Liability Rules and Corporate Risk Management

by

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INTRODUCTION

The U. S. liability system has been described as an attempt to use one mechanism to perform two functions, i.e., accident prevention and compensation (Calfee & Winston, 1988) . The liability system may also be depicted as a mechanism that allocates risk bearing. An effort may be made to structure the allocation of risk bearing through the liability system to achieve the prevention and compensation goals. The primary purpose, however, of a financial market system is also the allocation of risk bearing. The allocation of risk bearing specified by a liability system may alter or be altered by the operation of the financial market system. Therefore, the liability and financial market systems cannot be viewed in isolation as has been the case in the literature. The interplay of these systems in allocating risk is explored here.

The nature of the interaction between the liability and financial market systems has not been investigated. The success of the liability mechanism in achieving the goal of either prevention or compensation depends on whether it transmits a consistent set of signals or incentives through the legal and financial market systems. The purpose here is to show how the strict liability and negligence rules provide incentives to corporate managers and influence their decisions, in a financial market setting. The purpose is also to show how effective the rules are in generating efficient allocations of risk and resources.

It is possible to claim that the assignment of liability in a financial market setting is irrelevant. The Coase theorem demonstrates the irrelevance of liability rules while the 1958 Modigliani-Miller theorem demonstrates the irrelevance of a firm's capital structure (Coase, 1960; Modigliani & Miller, 1958) . The Coase theorem is to law and economic what the 1958 Modigliani-Miller theorem (MM 58) is to finance. It must be observed, however, that the MM 58 theorem does not typically hold in the presence of agency problems and that the analysis in the Coase theorem starts with the existence of an agency conflict. The Coase theorem says that the allocation of resources is efficient and independent of the assignment of liability. The law and economics literature provides a partial demonstration of the Coase theorem. For example, it shows that a strict liability case yields an efficient allocation; the proof is not completed by showing that the no liability case also yields an efficient allocation. In fact, the Coase theorem provides little guidance in showing how the incentive problem in the no liability case is resolved. The analysis here shows that without further contracting the strict liability case does not always yield an efficient allocation. It is also clearly true that without further contracting the no liability case does not yield an efficient allocation. Therefore, even if one accepts the Coase theorem, the two situations imply that different contracts must be written to resolve the conflict of interest problem.[1] Hence the nexus of contracts that define the corporation in the two situations are different. Thus, the composition of the contract set is relevant. This analysis takes the first step toward establishing the relevance of the contract set by showing that in the absence of further contracting two of the most well known liability rules can yield different allocations both of which are inefficient.

Two of the most well-known liability rules are analyzed here in a financial market framework. In the law and economics literature, both the strict liability and the negligence rules have been shown to generate the socially efficient accident prevention decisions (Shavell, 1987). In a financial market framework, however, the success of any liability rule in achieving its prevention and compensation goals depends on whether the allocation of risk specified by the rule is supported or reversed in the financial markets. While a liability rule specifies an allocation of risk, the allocation of risk is also affected by the corporation's capital structure. The capital structure affects the manner in which the liability rule apportions risk among the corporation's security holders. The analysis here shows that both the liability rule and the corporate capital structure have an impact on the investment decisions made by the corporation. In a setting where financial distress is important, the analysis shows that neither liability rule generates a socially efficient investment decision.[2] Therefore, the analysis here takes a first step in showing that an incentive problem exists and that some institutional arrangements, that have been shown to solve incentive problems in other contexts, are not robust to a financial market framework.

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[1]The literature on the Coase theorem is rather extensive and the theorem is not universally accepted. For example, see (Aivazian & Callen, 1981; Coase, 1981; Farrell, 1987; Gould, 1975; Hansmann, 1977; Illing, 1992; Inada & Kuga, 1973; Magnan & Jean, 1986; Samuelson, 1985; Schweizer, 1988; Vind, 1992; Wohar, 1988) .

[2] A decision is socially efficient if it maximizes the value of all stakeholders in the corporation including liability claimants. A set of socially efficient decisions in the economy would yield a Pareto efficient allocation of resources.

