Journal of Financial Economics 14 (1985) 501-521. North-Holland

AN ANALYSIS OF SECURED DEBT*

René M. STULZ

The Ohio State University, Columbus, OH, 43210, USA

Herb JOHNSON

University of California, Davis, CA 95616, USA

Received May 1983, final version received March 1985

This paper analyzes the pricing of two types of secured debt and shows that secured debt can be used to increase the value of the firm. In particular, it is shown that some profitable projects will not be undertaken by a firm which can use only equity or unsecured debt to finance them but will be undertaken if they can be financed with secured debt. Secured debt is priced for a firm with two assets and some unsecured debt outstanding. The pricing results are used to illustrate the benefits of the security provision of secured debt.

1. Introduction

The use of provisions which give specified creditors priority over the proceeds of the sale of some asset in the event of bankruptcy or liquidation is extremely widespread. Such security provisions are used, for instance, in project financing, home mortgages and mortgage bonds, equipment trust certificates, leases, short-term loans to corporations (for instance, inventory loans) and most personal loans. However, the pricing of debt which includes a security provision (henceforth called secured debt) has not been studied systematically and, as argued by Schwartz (1981), the extant literature lacks convincing explanations for the use of security provisions. Furthermore, no explanation has been advanced for the fact that firms generally retain in bond indentures the option of financing new projects with secured debt.[1]

*René Stulz is grateful for financial support from the Managerial Economics Research Center, University of Rochester. The work on this paper was started while René Stulz was at the University of Rochester and Herb Johnson was at the Louisiana State University. We are grateful for useful comments from Cliff Ball, Jim Booth, Harry DeAngelo, John Long, Ron Masulis, Stew Myers (a referee), Jerry Warner, and an anonymous referee; for computer assistance from Ho Yang and B.M. Miller; and especially for useful discussions with and comments from Cliff Smith. We also thank the participants in seminars at Harvard University, Louisiana State University, Ohio State University, University of Rochester, Duke University, University of Michigan and Purdue University.

[1]See ABF (1971, sec. 10-10, in particular pp. 359–360) for a discussion of the relevant bond covenant. This covenant constitutes a notable exception to the 'me-first' rules discussed in Fama–Miller (1972).

This paper provides an analysis of the properties of secured debt and shows how these properties can explain the existence of secured debt. First, we look at the pricing of secured debt using the contingent-claims pricing techniques developed by Black–Scholes (1973) and Merton (1973, 1974).[2] Secured debt can exhibit some surprising features. It is shown, in particular, that the value of secured debt can increase if the standard deviation of the rate of return of the collateral or of the other assets held by the firm increases. Second, we use the pricing results to provide an analysis of when a firm will find it more attractive to raise funds with an issue of secured debt than with some other financing instrument. We demonstrate that it is possible that a firm will undertake a profitable project if it can finance it with secured debt, but that it will not undertake it if it has to finance it by raising additional equity or by issuing unsecured debt. Furthermore, we show that in general the existing bondholders are made better off if the firm undertakes a new project and finances it partly with secured debt, which helps to explain why firms generally retain in bond indentures the option to finance new projects with secured debt. We also discuss how the use of secured debt reduces the monitoring costs of debt.

Throughout most of the paper we focus on pricing secured debt when the firm also has some other debt outstanding. In the event of default, the other creditors of the firm can have a rank either equal to or higher than the rank of the secured creditors over the proceeds of the sale of the assets not used as collateral. The existence of other potential creditors, besides the secured creditors, is necessary to make the pricing problem interesting. If the only debt currently issued by the firm is the secured debt, the payoff of the secured debt in liquidation does not differ from the payoff of unsecured debt. The existence of some other form of debt is also crucial for our analysis of the use of secured debt by firms. Secured debt is a form of debt which allows shareholders to sell claims to some payoffs of a new project which otherwise would accrue to the existing creditors of the firm. It follows that issuing secured debt, compared to issuing other forms of debt, decreases the benefits which accrue to existing bondholders and increases the benefits which accrue to shareholders from the adoption of a new project, thereby making it more attractive for shareholders to undertake the project.

Our analysis of why firms issue secured debt can be used to explain the use of other financing instruments. For instance, Smith–Wakeman (1985) show how this analysis applies to the use of financial leases. Furthermore, Mian (1984) points out that setting up a captive financing subsidiary to issue debt is similar to issuing secured debt.

[2] Existing results about secured debt differ according to the assumptions made about the distributions of the two assets. Scott (1977) and Smith (1980) assume the returns are perfectly correlated. Stulz (1982) assumes that the value of the firm and of the collateral follow lognormal distributions, which implies that the asset not used as collateral can take negative values and satisfies a distribution which is difficult to characterize and unlikely to obtain in practice.

Most of the analysis in this paper assumes that the firm owns two assets with returns that accrue only in the form of capital gains. In section 2, we derive distribution-free comparative statics results. In section 3, we obtain comparative statics results when both assets held by the firm follow a lognormal distribution. Section 4 discusses how the use of secured debt can reduce monitoring costs and provides an analysis of how secured debt financing mitigates the underinvestment problem. Section 5 discusses possible extensions of our work and provides a summary of the results.

2. Preliminary results

In this section, we first present the framework used throughout this paper for the valuation of secured debt. Next, we define formally the payoff function for the two types of secured debt analyzed in this paper. We also present some distribution-free results which make it possible to understand better the payoffs to secured debtholders.

2.1. Assumptions and notation

The firm considered here owns two assets, A and B, with values $A(t)$ and $B(t)$. In the following, it is assumed that asset B is used as collateral. All debt of the firm has the same maturity T and pays nothing until maturity.[3] The firm pays no dividends until date T, when it pays a liquidating dividend. At maturity, if $B(T)$ is smaller than the face value F of the secured debt, the secured bondholders get $B(T)$ plus a claim on $A(T)$; otherwise, they simply receive F. The debt of the firm which is not secured by asset B may or may not have a prior claim on asset A. The debt which is not secured by asset B, called the unsecured debt (even though it may be equivalent to secured debt with A as collateral), has a face value equal to H. The secured debt is called junior secured debt with value $DJ(t)$, if the other debt has a prior claim on asset A, and senior secured debt with value $DS(t)$, if its claim on asset A for the residual is equal to that of the unsecured debt.

