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A Reconsideration of the Risk Sensitivity of U.S. Banking Organization Subordinated Debt Spreads: A Sample Selection Approach

1. Introduction

Since the mid-1980s, a growing number of proposals have been set forth that would require large banking organizations to publicly issue subordinated debt on a regular basis.[1] The earliest mandatory subordinated debt proposals were aimed at increasing the size of the financial cushion that could be used by the deposit insurer in the event of a bank failure. Subordinated debt was viewed as a relatively inexpensive substitute for equity capital, because subordinated investors receive their funds only after the deposit insurer is fully compensated and because the tax code permits corporations to deduct interest payments on debt instruments but not dividend payments on equity. Subsequent proposals were aimed at reducing regulatory forbearance. While such proposals vary in their specific details, some would use a bank's ability to issue new subordinated debt as a market signal of its viability,[2] others would use yields on subordinated debt to trigger supervisory actions,[3] and still others would require banking organizations to shrink their assets when they could not issue subordinated debt instruments at a rate below a specified cap.[4]

The evolution of mandatory subordinated debt proposals has reflected deposit insurance reforms that were implemented since the mid-1980s as well as empirical information on the risk sensitivity of banking organization subordinated debt spreads. The 1980s began with considerable de facto too-big-to-fail (TBTF) protection provided to subordinated debtholders.[5] Studies using subordinated debt market data from the 1983-84 period (for example, Avery, Belton, and Goldberg [1988] and Gorton and Santomero [1990]) and from the 1985-88 period (for example, Flannery and Sorescu [1996]) were unable to detect a significant correlation between bank-specific accounting risk measures and secondary-market subordinated debt spreads over comparable-maturity Treasury securities.[6] Because subordinated debt investors were not found to receive a premium for default risk, it was reasonable to infer that these investors could not substitute, even partially, for government regulatory oversight of large banking firms.

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By the mid-1980s, however, the FDIC had put in place mechanisms, such as purchase and assumption transactions, by which it could rescue an insured bank subsidiary without protecting the holding company, or even all of the creditors of the insured bank.[7] As these reforms were implemented, bank-specific risks were found to be increasingly correlated with secondary-market subordinated debt spreads.[8] With this increased risk sensitivity, mandatory subordinated debt proposals shifted toward using market signals to trigger supervisory actions (in some proposals, such actions would even include the revocation of a bank's charter).

In 1991, the Federal Deposit Insurance Corporation Improvement Act (FDICIA): 1) required least-cost resolutions of failed depositories and 2) established the system of prompt corrective action (PCA). The PCA system imposes increasingly severe actions on undercapitalized banking organizations as their capital ratios decline, including restrictions on deposit interest rates; elimination of brokered deposits; restrictions on asset growth; restrictions on interaffiliate transactions; and required approvals for acquisitions, branching, and new activities.[9]

Under PCA criteria, critically undercapitalized banks, defined as those with tangible equity capital less than 2 percent of total assets, must be placed in receivership within ninety days, unless such actions would not achieve the purposes of PCA, or within one year, unless specific statutory requirements are met.[10] Also under PCA, sixty days after a bank is determined to be critically undercapitalized, the bank cannot make payments on subordinated debt without regulatory approval. Although these reforms could potentially reduce the expected default losses borne by subordinated debt investors, because of more timely and lower cost resolutions, numerous studies have consistently found evidence that post-FDICIA subordinated debt spreads remained closely correlated with various indicators of bank risk, including nonaccruing loans to assets, past due loans to assets, "other real estate owned" to assets, the ratio of (book) equity to assets, the ratio of total (book) liabilities to the market value of common stock plus the book value of preferred stock, cardinalized Standard and Poor's or Moody's bond ratings, supervisory ratings, and portfolio shares for lending and for trading activities.[11]

The National Depositor Preference Act of 1993 amended the Federal Deposit Insurance Act to establish a clear priority for the distribution of (unsecured) claims realized from the liquidation or other resolution of any insured depository. Because the National Depositor Preference Act lowered the liquidation standing of bank subordinated debt, it made it more likely that subordinated investors would incur losses in the event of a bank failure.[12] In principle, this reform would unambiguously strengthen the subordinated debt market's sensitivity to bank-specific risks. In fact, when Morgan and Stiroh (1999) compared the risk sensitivity of banking organization bond issuance spreads with the risk sensitivity of other corporate firm bond issuance spreads during the 1993-98 period, they found that the relationship between issuance bond spreads and bond ratings was about the same for banks as it was for other corporate firms.[13] This finding suggests that the market discipline exerted in the primary bond market (in the form of spread sensitivity to risk) was about equal for banking organizations and for other corporate firms during the post-FDICIA period.

In this paper, we analyze banking organization funding strategies using a subordinated debt issuance decision model estimated with data from three deposit insurance regimes: the de facto too-big-to-fail (1985-87) regime, the purchase and assumption (1988-92) regime, and the post-FDICIA (1993-2002) regime. We argue that banking organization subordinated debt issuance decisions can potentially censor the data available on issuance spreads for subordinated debt instruments. To test this hypothesis, we estimate a sample selection model, which incorporates the issuance decision model, and an ordinary least squares (OLS) model, which does not correct for sample selection bias, to consider the risk sensitivity of *observed* issuance spreads (over comparable-maturity Treasury securities) as well as the effects of instrument characteristics, such as issue size and frequency of coupon payments, on such spreads. The model is identified using information available to funding managers, such as supervisory ratings, but not to investors. Using this model, we find that issuance spreads are risk sensitive during all three deposit insurance regimes when a sample selection model is used. Importantly, we also demonstrate that the sign and significance of parameter estimates that do not correct for sample selection bias can be seriously misleading.

The paper proceeds as follows. We begin by specifying an issuance decision model for funding managers at large U.S. banking organizations with respect to subordinated notes and debentures. In Section 3, we use this issuance decision model in the specification of the sample selection model for observed issuance spreads on subordinated debt instruments. Parameter estimates are presented in Section 4 for the issuance decision model, for the sample selection model of issuance spreads, and for the OLS model of issuance spreads that does not correct for sample selection bias for each of the three regulatory regimes under consideration. Section 5 draws inferences from the estimated models about the credit risk sensitivity of subordinated debt spreads under different regulatory regimes and reinterprets the findings of previous market discipline studies.

2. An Issuance Decision Model for Subordinated Debentures

It is widely recognized that firms gauge the market carefully in order to choose an opportune time to issue debt.[14] In 1982, the Securities and Exchange Commission began allowing firms to register securities in advance of issuance under Rule 415. Shelf registrations allow firms considerable flexibility in the timing of their debt issuance.[15] Securities "on the shelf" not only enable firms to require investment bankers to bid competitively, but also allow firms to refuse to sell when desirable bids for their securities are not forthcoming.

Banking organizations, like other corporate entities, may reduce their reliance on debt when their default probability rises. If expected funding costs are sufficiently risk sensitive, then riskier banking organizations may be less likely to issue subordinated debt instruments.[16] Moreover, according to the "informed investor hypothesis," a banking organization would issue subordinated debt upon the receipt of "good" news and would issue senior debt upon the receipt of "bad" news to separate investors with different, yet unobservable, beliefs on the probability of its failure.[17]

To measure the expected default probability of a given banking organization, we examine several bank risk proxies that have been used in previous bank market discipline studies. These include the ratio of nonaccruing loans to total assets ($NATA_{it}$), the ratio of accruing loans past due ninety days or more to total assets ($PDTA_{it}$), the ratio of other real estate owned to total assets ($OREO_{it}$), the absolute value of the difference between assets and liabilities maturing or repricing within one year as a proportion of equity value ($AGAP_{it}$), and the ratio of total book liabilities to the sum of the market value of common stock and the book value of preferred stock ($MARKETLEV_{it}$).[18] Higher values for these proxies should reflect greater default risk and/or a deteriorating financial condition for the banking organization, so it is expected that subordinated debt issuance would be less likely as these risk proxies rise in value.