In the next section, the financial market model is constructed. The standard model in which one agent causes an accident is re-framed in a financial market setting. The story is told in terms of an accident prevention example but is more general. In order to create an incentive for trading in financial markets and allow for an accident, two sources of risk are introduced. One source of risk is common to all securities and motivates investors to form diversified portfolios. The other source of risk is introduced to allow for random damages due to accidents; this second source of risk causes some incompleteness in an otherwise complete set of financial markets and either motivates risk averse investors to form option portfolios to hedge that risk or firms to purchase insurance to hedge the risk. The diversification and hedging decisions generate the corporate values demonstrated in this section and the security values in the next. In following section, the strict liability and negligence rules are analyzed in a setting where financial distress is important. In addition to showing that neither rule motivates an efficient decision, the analysis shows that the negligence rule motivates a decision identical to that of strict liability. Further, increasing the required level of care necessary to avoid negligence does not affect the manager's choice of a care level. Finally, the analysis also shows that an increase in the risk of the corporate payoff reduces the manager's choice of a care level; in the absence of insolvency risk, the manager's choice of care is independent of the increase in market risk. The last section contains some concluding remarks.

THE FINANCIAL MARKET MODEL

Consider a financial market model in which corporate managers make investment and financing decisions *now* and receive the payoffs on those decisions *then*. The model will focus on corporations, i.e., injurers, that might cause accident losses for victims. These corporations can lower the probability of accidents by investing in accident prevention. The victims cannot affect the accident probabilities and so the analysis will focus on the injurer.

These corporations raise money for their investments by selling securities to risk averse investors. Trading in securities occurs *now* and the payoff on the securities occurs *then*. The security payoffs are random. The trading process allows risk averse investors to share the risks and determine security values *now*. This valuation process gives the corporate managers, who act in the interests of shareholders, an incentive to make decisions on corporate account that maximize current shareholder value.[3]

The following notation will be used in the development of the model:

$\xi \in \Xi$	economic state variable and set
$\zeta \in Z$	accident state variable and set
$F(\zeta)$	distribution of accident states
$\Pi(\xi)$	payoff *then*; $\Pi' > 0$
x	level of care
c(x)	cost of care; $c' > 0$, $c'' > 0$
ℓ	loss; $\ell > 0$
b	promised payment *then* on bond issue
$\lambda(x)$	accident probability
$p(\xi)$	basis stock price

The classic Fisher model of financial markets assumes the existence of a state variable ξ that affects all security payoffs. Suppose that there are at least as many securities as states and that the securities are linearly independent in ξ. Then the financial markets are said to be complete. Given complete financial markets, it is possible to construct a set of securities, subsequently called the basis securities, that payoff one dollar in a state ξ and zero otherwise; $p(\xi)$ is the price *now* of such a security and is hereafter referred to as a basis stock price. Risk averse investors determine the basis stock prices $p(\xi)$ for all $\xi \in \Xi$. In the

[3]The assumption that the manager acts in the interests of shareholders is maintained throughout this analysis. If there is no new stock issue then stock value and current shareholder value are equivalent. If there is a new stock issue then current shareholder value refers to the value of the old shares.

absence of the accident risk that is introduced subsequently, it is possible to express all security values as values of portfolios of basis securities that have the same payoff structure.

Next, consider the accident states. Let the set of accident states Z have the compact support [0, z]. Suppose that the states $\zeta \in [0, x]$ corresponds to the no accident event given the care level x. Then the accident probability is

$$\lambda(x) = \int_x^z dF(\zeta) \tag{1}$$

and given the fixed loss ℓ, the expected loss is $\lambda(x)\,\ell$.

If the firm is not liable for the accident losses then its corporate value is V(x), where

$$V(x) = \int_0^\omega \Pi(\xi)\, dP(\xi)$$

where $\Xi = [0, \omega]$ and $P(\xi)$ is the sum of the basis stock prices from zero to ξ.[4] The current shareholder value is S(x) where

$$S(x) = -\,c(x) + \int_0^\omega \Pi(\xi)\, dP(\xi)$$

The c(x) represents both the cost of care and the value of either the debt or stock issue necessary to finance the investment in accident prevention. If the firm is liable for accident losses then this otherwise complete financial market model becomes incomplete and valuing the financial instruments of a corporation is problematic.[5]

Consider the strict liability case. If no accident occurs then the corporate payoff is $\Pi(\xi)$ while if an accident does occur then the corporate payoff is $\Pi(\xi) - \ell$. Let Γ denote this random payoff. Then

$$\Gamma = \begin{cases} \Pi & 1-\lambda \\ \Pi - & \lambda \end{cases}$$

A simple basis stock portfolio cannot duplicate this corporate payoff. One can argue that portfolio diversification solves this problem but that begs the question of how to value the corporation. One can argue that the problem can be eliminated with corporate insurance but that begs the question of how to value the insurance premium and so how to value the corporation.

