MARKET DISCIPLINE AND THE VALUATION OF BANK SUBORDINATED DEBT

by

Gary Gorton
Anthony M. Santomero

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RODNEY L. WHITE CENTER FOR FINANCIAL RESEARCH
The Wharton School
University of Pennsylvania
Philadelphia, PA 19104-6367

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Gary Gorton and Anthony M. Santomero
Department of Finance
The Wharton School
University of Pennsylvania

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Abstract

The usual approach to determine if market prices of uninsured bank liabilities reflect the risk of default is to regress the yield spread of bank debt against accounting measures of bank risk. To date these results have been mixed. Here we argue that this is because previous investigations lack a theoretical model of bank liability pricing. Without this, linear regressions have difficulty addressing the question. In this essay we use contingent claims valuation to determine whether implied volatilities embedded in bank liability prices are correlated with accounting measures of bank risk. Observed yields on subordinated bank debt over equivalent maturity treasuries are used to compute implied bank volatility. Accounting measures of bank risk turn out to predict the volatility of bank assets and suggest the existence of market discipline.

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I. Introduction

A lengthy literature in banking has addressed the question of whether the market prices of bank liabilities reflect the individual risk-taking activity of banks. That is, researchers have often asked whether there exists "market discipline". This is the key public policy question for bank (de-) regulation because if bank risk-taking is priced by the market, then the rationale for bank regulation is less compelling. The key argument for bank regulation is the alleged presence of an information asymmetry between bank managers and bank liability holders. Liability holders, and depositors in particular, are said to be unaware of the quality of the assets and the value of the bank. Consequently, bank debt has been insured and banks regulated. But, insofar as "market discipline" exists, the assumed information asymmetry that underlies the need for insurance and regulation is absent. However, despite the importance of the question the current record has led to no consensus on the issue of market discipline. Results have been contradictory.

In this study we argue that a basic reason for these mixed results springs from the lack of a theoretical model of bank instrument valuation and a failure to adequately account for the fact that banks are currently regulated. Therefore, the empirical models have lacked the necessary exactness to isolate the appropriate null hypotheses. To redress this shortcoming in the literature, we use a pricing model which comes from the options pricing literature. In particular, we price subordinated debt.

With a contingent claims pricing model it is clear that the value of bank subordinated debt is not a linear, monotonic, function of bank risk. Moreover, we can investigate hypotheses about the effects of current bank regulation on the existence of market discipline. These complications mean that simple regressions are not likely to adequately address the relationship between the value of subordinate debt and underlying risk. Nevertheless, empirically, using contingent claims pricing, accounting measures of bank risk do predict the volatility of bank assets, and offer evidence in favor of the existence of market discipline.

A) The State of the Literature

The literature on market discipline of the banking firm tests for the existence of market sensitivity to bank risk by regressing the relative cost of bank funds on balance sheet and/or income statement measures of risk, return, and market position. The basic issue is whether the measures of bank risk are significantly related to movements in bank liability or equity prices. If they are, then "market discipline" is said to exist.

The earliest work by Jacobs, Beighley and Boyd (1975), Beighley, Boyd and Jacobs (1975), and Humphrey and Talley (1975) examined bank equity prices. All found leverage and credit risk proxies to have a significant effect on equity values during the period 1970-75. However the results were not robust. Subsequent work by Silverberg (1975) and Pettway (1976) showed only mixed results for both risk measures. Work by Ji (1987), some ten years later, shows similar uncertainty.

A second strand of the literature centers around the pricing of uninsured deposit claims of the bank. Here the results of Humphrey and Talley (1975) and Pettway (1976) offered contradictory conclusions. Ten years later Cramer and Rogowski (1985) investigated the relationship between deposit cost and bank-specific risk measure, but failed to find any. On the other hand, Goldberg and Lloyd-Davies (1985) find a clear and significant relationship between deposit costs and bank risk. This is supported by subsequent work by Baer and Brewer (1986) which finds that these rates are positively related to risk measures over the period 1979:4 to 1982:3. Even more recently, Hannan and Hanweck (1988) conclude that the market does, indeed, extract a price for bank risk taking.

The post '85 deposit literature appears to bear evidence that bank costs do respond to risk-taking measures embedded in the balance sheet and income statement. However, this may oversell the results. In Baer and Brewer (1986), for example, overall R^2 is under .4, with changes in the Treasury Bill rate accounting for 37% of the variation of CD rates, and risk measures explaining less than 5% additionally. So too, in the Hannan and Hanweck (1988) study the R^2 hovers below .1 in the basic equation. The results, therefore, while significant, do not completely explain the underlying relationship.

The final area of inquiry is subordinated debt pricing. Here, one might think, the issue should be clearer. Subordinated debt is junior to uninsured certificates of deposit so that its pricing ought to show clear responses to risk measures. The data, however, do not bear this out. Avery, Belton, and Goldberg (1988) conduct a cross section study of subordinate debt pricing for both 1983 and 1984. Examining the spread over the comparable Treasury yields these authors were unable to demonstrate the effect of any balance sheet or income statement data on bank costs.

B) What are the Lessons from the Literature

The literature suggests that market self-regulation of risk taking is not clearly evident in the banking industry. Therefore, it would appear that the industry should not be allowed to operate without the control of a regulatory structure that issues it insurance and is responsible for its stability and solvency. Yet, before this conclusion is accepted, it is worthwhile to examine the methodology used to arrive at these conclusions, reviewed above.

