In both halves of the sample, most of the effects are statistically significant with signs consistent with price and quantity discipline. The most prominent effects are those of the credit-risk proxies. In particular, all three of the loan-delinquency variables are associated with higher rates and lower borrowing throughout the entire sample. Other real estate owned (OREO), a measure of mortgage foreclosures, also leads to decreased borrowing, although it has a counterintuitive negative effect on pricing in the first half of the sample. (The latter result is consistent with other market-discipline studies, such as Flannery and Sorescu, 1996.)

As mentioned above, Furfine (2001) also examined fed-funds pricing with respect to credit risk and found statistically significant results using a sample from 1998. Yet, where the comparison is possible, my results place even more emphasis on credit risk than Furfine's. For example, depending on the specification, the results here indicate that a 1-percentage-point increase in the ratio of nonaccrual loans to total assets raises a bank's interbank rate by about 2 basis points in the post-1995 period. Furfine's baseline estimate was just 0.7 basis points. For a similar increase in loans 90 days past due, I find a positive response of 9.9 basis points, whereas Furfine estimated a *negative* response of 2.6 basis points. I also find statistical significance for 30-89-days past-due loans.

Beyond credit risk, there is also evidence that interbank lenders respond to liquidity risk. In particular, larger securities holdings are associated with lower rates and greater interbank borrowing in both periods, and reliance on large time deposits has the opposite effects. (Of course, these variables are likely determined to some extent jointly with interbank borrowing, as part of each bank's overall funding strategy, so that their interpretation requires some caution.)

Interestingly, the effects of bank capital are modest. Furfine (2001) found statistical significance of capital in pricing, and I replicate this result.[16] However, as in his analysis, the economic significance is small—a one-percentage-point increase in capital reduces funding costs by less than a basis point, even in the later part of the sample. Moreover, the rationing effect is statistically insignificant in both periods. Meanwhile, profitability (as measured by return on assets) had positive effects on rates paid in both periods and negative effects on reliance. Although this is counterintuitive if earnings are viewed are reducing default probability, it is consistent with the possibility that higher earnings signal greater risk-taking by bank managers.

The results for the asset-allocation variables are also subject to interpretation. For residential real estate loans, which are typically considered to be among the safest assets, we should expect negative effects in the rate equations and positive effects in the borrowing equations. In the event, the rate effect is negative in the first half of the sample but insignificant in the second half, and the quantity effect is positive in the second half but negative in the first. For both price and quantity, the results for commercial and industrial loans are consistent with discipline in both periods if these loans are viewed as less risky than the asset classes that are omitted from the regressions—principally commercial real estate and consumer loans.

Finally, the results using the individual risk proxies are consistent with the main points made in the previous section. Nearly all of the marginal effects moved in the direction of greater market discipline in the post-1995 period and, as shown in the highlighted columns, many of these increases were statistically significant. Furthermore, the economic significance of the quantity effects appear to be at least as great as that of the price effects and to have exhibited at least as great an increase. Again, the most pronounced of these results occur among the credit-risk variables.

5. CONCLUSION

The results I have presented indicate that the rate an individual bank pays for interbank loans depends to some degree on its risk—particularly its credit risk—and that reliance on these funds tends to decrease as their cost rises. In the wake of the early-1990s legislation designed to shift more of the burden of bank failure to uninsured creditors, the price elasticity of interbank borrowing with respect to risk increased substantially. However, over the whole sample, quantity rationing appears to be at least as important as yield responses to risk, with the incidence of such rationing also increasing in recent years. Together, the results are consistent with significant and improving discipline in the interbank market, in both the price and quantity dimensions.

Still, even in the most recent period, the response to bank risk does not seem large enough to compel management to restrain its risk appetite. In the terminology of Bliss and Flannery (2002), this market may exhibit *monitoring* but not *influence*. From a supervisory perspective, the effectiveness of federal-funds sellers themselves in imposing discipline on other banks could thus be limited. On the other hand, the statistical strength of the risk coefficients opens the possibility that interbank data—on both prices and quantities—may be a useful supervisory tool.

Because interbank borrowing is an essential source of liquidity for many banks, the positive risk elasticity of its price and the evidence of rationing implies that risky banks may find themselves with limited access to short-term funding, potentially raising their risk even further. Such interactions between liquidity and other types of risk have garnered increased interest recently, as government supervisors have come to recognize the limitations of traditional liquidity metrics. For instance, if a risky bank is priced or rationed out of the fed-funds market, it is likely to turn (at somewhat higher cost) to alternative sources of short-term funding that are not risk priced. The most obvious candidates for this liquidity are the repo market, the Federal Home Loan Bank, and the Discount Window, all of which require collateral on short-term loans and which consequently may not risk-price these loans.[17] The availability of these funds provides a buffer that can prevent the magnification of shocks to bank risk through liquidity shortfalls. However, if these sources should dry up, it is possible that idiosyncratic liquidity shocks to risky but otherwise solvent banks could lead to firesales and precipitate deterioration.