It is assumed throughout the paper that:

A.1. Markets for traded assets are perfect, i.e., there are no taxes, no transaction costs, no limits on short sales and all investors are price-takers.

A.2. There exist unlimited lending and borrowing at the constant rate of interest R per unit of time.

[3]A more general treatment would permit the two debt issues to mature at different times. In this case, it would be possible to study the effect of an increase in the time to maturity of the secured debt while keeping the time to maturity of the unsecured debt constant. In this more complicated setting, it would be possible for the unsecured debt to be less risky if it matured first. See Geske (1977) and Geske–Johnson (1984) for the valuation of junior debt when it matures at a different date from senior debt, and see Jensen–Smith (1985) for a discussion of the incentive problem which arises when the junior debt matures first.

A.3. $A(t)$ and $B(t)$ cannot take negative values. Furthermore, the joint distribution of the rates of return of $A(t)$ and $B(t)$ is not affected by a change in $A(t)$ or $B(t)$.
A.4. Markets are complete in the sense that it is possible to construct a portfolio which pays nothing until date T and $A(T)$ at time T and a portfolio which pays nothing until date T and $B(T)$ at time T.
A.5. Priority rules are observed exactly in the event of default.[4]

With these assumptions, the value of the firm at time t, $V(t)$, is equal to the value of its assets, $A(t)+B(t)$. If it is possible to construct a portfolio which pays $V(T)$ at time T by investing in the two types of debt of the firm and its common stock, assumption A.4 is satisfied if there exists either a portfolio which pays $A(T)$ or a portfolio which pays $B(T)$ at time T. One would expect the collateral to be a tradeable asset, which makes assumption A.4 less restrictive than it seems.

2.2. *Results*

It follows from the definition of junior secured debt that

$$DJ(T) = \min\{B(T) + \max(A(T) - H, 0), F\}. \tag{1}$$

To obtain distribution-free results, it is useful to create an artificial asset Q which pays nothing until date T and pays $B(T) + \max\{A(T) - H, 0\}$ at date T. Let $Q(A, B, H, T-t)$ be the current value of asset Q. Define $C(x, K, T-t)$ $\times(P(x, K, T-t))$ to be the current value of a European call (put) option on asset x with exercise price K and maturity at date T. It immediately follows that

$$Q(A, B, H, T-t) = B(t) + C(A, H, T-t), \tag{2}$$

so that the current value of asset Q is equal to the sum of the value of asset B plus the value of a call option on asset A.

The current value of an asset which pays $DJ(T)$ at date T, written $DJ(A, B, H, F, T-t)$, can be expressed as a function of the current value of

[4] Warner (1977) shows that the courts do not uphold priority rules rigorously. In the event of a reorganization, the courts generally issue new claims. The secured creditors receive claims the face value of which is equal to the value of the secured debt. However, the true value of the claims received by the secured creditors is smaller than the value of their claim against the assets of the firm. Whereas the evidence shows that secured creditors benefit from having obtained collateral, the pricing results of this paper are likely to overstate the value of secured debt. Nevertheless, one would not expect the qualitative results of this paper to be affected by the fact that priority rules are not observed rigorously by the courts.

asset Q:

$$DJ(A,B,H,F,T-t)=F\mathrm{e}^{-R(T-t)}-P(Q,F,T-t). \tag{3}$$

Eq. (3) shows that the current value of junior secured debt is equal to the current value of a default-free discount bond which matures at the same date as the secured debt minus the value of a European put option on asset Q. We can therefore obtain comparative statics results using the distribution-free results of Merton (1973):

$$\partial DJ/\partial A=-P_Q(\partial Q/\partial A)>0, \tag{4a}$$

$$\partial DJ/\partial B=-P_Q(\partial Q/\partial B)>0, \tag{4b}$$

$$\partial DJ/\partial F=\mathrm{e}^{-R(T-t)}-P_F>0, \tag{4c}$$

$$\partial DJ/\partial H=-P_Q(\partial Q/\partial H)<0. \tag{4d}$$

These results state that the value of junior secured debt increases if the value of the assets owned by the firm increases or if the face value of the secured debt increases, and falls if the face value of the unsecured debt increases. The intuition for the first three results is the same as the intuition for the pricing of unsecured bonds and does not need to be repeated here.[5] The fourth result, i.e., that the value of secured debt is a decreasing function of the face value of the unsecured debt, is explained by the fact that a higher face value for the unsecured debt implies a decrease in the amount from the sale of asset A left to pay the secured creditors in each state of the world.

Differentiating eq. (3) completely with respect to time t and using put–call parity, we get

$$\partial DJ/\partial t=-\partial C/\partial t-P_Q(\partial Q/\partial t). \tag{5}$$

Eq. (5) shows that a decrease in time to maturity has an ambiguous effect on the value of junior secured debt. If time to maturity decreases while Q is kept constant, the decrease in time to maturity unambiguously increases the value of secured debt. However, the value of secured debt is equal to the value of a default-free discount bond minus the value of a put option on Q. As time to maturity decreases, the value of Q falls because it is the sum of the value of asset B plus the value of a call option on asset A. If Q falls sufficiently as time to maturity decreases, the value of secured debt can fall as time to maturity decreases. To understand this, notice that if the value of the collateral is small

[5]See Merton (1974).

relative to the face value of the secured bond and if the value of asset A exceeds the value of the collateral, the secured bond is very much like a subordinated bond.[6] The fact that secured debt can behave like subordinated debt implies that if $B(t)$ is small compared to $A(t)$ and F, and $A(t)+B(t)$ is smaller than the current value of a default-free bond which pays $F+H$ at time T, junior secured debt is likely to have the same characteristics as an equity claim. With the assumptions made so far, the value of the equity of the firm is equal to the value of a call option with exercise price equal to the face value of the debt and with maturity at date T. The value of the equity of the firm is, consequently, an increasing function of time to maturity. A similar result can be obtained for an increase in the interest rate R.

