On Corporate Insurance

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1. Introduction

Insurance contracts are regularly purchased by corporations and play an important role in the management of corporate risk.[1] In spite of this fact, only recently has this role received much attention in the finance literature, even though insurance contracts are simply another type of financial contract in the nexus of contracts that comprise the corporation.

In the insurance literature, the incentive to buy insurance is often assumed to be risk aversion.[2] Risk aversion might be is a sufficient motivation for the closely held corporation but it is not sufficient for the publicly held corporation. According to Mayers and Smith (1982) "The corporate form provides an effective hedge since stockholders can eliminate insurable risk through diversification." Equivalently, the value of the insured corporation is the same as the value of the uninsured corporation. If these claims hold, then insurance is not a necessary tool in managing corporate risk. A characterization of the market conditions in which the claim does and does not hold should be important to corporate managers as well as insurance companies. The claim is intuitively appealing. If the corporation is viewed as a set of financial contracts, then it is a generalization of the 1958 Modigliani-Miller Theorem (see Modigliani and Miller (1958)). The generalized theorem says that the composition of the contract set is irrelevant. The irrelevance claim was established in MacMinn (1987); that analysis also provided a number of relevance results. This analysis provides a generalization and extension of the earlier results. The model provided here demonstrates some of the market conditions in which insurance is an important tool for managing corporate risk.

The first step is to formally establish the claim that corporations need not buy insurance since competitive risk markets already provide sufficient opportunity to diversify risk. To establish or refute this claim requires a model of the economy that includes stock, bond and insurance markets. Those markets are introduced in the next section of this paper. The basic model includes debt, equity and insurance. The model is used first to develop the corporate objective function and then to investigate the insurance decision. The analysis shows that as long as bankruptcy is costless, markets are competitive and efficient then the risk adjusted net present value of the insurance decision is zero and the claim that insurance is irrelevant is formally established.

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[1] As a use of funds, corporate property-casualty insurance premium payments are economically significant, typically exceeding dividend payments by an order of magnitude of 30-40 percent (see Mayers and Smith (1982) and Davidson *et al.* (1992)). Survey evidence compiled by Tillinghast-Towers Perrin and Risk and Insurance Management Society (1995) finds that direct property-casualty insurance costs for most U.S. and Canadian business organizations typically average around 0.4% of revenues. Similar findings on the economic significance of corporate insurance purchases obtain for other industrialized countries; e.g., Yamori (1999) reports that in 1994, Japanese non-financial corporations paid 2.3 percent of their operating profits for property-casualty insurance premiums.

[2] For example, Borch (1960, 1962) and Blazenko (1986) motivate insurer demand for reinsurance on this basis.

In the section on Costly Bankruptcy, the model is altered to allow for the transaction costs of bankruptcy. Mayers and Smith (1982) note that bankruptcy costs provide the firm with an incentive to insure because, by shifting risk to the insurance company, the firm decreases the probability that the cost is actually incurred. The analysis here, as in MacMinn (1987), shows that the total market value of the insured firm is equal to that of the uninsured firm plus the present value of the savings on bankruptcy costs; equivalently, the analysis shows that the value of the insured firm exceeds the value of the uninsured firm. This provides the corporation with an incentive to insure.

In the section on Agency Problems, the basic model is generalized so that it incorporates conflict of interest problems between corporate management and bondholders. Conflict of interest problems arise when the corporate manager, acting in the interests of stockholders, has the incentive to select actions that are not fully consistent with the interests of other groups of claimholders. Two classic examples of the conflict of interest problems are developed. The analysis necessary to show how the insurance contract may be used to limit the divergence between the interests of claim holders and management is developed. The first agency conflict considered is usually referred to as the "under-investment" problem, e.g., see Myers (1977), MacMinn (1987), Mayers and Smith (1987), and Garven and MacMinn (1993). In this example, the manager of a levered firm has an incentive to limit the scale of investment because the additional returns from further investment accrue primarily to bondholders rather than shareholders. The analysis here shows that insurance can be used to eliminate this underinvestment problem. The investment decision approaches the socially optimal level as insurance is used to reduce the probability of insolvency.

The second agency conflict considered is usually referred to as the asset substitution problem, or equivalently, as the risk-shifting problem, e.g., see Jensen and Meckling (1976), Green (1984), Mayers and Smith (1982), MacMinn (1987) and MacMinn (1993). Once a corporation has obtained debt financing, it is well known that by switching from a relatively safe investment project to a riskier one, the corporation can increase the value of its equity at the expense of its bondholders. Mayers and Smith (1982) discuss this conflict and note that rational bondholders recognize this incentive to switch and incorporate it into the bond price. Consequently, an agency cost is represented in the bond price and a reduction in the total market value of the firm. Mayers and Smith also note that an important role played by insurance in this corporate environment is in bonding the corporation's investment decision. They suggest that the incentive to include insurance covenants in bond contracts increases with firm leverage. The analysis here shows that the asset substitution problem only exists for highly levered firms and that an indenture provision, requiring insurance, can be structured so that any incentive for risk-shifting is eliminated. Thus, the model shows how insurance may be used to eliminate this agency cost.

In the section on Tax Asymmetries, the basic model is altered to allow for the corporate income tax as well as agency costs. It is well known that under the U.S. corporate tax code, income and losses to the firm are taxed in an asymmetric fashion. A number of potential sources for tax asymmetries exist, including incomplete tax loss offsets and progressive marginal tax rates. Several articles have utilized asymmetric taxes to rationalize a number of different aspects of financial contracting, including optimal capital structure (see DeAngelo and Masulis (1980)), leasing (see Heaton (1987)), corporate risk management (see Green and Talmor (1985) and Campbell and Kracaw (1990)), corporate insurance demand (Mayers and Smith (1982)), corporate hedging (Smith and Stulz (1985)), and the demand for reinsurance (Garven and Louberge (1996)). The analysis presented here shows that the asymmetric nature of the corporate income tax constitutes a sufficient condition for the corporation to purchase insurance. Taxes reinforce further the basic result that optimally insured firms command higher market values than otherwise identical uninsured firms. Insurance is viewed here as a mechanism that enables the firm to 1) optimally trade off agency and tax-related costs, and 2) replace a risky tax shelter (represented by loss costs related to property risks) with a safe tax shelter (represented by debt service costs).

The final section of this paper presents some conclusions and comments on the role that insurance contracts play in managing corporate risk. It also provides a brief discussion of some empirical implications, as well as suggestions for future research.