Recall that the basic approach used in this literature regresses the cost of one funding source against balance sheet, income statement, and normalization variables. This is motivated by some heuristic view of the firm's objective function, constrained by size, geography or market regulation. The presumption of these studies is that if market discipline is present then it will be revealed by significant correlations between accounting measures of risk and the costs of bank liabilities.

Failure to observe such a relationship, however, may derive from several factors, as the market discipline search involves a joint hypothesis. There are at least four separable issues, all of which are part of the underlying null hypothesis. These may be listed as follows:

(i) Markets are efficient;

(ii) Accounting measures of risk are accurate proxies for true risk;

(iii) The model, a linear regression, is correct;

(iv) The FDIC has well-defined and well-understood closure rules.

Since there is a great deal of evidence, outside the banking industry, that (i) is correct, little is made of this assumption. The second has its shortcomings, but is generally accepted. Accounting data are presumed to have noise, but are assumed to be unbiased measures of underlying risk both here and in other areas of financial research. Given the lack of an explicit pricing theory, condition (iii) is taken as a first approximation. Thus, explanations for differential findings involve recourse to the fourth assumption. If discipline is found, it is alleged that the market responds to risk. If not, it must be the result of market naivete or a deference to the regulator's role as monitor. In essence, any result can be explained by some view of the alleged market perception of the "regulatory umbrella". While it is difficult to model the market's view of regulatory response, any test of market discipline must be conditional on some hypothesis about the regulatory authorities' behavior. Previous researchers have tended to be very ambiguous about this issue even though it seems central to the question being asked.

In this study we investigate whether market discipline exists using an explicit pricing model for bank subordinated debt. Consistent with previous work in the area we, too, assume market efficiency and the general usefulness of accounting data. But we can be more precise about bank liability pricing and the effect of different FDIC closure rules on our results. However, this exactness is not without its cost. To use this theory requires strong assumptions to which we now turn.

II. Contingent Claims Valuation of Bank Subordinated Debt

The contingent claims valuation model derived by Black and Scholes (1973) is the only equilibrium model available for liability pricing. However, the theory, due to Merton (1974), covers only the case of a single issue of nonconvertible debt. In reality, capital structures involve equity and multiple issues of callable non-convertible sinking fund coupon debt of different maturities and possibly different pricing mechanisms. Basically the existing contingent claims valuation theory is not yet sufficiently rich enough to capture many aspects of real world securities.[1]

Nevertheless, our subsequent empirical tests are based on contingent claims pricing. We do so to demonstrate that only by adopting the contingent claims approach can one address questions of market discipline. This is because the theoretical relationship is nonlinear, and subordinated debt sometimes behaves like an equity claim and sometimes like a senior debt claim, as explained below. Accordingly, simple linear regressions of bank risk measures on spreads of yields on bank subordinated debt over riskless debt are not appropriate and their results not adequate tests.

Clearly the issue of bank subordinated debt pricing is complicated by the fact that banks are regulated. Since the FDIC can effectively close banks on the basis of on-(or off)-site audits the value of bank liabilities may, in part, be determined by restrictions imposed by the insolvency rules applied by regulators. The fact that regulators may apply insolvency rules in ways which violate the claimant hierarchy which private agents have established complicates the valuation process. Assumptions about the behavior of the regulators with respect to closing banks will be crucial to what follows.

In this section we first briefly review the existing theory of contingent claims for the valuation of subordinated debt. Then, the effects of FDIC closure rules on the problem are discussed. Finally, the empirical methodology is laid out, together with the data.

A) The Valuation of Subordinated Debt Using Contingent Claims Pricing

Consider a firm that has a capital structure composed of equity and two types of debt, differentiated by their priorities as claimants on the firm. Assume that both have the same maturity date. If, at maturity, the value of the firm is greater than the promised repayment on the senior debt, denoted as X_1, then the senior debt is paid in full. Otherwise, the senior debt holders receive the value of the firm and the junior debt holder and equity holders get nothing. If the value of the firm at maturity is greater than the sum of the promised repayments to both the junior and senior debt, $X_1 + X_2$, then all the debt is paid off and the equity holders get the residual. If the value of the firm at maturity, V^*, is between X_1 and $X_1 + X_2$, i.e., $X_1 < V^* < X_1 + X_2$, then the junior debt receives the difference between the value of the firm, V^*, and X_1. Therefore, at maturity the value of these claims on the assets of the firm may be written as:

$$D_1^* = \min[V^*, X_1] \quad (1)$$

$$D_2^* = \max[\min(V^* - X_1, X_2), 0] \quad (2)$$

$$E^* = \max[V^* - (X_1 + X_2), 0] \quad (3)$$

where E^* is the value of equity at maturity; D_1^* is the value of senior debt at maturity; D_2^* is the value of the junior debt at maturity.