Moreover, when economic conditions deteriorate, it stands to reason that fewer positive net present value projects may require external debt finance. Several proxies are used to assess the effects of business conditions on banking organization debt issuance decisions. First, poor current macroeconomic conditions may curtail the growth prospects of many firms simultaneously. Thus, a relatively high unemployment rate (UE) could be a harbinger of retrenchment in debt issuance activities by the corporate sector.[19] Second, because stock market excess returns have been found to be negatively correlated with contemporaneous investment (Lamont 2000) and positively correlated with subsequent corporate investment (Fama 1981; Fischer and Merton 1984; Barro 1990), it is likely that corporate debt issuance would also be negatively correlated with contemporaneous stock market excess returns (XR).[20,21,22] Third, bond market stress may make it difficult for some firms to issue debt. For example, during periods when liquidity is at a premium, better known firms as well as larger issues are much more prominent in the primary debt market (Harrison 2001).[23] Because bond price volatility—regardless of whether it is driven by liquidity shocks or credit-quality shocks—tends to increase underwriting costs in a nonuniform manner across firms, some firms may find it too costly to enter the public debt market when such volatility is relatively high. As a general measure for bond market stress, we use an implied stock volatility measure based on real-time S&P 100 (OEX) index option bid/ask quotes, supplied by the Chicago Board Options Exchange ($MKTVOL$).[24] It is expected that bond issuance activities would be negatively correlated with $MKTVOL$.

In addition, the costs and benefits of external finance are likely to vary across firms. For example, becoming a known "name" is said to lower issuance costs and to increase market demand and liquidity for an issuer's debt.[25] Because frequent issuers are likely to have issued subordinated debt more than once during an annual period, an indicator variable that equals 1 when the banking organization has issued subordinated debt in the previous period ($ISSUE_{i,t-1}$) is included in the issuance decision model to proxy for subordinated debt market name recognition.[26]

Because information is costly to analyze, major buyers of subordinated debt typically specialize so that they purchase large amounts of debt of a small number of large firms.[27] This practice tends to reduce issuance costs for large firms. To detect this effect, we include the natural log of total assets, $ln(ASSET_{it})$, in the issuance model.[28]

The existence of tax shelter benefits for corporate debt and increased risks of bankruptcy and agency costs with increased leverage not only affect the market value of each firm, but also determine its optimal capital structure. Hence, the firm's tax rate and its leverage are important inputs for its debt issuance decisions. The higher the banking organization's marginal tax rate, the greater its benefit from being able to deduct the interest payments paid to subordinated debt bondholders. As a proxy for the marginal tax rate facing each banking organization, we use its foreign and domestic income taxes as a percentage of net income ($AVGTAX$). As the amount of debt in the capital structure increases, the present value of tax savings will cause the market value of the firm to rise. However, at some point, the increased risk of bankruptcy and agency costs

resulting from increased leverage will cause the market value of the firm to be less than it would have been if the only influence was taxes. Indeed, it is possible that bankruptcy and agency costs become so large that the market value of the firm would actually decline with an increase in leverage. Thus, the capital structure of a firm at the time an issuance decision is made is likely to determine whether bond issuance would increase its market value. To account for differences in capital structure across banking organizations, we include the ratio of book equity to book total assets (*K/A*) in the issuance decision model. When this ratio is large, tax benefits from debt issuance are likely to outweigh the increased risk of bankruptcy and agency costs resulting from increased leverage, but this is less likely to be the case when *K/A* is small. Therefore, the rise in bankruptcy and agency costs associated with increased leverage suggests that debt issuance activities would be positively correlated with *K/A*.

Lastly, supervisors of a banking organization could potentially pressure its management to raise regulatory capital.[29] To consider whether such pressure may have led some banking organizations to issue subordinated debt, we include two indicator variables. The first, *BOPEC2*, equals 1 if the composite supervisory rating equals 2, and 0 otherwise. The second, *BOPEC345*, equals 1 if the composite supervisory rating equals 3, 4, or 5, and 0 otherwise. Banking organizations with a composite supervisory rating of 1 or 2 are considered by supervisors the safest and most well-managed institutions. However, banking organizations with a composite supervisory rating of 3, 4, or 5 have moderate to substantial deficiencies that were uncovered during the examination process. Therefore, we would expect banking organizations with a composite supervisory rating of 3, 4, or 5 to be under some pressure to improve their total regulatory capital, which includes subordinated debt after implementation of the Basel Accord.

The foregoing discussion suggests that banking organization *i*'s decision to issue subordinated debt at time *t* will likely depend on its default probability ($NATA_{it}$, $PDTA_{it}$, $OREO_{it}$, $AGAP_{it}$, and $MKTLEV_{it}$), business and bond market conditions (UE_t, XR_t, and $MKTVOL_t$), factors that determine firm-specific benefits and costs associated with debt issuance ($ISSUE_{i,\,t-1}$, $ln(ASSETS)_{it}$, $AVGTAX_{it}$, and K/A_{it}), and supervisory pressure ($BOPEC2_{it}$ and $BOPEC345_{it}$). Thus, the decision to issue subordinated debt can be represented by

$$(1)\ ISSUE_{it} = h([NATA_{it}, PDTA_{it}, OREO_{it}, AGAP_{it}, MKTLEV_{it}], [UE_t, XR_t, MKTVOL_t], [ISSUE_{i,t-1}, ln(ASSET_{it}), AVGTAX_{it}, K/A_{it}], [BOPEC2_{it}, BOPEC345_{it}]),$$

where the variable $ISSUE_{it}$ equals 1 if banking organization *i* decides to issue subordinated debt in period *t*, and 0 otherwise.[30] It is assumed that *h(.)* is linear in all of the variables.[31] This yields the following specification,[32]

$$(2)\ ISSUE_{it} = \beta_0 + \beta_1 NATA_{it} + \beta_2 PDTA_{it} + \beta_3 OREO_{it} + \beta_4 AGAP_{it} + \beta_5 MKTLEV_{it} + \beta_6 UE_t + \beta_7 XR_t + \beta_8 MKTVOL_t + \beta_9 ISSUE_{i,t-1} + \beta_{10} ln(ASSET_{it}) + \beta_{11} AVGTAX_{it} + \beta_{12} K/A_{it} + \beta_{13} BOPEC2_{it} + \beta_{14} BOPEC345_{it} + \varepsilon_{it},$$

where the expected signs of parameters for the default risk measures (*NATA*, *PDTA*, *OREO*, *AGAP*, and *MKTLEV*) are negative; the expected signs of the parameters for business conditions (*UE*, *XR*, and *MKTVOL*) are negative; the expected signs of the parameters for banking-organization-specific factors ($ISSUE_{t-1}$, *ln*(*ASSETS*), *AVGTAX*, and *K/A*) are positive; and the expected signs of parameters for supervisory pressure (*BOPEC2* and *BOPEC345*) are positive.

To estimate equation 2, we use standard latent variable techniques and treat the decision to issue as a continuous unobserved variable representing the probability that a banking organization issues subordinated debt. These techniques imply,

$$(3')\ Prob(ISSUE_{it} = 1) = \Phi\,[\beta_0 + \beta_1 NATA_{it} + \beta_2 PDTA_{it} + \beta_3 OREO_{it} + \beta_4 AGAP_{it} + \beta_5 MKTLEV_{it} + \beta_6 UE_t + \beta_7 XR_t + \beta_8 MKTVOL_t + \beta_9 ISSUE_{i,t-1} + \beta_{10} ln(ASSET_{it}) + \beta_{11} AVGTAX_{it} + \beta_{12} K/A_{it} + \beta_{13} BOPEC2_{it} + \beta_{14} BOPEC345_{it}\,]$$

and

$$(3'')\ Prob(ISSUE_{it} = 0) = [1 - Prob(ISSUE_{it} = 1)],$$

where Φ is the standard normal cumulative distribution function. This probit model was estimated using quarterly data for the top fifty U.S. bank holding companies[33] for three regulatory regimes: the de facto TBTF (1985-87) regime, the purchase and assumption (1988-92) regime, and the post-FDICIA (1993-2002) regime.

