Corporate Insurance and the Underinvestment Problem

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ABSTRACT

A casualty loss produces option-like characteristics in assets because their value depends on further discretionary investment. With risky debt in the firm's capital structure, the shareholders can have incentives to forgo the discretionary investment, even though it has a positive net present value. Thus a potential incentive conflict exists between the bondholders who want the investment made and the shareholders who do not. The incentive problem can be controlled by including a covenant in the bond contract requiring insurance coverage. Full coverage is generally not required. The maximum deductible depends on the amount of debt in the firm's capital structure and the feasible set of net casualty losses.

1. Introduction

Mayers/Smith [3] and Main [2] analyze the corporate demand for insurance. Their analyses focus on corporations with diffuse ownership in which the corporation's capital owners, the stockholders and bondholders, can eliminate insurable risk through portfolio diversification. Thus, even though stockholders and bondholders are individually risk averse, that is not sufficient to provide a rational demand for insurance by a value maximizing corporation.

Mayers/Smith treat corporate insurance purchases as part of a firm's financing policy. Modigliani/Miller [5] show that given corporate investment policy, with no contracting costs or taxes, corporate financing policy has no impact on the current market value of the firm. Thus, if corporate insurance purchases affect the value of the firm, they must do so through (1) taxes, (2) contracting costs, or (3) the impact of financing policy on the firm's investment decisions. Each provides a partial explanation of observed

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insurance purchases by corporations. The Mayers/Smith analysis suggests that corporate insurance purchases are motivated by the ability of the insurance contracts to provide the corporation with: (1) low-cost claims administration services; (2) assistance in assessing the value of safety and maintenance projects; (3) an improvement in the incentives to undertake investments in safety and maintenance projects; (4) increased efficiency in the allocation of riskbearing among the corporation's claimholders; and (5) a reduction in the corporation's expected tax liability. In this paper, the authors examine an additional motivation for corporate insurance purchases: the control of a form of the underinvestment problem associated with casualty losses.

Myers [6] shows that "a firm with risky debt outstanding, and which acts in its stockholders' interests, will . . . in some states of nature, pass up valuable investment opportunities—opportunities which could make a positive net contribution to the market value of the firm." Myers distinguishes between (1) assets that can be regarded as call options in the sense that their ultimate value depends on further discretionary investment, and (2) assets whose ultimate value is insensitive to further discretionary investment. Myers demonstrates that in some states, the benefit from undertaking a value-increasing discretionary investment project will accrue to the bondholders to such an extent that the stockholders will be worse off than if the investment had not been made. Thus risky debt in the firm's capital structure can induce the stockholders to forgo investments that in the absence of the debt claims would be undertaken.

Of course, in an efficient rational market, bondholders will anticipate the stockholders' actions and bond prices will reflect the costs of anticipated underinvestment problems at the time the bonds are issued. Thus, the stockholders bear the costs of the incentive problem and hence are induced to offer contractual guarantees that control the problem. For example, bond covenants that restrict dividend payments can help control the underinvestment problem by forcing the firm to retain funds and undertake investment projects (Myers [6], Smith/Warner [10] and Kalay [1]). Similarly, sinking funds (Smith/Warner [10]), debt maturity (Myers [6]), security provisions (Stulz/Johnson [11]), leasing (Smith/Wakeman [9]), and captive finance subsidiaries (Mian/ Smith [4]) have been analyzed as contractual mechanisms to control aspects of the underinvestment problem.

Mayers/Smith [3] note that bond indentures frequently contain covenants requiring the firm to maintain stipulated levels of insurance coverage. They ascribe these provisions to controlling other incentive problems regarding corporate investment policy, not the underinvestment problem. The point emphasized here is that a casualty loss creates an asset that is like a call option since its value depends on further discretionary investment. Prior to the casualty loss, the asset's value might have been generally insensitive to future investment decisions—what Myers refers to as an "asset-in-place". However, once the casualty occurs, the stockholders have the option of replacing the asset or not. And with risky debt outstanding, the firm, if it acts in stockholders' best interest, will decide in some states of the world not to replace the asset even though replacement has a positive net present value.