If, in the event of bankruptcy, the secured creditors rank *equally* with the other creditors for the fraction of their claims which is not paid by the proceeds of the sale of the collateral, then we have senior secured debt and the payoff at maturity of this type of secured debt is given by

$$DS(A, B, H, F, T)$$

$$= F - \max\left\{ F - B(T) - \left\{ \frac{\max(F - B(T), 0)}{\max(F - B(T), 0) + H} \right\} A(T), 0 \right\}. \qquad (6)$$

It follows that the payoff of secured debt is again equal to the payoff of a default-free bond minus the payoff of a put option. In this case, the present value of the risky asset on which the put is written cannot be expressed as the sum of the present values of risky assets with properties that are well-known. However, by taking partial derivatives of the payoff of senior secured debt at maturity, it can be verified that this payoff is an increasing function of A and B in bankruptcy states and is a non-decreasing function of A and B in the other states. Hence, an increase in $A(t)$ or $B(t)$ increases the value of senior secured debt. If the secured debt is a risky asset, an increase in H decreases the payoff of secured debt in some states of the world. Consequently, $DS(A, B, H, F, T-t)$ is a decreasing function of the face value of the unsecured debt. Furthermore, an increase in the face value of secured debt increases its value.

It is not possible to obtain results about the effect on the price of secured debt of changes in some measure of risk of assets A and B without making assumptions which restrict preferences or the joint distribution of $A(T)$ and $B(T)$. Even with such restrictions, one generally obtains ambiguous results because the variance of the rate of return of the firm is not always an increasing function of the variance of the rate of return of A or of B.

[6] Black and Cox (1976) show that the value of subordinated debt can be a decreasing function of time to maturity.

3. The lognormal case

In section 2, we were able to derive only a limited number of distribution-free results about the pricing of secured debt. To get further insights into the determinants of the price of secured debt, it is necessary to make assumptions about preferences or the joint distribution of the returns of assets A and B. We pursue here a route which has often been followed in financial economics, as we maintain the assumptions of section 2 and assume furthermore that A and B are lognormally distributed and that trading takes place continuously. As we are not able to obtain closed-form solutions, we compute numerically values for both types of secured debt. The numerical analysis makes it possible to compute a large number of comparative statics results which provide useful insights into the determinants of the price of senior and junior secured debt. While these results are interesting in their own right, some of them have useful implications for our analysis of why secured debt exists. In particular, some of the discussion in section 4 relies heavily on the comparative statics of the value of secured debt with respect to changes in the variance of the return of asset A. We also compute the debt value for both types of secured debt when the security provision is removed, which allows us to find the value of the security provision. The value of the security provision of junior and senior secured debt is written $VDJ(A, B, F, H, \tau)$ and $VDS(A, B, F, H, \tau)$, respectively. The results on the value of the security provision will be useful in section 4.

The dynamics for A and B are given by

$$\mathrm{d}x/x = \mu_x \mathrm{d}t + \sigma_x \mathrm{d}z_x, \qquad x = A, B, \tag{7}$$

where $\mathrm{d}z_x$ is the increment of a standard Wiener process. For simplicity it is assumed that $A(t)$ and $B(t)$ are the prices at time t of traded assets which at time T will have the same value as the assets of the firm.

Let $V^i(A, B, F, H, \tau)$ be the value at date $t = T - \tau$ of a self-financing portfolio which satisfies the following boundary condition:

$$\begin{aligned} V^i(A, B, F, H, 0) &= DJ(A, B, F, H, 0), \qquad i = 0, \\ &= DS(A, B, F, H, 0), \qquad i = 1. \end{aligned} \tag{8}$$

It can be shown that $V^i(A, B, F, H, \tau)$ satisfies the following partial differential equation:[7]

$$\begin{aligned} -V^i_\tau &= RV^i - RV^i_A A - RV^i_B B \\ &\quad - \tfrac{1}{2}\left\{ V^i_{AA} A^2 \sigma_A^2 + V^i_{BB} B^2 \sigma_B^2 + 2V^i_{AB} AB\rho\sigma_A\sigma_B \right\}, \qquad i = 0, 1, \end{aligned} \tag{9}$$

[7]See, for instance, Stulz (1982) or Johnson (1981).

Table 1

Comparative statics analysis of debt values.[a]

σ_A	σ_B	ρ	R	τ	F	H	A	B	DS	VDS	DJ	VDJ
0.20	0.20	0.50	0.15	20	1,000(49.8)	1,000(49.8)	50	50	39.1	4.4	34.7	4.5
0.10									41.3	2.9	34.7	2.4
0.15									40.2	3.7	34.8	3.5
0.25									38.0	5.1	34.4	5.3
0.30									37.1	5.9	34.2	6.1
	0.10								44.5	6.1	42.0	6.4
	0.15								41.7	5.2	38.3	5.4
	0.25								36.6	3.8	31.3	3.6
	0.30								34.3	3.1	28.2	3.0
		−0.50							43.4	4.5	38.9	4.4
		−0.25							42.2	4.4	37.8	4.5
		0.00							41.2	4.5	36.7	4.5
		0.25							40.1	4.4	35.7	4.5
			0.05						71.3	21.5	49.8	21.5
			0.10						61.1	14.1	47.0	14.1
			0.20						17.7	0.5	17.2	0.4
			0.25						6.7	0.0	6.7	0.0
				10					70.4	20.5	49.9	20.5
				30					10.8	0.2	10.6	0.2
					100 (5.0)				5.0	0.7	5.0	1.0
					300(14.9)				14.3	1.9	14.1	2.6
					3,000 (149)				72.3	5.6	56.1	3.0
					10,000 (498)				93.7	3.4	66.4	1.1

