Evidence of Bank Market Discipline in Subordinated Debenture Yields: 1983- 1991
Author(s): Mark J. Flannery and Sorin M. Sorescu
Source: *The Journal of Finance*, Vol. 51, No. 4 (Sep., 1996), pp. 1347-1377
Published by: Blackwell Publishing for the American Finance Association
Stable URL: http://www.jstor.org/stable/2329397
Accessed: 25/11/2009 10:19

THE JOURNAL OF FINANCE • VOL. LI, NO. 4 • SEPTEMBER 1996

Evidence of Bank Market Discipline in Subordinated Debenture Yields: 1983–1991

MARK J. FLANNERY and SORIN M. SORESCU*

ABSTRACT

We examine debenture yields over the period 1983–1991 to evaluate the market's sensitivity to bank-specific risks, and conclude that investors have rationally reflected changes in the government's policy toward absorbing private losses in the event of a bank failure. Although this evidence does not establish that market discipline can effectively control banking firms, it soundly rejects the hypothesis that investors cannot rationally differentiate among the risks undertaken by the major U.S. banking firms.

AN INCREASINGLY IMPORTANT ISSUE in the regulation of financial institutions concerns the extent to which market investors can (will) recognize and control the risks of banking firms. Although the Banking Act of 1933 replaced some private risk-bearing with federal deposit insurance, legislators were reluctant to displace market discipline very extensively (Flood (1992)). By the early 1980s, however, U.S. regulators had come to protect virtually all bank liability holders from credit losses—most visibly at large banks which were deemed "too big to fail" (Sprague (1986), O'Hara and Shaw (1990)). This extension of the government safety net largely reflects a skepticism on the part of regulators that "normal" market forces could adequately identify and control bank risks. While U.S. regulators have recently shown an increased willingness to let some bank investors bear default losses, an official suspicion of the efficacy of market discipline remains widespread. By contrast, some prominent academic economists argue that market investors in bank debentures could provide timely and effective control over banking firms' risk exposures, and that the social cost of supervising banks would be lower if regulators ceded greater

* Flannery is Professor of Finance in the Graduate School of Business, University of Florida. Sorescu is a Ph.D. Candidate in Finance at the University of Florida. This research project was inspired by an insightful conversation with Brian C. Gendreau of Morgan Guaranty Bank. We thank David Ling and Michael Giliberto for help in computing option-adjusted interest rate spreads and Rick Borgman for research assistance. Helpful comments and suggestions have been provided by George Benston, Allen Berger, Matt Billett, Dave Brown, Rebel Cole, Bob Eisenbeis, Ed Ettin, Mark Flood, Alton Gilbert, Gary Gorton (the referee), Joel Houston, Jim Moser, René Stulz (the editor), Carolyn Takeda, and seminar participants at the Atlanta Finance Forum, Laval University, University of Maryland, Berkeley, Stanford, University of Wisconsin at Madison, University of Wisconsin at Milwaukee, University of Central Florida, and the Federal Reserve Bank of San Francisco. The second author gratefully acknowledges financial support from the Social Sciences and Humanities Research Council of Canada.

control to the market forces that operate for nonbank firms (e.g., Kaufman and Benston (1993)).

Prior studies of bank market discipline have sought to identify rational default risk premia in the rates paid on large certificates of deposit (CDs) and subordinated notes and debentures (SNDs). While some authors report evidence that large CD rates contain appropriate risk premia,[1] two studies of bank subordinated debentures find no relation between balance sheet risks and SND pricing (Avery, Belton, and Goldberg (1988) and Gorton and Santomero (1990)).[2] It seems implausible that CD investors receive a premium for default risk when subordinated debenture holders (who enjoy a less firm conjectural government guarantee) do not. The ability of SND holders to assess bank risk is important because their claims have a priority similar to the FDIC's following a bank failure. If investors incorporate appropriate risk premia into debenture rates, market claimants may be able to substitute, at least partially, for government regulatory oversight of large banking firms.

Our major purpose in this article is to investigate the market's ability to recognize default risk in one important class of bank obligations—subordinated debentures. We utilize a more extensive data set than earlier studies. Because the value of implicit government insurance on SNDs eroded quite substantially over our sample period, we hope to identify investors' reactions to the changing regulatory environment. In particular, we hypothesize that SND yields will become more closely correlated with indicators of bank risk as regulatory treatment of failed banks' debentures became more harsh.

This article proceeds as follows. Section I reviews and evaluates the two most recent studies of bank SND pricing. Section II describes how regulators treated SND investors in bank failures over our sample period (1983–1991). Section III describes data sources, and Section IV specifies a variety of regression models. Section V presents our results when SND yield spreads are regressed on accounting measures of risk, and on fair spread estimates from a theoretical bond valuation model. Section VI investigates whether spreads are rationally related to bond ratings. The article concludes with a summary and discussion of investor rationality and the potential for increasing reliance on market discipline in banking.

I. Past Studies of SND Market Discipline

Two prior studies have explicitly evaluated whether bank SND yields reflect the issuer's risk of default. Avery, Belton, and Goldberg (1988) collected year-end yields on SNDs issued by the largest 100 U.S. bank holding companies. After adjusting these yields for the value of embedded call (prepayment) options, they produce an option-adjusted spread over a similar-maturity Trea-

[1] Baer and Brewer (1986), James (1988, 1990), Hannan and Hanweck (1988), Keeley (1990), Cargill (1989), Ellis and Flannery (1992), and Cook and Spellman (1994).

[2] Gilbert (1990) reviews and assesses a larger group of SND pricing studies. See especially pp. 14–17.

sury bond for each SND at year-end 1983 and 1984. Avery *et al.* reason that this spread should increase with perceived default risk, and therefore regress the option-adjusted spread on "generally accepted measures of risk that apply to the issuer" (p. 600). Surprisingly, they find no significant effect of measured balance sheet risks on SND spreads, and conclude that market investors do not discipline and control bank risk-taking in the usual manner:

> . . .the potential for market discipline to effectively and constructively augment regulatory controls via the subordinated note and debenture capital market is *weak*. The pricing signals that bankers receive from this market appear to be *at odds with the directions desired by regulators* (p. 609, emphasis added).

Despite the fact that Avery *et al.* find no effect of balance sheet risk measures on SND spreads, they *do* report that bond credit ratings are significantly correlated with spreads: for example, their AAA-rated bonds had an average spread of 0.88 percent compared to 2.39 percent for B and C-rated bonds.

Gorton and Santomero (1990) suggest that Avery *et al.* may fail to detect risk premia in bank SND because their regression specification mistakenly imposes a monotonic relation between a firm's asset risk and the required SND spread. Gorton and Santomero point out that Black and Cox's (1976) model of SND pricing indicates that the default spread will be *either* increasing *or* decreasing in asset risk, according to the firm's leverage.[3] Gorton and Santomero argue that the asset volatility implied by a firm's SND spread should be monotonically related to balance sheet risk measures, even if the yield spread is not. Gorton and Santomero use the Black-Cox formula and data on the book value of bank leverage to compute implied asset volatilities, which they then regress on balance sheet risk measures. Upon finding virtually no relation between a bank's risk measures and its implied asset volatility, Gorton and Santomero conclude that their results "offer little support for the presence of market discipline in the subordinated debt market" (p. 127).

These two studies address a fundamental policy issue: whether market forces can accurately identify an individual bank's default risk. The conclusion that SND investors do not respond to conventional risk measures seems to imply that market forces do not operate in this sector. Many government regulators believe that market discipline *cannot* operate effectively in the banking sector. For example, the American Bankers Association (1991, p. 8) notes that "Bank regulators tend to dismiss the idea that investors in uninsured deposits are capable of making useful judgments as to the safety of individual banks." (See also Randall (1994)). Yet this conclusion fails to recognize several potential shortcomings of these studies.

[3] The SND-holder's claim is senior to equity's, but junior to nonsubordinated debt. When an issuer's stock value is very low, SND values behave much like equity, in the sense that risk increases raise their expected payoff. Conversely, when the issuer is well-capitalized, SNDs resemble senior debt, which means that an increase in asset risk reduces their value.

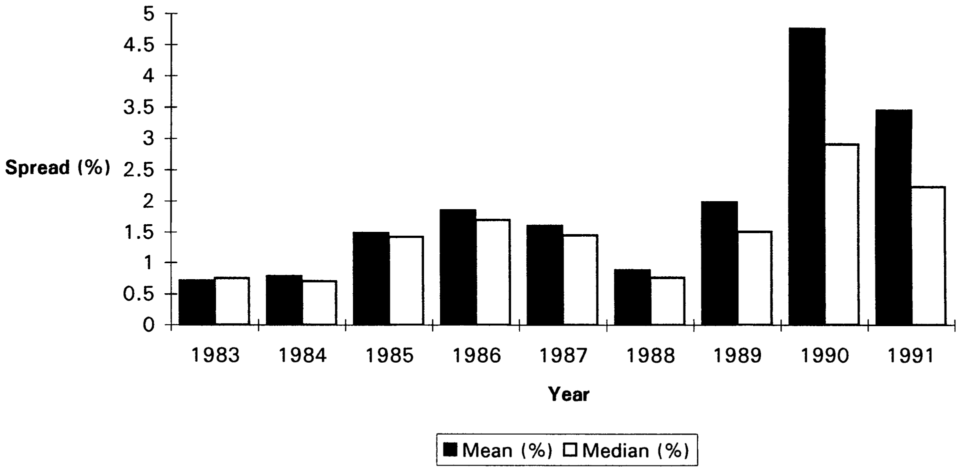

Figure 1. Option adjusted spreads on bank subordinated debentures.

First, SND investors may plausibly have felt protected by a conjectural government guarantee during the studies' 1983–1984 sample period. If so, we should observe that SND prices became more sensitive to risk measurements later in the decade, as bank SND holders became more likely to suffer default losses in a bank failure.

Second, the 1983–1984 cross-sectional variation in bank risk (or risk premia) may have been too limited to permit strong statistical inferences. The data assembled for this study are consistent with this possibility. Figure 1 plots the mean and median values of our sample banks' option-adjusted spreads by year. The mean (median) spread is never smaller than it was at the time of Avery, Belton, and Goldberg's data, consistent with the hypothesis that government policies rendered bank default risk irrelevant in 1983–1984. Figure 2 demonstrates that bank spreads were also relatively homogeneous early in our sample period: only in 1988 was the cross-sectional dispersion of spreads as small as in 1983–1984. These two figures suggest that we may find a significant correlation between SND pricing and bank default risks over a longer time period, even if market discipline cannot be identified during 1983–1984.[4]

Third, the regression specifications used in previous studies may be incorrect. While theory indicates that asset risk and leverage should affect SND spreads in a nonlinear, interactive manner, Avery *et al.* run a simple linear regression of spread on balance sheet and income ratios. Similarly, Gorton and Santomero derive their estimates of asset volatility from a stylized model of

[4] A quick inspection of Figures 1 and 2 strongly suggests that market discipline became more prominent later in the sample period. Similarly, the proportion of our sample banks whose SNDs were rated (by Moodys or Standard and Poor) rose from 74.8 percent (in 1983–1984) to 91.9 percent (in 1990–1991), consistent with investors' increased demand for credit information. Much of our article evaluates whether the higher, more variable SND spreads following 1984 are rationally related to other measures of bank default risk.