APPENDIX. ROBUSTNESS TO DIFFERENT SCREENING CRITERIA

This appendix reports the results the marginal effects of failure probability on interbank rates and reliance—as given in equations (7)—when different criteria are used to screen admissible observations. As noted in the text, average quarterly rates computed from Call Report data can be somewhat noisy, especially when the quantities borrowed are small, due to rounding and data-reporting errors. The first restriction I imposed to reduce this noise was each bank's calculated quarterly rate paid must be within 200 basis points of the average effective fed-funds rate for that quarter. Rows (2) and (3) of Table A.I show that this range can be cut in half or doubled without substantively affecting the estimates of the marginal effects of failure probability.

Similarly, row (4) of the table illustrates that the results are not sensitive to including mergering and *de novo* banks in the sample, and row (5) shows that including "heavy borrowers" in the interbank market (those with over 20% of their average liabilities in interbank borrowing) also makes little difference. Indeed, only when no restrictions at all do the marginal effects in the rate equations become statistically insignificant, as shown in row (6). This is due to a few extreme observations on interbank rates (e.g., below 0% or over 100%). Even in this case, the basic results for quantities borrowed remain, however.

FOOTNOTES

[1] In addition to Ho and Saunders (1985), see Poole (1968) and, more recently, Bartolini et al. (2002) and Clouse and Dow (2002).

[2] Flannery (1998) provides a review. More recently, see Bliss and Flannery (2001), Martinez Peria and Schmukler (2001), and Sironi (2003).

[3] The fear of this type of contagion effect was also a primary reason for the FDIC's decision to protect uninsured creditors (including fed-funds sellers) of Continental Illinois under the "too big to fail" doctrine. See FDIC (1998).

[4] In their surveys of fed-funds activity, Goodfriend and Whelpley (1993) and Edwards (1997) both document the possibility of risk pricing, but neither presents evidence on its pervasiveness. Taking a historical perspective, Calomiris and Kahn (1996) find that banks effectively risk-priced loans to other banks in New England in the early 19th century.

[5] For example, Allen et al. (1989) report the following case in a footnote: "In fall 1973, Morgan Guaranty refused to sell [federal funds] to Franklin National Bank, almost one year before the latter failed (in October 1974)." Although not technically fed-funds transactions, several banks in Europe in Japan also withdrew short-term deposits from Continental Illinois immediately prior to its bailout (FDIC, 1998).

[6] The effective rate is calculated as a volume-weighted average of the average daily rates quoted by a sample large fed-funds brokers. In their studies, Furfine (2001) used a 50-basis-point band and Demiralp et al. (2004) used a 100-basis-point band around this value to eliminate outliers.

[7] On average, the Call Report figure is about 10 basis points lower than the effective fed-funds rate. This difference is likely due to three factors. First, the brokered transactions that are used to calculate the effective rate include a bid-ask spread that is not reflected in the Call Report data. Second, as reported in Demiralp et al. (2004), correspondent re-bookings, which are included in the Call Report data but not in the effective rate, tend to be priced about 25 basis points below brokered rates. Finally, as mentioned, the Call Report data contain some repos, which typically carry somewhat lower yields than fed funds.

[8] The existing evidence on the disciplining effects of FDICIA is mixed. Goldberg and Hudgins (2002) argue that riskier thrifts had less access to jumbo CDs after the legislation passed. However, Hall et al. (2002) and Covitz et al. (2004) find only weak evidence of enhanced market discipline at commercial banks. Sironi (2003) provides evidence of the discipline-enhancing effects of retreating from too-big-to-fail policies for European banks in the 1990s.

[9] Since, with the regressions I run, the independent variables in (5) turn out to be a subset of the independent variables in (6), SUR provides no efficiency gains over OLS in the estimation of the second-stage equations.

[10] Beginning in March 2006, the Fed phased out SEER, in favor of a model of supervisory-rating downgrades.

[11] SEER is estimated over a two-year horizon, but the interest rates to which I want to compare it are all reported on an annual basis. I therefore apply a constant-proportional-hazard-rate transformation to the SEER probabilities to obtain one-year figures. This adjustment turns out to make little qualitative difference in the regression results.

[12] Members of the FHLB system have nearly instantaneous access to a large line of credit on flexible terms, which can in some cases serve as a substitute for borrowing in the fed-funds market. Data on membership from 1992:4 onward were supplied by the FHLB. Prior to this, the dummy variable is set to zero for all banks. (Although membership technically became available in 1989, very few banks became members before 1992.)

[13] Asymptotic standard errors for the second-stage regressions are computed using the correction of Heckman (1979). Standard errors for the marginal effects are computed under the assumption that d is uncorrelated with a_3 and b_3.

[14] As indicated in Table 3, 10 percentage points would represent an economically large change in failure probability—the standard deviation of these probabilities over the sample was just 6 percentage points, and the mean probability was less than 1%.

[15] The coefficients on the inverse Mill's ratio (not reported in the table) indicate the correlation between the probability of market participation and yield (a_3) and quantity borrowed (b_3). In the pre-1996 subsample, these coefficients are 0.37 and 4.15, respectively; in the post-1995 subsample, they are 0.45 and 3.53. Although the changes in these coefficients are statistically significant, they are economically small, suggesting that most of the increase in risk pricing between the two periods was due to the direct effects of default probability, rather than to indirect effects operating through participation.

