Subordinated Debt and Equity: Complements or Substitutes?

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Abstract

The paper extends the contingent valuation framework of Black and Cox (1976) to value subordinated debt by explicitly incorporating bankruptcy costs in the model. I show that subordinated debt prices have “value added” relative to equity. In fact, the joint use of equity and subordinated debt prices can provide information on magnitude of expected bankruptcy costs. Knowing the magnitude of expected bankruptcy costs is necessary for calculating variables underlying policy objectives. In particular, it is illustrated that the value of expected liability of a deposit insurer would be underestimates if the bankruptcy costs were not taken into account.

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I. Introduction

The effectiveness of market discipline in mitigating the moral hazard problem among banks has been a major policy issue for almost two decades. Academics, regulators, and public officials have extensively investigated the potential benefits of using the private sector to monitor and regulate bank risk-taking and suggested alternative market participants best situated to perform these functions.

Lately, market discipline has been explicitly recognized as one of the three mutually reinforcing pillars that allow banks and supervisors to evaluate properly the various risks that banks face (Basel Committee on Banking Supervision (2001))[1]. The main supposed advantage of market discipline according to its advocates is that market participants process information on banks more efficiently than do government regulators and have better incentives to gather and act upon this information due to financial incentives.

A large number of regulatory proposals[2] argue that introducing minimum subordinated debt requirements in banking may be a preferred method of imposing market discipline. According to these proposals, the requirement to issue an uninsured junior debt could potentially reach the following five objectives: (1) improve direct market discipline (2) augment indirect market discipline (3) improve depository institutions transparency and disclosure (4) increase the size of the financial cushion for the deposit insurer and (5) reduce regulatory forbearance (The Board of Governors of the Federal Reserve System and the Secretary of the U.S. Department of Treasury (2000)).

One important part of the debate about the mandatory subordinated debt proposals is a relative advantage of subordinated debt and equity prices in conveying an expected default frequency (EDF) and/or signaling the default risk (Saunders (2001)). From a theoretical point of view, neither debt nor equity prices are superior

[1] The New Basel Capital Accord (Basel Committee on Banking Supervision (2001)) focuses on: minimum capital requirements, which seek to refine the measurement framework set out in the 1988 Accord; supervisory review of an institution's capital adequacy and internal assessment process; and market discipline, through effective disclosure to encourage safe and sound banking practices.

[2] The report by the Federal Reserve Study Group on Subordinated Notes and Debentures (1999) contains the detailed analysis of the proposals. The earliest ones are actually dated by 1983.

to each other but in practice the list of comparative advantages and disadvantages is rather long. An important feature of the discussion on the mandatory subordinated debt proposal is that debt and equity are either contrasted to each other or said to provide the same information, there is little discussion on the potential complementarities of observed debt and equity prices.

This paper extends the contingent valuation framework of Black and Cox (1976) to value subordinated debt by explicitly incorporating bankruptcy costs in the model. I show that subordinated debt prices have “value added” relative to equity prices. In fact, the joint use of equity and subordinated debt prices can provide information on the magnitude of expected bankruptcy costs.

I show that knowing the magnitude of expected bankruptcy costs is necessary for calculating the variables underlying policy objectives. In particular, it is illustrated that the value of expected liability of the deposit insurer would be underestimated if the bankruptcy costs were not taken into account.

The remainder of the paper is organized as follows: Section II develops a contingent valuation framework of a subordinated debt with and without bankruptcy costs; Section III illustrates a possibility of joint use of debt and equity prices to extract information on the value of assets; Section IV illustrates the link between bankruptcy costs and deposit insurer’s liability; Section V provides summary of the results and conclusions of the paper.

II. Contingent Claim Valuation of Subordinated Debt

A. No Bankruptcy Costs Case[3]

Contingent claims valuation approach can be applied to bank’s subordinated debt. The original approach of a contingent claim valuation was developed by Black and Scholes (1973). Merton (1974) used it to price liabilities in the case of single issue of nonconvertible debt. The model with multiple debt claims was derived by Black and Cox (1976).

The latter model does not take into account bankruptcy costs and assumes that a capital structure of a firm consists of equity and two types of debt. The debt claims on the firm are differentiated by their priorities and assumed to have the same maturity date. The payoffs of different claims depend on the firm value at the maturity of this claim.