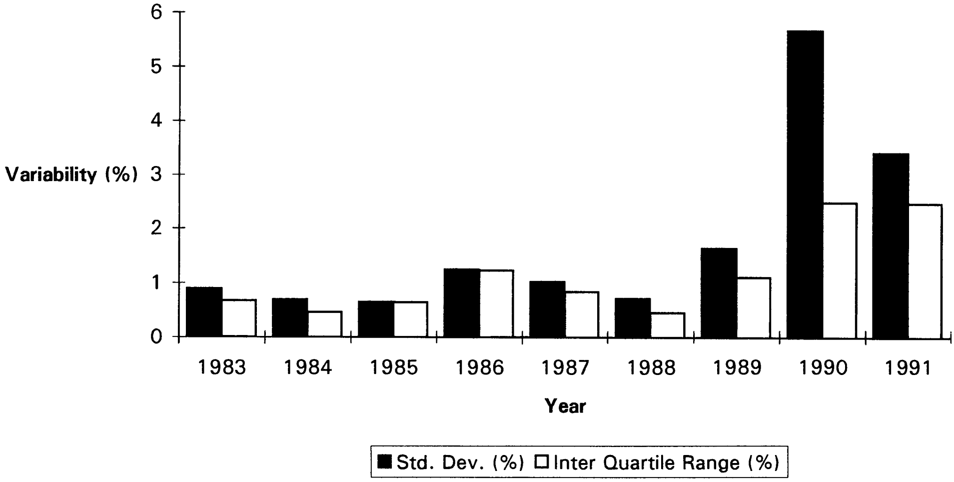

Figure 2. Cross-sectional variability in SPREAD.

SND valuation, but report only the results of a linear regression of these volatility estimates on bank accounting variables.

Finally, measurement errors in the dependent variables may leave these studies' regression tests with low power to reject the null hypothesis (of no market discipline). The yield differential between private, risky bonds and similar-maturity treasuries reflects several factors that are difficult to measure: the value of the private bonds' call option, state and local taxes, and differences in secondary market liquidity. Although Avery *et al.* apply sophisticated adjustments to value the call options embedded in most bank SNDs, they must necessarily be measuring the default risk component of SND spreads with some error. Similarly, Black and Cox's closed-form valuation of SNDs imposes strong seniority and distributional assumptions that could induce large measurement errors in Gorton and Santomero's estimates of asset volatility.

In summary, these two prior SND studies employed the same, relatively small data set, which was taken from a quiescent market period. Neither concludes that investors price SNDs to reflect the issuers' accounting risk measures, although Avery *et al.* find a significant impact of Moody's credit ratings on SND spreads. Our study provides four improvements. First, we analyze data from a longer time period, during which the government's treatment of SND creditors changed substantially. Second, we use a new data source to expand the number of sample banks with traded SNDs. This data set should permit a more reliable—and timely—assessment of market discipline by SND investors. Third, we explore a number of regression specifications, to assess the robustness of our conclusions about market discipline. Finally, we evaluate both market and accounting measures of risk.

II. Government Conjectural Guarantees During the 1980s

The most celebrated instance in which a bank holding company's SND holders emerged unscathed from a financial crisis involved the Continental Illinois Corporation in July 1984. The Corporation's major subsidiary, Continental Illinois Bank, suffered extensive credit losses, partly in connection with the 1982 failure of Penn Square. By May 1984, losses had severely depressed Continental's capital, and its failure appeared imminent. Federal regulators applied the administrative doctrine of "essentiality," according to which the Bank's failure was considered a threat to the nation's financial stability. After unsuccessfully seeking a private merger partner for Continental Bank, the FDIC decided to provide "open bank assistance" in the form of a direct capital infusion. However, Continental Bank could not sell new equity claims to an outsider without rendering the holding company's SNDs immediately due and payable. Since the holding company had no immediate means of repaying its debt obligations, FDIC could not save the Bank without injecting funds directly into the parent. This it did, by purchasing one billion dollars of preferred stock in the Corporation, which was immediately downstreamed to the Bank as common equity. A controversial byproduct of the transaction was that the Corporation's SND holders suffered no diminution of their claims (indeed, there was an enhancement), thereby extending federal insurance protection to all claimants of the bank's holding company.[5]

In Congressional testimony several months after the Continental episode, the Comptroller of the Currency formalized this "too big to fail" (TBTF) guarantee when he "told Congress that the federal government won't currently allow any of the nation's 11 largest banks to fail." (Carrington (1984), p. A2). The private value of this policy has been documented by O'Hara and Shaw (1990), who report an average 1.3 percent abnormal return to the common equity of the banks specifically identified as "too big to fail" in a newspaper account of the Comptroller's testimony. Clearly, the market believed that government policy would protect bank owners from at least some types of financial difficulties; since SND investors held claims senior to equity, they would logically consider themselves protected as well.

The FDIC felt unduly constrained by federal bankruptcy and bank failure legislation in the wake of Continental's rescue, and sought mechanisms by which they could rescue bank subsidiaries without protecting the holding company (or even all creditors of the bank itself). These efforts slowly bore fruit. In July 1986, when the First National Bank of Oklahoma City failed, FDIC negotiated a purchase and assumption transaction in which First Interstate agreed to assume liability for all the *bank's* obligations, while the holding company—whose primary asset had been the now worthless bank—defaulted

[5] A precedent for this protection of holding company SND investors was provided by the 1979 rescue of First Pennsylvania Corporation, in which the FDIC and private banks purchased subordinated notes from the bank, thereby preventing the holding company's investment in the bank's equity from becoming worthless.

on its outstanding debentures.[6] This trend continued over the next few years, reinforced by the FSLIC's growing willingness to impose losses on the bondholders of thrift holding companies. By the time First Republic Bank Corporation encountered serious problems in March 1988, Shaw (1988) observed that holding company claimants confronted much more risk than those of the bank itself:

> It is, of course, important to note that the FDIC has not rescued the shareholders in these large banks. *Nor, in recent years, has it saved the bank holding companies, since it now can isolate the insured bank from the holding company structure.* However, the customers and creditors of these failed banks enjoy a privilege shared in no other sector of the economy—their risks are covered by the full faith and credit of the United States government (p. 4, emphasis added).

Since 1988, many bank (and thrift) debenture holders have suffered losses when their firm's subsidiary financial institutions failed, including First Republic (July 1988), Bank of New England (January 1991), and Southeast Banking Corp. (September 1991). A discussion paper included in the U.S. Treasury's (1991) proposal to reform the financial system notes:

> As bank regulators have made it increasingly clear in the latter part of the 1980s that subordinated debtholders are *not* protected, it appears that SND yields have come to better reflect the relative riskiness of banking organizations (p. II-22).

The debenture spreads illustrated in Figures 1 and 2 are consistent with this assessment of SND pricing.

In summary, therefore, the regulatory treatment of bank SND investors changed substantially over the period 1983–1991. While the Continental bailout implied that a large bank holding company's debentures were effectively riskless before 1986, subsequent policy changes increased the default risk on bank SNDs. Effective market discipline may therefore be more readily identified using data from later in the decade.

III. Data Sources

Two types of data are required to evaluate the relation between bank risks and SND pricing: SND yield premia and the issuing banks' contemporaneous financial characteristics.

[6] See Kaufman (1990, p. 9) and the FDIC 1986 *Annual Report* (p. 8). The regulatory treatment of uninsured depositors started to change only after 1991, when passage of the FDIC Improvement Act (FDICIA) mandated that FDIC pursue least-cost resolutions *except* when a bank's failure would pose a widespread, systemic risk to other parts of the financial system. In the first year following FDICIA's passage, 49 percent of bank failures involved some loss to uninsured depositors, while the corresponding number for the period 1989–1991 was 14 percent. (Government Accounting Office (1993, p. 54)). *The Harvard Law Review* (1991) provides a detailed discussion of how the FDIC has sought to exclude certain bank creditors from the full guarantees it continues to prefer for depositors.

A. SND Yield Premia

The Warga-Lehman Brothers Fixed Income Database reports monthly information on the major private and government debt issues traded in the United States, including detailed information about the debt's structure. We identify all fixed-rate, nonconvertible subordinated debentures on the Database issued by a bank or bank holding company, and collect data on their maturity, coupon rate, prepayment options, and a month-end market price for each December during the period 1983 through 1991.[7] While most prices reflect "live" trader quotes, some are "matrix" prices estimated from transaction prices for bonds with similar features. Our SND sample includes a total of 422 issues for 83 different banking firms. Of the 422 bonds, only three were issued by a commercial bank, as opposed to a bank holding company.

In order to compute a default risk premium for each SND, we also collect the yield to maturity on a Treasury bond with approximately the same maturity date as the bank debenture. The difference between the SND yield and the corresponding Treasury yield is a raw spread, which must be adjusted for noncredit-related factors that can affect bond yields. Perhaps the most important such adjustment is the value of call options embedded in many of the bank SNDs. The Appendix explains how we estimate the value of SND call options. Subtracting this call option value from the raw spread yields our main dependent variable, SPREAD.[8] The SPREAD data are summarized in Figure 1 and in Panel A of Table I. SND spreads were relatively low in 1983–1984, rose during 1985–1987, and fell again in 1988 before rising sharply in the period's last three years. Figure 2 and the last column in Panel A show that the cross-sectional standard deviation followed a similar path: the sample banks' SNDs were priced more homogeneously early in the period than they were later on. Broadly speaking, higher mean SPREADs were associated with greater variation across issuers.

B. Issuer Balance Sheet Data

We hypothesize that a bank's SPREAD should be increasing in the amount of risk implied by its accounting reports, as measured by loan quality, leverage, interest rate risk exposure, and profitability. Because nearly all our sample SNDs are issued by bank holding companies (as opposed to the individual subsidiary banks), the relevant accounting risk measures should describe the holding companies' consolidated condition. Moreover, the data should correspond to the year-end dates for which we have collected SND prices. Such information is readily available from the quarterly "Consolidated Financial

[7] This database is obtained from the Fixed Income Research Program at the University of Wisconsin-Milwaukee. See Warga (1995) for details. Because the database is substantially incomplete for December 1984, we use January 1985 bond prices in place of the (missing) data for December 1984.

[8] This methodology implicitly assumes that the entire option-adjusted spread (SPREAD) reflects perceived default risk, even though the equilibrium SND yield should also exceed the Treasury rate on account of state and local taxes and their relative illiquidity. Avery *et al.* (1988) and Gorton and Santomero (1990) data share the same shortcomings.