[16] Furfine used risk-based capital, which is arguably a better measure. I do not consider it here because the accounting data to compute it do not exist prior to 1996 and total net worth (book capital to assets) is the variable used in SEER.

[17] Billet et al. (1998) and Billet and Garfinkel (2004) flesh out this liability-substitution theory in detail and provide some empirical evidence from the subordinated-debt market. With respect to the FHLB, Stojanovic et al. (2001) find that riskier banks have a greater tendency to become members and to rely on advances.

Table 1

Summary Statistics for Interbank-Borrowing Rates, 1986:1 – 2005:4

This table compares the time-series and cross-sectional variation of individual interbank rates calculated from Call Report data with the effective fed-funds rate. The sample includes 162,293 quarterly observations on commercial banks that borrowed in the interbank market (an average of 2,029 per quarter), after being screened according to the criteria described in the text. The statistics for the effective fed-funds rate are calculated using daily data. The individual bank rates are calculated by dividing quarterly interest expense on interbank borrowing by the quarterly average of the daily quantity of these borrowings outstanding. Data for the effective fed funds rate is sampled at a daily frequency. The $500-million cutoff is in 1996 dollars.

		Average of Quarterly Averages	Average Quarterly Std. Dev.	Std. Dev. of Quarterly Averages
1986 - 2005	*Effective fed-funds rate*	4.96	0.26	2.23
	Sample interbank rate:			
	All Borrowing Banks	4.86	0.69	2.11
	Banks < $500 mil in assets	4.88	0.72	2.08
	Banks > $500 mil in assets	4.80	0.55	2.19
1986 - 1995	*Effective fed-funds rate*	6.07	0.33	2.00
	Sample interbank rate (all banks)	5.94	0.70	1.89
1996 - 2005	*Effective fed-funds rate*	3.86	0.19	1.90
	Sample interbank rate (all banks)	3.79	0.68	1.76

Table 2

Comparison of Interbank Borrowing at Failing and Surviving Banks, 1986-2005

This table shows the patterns of reliance on and pricing of interbank borrowing at failing commercial banks between 1986 and 2005, compared to contemporaneous banks that did not fail. The small quarterly changes in the averages for the surviving banks reflect the systematic time trends in the data. Statistics in Panel A are computed only for those banks with sufficient borrowings to compute reliable quarterly yields. Statistical significance at the 1% level for the one-tailed difference-of-means tests is denoted by **.

Panel A. *Individual interbank rate paid less effective fed-funds rate (percentage points)*

Quarters prior to failure	Failed banks		Surviving banks		Difference (t-statistic)
	# Obs.	Mean (Std. Dev.)	# Obs.	Mean (Std. Dev.)	
1 Qtr	240	0.163 (0.861)	275,664	-0.077 (0.810)	0.240** (4.32)
2 Qtrs	293	0.112 (0.817)	271,663	-0.076 (0.812)	0.188** (3.94)
4 Qtrs	288	0.136 (0.875)	263,804	-0.074 (0.816)	0.210** (4.07)
8 Qtrs	282	0.125 (0.797)	236,329	-0.069 (0.823)	0.194** (4.08)

Panel B. *Interbank borrowing / total liabilities (%)*

Quarters prior to failure	Failed banks		Surviving banks		Difference (t-statistic)
	# Obs.	Mean (Std. Dev.)	# Obs.	Mean (Std. Dev.)	
1 Qtr	1,180	0.911 (3.570)	803,563	1.620 (4.700)	-0.709** (-6.81)
2 Qtrs	1,182	0.897 (2.864)	800,200	1.604 (4.671)	-0.707** (-8.47)
4 Qtrs	1,181	1.128 (4.226)	793,339	1.575 (4.615)	-0.447** (-3.63)
8 Qtrs	1,048	1.245 (3.555)	739,874	1.528 (4.546)	-0.283** (-2.57)

Panel C. *Banks with non-zero borrowing*

Quarters prior to failure	Failed banks		Surviving banks		Difference (t-statistic)
	# Obs.	%	# Obs.	%	
1 Qtr	1,180	35.6	803,563	48.4	-12.8** (-9.17)
2 Qtrs	1,182	39.4	800,200	48.1	-8.7** (-6.11)
4 Qtrs	1,181	41.9	793,339	47.6	-5.7** (-3.96)
8 Qtrs	1,048	44.4	739,874	46.7	-2.3 (-1.50)

Table 3

Summary Statistics for Regression Variables

This table reports summary statistics for the variables used in the system estimation reported in Table 4. The first stage includes all institutions that met the screening criteria described in the text, regardless of their participation in the interbank market. The second stage includes only those institutions whose participation in the market was sufficient to compute an interbank borrowing rate.