Using Black-Scholes methodology, it is well-known that the current values of the claims on the firm can be obtained by solving a partial differential equation which is a function of firm value, V, and time. Following the work of Black and Cox (1976), the solution for the current value of the subordinated debt is:

$$D_2 = V[N(d_1) - N(\hat{d}_1)] - X_1\exp[-R_f\tau](N(d_2) - N(\hat{d}_2)] \quad (4)$$
$$+(X_1 + X_2)\exp[-R_f\tau]N(\hat{d}_2)$$

where $\hat{d}_1 = [\ln(V/(X_1 + X_2)) + (R_f + \sigma^2/2)\tau]/\sigma\tau^{\frac{1}{2}}$, and $\hat{d}_2 = \hat{d}_1 - \sigma\tau$. σ^2 is the volatility of the logarithm of the value of the firm and N(z) is the univariate cummulative normal distribution function. In what follows attention will focus on σ^2 because it measures the risk of the firm. In particular, the price of the firm's subordinated debt relative to the risk free rate is a function of σ^2. To see this note that equation (4) can be rearranged so that the default risk premium can be expressed as the spread between the yield on subordinated debt, R_2, and the riskless rate, R_f, of the same maturity:

$$R_2 - R_f = -\ln\{V/X_2\exp(R_f\tau)\ [N(d_1) - N(\hat{d}_1)] - (X_1/X_2)[N(d_2) - N(\hat{d}_2)]$$
$$-\{(X_1+X_2)/X_2\}N(\hat{d}_2)]\}/\tau \quad (5)$$

This risk premium is a function of V/X_2, $(X_1 + X_2)/X_2$, which are the two leverage terms, as well as σ^2 and maturity, τ.

This may be compared to the default risk premium in the case of a single class of debt issue:

$$R - R_f = -\ln[(V/X) \exp(R_f\tau) N(-d_1) + N(d_2)]/\tau \tag{6}$$

where $d_1 = [\ln(V/X) + (R_f + \sigma^2/2)\tau]/\sigma\tau^{\frac{1}{2}}$, and $d_2 = d_1 - \sigma\tau$. As others have noted, the value of the junior debt behaves differently than does senior debt with respect to time to maturity (τ), the volatility of the firm's assets (σ^2), and the riskless rate (R_f). Unlike the case of a single debt issue, the response of the value of junior debt to these variables is ambiguous and dependent upon the leverage ratios. If the promised payment of the senior debt is close to the value of the firm, then the junior debt is effectively the residual claimant and will behave like an equity claim. If, however, the value of the firm is significantly higher than the promised payment on the senior debt so that the likelihood of default on the senior debt is small, then the junior debt will behave like debt.

Black and Cox (1976) were the first to point this out. They show that junior debt is initially a convex function of the value of the firm and then becomes a concave function at a high enough value of the firm. Importantly, there is a single inflection point, $\hat{V}$, given by:

$$\hat{V} = [(X_1(X_1 + X_2)^{\frac{1}{2}}) \exp[-(R_f + \frac{\sigma^2}{2})\tau] \tag{7}$$

Unlike senior debt, the default risk premium on junior debt is a <u>decreasing function</u> of σ^2 when V is less than $\hat{V}$ and an <u>increasing</u> function of σ^2 when V is greater than $\hat{V}$.[2]

This fact is potentially important when addressing the question of "market discipline". Consider the usual procedure employed to empirically verify its existence. A set of measures of bank risk, proxying for σ^2, are regressed on a cross section of bank default risk premia, i.e., spreads like $R_2 - R_f$. It should be clear from the above that no inferences can be drawn from the results about "market discipline" unless it can be stated ahead of time that the entire sample of banks is on one or the other sides of the inflection point given by equation (7), and that linearity of the pricing equation is a good approximation to the underlying nonlinear relationship.[3] Different samples of banks and different sampling dates could easily give different results. Moreover, an insignificant coefficient on a measure of bank risk could result simply because the sample of banks has some banks on each side of the inflection point or from nonlinearities in the true pricing function. It is not clear how such results should be interpreted.

These considerations motivate undertaking a different procedure, namely an explicit empirical verification of the relationships contained in the contingent claims pricing. However, regulation of banks does present a set of unique issues that must be addressed before a direct empirical investigation of the pricing model can be conducted. These regulatory issues are addressed the next section.

B) Regulatory Closure Rules and the Maturity of Bank Debt

An empirical investigation of the pricing of bank liabilities is complicated by the fact that banks are regulated by regulatory authorities that have broad discretionary powers. The FDIC may keep a troubled bank open; it may liquidate the bank and pay off depositors; it may undertake some modified payoff approach or use the purchase and assumption method of dealing with the bank.[4]

In order to use contingent claims pricing some assumption must be made about the regulatory authority's closure rules. Typically researchers have faced this difficulty by assuming an exogenously given closure rule. Merton (1978), when calculating the value of FDIC insurance, assumes that banks are audited once a year and that a bank will be closed if, at that time, its assets-to-deposits ratio is below one. Ronn and Verma (1986) also assume the bank will be audited once a year with an exogenously given assets-to-deposits ratios below which the bank is closed. Ramaswamy (1978) does not assume that banks are audited once a year. Instead, following Black and Cox (1976)'s work on bond indentures, a boundary is imposed on the value of the bank's assets such that if the closure boundary is hit at any time the bank is closed and the depositors are paid off. All these approaches are motivated by tractability.

Recent theoretical work by Acharya and Dreyfus (1988) indicates that realistic closure rules are much more complicated than the exogenous rules which have been considered to date in the literature. They ask what the optimal bank closure policy would be for a pure cost-minimizing insurer/regulator. Solving for the optimal closure rule and bank-specific insurance premium policy simultaneously they show that the optimal closure rule is not exogenous but is bank-specific and determined endogenously.