Table I

Sample Characteristics

Panel A: Option Adjusted Spreads (%)

The option adjusted spread is the difference between the SND's actual yield to maturity and the constructed yield on a "callable treasury bond" with the same maturity. This corresponds to the SPREAD variable used in Tables III, IV, V, VI, and VII. As indicated in the text, approximately 10% of our individual bonds have a negative SPREAD. This is *particularly true* for 1983 where the −1.83% spread refers to Mellon Bank Corporation.

Year	*N*	Mean	Median	Minimum	Maximum	Standard Deviation
1983	47	0.71	0.75	−1.83	5.10	0.89
1984	61	0.78	0.70	−0.78	3.57	0.69
1985	65	1.48	1.42	0.01	4.33	0.65
1986	69	1.85	1.69	0.21	6.80	1.23
1987	73	1.60	1.44	−0.93	5.88	1.01
1988	68	0.87	0.76	−0.18	4.20	0.70
1989	67	1.97	1.50	0.44	8.60	1.61
1990	63	4.75	2.90	0.92	32.53	5.64
1991	60	3.44	2.22	0.81	19.55	3.37

Panel B: Moody's Credit Ratings

The Moody rating variable is a weighted average of the ratings on all outstanding fixed-rate debentures. The correspondence between the Moody Rating and the assigned numerical value is:

Aaa+	1	A2	7	Ba2	13	Caa2	19
Aaa	2	A3	8	Ba3	14	Caa3	20
Aa1	3	Baa1	9	B1	15	Ca	21
Aa2	4	Baa2	10	B2	16	C	22
Aa3	5	Baa3	11	B3	17	D	23
A1	6	Ba1	12	Caa1	18		

Year	*N*	Mean	Median	Minimum	Maximum	Standard Deviation
1983	36	5.55	5.48	2.82	10.00	1.83
1984	47	5.89	6.00	2.00	13.00	2.00
1985	53	6.18	6.00	2.00	13.00	2.06
1986	58	6.94	6.21	2.00	15.00	2.86
1987	65	7.69	7.11	2.25	15.00	2.70
1988	60	7.79	7.00	2.82	14.00	2.70
1989	60	8.17	7.82	3.08	15.00	2.70
1990	58	9.17	8.25	3.42	15.00	3.27
1991	55	9.56	8.27	3.43	19.00	3.59

Statements" (FR Y-9 reports) filed with the Federal Reserve Board by each U.S. bank holding company. These statements consolidate the parent corporation with all of its bank and nonbank subsidiaries.[9]

[9] We are implicitly assuming that each bank's year-end balance sheet and income information was impounded in December 31 debenture prices. This is a relatively strong assumption, which implies "strong form" market efficiency. To the extent that investors had incomplete information, our tests should be biased against finding evidence of effective market discipline on account of errors in variables. Had we been unable to document effective market discipline with these balance sheet data, we would have used January 31 bond data, which post-dates the release of banks' year-end financial results.

The Y-9 reports did not include detailed information about loan quality until 1985, or about the holding company's asset-liability maturity gap until 1986. When loan quality or maturity gap data are unavailable at the holding company level, we follow Avery *et al.* (1988) and Gorton and Santomero (1990) in collecting the required data from the quarterly Report of Income and Condition ("Call Report") filed by each of the holding company's subsidiary banks. Aggregated Call Report data entirely ignore the positions of nonbank subsidiaries, and do not permit us to consolidate inter-bank holdings. Nevertheless, it is the only feasible approach for measuring two key asset risk features—maturity gap and nonaccrual/past due loans—early in our data period.[10]

IV. Identifying Market Discipline

"Market discipline" is the process by which informed market investors gather and evaluate information about a firm's activities and prospects, and incorporate that information into its traded securities. The most valuable type of discipline requires that investors anticipate likely future changes in bank risk, and price the effects into the securities offered for sale today. Such anticipatory pricing "disciplines" bank owners and managers, in the sense that it causes them to take into account the full impact of their business decisions on all bank claimants. Even if investors can not regularly anticipate changes in bank risk, market discipline could still complement government supervision if investors could promptly recognize changes in risk exposure once they occur. Even this level of risk recognition passes at least part of the cost of higher risk back to bank decision-makers, and therefore constitutes a partial check on shareholders' incentives to raise asset risk and lower equity. If SND prices never reflect bank risks, there can surely be no effective market discipline.[11]

Despite the fact that SND spreads clearly rose late in our sample period, demonstrating that market investors were rationally pricing bank-specific risks requires that spreads be correlated with plausible indicators of default probabilities. During the 1983–1991 sample period, an SND's default risk may have been affected by either:

[10] In order to investigate the extent to which data problems prevented previous researchers from identifying a significant relation between accounting risk measures and SND spreads, we collected analogous data from the Y-9 and Call Report sources for the period 1986–1989. We found no significant differences in our SPREAD regressions when we used one versus the other set of asset quality and interest rate risk measures.

[11] Our empirical methods cannot distinguish anticipatory pricing from investors' recognition of current bank condition, largely because it is not clear whether the accounting measures we use to measure bank risk should be interpreted as ex ante or ex post risk measures. (High current loan problems, for example, could be interpreted as either an indicator of the bank's present condition or a forecast that its future performance will be poor.) Similarly, we cannot distinguish the hypothesis that investors *do not care* about bank-specific risks from the hypothesis that they *are unaware of* those risks (perhaps due to severe information asymmetry about the quality of bank assets).

1) the bank's ability to repay out of its own resources, or
2) the government's perceived willingness to absorb default losses on behalf of private creditors.

If SND premia are unrelated to balance sheet risks, we cannot conclude that investors were necessarily insensitive to bank risks, since they may have been relying on the government's conjectural guarantee as security for their funds. Since the government's apparent willingness to insure bank SND holders declined over our sample period, we may find that the effect of measured default risk on SND pricing varies as well. How, then, should effective market discipline be reflected in our SND premia? So long as investors believe the government *may not* protect them from losses, the equilibrium SND spread should increase with the issuer's apparent default risk. Moreover, bank-specific risk measures should explain a larger proportion of the cross-sectional variation in SND prices as the relative importance of government guarantees declines (ceteris paribus).

Our basic analysis involves panel regressions of the form

$$\mathrm{SPREAD}_{it} = f(X_{it}, Y_{it}) + \varepsilon_{it} \tag{1}$$

where

SPREAD_{it} = the option-adjusted difference between the SND yield to maturity and the yield of a Treasury security with the same maturity;

X_{it} = measures of bank i's risk; and
Y_{it} = other control variables affecting bank I's SND spread.

Because theory provides no compelling guidance about the proper functional form for $f(.,.)$, we report complete results for three different specifications and summarize several others. For comparison with the earlier studies, we first evaluate the following linear specification, which can be interpreted as an approximation to a monotonic relation between SPREAD and bank risk:[12]

$$\mathrm{SPREAD}_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k X_{kit} + \sum_{j=K+1}^{J} \beta_j Y_{jit} + \varepsilon_{it} \tag{2}$$

The following accounting measures of bank risk (X_{kit}) were measured at each calendar year-end:[13]

[12] Recall that Gorton and Santomero criticize Avery *et al.*'s linear specification because a subordinated debenture's spread is not monotonically related to its asset risk. The appeal of this theoretical insight is substantially reduced when Gorton and Santomero report (p. 127) that the equilibrium SND spread was increasing monotonically with asset risk for every bank in their sample. Our sample banks manifest the same property, and we consequently ignore the potential concavity of SPREAD in asset risk when estimating regression (2).

[13] In place of the first three loan-quality variables, we also evaluate two other measures of loan quality:

BADTA – the sum of all three problem loan categories (NATA + PDTA + OREOTA).
ALLTA – the ratio of the allowance for loan and lease losses to total assets.

NATA — the ratio of nonaccrual loans to total assets.[14] Larger NATA should raise SPREAD, either because it indicates that the bank is in poor condition, or because high nonaccruals imply greater uncertainty about the bank's future performance.

PDTA — the ratio of accruing loans past due 90 days or more to total assets. More past due loans implies greater default risk, ceteris paribus.

OREOTA — the ratio of other real estate owned ("OREO") to total assets.[15] As for NATA and PDTA, higher OREO should tend to raise SPREAD.

MKTLEV — the ratio of total (book) liabilities to (the market value of common stock plus the book value of preferred stock). Higher leverage should raise default risk.

AGAP — absolute value of the bank's maturity gap,[16] as a proportion of equity market value. A higher AGAP should reflect greater overall risk, ceteris paribus.

ROA — the ratio of annual net income to year-end total assets. Higher ROA could reflect monopoly profits or greater efficiency, which would imply that ROA should be negatively related to SPREAD. Alternatively, higher ROA could reflect primarily compensation for higher risk-taking, which should make *it* positively related to SPREAD.

"Control variables" (Y_{jit}) in equation (2) include:

ln(*TA*) — the log of the issuing bank's total assets. This could capture either (or both) of two effects. First, larger banks might be considered safer, because they are better diversified, better managed, or more likely to benefit from a TBTF policy. Second, larger banks' SND issues are likely to be more liquid, and hence to trade at lower spreads over Treasury.

D84, D85, . . . D91 — Year dummies, which will capture intertemporal variations in market conditions, tax effects, and the extent of conjectural guarantees on bank SNDs.

Although BADTA measures asset quality much more reliably than ALLTA, our conclusions about market discipline are not materially affected by either substitution.

[14] Loan interest income is typically accrued, which means that accounting income recognizes interest due even if the payment has not actually been received. Nonaccrual loans have such serious payment problems that GAAP requires the bank to recognize payments only on a cash basis. Payments received on nonaccruing loans are generally not taken as income, but rather are applied to reduce outstanding principal.

[15] Other real estate owned has been taken in (full or partial) satisfaction of a loan which did not repay as agreed.

[16] Flannery and James (1984a, 1984b) define maturity gap as the difference between assets and liabilities maturing or repricing within one year.

Table II

Sample Summary Statistics

SPREAD is the option adjusted spread obtained by taking the difference between the SND's actual yield and the constructed yield on a "callable treasury bond" with the same maturity. SPRDRF is the ratio of SPREAD to the constructed (callable) treasury yield. SPREAD2 is the subsample of SPREAD, calculated only from noncallable bonds. SPREAD3 is the subsample of SPREAD, calculated from noncallable bonds and from callable bonds with call option considerably out-of-the-money. FSPR1 is a theoretical measure of fair default premium, estimated using the Black and Cox model, with effective asset maturity assumed to be 1 year. FSPR3 is a theoretical measure of fair default premium, estimated using the Black and Cox model, with effective asset maturity assumed to be 3 years. ALLTA is the ratio of the bank's allowance for loan and lease losses to total assets. NATA is the ratio of nonaccruing loans to total assets. PDTA is the ratio of accruing loans past due 90 days or more to total assets. OREOTA is the ratio of other real estate owned to total assets. BADTA is the sum of NATA, PDTA, and OREOTA. MKTLEV is the ratio of total (book) liabilities to the (market value of common stock plus the book value of preferred stock). BOOKLEV is the ratio of total (book) liabilities to the book value of (common plus preferred) equity. AGAP is the absolute value of the bank's maturity gap, as a proportion of equity market value. ROA is the ratio of annual net income to year-end total assets. NLTA is the ratio of net loans to total assets. ln(TA) is the log of the issuing bank's total assets. MOODY is the average MOODY rating of a bank's outstanding SNDs, weighted by their face value. The cardinality of this variable is defined in Table I, Panel B.