If the realized firm value (V_T) is greater than the promised repayment of the senior debt (S), then the senior debt is paid in full. Otherwise, the senior claimants obtain the realized value of the firm and other claimants get nothing. The value of the senior debtholders' claim, D_S, is therefore

$$D_S = min\ [V_T, S] \qquad (1)$$

If the firm value at the maturity is greater than the total amount of junior and senior debt $(S + J)$ then the debtholders get repaid in full and equityholders receive the residual amount. If the value of the firm is greater than the promised payment on the senior debt but smaller than the total outstanding amount of debt claims ($S < V_T < S + J$) than the junior creditors receive the difference between the firm value V_T and S. The value of the equityholders' claims (E) and junior creditor claims (D_J) therefore can be written as

$$D_J = max\ [min\ (V_T – S, J), 0] \qquad (2)$$

$$E = max\ [V_T - (S + J), 0] \qquad (3)$$

[3] The presentation of the contingent claim valuation of the subordinated debt without bankruptcy costs is similar to the one in Gorton and Santamero (1990).

The payoffs to the claimholders for various realized asset values are summarized in Table 1.

Table 1: Claimholders' Payoffs for Various Realized Asset Values at the Debt Maturity Date

	$S + J < V_T$	$S < V_T < S + J$	$V_T < S$
Senior debt	S	S	V
Junior (subordinated) debt	J	$V_T - S$	0
Equity	$V_T - (S+J)$	0	0

Recognizing that the payoff of the above claims resemble the payoffs of the put and call options and using the assumption of Black-Scholes model, Black and Cox (1976) showed that the current value of subordinated debt can be expressed as

$$D_J = V\left[N(d_1) - N\left(\hat{d}_1\right)\right] - Se^{-R_f t} N(d_2) + (S+J)e^{-R_f t} N\left(\hat{d}_2\right) \qquad (4)$$

where

$$d_1 = \frac{\left[\ln\left(\frac{V}{S}\right) + \left(R_f + \frac{s^2}{2}\right)t\right]}{s\sqrt{t}}$$

$$d_2 = d_1 - s\sqrt{t}$$

$$\hat{d}_1 = \frac{\left[\ln\left(\frac{V}{S+J}\right) + \left(R_f + \frac{s^2}{2}\right)t\right]}{s\sqrt{t}}$$

$$\hat{d}_2 = \hat{d}_1 - s\sqrt{t}$$

s is the volatility of the logarithm of the value of the firm, t is a time to maturity of the subordinated debt, and $N(x)$ is the univariate cumulative normal distribution.

Equation (4) states that the value of subordinated debt is the difference between the value of a call option on the value of the bank with exercise price equal to the face value of senior debt (*S)*, bought from senior debtholders, and a call option on the value of the bank with exercise price equal to the face vale of total debt (*S*+*J)*, sold to equityholders:

$$D_J = C(V,S,t\ ) - C(V,S+J,t\ ) \tag{5}$$

Equation (4) can be rewritten in terms of the spread between the yield on subordinated debt (R_J) and the riskless rate (R_f) of the same maturity:

$$R_J - R_f = -\frac{\ln\left\{\frac{V}{J}e^{R_f t}\left[N(d_1) - N\left(\hat{d}_1\right)\right] - \frac{S}{J}N(d_2) + \frac{S+J}{J}N(\hat{d}_2)\right\}}{t} \tag{6}$$

The risk premium $R_J - R_f$ in equation (6) is a function of leverage terms *V/J* and *(S+J)/J*, as well as volatility s and time to maturity t .

B. Bankruptcy Costs Cases

The model above can be modified to account for bankruptcy costs. Bankruptcy costs are introduces as a value *K* that is lost when the bank is liquidated or reorganized[4]. Bankruptcy is costly both because of direct costs and because of disruption in bank's activities. The transfer of the insolvent bank's assets is costly. The direct costs, such as legal costs, reflect costly verification of collateral value. Indirect costs include potential loss of bank-specific human capital resulting in a time delay before the assets are utilized (if possible) at their full efficiency level after the transfer of control. Like in Anderson and Sundaresan (1996), I assume that bankruptcy costs reduce the collateral value of assets in a liner fashion, so the later is

[4] In U.S., the liquidation of bank assets has historically been used in situations where a merger was unavailable or too costly or where the bank's loss to the community would impose few local costs. Reorganization of the failed banks traditionally included a merger of all or part of the assets of the insolvent bank with a stronger healthy bank's assets. In U.S., with the exception of the systematic risk exemption the least-cost resolution strategy requires the Federal Deposit Insurance Corporation (FDIC) to employ the method that imposes most failure costs on the uninsured depositors (Saunders (1999)).

simply the market value of assets net of bankruptcy costs, V-K[5]. Bankruptcy costs are incurred if the realized value of the bank's assets is below the total amount of debt (S+J) at the debt maturity[6].