An insurance policy written for some critical minimum portion of the asset's replacement cost controls this underinvestment incentive. Since the stockholders fully bear the costs of any adverse incentive related to bondholders, they have the incentive to guarantee, via bond covenants, that this insurance coverage will be purchased. For rationally purchased insurance the stockholders are fully compensated for the outlay of the insurance premium through the higher proceeds at the date the bonds are issued.

In section 2, the authors model the problem employing a state-preference model. The analysis highlights the incentive conflict and shows how it modifies the firm's choice of investment decisions. Two mechanisms for controlling this underinvestment problem are offered: (1) restriction of the amount of debt in the firm's capital structure and (2) the purchase of a casualty insurance policy. The conclusions are presented in section 3.

2. The Underinvestment Problem

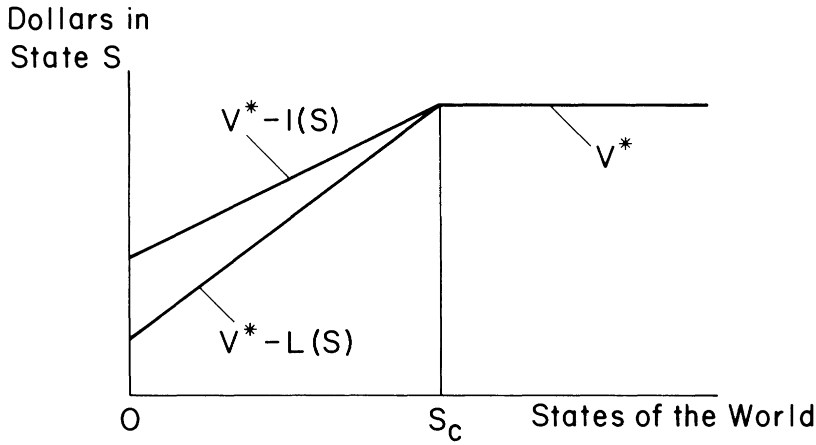
In the model the firm is a centralized activity where the only uncertainty concerns the possibility of a casualty loss. Assume a simple two-date, states-of-the-world framework. If no casualty occurs, V^* is the dollar payout or the value of the firm at the second date. If a casualty occurs, this value, V^*, is reduced by a state-dependent amount, $L(S)$. Thus $V^* - L(S)$ is the reduced value of the firm if a casualty occurs, given that the asset is not rebuilt.

However, if a casualty occurs, a state-dependent investment, $I(S)$, can be made restoring the value of the firm. Assume that rebuilding (making the investment) is a positive net present value project; i.e., $L(S) - I(S) > 0$. Note that $L(S)$ is not just the material loss of the casualty; it includes as well the opportunity loss associated with not being able to operate the firm at full efficiency. Also assume that investment decisions are under the control of the shareholders in all states. This assumption is discussed more fully at the conclusion of this section.

If the firm is financed as an all equity firm, no underinvestment problem exists. The firm will rebuild (with the authors' assumptions) in all states of nature where a casualty occurs. Figure 1 illustrates the investment decision. States of the world are in order of increasing firm value; for states less than S_c, $L(S) > 0$ and the losses are larger the lower the order of the state of the world. The Line, $V^* - L(S)$, indicates the second-date value of the firm without investment for states less than S_c and the line, $V^* - I(S)$, similarly indicates the second-date firm value with investment. Assume complete markets and denote the state-contingent claim price (for delivery of a dollar at the second date) as a $g(S)$. The value of the firm at the first date under all equity financing is given by the following equation:

Figure 1

The Firm's Investment Decision Under All Equity Financing



States lower than S_c are casualty loss states.
V* is the second date value with no loss.
V*-L(S) indicates the second date value with a loss and without investment.
V*-I(S) indicates the second date value with a loss and with investment.