Panel A. *1986 – 1995*

		First Stage (454,345 obs.)		Second Stage (86,068 obs.)	
		Mean	Std. Dev.	Mean	Std. Dev.
Depend. Variables	Interbank participation (dummy)	0.19	0.39		
	Individual interbank rate(%)			5.96	1.96
	Interbank borrowing / liabilities (%)			5.02	4.21
Indep. Variables	SEER failure probability(%)	2.68	11.59	1.95	9.81
	Log assets	10.87	1.20	12.23	1.37
	FHLB membership (dummy)	0.07	0.25	0.13	0.33
	Deposit growth (%)	1.91	11.31	1.60	10.69
	Loan growth (%)	1.55	6.33	1.80	5.62
	Non-pledged securities / assets (%)	22.20	15.22	16.60	12.39

Panel B. *1996 – 2005*

		First Stage (306,135 obs.)		Second Stage (76,225 obs.)	
		Mean	Std. Dev.	Mean	Std. Dev.
Depend. Variables	Interbank participation (dummy)	0.25	0.43		
	Individual interbank rate(%)			4.10	1.80
	Interbank borrowing / liabilities (%)			4.88	3.96
Indep. Variables	SEER failure probability(%)	0.35	2.96	0.14	1.26
	Log assets	11.43	1.23	12.51	1.37
	FHLB membership (dummy)	0.64	0.48	0.79	0.40
	Deposit growth (%)	2.14	11.46	1.71	12.06
	Loan growth (%)	2.35	5.69	2.78	5.15
	Non-pledged securities / assets (%)	16.70	13.10	13.34	10.86

Table 4

Two-Stage Regression Results for Interbank Pricing and Borrowing Levels

This table shows the results of the two-stage Heckit procedure for interbank-market participation, borrowing levels and rates paid. The first stage, reported in column (2), is a probit model for each bank's participation decision, with failure probability and controls as the explanatory variables. The second stage, reported in columns (3) and (5), consists of linear regressions of individual interbank rates and borrowing on the indicated variables and the inverse Mill's ratio from the first stage. OLS results for these regressions are reported for robustness. Standard errors appear in parentheses. Time dummies are also included in all regressions. Marginal effects for the Heckit model are evaluated at the full-sample mean of the inverse Mills ratio, using the calculations described in the text. Statistical significance at the 5% and 1% levels is denoted by * and **, respectively.

Panel A. *1986 – 1995*

	Participation Probit	Dependent Variable: *Individual interbank rate*		Dependent Variable: *Interbank borrowing / liabilities*	
		Heckit Marg. Effect	OLS	Heckit Marg. Effect	OLS
SEER failure probability	-0.006**	0.0045**	0.0041**	-0.0196**	-0.0197**
	(0.0003)	(0.0003)	(0.0002)	(0.0015)	(0.0015)
Log real assets	0.814**	-0.0577**	-0.0250**	0.2844**	0.7319**
	(0.003)	(0.0095)	(0.0017)	(0.0578)	(0.0104)
FHLB membership (dummy)	0.156**			0.0906	-0.1821**
	(0.010)			(0.0514)	(0.0503)
Deposit growth	-0.003**			-0.0051**	-0.0064**
	(0.0003)			(0.0014)	(0.0015)
Loan growth	0.005**			0.0056*	0.0064*
	(0.001)			(0.0025)	(0.0025)
Non-pledged securities / assets	-0.011**			-0.0446**	-0.0422**
	(0.0002)			(0.0014)	(0.0012)
Individual interbank rate				0.0245	0.1962**
				(0.0192)	(0.0195)
R^2		0.874	0.872	0.135	0.092
# Obs.	454,345	86,068			

Panel B. *1996 – 2005*

	Participation Probit	Dependent Variable: *Individual interbank rate* Heckit Marg. Effect	OLS	Dependent Variable: *Interbank borrowing / liabilities* Heckit Marg. Effect	OLS
SEER failure probability	-0.0399**	0.0081**	0.0106**	-0.1138**	-0.0902**
	(0.0022)	(0.0024)	(0.0020)	(0.0117)	(0.0112)
Log real assets	0.7256**	-0.1018**	-0.0589**	0.0213	0.4149**
	(0.0031)	(0.0093)	(0.0019)	(0.0627)	(0.0106)
FHLB membership (dummy)	0.2732**			-0.1124**	-0.4693**
	(0.0070)			(0.0464)	(0.0365)
Deposit growth	-0.0032**			-0.0052**	-0.0060**
	(0.0003)			(0.0012)	(0.0012)
Loan growth	0.0080**			-0.0067**	-0.0067*
	(0.0005)			(0.0029)	(0.0028)
Non-pledged securities / assets	-0.0106**			-0.0349**	-0.0347**
	(0.0003)			(0.0016)	(0.0013)
Individual interbank rate				-0.4703**	-0.3120**
				(0.0202)	(0.0202)
R^2		0.856	0.853	0.076	0.046
# Obs.	306,135	76,225			

Table 5

Pricing and Rationing with Multiple Risk Variables

This table shows the Heckit marginal effects on interbank rates and borrowing when the system is estimated using a vector of risk variables, for the 1986-1995 and 1996-2005 sample periods. Shaded columns report tests of differences in the coefficients across these periods. Control variables, including time dummies, are used in the regressions but not reported. Standard errors are given in parentheses. Statistical significance at the 1% level is denoted by **.