Variable Name	*N*	Mean	Median	Min	Max	Standard Deviation
SPREAD (%)	573	1.95	1.39	−1.83	32.53	2.65
SPRDRF (%)	573	27.16	17.45	−14.73	433.12	38.66
SPREAD2 (%)	366	2.01	1.36	−0.78	28.14	2.76
SPREAD3 (%)	460	1.89	1.24	−0.78	32.66	2.88
FSPR1 (%)	573	0.16	0.00	0.00	8.50	0.59
FSPR3 (%)	573	0.70	0.02	0.00	22.27	1.90
ALLTA (%)	573	2.12	1.55	0.68	10.07	1.33
NATA (%)	573	2.33	1.66	0.00	14.38	1.94
PDTA (%)	573	0.45	0.38	0.00	3.48	0.37
OREOTA (%)	573	0.64	0.32	0.00	6.53	0.86
BADTA (%)	573	3.43	2.56	0.00	19.38	2.63
MKTLEV	573	17.87	14.48	4.66	190.45	12.65
BOOKLEV	573	15.46	14.93	8.79	59.55	3.34
AGAP	573	3.65	2.72	0.00	29.24	3.74
ROA (%)	573	0.52	0.74	−4.11	1.73	0.75
NLTA (%)	573	61.63	63.38	12.23	85.47	9.98
ln(TA)	573	16.39	16.27	13.68	19.26	1.09
MOODY	492	7.56	7.00	2.00	19.00	3.00

Table II reports summary statistics for these explanatory variables.

The linear specification (2) is theoretically inappropriate because it does not reflect the nonlinear, interactive effect of asset risk and leverage on a risky bond's default premium. To incorporate these effects into our estimation, we use Black and Cox's formula for the market yield on a subordinated debenture to estimate the appropriate default risk premium for each sample bank at each point in time. Gorton and Santomero (1990) report (see their equation (5), p. 121) that a subordinated debenture's yield should be:

$$(R_s - R_f) = -\ln\left\{\left(\frac{V}{X_2}\right)\exp(R_f\tau)[N(d_1) - N(\hat{d}_1)] - \left(\frac{X_1}{X_2}\right)N(d_2) + \left(\frac{X_1 + X_2}{X_2}\right)N(\hat{d}_2)\right\} \cdot \left(\frac{1}{\tau}\right) \quad (3)$$

where

R_s = yield on the subordinated debt
R_f = yield on a riskless security with the same maturity
V = current value of the firm's assets
X_1 = promised repayment to senior debt
X_2 = promised repayment to subordinated debt
τ = SND's maturity
σ = standard deviation of the log of the firm's asset value

and

$$d_1 = \frac{\ln(V/X_1) + (R_f + \sigma^2/2)\tau}{\sigma\tau^{1/2}}$$

$$d_2 = d_1 - \sigma\tau^{1/2}$$

$$\hat{d}_1 = \frac{\ln(V/(X_1 + X_2)) + (R_f + \sigma^2/2)\tau}{\sigma\tau^{1/2}}$$

$$\hat{d}_2 = \hat{d}_1 - \sigma\tau^{1/2}$$

We obtain the required balance sheet values from the Y-9 reports and assume (following many earlier writers) that scheduled government examinations make the effective maturity (τ) of a bank's obligations equal to one year. We estimate each bank's asset volatility using the method of Ronn and Verma (1986).

Having constructed a theoretical estimate of the appropriate default premium for each bond from equation (3), we estimate the regression:

$$\text{SPREAD}_{it} = \alpha_0 + \alpha_1\text{FSPR}_{it} + \alpha_2\ln(TA) + \delta_{it} \quad (4)$$

where FSPR_{it} is the estimated fair value of equation (3) for bank I at time t. A significant positive effect of FSPR_{it} on SPREAD_{it} is consistent with the presence of market discipline in the SND markets.

A drawback to regression specification (4) is that it relies on the strong assumptions underlying Black and Cox's SND pricing model. In order to assess whether these assumptions have an important effect on our conclusions about market discipline, we also estimate a less specific, nonlinear relationship between SPREAD and bank accounting measures:

$$\text{SPREAD}_{it} = \beta_1 + [\beta_2\text{NATA} + \beta_3\text{PDTA} + \beta_4\text{OREOTA} + \beta_5\text{AGAP} + \beta_6\text{ROA}]*[\text{MKTLEV} + \beta_7(\text{MKTLEV}^2)] + \beta_8 \ln TA + v_{it} \quad (5)$$

where the independent variables are defined above. The first bracketed expression in equation (5) measures the bank's asset risk, while the second bracketed expression allows a nonlinear impact of leverage on SPREAD. (The coefficient on MKTLEV must be constrained to a specific value, here unity, to identify the regression's other coefficients.) In this specification, the impact of any one accounting variable on SPREAD depends on the value of at least one other independent variable. For example, the derivative of SPREAD with respect to leverage is:

$$\frac{\partial\text{SPREAD}}{\partial\text{MKTLEV}} = (\beta_2\text{NATA} + \beta_3\text{PDTA} + \beta_4\text{OREOTA} + \beta_5\text{AGAP} + \beta_6\text{ROA})*(1 + 2\beta_7\text{MKTLEV}) \quad (6)$$

and the derivative with respect to one of the five "asset risk" measures is (e.g.):

$$\frac{\partial\text{SPREAD}}{\partial\text{NATA}} = \beta_2(\text{MKTLEV} + \beta_7(\text{MKTLEV})^2) \quad (7)$$

In Table V, we report the estimated values and t-statistics for this sort of derivative.

Bank default risk may also be measured by Moody's or Standard and Poor's ratings of outstanding SNDs. While these bond ratings constitute "market-based" measures of SND default probabilities, explicitly including them in our regressions raises several problems. First, there is no obvious way to cardinalize the ratings' letter categories. Second, bond ratings should be correlated with a bank's balance sheet and income ratios, making it difficult to infer the size and significance of any estimated coefficient in a regression that includes both accounting data and bond ratings. Third, including a bond rating would reduce our available sample by almost 15 percent. Because of these difficulties, our main results exclude any measure of SND rating. Section VI does, however, summarize the effect of ratings on SPREAD.

Finding nonzero coefficients on any of the bank risk measures (the X_{kit}, FSPR_{it}, or the bond ratings) is consistent with the hypothesis that market investors were pricing bank default risk over the sample period. While the individual coefficients are of some interest, their individual significance levels may be understated if the different risk measures are correlated with one another. Consequently, the efficacy of market discipline is best evaluated via F-statistics (reported near the bottom of each table) which test for the joint effect of bank risk measures on SPREAD. We estimate regressions (2), (4), and

(5) for different time periods, corresponding to different types of apparent governmental guarantees.

V. The Impact of Bank Risk on SPREAD

We analyze our time series-cross section dataset in two ways. First, we run "fixed effects" panel regressions for the entire data set, including a separate dummy variable for each calendar year. These results are reported in Tables III, IV, and V. Each table presents regression estimates for five time periods: the 1983–1984 period used in two earlier studies, the overall sample period, and three equal-length subperiods. During the earliest subperiod (1983–1985), the TBTF doctrine was most credible and we expect the weakest correlation between SPREAD and bank risk measures. During the middle period (1986–1988), federal regulators were reducing the (conjectural) protection provided to SND investors, as they acquired the power and inclination to fail bank holding companies and impose losses on their bondholders. During the most recent period (1989–1991), bank investors should have understood that their debentures were indeed subject to default risk. We therefore conjecture that at least this last period will exhibit rational pricing of bank risks. The advantage of pooled estimation is that we can control—via the bank-specific intercept term—for unmeasured bank characteristics that influence SND spreads and remain constant over time. However, panel estimation constrains the estimated coefficients on each independent variable to be equal across several years. In order to determine whether these constraints influence our conclusions, we also estimate several sets of nine cross-sectional regressions (one for each sample year). An example of these estimations is reported in Table VI. Fortunately, our conclusions about bank market discipline are consistent across all our estimation techniques and regression specifications.

A. Pooled Time-Series, Cross-section Regression Results

Table III reports the results from estimating a pooled, "fixed-effects" version of equation (2) for various subsets of the 1983–1991 sample period. The first column estimates our model for the time period covered by Avery *et al.*'s study, 1983–1984. Neither asset quality variables, leverage, nor AGAP significantly affected SPREAD during this period. Profitability (ROA) has a negative, marginally significant coefficient, indicating that more profitable banks were viewed as less likely to default, and the significantly negative coefficient on ln(TA) indicates that smaller banks pay higher SPREADs. The regression's F-statistic is significant, but the F-statistic testing whether the six bank risk measures jointly differ from zero is not ($p = 0.619$). Similarly, the F-statistic for the joint hypothesis that the three loan quality variables carry zero coefficients fails to reject this null ($p = 0.627$). Taken together, this regression provides no real evidence that market discipline was operating during the

Table III

Linear Panel Regressions of SPREAD on Bank Accounting Ratios

Dependent variable is the weighted average, option-adjusted SPREAD (measured in percent) for each SND-issuing bank holding company. Estimation method is "fixed effects" panel estimation, in which each bank is permitted to have its own (unreported) intercept term. Estimated standard errors are computed using White's method. Heteroskedasticity-consistent t-statistics are reported in parentheses below each coefficient estimate. Explanatory variables are defined as follows:

SPREAD — the difference (expressed in percentage) between the SND's actual yield and the constructed yield on a "callable treasury bond" with the same maturity.
NATA — the ratio of nonaccruing loans to total assets.
PDTA — the ratio of accruing loans past due 90 days or more to total assets.
OREOTA — the ratio of other real estate owned to total assets.
AGAP — absolute value of the bank's maturity gap, as a proportion of equity market value.
ROA — the ratio of annual net income to year-end total assets. Higher ROA could indicate either a safer bank, or one that is being compensated for taking higher risks.
MKTLEV — the ratio of total (book) liabilities to the (market value of common stock plus the book value of preferred stock).
ln(TA) — the log of the issuing bank's total assets.
D84, D85, . . . D91 — Year dummies.