The basic strategy we will follow is to avoid explicitly stating a closure rule. Rather we will proceed by specifying two polar cases of rules and attempt to determine whether the empirical results reported below vary. The first rule is related to the traditionally assumed exogenous rule based on the fact that banks are examined each year to determine whether or not they should be closed. We assume that the examiners check to see if the bank is satisfying some set of criteria which, as discussed above, is not precisely known. With the arrival of the regulators the stockholders have a choice of satisfying the criteria or forfeiting the bank to the regulators. That is, we adopt, as a polar case, the assumption that the effective maturity of the subordinated debt is one year.

The other extreme is to assume that the regulators do not impose any additional closure rules other than those privately negotiated. In this case the value of the subordinated debt is unaffected by the presence of regulation. Visits by examiners are of no consequence to the holder of subordinated debt. The appropriate boundary conditions under this set of assumptions just depend on the maturity of the junior debt since the bank is assumed not to default except at maturity of this debt.[5] In the empirical section below we will proceed by exploring these two polar cases and attempt to determine whether the results obtained concerning the issue of market discipline vary under these two scenarios.

C) Empirical Methodology Implied by the Pricing Model

Contingent claims pricing demonstrates that the price of a corporate liability is a function of a small number of variables, including τ, σ^2, and R_f. For our current interest, the variance of the firm's assets is the underlying driving variable. The riskiness of a firm is completely captured by this variance or volatility. Thus, the basic empirical strategy to be subsequently implemented begins by calculating the value of this variance which is implied by the current price of the subordinate debt issue, its maturity, the value of senior debt, and the general level of interest rates. Using the spreads of yields on bank subordinated notes and debentures over Treasuries of the same maturity we calculate implied σ^2s using either formula (5) or (6). That is, given the spread and the other information necessary, the formula is simply inverted to find the volatility, σ^2, implied by that market spread.

Implied volatilities of bank assets are calculated for a cross section of banks at two points in time. Then these σ^2s are regressed on the measures of bank risk as in previous studies. Once the risk measures, σ^2s, have been calculated the approach is similar to previous studies. However,the procedure has the advantage of being able to directly assess whether accounting measures of risk are correlated with market risk while avoiding direct use of the yield spreads which are neither linerly nor monotonically related to bank asset risk.

In order to calculate the risk measures, σ^2s, from contingent claims pricing, equations (5) and (6), the usual assumptions employed to use the Black-Scholes formula are employed.[6] The following additional assumptions are needed as well for one or the other calculations of the implied risk measure contained in market spreads.

(1) Deposit insurance is fairly priced.

(2) Aggregation of a bank's multiple issues of subordinated debt by weighted averages of yields and maturities is a good approximation.

(3) The book values of balance sheet items are unbiased estimates of their market value, in a cross-section.

Some of these assumptions are more restrictive than others. For example, the assumption that deposit insurance is fairly priced has received a fair amount of empirical support. See, for example, Pennacchi (1987). On the other hand, assumptions (2)-(3) are somewhat heroic. The first of these is necessitated by the fact that some banks in the sample, which is discussed below, have multiple issues of subordinated debt of differing maturities. Therefore, some form of aggregation is necessary. The last assumption is adopted because market valuation does not exist in bank reporting data, and in some cases, may be impossible to obtain by either researcher or investor.[7]

For the first polar case, we adopt the assumption that all bank debt has a maturity of one year. This clearly overstates the power of the regulators in that even in the event of closure one would anticipate a positive expected value for the continuation of payoffs of the subordinate claims. However, the assumption that debt is effectively of one year maturity does not mean that regulators ignore the hierarchy of claimants on the value of the bank. We will consider both cases where the distinction between senior and junior debt is maintained and where all debt is treated as homogeneous. In the second polar case we will adopt the maturity of the average subordinate debt. While this avoids the regulatory issues, it asserts that the average debt maturity coincides with the bank's horizon and regulatory activity is irrelevant. This may be too extreme.

D) Data Used for the Investigation

The data used here are from Avery, Belton and Goldberg (1988) (hereafter referred to as ABG). ABG collected (sale or bid) prices of all publicly traded bank subordinated notes and debentures for the 100 largest U.S. bank holding companies (BHC) as of December 31,1983 and December 31,1984. As explained by ABG, some issues were dropped for various reasons, leaving a final sample of 137 issues from 71 BHC. Next ABG compute the spread, $R_2 - R_f$, by "first computing the price of a Treasury bond identical in maturity and callability to each issue and solving for the difference in yield to maturity from that actually quoted for each bank holding company issue."[8] ABG used the average premium of all outstanding issues for each bank holding company for each year as the dependent variable in their study. We use the average premium outstanding for each BHC for each year as the input into calculating each BHC's σ^2 for that year. Then the σ^2s are used as the dependent variable in regressions on measures of bank risk. ABG provide some stylized facts about the computed spreads. Readers are referred to ABG for more detail.

Data used to form measures of bank risk, explained below, are from the Call and Income Reports and were found by aggregating all banks within a holding company.