	Marginal Effects on Rates			Marginal Effects on Borrowing		
	1986-1995	1996-2005	Difference	1986-1995	1996-2005	Difference
Tangible capital	-0.0040** (0.0014)	-0.0066** (0.0014)	-0.0026 (0.0020)	-0.0087 (0.0067)	-0.0083 (0.0066)	0.0004 (0.0094)
Loans 30-89 days past due	0.0329** (0.0037)	0.0581** (0.0050)	**0.0252**** **(0.0062)**	-0.0681** (0.0169)	-0.1748** (0.0235)	**-0.1133**** **(0.0289)**
Loans past due 90+ days	0.0233** (0.0061)	0.0993** (0.0103)	**0.0760**** **(0.0120)**	-0.0778** (0.0284)	-0.0063 (0.0470)	0.0715 (0.0549)
Nonaccrual loans	0.0086** (0.0033)	0.0200** (0.0062)	0.0114 (0.0070)	-0.0850** (0.0149)	-0.2051** (0.0282)	**-0.1201**** **(0.0319)**
Other real estate owned	-0.0170** (0.0035)	-0.0053 (0.0124)	0.0117 (0.0129)	-0.2886** (0.0163)	-0.5534** (0.0574)	**-0.2648**** **(0.0597)**
Commercial & industrial loans	-0.0018** (0.0005)	-0.0017** (0.0005)	0.0001 (0.0007)	0.0054* (0.0022)	0.0432** (0.0024)	**0.0378**** **(0.0033)**
Residential real estate loans	-0.0012** (0.0004)	-0.0003 (0.0003)	0.0009 (0.0005)	-0.0421** (0.0017)	0.0061** (0.0016)	**0.0360**** **(0.0023)**
Net income (ROA)	0.0128** (0.0036)	0.0419** (0.0048)	**0.0291**** **(0.0060)**	-0.1666** (0.0168)	-0.1626** (0.0214)	0.0040 (0.0272)
Investment securities	-0.0078** (0.0005)	-0.0052** (0.0005)	**0.0026**** **(0.0007)**	0.1429** (0.0034)	0.1337** (0.0034)	-0.0092 (0.0048)
Large time deposits	0.0112** (0.0005)	0.0096** (0.0005)	-0.0006 (0.0007)	-0.0546** (0.0024)	-0.0725** (0.0025)	**-0.0179**** **(0.0035)**

Table A.1

Marginal Effects of Risk with Different Samples

This table shows the marginal effects of failure probability in the second-stage rate and borrowing equations, for both the 1986-1995 and 1996-2005 subsamples, when different criteria are used to screen the observations. Control variables, including time dummies, are used in the regressions but not reported. Standard errors are given in parentheses. Statistical significance at the 1% level is denoted by **.

	Marginal Effects on Rates		Marginal Effects on Borrowing	
	1986-1995	1996-2005	1986-1995	1996-2005
(1) Baseline	**0.0045** (0.0003)**	**0.0081** (0.0024)**	**-0.0196** (0.0015)**	**-0.1138** (0.0117)**
(2) 100 bp range	0.0033** (0.0002)	0.0058** (0.0020)	-0.0210** (0.0017)	-0.1117** (0.0126)
(3) 400 bp range	0.0052** (0.0004)	0.0114** (0.0029)	-0.0193** (0.0014)	-0.1084** (0.0110)
(4) Incl. mergers & *de novos*	0.0046** (0.0003)	0.0081** (0.0024)	-0.0200** (0.0015)	-0.1138** (0.0117)
(5) Incl. heavy borrowers	0.0045** (0.0003)	0.0070** (0.0023)	-0.0293** (0.0026)	-0.1385** (0.0210)
(6) No restrictions	-4042.1 (8106.3)	-37.992 (358.652)	-0.0223** (0.0014)	-0.1066** (0.0328)

Figure 1. Comparison of effective federal-funds rate and sample interbank rate.