100 (5.0)			43.6	0.2	42.7	0.0
300(14.9)			42.3	1.0	39.7	0.3
3,000 (149)			35.7	13.5	22.2	16.2
10,000 (498)			33.7	24.7	9.0	27.4
	25		36.2	6.9	33.0	7.2
	75		41.3	3	36.7	2.8
	100		43.0	2.2	38.6	1.8
	125		44.2	1.6	40.3	1.3
	200		46.6	0.8	43.9	0.5
		25	32.8	3.5	26.6	4.1
		75	42.6	4.3	39.8	4.6
		100	44.8	4.0	42.9	4.3
		125	46.2	3.6	44.9	3.9
		200	48.2	2.4	47.7	2.7

[a]σ_A (σ_B): standard deviation of the return of asset A (B);
ρ: correlation coefficient between the returns of assets A and B;
R: interest rate on default-free bonds;
τ: time to maturity;
F (H): face value of secured (unsecured) debt;
A (B): current value of asset A (B);
DS (DJ): value of senior (junior) secured debt;
VDS (VDJ): value of the security provision of senior (junior) secured debt.

When not stated otherwise, σ_A, σ_B, ρ, R, τ, F, H, A, B have values 0.2, 0.2, 0.5, 0.15, 20, 1000, 1000, 50, 50, respectively. The present values of default-free bonds with face value F and H are given in parentheses.

where ρ is the instantaneous correlation coefficient between the dynamics of A and the dynamics of B. We assume that ρ is a constant. The remainder of this section describes our numerical solutions to the partial differential eq. (9) for the boundary conditions at maturity given by eq. (8).

Table 1 gives results for various cases, most of which have $\rho = 0.5$. In this table, σ_A, σ_B, ρ, R, τ, F, H, A, B have the values $0.2, 0.2, 0.5, 0.15, 20, 1000, 1000, 50, 50$, respectively, unless otherwise stated.[8] Notice that the current value of a default-free bond paying 1000 twenty years from now with $R = 0.15$ is equal to 49.8. The face value of the debt is chosen to be large to make it easier to understand how variations in the parameters affect the value of secured debt. As A and B increase relative to the prices of risk-free bonds with the same terms, i.e., $He^{-R\tau}$ and $Fe^{-R\tau}$, the debt becomes less risky and changes in the parameters have less of an impact on the value of secured debt.

From section 2, we know that the price of senior secured debt is an increasing function of the face value of secured debt F and of the prices of A and B, and a decreasing function of the face value of unsecured debt. In table 1, the price of senior secured debt is also a decreasing function of the instantaneous variance of the returns of A and B, of the instantaneous correlation coefficient between the returns of A and B, of the interest rate R, of time to maturity τ and of the face value of the unsecured debt H. Numerous other cases were studied numerically. All these cases yielded the same qualitative results for the pricing of senior secured debt except for the effect of increases in the standard deviation of the return of assets A and B (respectively, σ_A and σ_B). If $\sigma_A A/\sigma_B B$ is small (large), it is possible for an increase in σ_A (σ_B) to increase the value of senior secured debt when the correlation coefficient of the returns of A and B is negative and close to minus one. To understand this, notice that the value of equity is equal to the value of a call option on $A + B$ with an exercise price equal to the sum of the face values of the outstanding debt of the firm. An increase in σ_A (σ_B) can decrease the variance of changes in $A + B$ if ρ is smaller than $-\sigma_A A/\sigma_B B$ ($-\sigma_B B/\sigma_A A$). As the value of equity is an increasing function of the variance of changes in $A + B$, it follows that an increase in σ_A (σ_B) can decrease the value of equity. A decrease in the value of equity must increase the total value of the debt claims against the firm if $A + B$ stays constant. (In addition, however, an increase in σ_A or σ_B can increase the value of secured debt at the expense of the unsecured creditors). In summary, the sign of the partial derivatives of the value of senior secured debt is

$$DS = DS(\overset{+}{A}, \overset{+}{B}, \overset{+}{F}, \overset{-}{H}, \overset{+/-}{\sigma_A}, \overset{+/-}{\sigma_B}, \overset{-}{\rho}, \overset{-}{R}, \overset{-}{\tau}). \tag{10}$$

[8]A description of the procedure followed to obtain these results is available from the authors.

In table 1, the comparative statics results for junior secured debt are the same as those obtained for senior secured debt except for changes in the standard deviation of the return of A. Starting from a low value an increase in this standard deviation first increases and then decreases the price of junior secured debt. To understand this result, remember that in section 2 we show that the price of secured debt is a decreasing function of a put option on an artificial asset Q whose price is equal to $B(t)+C(A,H,T-t)$, where $C(A,H,T-t)$ is the price of a call option on asset A with exercise price H and maturity at time T. An increase in σ_A brings about a proportionately larger increase in $C(A,H,\tau)$ if σ_A is low than if it is high. For low values of σ_A, an increase in $C(A,H,\tau)$ due to an increase in σ_A overwhelms the effect on the price of secured debt of the increase in the standard deviation of asset Q due to an increase in σ_A. If the value of σ_A is large, an increase in σ_A does not increase the price of the call option on A sufficiently to increase the price of secured debt. Numerous other cases were studied numerically. It turns out that if the value of the collateral is small compared to the face value of the secured debt and compared to the value of A (for instance, $A=500$, $B=50$ and $F=H=1000$), the value of junior secured debt increases with the standard deviation of asset A, the interest rate and the time to maturity. These results occur because, when B becomes very small, the price of secured debt becomes almost equal to the price of a default-free bond with face value F minus the price of a put option on $C(A,H,\tau)$. Furthermore, when the standard deviation of price changes of B is small compared to the standard deviation of price changes of A and when the correlation coefficient between the returns of A and B is negative and close to minus one, it is possible for increases in the standard deviation of the return of asset B to decrease the standard deviation of the return of asset Q and hence increase the value of secured debt. (For instance, if $A=1000$, $B=50$, $\sigma_A=0.4$, $F=H=1000$, $\rho=-0.9$, an increase in σ_B from 0.3 to 0.35 increases the value of junior secured debt.) In summary, the sign of the partial derivatives of the value of junior secured debt is