3. A Sample Selection Model for Observed Issuance Spreads

At the time of issue, each subordinated debt instrument is most likely to be "on-the-run," rather than "off-the-run."[34] Thus, when the risk sensitivity of observed issuance spreads is considered, the potentially important effects of liquidity differences on bond spreads are minimized.[35]

Issuance spreads are likely to depend on the issuing banking organization's financial condition, size, and frequency of coming to the market; on systematic risks; and on the characteristics of the instrument that is issued. As with the issuance decision model, we measure the financial condition of banking organization *i* by the ratio of nonaccruing loans to total assets ($NATA_{it}$), the ratio of accruing loans past due ninety days or more to total assets ($PDTA_{it}$), the ratio of other real estate owned to total assets ($OREO_{it}$), the absolute value of the difference between assets and liabilities maturing or repricing within one year as a proportion of equity value ($AGAP_{it}$), and the ratio of total book liabilities to the sum of the market value of common stock and the book value of preferred stock ($MARKETLEV_{it}$). Bank size is again measured by $ln(ASSET)$ and the frequency of issuance is proxied by $ISSUE_{i,t-1}$.

Investors may require a risk premium to compensate for systematic, rather than diversifiable, risk.[36] Several researchers have demonstrated that corporate bond returns vary systematically with the same factors, such as excess stock returns, that are commonly accepted as explaining risk premiums for common stocks.[37] Moreover, time-series models for secondary-market subordinated debt spreads for large U.S. banking organizations suggest that such spreads are correlated with excess stock returns.[38] Hence, a quarterly excess stock return constructed from the Center for Research in Security Prices' daily value-weighted return on NYSE, Amex, and Nasdaq stocks and daily one-month Treasury bill rates, *XR*, is included in our observed issuance spread model.

Table 1 presents instrument characteristics—such as imbedded call options, maturity lengths, and coupon frequencies—for the subordinated notes and debentures with issuance amounts in excess of $75 million that were issued by the top fifty bank holding companies during the 1985-2002 period.[39] Fixed-rate, noncallable, semiannual coupon, long-term (ten-to-twenty-year) bonds were the most commonly issued instruments during the sample period. By and large, issues of the twenty largest BHCs tended to be more standardized than issues of smaller BHCs.[40] In addition, larger holding companies were more likely to issue subordinated debt with a larger issue size.[41]

In principle, the value of a call option is always non-negative. This means that the "raw" calculated subordinated debt spread *overestimates* the default risk premium.[42] An indicator variable, *CALL*, that equals 1 when an issue has a call option, and 0 otherwise, is included in the regression equation for observed issuance spreads. Since call options are always non-negative, it is expected that the sign on *CALL* would be positive.[43] The percentage of new subordinated debt issues that are callable varies considerably across time for the top fifty banking organizations (Table 1).

In addition, bonds with nonstandard maturities may be less liquid than bonds with standard maturities.[44] If so, then bonds with nonstandard maturities would have larger spreads, ceteris paribus. To capture nonstandard maturity effects on spreads, we include an indicator variable for bonds issued with a maturity of less than ten years, *MATLT10*, and an indicator variable for bonds issued with a maturity greater than twenty years, *MATGT20*, in the issuance spread regression.[45] Each of these indicator variables equals 1 for the specified maturity range, and 0 otherwise. Since nonstandard maturities are expected to raise spreads, it is expected that the sign on these maturity indicator variables would be positive.

It also seems reasonable that coupon frequency could affect the types of investors willing to purchase an issue. Presumably, a higher coupon frequency (for example, with monthly coupon payments) would attract smaller "retail" investors, and the resulting higher demand would lower the issuance spread. To capture this potential effect on the subordinated debt spread, we include two indicator variables, *COUPON12* and *COUPON2*, that equal 1 when the coupon frequency is monthly and semiannual, respectively, and 0 otherwise. Our reasoning suggests that the coefficients on the monthly coupon frequency indicator will be negative. Interestingly, monthly coupons are observed only on subordinated notes and debentures issued in the post-FDICIA period (Table 1).

It is expected that issuance spreads are likely to be negatively correlated with issuance size (*ISSUESIZE*) for at least two reasons. First, larger issues may command higher prices (lower spreads) because smaller issues tend to be less liquid in the secondary market.[46] For this reason, smaller issues are more difficult and expensive to sell to institutional investors.[47] Second, given a banking organization's total assets and its equity-capital ratio, a larger bond issue (one with a larger issuance size) could reflect an organization having a larger proportion of subordinated bonds relative to deposits. The higher preference given to depositors than to subordinated debtholders in bankruptcy implies that expected recovery rates on subordinated debt are higher when there is more

Table 1

Characteristics of Subordinated Debt Instruments Issued by Large U.S. Banking Organizations

Annual Data, 1985-2002

	Pre-FDICIA Period							
	1985	1986	1987	1988	1989	1990	1991	1992
Maturity (percent)								
Less than ten years	0.00	0.00	16.67	0.00	22.22	10.00	46.67	34.48
Ten to twenty years	66.67	50.00	79.17	100.00	66.67	80.00	46.67	65.52
More than twenty years	33.33	50.00	4.17	0.00	11.11	10.00	6.67	0.00
Call option (percent)								
Yes	33.33	100.00	12.50	25.00	11.11	0.00	0.00	0.00
No	66.67	0.00	87.50	75.00	88.89	100.00	100.00	100.00
Coupon frequency (percent)								
Monthly	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Semiannual	100.00	100.00	100.00	100.00	100.00	100.00	96.67	100.00
Quarterly	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zero coupon	0.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00
Amount issued (millions of dollars)								
Maximum	150.00	250.00	300.00	300.00	400.00	200.00	750.00	500.00
Minimum	150.00	150.00	75.00	150.00	100.00	100.00	100.00	100.00
Mean	150.00	200.00	188.54	187.50	180.56	138.70	174.00	192.79
Median	150.00	200.00	200.00	150.00	150.00	118.50	137.50	200.00
Total	450.00	800.00	4,525.00	750.00	3,250.00	1,387.00	5,220.00	11,182.00
Floating rate (percent)	0.00	0.00	8.33	0.00	11.11	0.00	0.00	0.00
Total number issued per annum	3	4	24	4	18	10	30	58

	Post-FDICIA Period									
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Maturity (percent)										
Less than ten years	20.00	25.00	41.46	28.57	7.69	15.00	30.00	33.33	35.71	0.00
Ten to twenty years	77.78	71.43	41.46	60.00	57.69	45.00	60.00	66.67	35.71	85.71
More than twenty years	2.22	3.57	17.07	11.43	34.62	40.00	10.00	0.00	28.57	14.29
Call option (percent)										
Yes	0.00	32.14	31.71	5.71	11.54	20.00	10.00	16.67	57.14	14.29
No	100.00	67.86	68.29	94.29	88.46	80.00	90.00	83.33	42.86	85.71
Coupon frequency (percent)										
Monthly	0.00	0.00	2.44	5.71	3.85	0.00	0.00	0.00	14.29	0.00
Semiannual	95.56	100.00	97.56	94.29	73.08	85.00	100.00	100.00	85.71	85.71
Quarterly	4.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.29
Zero coupon	0.00	0.00	0.00	0.00	23.08	15.00	0.00	0.00	0.00	0.00
Amount issued (millions of dollars)										
Maximum	600.00	300.00	443.40	500.00	800.00	601.50	1,000.00	1,900.00	3,000.00	700.00
Minimum	75.00	100.00	99.80	75.00	85.00	100.00	173.60	75.00	76.03	225.00
Mean	205.00	188.36	193.22	244.87	289.13	284.34	456.95	679.17	458.02	403.57
Median	200.00	150.00	150.00	247.90	250.00	250.00	374.30	400.00	149.61	300.00
Total	9,225.00	5,274.20	7,921.90	8,570.50	7,517.30	5,686.68	4,569.50	4,075.00	6,412.24	2,825.00
Floating rate (percent)	4.44	0.00	0.00	2.86	0.00	15.00	0.00	0.00	0.00	0.00
Total number issued per annum	45	28	41	35	26	20	10	6	14	7

Sources: Moody's Default Risk Service database; Fixed Investment Securities database; Warga database; Bloomberg database.