$$V = \int_0^\infty V^* g(S)ds - \int_0^{S_c} L(S)g(S)ds + \int_0^{S_c} [L(S) - I(S)]g(S)ds \quad (1)$$
$$= \int_0^{S_c} [V^* - I(S)]g(S)ds + \int_{S_c}^\infty V^* g(S)ds.$$

However, as suggested above, if the firm is partially financed with debt, it will not always rebuild. Figure 2 diagrams the investment decision with prior debt financing. The face value of the debt is indicated as F. For states of the world between zero and S_a,

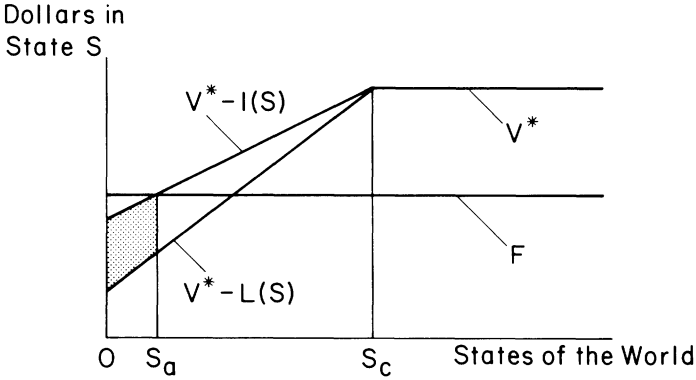
$$V^* - I(S) - F < 0,$$

and the shareholders would be worse off if the firm rebuilt than if it did not. For states of the world below S_a the firm is bankrupt whether or not the investment is undertaken and all benefits from investment accrue to bondholders. Thus the investment outlay in those states is an avoidable loss for shareholders. Hence they will not undertake the investment but will default to the bondholders. Thus when shareholders control the investment decisions and the firm is partially financed with debt, the value of the firm at the first date is

$$V = \int_0^{S_a} [V^* - L(S)]g(S)ds + \int_{S_a}^{S_c} [V^* - I(S)]g(S)ds + \int_{S_c}^\infty V^* g(S)ds \quad (2)$$

Figure 2

The Firm's Investment Decision with Prior Debt Financing



States lower than S_c are casualty loss states.
V* is the second date value with no loss.
V*-L(S) indicates the second date value with a loss and without investment.
V*-I(S) indicates the second date value with a loss and with investment.
F is the face value of outstanding debt.
The shaded area represents the reduction in firm value because of the underinvestment problem.

Comparing equations (1) and (2) shows that the value of the firm is lower with risky debt in the capital structure by the amount

$$\int_0^{S_a} [L(S)-I(S)]g(S)ds$$

(graphically, the shaded area in Figure 2). This value is forgone because of the inventive incompatibility between shareholders' interests and bondholders' interests.
Note from Figure 2 that as long as the face value of debt is less than V*-I(S) in the worst state of nature, no incentive incompatibility nor underinvestment problem exists. Thus one solution for the firm that wants to issue risky debt is to insure that

$$F < V^* - I(S) \text{ for all } S.$$

An insurance policy (guaranteed in the bond contract) can assure incentive compatibility and control the underinvestement problem. From Figure 2, the incompatibility is for states less than S_a. Thus it is the larger losses that have to be insured against. Essentially, $V^* - I(S)$ has to be raised above F, the face value of the debt, by purchasing some critical amount of coverage; i.e., some maximum deductible. The larger the face value of the debt, the smaller the deductible or the greater the effective coverage. The maximum deductible also is a negative function of the maximum feasible net loss, L(0)-I(0).