III. Empirical Results and Interpretations

This section presents and discusses the results obtained by calculating σ^2s from equations (5) and (6). The implied values from this procedure are contained in Table 1. Panel (A) of the table lists computed σ^2s for the fourth quarter of 1983; Panel (B) lists those for the fourth quarter of 1984. Note that the table contains five columns of values for each bank in the sample. For each institution the reported σ^2 represents the value implied by the aggregation of all that institution's junior debt.[9]

The σ's in the first two columns of Table 1 were calculated by treating bank debt as homogeneous, but differ by leverage assumption. In both cases the maturity of the debt is assumed to be one year. In the first case, the subordinated debt is viewed as a senior claimant on the value of the bank after subtracting insured deposit claims from the value of the bank. In other words, subordinated debt is treated as senior debt on the uninsured bank value. This corresponds to a regulatory view which treats banks as essentially two separate institutions, one insured and one uninsured. In the second case, the subordinated debt is combined with the insured debt, treating the two as implicitly of equal claimant status. In other words, regulators treat the entire bank as insured over the one year horizon. Columns (3)-(5) of Table 1 compute the implied σ^2s with full recognition of the different claimant classes, junior and senior debt. Column (3) continues with the assumption of one year maturity. Column (4) assumes the average maturity of the subordinated debt, while column (5) uses the average (simple) duration of subordinated debt as its maturity.

A) <u>σ^2s and Accounting Based Risk Measures</u>

The basic question of this exercise is whether or not these measures of bank risk implied by spreads on subordinated debt are statistically related to accounting measures of risk contained in the balance sheet. To investigate this question we regress accounting risk measures on the cross-section values of σ^2. In each case accounting proxies for both credit risk and interest rate risk are used. Credit risk is measured by the ratios of non-accruals, charge-offs, or nonperforming loans, to assets alternatively, while interest rate risk uses one year gap measures.[10] In all cases these data are for the consolidated holding company. These results are presented in Tables 2, 3 and 4 for various assumptions about seniority and closure.

Tables 2 and 3 report the results for the case of debt of one year maturity. In the first of these the σ^2s used as dependent variables are from columns (1) and (2) of Table 1. These σ^2s assumed bank debt to be homogeneous and only differ by different leverage assumptions. The measure of σ^2 which treats subordinated debt as an option on the residual value of the firm, i.e., the value of the bank after insured debt, is the first reported. This indicates that risk premiums are significantly related to the two accounting risk measures used in our study. They are related to interest rate risk as measured by the one year interest rate gap, i.e., the book value of the bank assets minus the book value of the bank liabilities that will be repriced within one year. This measure of interest rate risk was used previously by Flannery and James (1984). They are also significantly related to the credit risk measure. The exact measure of credit risk is the ratio of consolidated bank nonaccruing loans and lease financing receivables to total bank assets. Also, noteworthy is the fact the R^2 is very good relative to the literature in this area.

However, in the second row of Table 2 the results are dramatically different. In this case there is no evidence of market discipline since this measure of σ^2 is not related to the accounting measures of bank risk. This measure of σ^2 treats insured debt and subordinated debt as being of equal claimant status. While this result is, perhaps, not surprising since it treats subordinated debt incorrectly, it is interesting that the first measure in contrast is successful. The success of the former may be interpreted as evidence of the importance of the market's view of the behavior of the regulatory authorities. It would appear that markets believe that the regulators will seize assets to cover the value of the insured liabilities in the event of problems with the institution. Accordingly, the risk premium on subordinated debt is more closely associated with a leverage ratio that excludes those assets which are thought of covering the insured liabilities.

Table 3 reports the results for the polar case of one year lived debt when junior and senior debt are distinguished. That is, in this Table σ^2s are calculated using (5) as reported in column (3) of Table 1. The results in Table 3 use three different measures of credit risk and the same one year interest rate gap measure as a proxy for interest rate risk. The results suggest that accounting based measures of risk are correlated with the computed σ^2, again supporting the market discipline hypothesis. The interest rate measure is always strongly significant, while the credit risk measures are significant at the fifteen percent level. The R^2s are uniformly high.

We now turn to the other polar case where banks are assumed to be unaffected by regulation in any way beyond the privately arranged claimant hierarchy. In this case, the maturity of bank debt is the weighted average maturity of the bank's subordinated debt issues, and the σ^2s are calculated using (5). The resulting regressions of this case are presented in Table 4. These results are clearly inferior to the other polar case. Whether the effective life of the bank's debt is measured by maturity or (simple) duration neither the credit risk measure nor the interest rate risk measure is significant, though both have the correct sign. The R^2s are low, though not when compared to other results in the literature.

B) The Behavior of Bank Subordinated Debt

Taken as a whole these results indicate that the data support the presence of market discipline in the subordinated debt market. In addition, to the extent that markets are efficient, and that accounting data provide information, the results suggest that the presence of the regulatory authorities is important. In fact, the results are quite encouraging under this scenario. The cases where the results are strongest correspond to those mesures of σ^2 which imposed relatively short closure rule assumptions.

The previous literature on market discipline tends to think of the issue differently. In particular, it tends to ignore the important role played by regulators and their implicit closure rules on the pricing of various debt instruments. Then researchers looks for evidence of market discipline. Failure to accept the null hypothesis, looking at results like those contained in Table 4, then leads one to conclude that the market does not discipline banks. Various explanations are then offered for this result, including implicit insurance. We do not approach the issue in this way. Rather we interpret the evidence as suggesting that when "market discpline" tests are conducted one should adopt as a joint null hypothesis a pre-specified regulatory policy concerning closure and the seniority of claims.

Avery, Belton and Goldberg (1987) point out in their study that implicit insurance of all bank debt is not a consistent explanation for the lack of correlation between default premia and accounting measures of risk because there is significant variation of risk premia across banks in the sample. Thus their results and other similar results are difficult to understand. We have suggested that there are three potential reasons for their paradoxical results. All relate to their use of simple linear regressions to capture the essence of market discipline. These are: (i) the nonlinearity of contingent claims pricing may not be captured; (ii) bank subordinated debt may sometimes behave like equity; and (iii) the effects of closure rules are not modeled at all. An important issue concerns which of these three problems is really the cause of our results relative to ABG.