The payoffs of different claims depend on the bank value at the maturity of these claims and the magnitude of bankruptcy costs, K.

When the magnitude of bankruptcy costs is smaller than the face value of subordinated debt, the junior claimants' payoff is positive only if the realized value of the bank's assets is greater than the sum of the face value of senior debt, S, and bankruptcy costs, K. When the opposite is true and the magnitude of bankruptcy costs is greater than the face value of subordinated debt, the junior debt claimants' payoff is positive only if the bank is solvent, i.e. the realized value of bank's assets is above the total amount of debt (S+J) at the debt maturity.

[5] Like in Anderson and Sundaresan (1996) I argue that other functional forms for collateral values can be accommodated at the cost of greater complexity.

[6] Unlike Anderson and Sundaresan (1996), this paper does not model the strategic debt service. Note that with the strategic debt service, the costliness of formal bankruptcy may induce creditors to accept deviations from contractual payments.

The payoffs to the claimholders for various realized asset values and alternative magnitudes of the bankruptcy cost are summarized in Table 2.

Table 2: Claimholders' Payoffs for Various Realized Asset Values at the Debt Maturity Date (with bankruptcy costs)

<table>
<tr><td></td><td colspan="3">Case 1: J>K</td></tr>
<tr><td></td><td>$S+J<V_T$</td><td>$S+K < V_T < S+J$</td><td>$V_T \leq S+K$</td></tr>
<tr><td>Senior debt</td><td>S</td><td>S</td><td>$Max\,[Min[V_T-K, S],0]$</td></tr>
<tr><td>Junior (subordinated) debt</td><td>J</td><td>$V_T - S-K$</td><td>0</td></tr>
<tr><td>Equity</td><td>$V_T-(S+J)$</td><td>0</td><td>0</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td></td><td colspan="3">Case 2: J≤K</td></tr>
<tr><td></td><td>$S+J<V_T$</td><td colspan="2">$V_T \leq S+J$</td></tr>
<tr><td>Senior debt</td><td>S</td><td colspan="2">$Max[Min\,[V_T-K, S],0]$</td></tr>
<tr><td>Junior (subordinated) debt</td><td>J</td><td colspan="2">0</td></tr>
<tr><td>Equity</td><td>$V_T-(S+J)$</td><td colspan="2">0</td></tr>
</table>

The structure of payoffs in Table 2 indicate that the expression for the value of subordinated debt with costly insolvency will depend on the relative magnitude of the total promised amount of subordinated debt, *J*, and bankruptcy costs, *K*.

***Case 1*: *K<J*.**

When the bankruptcy costs are effectively subordinated to the most junior claims, the modified equation for the value of subordinated debt, D_J^{bc}, becomes

$$D_J^{bc} = V\left[N(b_1) - N\left(\hat{d}_1\right)\right] - Se^{-R_f t}N(b_2) + (S+J)e^{-R_f t}N(\hat{d}_2) + Ke^{-R_f t}N(\hat{d}_2) \qquad (7),$$

where

D_J^{bc} is the value of subordinated debt of the bank in the presence of bankruptcy costs smaller than the face value of subordinated debt.

$$b_1 = \frac{\left[\ln\left(\frac{V}{S+K}\right)+\left(R_f+\frac{s^2}{2}\right)t\right]}{s\sqrt{t}}$$

$$b_2 = d_1 - s\sqrt{t}$$

$$\hat{d}_1 = \frac{\left[\ln\left(\frac{V}{S+J}\right)+\left(R_f+\frac{s^2}{2}\right)t\right]}{s\sqrt{t}}$$

$$\hat{d}_2 = \hat{d}_1 - s\sqrt{t}$$

In the presence of bankruptcy costs, the value of the bank's subordinated debt becomes the difference between the value of a call option on the value of the bank with exercise price *S*+*K* purchased from the senior debtholders and two sold call options: one, on the value of the bank with exercise price *S*+*J* sold to equityholders and second, a digital call option on the value of the bank paying *K* if the realized firm value is greater than *S*+*J* and zero otherwise sold to senior debtholders:

$$D_J^{bc} = C(V,S+K,\ t\ ) - C(V,S+J,\ t\ ) + C^d(V,S+J,K,\ t\ ) \qquad (8)$$

Case 2: K>J

When the magnitude of the bankruptcy costs is greater than the promised amount of subordinated debt, the holders of subordinated debt have a positive payoff only when the value of the bank's assets are greater than the total amount of debt outstanding. In this case the value of subordinated debt resembles a payoff of a digital call option on the value of the bank's assets with a strike price *S*+*J*, paying *J* is *V*>*S*+*J* and zero otherwise.