Before continuing any further, a *caveat* is in order. Most insurance models, beyond those designed to simply consider the reallocation of risk, might be classified as hidden action or hidden knowledge models. The hidden action is an action, e.g., an investment or production decision, taken by an agent that cannot be observed by the principals or claim holders; models characterized by hidden action or equivalently moral hazard problems are considered here. The cases covered are not exhaustive. Mayers and Smith (1982) argue that insurance is a mechanism that can be used to reduce the impact of regulatory constraints and that is consistent with the current model structure. Froot, Scharfstein and Stein (1993) posit a "crowding out" hypothesis to rationalize corporate hedging decisions that may also provide a useful framework for addressing the demand for corporate insurance.[3] The hidden knowledge is a difference in information possessed by insiders versus outsiders or by different groups of claim holders in this setting; models characterized by hidden knowledge or equivalently, in some cases, by adverse selection, require more closure than the current model provides. The monitoring role of insurance noted by Mayers and Smith among others would fit this category. The work done on optimal contracting by Caillaud, Dionne

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[3]In the Froot, Scharfstein and Stein model, hedging adds value by enabling the firm to avoid external financing costs associated with capital market imperfections. Hedging helps to ensure that a corporation has sufficient and less costly internal funds available to take advantage of attractive investment opportunities. Corporate insurance contracts can play a similar role. Since insurance premiums are paid *ex ante* in anticipation of possible future losses, *ex post* claims payments enable firms to reinvest in valuable corporate assets without having to rely upon external capital markets. Furthermore, as Doherty (1997a) points out, insurance is a "leverage neutral" loss financing strategy because it enables the firm to fund losses without having to rely upon issuing new equity or debt or relying upon internal funds that would otherwise be used to invest in other capital projects.

and Jullien (1996) would also fit this category. These are important considerations and await a more general version of the model outlined here. The focus here will be on the efficiency gains that can be derived from using corporate insurance contracts to reduce bankruptcy costs, agency costs, and tax costs.

2. Basic Model

Assume that there are many individual investors indexed by i in the set I, and that there are many firms indexed by f in the set F. There are two dates, t = 0 and t = 1, that will be subsequently referred to as *now* and *then*, respectively. All decisions are made *now* and all payoffs from those decisions are received *then*. The payoffs depend on which state of nature ξ in the set Ξ occurs *then*. The model is developed with debt, equity and insurance. The Fisher model is used in this setting.[4]

There are many individual investors. Investor i is endowed with income *now* and *then* represented by the pair (y_{i0}, y_{i1}). Furthermore, investor i has a consumption pair (c_{i0}, c_{i1}) and an increasing concave utility function u_i: $D \rightarrow R$, where D is a subset of $R \times R^n$; u_i expresses the individual's preferences for consumption *now* versus *then*. In order to introduce uncertainty, let $(\Xi, \mathcal{F}, \Psi)$ denote the probability space for individual i, where Ξ is the set of states of nature, $\mathcal{F}$ is the event space, and Ψ is the probability measure. If the number of states of nature is finite, i.e., $\Xi = \{\xi_1, \xi_2, \ldots, \xi_n\}$, then the event space $\mathcal{F}$ is the power set, i.e., the set of all subsets of Ξ. To make the uncertainty operational, suppose that the investor can only transfer dollars between dates by buying or selling stock, bond, or insurance contracts. In this complete markets setting, suppose that a basis stock of type ξ is a promise to pay one dollar if state ξ occurs and zero otherwise, and let its price be denoted as $p(\xi)$.[5] Then the investor's budget constraint may be expressed as

$$c_{i0} + \sum_{\Xi} p(\xi)\, c_{i1}(\xi) = y_{i0} + \sum_{\Xi} p(\xi)\, y_{i1}(\xi) \tag{1}$$

The left-hand side of equation (1) represents the risk-adjusted present value of the consumption plan, while the right hand side represents the risk-adjusted present value of income. Now the investor’s constrained maximization problem can be stated as

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[4]See Fisher (1930). The Fisher model is developed under uncertainty in Hirshleifer (1965) and MacMinn and Martin (1988).

[5]These stock contracts form a basis for the payoff space.

$$\begin{aligned} &\text{maximize} \int_{\Xi} u_i(c_{i0},\, c_{i1}(\xi))\; d\Psi(\xi) \\ &\text{subject to } c_{i0} + \sum\nolimits_{\Xi} p(\xi)\; c_{i1}(\xi) = y_{i0} + \sum\nolimits_{\Xi} p(\xi)\; y_{i1}(\xi) \end{aligned} \tag{2}$$

This is the classic statement of the investor's problem; it may also be expressed in terms of a portfolio of financial contracts and more financial contracts can be introduced. As long as any new contracts are spanned by the basis stock, the financial markets remain complete. Any spanned contract has a value equal to that of a portfolio of basis stock that provides the same payoff structure *then*.[6] Hence, letting $\Pi(a, \xi)$ denote a corporate payoff *then* that depends on the state of nature and an action taken by management. That action may be an investment decision or a production decision. Both decisions are examined in the subsequent analysis. The value of the unlevered corporate payoff is $S(a)$ where

$$S(a) = \int_{\Xi} \Pi(a,\, \xi)\; dP(\xi) \tag{3}$$

and $P(\xi)$ represents the sum of basis stock prices up to state ξ. If the firm issues a zero coupon bond with a promised payment of b dollars *then*, the value of the bond issue is $B(a, b)$, where

$$B(a,\, b) = \int_{\Xi} \min\left\{\Pi(a,\, \xi),\, b\right\}\, dP = \int_{\mathrm{B}} \Pi(a,\, \xi)\; dP + \int_{\Xi\setminus\mathrm{B}} b\; dP \tag{4}$$

B represents the bankruptcy event, i.e., $\mathrm{B} = \{\xi \mid \Pi(a, \xi) < b\}$ and $\Xi\setminus\mathrm{B}$ represents the complement of the bankruptcy event relative to Ξ. The stock or equity value in this levered case is $S(a, b)$ where

$$S(a,\, b) = \int_{\Xi\setminus\mathrm{B}} \left(\Pi(a,\, \xi) - b\right)\, dP\,. \tag{5}$$

In each case the value represents a risk-adjusted present value of a contract payoff.[7]

Next we introduce insurance. Suppose the corporation faces property risks. Let the corporate payoff be $\Pi = R - L + \max\{0, L - d\}$, where R represents the quasi-rent *then* on an investment of I dollars *now*, L represents the property losses and d represents the deductible

[6] This may be demonstrated by direct calculation but it also clearly follows by a no-arbitrage argument.
[7] See MacMinn (1990) for more on this interpretation.

on the insurance; the insurance contract payoff is $\max\{0, L - d\}$. Let i denote the premium *now* on the insurance contract. In this setting, the premium value is

$$i = \int_{\Xi} \max\left\{0,\ L - d\right\}\, dP\,. \tag{6}$$

Finally, the model provides enough structure to allow the derivation of the corporate objective function that incorporates the insurance decision along with the financing and investment decisions.