$$DJ = DJ(\overset{+}{A}, \overset{+}{B}, \overset{+}{F}, \overset{-}{H}, \overset{+/-}{\sigma_A}, \overset{+/-}{\sigma_B}, \overset{-}{\rho}, \overset{+/-}{R}, \overset{+/-}{\tau}). \tag{11}$$

Finally, inspection of table 1 shows that the value of the security provision is always positive for both types of secured debt. This result is not surprising, as the security provision enables secured creditors to have a bigger claim on the asset used as collateral then they would have in the absence of that provision. It can be shown that this result holds irrespective of the joint distribution of the returns of assets A and B. The comparative statics of the value of the security provision will be discussed in section 4.

4. Why does secured debt exist?

4.1. Secured debt theories and the value of the firm

In a recent review of theories explaining the existence of secured debt, Schwartz (1981, p. 3) concludes that 'efficiency explanations for why firms issue secured debt either predict wrongly when it will or will not be sold, fail to account for the use of security rather than other contractual devices that apparently accomplish the same ends, or fail to show that security reduces net social costs'. In other words, existing theories do not convincingly demonstrate that the use of secured debt increases the value of the firm rather than redistributing the value of the firm among various claimholders. Furthermore, the current literature does not explain why firms retain in bond indentures the option to finance new projects with secured debt.

In this section, we show how secured debt can be used to increase the value of a firm. We divide our analysis into two parts. First, we discuss how the security provision can decrease the monitoring costs of debt. Then, we show that the possibility of financing new projects with secured debt makes it more advantageous for a firm's shareholders to undertake positive net present value (NPV) projects when the firm has risky debt outstanding.

Before turning to our analysis of the use of secured debt, we want to point out that a viable theory of the use of secured debt cannot focus merely on the redistribution of wealth among claimholders for a given investment policy of the firm.[9] Unexpectedly issuing secured debt (or, for that matter, any kind of senior debt) without changing a firm's investment policy reduces the value of the firm's existing debt and increases the shareholder's wealth. One would expect existing creditors to anticipate the issue of secured debt and to protect themselves *ex ante* by requiring a higher yield on the debt when they become creditors. As issuing secured debt is costly, the firm is likely to find it advantageous to pre-commit itself not to issue secured debt for a given investment policy.

4.2. Secured debt and monitoring costs

As argued by Jensen–Meckling (1976) and others,[10] debt involves agency costs which arise because of the conflict of interest between shareholders and bondholders. To reduce these agency costs, shareholders generally find it advantageous to attach various covenants to debt issues. Without these covenants, creditors would require a higher yield on bonds. For bond covenants to

[9]Smith–Warner (1979a) make this point in their comment on Scott's (1977) argument for the use of secured debt.

[10]See Galai–Masulis (1976), Myers (1977), Fama (1978) and Smith–Warner (1979b).

have value, they have to be respected by the firm. Consequently, bondholders must spend resources to monitor the firm's observance of these bond covenants. As these monitoring costs are forecast by potential bondholders and reflected in the prices they are willing to pay for the debt when issued, stockholders have strong incentives to choose efficient combinations of bond covenants.

Jensen–Meckling (1976) argue that shareholders can reduce the value of the firm's bonds by engaging in asset substitution i.e., by substituting riskier assets for less risky ones. With the distributional assumptions of section 3, the value of the debt falls if the variance of the rate of change of the value of the firm increases. Bond covenants which specify carefully the firm's investment decisions would prevent asset substitution. However, such covenants would be expensive to monitor and would make it difficult for managers to adjust the firm's production and investment plans. Smith–Warner (1979a) and Jackson–Kronman (1979) argue therefore that secured debt offers a way to limit asset substitution which is not as expensive to monitor as alternative forms of bond covenants which achieve the same end. Of course, this requires that suitable collateral be available.

The security provision prevents the firm from selling the collateral to pay a dividend or from exchanging the collateral for a more risky asset. This feature of secured debt also (partly) protects secured creditors against asset substitutions or cash payouts which do not involve the sale or exchange of the collateral. Fig. 1 shows that the value of secured debt, in the model used in section 3, depends less on the variance of the rate of return of the asset which is not used as collateral than does the value of unsecured debt which otherwise has the same characteristics as the secured debt. Notice that if the firm has some other debt outstanding, the existence of secured creditors does not affect the firm's incentives to engage in cash payouts or asset substitutions, as it can still act opportunistically to reduce the value of the claims of unsecured creditors. This follows from the fact that the value of the firm's common stock is given by the value of a call option on $A+B$ with exercise price $F+H$. The value of the call option does not depend on how claims are split among various creditors of the firm. Hence, while issuing secured debt reduces the firm's opportunities to engage in asset substitution, it does not make asset substitution less profitable given that the firm also has unsecured debt.