Notes: In each quarter, we include a banking organization in our sample only if it was in the top fifty after all U.S. bank holding companies were ranked by total assets. Each subordinated debt instrument has an issuance size of at least $75 million. FDICIA is the Federal Deposit Insurance Corporation Improvement Act of 1991.

subordinated debt relative to deposits, ceteris paribus. Higher expected recovery rates would imply lower issuance spreads.[48]

Although previous market discipline studies have used ordinary least squares techniques to estimate the risk sensitivity of banking organization subordinated debt spreads, we recognize that such procedures are inappropriate because subordinated debt spreads are observed only for those bank holding companies that have actually chosen to issue subordinated debt. For example, banking organizations that would have had an issuance spread above their reservation spread level would not be included in such estimation procedures. Since the data on issuance spreads are censored, OLS estimates based on such subsamples would not provide consistent estimates for the risk sensitivity of debt spreads. To address this sample selectivity problem, we use Heckman's two-stage method.[49] This method involves estimating the issuance decision equation with probit (described above), and then using the inverse Mills ratio function of the probit residuals as an extra variable in a regression for the observed issuance spreads.[50]

In summary, the regression estimated for observed issuance spreads over Treasury securities with comparable maturities is:[51,52]

$$
\begin{aligned}
(4)\quad SPREAD_{it} = {} & \alpha + \gamma_1 NATA_{it} + \gamma_2 PDTA_{it} + \gamma_3 OREO_{it} \\
& + \gamma_4 AGAP_{it} + \gamma_5 MKTLEV_{it} + \gamma_6 ISSUE_{i,t-1} \\
& + \gamma_7 ln(ASSET_{it}) + \gamma_8 XR_t + \gamma_9 CALL_{it} \\
& + \gamma_{10} MATLT10_{it} + \gamma_{11} MATGT20_t \\
& + \gamma_{12} COUPON12_{it} + \gamma_{13} COUPON2_{it} \\
& + \gamma_{14} ISSUESIZE + \gamma_{15} MILLSRATIO_{it} + \varepsilon_{it}.
\end{aligned}
$$

Each observed $SPREAD_{it}$ was calculated from observed bond prices using derived yields on each bond calculated by the Newton-Ralphson iterative method and an interpolated Treasury yield of the same maturity.[53]

4. Empirical Results

4.1 Issuance Decisions

The issuance decision and issuance spread models were estimated using quarterly data. Table 2 presents parameter estimates (with *t*-statistics in parentheses) for the issuance decision probit model, equation 3, for each of the three regulatory regimes: the de facto too-big-to-fail (1985-87) regime, the purchase and assumption (1988-92) regime, and the post-FDICIA (1993-2002) regime.[54] Because explanatory variables such as banking-organization-specific risk proxies, supervisory ratings, leverage, and asset size are related to each other, the variances of each of these individual parameter estimates can be misleadingly large. Such relationships imply that joint tests of parameter estimates (Wald tests) for the traditional risk proxies (*NATA*, *PDTA*, *OREO*, *AGAP*, and *MKTLEV*) are more appropriate than mere tabulations of their individual parameters with the expected and significant sign.

Interestingly, the traditional banking-organization-specific risk proxies significantly affected the likelihood that large U.S. banking organizations would issue subordinated debt in the purchase and assumption regime and in the post-FDICIA period. Wald test statistics for the traditional risk proxy parameter estimates jointly equaling 0 are 45.3 and 76.0 in these two periods, respectively. Each of these test statistics is greater than the critical value for the Wald test at a 5 percent confidence level (11.1).[55] In contrast, the Wald statistic for this joint test for the significance of the traditional banking-organization-specific risk proxies is only 8.6 in the de facto TBTF regime.

Banking-organization-specific factors, such as asset size ($ln(ASSETS)$) and whether the banking organization had issued subordinated debt in the previous six-month period ($ISSUE_{t-1}$), also significantly influenced funding manager decisions. Larger banking organizations and more frequent issuers were more likely to issue subordinated debt during each of the three deposit insurance regimes considered.

Overall market conditions matter when it comes to bank subordinated debt issuance decisions. In the de facto TBTF period, higher unemployment (*UE*) significantly reduced bank subordinated debt issuance activities. In addition, in both the de facto TBTF period and the purchase and assumption period, it was less likely for a large U.S. banking organization to issue subordinated debt in periods of bond market illiquidity, that is, when the implied volatility (*MKTVOL*) increased.

Importantly, banking organizations with supervisory ratings in the 3 to 5 range were less likely to issue subordinated debt during the de facto TBTF period. To the extent that this risk measure proxies for "private information" held by the funding manager, this finding suggests that subordinated debt issuance activities were used to signal "good" financial prospects to the market.[56] These results also suggest that supervisors were not pressuring banking organizations that were in financial distress during this period to increase the noninsured liabilities "buffer" that would absorb potential losses from their failure.

Table 2

Parameter Estimates for Issuance Decision Model for Subordinated Debt

Large U.S. Banking Organizations, Alternative Deposit Insurance Regulatory Regimes

	Dependent Variable/Deposit Insurance Regime					
	Decision to Issue					
Explanatory Variables	De Facto TBTF, 1985:1-1987:4 (1)	Expected and Significant Sign?	Purchase and Assumption, 1988:1-1992:4 (2)	Expected and Significant Sign?	Post-FDICIA Sample, 1993:1-2002:4 (3)	Expected and Significant Sign?
Accounting- and market-based risk measures						
Ratio of nonaccruing loans to total assets (*NATA*)	27.261 (1.91)		-12.760 (-1.70)	X	-16.255 (-1.27)	
Ratio of accruing loans past due ninety days or more to total assets (*PDTA*)	-66.860 (-1.56)		-63.216 (-1.61)		10.175 (0.39)	
Ratio of other real estate owned to total assets (*OREO*)	-6.584 (-0.16)		8.183 (0.51)		38.117 (1.38)	
Absolute value of difference between assets and liabilities maturing or repricing within one year as proportion of equity value (*AGAP*)	-0.066 (-1.97)	X	0.002 (0.51)		-0.033 (-1.28)	
Ratio of total book liabilities to sum of market value of common stock and book value of preferred stock (*MKTLEV*)	0.017 (0.75)		-0.019 (-0.70)		0.030 (1.15)	
Other banking-organization-specific factors						
Natural log of total assets (*ln*(*ASSETS*))	0.526 (3.28)	X	0.647 (6.19)	X	0.536 (11.44)	X
Indicator variable that equals 1 if banking organization issued subordinated debt in preceding six-month period, and 0 otherwise (*ISSUE_-1*)	0.322 (1.34)	X	0.346 (2.43)	X	0.746 (8.63)	X
Foreign and domestic income taxes as percentage of net income (*AVGTAX*)	0.003 (1.44)		-0.00004 (-0.13)		0.000 (-1.22)	
Ratio of book equity to book total assets (*K/A*)	9.658 (0.68)		-6.942 (-0.788)		-2.085 (-0.654)	
Business and bond market conditions						
Unemployment rate (*UE*)	-0.764 (-1.95)	X	0.125 (0.37)		0.242 (3.09)	
Stock market excess returns (*XR*)	-0.007 (-0.57)		-0.007 (-0.63)		-0.012 (-1.86)	
Implied stock volatility measure calculated from option prices traded on Chicago Board Options Exchange (*MKTVOL*)	-0.082 (-1.84)	X	-0.041 (-1.65)	X	-0.021 (-2.30)	X
Supervisory pressure						
Indicator variable that equals 1 if composite supervisory rating equals 2 (*BOPEC2)*	-0.302 (-1.40)		0.082 (0.54)		0.033 (0.39)	
Indicator variable that equals 1 if composite supervisory rating equals 3, 4, or 5 (*BOPEC345*)	-0.984 (-2.59)	X	-0.083 (-0.37)		0.041 (0.13)	

Table 2 (Continued)

Parameter Estimates for Issuance Decision Model for Subordinated Debt

Large U.S. Banking Organizations, Alternative Deposit Insurance Regulatory Regimes

Model Statistics	De Facto TBTF	Purchase and Assumption	Post-FDICIA Sample
Wald tests			
Wald test statistics for traditional risk coefficients jointly equaling 0	8.6	45.3	76.0
Critical value for Wald test at 5 percent confidence level	11.1	11.1	11.1
Goodness-of-fit measures			
Fraction of correct predictions for issuance decision	0.88	0.84	0.85
R^2	0.24	0.21	0.31
Number of observations	539	941	1,933
Percentage that issued subordinated debt	14.47	18.28	21.83

Source: Authors' calculations.