Theorem 1. Suppose the corporate manager receives a salary package (y_0, y_1) and m shares of stock in the corporation *then*. Suppose the manager pursues her own self-interest in making decisions on personal and corporate account. The decisions on personal account may be separated from those on corporate account and the decisions on corporate account are made to maximize the objective function $F = S + B - I - i$.

Proof. The pursuit of self-interest yields the following constrained maximization problem:

$$\begin{gathered}\text{maximize} \int_{\Xi} u(c_0,\, c_1(\xi))\; d\Psi(\xi) \\ \text{subject to } c_0 + \sum\nolimits_{\Xi} p(\xi)\; c_1(\xi) = y_0 + \sum\nolimits_{\Xi} p(\xi)\; y_1(\xi) + S^m \text{ and } S^n + B = I + i,\end{gathered} \tag{7}$$

where S^m is the manager's equity stake and S^n is the value of the issue of new shares of stock. Letting S^o denote the current shareholder value and N denote the number of existing shares, note that

$$S^m = \frac{m}{N + m + n}\, S\,,\ S^n = \frac{m + n}{N + m + n}\, S\,, \text{and } S^o = \frac{N}{N + m + n}\, S\,. \tag{8}$$

The constrained maximization function includes the budget constraint and financing constraint, i.e., the personal account and corporate account constraints.

The Lagrange function for this constrained maximization problem is

$$\begin{aligned}L(a,\, b,\, n,\, \lambda,\, \delta) = \int_{\Xi} u\; d\Psi + \lambda\left(m_{i0} + \sum\nolimits_{\Xi} p\; m_1 + S^m - c_{i0} - \sum\nolimits_{\Xi} p\, c_1\right) \\ + \delta\left(S^n + B^n - I - i\right).\end{aligned} \tag{9}$$

Direct calculation shows that the manager makes decisions on corporate account to maximize $\lambda\, S^m + \delta\, (S^n + B - I - i)$. Direct calculation also shows that

$$\delta = \lambda \frac{m}{N}. \tag{10}$$

and it follows that

$$\begin{aligned} \lambda S^m + \delta\left(S^n + B - I - i\right) &= \lambda\left(S^m + \tfrac{m}{N}\left(S^n + B - I - i\right)\right) \\ &= \lambda \tfrac{m}{N}\left(S^o + S^n + B - I - i\right) \\ &= \lambda \tfrac{m}{N}\left(S + B - I - i\right). \end{aligned} \tag{11}$$

QED

Theorem 1 establishes a financial market version of Fisher's famous separation theorem. Like Fisher's result, this theorem shows that decisions made on corporate account are separable from decisions made on personal account. The manager will make the finance, insurance and other corporate decisions to maximize the current shareholder value S^m subject to a financing constraint. The manager's measure of risk aversion will affect the saving and portfolio decisions made on personal account, but not those decisions made on corporate account.

It is possible to see the irrelevance result in this setting. If the insurance decision is a matter of indifference to shareholders then the current shareholder value must be independent of the insurance decision. Let $U > L(\xi)$ for all ξ so that a deductible of U corresponds to no insurance. The following theorem shows that insurance is irrelevant in the absence of some of the problems addressed in subsequent sections.

Theorem 2. The current shareholder value of the uninsured firm equals that of the insured firm, in the absence of taxes, agency, and information problems.

Proof. The uninsured current shareholder value is

$$F^u(a,b,U) = -I + \int_{\Xi}\left(R - L\right)dP \tag{12}$$

The current shareholder value of the insured firm is

$$
\begin{aligned}
F(a,b,d) &= -i - I + S(a,b,d) + B(a,b,d) \\
&= -i - I + \int_{\Xi} \Pi \; dP \\
&= -\int_{\Xi} \max\{0,\ L - d\} \; dP - I + \int_{\Xi} \left(R - L + \max\{0,\ L - d\} \right) \; dP \\
&= -I + \int_{\Xi} \left(R - L \right) \; dP \\
&= F(a,b,U)
\end{aligned} \tag{13}
$$

The second equality in (13) follows by (4) and (5) while the third equality follows by (6). QED

3. Costly Bankruptcy[8]

In this section, the impacts of bankruptcy costs are considered. Suppose that there is a cost c > 0 associated with the bankruptcy event. The uninsured firm's earning is $R(a, \xi) - L(\xi)$. The bankruptcy event for an uninsured firm is $B = [0, \delta)$, where δ is the boundary of the insolvency event and is implicitly defined by the condition $R(a, \delta) - L(\delta) - b = 0$. The stock value of the levered uninsured firm's stock is *S(a,b,U)*, where

$$
S(a,b,U) = \int_{\delta}^{\omega} [R(a,\xi) - L(\xi) - b] \; dP \,, \tag{14}
$$

Similarly, the value of the levered uninsured firm's debt, given costly bankruptcy, is *B(a, b, U)*, where

$$
B(a,b,U) = \int_{0}^{\delta} \left(R(a,\xi) - L(\xi) - c \right) dP + \int_{\delta}^{\omega} b \; dP \tag{15}
$$

It follows that the total value of the levered uninsured firm is

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[8] This section is similar to MacMinn (1987).

$$
\begin{aligned}
V(a,b,U) &= B(a,b,U) + S(a,b,U) \\
&= \int_0^{\delta} \big(\mathrm{R}(a,\xi) - L(\xi) - c\big)\, dP + \int_{\delta}^{\omega} b \; dP + \int_{\delta}^{\omega} [\mathrm{R}(a,\xi) - L(\xi) - b]\; dP \qquad (16) \\
&= \int_0^{\omega} \big(\mathrm{R}(a,\xi) - L(\xi)\big)\, dP - \int_0^{\delta} c \, dP
\end{aligned}
$$

The current shareholder value is

$$F(a,b,U) = -I + V(a,b,U) \qquad (17)$$

The last term on the right-hand side of equation (16) is the risk adjusted present value of the bankruptcy costs. It may be noted that the 1958 Modigliani-Miller theorem holds here if either the bankruptcy cost is zero or the bankruptcy set is empty; otherwise, the firm's capital structure is relevant. Of course, this value does not incorporate insurance and it seems apparent that insurance allows the firm to avoid some bankruptcy costs.