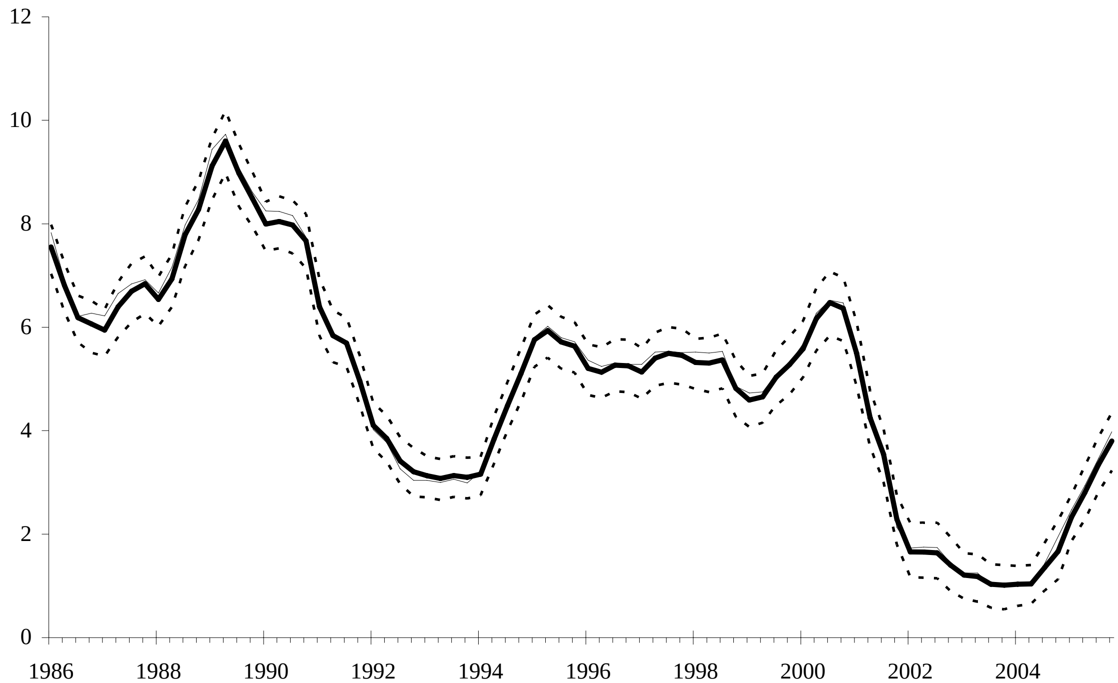

Figure 2. Marginal effects of failure probability in year-by-year regressions.

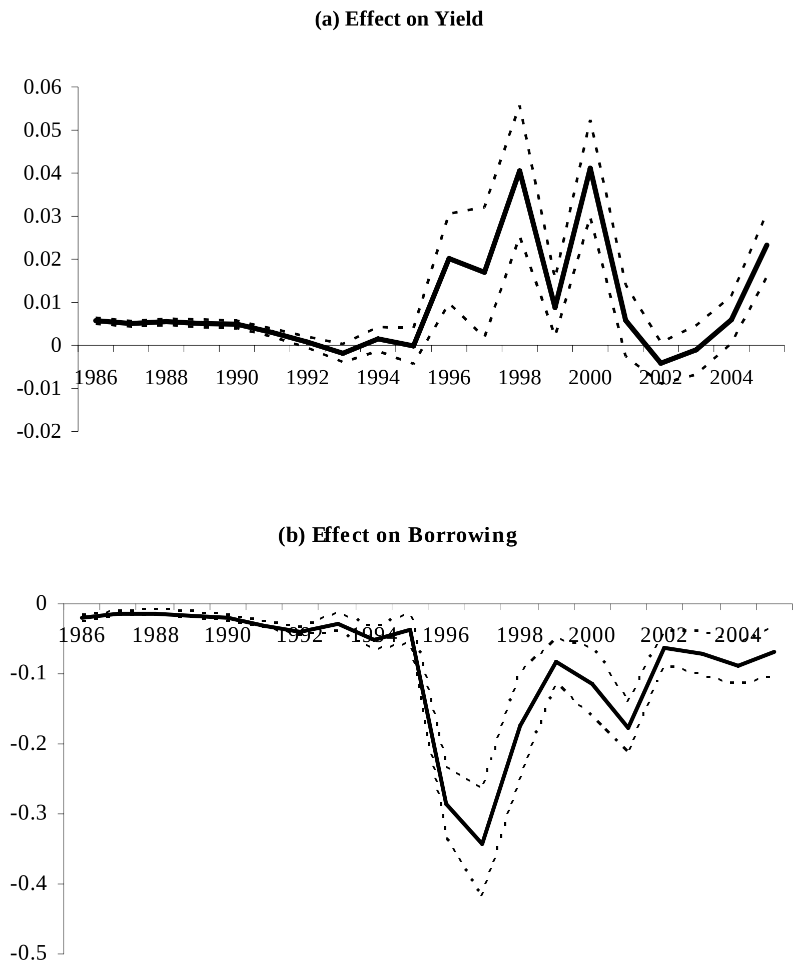

Figure 3. Interbank-borrowing composition versus marginal effect of risk, 1988-96.