	(1) 1983–84	(2) 1983–91	(3) 1983–85	(4) 1986–88	(5) 1989–91
NATA	9.152	55.308***	20.594*	−6.997	146.093***
	(0.552)	*(4.237)*	*(1.851)*	*(−1.136)*	*(2.938)*
PDTA	−12.159	−14.686	−36.391*	1.885	527.872**
	(−0.464)	*(−0.328)*	*(−1.799)*	*(0.078)*	*(2.445)*
OREOTA	−81.210	133.057***	−51.025	25.606	−61.056
	(−1.232)	*(4.011)*	*(−1.194)*	*(0.967)*	*(−0.798)*
AGAP	−0.046	0.040	−0.003	0.004	0.055
	(−1.047)	*(1.262)*	*(−0.107)*	*(0.236)*	*(0.528)*
ROA	−195.374*	7.684	−79.624*	−8.520	60.996
	(−1.856)	*(0.441)*	*(−1.695)*	*(−1.229)*	*(1.532)*
MKTLEV	−0.046	0.045***	0.007	0.003	0.180***
	(−1.160)	*(4.244)*	*(0.347)*	*(0.781)*	*(5.374)*
ln(TA)	−2.357***	−0.557	−0.974***	−0.040	−1.082
	(−5.315)	*(−1.525)*	*(−3.742)*	*(−0.125)*	*(−0.684)*
D84	0.370*	−0.278	0.012	—	—
	(1.912)	*(−0.715)*	*(0.082)*		
D85	—	0.605	0.937***	—	—
	—	*(1.571)*	*(5.639)*		
D86	—	1.041***	—	—	—
		(2.555)			
D87	—	0.218	—	−0.236***	—
		(0.494)		*(−2.991)*	
D88	—	−0.066	—	−0.847***	
		(−0.143)		*(−9.146)*	
D89	—	0.951**	—	—	—
		(2.002)			
D90	—	2.458***	—	—	−0.086
		(4.800)			*(−0.163)*
D91	—	1.425**	—	—	0.550
		(2.554)			*(0.989)*
F^a	4.645***	32.108***	11.356***	20.682***	19.932***
F^b	0.742	33.156***	1.907*	1.107	19.050***
F^c	0.588	16.348***	2.026	0.591	7.520***
E(SPREAD)	0.748	1.951	1.023	1.446	3.355
Nobs	108	573	173	210	190
$\bar{R}^2$	0.465	0.555	0.573	0.885	0.723

[a] Regression F-statistic (df = [ncoef-1], [nobs-ncoef]).

[b] Hypothesis that the six bank-specific variables' coefficients are jointly zero (df = 6, [nobs-ncoef]).

[c] F-statistic for the hypothesis that all three coefficients of the credit quality measures (NATA, PDTA, OREOTA) equal zero. (df = 3, [nobs-ncoef].)

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

1983–1984 period.[17] By contrast, regression results for the full 1983–1991 estimation period (column 2) provide strong evidence that SND investors heed accounting measures of bank risk. SPREAD increases significantly with loan problems (NATA and OREOTA) and leverage (MKTLEV). The six accounting risk measures as a group explain a significant proportion of the variation in SPREAD ($F_{6,475} = 32.11, p < 0.01$), as do the three loan quality variables ($p < 0.01$). The insignificant coefficient on ln(TA) indicates no effect of size per se on SPREAD. Many of the year-dummies differ reliably from zero. Note in particular the large positive coefficient for 1990, when SPREADs averaged almost 2.5 percentage points higher than in 1983 after controlling for the bank risk indicators. (By comparison, the spread between BAA and AAA corporate bonds was only 40 basis points higher at year-end 1990 than it was at year-end 1983.)

The pooled regression for 1983–1985 (column 3) provides little evidence that investors were pricing SNDs in relation to perceived bank risks. NATA and PDTA carry (marginally significant) coefficients with offsetting signs, and the hypothesis that the coefficients on all three credit risk measures equal zero is not rejected at the 10 percent level ($F_{3,98} = 2.03$). Leverage and interest rate risk have no effect on SPREAD, although ROA and asset size lower SPREAD. The hypothesis that all six bank risk measures carry zero coefficients is marginally rejected at the 10 percent level ($F_{6,98} = 1.97$). The results for the 1986–1988 period (in column 4) imply even less impact of accounting risk measures on SPREAD: no variable carries a significant coefficient, nor is either of the joint test statistics reliably different from zero.

The impact of market risk evaluations on bank SND spreads becomes readily apparent in the 1989–1991 subperiod. NATA and PDTA both carry significantly positive coefficients, and the hypothesis that all three asset quality measures are unrelated to SPREAD is rejected at better than the 1 percent level ($F_{3,111} = 7.52$). Higher leverage significantly raises SPREAD, while interest rate risk and bank size (ln(TA)) now have no effect. ROA is positive but insignificant. The hypothesis that all six bank risk measures carry zero coefficients is soundly rejected by the data ($F_{6,111} = 19.05, p < 0.001$). In short, the 1989–1991 regression clearly indicates that bank investors responded strongly to accounting risk measures once conjectural guarantees of SND principal had been effectively eliminated. Finally, the hypothesis that the regression coefficients are equal in all three subperiods is rejected at better than the 0.1 percent confidence level ($F_{146,329} = 3.90$).

Table IV analyzes the same time periods as Table III, using the fitted spread from equation (3) as the sole measure of bank risk.[18] These regressions therefore test the joint hypothesis that equation (3) is an appropriate measure of bank default risk and that the market prices that risk. Corresponding to Table

[17] This regression may lack statistical power, because it estimates 63 "fixed effect" terms with only 108 observations. Avery *et al.* (1988) do not include fixed effect terms, but we reject the hypothesis that all bank-specific intercepts are jointly zero ($p = 0.0257$).

[18] Table IV contains more observations than Table III or V, because the data have 23 observations missing for AGAP.

Table IV

Panel Regressions of SPREAD on a Theoretical Measure of Fair SND Default Premium

Dependent variable is the weighted average, option-adjusted SPREAD (measured in percent) for each SND-issuing bank holding company. Estimation method is "fixed effects" panel estimation, in which each bank is permitted to have its own (unreported) intercept term. Estimated standard errors are computed using White's method. Heteroskedasticity-consistent t-statistics are reported in parentheses below each coefficient estimate. Explanatory variables are defined as follows:

SPREAD — the difference (expressed in percentage) between the SND's actual yield and the constructed yield on a "callable treasury bond" with the same maturity.

FSPR1 — a theoretical measure of fair default premium, estimated using the Black and Cox model, with effective asset maturity assumed to be 1 year.

ln(TA) — the log of the issuing bank's total assets.

D84, D85, . . . D91 — Year dummies.

	(1) 1983–84	(2) 1983–91	(3) 1983–85	(4) 1986–88	(5) 1989–91
FSPR1	25.361*	0.904***	1.661	−0.014	2.097***
	(1.741)	*(5.215)*	*(0.809)*	*(−0.300)*	*(3.790)*
ln(TA)	−1.006	−0.814**	−0.077	−0.085	−2.661
	(−1.442)	*(−2.074)*	*(−0.257)*	*(−0.268)*	*(−1.366)*
D84	0.181	0.103	0.036	—	—
	(1.365)	*(0.285)*	*(0.371)*		
D85	—	0.909**	0.693***	—	—
		(2.448)	*(5.647)*		
D86	—	1.568***	—	—	—
		(3.952)			
D87	—	0.775*	—	−0.170**	—
		(1.805)		*(−2.239)*	
D88	—	0.625	—	−0.836***	—
		(1.414)		*(−9.758)*	
D89	—	1.682***	—	—	—
		(3.666)			
D90	—	4.177***	—	—	2.129***
		(8.585)			*(3.737)*
D91	—	3.267***	—	—	1.688***
		(6.647)			*(3.109)*
F[a]	2.181***	24.658***	19.166***	44.346***	13.072***
E(SPREAD)	0.765	1.911	1.011	1.446	3.341
Nobs	127	596	195	210	191
$\bar{R}^2$	0.539	0.412	0.611	0.883	0.524

[a] Regression F-statistic (df = [ncoef-1], [nobs-ncoef]).

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

III, this specification provides no evidence of market discipline (that is, no significant coefficient on FSPR1) for 1983–1985 or 1986–1988. For the overall period and for 1989–1991, however, FSPR1 is significantly positively related to SPREAD. These two regressions, which are influenced by the removal of TBTF protection late in the sample period, strongly support the correspondence between theoretical assessments of bank risk exposures and those actually paid in practice.[19] We find it interesting that FSPR1 carries a significant (10 percent level) positive sign in 1983–1984, but this result is not very robust: substituting FSPR3 for FSPR1 yields an insignificant coefficient (t = 0.90) in 1983–1984 without affecting any of the other time periods' regressions.

The specification in Table V evaluates the importance of accounting risk measures without imposing either the (inappropriate) linearity of Table III or the theoretical assumptions underlying FSPR1 in Table IV. Note that the numbers reported for the first six variables listed (NATA through ROA) are *not* the simple coefficient estimates for β_2 through β_7. Instead, we report the estimated *derivative* of SPREAD with respect to each balance sheet variable (as in equations (6) and (7)), and the associated t-statistics, based on a Wald test. These derivatives are evaluated at the sample mean value for each balance sheet variable. (Using the 75th-percentile values yields very similar results.) Table V provides the standard information for ln(TA) and the year dummies: their coefficient estimates and (heteroskedasticity-adjusted) t-statistics. The results in Table V closely resemble those in Tables III and IV: the evidence for market pricing of bank-specific risk factors is greatest in the overall period and in the latest (1989–1991) sub-period. (Even the pattern of significant explanatory variables in these regressions parallels the Table III results.) For the other three periods in Table V, neither the three loan-risk variables nor the six bank-specific variables are jointly different from zero.

Taken all together, Tables III–V strongly support the hypothesis that bank SND investors began to evaluate bank-specific risks when the government's conjectural guarantee was (at least partially) eliminated.

B. Annual Ordinary Least Squares (OLS) Regressions

Table VI presents a separate, linear regression of SPREAD on bank-specific characteristics for each sample year. Although we present results only for the linear specification (2), the specifications (4) and (5) yielded similar results and conclusions about market discipline. In Table VI, SPREAD generally increases in two of the three asset quality measures (NATA, PDTA), although only about one-third of the estimated coefficients are significant at conventional confi-

[19] In addition to the FSPR1 variable shown in Table IV, we construct FSPR3 based on the assumption that bank examinations occur every *three* years, rather than annually. The results are virtually identical for every time period except 1983–84, when FSPR3 is insignificant. We also estimate the expected loss to each bank's debenture holders, assuming normally distributed asset returns with variances estimated via Ronn and Verma's (1986) method. This measure is very highly correlated with the FSPR estimates, and yields results similar to Table IV when the expected loss is substituted for FSPR.