Notes: All specifications include a constant term significant at the 5 percent level. Year indicator variables, which equal 1 in a specific year of each panel, and 0 otherwise, are also included, although these coefficient estimates are not reported. Observed spread regressions are heteroskedastic-consistent. *t*-statistics are in parentheses. Significance is indicated at the 10 percent level. TBTF is too-big-to-fail; FDICIA is Federal Deposit Insurance Corporation Improvement Act of 1991.

4.2 Issuance Spreads

The importance of correcting for sample selection biases that result from funding manager decisions is strikingly apparent from Table 3. The table presents parameter estimates for the sample selection model (that includes the inverse Mills ratio), equation 4, and an OLS model (that does not include the inverse Mills ratio) for banking organization primary-market spreads in each of the three deposit insurance regimes. In these models, as was the case with the issuance decision model, the relationships between the banking-organization-specific risk proxies imply that the variances of each of these individual parameter estimates can be misleadingly large. Therefore, it is important to again consider joint tests of parameter estimates (Wald tests) for the traditional risk proxies (*NATA*, *PDTA*, *OREO*, *AGAP*, and *MKTLEV*).[57] To ascertain the sign of the joint risk effect, we present in Table 3 information on: 1) the distribution of the joint risk effects calculated using the parameter estimates and banking-organization-specific values for the five risk proxies, 2) the sign and significance of a risk aggregate that is constructed using principal components techniques,[58] and 3) the sum of the "normalized" marginal risk effects.[59]

Importantly, in the de facto TBTF period, the Wald statistic for the joint test for the significance of the traditional banking-organization-specific risk proxies is well in *excess* of the critical value for the 5 percent confidence level when a sample selection model is used, but the Wald statistic is *below* this critical threshold when an OLS model that does not correct for sample selection bias (henceforth referred to as the "OLS model") is used. In addition, the distribution of the joint risk effects has a *positive* mean, with the vast majority of banking organizations having fairly large *positive* joint risk effects in the de facto TBTF period when a sample selection model is used (column 1), but the corresponding mean is *negative* and the vast majority of banking organizations have a *negative* joint risk effect when an OLS model is specified (column 2).[60] Moreover, the principal component derived from banking-organization-specific risk effects is positive, albeit not significant, and the sum of the normalized marginal risk effects is also positive when a sample selection model is used. However, the normalized marginal risk effect is negative when an OLS model is used. The lack of much of a positive relationship between risk proxies and banking organization subordinated debt spreads when using the OLS model for the de facto TBTF (1985-88) period is consistent with results from similar tests performed in the literature using

Table 3

Parameter Estimates for Sample Selection Model and Ordinary Least Squares (OLS) Model for Observed Subordinated Debt Issuance Spreads

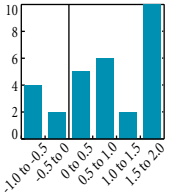
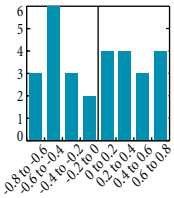
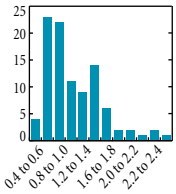
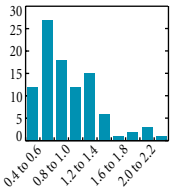
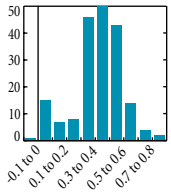
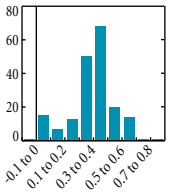
Large U.S. Banking Organizations, Alternative Deposit Insurance Regulatory Regimes

	Deposit Insurance Regime/Explanatory Variable											
	De Facto TBTF, 1985:1-1987:4				Purchase and Assumption, 1988:1-1992:4				Post-FDICIA Sample, 1993:1-2002:4			
	Spread over Treasury Securities with Comparable Maturities											
Explanatory Variables	Sample Selection (1)	ESS?	OLS (2)	ESS?	Sample Selection (3)	ESS?	OLS (4)	ESS?	Sample Selection (5)	ESS?	OLS (6)	ESS?
Accounting- and market-based risk measures												
NATA[a]	51.183 (1.98)	X	29.713 (1.21)		-9.384 (-1.75)		-10.436 (-1.96)		-3.430 (-0.48)		-0.930 (-0.16)	
PDTA[a]	618.065 (2.92)	X	247.794 (2.59)	X	56.914 (1.53)		22.400 (0.90)		78.157 (3.01)	X	78.877 (2.88)	X
OREO[a]	-291.452 (-2.61)		-156.762 (-1.80)		59.531 (4.14)	X	58.070 (4.05)	X	-3.808 (-0.32)		-9.462 (-1.09)	
AGAP[a]	-0.158 (-1.41)		-0.105 (-0.98)		0.007 (1.69)	X	0.006 (1.48)		-0.002 (-0.14)		0.003 (0.24)	
MKTLEV[a]	-0.062 (-1.58)		-0.046 (-1.17)		0.075 (4.79)	X	0.073 (4.86)	X	0.053 (3.57)	X	0.046 (4.38)	X
Banking-organization-specific factors												
ln(*ASSETS*)[a]	-2.060 (-1.85)	X	-0.035 (-0.08)		-0.210 (-0.95)		0.037 (0.40)		0.108 (0.61)		-0.025 (-0.90)	
ISSUE_-1[a]	-1.328 (-1.75)	X	-0.419 (-0.91)		-0.187 (-1.46)		-0.054 (-0.65)		0.023 (0.09)		-0.147 (-3.24)	X
Business conditions												
XR[a]	0.024 (1.33)		-0.005 (-0.31)		0.011 (1.56)		0.013 (1.69)	X	0.007 (1.52)		0.010 (2.36)	X
Instrument characteristics												
Indicator that equals 1 when issue has call option (*CALL*)	0.359 (0.58)		0.290 (0.34)		0.177 (1.00)		0.158 (0.91)		0.211 (3.50)	X	0.215 (3.47)	X
Indicator that equals 1 when issue has maturity of less than ten years (*MATLT10*)	-0.826 (-1.77)		-0.412 (-1.15)		0.613 (1.98)	X	0.144 (1.68)	X	0.149 (3.93)	X	0.136 (3.38)	X
Indicator that equals 1 when issue has maturity greater than twenty years (*MATGT20*)	1.218 (1.87)	X	1.900 (2.32)	X	0.265 (1.97)	X	0.258 (1.86)	X	0.130 (1.70)	X	0.114 (1.48)	
Indicator that equals 1 when coupon frequency is monthly (*COUPON12*)	—		—		—		—		-0.314 (-2.08)		-0.328 (-2.17)	
Indicator that equals 1 when coupon frequency is semiannual (*COUPON2*)	—		—		0.569 (3.85)	X	0.582 (3.96)	X	-0.281 (-2.65)		-0.294 (-2.83)	
Dollar amount of issue (*ISSUESIZE*)	-0.001 (-0.03)		-0.002 (-0.45)		-0.001 (-1.78)	X	-0.001 (-1.64)		0.0003 (3.47)		0.0003 (3.74)	

Table 3 (Continued)