From Figure 2, the deductible that will make the shareholders indifferent to rebuilding, or the critical deductible, is $I(S_a)$—graphically, the vertical distance between V* and $V^* - I(S_a)$. Thus the minimum coverage for solving the underinvestment problem should be for I(0) (rebuilding or replacement cost) with a deductible equal to $I(S_a)$. Assuming actuarially fair insurance, the premium for such a policy would be

$$\pi = \int_0^{S_a} [I(S)-I(S_a)]g(S)ds.$$

The date-one value of the firm with risky debt and insurance is

$$V = \int_0^{S_a} Fg(S)ds + \int_{S_a}^{S_c} [V^* - I(S)]g(S)ds + \int_{S_c}^{\infty} V^*g(S)ds - \int_0^{S_a} [I(S_a)]g(S)ds; \tag{3}$$

i.e., the value of all the payoffs to the stockholders and bondholders less the insurance premium. From the geometry of Figure 2,

$$\int_0^{S_a} Fg(S)ds = \int_0^{S_a} [V^* - I(S)]g(S)ds + \int_0^{S_a} [I(S) - I(S_a)]g(S)ds.$$

Thus the date-one value of the firm with risky debt and insurance is

$$V = \int_0^{S_c} [V^* - I(S)]g(S)ds + \int_{S_c}^{\infty} V^*g(S)ds \tag{4}$$

which is the same as equation (1), the value of the firm at the first date under all equity financing. (A numerical example is presented in the Appendix.)

In this analysis the authors have made some assumptions to simplify the exposition. For example, the insurance policy premium is assumed to be actuarially fair. However, a positive loading fee changes no basic result. A loading fee for the insurance policy reduces the benefits of additional debt in the capital structure. As long as the benefit (the marginal gain) is greater than the loading fee (the marginal cost), the additional debt should be issued and an insurance policy purchased.

Complete markets have been assumed for pricing the uncertain cash flows in our model. This assumption is not incompatible with the incentive problem between stockholders and bondholders which drives the analysis. Market completeness requires that investment decisions are predictable and conditional on that predictable decision, a unique present value can be assigned. With investment decisions under shareholders' control, the authors have demonstrated that predictable incentives exist to deviate from firm value maximizing policy because, by assumption, the firm cannot precommit to rebuilding if a casualty loss occurs. These issues do not arise in the standard Arrow-Debreu analysis because value maximization is assumed; it is not an implication of their analysis.

Note that if bondholders could obtain immediate control of the firm's investment decisions at the date of the casualty loss, they could take the project and eliminate the costs of this underinvestment problem. Nothing precludes this alternative solution in the authors' simple two-date model with costless contracting. However, at least two factors limit this solution. First, the bondholders have no control over investment policy unless a default occurs under the provisions of the bond contract (see Smith/Warner [10]; a default may lag significantly behind a casualty loss. Second, the bondholder's rights are typically enforced in a bankruptcy proceeding. And as Warner [12, p. 339] argues:

> The bankruptcy trustee, as an agent of the court, has the authority to operate the firm. It is not clear that this agency relationship gives the trustee any incentive to run the firm efficiently and make decisions which are in fact value-maximizing. Unlike management, the trustee is responsible to the court and not directly to the firm's claimholders.

Therefore, the bondholders' ability to replace the asset immediately if a casualty loss occurs is limited.

If the dates of the casualty loss, the rebuilding decision, and the debt maturity are not coincident, the range of investment alternatives expands beyond a simple choice of rebuilt or not. The managers can rebuild immediately, or wait and only rebuild in the future if the project offers a positive net present value to the shareholders. Moreover, if alternative rebuilding technologies are available, the underinvestment problem can affect other dimensions of the investment decision. As an example, consider the choice of asset durability for a firm with debt maturing in five years. Assume that after a casualty loss the firm faces rebuilding technologies having useful lives of either 10 or 20 years. The firm is more likely to reinvest in the ten-year technology, even if the twenty-year technology has a higher net present value. If the firm defaults at the debt maturity, the assets turned over to the bondholders are less valuable.