Consider how risk averse investors can hedge the additional source of risk due to the accident if the corporation has no debt in its capital structure and is liable for the accident.[6] Let $E\{\Gamma \mid \xi\}$ be the expected payoff conditional on a particular state ξ. Suppose the investor goes long in put options and short in call options and the options have the exercise prices $E\{\Gamma \mid \xi\}$. Then the payoff on a long position in the corporate stock combined with the option positions is

$$\Gamma + \max\{0, E\{\Gamma|\xi\} - \Gamma\} - \max\{0, \Gamma - E\{\Gamma|\xi\}\} = E\{\Gamma|\xi\}$$

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[4] It is obvious in this case that the firm optimally selects x = 0.

[5] It should also be noted that if the injurer is not liable for the loss and the victim is a corporation then valuing the victim corporation is problematic. Hence, the introduction of accident states yields incomplete markets independent of who is liable.

[6] The same principle can be applied in other cases where the capital structure of the firm is more complex.. Other capital structures are considered in the subsequent analysis.

where $E\{\Gamma \mid \xi\} = (1 - \lambda)\,\Pi + \lambda\,(\Pi - \ell) = \Pi - \lambda\,\ell$. Therefore, this hedge portfolio allows the investor to eliminate the accident risk and generate a portfolio payoff that only depends on the economic state variable. Since risk averse investors prefer the expected value of a risk to the risk, such a hedge is optimal and the current shareholder value may be expressed as [7]

$$S_e(x) = -\,c(x) + \int_0^{\omega} \big)\Pi(\xi) - \lambda(x)\,\big)\; dP(\xi) \qquad (2)$$

if $\Pi(\xi) - \ell \geq 0$ for all $\xi \in \Xi$. Decisions that maximize the corporate value S_e make all stakeholders better off and are socially efficient. The investment in accident prevention that maximizes S_e will be referred to as the socially efficient decision. It will be denoted by x_e and will be treated as a benchmark.

It is also possible to hedge the risk on corporate account rather than the investors hedging on personal account. Consider the following hedging scheme. Suppose the firm constructs a portfolio of put options with an exercise price $\Pi(\xi)$ in each state ξ. The payoff on the corporation plus the payoff on the put portfolio is $\Gamma + \max\{0, \Pi(\xi) - \Gamma\} = \Pi(\xi)$. Hence, this portfolio of put options eliminates the accident risk and the current shareholder value is

$$S(x) = -\,P + \int_0^{\omega} \Pi(\xi)\, dP(\xi)$$

where P is the value of the put option portfolio. This put portfolio can also be interpreted as an insurance contract. Notice that

$$\max\{0, \Pi - \Gamma\} = \max\{0, \ell\}$$

Hence, the payoff on the put portfolio is zero if no loss occurs and the loss if it does occur. Also observe that indicates that the contract could have been written on the accident states rather than the economic states. This would have allowed the firm to write one contract rather than writing a put option for each economic state. This process is similar in spirit to what Arrow demonstrated (Arrow, 1963). Recall that Arrow showed that the same efficient allocation of resources could be achieved by a stock market economy as by a contingent claims economy and that the number of contracts required to achieve the allocation was smaller for the stock market economy! Condition also shows that the value of the insurance contract must be equivalent to the value of the put option portfolio and so it provides a method for determining the premium!

LIABILITY RULES

Liability rules are designed both to prevent accidents and to compensate victims when there is an accident. The rules perform these functions by allocating risk among the affected agents. Financial markets, however, also allocate risks among agents. Since the role of financial markets in allocating risks has not been considered in conjunction with liability rules, the interaction of these two mechanisms has not been explored. The success of any liability rule in achieving its prevention and compensation goals depends on whether the allocation of risk specified by the rule is supported, reversed or otherwise modified in the financial markets. While a liability rule specifies an allocation of risk, the allocation of risk is also affected by the corporation's capital structure. The capital structure affects the manner in which the liability rule apportions risk and value among the corporation's stakeholders. Therefore, both the liability rule and the corporate capital structure have an impact on the investment decisions made by the corporation.