The value of subordinated debt is therefore can be expressed as

$$D_J^{bc'} = C^d \left(V, S + J, J, t\right) = Je^{-R_f t} N(\hat{d}_2) \qquad (9)$$

where

$D_J^{bc'}$ is the value of subordinated debt of the bank in the presence of bankruptcy costs greater than the face value of the subordinated debt.

III. Subordinated Debt and Equity Information

One important part of the discussion on the mandatory subordinated debt proposals is the relative advantage of subordinated debt prices versus equity prices in conveying an expected default frequency (EDF) and/or signaling the default risk (see Saunders (2001) for in-depth discussion). The useful starting point of the analysis of this issue is an observation that in a world of complete markets and no frictions, bond prices or equity prices provide exactly the same information about the parameters in question and therefore are equally valuable for market discipline purposes[7].

Taking into account various market imperfections results in a number of factors pointing out some relative advantages and disadvantages of debt versus equity prices.

Saunders (2001) quotes three reasons why people believe that subordinated debt prices would give better information signals than equity. The first reason is that the credible commitment not to bailout subordinated debtholders would “clean” the subordinated debt prices from “too big to fail” type of guarantees. The second reason is that the payoff structure of subordinated debt aligns the incentives of subordinated debtholders and the regulators. The third and final reason is some evidence on the value added of subordinated debt prices versus accounting variables.

The important weakness of subordinated debt in comparison to equity includes the relative illiquidity and inefficiency of the former market – the debt is traded infrequently, and the number of buyers and sellers is small relative to equity markets.

Large part of the empirical evidence on the informativness of subordinated debt is convoluted by a number of problems, such as incorporation of the appropriate return-generating model for bonds, accounting for the microstructure of bond markets, adjusting bond spreads for different option features, and accounting for taxes. Another problem is that the prices/spreads of subordinated debt start behaving like equity when the credit quality of the issuer falls. This last fact can be illustrated using the model developed in this paper and explored in more details in Nivorozhkin (2001).

Finally, in addition to the EDFs subordinated debt spreads also reflect recovery rates. To extract the information from subordinated debt prices we need to know loss given default perceived by a bondholder, which is uncertain and depends on bankruptcy priority rules and objective functions (Saunders (2001)).

In the model developed in this paper, the recovery rates of subordinated debt will depend on the magnitude of bankruptcy costs, K. The parameter K is likely to be uncertain and can vary both over time and across banks. What I propose next is a simple framework of using market prices of debt and equity to infer the value of K.

An important observation that I will illustrate next is that, in my model, equity prices do not contain information about bankruptcy costs parameter K. On the other hand, subordinated debt prices do contain this information under certain conditions. Inspection of equations (7) and (9) reveals that the subordinated debt prices include the information on the magnitude of bankruptcy costs, K, when the face value of subordinated debt exceeds the amount of bankruptcy costs, $J>K$[8].

In fact, I will illustrate next that the subordinated debt prices can be used together with equity prices to infer the market perception of the value of K when $J>K$.

Using the standard option valuation approach, the value of a bank's equity (E) and the market value of assets are related by the following expression:

[7] Levonian (2000) shows it formally in the contingent-claim valuation framework.

[8] If we assume an alternative closure rule where the authorities intervene before the net worth of the bank's assets drops to zero then the model can be extended to the cases where the equity value is positive gross of bankruptcy costs but negative net of bankruptcy costs. In that case, the equity prices would reflect some part of the bankruptcy costs while subordinated debt prices would reflect the remaining part. Note that if we can specify a closure rule where the value of equity is zero net of bankruptcy costs, then the problem of bank insolvency becomes a trivial one.

$$E = VN\left[\frac{ln\left(\frac{V}{S+J}\right)+(R_f+\frac{s^2}{2})t}{s\sqrt{t}}\right]-(S+J)e^{-rt}N\left[\frac{ln\left(\frac{V}{S+J}\right)+(R_f-\frac{s^2}{2})t}{s\sqrt{t}}\right] \tag{10}$$

The relationship between asset and equity volatility is

$$s = s_E \frac{E}{VN\left[\frac{ln\left(\frac{V}{S+J}\right)+(R_f+\frac{s^2}{2})t}{s\sqrt{t}}\right]} \tag{11}$$

The notations in (11) are the same as before in the paper except s_E, which denotes volatility of the bank's equity.

Together with the equations (7) for subordinated debt value D_J^{bc}, equations (10) and (11) contain four unknown parameters: $s_{E,}$ s , *V,* and *K*. In order to solve three equations for four unknown parameters we have to estimate one of them - s_E - elsewhere.