3. Conclusions

A casualty loss produces option-like characteristics in assets because their value depends on further discretionary investment. With risky debt in the firm's capital structure, the shareholders can have incentives to forgo the discretionary investment, even though it has a positive net present value. Thus a potential incentive conflict exists between the bondholders who want the investment made and the shareholders who do not. The incentive problem can be controlled by restricting the amount of debt the firm issues. With a low enough level of debt, the incentives of the two groups are compatible. However, with more debt in the capital structure, the firm can guarantee incentive compatibility by including a covenant in the bond contract requiring insurance coverage. Full coverage is generally not required. The maximum deductible depends on the amount of debt in the firm's capital structure, and the feasible set of net casualty losses.

This paper analyzes the problem of a firm with risky debt outstanding that has access to insurance for hedging the risk of a casualty loss. However, the analysis is more general. This problem arises whenever the realization of a particular state of the world coincides with a hedgeable loss and the firm has risky debt outstanding. The loss reduces the value of the firm's assets, effectively increasing leverage and the incentive to reject positive net present value projects. Hence, levered firms facing risks from interest rate exposure, commodity price exposure or foreign exchange exposure also have the problem analyzed in this paper. In these cases the problem can be solved by either limiting the amount of debt outstanding or hedging through the purchase of options, forwards, futures, or swaps. Therefore, our analysis adds to the more general problem of corporate hedging policy (See also Shapiro/Titman [7] and Smith/Stulz [8]).

APPENDIX: A NUMERICAL EXAMPLE

Assume the stockholders (the organizers) of the firm have made the initial investment and are considering different financing alternatives. Also assume a simple two-date, two-state model with equal probabilities of either state occurring and a zero rate of interest between dates. At the second date the firm will either be worth \$1000 (no fire, state 1) or \$200 (fire, state 2). If a fire occurs, the firm can rebuild for \$600, again making the firm worth \$1000. Thus rebuilding, if a fire occurs, is a positive net present value project. The net gain over not rebuilding is \$200.

Consider first the case of all equity financing. If the firm is all equity financed, its value at the first date will be

$$V(\text{firm}|\text{equity}) = (\$1000)1/2 + (\$1000 - \$600)1/2 = \$700.$$

Thus, if state 2 occurs, the firm optimally rebuilds, boosting the state 2 net payoff by \$200.

Now consider the case where the firm is partially financed with debt. Assume the face value of outstanding debt is \$500. In this case the market value of debt (the proceeds from the debt issue) will be

$$MV(D) = (\$500)1/2 + (\$200)1/2 = \$350.$$

and the market value of the equity will be

$$MV(E) + (\$500)1/2 + (\$0)1/2 = \$250.$$

This means that the value of the firm is now

$$V(\text{Firm}|\text{Debt}) = MV(D) + MV(E) + \$600.$$

Thus the value of the firm is now \$100 less than in the all equity case. The shareholders would not rebuild in this case because it is not in their interest to do so. If they do rebuild the bondholders' claim becomes risk-free and thus worth \$500. But this \$150 increase in the value of the bonds exceeds the \$100 increase in the value of the firm; thus, the equityholders' wealth is lower if they rebuild after the fire.

The shareholders would like to promise at date 1 to rebuild if a fire occurs at date 2. If they could convince the bondholders of this, they would receive a higher price when the bonds are issued, but the bondholders know that if a fire occurs at date 2, it will not be in the shareholders' interest at that time to rebuild. All of the gain and more will accrue to the bondholders. The firm will receive \$1000 for \$600, but \$500 must be paid to the bondholders leaving the shareholders with a \$100 net loss. This net loss could be avoided by simply not carrying out the promise to rebuild and defaulting the firm to the bondholders. One solution to this problem is to issue less debt. For example, if the firm issued debt with a \$200 face value, the debt would be *riskless*. No adverse incentive would exist and the shareholders would gain the full benefit of the rebuilding project. With the face value of debt at \$400 the shareholders would just recover their investment and would be indifferent between rebuilding or not. Thus in this example, the underinvestment problem commences when the promised debt repayment reaches \$400.