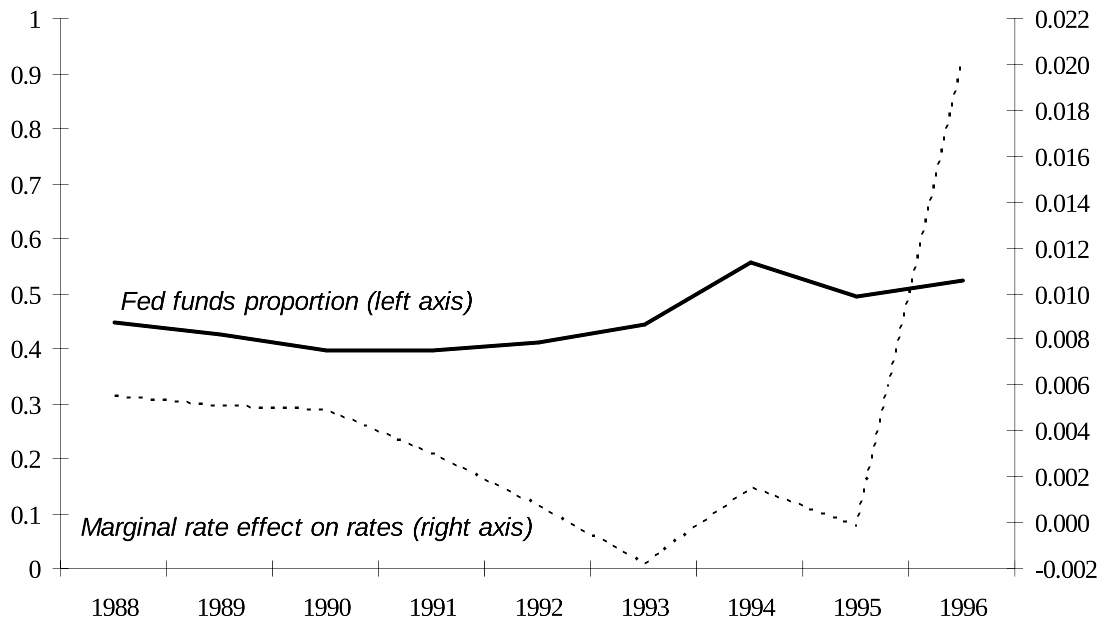

FIGURE CAPTIONS

Figure 1. This figure shows the quarterly average of the effective federal-funds rate (thin solid line) and the quarterly average of the sample interbank-borrowing rates computed from the Call Report data (thick solid line). Dotted lines show the quarterly inter-quartile range of the sample rates.

Figure 2. This figure displays the coefficient on failure probability in yearly estimations of equation (2), which has individual interbank borrowing rates as the dependent variable, and equation (3), which has interbank reliance as the dependent variable. All control variables listed in Tables 4 and 7 are also included in these regressions. Dotted lines show standard-error bands.

Figure 3. This figure shows the average ratio of federal funds purchased to total interbank borrowing for the sample banks, year by year (sold line), using end-of-quarter Call Report data collected over the years 1988-1996. For comparison, the yearly marginal effect of failure probability on interbank rates paid (dotted line) from Figure 2, is also shown.

REFERENCES

Allen, Linda, Stavros Peristiani, and Anthony Saunders. (1989) "Bank Size, Collateral, and Net Purchase Behavior in the Federal Funds Market: Empirical Evidence." *Journal of Business*, 62, 501-15.

Bartolini, Leonardo, Giuseppe Bertola, and Alessandro Prati. (2002) "Day-to-Day Monetary Policy and the Volatility of the Federal Funds Interest Rate." *Journal of Money, Credit, and Banking*, 34, 137-59.

Benston, George, and George Kaufman. (1998) "Deposit Insurance Reform in the FDIC Improvement Act: The Experience to Date." *Federal Reserve Bank of Chicago Economic Perspectives (Second Quarter)*, 2-20.

Billet, Matthew T., and Jon A. Garfinkel. (2004) "Financial Flexibility and the Cost of External Finance for U.S. Bank Holding Companies." *Journal of Money, Credit, and Banking*, 36:5, 827-52.

Billet, Matthew T., Jon A. Garfinkel, and Edward S. O' Neal. (1998) "The Cost of Market vs. Regulatory Discipline in Banking." *Journal of Financial Economics*, 48, 333-58.

Bliss, Robert R., and Mark J. Flannery. (2002) "Market Discipline in the Governance of U.S. Bank Holding Companies: Monitoring versus Influencing." *European Finance Review*, 6:3, 361-95.

Calomiris, Charles W., and Charles M. Kahn. (1996) "The Efficiency of Self-Regulated Payments Systems: Learning from the Suffolk System." *Journal of Money, Credit, and Banking*, 28, 766-97.

Carpenter, Seth, and Elizabeth Klee. (2006) "Market Power in the Federal Funds Market." *Board of Governors of the Federal Reserve System*, working paper.

Clouse, James A., and James P. Dow, Jr. (2002) "A Computational Model of Banks' Optimal Reserve Management Policy." *Journal of Economic Dynamics and Control*, 26, 1787-1814.

Cole, Rebel A., Barbara G. Cornyn, and Jeffery W. Gunther. (1995) "FIMS: A New Monitoring System for Banking Institutions." *Federal Reserve Bulletin*, 81, 1-15.

Covitz, Daniel M., Diana Hancock, and Myron L. Kwast. (2004) "A Reconsideration of the Risk Sensitivity of U.S. Banking Organization Subordinated Debt Spreads: A Sample Selection Approach." *Federal Reserve Bank of New York Economic Policy Review*, 10:2, 73-92.

Demiralp, Selva, Brian Preslopsky, and William Whitesell. (2004). "Overnight Interbank Loan Markets." *Federal Reserve Board of Governors, Finance and Economic Discussion Series*, 2004-29.

Dick, Astrid. (2006) "Nationwide Branching and Its Impact on Market Structure, Quality, and Bank Performance." *Journal of Business*, 79, 567-92.

Edwards, Cheryl L. (1997) "Open Market Operations in the 1990s." *Federal Reserve Bulletin*, 83, 859-74.