Whether the firm currently has unsecured debt outstanding or not, however, costs caused by the possibility of asset substitution can be reduced in a number of ways by attaching a security provision to the debt. First, given the nature of the secured creditors' claim, it is in their interest to spend fewer resources to gather information about the firm in the process of negotiating the loan and thereafter to monitor the firm's observance of bond covenants. Second, secured creditors are likely to agree to less restrictive covenants about what the firm can or cannot do later on, as the actions of the firm affect those creditors less

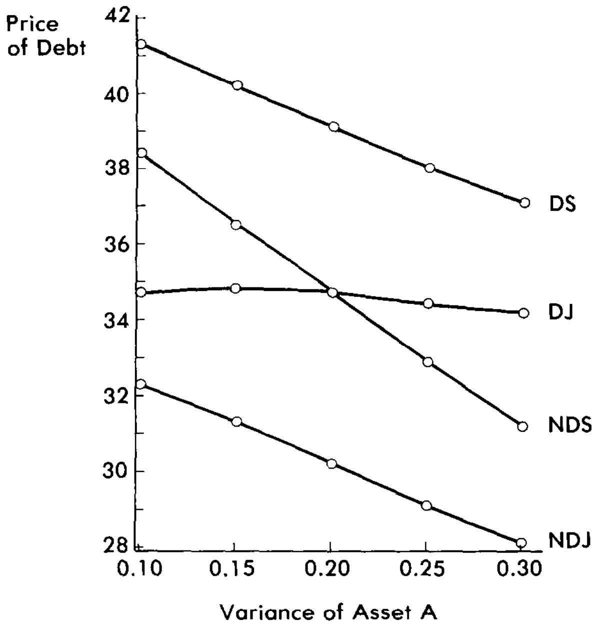

Fig. 1. The effect on junior secured debt (DJ), junior unsecured debt (NDJ), senior secured debt (DS) and senior unsecured debt (NDS) of an increase in the variance of asset A, i.e., the asset of the firm not used as collateral. The data used for this figure are based on table 1.

than if their claim were not secured by some collateral. For instance, if the firm issues unsecured instead of secured debt, it might have its investment policy constrained by bond covenants which prevent it from taking projects it would take in the absence of unsecured debt. Finally, because secured debt is safer than unsecured debt, secured creditors benefit less from new investments undertaken by the firm than unsecured creditors.[11] Therefore, when a firm has no debt, issuing secured debt instead of some other form of debt makes it less likely that the underinvestment problem discussed by Myers (1977) will arise. Obviously, issuing secured debt instead of unsecured debt also has some costs against which the benefits just discussed must be weighed by the issuing firm.

The monitoring cost argument for the use of secured debt can help explain why security provisions are often included in short-term debt agreements. If a security provision is attached to his claim, a creditor does not require as much information about a firm as he otherwise would. Consequently, a security

[11] The fact that secured debt is safer has an obvious advantage in the models with asymmetric information explored by Myers–Majluf (1984) and Myers (1984), as in these models firms want to issue the safest claims first. This follows from the fact that agents with different information sets will value safe debt similarly.

provision reduces the costs of negotiating a debt agreement. Furthermore, when the collateral is a pool of assets which would be sold anyway by the firm (for instance, receivables or inventories), the security provision makes it superfluous to negotiate covenants which prevent the proceeds from the sale of these assets from being shunted off to shareholders (or other creditors).

4.3. Secured debt and the underinvestment problem

4.3.1. The main argument

In this subsection, we show that the possibility of financing new projects with secured debt makes it more advantageous for shareholders to undertake positive net present value projects. That is, secured debt can be used, in some circumstances, to solve the underinvestment problem analyzed by Myers (1977).

Shareholders can try to avoid the underinvestment problem by financing the new project with debt. If the debt used is of rank equal to the rank of the existing debt, the firm will undertake some projects which would be turned down if they were equity-financed. Nevertheless, some projects will still be turned down unless the firm can issue debt whose value exceeds the financing required for the projects. In this case, debt is sold so that shareholders can pay themselves a dividend. However, such an approach implies higher flotation costs than if the firm issues debt only to finance the expenditures associated with the project. Furthermore, in general, bond issues include bond covenants which limit dividend payments, so that shareholders can pre-commit themselves not to siphon money away from the bondholders through dividend payments. These bond covenants usually require the firm to earn its dividend payments. An exception to these bond covenants which would allow the firm to issue debt and pay dividends, so that it will take all positive NPV projects, seems to imply prohibitive monitoring costs, as bondholders would want to make sure that the firm does not use its investment policy to redistribute wealth away from the bondholders. Therefore, such an exception would amount to requiring that bondholders and shareholders agree on the amount of debt to be issued.

If the monitoring costs are prohibitively high for a bond covenant which allows shareholders to issue debt so that the firm will accept all positive NPV projects, shareholders can find other ways to reduce the importance of the underinvestment problem. For instance, they can engage in asset substitution or sell assets to pay a dividend. However, these actions are precisely actions that shareholders commit themselves not to take through various bond covenants so as to reduce the agency costs of debt. If shareholders want to have the option to engage in these actions when the underinvestment problem arises, it will be extremely difficult for bondholders to make sure that these actions are taken only to alleviate the underinvestment problem, as promised by the shareholders, and not to transfer wealth from bondholders to shareholders. Instead, shareholders could refund the debt. However, if they can pay off their creditors easily, the underinvestment problem cannot be severe. Finally, shareholders could negotiate a side-payment from the bondholders. In general, one would not expect bondholders and shareholders to reach easily an agreement whereby they share the benefits of the new project so that both parties are better off.[12]

Compared to the various ways of solving the underinvestment problem just discussed, financing the project with secured debt, when this option is available, often involves lower monitoring and contracting costs. This is especially true if the shareholders would otherwise take the project only if they can issue unsecured debt to pay themselves a dividend. If the firm owns asset A and has an option to buy asset B at a price lower than its market value, it will purchase asset B if by doing so it increases the wealth of its shareholders. If the firm can finance the purchase of asset B partly by issuing new debt, it is advantageous for the shareholders to use asset B as collateral for the new debt as the security provision diverts from the unsecured bondholders some payoffs of asset B which would otherwise accrue to them. As the new bondholders acquire the debt at its fair market value, the gains associated with diverting payoffs of asset B away from unsecured bondholders accrue to the shareholders and increase their incentives to undertake the project. Therefore, the option to finance new projects with secured debt can be valuable to the shareholders, as it makes it more likely that they will accept positive NPV projects.