It is difficult to pinpoint the reason for the differences in results. We suggested above that the issue of closure rules seems crucial. Whether there is any equity-like behavior of bank subordinated debt in the sample is hard to answer. If this were the case for the banks in the data, then when we calculate the inflection point for each bank, using equation (7) above, some banks should be on each side of that point. However, when we directly calculate the inflection point using our estimated σ^2s all banks have $V > \hat{V}$. However, uncertainty about the market's perceived closure rule makes such an estimation of the inflection point problematical.

There is another way to address this issue, however. If, in the cross section of banks, all banks have subordinated debt which is behaving like debt, then one should observe a positive correlation between our calculated σ^2s and the spread, $R_2 - R_f$. This null hypothesis is only conditional on the assumption that $V > \hat{V}$, and that we have obtained appropriate measures of σ^2 and V. On the other hand, if $V < \hat{V}$ this simple correlation should be negative. The results of calculating these correlations are mixed, but, importantly, in the case of junior-senior debt with one year to maturity the correlation is -0.27 and significant at the .05 level.[11] While not conclusive, such a result is suggestive of something beyond a simple debt relationship.

IV. Summary and Conclusion

If market prices of uninsured bank liabilities reflect the risk of default, then the market is "disciplining" banks. The usual approach to question whether market prices of uninsured bank debt contain individual bank risk premia is to regress the yield spread against accounting measures of bank risk. To date these results have been mixed. However, we know theoretically uninsured bank debt liabilities are subordinated claimants which are not linearly or monotonically functions of bank risk. In addition, the underlying risk is dependent upon regulatory behavior. Without recognizing these complications linear regressions may have difficulty addressing the question. In this paper we used contingent claims valuation to derive an explicit pricing model for bank subordinated debt. The implied volatilities were then extracted and correlated with accounting measures of bank risk. Observed market spreads of yields on subordinated bank debt over equivalent maturity Treasuries were used to compute implied bank volatilities under different assumptions concerning the effects of regulation on security valuation. Accounting measures of bank risk turned out to predict the volatility of bank assets.

Detecting the presence of market discipline in the pricing of bank uninsured debt is complicated by the little understood presence of regulators who can and do close banks under conditions which deviate from privately contracted closure rules. Without being able to exactly specify what the regulatory closure rules we adopted the approach of modeling two polar cases. In one case there was assumed to be no additional constraints imposed by the presence of regulation. In the other case, bank debt was assumed to have an effective life of one year. Both cases are extremes. In addition, we considered explicitly treating the subordinated debt as subordinated. With this explicit treatment and under the second polar case, accounting measures of bank risk are significantly correlated with the bank risk implied by market prices. The results in this case are consistent with market discipline and a closure rule close to the one year assumption.

We believe that raising these issues in, at least, a modestly tractable way is as important as any of our results.

Footnotes

[1] The only test of the applicability of the model, with mixed results, for the valuation of debt in typical corporate capital structures is Jones, Mason and Rosenfeld (1984).

[2] It is important to keep in mind that this is a statement about cross-sections of firms. A maintained assumption of the Black-Scholes option pricing model is that σ^2 is constant.

[3] Empirical work in option pricing theory is just beginning to investigate the properties of linear approximations on pricing simple debt contracts. See Weinstein (1983).

[4] See Macey and Miller (1988).

[5] By assumption banks do not default on their coupon payments, which presumably can be financed by borrowing if necessary.

[6] A standard assumption of the Black-Scholes option pricing model is that the interest rate is nonstochastic. Under our assumed polar case of one year maturity it may not be a problem. But for the other polar case, of average maturity of the subordinated debt, it may be a problem. Other researchers investigating related banking questions using the Black-Scholes model have, however, shown that the relative contribution of interest rate variance to overall variance of bank assets appears small. See Ronn and Verma (1986).

[7] Calculating the σ^2s by inverting equation (5) or equation (6) is complicated by two other technical problems. First, bank liabilities include items other than junior and senior debt, and equity. "Other borrowings" are included. Finally, both junior and senior debt pay interest. Our basic procedure for computing the implied σ^2s was to treat all debt as pure discount debt by calculating a face value to be paid off at maturity. Book values were "grown" at their market rates to produce the X_is used in the formulae. The results are robust to treating "other borrowings" in various ways, either including them in subordinated debt, or omitting them by substracting other borrowings from the value of the bank.

[8] Avery, Belton, and Goldberg (1988), p. 599.

[9] Results are very similar to those reported if instead of averaging the yields on subordinated debt σ^2s are calculated using the yield on the largest issue of subordinated debt for each bank.

[10] The significance of credit risk proxies varied somewhat across the sample of σ^2s in the study. In general, we report the best explanatory variable in the accompanying tables.

[11] When the average maturity of junior-senior debt is considered the correlation -0.15, but not significant. When the average duration of junior-senior debt is considered, the correlation is 0.24 and is significant at the .06 level.