Table V

Nonlinear Panel Regressions of SPREAD on Bank Accounting Ratios

Estimation of the regression

$$\text{SPREAD}_{it} = [\beta_1 + \beta_2\text{NATA} + \beta_3 PDTA + \beta_4\text{OREOTA} + \beta_5\text{AGAP} + \beta_6\text{ROA}]*[\text{MKTLEV} + \beta_7(\text{MKTLEV}^2)] + \beta_8\text{lnTA} + \eta_{it} \quad (5)$$

Estimation method is "fixed effects" panel estimation, in which each bank is permitted to have its own (unreported) intercept term. Explanatory variables are defined as below. The reported estimates and their t-statistics are not for the simple coefficients β_3–β_8. Rather, we report the derivative of SPREAD with respect to each dependent variable (as in equations (6) and (7)), evaluated at the mean value of all dependent variables. Heteroskedasticity-consistent t-statistics are reported in parentheses below each coefficient estimate. Explanatory variables are defined as follows:

SPREAD — the difference (expressed in percentage) between the SND's actual yield and the constructed yield on a "callable treasury bond" with the same maturity.
NATA — the ratio of nonaccruing loans to total assets.
PDTA — the ratio of accruing loans past due 90 days or more to total assets.
OREOTA — the ratio of other real estate owned to total assets.
AGAP — absolute value of the bank's maturity gap, as a proportion of equity market value.
ROA — the ratio of annual net income to year-end total assets. Higher ROA could indicate either a safer bank, or one that is being compensated for taking higher risks.
MKTLEV — the ratio of total (book) liabilities to the (market value of common stock plus the book value of preferred stock).
ln(TA) — the log of the issuing bank's total assets.
D84, D85, . . . D91 — Year dummies.

	(1) 1983–84	(2) 1983–91	(3) 1983–85	(4) 1986–88	(5) 1989–91
NATA	9.200***	44.649**	12.079**	−0.844	115.222***
	(4.584)	*(2.488)*	*(2.511)*	*(−0.181)*	*(2.613)*
PDTA	−16.626***	3.455	−17.690***	−27.717	340.919***
	(−5.515)	*(0.082)*	*(−3.134)*	*(−0.769)*	*(4.042)*
OREOTA	−41.939	71.232**	−22.337	12.176	−37.593
	(−1.189)	*(2.338)*	*(−0.931)*	*(0.729)*	*(−0.630)*
AGAP	−0.070	0.022	0.001	0.012	−0.204***
	(−1.471)	*(0.900)*	*(0.067)*	*(1.219)*	*(−3.072)*
ROA	−69.687	3.249	−51.585*	−4.403	87.703***
	(−0.988)	*(0.236)*	*(−1.866)*	*(−1.170)*	*(3.235)*
MKTLEV	−0.039	0.062***	0.004	0.001	0.135***
	(−1.565)	*(5.920)*	*(0.419)*	*(0.119)*	*(5.103)*
ln(TA)	−0.404	−0.431	−0.112	0.042	−1.831*
	(−1.418)	*(−1.033)*	*(−0.522)*	*(0.166)*	*(−1.915)*
D84	0.046	−0.333	−0.091	—	—
	(0.543)	*(−1.187)*	*(−0.953)*		
D85	—	0.537*	0.666***	—	—
		(1.844)	*(4.751)*		
D86	—	0.854**	—	—	—
		(2.383)			

Table V (continued)

	(1) 1983–84	(2) 1983–91	(3) 1983–85	(4) 1986–88	(5) 1989–91
D87	—	0.169	—	−0.292***	—
		(0.345)		*(−4.639)*	
D88	—	−0.087	—	−0.872***	—
		(−0.197)		*(−11.318)*	
D89	—	0.954**	—	—	—
		(2.061)			
D90	—	2.160***	—	—	0.530*
		(4.758)			*(1.712)*
D91	—	1.601***	—	—	0.821***
		(2.689)			*(2.867)*
F[a]	0.238	34.230***	6.428***	14.651***	25.479***
F[b]	0.273	31.901***	0.679	1.078	23.299***
F[c]	0.209	31.047***	0.391	1.187	17.989***
E(SPREAD)	0.748	1.951	1.023	1.446	3.355
Nobs	108	573	173	210	190
$\bar{R}^2$	−0.276	0.620	0.572	0.883	0.791

[a] Regression F-statistic (df = [ncoef-1], [nobs-ncoef]).
[b] Hypothesis that the six bank-specific variables' coefficients are jointly zero (df = 6, [nobs-ncoef]).
[c] F-statistic for the hypothesis that all three coefficients of the credit quality measures (NATA, PDTA, OREOTA) equal zero (df = 3, [nobs-ncoef]).
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

dence levels. The third measure of asset quality, OREOTA, is significantly *negative* in 1983 and 1984, implying that a higher concentration of re-possessed real estate tends to *lower* debenture SPREAD, ceteris paribus. This relationship is difficult to rationalize, and suggests that investors were not evaluating SND risks in 1983–1984 in a very standard fashion. By contrast, OREOTA carries significant positive signs in 1989–1991, consistent with the hypothesis that investors were rationally evaluating bank risks during this period.

MKTLEV is either insignificant (10 percent level) or positively related to SPREAD, as it should be. Interest rate risk exposure (AGAP) should raise SPREAD, but it carries a significantly positive coefficient only in 1987. In 1989 and 1991, AGAP has a marginally significant, negative coefficient. We conjecture that the maturity of a large bank's on-book assets and liabilities cannot adequately capture its interest rate risk exposure during this period, in which off balance sheet dealings became relatively important. Greater profitability (ROA) could either raise or lower SPREAD, according to whether the profits arise from monopoly rents or from greater risk-taking. The evidence in Table VI suggests that bank profits in 1983–1985 derived primarily from monopoly rents, while in 1991 it appears that the sample banks had shifted toward taking greater risks in order to earn higher returns. Finally, ln(TA) always carries a negative sign, although it is significant only after 1986. The negative coefficients on bank size may reflect a market perception that large banks remain TBTF; it may also indicate that large banks are better diversified, or that their SNDs trade in more liquid secondary markets.

The F-tests provide evidence of market discipline throughout our sample period, especially in 1989–1991. (These years' R^2 statistics also exceed those for earlier cross-sections.) The overall regression is significant at the 5 percent level or better in *all nine* sample years. The set of six accounting risk measures provides significant explanatory power in every year except 1988. Finally, the three credit risk measures (NATA, PDTA, and OREOTA) are jointly different from zero (10 percent level) in six years, including 1983. However, since OREOTA carries a significant coefficient of the wrong sign in 1983 and 1984, we do not interpret these regressions as supporting the presence of rational market discipline early in the period.

C. The Impact on Funding Costs

We assess the importance of intertemporal changes in SND pricing by using the cross-sectional regression results from Table VI to estimate how an individual bank's SPREAD would have varied across time, assuming that its financial characteristics remained constant.[20] For example, we take the accounting measures from our sample in year A and fit the estimated SND SPREADs that would have obtained in year B by applying year B's regression coefficients to the year A data. We then test whether the average sample bank would have paid a higher or lower SPREAD in year B than it actually paid in year A. If, for example, market investors charged more for bank default risk in 1991 than they did in 1983, we should find that the average fitted spread is lower in 1983 than the actual SPREAD was in 1991.

Table VII presents the results. The top entry in each cell is the mean fitted SPREAD less the mean actual SPREAD paid in the year to which the bank's data apply. Moving from left to right across each row, we see the mean difference between the fitted spread based on each year's regression (from Table VI) and the actual SPREAD paid in the year listed in the left margin. Consider the first row, which evaluates the cost of issuing debentures in later years for the banks that actually issued in 1983. In moving from left to right, we see that the mean SPREAD would have been significantly higher in any year after 1984 than it actually was in 1983. The other rows in Table VII present the same impression: applying later years' coefficients to the earlier years' data yields higher estimated funding costs later in the period. Although the fitted funding costs do not increase monotonically over the sample period, there is a pronounced tendency for the later years' fitted SPREADS to exceed actual SPREADS paid earlier in the sample period. These results indicate that the change in market pricing policies over our sample period generated economically meaningful increases in SND premia, independent of any credit

[20] Thanks to David T. Brown for suggesting these tests.

Table VI

Cross-Section, Linear Regressions of SPREAD on Bank Accounting Ratios

Dependent variable is the weighted average, option-adjusted SPREAD (measured in percent) for each SND-issuing bank holding company. Regressions for each calendar year-end are computed via Ordinary Least Squares (OLS), with a (White) heteroskedasticity-consistent variance-covariance matrix. Heteroskedasticity-consistent t-statistics are reported in parentheses below each coefficient estimate. Explanatory variables are defined as follows:

SPREAD — the difference (expressed in percentage) between the SND's actual yield and the constructed yield on a "callable treasury bond" with the same maturity.
NATA — the ratio of nonaccruing loans to total assets.
PDTA — the ratio of accruing loans past due 90 days or more to total assets.
OREOTA — the ratio of other real estate owned to total assets.
AGAP — absolute value of the bank's maturity gap, as a proportion of equity market value.
ROA — the ratio of annual net income to year-end total assets. Higher ROA could indicate either a safer bank, or one that is being compensated for taking higher risks.
MKTLEV — the ratio of total (book) liabilities to the (market value of common stock plus the book value of preferred stock).
ln(TA) — the log of the issuing bank's total assets.
D84, D85, . . . D91 — Year dummies.

	1983	1984	1985	1986	1987	1988	1989	1990	1991
Constant	5.421*	6.792**	3.630*	3.471	4.800**	4.695**	8.705***	12.866	12.364***
	(1.708)	(2.510)	(1.788)	(1.216)	(2.084)	(2.489)	(4.362)	(1.333)	(2.778)
NATA	0.752	38.455*	7.312	−9.042	23.451**	2.857	5.561	182.457*	74.853
	(0.117)	(1.856)	(0.582)	(−0.560)	(2.282)	(0.331)	(0.468)	(1.955)	(1.658)
PDTA	−1.772	15.775	45.878	37.902	168.512**	78.551	175.671**	302.301	−232.213
	(−0.220)	(0.318)	(0.947)	(0.521)	(2.157)	(1.277)	(2.009)	(1.361)	(−1.351)
OREOTA	−185.741***	−81.477**	−14.248	113.035	35.143	19.255	64.609**	159.839**	222.989**
	(−3.022)	(−2.255)	(−0.463)	(1.137)	(1.062)	(0.552)	(2.260)	(2.277)	(2.563)
AGAP	−0.046	0.033	−0.005	0.053	0.060**	−0.015	−0.097**	−0.012	−0.185*
	(−0.316)	(0.970)	(−0.169)	(1.596)	(2.417)	(−0.781)	(−2.052)	(−0.134)	(−1.841)
ROA	−223.068*	−187.280**	−106.693***	37.443	16.415	14.713	−9.044	86.091	119.560**
	(−1.708)	(−2.635)	(−3.120)	(0.558)	(1.042)	(0.869)	(−0.625)	(0.830)	(2.290)
MKTLEV	−0.019	−0.042	−0.012	0.048	0.004	0.032	0.157***	0.119**	0.144***
	(−0.594)	(−1.084)	(−0.559)	(1.570)	(1.108)	(1.536)	(4.961)	(2.090)	(2.958)
ln(TA)	−0.146	−0.274*	−0.086	−0.194	−0.271*	−0.283**	−0.568***	−1.022*	−0.826***
	(−1.018)	(−1.751)	(−0.618)	(−1.021)	(−1.901)	(−2.305)	(−4.629)	(−1.686)	(−3.016)
F^a	2.582**	3.397***	2.431**	7.449***	8.542***	3.215***	24.033***	10.168***	15.548***
F^b	3.012**	3.962***	2.681**	8.445***	9.858***	1.791	24.234***	11.790***	17.329***
F^c	3.838**	2.154	0.744	2.209*	6.556***	0.885	3.036**	4.434***	7.964***
E(SPREAD)	0.707	0.779	1.480	1.848	1.602	0.870	1.968	4.751	3.439
Nobs	47	61	65	69	73	68	67	63	60
$\bar{R}^2$	0.194	0.219	0.135	0.399	0.423	0.188	0.710	0.509	0.633

[a] Regression F-statistic (df = 7, [nobs-8]).
[b] Hypothesis that the six bank-specific variables' coefficients are jointly zero (df = 6, [nobs-8]).
[c] F-statistic for the hypothesis that all three coefficients on the credit quality measures (NATA, PDTA, OREOTA) equal to zero (df = 3, (nobs-8)).
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

Table VII

Simulated versus Actual SND Funding Costs

The year indicated at the left of each row specifies when the data were taken from. The year indicated at the top of each column specifies which cross-sectional regression in Table IV produced the coefficients used to estimate the SPREAD. The top entry in each cell reports the sample mean difference between a bank's fitted SPREAD (using actual data and estimated coefficients) and its true SPREAD in the year from which its data were taken. The second entry is a t-statistic for the hypothesis that the mean difference is zero.