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[7] It is a little more complicated than this in this uncertainty version of the Fisher model because expected utility is a function of consumption *now* and *then*; both consumption terms are affected by the portfolio choices and consumption *then* is a random variable. This hedging behavior, however, may be shown to leave consumption *now* unaltered while replacing the risk *then* with the expected value of the risk.

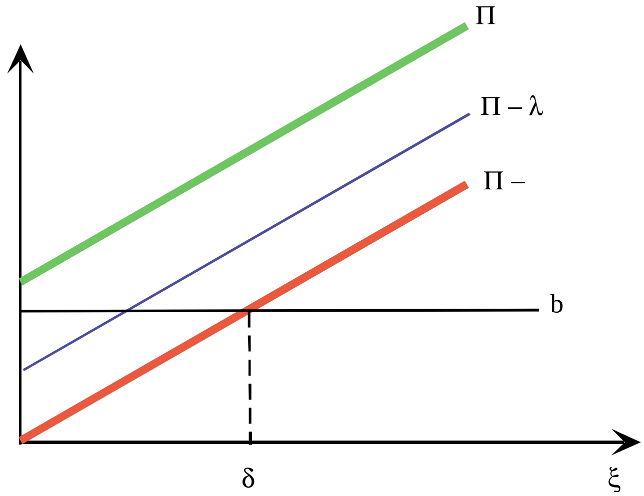
The purpose in this section is to provide an analysis of the impact that two well-known liability rules have on decisions made by the corporate manager in a financial market setting.[8] The strict liability and the *ex ante* version of the negligence rule are considered here first for an unlevered and then a levered firm. In the law and economics literature, Shavell and others have shown that strict liability leads to an efficient level of care decision (Shavell, 1987) . Shavell and others have also shown that the *ex ante* version of the negligence rule can also motivate an efficient care decision if the level of due care is appropriately specified. The preliminary analysis here shows that these conclusions cannot be extended to a financial market framework without qualification.

Strict Liability

Given a strict liability rule, the corporation bears the loss ℓ if an accident occurs. If there is a positive probability that the firm's asset value does not cover the loss *then*, shareholders are protected by limited liability and the corporation does not bear the entire loss. Therefore, limited liability increases stock value and affects the manager's investment decisions.

Suppose the corporation is levered and the bond issue specifies a promised payment of b dollars *then*. Suppose that $P\{\Pi - b \geq 0\} = 1$ and $P\{\Pi - b - \ell \geq 0\} < 1$. Then the corporation faces insolvency in the accident event but not otherwise. This liability rule necessitates some hedging by bondholders and stockholders or by the corporation. The capital structure apportions the risk between the two groups of security holders.

Figure 1: The Corporate Payoff and Loss



For states $\xi < \delta$ the equity payoff is Π - b if there is no accident and zero otherwise. Then the hedged equity payoff is $(1 - \lambda)(\Pi - b)$. For states $\xi \geq \delta$ the equity payoff is Π - b if there is no accident and $\Pi - b - \ell$ otherwise. Then the hedged equity payoff is $(1 - \lambda)(\Pi - b) + \lambda(\Pi - b - \ell)$. The current shareholder value of the strictly liable levered firm is $S_s(b, x)$ where

$$S_s = -c(x) + \int_0^{\delta} \big(1 - \lambda(x)\big)\big(\Pi(\xi) - b\big)\, dP(\xi) + \int_{\delta}^{\omega} \big(\Pi(\xi) - b - \lambda(x)\ell\big)\, dP(\xi) \qquad (3)$$

The corporate manager, acting in the interests of the shareholders, selects the care level to maximize stock value. The optimal care is implicitly defined by the condition

[8] This is a partial partial equilibrium analysis in the same sense that Rothschild used the expression (Rothschild, 1973) ; it is neither a general nor a partial equilibrium analysis. The analysis is pursued with the usual claim that although the first order effects may be modified in a more general setting they will not be reversed.

$$\frac{\partial S_s}{\partial x} = - c' - \lambda' \int_0^\delta [(\Pi(\xi) - b)] \, dP(\xi) - \lambda' \int_\delta^\omega dP(\xi) = 0 \quad (4)$$

Let x_s be the care level implicitly defined by. The socially efficient level of care x_e is the care level that maximizes the corporate value in (2). Hence, the socially efficient level of care is implicitly defined by the following first order condition

$$\frac{\partial S_e}{\partial x} = - c' - \lambda' \int_0^\omega dP = 0 \quad (5)$$

Recall that x_e denotes the socially efficient investment in accident prevention. If the corporate manager chooses a smaller or larger investment then it will be referred to as under-investment or over-investment, respectively. The next theorem shows that corporate leverage dilutes the manager's incentive to invest in accident prevention.