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TABLE 1

(A) Computed σ^2s for Fourth Quarter of 1983

Bank Name	(1) SIGMA1	(2) SIGMA2	(3) SIGMA3	(4) SIGMA4	(5) SIGMA5
FIRST INTERSTATE BANCORP	1.0125	0.1500	3.35000	1.18750	1.40313
BARNETT BANKS INC	0.0000	0.0813	1.83750	0.45000	0.54375
SHAWMUT CORP	0.4500	0.0953	2.14375	0.55000	0.65000
FIRST BANK SYSTEM INC	0.7625	0.0875	2.74062	0.97500	1.20000
NORWEST CORP	0.6125	0.0719	2.48750	0.96563	1.09844
FIRST CITY BANCORP (TEXAS)	0.4437	0.1000	2.46563	0.72813	0.85313
IRVING BANK CORP	0.9750	0.0844	3.37500	0.80000	0.95000
SOUTHEAST BANK CORP	1.4000	0.1000	5.14453	1.67500	1.90000
COMMERCE BANCSHARES INC	0.3875	0.0500	2.37969	0.88750	1.10000
BANC ONE CORP	0.3000	0.0500	2.51562	0.82813	0.96250
UNITED JERSEY BANKS	0.4938	0.1000	2.77500	1.14375	1.23594
BOATMEN'S BANCSHARES INC	0.6156	0.2063	2.08750	1.55469	1.61094
MERCANTILE BANCORPORATION	0.6000	0.0875	2.86016	0.95000	1.09375
TEXAS COMMERCE BANCSHARES	0.7000	0.0500	2.36953	1.87969	1.97500
NORTHERN TRUST CORP	1.2750	0.0844	4.21328	1.36875	1.60000
KEYCORP	0.0000	0.1375	1.64219	0.35000	0.40000
SECURITY PACIFIC CORP	1.8000	0.0500	5.41953	3.16562	3.37812
SOVRAN FINANCIAL CORP	1.6000	0.1000	5.15312	1.99063	2.24844
ALLIED BANCSHARES INC-TX	0.0000	0.0750	1.78125	0.52500	0.61563
HARTFORD NATIONAL CORP	1.7625	0.0844	5.67812	1.61875	1.86875
BANK OF BOSTON CORP	1.2000	0.1000	4.16562	2.59375	2.76719
FLEET FINANCIAL GROUP INC	2.0000	0.1000	5.56093	1.82500	2.11250
MANUFACTURERS HANOVER CORP	1.5000	0.0719	4.93125	1.81563	2.12500
MORGAN (J.P) & CO	1.5000	0.0750	4.64375	3.11250	3.20000
CHASE MANHATTAN CORP	1.5000	0.0844	4.89687	3.17812	3.30469
CITICORP	1.6125	0.1094	4.67578	1.54375	1.81250
MELLON BANK CORP	1.3500	0.0500	4.48750	2.27969	2.46250
FIDELCOR	0.9000	0.1500	3.42500	1.01563	1.16250
FIRST UNION CORP (N.C.)	1.6500	0.1000	4.95469	1.42500	1.70000
NCNB CORP	1.5000	0.1000	4.87500	1.40469	1.67500
FIRST CHICAGO CORP	1.3750	0.0563	4.91875	2.94062	3.10000
TEXAS AMERICAN BANCSHARES	0.4625	0.1250	2.33750	0.75000	0.95000
US BANK CORP	1.7625	0.1375	5.16562	1.30313	1.62500
BANKAMERICA CORP	1.8000	0.0500	6.20078	1.96563	2.19219
RAINIER BANCORPORATION	1.4750	0.1500	4.76250	3.83594	3.99062
WELLS FARGO & CO	1.6625	0.0719	5.49648	2.43750	2.74141

SIGMA1 treats bank debt as homogeneous, imposes a one year maturity, and uses KND/(A - D) as the leverage variable, where KND ≡ capital notes and debentures; D ≡ all bank insured debt; A ≡ total bank assets. SIGMA2 is the same as SIGMA1, except that the leverage variable is (KND + D)/A. SIGMA3, SIGMA4 and SIGMA5 distinguish between junior and senior debt. SIGMA3 imposes a one year maturity. SIGMA4 and SIGMA5 are average maturity and average duration, respectively.