There are several alternative procedures for estimating volatility of equity, s_E. If there exist a traded option on the bank equity then the implied volatility from the option prices can be used as s_E. Alternatively, the historical volatility of equity can be used as a proxy for s_E. Knowing s and *V*, the subordinated debt prices can be used to extract the value of bankruptcy costs *K*. In addition, more complex procedures like the ones adopted by KMV (Crosbie (1999)) can be adopted to solve the system of equations above.

Although KMV developed a model which is able to provide the EDF estimates and loss given default (LGD) without using the information from bond prices (At least I have not seen it mentioned anywhere), the procedure proposed above gives an opportunity to obtain an alternative estimates, calibrate the model and check the robustness of the previous results.

IV. Bankruptcy Costs and Deposit Insurer's Liability

Knowing the magnitude of bankruptcy costs *K* is also important from the regulatory point of view. If we take into account the issue of deposit insurance, an important observation is that the expression for the liability of the deposit insurance provider changes depending on the magnitude of the bankruptcy costs relative to the amount of subordinated debt.

When *J*>*K*, the insurer's liability is equivalent to a written put option on the value of bank assets with an exercise price of *S*+*K* (see equation (12)). If the value of the bank at the maturity of debt is below the total amount of senior debt plus the bankruptcy costs and the bank is liquidated, the liability of insurer is positive and the insurer has to pay insufficient funds to the senior creditors and incur bankruptcy costs recovering the salvage value of the bank assets.

$$L^{bc} = (S+K)\, e^{-R_f t}\, N\left[-\frac{ln(\frac{V}{S+K}) + (R_f - \frac{s^2}{2})t}{s\sqrt{t}}\right] - VN\left[-\frac{ln(\frac{V}{S+K}) + (R_f + \frac{s^2}{2})t}{s\sqrt{t}}\right] \tag{12}$$

where

L^{bc} is an expected liability of the deposit insurer in the case where the face value of junior debt is greater than the amount of bankruptcy costs.

When the magnitude of the bankruptcy cost is greater than the amount of subordinated debt (*J*<*K)*, an expected liability of the deposit insurer is:

$$L^{bc'} = (S+K)\, e^{-R_f t}\, N\left[-\frac{ln(\frac{V}{S+J}) + (R_f - \frac{s^2}{2})t}{s\sqrt{t}}\right] - VN\left[-\frac{ln(\frac{V}{S+J}) + (R_f + \frac{s^2}{2})t}{s\sqrt{t}}\right] \tag{13}$$

where

$L^{bc'}$ is an expected liability of the deposit insurer in the case where the face value of junior debt is less than the amount of bankruptcy costs.

The insurer's liability is equivalent to a written put option on the value of bank assets with an exercise price of *S*+*J*. If the value of the bank at the maturity of debt is below the total amount of debt and the bank is liquidated, the value of the subordinated debt is zero because the latter is smaller than the bankruptcy costs and the insurer has to pay senior creditors and incur bankruptcy costs recovering the salvage value of the bank assets[9].

Without taking into account bankruptcy costs, the liability of the safety net provider (L) is:

$$L = S\, e^{-R_f t} N\left[-\frac{ln(\frac{V}{S}) + (R_f - \frac{s^2}{2})t}{s\sqrt{t}} \right] - VN\left[-\frac{ln(\frac{V}{S}) + (R_f + \frac{s^2}{2})t}{s\sqrt{t}} \right] \quad (14)$$

Comparison of equations (12), (13) and (14) reveals that the liability of the safety net provider calculated without taking into account bankruptcy costs underestimates its true value.

V. Summary and Conclusions

This paper contributes to the discussion of the mandatory subordinated debt requirement and the use of market information for the regulatory purposes by developing a framework showing important complementarity of the information of equity prices and debt prices.

The subordinated debt prices can provide additional information to equity prices when the bankruptcy costs are unknown and the subordinated debt claims exceed the bankruptcy costs. Equity prices together with subordinated debt prices (and preferably option prices of equity) can be used to extract the information on the unknown bankruptcy costs parameter. It is shown that knowing the magnitude of expected bankruptcy costs is necessary for calculating the variables underlying policy objectives. In particular, it is illustrated that the value of expected liability of the

[9] This paper does not consider the issues of insurer's ex-post incentives in liquidating the bank when $K>J$. This problem is a subject of another paper, which is a work in progress right now.

deposit insurer would be underestimated if the bankruptcy costs were not taken into account.

In the framework of the model, requiring banks to hold the subordinated debt in excess of expected bankruptcy costs provides additional information on the value of bank assets.

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