When shareholders sell unsecured debt, they can include in the bond indenture a covenant which enables them to finance new projects with secured debt if it is profitable to do so. Such a covenant can increase the likelihood that shareholders will be able to redistribute wealth after the unsecured debt is issued by diluting the claim of the unsecured creditors. When investors buy the unsecured bond issue, they pay a price which takes into account the actions they expect the shareholders to take. Therefore, the additional agency costs created by including the option to finance new projects with secured debt in the bond indenture are borne by the shareholders. It is worthwhile for the shareholders to bear these costs if they expect that the acquired option will enable them to take positive NPV projects they would reject otherwise. The value of the option to finance new projects with secured debt depends crucially on the nature of the projects which are forecast to become available before the maturity of the unsecured debt. The more likely it is that some positive NPV projects would be rejected in the absence of this option, the more valuable this

[12] In the absence of contracting costs, it would seem that the incentives mentioned by Fama (1978) are powerful enough to decrease substantially the importance of the conflict between bondholders and stockholders.

option is to the shareholders. This option affects the investment policy of the firm in such a way that including it in the indenture of an issue of unsecured debt may increase the value of unsecured debt as, in the event of bankruptcy or liquidation, a fraction of the proceeds from the sale of the collateral for the secured debt may be used to pay off part of the claim of the unsecured bondholders. In contrast, including in a bond's indenture the right to issue secured debt without making new investments allows the shareholders to redistribute wealth away from the bondholders and consequently, in general, decreases the price at which the debt can be sold initially. This discussion implies that the option to finance new projects with secured debt can increase the value of the claims against the future cash flows of the firm because it affects the investment policy of the firm.

4.3.2. The cost of the option of secured debt financing

To understand the cost of the option of secured debt financing, we use the model of sections 2 and 3 to study the effect on the value of the unsecured debt of the firm's decision to exercise its option of secured debt financing. We assume that the firm has one asset in place, A, and has the option to acquire another asset, B, by investing I. The only debt the firm currently has is unsecured debt with face value H. The firm liquidates at time T. If the firm acquires the project and finances it (partly) with an issue of secured debt with maturity T and face value F, the secured debt is priced according to the earlier results of this paper.

With junior secured debt, the value of the unsecured debt always increases when the firm uses its option of secured debt financing, as the unsecured creditors obtain a claim to some payoffs of asset B and lose nothing (provided B cannot take negative values). With senior secured debt, it is possible for the unsecured creditors to be made worse off when the firm exercises its option of secured debt financing. To understand this, notice that if the firm defaults and the value of the collateral is smaller than the face value of the secured debt, i.e., $B(T) < F$ and $A(T)+B(T) < F+H$, the secured creditors have a claim on $A(T)$, which implies a decrease in what the unsecured creditors would otherwise receive. Table 1 shows that, when A and B are lognormally distributed, the lower the variance of the rate of return of asset B, the more likely it is that unsecured bondholders gain with a senior secured debt issue. Numerical analysis also shows, for the same distributional assumptions, that the value of the unsecured debt is an increasing function of the value of asset B and a decreasing function of the coefficient of correlation between the returns of assets A and B and of the face value of secured debt. For a given face value of the secured debt, an increase in the value of asset B corresponds to an increase in the NPV of the project, i.e., $B-I$, or else to an increase in the equity used to finance the project.

If the unsecured bondholders believe it likely that shareholders will use the option of secured debt financing for projects which redistribute wealth, they will price-protect themselves when they purchase the unsecured debt, which will worsen the underinvestment problem in the future. Shareholders can reduce the importance of this problem by committing themselves to finance only a fraction x $(0 < x < 1)$ of a new project with secured debt. The smaller x, the more likely it is that the value of the unsecured debt is higher with the project than without it, but also the less likely it is that the project will be undertaken.

4.4. *Empirical implications*

The analysis of this section has established that there are projects such that both unsecured bondholders and shareholders benefit if these projects are undertaken and financed with secured debt, and that these projects would not be undertaken if they had to be financed otherwise. The fact that it can be in the interest of existing bondholders to let the firm finance the acquisition of new assets with secured debt is generally recognized in bond indentures. Although bond indentures usually prohibit the firm from issuing secured debt without new investments, they often allow the firm to use 'purchase money, mortgages, liens, pledges or security interests' up to some percentage of the cost of an asset newly acquired by the firm.[13]

From the analysis of this section, it is possible to get some idea of when one would expect secured debt to be used. For a firm, the option of financing new projects with secured debt is costly because it increases the agency costs associated with the initial unsecured debt issue. The use of secured debt itself is costly for several reasons. First, the contracting costs of secured debt can be higher than the contracting costs of unsecured debt. For instance, security interests must often be registered. Second, secured debt implies a loss of flexibility for the firm, as it cannot sell the collateral without renegotiating the debt, which can be difficult. Finally, while the use of secured debt can reduce monitoring costs, as argued earlier in this section, it also involves some monitoring costs which do not arise in the case of unsecured debt. For instance, if a project undertaken by the firm involves the purchase of a large number of assets which can be sold without the transfer of an explicit title to these assets, e.g., typewriters, the monitoring costs specific to secured debt may be prohibitive.[14]

As it is expensive for the firm to acquire the option of financing projects with secured debt, it will purchase this option only if it expects its benefits to

[13] See footnote 1.

[14] Benjamin (1978) provides an analysis of the advantages and disadvantages of using various types of goods as collateral.

be sufficiently large. Thus, the firm will do so only if it is likely that there will be available sufficient positive *NPV* projects for which secured debt financing will be advantageous. In the following, we show when one would expect secured debt financing to be advantageous. To focus the discussion on the fact that secured debt can be used to reduce the underinvestment problem, we consider here the case when secured debt has no other benefit.