TABLE 1

(B) Computed σ^2s for Fourth Quarter of 1984

Bank Name	(1) SIGMA1	(2) SIGMA2	(3) SIGMA3	(4) SIGMA4	(5) SIGMA5
FIRST INTERSTATE BANCORP	0.8625	0.0875	3.38750	1.16563	1.40000
BARNETT BANKS INC	0.0000	0.0938	2.23125	0.61875	0.71250
SHAWMUT CORP	0.4000	0.1000	2.15000	0.50000	0.60000
FIRST BANK SYSTEM INC	0.7625	0.0875	2.80000	0.97813	1.15000
NORWEST CORP	0.6750	0.0750	2.47500	1.05000	1.20469
FIRST CITY BANCORP (TEXAS)	0.5250	0.0844	2.53437	0.79375	0.91875
IRVING BANK CORP	1.0000	0.0813	3.26875	0.80000	0.94063
SOUTHEAST BANK CORP	1.3000	0.0500	4.81679	1.67344	1.91875
COMMERCE BANCSHARES INC	0.1250	0.0719	2.18594	0.86250	0.97813
BANC ONE CORP	0.3875	0.0844	2.58594	0.91250	1.02500
UNITED JERSEY BANKS	0.6000	0.0000	2.72500	1.23750	1.31250
BOATMEN'S BANCSHARES INC	0.4906	0.1844	2.15625	2.42813	2.45000
MERCANTILE BANCORPORATION	0.6438	0.1000	2.80000	0.95000	1.13750
TEXAS COMMERCE BANCSHARES	0.6000	0.1125	2.40000	3.14766	3.20625
NORTHERN TRUST CORP	1.2000	0.0750	4.04062	1.37813	1.60625
SECURITY PACIFIC CORP	1.3750	0.1500	4.07578	2.40625	2.59375
SOVRAN FINANCIAL CORP	1.5500	0.0875	5.24375	4.16875	4.32500
ALLIED BANCSHARES INC-TX	0.3500	0.0719	2.43750	0.75000	0.95000
HARTFORD NATIONAL CORP	1.4000	0.0969	4.52969	1.34063	1.54375
BANK OF BOSTON CORP	1.1500	0.0813	3.86562	3.07500	3.23750
FLEET FINANCIAL GROUP INC	2.0938	0.1344	5.48203	2.26250	2.59844
MANUFACTURERS HANOVER CORP	1.5000	0.0969	4.40000	1.77500	2.03750
MORGAN (J.P) & CO	1.5500	0.0969	4.66250	4.24219	4.34375
CHASE MANHATTAN CORP	1.5438	0.1219	4.59062	2.80000	2.83516
CITICORP	1.5500	0.0875	4.61875	1.44844	1.71563
MELLON BANK CORP	1.2750	0.0875	3.83594	2.26094	2.39375
FIDELCOR	1.4625	0.1063	4.78437	1.42813	1.63750
PNC FINANCIAL CORP	1.3000	0.0813	4.24375	1.92344	2.10625
FIRST UNION CORP (N.C.)	1.8750	0.1500	5.31875	1.61250	1.86719
NCNB CORP	1.5250	0.1500	4.87265	1.46875	1.70625
FIRST CHICAGO CORP	1.3500	0.0969	4.44375	3.32500	3.41719
TEXAS AMERICAN BANCSHARES	0.4375	0.1375	2.59453	0.95313	1.11250
US BANCORP	1.8000	0.1500	5.15078	1.37813	1.67500
BANKAMERICA CORP	1.2750	0.0750	4.72500	1.57969	1.75000
RAINIER BANCORPORATION	1.6625	0.1000	5.09453	6.92343	6.92343
WELLS FARGO & CO	1.3500	0.0813	4.36094	1.94219	2.18594

SIGMA1 treats bank debt as homogeneous, imposes a one year maturity, and uses KND/(A - D) as the leverage variable, where KND ≡ capital notes and debentures; D ≡ all bank insured debt; A ≡ total bank assets. SIGMA2 is the same as SIGMA1, except that the leverage variable is (KND + D)/A. SIGMA3, SIGMA4 and SIGMA5 distinguish between junior and senior debt. SIGMA3 imposes a one year maturity. SIGMA4 and SIGMA5 are average maturity and average duration, respectively.

Table 2

The Polar Case of One Year Lived Debt

All Debt Treated as Equal Claimant Status

	Explanation of σ^2 Leverage Variable	Intercept	Independent Variables[1] Credit Risk Measure[2]	Interest Rate Risk Measure[3]	R^2
(1)	SIGMA1	1.019 (11.15)	10.62** (1.76)	0.148* (10.27)	.6356
(2)	SIGMA2	0.107* (11.726)	-0.772 (-1.29)	0.0007 (0.509)	.0244

[1]T-statistics are in parentheses: * denotes significance at .05 level, ** denotes significance at .10 level.

[2]The credit risk measure is the ratio of consolidated bank nonaccruing loans and lease financing receivables to total bank assets (from the consolidated Call and Income Reports).

[3]The interest rate risk measure is the consolidated bank's one year interest rate gap, i.e., the difference between assets and liabilities subject to repricing within the next years.

Table 3

The Polar Case of One Year Lived Debt

Junior and Senior Debt Distinguished[1]

(SIGMA3)

Independent Variables[2]	(1)	(2)	(3)
Intercept	3.74* (18.34)	3.69* (17.27)	3.84* (26.37)
NONACC2	19.21*** (1.43)	--	--
NONPAC2	-	18.52*** (1.61)	-
NCO2	-		64.24*** (1.42)
1YRGAP	0.329* (10.23)	0.329* (10.31)	0.329* (10.19)
R^2	.6288	.6316	.6287

[1]T-statistics are in parentheses. * denotes significance at .05 level. ** denotes significance at .10 level. *** denotes significance at .15 level.

[2]NONACC ≡ nonaccruals divided by total bank assets. NONPAC ≡ nonperforming loans divided by total bank assets. NCO ≡ net charge offs divided by total loans. All data are from the Call and Income Reports.

Table 4

The Polar Case of Unrestricted Debt Life

	Measure of Debt Life	Intercept	Independent Variables[1] Credit Risk[2]	Interest Rate Risk[3]	R^2
(1)	Maturity (SIGMA4)	1.75* (9.03)	30.62 (0.51)	0.155* (3.62)	.1765
(2)	Duration (SIGMA5)	1.92* (10.25)	33.03 (0.567)	0.168* (4.043)	.2106

[1]T-statistics are in parentheses. * denotes significance at .05 level.

[2]The credit risk measure is net charge offs divided by total loans, from the Call and Income Reports.

[3]The interest rate risk measure is the consolidated bank's one year interest rate gap, i.e., the difference between assets and liabilities subject to repricing in the next year.