Consider the value of the levered insured firm compared to the value of an otherwise identical levered uninsured firm. Suppose that the insurance is purchased before the firm levers or in conjunction with the bond issue. The insured firm purchases a policy with a deductible of *d* for the price *i*, where *i* is given by equation (6). By purchasing such a policy, the net earnings for the insured firm in any state becomes $R(a, \xi) - L(\xi) + \max\{0, L(\xi) - d\}$ $= R(a,\xi) - \min\{L(\xi), d\}$. The bankruptcy event of the insured firm is $[0, \beta)$ where β is implicitly defined by the condition $R(a, \beta) - L(\beta) + \max\{0, L(\beta) - d\} - b = 0$. Note that $\beta < \delta$. Then the value of the levered insured firm is

$$
\begin{aligned}
V(a,b,d) &= B(a,b,d) + S(a,b,d) \\
&= \int_0^{\beta} \big(\mathrm{R}(a,\xi) - L(\xi) + \max\{0, L(\xi) - d\} - c\big)\, dP + \int_{\beta}^{\omega} b \; dP \\
&\quad + \int_{\beta}^{\omega} [\mathrm{R}(a,\xi) - L(\xi) + \max\{0, L(\xi) - d\} - b]\; dP \qquad (18) \\
&= \int_0^{\omega} \big(\mathrm{R}(a,\xi) - L(\xi) + \max\{0, L(\xi) - d\}\big)\, dP - \int_0^{\beta} c \, dP
\end{aligned}
$$

Similarly, the current shareholder value is

$$
\begin{aligned}
F(a,b,d) &= -I - i + V(a,b,d) \\
&= -I - i + \int_0^{\omega} \left(\mathrm{R}(a,\xi) - L(\xi) + \max\{0, L(\xi) - d\} \right) dP - \int_0^{\beta} c \, dP \\
&= -I + \int_0^{\omega} \left(\mathrm{R}(a,\xi) - L(\xi) \right) dP - \int_0^{\beta} c \, dP
\end{aligned}
\tag{19}
$$

and the difference in current shareholder values is

$$
\begin{aligned}
F(a,b,d) \ + F(a,b,U) &= -I - i(d) + V(a,b,d) + I + i(U) - V(a,b,U) \\
&= \int_0^{\delta} c \, dP - \int_0^{\beta} c \, dP \\
&= \int_{\beta}^{\delta} c \, dP > 0
\end{aligned}
\tag{20}
$$

where $i(d)$ is the insurance premium for a deductible of d and $i(U) = 0$ is the insurance premium for a deductible of U. The increase in value, due to insurance, is simply the present value of the saving in bankruptcy costs. Hence, the firm has an incentive to insure as noted in the following theorem.

Theorem 3. A transaction cost c > 0 in the event of bankruptcy is sufficient to show that insuring increases current shareholder value.

4. Agency Problems

In this section, the use of insurance contracts in resolving conflict of interest problems between corporate manager and bondholders is analyzed. Since the corporate manager also represents the interests of stockholders, there is a potential for conflict between the manager and bondholders, or equivalently, between the manager and the bondholders' trustee. This will be the case if it is possible for the manager to take actions that benefit one group, which are detrimental to the other. If the bonds represent safe debt then there is no conflict. If not, then an agency problem may exist.

The agency relationship can be thought of as a contract between the principal, i.e., the bondholders' trustee,[9] and an agent, i.e., the corporate manager. The agent acts on behalf of the principal. The contract specifies the bounds on the actions that may be taken by the agent. If the contract covers all possible contingencies then there is no real delegation of authority and therefore no agency problem. If the contract is incomplete so that the agent has some discretion in the selection of actions then there is at least the potential for a conflict of interest. The conflict occurs because both the principal and the agent behave in accordance with their own self-interests. The principal can limit the divergence of interests by providing provisions in the contract that give the agent the appropriate incentives to act in the principal's interest; in addition, the principal can monitor the activity of the agent. However it is not usually possible to specify the contract in such a way as to completely eliminate the conflict of interest problem. Hence, it will usually be the case that there is a difference between the action taken by the agent and the action that is in the best interests of the principal. Jensen and Meckling (1976) define agency cost as the sum of the monitoring expenditures of the principal, the bonding expenditures of the agent, and the residual loss; this residual loss is the loss in the market value of the corporation.[10]

Underinvestment

The first agency problem considered here occurs when the manager makes investment decisions. Jensen and Smith (1985) note that one source of conflict is underinvestment. They observe that

> . . . when a substantial portion of the value of the firm is composed of future investment opportunities, a firm with outstanding risky bonds can have incentives to reject positive net present value projects if the benefit from accepting the project accrues to the bondholders (Jensen and Smith (1985), p. 111).

The incentive need not be so extreme that it causes the manager to reject a project; the manager may under-invest by limiting the size of the project. Suppose the firm's earnings are $\Pi(I, \xi) = R(I, \xi) - c - L(I, \xi)$, where R represents the quasi-rents from the investment projects, c represents a fixed obligation to creditors, and L represents property losses. The

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[9]The legal trustee for the bondholders may be treated as the single principal. It should be added that the trustee acts on behalf of the bondholders. The trustee's problem is the selection of bond covenants that limit the divergence of interests between corporate management and the bondholders. In general, the trustee may have a problem in selecting covenants that provide a solution to the conflict because of the different risk aversion measures of the bondholders. In the two cases considered here, however, the bondholders will unanimously support a covenant that provides management with the incentive to maximize the risk adjusted net present value of the corporation. It should also be noted that in general there might be an agency problem between the trustee and bondholders (i.e., between the agent and the principals). In the cases considered here that problem does not arise because of the unanimity.

[10]Jensen and Meckling (1976) also define the residual loss as the dollar equivalent of the loss in expected utility experienced by the principal. Although this notion of residual loss is measurable for a particular principal, this definition poses problems when a trustee represents many principals because the residual loss of any bondholder will depend on the bondholder's measure of risk aversion and on the proportion of the contract owned.

fixed obligation c may be a commitment on previously issued bonds, but it need not be limited to that. Suppose Π is increasing and concave in the investment level I. Let X denote the event that the firm cannot pay its claimants and creditors. Let B denote the firm's bankruptcy event. The event X is a subset of B. Then, with no corporate taxes, the market value of the firm's equity is $S(b, d, I)$, where

$$S(b, d, I) = \int_{\Xi \backslash \mathrm{B}} \big(\Pi + (L - d) - b\big)\, dP\,, \tag{21}$$

where $\Xi \backslash \mathrm{B} = \{\xi \in \Xi \mid \Pi(I, \omega) - (L - d) - b \geq 0\} = [\beta, \omega]$. Note that β is the boundary of the insolvency event here and will be positive even if no new debt is issued, i.e., b = 0. The market value of the corporation's creditor stake is $C(b, d, I)$ where

$$C = \int_{\mathrm{B}} \tfrac{c}{b+c} \Big(\big(\mathrm{R} - L\big) + L - d\Big)\, dP + \int_{\Xi \backslash \mathrm{B}} c\; dP\,. \tag{22}$$