Theorem 1. Given strict liability, the manager of a levered corporation under-invests in accident prevention if the probability of insolvency is positive, i.e., $P\{\Pi - \ell < b\} > 0$.
Proof. It suffice to note that

$$\frac{\partial S_s}{\partial x} - \frac{\partial S_e}{\partial x} = - \lambda' \int_0^\delta [(\Pi(\xi) - b - \;)] \, dP(\xi) < 0$$

QED

Next, consider the relationship between the optimal investment x_s and the firm's leverage.

Theorem 2. Given strict liability, the optimal investment in accident prevention is a decreasing function of leverage, i.e., $x_s'(b) < 0$, if the probability of insolvency is positive.
Proof. The first order condition in (4) implicitly defines the relationship between x_s and b. If the second partial of stock value with respect to the accident prevention level is negative then

$$\frac{\partial^2 S_s}{\partial x \partial b} + \frac{\partial^2 S_s}{\partial x^2} \frac{\partial x_s}{\partial b} = 0$$

Equivalently,

$$\frac{\partial x_s}{\partial b} = - \frac{\dfrac{\partial^2 S_s}{\partial x \partial b}}{\dfrac{\partial^2 S_s}{\partial x^2}}$$

It follows that x_s is decreasing in b if and only if the numerator is negative.

$$\frac{\partial^2 S_s}{\partial x \partial b} = \lambda' \int_0^{\delta} dP(\xi) - \lambda' \left[\Pi(\delta) - b\right] p(\delta) \frac{\partial \delta}{\partial b} + \lambda' \quad p(\delta) \frac{\partial \delta}{\partial b}$$
$$= \lambda' \int_0^{\delta} dP(\xi) \tag{6}$$
$$< 0$$

The second equality in (6) follows by direct calculation since $\Pi(\delta) - b = \ell$. QED

Theorem two shows the linkage between the leverage decision and the accident prevention decision. The leverage does, *ceteris paribus*, dilute the incentive to prevent accidents. This result follows because of the structure of the decision. The investment expenditure is incurred *now* and so there can be no dilution in the cost; the loss, however, occurs *then* and can be no greater than the corporate payoff. If the loss is large enough to cause insolvency in some states then not all of the loss is borne by the security holders. A smaller loss at the margin then implies a smaller investment in prevention as the theorem shows.

Negligence

Consider an ex ante version of the negligence rule. Under a negligence rule the injurer is held liable for the losses only if two conditions are satisfied (Kahan 1989). First, the injurer must have acted negligently, i.e., must have exercised less than **due care**, where **due care** is specified by the courts. Second, the injurer's negligence must have caused the accident, i.e., the accident would not have occurred in the absence of the negligence. Both conditions play a role in developing the probability of being found liable.[9]

Although Kahan did not develop the probability of being found liable, he did tell a story which distinguishes between the two conditions and which will be used here to motivate the probability. Consider accidents in which a cricket ball flies over a fence surrounding the playing field and causes damage. Suppose the fence must be ten feet tall for the owner of the cricket field to avoid negligence. The cricket field owner is only liable for accidents that are caused by her negligence. Hence, if the fence is built nine feet high then the owner is only liable for damages caused by balls that fly over the fence between nine and ten feet. Let t denote the event that a ball flies over the fence at a height of t feet and causes damage; let F(t) be the distribution function. Similarly, interpret x as the fence height selected by the field owner. Then the accident probability is $\lambda(x)$ where

$$\lambda(x) = \int_x^{\infty} dF(t) \tag{7}$$

This, however, is not the probability of being found liable in the negligence case. Let x_e denote the height required by the due care standard. Then the probability of being found liable is $\eta(x)$ where

$$\eta(x) = \int_x^{\infty} dF(t) - \int_{x_e}^{\infty} dF(t) = \int_x^{x_e} dF(t) \tag{8}$$

Note that this probability is the probability of an accident minus the probability that the negligence did not cause the accident. The following lemma provides a comparison of the probabilities.