Suppose for some reason it is desirable to have more debt in the capital structure. Then another solution is for the shareholders to purchase an insurance policy for the replacement cost of the asset. Guaranteeing that they will do this, by way of a bond covenant, affects the issue price of the bonds. Assume, for this example, that the insurance policy premium is paid out-of-pocket by the shareholders and the policy is actuarially fair. Thus the insurance policy will cost \$300. In this case the market value of the debt (the proceeds of the debt issue) will be

$$MV(D) = (\$500)1/2 + (\$500)1/2 = \$500,$$

the market value of the equity will

$$MV(E) = (\$500)1/2 + (\$500)1/2 = \$500,$$

and the value of the firm is now

$$V(\text{Firm} \mid \text{Debt and Insurance}) = MV(D) + MV(E) = \$1000.$$

Thus the organizers of the firm (the shareholders) have received \$500 from the bond sale, they have shares worth \$500, and they have purchased an insurance policy for the replacement cost of the asset for \$300. Thus their net wealth position is the same as for the case of all equity financing. The insurance policy has solved the underinvestment problem while allowing the firm to have \$500 of debt in the capital structure.

Full insurance coverage has been assumed in this example, but it is not necessary for the insurance policy to be written for the full replacement cost of the asset. For example, an insurance policy that pays off as little as \$101 would also control the incentive problem when the face value of the debt is \$500. The shareholders would have to come up with \$499 to undertake the investment, but they would recover \$500. Thus the insurance policy has to be written for at least the critical amount that assures incentive compatibility. In this example, the critical amount can be determined by the formula:

$$\text{Critical Amount} = \text{Debt Face Value} - \$399.$$

REFERENCES

1. Kalay, A., "Stockholder-Bondholder Conflict and Dividend Constraints," *Journal of Financial Economics* Vol. 10, No. 2, (July 1982) pp. 211-233.
2. Main, B. G. M., "Corporate Insurance Purchases and Taxes" *Journal of Risk and Insurance* Vol. L, No. 2, (June 1983) pp. 197-223.
3. Mayers, D. and C. W. Smith, "On the Corporate Demand for Insurance," *Journal of Business* Vol. 55, No. 2 (April 1982) pp. 281-296.
4. Mian. S. and C.W. Smith, "Alternative Policies for Financing Accounts Receivable," University of Rochester, unpublished manuscript (1986).
5. Modigliani, F. and M. H. Miller, "The Cost of Capital, Corporation Finance and the Theory of Investment," *American Economic Review* Vol. 48, No. 3 (June 1958), pp. 333-391.
6. Myers, S. C., The Determinants of Corporate Borrowing," *Journal of Financial Economics* Vol. 5, No. 2 November 1977), pp. 147-175.
7. Shapiro, A. C. and S. Titman, "An Integrated Approach to Corporate Risk Management" *Midland Corporate Finance Journal* Vol 3, No. 2 (Summer 1985), pp. 41-56.
8. Smith, C. W. and R. M. Stulz, "The Determinants of Firms' Hedging Policies" *Journal of Financial and Quantitative Analysis* Vol. 20, No. 4 (December 1985), pp. 391-405.
9. Smith, C. W. and L. M. Wakeman, "Determinants of Corporate Leasing Policy" *Journal of Finance* Vol. 40, No. 3 (July 1985), pp. 895-908.
10. Smith, C. W. and J. B. Warner, "On Financial Contracting: An Analysis of Bond Covenants," *Journal of Financial Economics* Vol. 7, No. 2 (June 1979), pp. 117-161.
11. Stulz, M. and H. Johnson, "An Analysis of Secured Debt," *Journal of Financial Economics* Vol. 14, No. 4 (December 1985), pp. 501-521.
12. Warner, J. B., "Bankruptcy Costs: Some Evidence," *Journal of Finance* Vol. XXXII, No. 2 (May 1977), pp. 337-348.