Suppose that the corporate payoff *then* is the sum of the payoffs from the corporate projects or operating divisions.[11] It is possible to motivate the underinvestment problem by noting how the creditor value is affected by changing the investment level on a project. Note that the value increases in the scale of the investment if there is a positive probability of insolvency, i.e., $\mathrm{P}\{\mathrm{B}\} > 0$, since

$$\frac{\partial C}{\partial I} = \left(\frac{c}{b + c}\big(\mathrm{R}(I, \beta) - d\big) - b\right) p(\beta)\, \frac{\partial \beta}{\partial I} + \frac{c}{b + c} \int_{\mathrm{B}} \frac{\partial \mathrm{R}}{\partial I}\, dP$$

$$= \frac{c}{b + c} \int_{\doteq} \frac{\partial \mathrm{R}}{\partial I}\, dP > 0. \tag{23}$$

This inequality provides analytic content for Jensen and Smith earlier statement.

The underinvestment may be relative to either the investment that would maximize the value of an unlevered corporation, or the investment that is socially efficient.[12] The socially efficient investment maximizes the value of all the corporate stakeholders; equivalently, the socially efficient investment satisfies the following first order condition

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[11] Here it suffices to think of the payoff as being the sum of old and new project payoffs, i.e., $\Pi(I, \xi) = \Pi_o(\xi) + \Pi_n(I, \xi)$.

[12] This is efficiency in the Pareto sense. An investment is socially efficient if it is not possible to make one investor better off without making another worse off.

$$\int_{\Xi} \frac{\partial \Pi}{\partial I}\, dP - 1 = 0\,. \tag{24}$$

This condition implicitly defines an investment level I^v that maximizes the value of all the stakeholders' claims on the firm. The extent of the underinvestment will be measured relative to the level of investment indicated here.

Theorem 1 shows that the corporate manager will make the investment decision for the corporation to maximize current shareholder value, or equivalently, the risk-adjusted net present value. The objective function is [13]

$$\begin{aligned} F &\equiv B(b, d, I) + S(b, d, I) - I - i \\ &= \int_{B} \tfrac{b}{b+c} \big((R - L) + (L - d)\big)\, dP + \int_{\Xi \setminus B} \big(\Pi + (L - d)\big)\, dP - I - i \end{aligned} \tag{25}$$

The following first order condition implicitly defines the optimal investment I^m that is selected by corporate management acting in the interests of current shareholders:

$$\begin{aligned} \frac{\partial F}{\partial I} &= \int_{B} \tfrac{b}{b+c} \frac{\partial R}{\partial I}\, dP + \int_{\Xi \setminus B} \frac{\partial R}{\partial I}\, dP - 1 - \frac{\partial i}{\partial I} \\ &= \int_{\Xi} \frac{\partial \Pi}{\partial I}\, dP - 1 - \int_{B} \tfrac{c}{b+c} \frac{\partial R}{\partial I}\, dP = 0. \end{aligned} \tag{26}$$

The first order condition in equation (26) shows that the manager under-invests, equivalently, $I^m < I^v$, where I^m and I^v represent the investment levels that maximize current shareholder value and total stakeholder value, respectively.

Insurance can play an important role in alleviating the underinvestment problem. The decision sequence is critical. To ensure that current shareholders receive the benefit of positive risk-adjusted net present value investment decisions, the insurance contract must precede the investment. If insurance can be used to eliminate insolvency risk then the first order condition in (26) shows that the underinvestment problem would be eliminated. The next theorem shows that even if insurance cannot eliminate the insolvency risk and the underinvestment problem, it can be effectively used to reduce the impact of this problem.

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[13] The objective function takes the form B + S - I - i, where B denotes the value of any new debt issue. Using corporate value here is inappropriate because there can be an old debt issue.

Theorem 4. If the probability of insolvency is positive, i.e., P{B} > 0, then the optimal investment increases with insurance coverage.

Proof. It suffices to show that

$$\frac{\partial I}{\partial d} = -\frac{\dfrac{\partial^2 F}{\partial d\,\partial I}}{\dfrac{\partial^2 F}{\partial I^2}} < 0\,. \tag{27}$$

The concavity of F makes the denominator negative and so the optimal investment is decreasing in the deductible if the numerator is negative. Note that the numerator is

$$\frac{\partial^2 F}{\partial d\,\partial I} = -\tfrac{c}{b+c}\frac{\partial \mathrm{R}(I,\beta)}{\partial I}\;p(\zeta)\,\frac{\partial \beta}{\partial d} < 0\,, \tag{28}$$

and the sign in (28) follows since the quasi-rent increases in the investment and the boundary of the insolvency event increases in the deductible. QED

This theorem shows that insuring mitigates the underinvestment problem. If the firm insures and increases its investment then it protects bond and general creditor values and so facilitates the movement of all additional value from investment to existing shareholders. The theorem also suggests that full insurance is optimal.

Asset Substitution

The second agency problem considered here is typically referred to as either the asset substitution or risk-shifting problem. It is encountered by the corporation in selecting the set of assets and liabilities that constitute the firm. The problem can occur when the firm selects among mutually exclusive investment projects (e.g., MacMinn (1990)), selects a portfolio of investment projects (e.g., Green (1984)), makes operating decisions, restructures, (e.g., MacMinn and Brockett (1995), etc. Jensen and Smith note that

> . . . the value of the stockholders' equity rises and the value of the bondholders' claim is reduced when the firm substitutes high risk for low risk projects (Jensen and Smith (1985), p. 111).[14]

[14] See Green (1984) and Hirshleifer (1965) for similar statements.

Rational bondholders are aware of the incentive to shift risk and so it is reflected in a lower value for the corporation's debt issues, or equivalently, in a higher interest rate on the debt. An insurance mechanism is constructed here that can reduce or eliminate the risk-shifting incentive and so another source of the agency cost of debt.