Lemma. $\eta(x) < \lambda(x)$ and $\eta'(x) = \lambda'(x)$.

Proof. Note that the marginal probability of being found negligent is

9 In this case, the firm manager knows the legal standard, or equivalently, the due care prior to making decisions on corporate account.

$$\eta'(x) = \frac{d}{dx}\left\{\int_x^{\infty} dF(\zeta)\right\} = -f(x) = \lambda'(x).$$

QED.

The socially efficient care level will be the due care standard used here. It is implicitly defined by (5). The corporation is held liable for losses if $x < x_e$. The liability is ℓ dollars if $x < x_e$ and zero otherwise. The current shareholder value is S_n where

$$S_n = -c(x) + \int_0^{\delta} [1-\eta(x)] [\Pi(\xi) - b] \, dP(\xi) + \int_{\delta}^{\omega} [\Pi(\xi) - b - \eta(x)] \, dP(\xi) \tag{9}$$

The probability of being found negligent is less than the probability of the loss but otherwise the structure of the hedged equity payoff is the same as in the previous case. The probability of insolvency is also the same in the two cases.

It may be observed that the current shareholder value is greater in the negligence case than it is in the strict liability case. Simply note that

$$S_n - S_s = \int_0^{\delta} [\lambda(x) - \eta(x)] [\Pi(\xi) - b] \, dP(\xi) + \int_{\delta}^{\omega} [\lambda(x) - \eta(x)] \, dP(\xi) > 0$$

It may also be observed that if there is no risk of insolvency, i.e., $\delta = 0$, then, as in the previous case, the manager optimally selects the efficient care level. Note that

$$\left.\frac{\partial S_n}{\partial x}\right|_{x=x_e} = -c'(x) - \eta'(x) \int_0^{\omega} dP(\xi) = 0$$

by (5) since $\lambda' = \eta'$. Finally, it may be observed that if there is no risk of insolvency then any due care standard $x_d < x_e$ will motivate the manager to choose the due care standard x_d. Similarly any due care standard $x_d > x_e$ will motivate the socially efficient choice x_e. Shavell also made this observation. This is a simple generalization of the standard result.

Now consider the condition for an optimal accident prevention choice given leverage. Let x_n denote the optimal choice. The first order condition is

$$\frac{\partial S_n}{\partial x} = -c' - \eta' \int_0^{\delta} [\Pi(\xi) - b] \, dP(\xi) - \eta' \int_{\delta}^{\omega} dP(\xi) = 0 \tag{10}$$

Due to the similarity in stock values, the first order conditions in (4) and (10) are qualitatively the same. The next theorem shows that the quantitative comparison also yields the same results.

Theorem 3. The optimal investment in accident prevention is the same in the negligence and strict liability cases, i.e., $x_n = x_s$.

The proof is an immediate consequence of the lemma. The next two results also flow from the lemma.

Theorem 4. Given the negligence rule, the manager of a levered corporation under-invests in accident prevention if the probability of insolvency is positive, i.e., $P\{\Pi - \ell < b\} > 0$.

Theorem 5. Given the negligence rule, the optimal investment in accident prevention is a decreasing function of leverage, i.e., $x_n'(b) < 0$, if the probability of insolvency is positive.

Increasing Risk

Finally, consider how the manager's choice of a care level changes with an increase in market risk. Characterize the increase in risk with the transformed payoff (1 + h) Π - h μ, where μ is the expected payoff**.** The characterization is a special case of a mean preserving spread (Rothschild & Stiglitz, 1970) and other things being equal such a transformation reduces corporate value (MacMinn 1993). Such a transformation also changes the boundary of the insolvency set. Let the state φ be implicitly defined by the condition (1 + h) Π - h μ - b = 0. For states ξ < φ, the equity payoff is (1 + h) Π - h μ - b with probability (1 - η) and zero otherwise. Similarly, for states ξ ≥ φ, the equity payoff is (1 + h) Π - h μ - b with probability (1 - η) and (1 + h) Π - h μ - b - η ℓ otherwise. It follows that the current shareholder value is

$$\begin{aligned} S_n &= -c(x) + \int_0^{\varphi} \big(1-\eta(x)\big)\big((1+h)\Pi(\xi) - h\mu - b\big)\, dP(\xi) \\ &\quad + \int_{\varphi}^{\omega} \big((1+h)\Pi(\xi) - h\mu - b - \eta(x)\big)\, dP(\xi) \end{aligned} \tag{11}$$