Parameter Estimates for Sample Selection Model and Ordinary Least Squares (OLS) Model for Observed Subordinated Debt Issuance Spreads

Large U.S. Banking Organizations, Alternative Deposit Insurance Regulatory Regimes

	Deposit Insurance Regime/Explanatory Variable					
	De Facto TBTF, 1985:1-1987:4		Purchase and Assumption, 1988:1-1992:4		Post-FDICIA Sample, 1993:1-2002:4	
	Spread over Treasury Securities with Comparable Maturities					
Model Statistics	Sample Selection (1)	OLS (2)	Sample Selection (3)	OLS (4)	Sample Selection (5)	OLS (6)
Wald tests						
Wald test statistics for traditional risk coefficients jointly equaling 0	27.4	10.4	80.4	90.8	40.2	15.8
Critical value for Wald test at 5 percent confidence level	11.1	11.1	11.1	11.1	11.1	11.1
Sign?						
Distribution of estimated risk effects[b]						
Mean of distribution of estimated effects	0.689	-0.019	1.134	1.000	0.425	0.399
Principal component derived using risk effects	0.030 (0.24)	0.018 (0.02)	0.233 (3.29)	0.228 (6.63)	0.055 (3.31)	0.054 (3.31)
Sum of normalized marginal risk effects	0.24	-0.10	0.62	0.51	0.25	0.23
Inverse Mills ratio						
Inverse Mills ratio coefficient	-4.189 (-1.79)	—	-0.602 (-1.26)	—	0.356 (0.74)	—
Goodness-of-fit measures						
R^2	0.93	0.88	0.74	0.73	0.68	0.67
Number of observations	31	31	120	120	232	232

Source: Authors' calculations.

Notes: All specifications include a constant term significant at the 5 percent level. Year indicator variables, which equal 1 in a specific year of each panel, and 0 otherwise, are also included. Observed spread regressions are heteroskedastic-consistent. *t*-statistics are in parentheses. Significance is indicated at the 10 percent level. TBTF is too-big-to-fail; FDICIA is Federal Deposit Insurance Corporation Improvement Act of 1991; ESS is expected and significant sign.

[a] Variable is described in Table 2.
[b] A vertical line appears at zero in each distribution of the estimated risk effects.

secondary-market subordinated debt spreads for this period.[61] In stark contrast, the evidence of a positive relationship between debt spreads and risk proxies when using the sample selection model is consistent with studies using (bankruptcy-remote) bank certificates of deposit during the mid-1980s.[62]

Wald test statistics for the traditional risk coefficients jointly equaling 0 are above the critical value for the 5 percent confidence level (11.1) in both the purchase and assumption (1988-92) period and the post-FDICIA (1993-2002) period, regardless of whether a sample selection model or an OLS model is used. Moreover, the distributions of the estimated banking-organization-specific joint risk effects contain *only* positive values in the purchase and assumption period (using either a sample selection model or an OLS model) and such distributions for the post-FDICIA period contain only a few negative joint risk effects. The mean of the distribution of the estimated joint risk effects is larger in the purchase and assumption period (1.134, column 3) than in the post-FDICIA period (0.425, column 5). These findings suggest that there may have been a decrease in the risk sensitivity of subordinated debt spreads between the purchase and assumption period and the post-FDICIA period.[63] Consistent with this view, the parameter estimate on the principal component derived using risk effects during the purchase and assumption period is four times larger (0.223, column 3) than the corresponding parameter estimate for the post-FDICIA period (0.055, column 5). In both periods, these parameter estimates are positive and significantly different from 0 at the 5 percent level of confidence. Finally, the sum of the normalized marginal risk effects is more than twice as large in the purchase and assumption period than it is in the post-FDICIA period (whether a sample selection model is used or not). Together, these findings are consistent with subordinated investors perceiving that prompt corrective action by bank supervisors would likely reduce their expected losses in the event of a bank failure, despite their lower liquidation standing due to FDICIA and depositor preference rules.

The sign and significance of banking-organization-specific factors, such as asset size ($ln(ASSETS)$), can also be misleading when an OLS model, rather than a sample selection model, is used to analyze subordinated debt spreads. In the de facto TBTF period, larger banks have significantly lower issuance spreads when a sample selection model is used, but this is not the case when an OLS model is used with the same observed spreads.

Interestingly, the effect of stock market excess returns on issuance spreads for banking organization subordinated debentures is only significant in the OLS models. This effect is positive and significant in the OLS models of issuance spreads for the purchase and assumption period and the post-FDICIA period. However, the effect of stock market excess returns is not significant in the sample selection models for banking organization subordinated debt spreads, regardless of the deposit insurance regime. This finding suggests that the effects of systematic risk factors on secondary corporate bond spreads, which have been documented in the literature,[64] may partly result from researchers not controlling for the effects of issuance decisions on bond spreads. This is because secondary spreads may be stale, or unavailable, for firms that have not recently issued debt securities.

Not surprisingly, instrument characteristics significantly influence observed issuance spreads. Looking across the deposit insurance regimes, we note that different instrument characteristics increase or reduce spreads more in some regimes than in others, but it remains the case that deviations from the "plain-vanilla" benchmark (fixed-rate, noncallable, ten-year-maturity debt) generally significantly influence observed spreads. This finding implies that funding manager decisions with respect to instrument characteristics are also important to consider when one compares issuance spreads across banking organizations.[65]

Although the parameter estimate on the inverse Mills ratio is by itself insignificant in each of the deposit insurance regimes considered, inclusion of this variable importantly affects the significance and magnitude of the other parameter estimates included in the sample selection model. This finding, of course, suggests that the inverse Mills ratio is correlated with other variables in the model for issuance spreads. It also implies that funding managers do consider bank-specific risks and the other factors included in our issuance decision model to be important when deciding about issuing subordinated debt.

5. Market Discipline in Banking Reconsidered

Several studies of banking organization subordinated debentures (for example, Avery, Belton, and Goldberg [1988], Gorton and Santomero [1990], and Flannery and Sorescu [1996]) have found *no* statistical relationship between accounting-based measures of risk and subordinated debt prices prior to 1989, but did find such a relationship after 1989. Other studies using post-1989 secondary-market data with similar empirical models (such as Jagtiani, Kaufman, and Lemieux [2000] and DeYoung et al. [2001]) have also found a significant *positive* correlation between banking-organization-specific risk measures and subordinated debt prices. Because deposit insurance reforms were implemented beginning in the late 1980s, some—maybe even most—observers took these

findings as evidence that conjectural government guarantees prior to these reforms made subordinated debt investors insensitive to banking-organization-specific risks.

In contrast, using information from the primary bond market during the 1985-88 period, we demonstrate that perceived government guarantees during that period did not make subordinated debt investors completely insensitive to bank-specific risks. Our sample selection model indicates that investors were able to differentiate rationally among the risks undertaken by major U.S. banking organizations. This result is consistent with early studies in the market discipline literature (Hannon and Hanweck 1988; Ellis and Flannery 1992) that have found that interest rates on relatively bankruptcy-remote large certificates of deposit were sensitive to bank-specific risks.

That being said, we also find market discipline to have been relatively weak in the pre-1989 period. During the de facto too-big-to-fail (1985-87) period, we find that the distribution of estimated joint risk effects had a 20/80 split between negative/positive effects, with about one-third of the observations lying between 1.5 and 2.0. Moreover, the parameter estimate on the joint risk effect derived using principal component techniques was positive, but statistically insignificant. Using the same issuance decision and sample selection models and the same methods for signing the joint effects, we find the strongest risk sensitivity of spreads during the purchase and assumption (1988-92) regime—a period when bank regulators reduced protections for large bank holding companies' creditors.[66]

Interestingly, in the post-FDICIA (1993-2002) period, the risk sensitivity of issuance spreads appears to have waned a bit. Using sample selection models, we find that the estimated joint risk effects were more tightly distributed near zero in the post-FDICIA period (Table 3, column 5) than they were during the purchase and assumption period (Table 3, column 3), that the mean of the distribution of joint risk effects was smaller in the post-FDICIA period than it was during the purchase and assumption period, and that the parameter estimate on the principal component during the post-FDICIA period was about a quarter of the size of the corresponding parameter estimate for the purchase and assumption period. These findings are consistent with the view that investors have taken seriously regulatory reforms that were tailored to limit the size of the safety net by increasing the losses borne by holding company subordinated debtholders in the event that their firm's subsidiary financial institutions fail, as well as reforms (such as prompt corrective action) designed to limit potential losses given a default. Our findings suggest that the resulting default premia contained in subordinated debt spreads have in part reflected investors' expectations with respect to these somewhat offsetting objectives.