In order to demonstrate the agency problem, suppose the corporation is considering an operating decision after its finance and insurance decisions have been made. Let q denote the operating decision *now* and let $\Pi(q, \xi)$ denote the random earnings. Suppose earnings are positive for all states.[15] Suppose also that the project satisfies the Principle of Increasing Uncertainty (PIU) (see Leland (1972); MacMinn and Holtmann (1983)); let the random payoff be defined by a function that maps the operating decision and state into earnings. Then the payoff is $\Pi(q, \xi)$ and by the PIU, $D_2\Pi > 0$ and $D_{12}\Pi > 0$.[16] These derivative properties say that the payoff increases in state as does the marginal payoff.[17] The PIU also implies that, after correcting for the changes in the expected payoff, an increase in scale increases risk in the Rothschild-Stiglitz sense.[18]

To establish the existence of the asset substitution problem consider the relationship between the scale and the level of debt. If the firm levers itself to finance the project then the stock value is S(b, q) and

$$\begin{aligned} S(b, q) &= \int_{\mathrm{B}} \big(\Pi(q, \xi) - b\big)\, dP(\xi) \\ &= \int_{\beta}^{\omega} \big(\Pi(q, \xi) - b\big)\, dP(\xi), \end{aligned} \tag{29}$$

where $B = \{\xi \mid \Pi(q, \xi) - b < 0\}$; β is the boundary of the insolvency event and is implicitly defined by the relation $\Pi(q, \beta) - b = 0$. Once the funds have been raised, the firm makes its operating decision to maximize shareholder value. The condition for an optimal operating decision is

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15The assumption $\Pi > 0$ for all $\xi \in \Xi$ simply allows the result $V^i = V^u$, for any insurance scheme, to be used here.

16 This notation denotes the partial derivative of Π with respect to its first argument and the cross partial of Π with respect to its first and second arguments, respectively.

17The state space is still assumed to be finite but it is easier to see the mean-preserving spread when Π_f is drawn as a continuous function of state.

18See Rothschild and Stiglitz (1970) for a definition of increasing risk. See MacMinn and Holtmann (1983) for a demonstration of this equivalence result.

$$\frac{\partial S}{\partial q} = \int_{\beta}^{x} \frac{\partial \Pi}{\partial q} \, dP = 0 \,. \tag{30}$$

It follows by the PIU that the output scale increases with leverage if the probability of insolvency is positive, i.e., P{Π - b < 0} > 0. To see this, note that

$$\frac{\partial q}{\partial b} = - \frac{\dfrac{\partial^2 S}{\partial b \, \partial q}}{\dfrac{\partial^2 S}{\partial q \, \partial q}} = - \frac{- \dfrac{\partial \Pi(q, \zeta)}{\partial q} \; p(\zeta) \, \dfrac{\partial \zeta}{\partial b}}{\dfrac{\partial^2 S}{\partial q^2}} > 0. \tag{31}$$

The inequality in (31) follows because the marginal payoff is negative at the boundary of the financial distress event by the PIU, the denominator is negative by the concavity of the payoff function, and the boundary state β of the financial distress event is an increasing function of leverage.

Also observe that the increase in scale reduces the debt and corporate values. The value of the bond issue is B(b, q), where

$$B(b, q) = \int_{0}^{\beta} \Pi \, dP + \int_{\beta}^{\omega} b \, dP \,. \tag{32}$$

The corporate value is

$$V(q) = B(b, q) + S(b, q) = \int_{0}^{\omega} \Pi \, dP \,. \tag{33}$$

The operating scale affects the probability of distress and the bond payoff in the distress event. Note that

$$\frac{\partial B}{\partial q} = \int_{0}^{\beta} \frac{\partial \Pi}{\partial q} \, dP < 0 \tag{34}$$

by the PIU. Hence, the increase in risk suffices to reduce the bond value. The same increase in risk, of course, increases the stock value. Although it may be less apparent, the increase in risk reduces the corporate value if the probability of financial distress is positive. To see this, observe that equation (21) implicitly defines operating scale that maximizes the stock value; let q^s denote that scale. The next equation implicitly defines that operating scale that maximizes the corporate value; let q^v denote that scale:

$$\frac{\partial V}{\partial q} = \int_0^{\omega} \frac{\partial \Pi}{\partial q}\, dP = 0\,. \tag{35}$$

By comparing equations (30) and (35), it is apparent that the PIU yields $q^s > q^v$ and so $V(q^s) < V(q^v)$. Therefore, in the absence of any mechanism to avoid the agency problem, the levered corporation has an incentive to increase the scale of its operation and so increase the risk of its debt issues. The agency cost of debt, in this case is $V(q^v) - V(q^s)$.

Now, consider whether a bond covenant requiring insurance can be written in a way that eliminates the risk-shifting problem. Let i denote the insurance premium. Without the insurance the corporate payoff is $\Pi(q, \xi) = R(q, \xi) - L(\xi)$, where R and L represent the quasi-rent and property loss, respectively. With insurance, the corporate payoff is $R - L + \max\{0, L - d\}$ where d is the deductible on the insurance. The insurance premium is the risk-adjusted presented value of the net loss, i.e.,

$$i = \int_0^{\omega} \max\{0,\, L - d\}\, dP\,. \tag{36}$$

The corporation makes the finance and insurance decisions *now*, knowing the impact that those decisions have on the subsequent production decisions. Green (1984) and MacMinn (1993) have shown that convertible bonds can be used to solve the risk-shifting problem. MacMinn (1987) showed that insurance contracts can also solve the risk-shifting problem. It is also possible to eliminate the problem by issuing equity rather than debt. Hence, there are capital structure choices that are not considered in the literature. The analysis here is a generalization of the literature.

Theorem 5. If the probability of insolvency is positive, i.e., $P\{B\} > 0$, then insuring the property risk is optimal.

Proof. Recall that the corporation makes an insurance decision and capital structure decision and subsequently makes the production. The production decision is a function of the leverage and insurance decisions. Hence, the condition for an optimal insurance decision is

$$\begin{aligned} \frac{\partial F}{\partial d} &= \frac{\partial V}{\partial q}\frac{\partial q}{\partial d} + \frac{\partial V}{\partial d} - \frac{\partial i}{\partial d} \\ &= \int_0^{\omega} \left(\frac{\partial R}{\partial q}\frac{\partial q}{\partial d} - 1 \right) dP + \int_0^{\omega} dP = 0. \end{aligned} \tag{37}$$

Evaluating this derivative at q^s yields

$$\frac{\partial F}{\partial d} = \frac{\partial q}{\partial d} \int_0^{\beta} \frac{\partial R}{\partial q}\, dP < 0 . \qquad (38)$$

The sign follows because the operating scale increases in the deductible and the marginal payoff or quasi-rent is negative in the financial distress event. Therefore a positive probability of financial distress makes it optimal, *ceteris paribus*, to purchase insurance. QED

Theorem 4 represents one more example of the link between finance decisions and operating decisions. This particular application of the risk-shifting problem is very common and the result shows that insurance can be effective in mitigating the effects of risk-shifting and so credibly committing the firm to a particular operating decision. The theorem shows that the insurance allows the current shareholder value to be increased despite the fact that, viewed by itself, the insurance is a zero risk-adjusted net present value decision. It may also be observed that the theorem implies that it is optimal to increase the insurance coverage as long as there is any insolvency risk; this, in turn, implies that full insurance is optimal if it does not eliminate the insolvency risk.