Bank Financial Characteristics Taken From:	Estimated Coefficients Taken from: 1983	1984	1985	1986	1987	1988	1989	1990	1991
1983	0.00	−0.24*	0.77***	1.24***	0.94***	0.57***	2.71***	1.53**	1.94***
(N = 47)		*(−1.79)*	*(7.59)*	*(7.47)*	*(6.96)*	*(4.75)*	*(17.09)*	*(2.18)*	*(5.51)*
1984	−0.25	0.00	0.65***	1.12***	0.94***	0.26***	1.71***	1.69***	1.63***
(N = 61)	*(−1.54)*		*(8.09)*	*(8.37)*	*(8.83)*	*(2.91)*	*(14.05)*	*(3.12)*	*(5.62)*
1985	−0.97***	−0.71***	0.00	0.34**	0.33***	−0.45***	0.88***	0.89	0.45
(N = 65)	*(−7.81)*	*(−8.57)*		*(2.50)*	*(2.87)*	*(−5.35)*	*(6.97)*	*(1.56)*	*(1.56)*
1986	−1.20***	−0.97***	−0.30***	0.00	−0.16*	−0.89***	0.51***	0.29	0.11
(N = 69)	*(−9.89)*	*(−12.02)*	*(−3.81)*		*(−1.80)*	*(−10.50)*	*(3.00)*	*(0.24)*	*(0.34)*
1987	−0.16***	−0.07***	0.37***	0.30	0.00	−0.65***	1.27***	1.18	1.00**
(N = 73)	*(−2.90)*	*(−2.58)*	*(3.67)*	*(1.56)*		*(−7.81)*	*(7.36)*	*(1.45)*	*(2.37)*
1988	−0.69***	−0.35***	0.44***	0.95***	0.66***	0.00	1.19***	1.26**	1.66***
(N = 68)	*(−5.15)*	*(−4.70)*	*(5.37)*	*(7.04)*	*(6.50)*		*(10.05)*	*(2.19)*	*(5.77)*
1989	−1.05***	−0.76***	−0.25***	−0.33*	−0.50***	−1.19***	0.00	−0.07	0.15
(N = 67)	*(−9.95)*	*(−11.10)*	*(−3.68)*	*(−1.77)*	*(−4.55)*	*(−12.56)*		*(−0.26)*	*(0.68)*
1990	−4.31***	−3.65***	−2.95***	−2.23***	−2.84***	−3.56***	−0.87***	0.00	−0.59
(N = 63)	*(−24.08)*	*(−29.17)*	*(−28.30)*	*(−12.74)*	*(−25.42)*	*(−32.86)*	*(−5.41)*		*(−1.35)*
1991	−3.31***	−2.29***	−1.64***	−1.21***	−1.57***	−2.52***	−0.92***	0.47	0.00
(N = 60)	*(−20.06)*	*(−19.72)*	*(−15.72)*	*(−6.11)*	*(−13.19)*	*(−23.82)*	*(−7.32)*	*(0.57)*	

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

deterioration the sample banks may have suffered between 1983 and 1991. (A similar conclusion follows from the significant year-dummy coefficients in the panel regressions.)

Table VII also permits us to measure the impact on SND spreads of changes in bank financials. For example, the top right-hand entry indicates that the banks which issued SNDs in 1983 would have paid an additional 1.94 percent in 1991. Similarly, the lower left-hand entry says that the 1991 issuing banks paid 3.31 percent more than if they had gone to market (with the same financial characteristics) in 1983. The difference (3.31 − 1.94 = 1.37 percent) measures the impact on SND pricing of the banks' financial deterioration. This difference has a t-statistic of 3.53, implying that the impact of financial deterioration on SND spreads was statistically significant as well as economically substantial.

D. Robustness Checks

We vary our basic regression specifications in Tables III and VI to assess the robustness of the conclusion that SND spreads significantly reflect bank risks. The results of these sensitivity analyses are summarized here.

First, we re-run the regressions for the dependent variable SPRDRF (which is SPREAD divided by the corresponding Treasury rate), with essentially identical results.

Second, we investigate alternative measures of bank size. We replace ln(TA) with the volume of each bank's outstanding debentures, with nearly identical results. We also replace ln(TA) in the cross-section regressions (Table VI) with a dummy variable to indicate banks which had been labeled "too big to fail":

TBTF—a dummy variable equal to unity if the bank was mentioned on either the Comptroller's or the *Wall Street Journal*'s list of "too big to fail" banks. (See O'Hara and Shaw (1990).)

A bank with TBTF = 1 should pay a lower SND rate if the market is sensitive to potential credit losses on smaller banks' debt. We find that the coefficient on TBTF is almost always negative, but significantly so (10 percent level) only in 1985–1987 and 1991. (Only in 1984 is the estimated coefficient on TBTF positive ($t = 0.529$).) Test statistics for the hypotheses that the accounting risk measures are jointly significant remain very similar to those shown in Table VI. In short, SND investors did not treat a bank's announced TBTF status as a sufficient statistic for their credit risk exposure.

Third, we add two additional explanatory variables to the basic linear specification. The ratio of loans to total assets (NLTA) might tend to raise SPREAD if loan risks are more difficult to understand than other assets' risk, but this variable was insignificant and did not affect the other coefficients or coefficient tests. We also include the outstanding SNDs' average maturity (AVGMAT), which Merton (1974) and others have shown can influence default risk premia. The coefficients on AVGMAT tend to be negative, but are significant (10 percent level) only for 1987, 1988, and 1991 in the cross-sectional regressions, and only for the 1983–1984 period's pooled regression. Including AVGMAT in the specification never alters our conclusions about the significance of market discipline.

Fourth, we replace MKTLEV with BOOKLEV, the ratio of the book value of total liabilities to the *book* value of (common plus preferred) equity. Generally, the coefficients on BOOKLEV are insignificant, and the other conclusions remain unchanged in both the cross-sectional and panel regressions.

Finally, we omit nine extreme SPREAD values (greater than 10 percent) from the 1990–1991 period to assess whether outliers are driving our basic conclusions about market discipline. This change reduces the significance of our "market discipline" tests, but does not reverse the basic patterns reflected in the full-sample results.

In summary, therefore, our basic conclusions about SND market discipline appear to be very robust to changes in specification and variable measurement.

VI. The Impact of Bond Ratings on SPREAD

Moody's credit rating should predict SND SPREADs if market investors are concerned about risk and respect Moody's opinion about a bond's credit quality.[21] Although we have no bond rating data for about 15 percent of our available observations, analyzing this subset of data may indicate the extent to which investors view credit ratings as redundant information.

Rather than imposing arbitrary cardinal values on the various rating categories (summarized in Table I, Panel B), we measure credit rating with a pair of dummy variables:

DGTA = unity for a bank rated Aa or Aaa, zero otherwise
DLTBAA = unity for a bank rated lower than Baa3, zero otherwise.

We replace the six accounting risk measures in Tables III and VI with these ratings dummies, to assess whether lower-rated banks pay significantly higher SPREADs.[22] In the panel regressions, we find that the coefficient of DGTA is generally insignificant, while the coefficient of DLTBAA is both significantly positive *and* significantly different from DGTA (1 percent level) in all but the 1986–1988 time period. In the cross-sectional regressions, DLTBAA always carries a significantly positive coefficient, indicating that lower rated bonds command higher yields. In addition, after 1987, DGTA carries a significantly negative coefficient, reinforcing our conclusion that market discipline was operating more effectively in the study's most recent sub-period.

We also assess whether bond ratings add significant explanatory power to the six accounting risk measures used above. We add the two rating variables to the explanatory variables shown in Table III, and find a significant impact of DLTBAA on SPREAD for all years except 1990 and 1991. As in the previous tests, DGTA is generally insignificant. The results suggest that, in determining the required SND spread, investors relied more heavily on bond ratings prior to 1990. During the last two years, bond ratings provide no additional information beyond that already contained in the accounting risk measures.

VII. Summary and Conclusions

This article investigates whether market debt prices appropriately reflected the issuing banks' default risks over the period 1983–1991. The evidence indicates that bank investors clearly impounded the value of conjectural government guarantees into debentures prices. As the strength of these guarantees changed over time, debenture prices came to reflect the specific risks of individual issuing banks. Bank-specific risk measures are correlated with debenture rates over our entire sample period (1983–1991) and, most prominently, in the last three years of that period when conjectural guarantees no longer covered (many) bank debentures. Asset quality and market leverage show the most consistent effect on SND spreads, with profitability less important and interest rate risk generally insignificant. Apparently, the market feels that poor credit quality and high leverage

[21] We find that Standard and Poor's credit ratings perform comparably to Moody's, but are slightly less numerous in our sample.

[22] Note that DLTBAA = 1 for noninvestment grade bonds. Our findings may therefore reflect greater liquidity in the market for investment-grade bonds, rather than indicating that investors independently value Moody's opinion about bank credit quality.

pose the greatest risks for banks; interest rate risk exposure, at least as measured by our proxies, does not generally affect bank SND prices. These conclusions hold for a wide variety of regression specifications and data construction methods.

Our empirical evidence indicates that SND investors became more diligent about pricing bank default risks, when regulators stopped protecting large bank holding companies' creditors. While it is logical to infer that market forces would even more effectively discipline large banking firms if regulators could credibly dismantle the remaining system of federal safety nets, our results provide no indication that market discipline could (or could not) *entirely* replace government supervision of bank risk-taking. This remains an important issue for further research. A good start in this direction would be to investigate the impact of bank assets' information opaqueness on the market's ability to price bank securities. For example, are bank SND yields systematically more or less sensitive to risk measures than nonbanking firms' debenture yields? This type of evidence would help assess the potential for market discipline to replace government supervision of banking firms.