Federal Deposit Insurance Corporation. (1998) Managing the Crisis – The FDIC and RTC Experience 1980 – 1994, vol. 1 Washington, DC: FDIC.

Federal Reserve Regulation F, 57 FR 60106, 18 December 1992.

Flannery, Mark J. (1998) "Using Market Information in Prudential Bank Supervision: A Review of the U.S. Empirical Evidence." *Journal of Money, Credit, and Banking*, 30, 273-305.

Flannery, Mark J., Simon H. Kwan, and M. Nimalendran. (2004) "Market Evidence on the Opaqueness of Banking Firms' Assets." *Journal of Financial Economics*, 71, 419-60.

Flannery, Mark J., and Sorin M. Sorescu. (1996) "Evidence of Bank Market Discipline in Subordinated Debenture Yields: 1983 – 1991." *Journal of Finance*, 51, 1347-77.

Furfine, Craig H. (2001) "Banks as Monitors of Other Banks: Evidence from the Overnight Market for Federal Funds." *Journal of Business*, 74, 33-57.

Gilbert, R. Alton, Andrew P. Meyer, and Mark D. Vaughan. (1999) "The Role of Supervisory Screens and Econometric Models in off-Site Surveillance." *Federal Reserve Bank of St. Louis Review*, 81(November/December): 31-56.

Goldberg, Lawrence G., and Sylvia C. Hudgins. (2002) "Depositor Discipline and Changing Strategies for Resolving Thrift Institutions." *Journal of Financial Economics*, 63, 263-74.

Goodfriend, Marvin, and William Whelpley. (1993) "Federal Funds." In *Instruments of the Money Market*. Federal Reserve Bank of Richmond.

Hall, John R., Thomas B. King, Andrew P. Meyer, and Mark D. Vaughan. (2002) "Did FDICIA Improve Market Discipline of Community Banks? A Look at Evidence from the Jumbo-CD Market." In *Prompt Corrective Action in Banking: 10 Years Later*, pp. 63-94. New York: JAI Press.

Hannan, Timothy H., and Gerald A. Hanweck. (1988) "Bank Insolvency Risk and the Market for Large Certificates of Deposit." *Journal of Money, Credit, and Banking*, 20, 203-11.

Heckman, James J. (1976) "The Common Structure of Statistical Models of Truncation, Sample Selection, and Limited Dependent Variables and a Simple Estimator for Such Models." *Annals of Economic and Social Measurement*, 5, 475-92.

Heckman, James J. (1979) "Sample Selection Bias as a Specification Error." *Econometrica*, 47, 153-61.

Ho, Thomas S. Y., and Anthony Saunders. (1985) "A Micro Model of the Federal Funds Market." *Journal of Finance*, 40, 977-88.

Jayaratne, Jith, and Philip E. Strahan. (1996) "The Finance-Growth Nexus: Evidence from Bank Branch Deregulation." *Quarterly Journal of Economics*, 111, 639-70.

King, Thomas B., Daniel A. Nuxoll, and Timothy J. Yeager. (2006) "Are the Causes of Bank Distress Changing? Can Researchers Keep up?" *Federal Reserve Bank of St. Louis Review*, 88 (January/February), 57-80.

Lumpkin, Stephen A. (1993) "Repurchase and Reverse Repurchase Agreements." In *Instruments of the Money Market*. Federal Reserve Bank of Richmond.

Marino, James A., and Rosalind L. Bennett. (1999) "The Consequences of National Depositor Preference." *FDIC Banking Review*, 12, 19-38.

Martinez Peria, Maria Soledad, and Sergio L. Schmukler. (2001) "Do Depositors Punish Banks for Bad Behavior? Market Discipline, Deposit Insurance, and Banking Crises." *Journal of Finance*, 56, 1029-51.

Meulendyke, Ann-Marie. (1998) U.S. Monetary Policy and Financial Markets. Federal Reserve Bank of New York.

Park, Sangkyun, and Stavros Peristiani. (1998) "Market Discipline by Thrift Depositors." *Journal of Money, Credit, and Banking*, 30, 347-64.

Petersen, Mitchell, and Raghuran Rajan. (2002) "Does Distance Still Matter? The Information Revolution in Small Business Lending." *Journal of Finance*, 57, 2533-70.

Poole, William. (1968) "Commercial Bank Reserve Management in a Stochastic Model: Implications for Monetary Policy." *Journal of Finance*, 21, 769-91.

Ringsmuth, Don. (1985) "Custodial Arrangements and Other Contractual Considerations." *Federal Reserve Bank of Atlanta Economic Review*, 70 (September), 40-48.

Sironi, Andrea. (2003) "Testing for Market Discipline in the European Banking Industry: Evidence from Subordinated Debt Issues." *Journal of Money, Credit, and Banking*, 35, 443-72.

Stojanovic, Dusan, Mark D. Vaughan, and Timothy J. Yeager. (2001) "Do Federal Home Loan Bank Advances and Membership Lead to More Bank Risk?" In *The Financial Safety Net: Costs, Benefits, and Implications for Regulations*. Federal Reserve Bank of Chicago.