5. Tax Asymmetries

The tax model has traditionally been the most important in corporate finance. The corporate tax motivates the use of debt and helps explain the optimal use of that contract either in the small or in the large. In the insurance literature either the convex random tax liabilities or differences in capital gain versus income tax rates are used to show that insurance can add value. A different perspective is provided here by introducing a second source of risk. The risk that has been introduced in the previous sections is an economic index and can be thought of as a market risk. The property risk[19] may arise as a consequence of accident or weather conditions and so be modeled with another index. That is the approach taken here.

In the economy constructed here the state space is expanded so that $(\xi, \zeta) \in \Xi \times Z$; ξ, as before, is interpreted as an index of economic conditions and $\Xi = [0, \omega]$ is the set of these index numbers. The state ζ represents an accident state and $Z = \{0, 1\}$ is the set of these states. The pure or equivalently accident risk is a random variable $\Lambda: Z \to R$.[20] Let $\Lambda(0) = 0$ and $\Lambda(1) = L$. The corporate payoff is $\Gamma = \Pi - \Lambda$, where Π is the random corporate payoff without the accident risk. This generalization of the financial model

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19 Pure risk, accident risk, and property risk are used synonymously here.

20 Any random variable may be interpreted as a function mapping index numbers into the real line. A speculative risk maps Ξ into the real line while a pure risk maps Z into the real line.

introduces a new valuation problem. Even if investors purchasing stock in the corporation know that a particular economic state will occur *then*, the corporate payoff is still uncertain until the accident state has been resolved. The introduction of a pure risk causes incompleteness in an otherwise complete financial market system. If the corporation does not hedge or otherwise insure the property risk then risk averse investors will hedge it. The financial values expressed here are a consequence of that hedging behavior.[21]

Suppose the property loss L occurs with probability θ so that no loss occurs with probability $1 - \theta$. Suppose the loss L is large enough so that there is a positive probability of bankruptcy if the accident occurs but not so large that there is a positive probability of bankruptcy if the accident does not occur.[22] Let the tax liability of the corporation be denoted by $T = t\max\{0, \Pi - b - \Lambda\}$ where t is the tax rate; this assumes that the principle and interest are deductible.[23] The equity payoff is $\Pi - b - \Lambda - T$ and so the stock value is[24]

$$\begin{aligned} S = &\int_0^{\delta} \Big((1-\theta)(1-t)\big(\Pi(q,\xi) - b\big)\Big)\, dP \\ &+ \int_{\delta}^{\omega} \Big((1-\theta)(1-t)\big(\Pi(q,\xi) - b\big) + \theta\,(1-t)\big(\Pi(q,\xi) - b - d\big)\Big)\, dP \end{aligned} \tag{39}$$

where δ is the boundary of the bankruptcy event and is implicitly defined by the condition $\Pi(q, \delta) - b - L - T(b, d, q, \delta) = 0$. The after-tax value of the firm is

$$\begin{aligned} V = &\int_0^{\delta} \Big((1-\theta)(1-t)\,\Pi + (1-\theta)\,t\,b + \theta\big(\Pi - d\big)\Big)\, dP \\ &+ \int_{\delta}^{\omega} \Big((1-t)\Pi + t\,b - \theta(1-t)\,d\Big)\, dP. \end{aligned} \tag{40}$$

Let the corporate objective be the current shareholder value $F = V - I - i$, as before, but where corporate value is now specified by equation (40). Here, as elsewhere, suppose the manager makes the financing decisions then the operating decisions.

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[21] See (MacMinn 1999) for on the hedging behavior that provides these values.

[22] The probability of bankruptcy is endogenous and so to be complete one would have to allow for a positive probability of bankruptcy for any accident loss as long as the leverage is sufficient. That generality is not necessary to make the point that is demonstrated here.

[23] The assumption is only made to simplify the analysis and make the models here approximately the same.

[24] Note that the shareholders may receive a payoff in what has been called the bankruptcy event. Now, however, the bankruptcy event also depends on whether or not an accident occurs.

The manager, acting in the interests of current shareholders, makes the finance and insurance decisions to maximize the objective function *F*. The first order condition for a bond issue is

$$\frac{\partial F}{\partial b} = (1-\theta)\, t \int_0^{\delta} dP + t \int_{\delta}^{\omega} dP + \frac{\partial q}{\partial b}\left\{\int_0^{\delta} \left((1-\theta)(1-t)\frac{\partial \Pi}{\partial q} + \theta \frac{\partial \Pi}{\partial q}\right) dP + \int_{\delta}^{\omega} (1-t)\frac{\partial \Pi}{\partial q}\, dP\right\}$$

$$= (1-\theta)\, t \int_0^{\delta} dP + t \int_{\delta}^{\omega} dP + \frac{\partial q}{\partial b}\left\{\int_0^{\delta} \theta \frac{\partial \Pi}{\partial q}\, dP\right\}. \tag{41}$$

The second equality in equation (41) follows due to the subsequent first order condition for an optimal output. The first two terms on the right hand side of equation (41) represent the marginal value of the debt tax shelter while the last term on the right hand side represents the marginal agency cost of the bond issue. Equation (41) implies the result that the firm issues bonds and pushes the bond issue to the point at which the marginal value of the tax shelter equals the marginal cost of the agency problem. Hence, *ceteris paribus*, equation (41) implies a risky debt issue.

The manager also makes an insurance decision to maximize current shareholder value. The first order condition is

$$\frac{\partial F}{\partial d} = -\theta \int_0^{\delta} dP - (1-t)\,\theta \int_{\delta}^{\omega} dP + \theta \int_0^{\omega} dP$$

$$+ \frac{\partial q}{\partial d}\left\{\int_0^{\delta} \left((1-\theta)(1-t)\frac{\partial \Pi}{\partial q} + \theta \frac{\partial \Pi}{\partial q}\right) dP + \int_{\delta}^{\omega} (1-t)\frac{\partial \Pi}{\partial q}\, dP\right\} \tag{42}$$

$$= \theta\, t \int_{\delta}^{\omega} dP + \frac{\partial q}{\partial d}\left\{\int_0^{\delta} \theta \frac{\partial \Pi}{\partial q}\, dP\right\}.$$

The second equality follows due to the subsequent first order condition for an optimal output. The first term on the right hand side of equation (42) represents the marginal value of the tax shelter while the second term on the right hand side represents the marginal agency cost. Equation (42) implies the result that the firm increases its deductible, equivalently, reduces its insurance to the point at which the marginal value of the tax shelter equals the marginal agency cost. Equation (42) does not yield a conclusion like the bond issue equation because setting the deductible to zero does not eliminate the default risk; the contrary is more nearly true.