Appendix

Computing Option Adjusted Spreads

One potentially important difference between bank SNDs and similar-maturity Treasury bonds is that the SNDs are often callable before maturity. A bond's call option value increases with its maturity and the volatility of market interest rates, and decreases with the required call premium. Naturally, the call option's value is always non-negative, which means that the SND spread over Treasury overestimates the default risk premium unless we adjust for the value of the embedded option.

We follow the approach of Avery, Belton, and Goldberg (1988) to estimate the value of each callable SND's prepayment option. For each SND we identify a similar-maturity, noncallable Treasury bond from the Federal Reserve Board's H.15 releases.[23] We then compute the required coupon rate on a (hypothetical) *callable* Treasury with the same maturity and call protection as the associated SNDs, and the same market price as the noncallable Treasury. The difference between the (actual) yield on the noncallable Treasury and the (higher) yield on our hypothetical, callable Treasury bond measures the value of the option to repay the bond early. We subtract these option values from the raw spread on each bond,[24] and construct a weighted average (using the bonds' outstanding principal values as the weights) of this spread across each sample bank's outstanding SNDs. This weighted average is our main dependent variable (SPREAD).

The required yield on our hypothetical callable Treasury bond is computed using a binomial lattice based on a single-factor model of the term structure. The term structure model has been used by Giliberto and Ling (1992) to value resi-

[23] When there was no precise match between the SND's maturity and that of an available Treasury bond, we interpolated to obtain the corresponding riskless rate.

[24] Approximately 10 percent of the individual bond SPREADs were negative.

Table VIII

Estimated SND Call Option Values

In columns (2), (3), (8), and (9) the top entry is the mean value, and the bottom entry (in parentheses) is the median value.

(1) Year	(2) Option Value (%)	(3) Raw Spread (%)	(4) Number of Obs.	(5) % Now Callable	(6) Yield Curve Slope[a] (%)	(7) Std. Dev. of Spot Rate (σ_t) (%)	(8) Time to Call	(9) Time to Maturity
1983	0.05	0.97	121	68.60	1.74	9.70	3.371	11.127
	(0.03)	*(0.78)*					*(3.263)*	*(9.539)*
1984	0.06	0.94	125	63.20	2.08	12.99	3.174	10.305
	(0.05)	*(0.77)*					*(2.704)*	*(8.789)*
1985	0.08	1.62	139	61.87	1.40	11.03	3.273	9.798
	(0.00)	*(1.46)*					*(2.834)*	*(9.417)*
1986	0.08	2.18	153	64.05	1.28	11.60	3.270	9.780
	(0.07)	*(1.94)*					*(3.101)*	*(9.122)*
1987	0.06	1.73	156	59.62	1.73	16.16	3.190	9.162
	(0.04)	*(1.44)*					*(2.636)*	*(8.167)*
1988	0.68	1.32	156	62.18	0.12	16.60	2.586	8.467
	(0.64)	*(0.99)*					*(2.321)*	*(7.167)*
1989	0.38	1.87	152	60.53	0.17	8.63	1.980	7.790
	(0.35)	*(1.41)*					*(1.632)*	*(6.250)*
1990	0.19	4.36	134	47.76	1.26	13.06	1.661	7.420
	(0.20)	*(2.55)*					*(2.085)*	*(5.792)*
1991	0.01	3.38	120	34.17	2.59	10.15	1.346	6.847
	(0.01)	*(2.68)*					*(1.211)*	*(5.053)*
Entire Sample	0.19	2.03	1256	58.36	1.37	12.21	2.761	8.951
	(0.09)	*(1.45)*					*(2.370)*	*(7.417)*

[a] Ten-year Treasury rate minus the one-year Treasury rate.

dential mortgage prepayment options. The model uses the entire term structure of Treasury rates to estimate two parameters of the short-term interest rate process—a drift term and a volatility. These terms then determine the value of market rates at each "node" in the interest rate lattice, and the value of callable bonds can be computed by the usual method of backward recursion. We modify their computer program to compute callable Treasury yields. Michael Giliberto generously provided us with the term structure model's estimated drift and volatility parameters for our year-end sample dates.

Table VIII reports mean and median option values annually for the 1983–1991 sample period, using the three-month Treasury rate as the model's single "short" rate.[25] The overall sample period's mean option adjustment is 0.19 percent, compared to a mean spread of 2.03 percent on these callable bonds. Despite the relatively low overall mean option value, the yearly mean option values vary substantially, from 5.1 basis points in 1983 to 67.8 basis points in

[25] We alternatively use the one-month Treasury rate as the model's "short" rate, with similar regression results.

1988. As expected, higher option values tend to be associated with flatter yield curves (particularly in 1988 and 1989) and with greater interest rate volatility (as measured by σ_t in column (7)).

An important question concerns whether this adjustment for the call value of a riskless Treasury adequately measures the value of our sample banks' call options. It seems that the value of a Treasury call option may underestimate the value of a risky bond's call option. Riskless bonds can be profitably called only when risk-free market rates fall. By contrast, SNDs may also be profitably called if the issuer's credit quality improves substantially. With more states of the world in which the call option will be exercised, it should be more valuable than what we have calculated—at least when the SND is first issued. Credit quality deterioration, however, *reduces* the value of an option to prepay because the lower-quality firm becomes unable to profit by prepayment even if riskless interest rates fall moderately. This situation characterizes our SND sample: bond ratings tended to decline quite sharply over the sample period. (Table I indicates that the average sample bank's credit deterioration was most substantial late in the period, when the evidence for market discipline is most compelling.) By overstating the value of banks' call options when their credit deteriorates, we are effectively under-valuing the increase in their SNDs' default-related spread during 1989–1991. Accordingly, our analysis should be biased against detecting significant effects of bank risk measures on SPREAD.

In order to check whether our treatment of the SND call premia affects our conclusions about bank market discipline, we repeat the analysis of Tables III, IV, V, and VI using each SND's unadjusted spread over Treasury and two subsets of our bond data. In the first subset, we eliminate all callable bonds, obviating the need to make any call option adjustments. This reduces our sample to 366 bank-year observations, from the 573 reported in the text. The second subset includes noncallable bonds plus any callable bond whose market price was less than $96, on the grounds that the remaining bonds' call options would be far out of the money (and hence worth little). This sampling procedure yields a total of 460 bank-years. Analysis of the raw spread and both alternative samples strongly support the presence of bank market discipline. In other words, our method of adjusting for embedded call options has no important effect on the conclusions of our empirical analysis.

REFERENCES

Avery, R., T. Belton, and M. Goldberg, 1988, Market discipline in regulating bank risk: New evidence from the capital markets, *Journal of Money, Credit, and Banking* 20, 597–610.

American Bankers Association, 1991, A response to the concerns about the final settlement payment approach, submitted as part of the written testimony of William H. Brandon, Jr. at Hearings on the economic implication of the "Too Big to Fail" policy, before the Subcommittee on Economic Stabilization of the Committee on Banking, Finance and Urban Affairs, House of Representatives, 102 Congress (First Session), May 9, 1991.

Baer, H., and E. Brewer, 1986, Uninsured deposits as a source of market discipline: Some new evidence, Federal Reserve Bank of Chicago *Economic Perspectives* (September/October), 23–31.

Black, F., and J. Cox, 1976, Valuing corporate securities: Some effects of bond indentures, *Journal of Finance* 31, 351–367.

Cargill, T. F., 1989, CAMEL ratings and the CD market, *Journal of Financial Services Research*, 347–358.

Carrington, Tim, 1984, U.S. won't let 11 biggest banks in nation fail, *Wall Street Journal*, September 20, p. A2.

Cook, D. O., and L. J. Spellman, 1994, Repudiation risk and restitution costs: Toward understanding premiums on insured deposits, *Journal of Money, Credit, and Banking* 26, 439–459.

Ellis, D. M., and M. J. Flannery, 1992, Risk premia in large CD rates: Time series evidence on market discipline, *Journal of Monetary Economics* 30, 481–502.

Flannery, M., and C. James, 1984a, Market evidence on the effective maturity of bank assets and liabilities, *Journal of Money, Credit and Banking* 16, 435–445.

Flannery, M., and C. James, 1984b, The effect of interest rate changes on the common stock return of financial institutions, *Journal of Finance* 39, 1141–1153.

Flood, M. D., 1992, The great deposit insurance debate, *Federal Reserve Bank of St. Louis Review* 74, 51–77.

Gilbert, R. A., 1990, Market discipline of bank risk: Theory and evidence, *Federal Reserve Bank of St. Louis Review* 72, 3–18.

Giliberto, Michael, and David Ling, 1992, An empirical investigation of the contingent-claims approach to pricing residential mortgage debt, *Journal of the American Real Estate and Urban Economics Association* 20, 393–426.

Gorton, G., and A. Santomero, 1990, Market discipline and bank subordinated debt, *Journal of Money, Credit, and Banking* 22, 119–128.

Hannan, T. H., and G. A. Hanweck, 1988, Bank insolvency risk and the market for large certificates of deposit, *Journal of Money, Credit, and Banking* 20, 203–212.

Harvard Law Review, 1991, Unsecured creditors of failed banks: It's not a wonderful life, *Harvard Law Review* 104, 1052–1071.

James, C. M., 1988, The use of loan sales and standby letters of credit by commercial banks, *Journal of Monetary Economics* 22, 395–422.

James, C. M., 1990, Heterogeneous creditors and the market value of bank LDC loan portfolios, *Journal of Monetary Economics* 25, 325–346.

Kaufman, G. G., 1990, Are some banks too large to fail? Myth and reality, *Contemporary Policy Issues* 8, 1–14.

Kaufman, G. G., and G. J. Benston, 1993, The intellectual history of the Federal Deposit Insurance Corporation Improvement Act of 1991, in Kaufman and Litan, eds.: *Assessing bank reform: FDICIA one year later* (The Brookings Institution, Washington D.C.), 19–32.

Keeley, M. C., 1990, Deposit insurance, risk, and market power in banking, *American Economic Review* 80, 1183–1200.

Merton, R. C., 1974, On the pricing of corporate debt: The risk structure of interest rates, *Journal of Finance* 29, 449–470.

O'Hara, M., and W. Shaw, 1990, Deposit insurance and wealth effects: The value of being "too big to fail," *Journal of Finance* 45, 1587–1600.

Randall, Richard E., 1994, The implications of financial cycles for subordinated debt proposals, in *The Declining(?) Role of Banking*, Proceedings of the Thirtieth Annual Conference on Bank Structure and Competition, Federal Reserve Bank of Chicago, 274–287.

Ronn, E., and A. Verma, 1986, Pricing risk-adjusted deposit insurance: An option-based model, *Journal of Finance* 41, 871–895.

Shaw, K. D., 1988, Who's insuring what for whom: First Republic's lessons, *American Banker*, April 8, p. 4.

Sprague, I. H., 1986, *Bailout: An insider's account of bank failures and rescues*, (Basic Books, New York).

U.S. Government Accounting Office, 1994, *1992 Bank Resolutions*, (May 1994).

Warga, A., 1995, A fixed income database, Fixed income research program, University of Wisconsin-Milwaukee.