Our results also suggest that market discipline has similar effects on banking organizations and other corporate entities. In particular, we demonstrate that issuance decisions for banking organizations are sensitive to firm-specific risks, just as others have found for nonfinancial firms (Castanias 1983; Marsh 1982). Consistently, Morgan and Stiroh (1999) find that the risk sensitivity of bank bond spreads is about the same as that of corporate bond spreads.

In sum, our empirical evidence indicates that market discipline is exerted on U.S. banking organizations in the primary debt market. Put differently, investors monitor banking organizations even in the absence of a formal mandatory subordinated debt policy. Our empirical analysis also suggests that tests for the risk sensitivity of secondary-market debt spreads could be influenced by funding manager decisions that are sensitive to banking-organization-specific risks. For example, if the riskiest banking organizations never issued subordinated debt, then no secondary subordinated debt prices would exist for these firms. In this case, the sample selection problems for issuance and secondary-market spread analyses would be identical. This remains an important issue for further research, since many academics use secondary spreads to test for market discipline and bank supervisors and market participants monitor the secondary subordinated debt market spreads of large U.S. banking organizations.

Endnotes

1. Board of Governors of the Federal Reserve System and U.S. Treasury Department (2000, pp. 58-65) contains a summary of fourteen subordinated debt proposals.

2. See, for example, Cooper and Fraser (1988) and Wall (1989).

3. See, for example, Evanoff (1993), Lang and Robertson (2000), and Evanoff and Wall (2000).

4. In the proposal set forth in Calomiris (1997), the subordinated debt rate would be capped at 50 basis points above the riskless rate; in Calomiris (1999), it would be capped at 3 percent above the Treasury bill rate.

5. For example, in July 1984 the Federal Deposit Insurance Corporation (FDIC) saved Continental Illinois Bank by providing "open bank assistance." This was accomplished by purchasing $1 billion of preferred stock in the parent holding company, which was immediately downstreamed to the bank as common equity. Flannery and Sorescu (1996, pp. 1352-3) argue that this direct capital infusion into the parent holding company essentially protected investors who held subordinated debentures of the holding company. Flannery (1998) refers to 1984-89 as the too-big-to-fail period, while Jagtiani, Kaufman, and Lemieux (2000) refer to it as the de facto protection period for uninsured deposits and other debt.

6. Both Gorton and Santomero (1990) and Flannery and Sorescu (1996) estimate specifications that allow for the potential concavity of spreads in asset risk.

7. See Flannery and Sorescu (1996, pp. 1352-3).

8. See Flannery and Sorescu (1996, pp. 1364-74).

9. Undercapitalized banks have a total risk-based capital ratio under 8 percent, or a Tier 1 risk-based capital ratio under 4 percent, or a Tier 1 leverage ratio under 4 percent.

10. See Jones and King (1995). FDICIA required federal banking agencies to implement a capital-based policy of PCA that would begin in December 1992.

11. See, for example, Jagtiani, Kaufman, and Lemieux (2000), DeYoung et al. (2001), Hancock and Kwast (2001), and Morgan and Stiroh (2001).

12. See Section 11(d)(11) of the Federal Deposit Insurance Act (codified as amended at 12 U.S.C. §1821(d)(11)(2000)).

13. The authors also report that this relationship was weaker for bigger and for less transparent banks than it was for other banks.

14. See Covitz and Harrison (forthcoming) for a discussion of why banking organizations strategically time their public bond issues, and evidence that they do so.

15. With a shelf registration, securities can be sold up to two years later.

16. See Board of Governors of the Federal Reserve System (1999) and Board of Governors of the Federal Reserve System and U.S. Treasury Department (2000, p. 36).

17. See Birchler and Hancock (2004, p. 4).

18. See, for example, Flannery and Sorescu (1996) and DeYoung et al. (2001). Balance-sheet and income statement data are from the consolidated financial statements for bank holding companies (Federal Reserve FR Y-9C Reports). These items are reported as of the close of business on the last calendar day of the quarter. Data on the market value of common stock are from the Center for Research in Security Prices tape, published by the University of Chicago's Graduate School of Business. Both data sets are publicly available.

19. Although the parameter estimates are not reported below, model specifications were tested that included a leading indicator (the BAA interest spread) and a coincident indicator (industrial production) in addition to a lagging indicator of business conditions (the unemployment rate). These additional business condition variables did not significantly influence issuance decisions.

20. Lags in the investment process (owing to delivery, planning, and construction lags) and time-varying risk premia can cause actual investment to be negatively correlated with current returns (Lamont 2000, p. 2720).

21. The influence of overall stock market excess returns on debt issuance activities may be weak. For example, Welch (2002) argues that the observed capital structure of U.S. firms is explained well by a firm's own past capital structure and by its stock price appreciation. For the contemporaneous stock market excess return, we use the

quarterly average of daily excess stock returns, calculated as the difference between the daily value-weighted return on New York Stock Exchange (NYSE), American Stock Exchange (Amex), and Nasdaq stocks and the off-the-run one-month Treasury return.

22. The daily excess stock return is calculated as the difference between the daily value-weighted return on NYSE, Amex, and Nasdaq stocks and the off-the-run one-month Treasury return. The quarterly excess stock market return is the quarterly average of daily excess stock market returns.

23. Harrison (2001) argues that a severe liquidity shock, such as after the Russian default in 1998:3, is in some ways as bad for the corporate bond market as a severe credit-quality shock, such as during 2000-01. With both types of shocks to the bond market, credit spreads widen, but issuance can be more strongly curtailed in the case of a liquidity shock, as some firms in the high-yield sector are completely shut out of the public debt market.

24. Implied stock volatility is exogenous to, but highly correlated with, bond market volatility.

25. See Board of Governors of the Federal Reserve System (1999, p. 46).

26. More explicitly, $ISSUE_{i,\,t\text{-}1}$ equals 1 if banking organization *i* issued subordinated debt in either quarter *t*-2 or quarter *t*-3, and 0 otherwise.

27. See Board of Governors of the Federal Reserve System (1999, p. 47).

28. This proxy will also detect the risk reduction typically achieved by greater diversification or liquidity effects present at larger firms. See, for example, Morgan and Stiroh (2001, p. 200).

29. In recent years, supervisors have placed increasing emphasis on banking organizations' internal processes for assessing risks and for ensuring that capital and other financial resources, such as subordinated debt, are adequate in relation to the overall organizational risk profiles. See Board of Governors of the Federal Reserve System, SR letter 99-18 (available at <http://www.federalreserve.gov/boarddocs/SRLETTERS/1999/SR9918.htm>).

30. To construct the $ISSUE_{it}$ variable, we use the CUSIP Masterfile to identify all subordinated debt issues of top fifty bank holding companies (BHCs). Then, for each subordinated debt issue, issuance dates are assigned using Moody's, Fitch, Bloomberg, and Warga databases. $ISSUE_{it}$ equals 1 if banking organization *i* issued subordinated debt in either quarter *t* or quarter *t*-1, and 0 otherwise. Two-quarter issuance intervals are appropriate because U.S. banking organizations rarely issue subordinated debt instruments more frequently than twice per year (Board of Governors of the Federal Reserve System 1999, p. 46). Explanatory variables are lagged to reflect what was publicly or privately available at time *t*.