If the existing debt of the firm is not very risky, there cannot be much of an underinvestment problem and, therefore, one would not expect the firm to use secured debt. The underinvestment problem is not likely to be serious for high *NPV* or high risk projects. However, if the existing debt of the firm is risky enough and there is a significant underinvestment problem one would expect secured debt to be used.

Secured debt is more likely to be used, *ceteris paribus*, the higher the value of the security provision, as this provision measures the value of the payoffs of B which, without it, would accrue to the unsecured creditors. Table 1 provides useful insights into the comparative statics of the value of the security provision when assets A and B are lognormally distributed. In particular, table 1 shows that the value of the security provision increases if the standard deviation of the return of the other assets of the firm increases. It follows that secured debt is particularly advantageous if the standard deviation of the return of the collateral is much lower than the standard deviation of the return of the remainder of the assets of the firm. This result is consistent with casual empiricism which suggests that assets with low standard deviations of returns are more frequently used as collateral than other assets. Furthermore, the value of the security provision is an increasing function of the face value of the secured debt, the face value of the unsecured debt, calendar time and the rate of interest. These results are explained by the fact that an increase in the probability of default, *ceteris paribus*, increases the value of the security provision when the distribution of the collateral is left unchanged. Since the value of the security provision is a decreasing function of time to maturity, our analysis can explain why one often sees short-term secured debt.[15] Since the value of the security provision is an increasing function of the face value of the unsecured debt, one would expect secured debt financing to be used more often if the firm has a high leverage ratio than otherwise.

5. Conclusion

This paper shows that secured debt can be used to increase the value of the firm. In particular, it is argued that the availability of secured debt mitigates the underinvestment problem. It is shown that if a firm can finance new

[15] Remember, however, that this result is derived under the assumption that the maturity of both types of debt is the same.

projects with secured debt, it is likely to undertake some new projects that it would otherwise reject. Comparative statics and numerical solutions are provided for the pricing of secured debt.

The analysis in this paper could be extended in a number of ways. The type of secured debt studied could be modified to allow for coupon payments. The firm could be allowed to pay dividends. More realistic assumptions could be made about the firm and about the asset used as collateral. For instance, the firm could hold options on projects which can be undertaken at a later date and the exercise policy for these options could be solved for when the debt is valued. As the firm has debt outstanding, not all positive *NPV* projects (i.e., projects for which the option is in-the-money at maturity) will be undertaken.

References

ABF, 1971, Commentaries on model indenture provisions 1965, Model debenture indenture provisions all registered issues 1967, and Certain negotiable provisions which may be included in a particular incorporating indenture (American Bar Foundation, Chicago, IL).

Benjamin, D.K., 1978, The use of collateral to enforce debt contract, Economic Inquiry 16, 333–359.

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

Black, F. and M. Scholes, 1973, The valuation of options and corporate liabilities, Journal of Political Economy 81, 637–659.

Fama, E., 1978, The effects of a firm's investment and financing decisions on the welfare of its stockholders, American Economic Review 68, 272–284.

Fama, E.F. and M. Miller, 1972, The theory of finance (Dryden Press, Hinsdale, IL).

Galai, D. and R.W. Masulis, 1976, The option pricing model and the risk factor of stock, Journal of Financial Economics 3, 53–81.

Geske, R., 1977, The valuation of corporate liabilities as compound options, Journal of Financial and Quantitative Analysis 12, 541–552.

Geske, R. and H.E. Johnson, 1984, The valuation of corporate liabilities as compound options: A correction, Journal of Financial and Quantitative Analysis 19, 231–232.

Jackson, T.H. and A.T. Kronman, 1979, Secured financing and priorities among creditors, Yale Law Review 88, 1143.

Jensen, M.C. and W.H. Meckling, 1976, Theory of the firm: Managerial behavior, agency costs and capital structure, Journal of Financial Economics 3, 305–360.

Jensen, M.C. and C.W. Smith, 1985, Stockholder, manager and creditor interests: Applications of agency theory, in: E. Altman and M. Subrahmanyam, eds., Recent advances in corporate finance (Dow-Jones Irwin, Homewood, IL) 93–131.

Johnson, H., 1981, The pricing of complex options, Unpublished manuscript.

Merton, R.C., 1973, The theory of rational option pricing, Bell Journal of Economics and Management Science 4, 141–183.

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

Mian, S., 1984, Captive finance companies and alternative policies for financing accounts receivable, Unpublished working paper (University of Rochester, Rochester, NY).

Myers, S., 1977, Determinants of corporate borrowing, Journal of Financial Economics, 5, 147–175.

Myers, S.C., 1984, The capital structure puzzle, Journal of Finance 39, 575–592.

Myers, S.C. and N.S. Majluf, 1984, Corporate financing and investment decisions when firms have information that investors do not have, Journal of Financial Economics 13, 187–222.

Schwartz, A., 1981, Security interests and bankruptcy priorities, Journal of Legal Studies 10, 1–37.

Scott, J.H., 1977, Bankruptcy, secured debt and optimal capital structure, Journal of Finance 32, 1–19.

Smith, C.W., 1980, On the theory of financial contracting, Journal of Monetary Economics 6, 333–357.

Smith, C.W. and J.B. Warner, 1979a, Bankruptcy, secured debt, and optimal capital structure: Comment, Journal of Finance 34, 247–251.

Smith, C.W. and J.B. Warner, 1979b, On financial contracting: An analysis of bond covenants, Journal of Financial Economics 7, 117–161.

Smith, C.W. and L.M. Wakeman, 1985, Determinants of corporate leasing policy, Journal of Finance 40, 895–908.

Stulz, R.M., 1982, Options on the minimum or the maximum of two risky assets: Analysis and applications, Journal of Financial Economics 10, 161–185.

Warner, J.B., 1977, Bankruptcy, absolute priority, and the pricing of risky claims, Journal of Financial Economics 4, 239–276.