Despite the limitations in interpreting the first order condition in equation (42), it is possible to demonstrate a demand for insurance in this version of the model. It is possible for the firm to increase its leverage with a bond issue and counter the increase in the agency cost by simultaneously increasing its insurance coverage. A one to one trade-off in the size of the bond issue and the size of the deductible suffices to eliminate the agency cost at the margin and to increase the value of the tax shelter. Hence, there is a tax driven demand for insurance. The result is summarized in the following theorem.

Theorem 6. The corporate tax suffices to generate a demand for insurance.

Sketch of Proof. Suppose that for every dollar increase in leverage, the firm reduces the deductible by a dollar. Then the firm can generate an increase in value. Letting v = (1, - 1) and D_vF denote the derivative of the objective function in the direction v, observe that[25]

$$D_v F(b,d) = \frac{\partial F}{\partial b} - \frac{\partial F}{\partial d} = (1-\theta)\ t \int_0^{\omega} dP > 0. \qquad (43)$$

follows by direct calculation. QED

Theorem 5 shows a rather strong motivation to insure. The property risk represents a risky tax shelter while the bond represents a certain tax shelter; the theorem shows that it is optimal to replace a risky with a safe tax shelter.[26] This is an intuitive result but it does require the introduction of the second index and so it is not a result that has been reported in the literature. It should be noted that the direction the financing takes, i.e., v = (1, - 1), does isolate the effect from the agency cost of debt because the probability of bankruptcy is held constant. Once the exchange of tax shelters is complete the firm still has the incentive specified in (41) to increase the size of the debt issue to the point at which the marginal benefit due to the tax shelter equals the marginal agency cost of the debt.

6. Concluding Remarks

The notion of risk management implies that the corporation plays an active role in reducing the risk of the corporate payoff in much the same way that an individual investor would reduce risk by diversifying his portfolio. The analysis here shows that it is not always necessary for the corporation to actively pursue any risk reduction policy (i.e., risk management is irrelevant). This is the case if the corporation's risk management operation does not affect the payoffs that investors can achieve by diversifying their own portfolios. The first and most naive version of the financial markets model demonstrates this case.

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[25] The derivative of a function in a direction v = (v_1, v_2) is $D_v F = v_1 D_1 F + v_2 D_2 F$.

[26] Of course, it should be recalled that the principal and interest are being deducted here. In a setting in which only interest on debt is deductible a similar result should hold if the interest rate, i.e., coupon interest on the issue, is sufficiently large relative to the probability of the loss.

The corporation has an active role to play in managing risk if it can alter the payoff distribution in a way that investors cannot duplicate on personal account. In the sections on costly bankruptcy and agency problems, the analysis shows that minor modifications of the financial markets model provide the corporation with an incentive to purchase insurance. Two results emerge from the analysis. The first is that current shareholder value is greater for an insured than an uninsured firm in an economy with costly bankruptcy. This is the case because the firm can reduce the bankruptcy cost and this is something that individual investors cannot achieve on personal account. This result is not substantially altered by the introduction of a corporate tax and debt. The second result is that insurance may be used to reduce or eliminate some of the agency costs of debt. The corporate manager who selects the investment level can alleviate the underinvestment problem by insuring and so increase current shareholder value. This agency cost is like a deadweight loss; in the process of eliminating it the manager can make all the corporate claimholders better off. The asset substitution, or equivalently, risk-shifting problem can also be alleviated by insuring. The analysis here shows that the firm with bankruptcy risk will, *ceteris paribus*, over-produce. The firm can increase current shareholder value by providing a credible commitment that it will not over-produce and insurance represents one way of providing such a credible commitment.

Although this model is based upon conventional indemnity contracts, in recent years there has been a proliferation of new derivative securities such as catastrophe bonds, exchange-traded catastrophe options, credit derivatives and weather derivatives that can be expected to play increasingly important roles in the management of risk. The catastrophe (CAT) instruments have been used primarily by insurers and re-insurers to expand reinsurance capacity for catastrophes, but there is every reason to expect non-insurance companies that are already accustomed to hedging financial risks with derivatives to consider the CAT instruments, credit and other derivatives as viable alternatives to conventional indemnity contracts. Doherty (1997b) notes that by linking payoffs to indices that are correlated with the insured's loss but over which the insured has little control, such instruments help to resolve moral hazard problems. This benefit must be traded off against basis risk. While the current model does not incorporate alternative risk transfer mechanisms such as derivatives, the framework provided is robust enough to accommodate such instruments and would be a very fruitful avenue for future research.

While a fair amount of attention has been paid to developing theories concerning the corporate demand for insurance, the empirical implications of these theories have largely gone untested. This has primarily been due to the difficulty in obtaining data on corporate insurance purchases. Mayers and Smith (1990) and Garven and Lamm-Tennant (1999) attempt to overcome this problem by examining the demand for reinsurance by insurance companies.[27] While these authors report empirical results that are not inconsistent with the bankruptcy and agency cost theories, unfortunately it is not possible to unambiguously distinguish empirically between these theories.[28] Furthermore, Garven and Lamm-Tennant's results on tax convexity are inconclusive. Studies of the corporate demand for insurance by non-financial firms that have some bearing on the theories presented here have been conducted by Davidson, Cross, and Thornton (1992), Core (1997) and Yamori (1999). Davidson *et al.* find no evidence that the purchase of insurance affects the cost of equity capital, a result that is consistent with the notion that shareholder risk aversion does not motivate the corporate demand for insurance. Core finds, among other things, that firms with higher financial distress probabilities are more likely to purchase directors' and officers' liability insurance. Yamori reports that more highly levered firms insure more, but like Garven and Lamm-Tennant his results on tax convexity are inconclusive. Future empirical research in this area will need to focus upon building empirical models that make use of better databases that have less severe data limitations as well as accomplish a better job of empirically discriminating between the theories discussed in this survey.

[27]Data availability is a less severe problem in this industry because insurance companies are required by regulatory fiat to systematically report their reinsurance transactions.

[28]Mayers and Smith find, among other things, that firms with lower Best's ratings reinsure more, while Garven and Lamm-Tennant find that more reinsurance is demanded the higher the firm's leverage and the lower the correlation between the firm's investment-returns and claims-costs.

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