31. For continuous right-hand-side variables, the average value for a two-quarter interval is used; for binary right-hand-side variables, the average of the appropriate underlying variable over two quarters is used. The left-hand-side variable is set equal to 1 if the bank issues in a two-quarter period, and 0 otherwise. To enhance the exogeneity of the right-hand-side variables, we lag explanatory variables by one quarter.

32. Based on Flannery and Sorescu (1996), we also considered a more general specification in which all of the accounting risk measures except *MKTLEV* were interacted with *MKTLEV* and $MKTLEV^2$. The empirical results from this more general specification were consistent with those of the linear specification described in the text, with similar conclusions about market discipline.

33. In each quarter, the top fifty BHCs were defined as those organizations that were among the fifty largest when such organizations are ranked by asset size according to holding company "Y Reports" submitted to the Federal Reserve. Thus, the top fifty BHCs can be different in each quarter. Most, but not all, top fifty BHCs have some publicly issued subordinated debt outstanding. Bond issues by top fifty BHCs were identified using Standard and Poor's Master CUSIP Directory.

34. Older, or off-the-run, issues generally become absorbed into investors' portfolios (see Sarig and Warga [1989], Amihud and Mendelson [1991], and Board of Governors of the Federal Reserve System [1999, p. 46]).

35. Empirically, the dearth of liquidity for older bonds presents itself through larger discrepancies in recorded prices across alternative data sources. For bonds that are not actively traded, large discrepancies in prices can develop because: 1) each source uses different traders or broker-dealers for price information and their price records need not be simultaneous when a bond is not actively traded, 2) exchange-based prices can contain significant liquidity-driven noise, and 3) it is difficult for investors to arbitrage price differences between illiquid

Note 35 continued
securities. Like other corporate bonds, discrepancies in recorded prices across alternative data sources for subordinated notes and debentures issued by large U.S. banking organizations tend to increase with the issue's age and to decline with issuance size (Hancock and Kwast 2001).

36. Elton et al. (2001) argue that corporate bond spreads could move systematically with other assets in the market because: 1) expected default losses could be correlated with equity prices (that is, default losses could decline with a rise in stock prices and default losses could increase with a fall in stock prices) and 2) the compensation for risk required in capital markets could change over time.

37. See Fama and French (1993) and Elton et al. (2001).

38. See Hancock and Kwast (2001).

39. Subordinated notes and debentures with issuance amounts of less than $75 million are generally included in medium-term note programs. Such issues are typically targeted toward specific retail investors and their issuance spreads include hefty liquidity premiums. Consequently, subordinated instruments with issuance amounts of less than $75 million are not included in the analysis of issuance spreads provided below.

40. See Board of Governors of the Federal Reserve System and U.S. Treasury Department (2000, pp. 9-13).

41. During the 1990s, the average size of a debt issue for the twenty largest BHCs more than doubled. Over the same period, the average size of a debt issue for the next thirty largest BHCs fluctuated around $200 million, despite the fact that the largest issue in some years was by a holding company in that group.

42. The value of a bond's call option increases with its maturity and the volatility of market interest rates, and decreases with the required call premium. See Avery, Belton, and Goldberg (1988), Gorton and Santomero (1990), and Flannery and Sorescu (1996) for discussions of the computation of option-adjusted spreads. Alternatively, Boardman and McEnally (1981) use a net present value calculation for deciding when to call an issue in their analysis of the factors that affect seasoned corporate bond prices.

43. A negative or zero coefficient on the call option indicator variable would imply that debtholders did not value the call option appropriately.

44. Nonstandard maturity instruments may be issued by banking organizations to match the duration of their liabilities with the duration of their assets, or these instruments may be issued when an organization wants to attract funds from small retail investors.

45. Maturities and other instrument characteristics for each subordinated bond were identified using the Moody's Default Risk Service database, the Fixed Investment Securities database, the Warga database, and the Bloomberg database as well as monthly issues of the *Mergent Bond Record* over the January 1984-December 2001 period, inclusive.

46. Smaller issues tend to be less liquid because they are typically absorbed rapidly into investor portfolios. Hancock and Kwast (2001) present histograms of weekly subordinated debt spread discrepancies between Bloomberg and Interactive Data Corporation pricing data sources over the January 1997-October 1999 period for bonds stratified by issuance size. The tightest distribution of spread discrepancies is for bonds with issuance sizes above $300 million. The next tightest distribution is for bonds with issuance sizes between $100 million and $300 million. The widest distribution is for bonds with issuance sizes below $100 million. The decreased dispersion in spread discrepancies for larger issues suggests that there may be a positive correlation between the flow of trade in a particular bond and its amount outstanding at issuance.

47. See Board of Governors of the Federal Reserve System (1999, p. 46).

48. See Pennacchi (2001).

49. See Heckman (1979) and Killingsworth (1983) for a discussion of this two-step method for sample selection models.

50. Since the conventionally estimated standard errors and associated *t*-statistics are not consistent estimates for the regression for observed issuance spreads, it was necessary to compute heteroskedastic-consistent standard errors. The heteroskedastic-consistent *t*-statistics, computed using White (1980), are reported below.

51. Note that there are extra identifying variables in the issuance decision model: *UE*, *BOPEC2*, and *BOPEC345*.

52. A nonlinear specification for the risk variables, similar to the one estimated by Flannery and Sorescu (1996), was also estimated. This specification yielded results that were qualitatively similar to those from the more straightforward to interpret linear specification

reported. In addition, an alternative specification of the sample selection model for subordinated debt issuance spreads is presented in Birchler and Hancock (2004). Their findings are also consistent with those reported below. Thus, the results are not sensitive to the particular specification used in this analysis.

53. Issuance prices were obtained from the Bloomberg "generic" bond pricing series, which is constructed using the consensus method that averages observed *trading prices* after dropping the highest and lowest observations. For the consensus method, a minimum of three observations is required, after dropping the highest and lowest observations, for a price to be valid, otherwise a missing value is entered for the trading price. Valid prices were obtained for all issuance dates. The term structure of Treasury interest rates was identified for each trading price issuance date by using a smoothing spline of the forward rate curve that incorporates a "roughness" penalty determined by generalized cross-validation. This splining technique is described in Fisher, Nychka, and Zervos (1995).

54. Parameter estimates with the expected and significant sign at the 10 percent level of confidence are indicated in each regime with an "X."

55. A two-tailed test statistic is appropriate for this joint test because it is unclear whether more organization-specific risk would increase or reduce the likelihood that a funding manager would issue subordinated debt.

56. See, for example, Covitz and Harrison (forthcoming).

57. This approach is also used in Flannery and Sorescu (1996, p. 1361).

58. Each principal component is a linear combination of the original risk variables, with coefficients equal to the eigenvectors of the covariance matrix. We use the first principal component, which has the largest variance of any unit-length linear combination of the observed risk variables.

59. The normalization involves multiplying a variable's marginal effect by the sample standard deviation of that variable. Summing these normalized effects across all risk proxies is akin to looking at the effect of a one-standard-deviation positive shock to all individual risk proxies. Given that the variables are highly correlated, shocking them all in the same direction is reasonable. Since the parameter estimates are not all positive, we note that this procedure does not provide an upper bound on the joint risk effect.

60. It is notable that the identifying variables in the issuance decision model (*UE*, *BOPEC2*, and *BOPEC345*) are jointly significant for the de facto TBTF period. The Wald test statistic is 10.664 against a critical value of 7.61 for a 5 percent confidence level.

61. See, for example, Flannery and Sorescu (1996, p. 1363).

62. See, for example, Hannon and Hanweck (1988) and Ellis and Flannery (1992).

63. The identifying variables in the issuance decision model (*UE*, *BOPEC2*, and *BOPEC345*) are jointly significant for the post-FDICIA period. The Wald test statistic is 9.782 against a critical value of 7.61 for a 5 percent confidence level.

64. See, for example, Fama and French (1993) and Elton et al. (2001).

65. These findings are consistent with those reported in Morgan and Stiroh (2001).

66. Flannery and Sorescu (1996) also find market discipline to be particularly strong during this period.

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