The first order condition becomes

$$\begin{aligned} \frac{\partial S_n}{\partial x} &= -c'(x) - \eta'(x)\int_0^{\varphi}\big((1+h)\Pi(\xi) - h\mu - b\big)\, dP(\xi) \\ &\quad - \eta'(x)\int_{\varphi}^{\omega} dP(\xi) \\ &= 0 \end{aligned} \tag{12}$$

and so it is apparent that the increase in risk has the potential to affect the accident prevention decision through its impact on the insolvency risk and the payoff in the insolvency event.

Theorem 6. Given the strict liability rule or the negligence rule and an increase in market risk, the manager of a levered corporation reduces the corporation's investment in accident prevention if the probability of insolvency is positive, i.e., P{(1 + h) Π - h μ - ℓ < b} > 0.

Proof. Equation (12) implicitly specifies the relationship between the risk parameter h and the accident prevention decision x_n. If the stock value is concave in the prevention variable then it follows by the Implicit Function Theorem that

$$\frac{\partial x_n}{\partial h} = -\frac{\dfrac{\partial^2 S_n}{\partial x \partial h}}{\dfrac{\partial^2 S_n}{\partial x^2}} \tag{13}$$

Given a concave stock value, the sign of the derivative in (13) is the same as the sign of the numerator. Note that

$$
\begin{aligned}
\frac{\partial^2 S_n}{\partial x \partial h} &= -\eta'(x) \int_0^{\varphi} \left(\Pi(\xi) - \mu\right) dP(\xi) - \eta'(x) \left[(1+h)\,\Pi(\varphi) - h\mu - \ell - b \right] p(\varphi) \frac{\partial \varphi}{\partial h} \\
&= -\eta'(x) \int_0^{\varphi} \left(\Pi(\xi) - \mu\right) dP(\xi) \qquad (14) \\
&< 0
\end{aligned}
$$

The second inequality in (14) follows because $(1 + h)\ \Pi(\varphi) - h\ \mu - \ell = b$ implicitly defines the state φ that is the boundary of the insolvency event. The inequality (14) follows because the $\Pi(\xi) < \mu$ for all $\xi \leq \gamma$ where γ is the state such that $\Pi(\gamma) = \mu$. Hence, the integral is negative if $\varphi \leq \gamma$. Alternatively, if $\varphi > \gamma$ then observe that

$$
\begin{aligned}
\int_0^{\varphi} \left(\Pi(\xi) - \mu\right) dP(\xi) &< \int_0^{\omega} \left(\Pi(\xi) - \mu\right) dP(\xi) \\
&= V - p\mu \qquad (15) \\
&< 0
\end{aligned}
$$

where V denotes the value of the random payoff Π and p denotes the sum of the basis stock prices or equivalently the discount factor for a safe asset. The right hand side of the first inequality in (15) may then be interpreted as the difference between a risky asset and a safe asset with the same mean. The last inequality in (15) is demonstrated in (MacMinn 1993). Therefore, an increase in risk reduces the value maximizing investment in accident prevention. QED

The theorem shows that the accident prevention choice is sensitive to increases in risk because greater business risk dilutes incentives in much the same way that the financial risk, equivalently, leverage affects incentives.

CONCLUDING REMARKS

The analysis here provides a first struggling attempt to explain the incentive effects of liability rules in a financial market framework. The model allows for two sources of risk so that the accidents that cause liability can be separated from other events that affect corporate payoffs. The additional source of risk causes some problems in valuing firms that are liable in the accident events but the analysis shows that the additional risk can be hedged by investors on personal account. Equivalently, the analysis shows that the additional risk can be hedged by the manager on corporate account via an insurance contract. This hedging behavior allows the security values to be expressed in terms of the remaining economic risk.

In a setting where financial distress is important, the analysis shows that the insolvency risk dilutes the corporate manager's incentive to invest in accident prevention. This result follows for both the strict liability rule and the negligence rule. Although this result is intuitively appealing it is overlooked in much of the law and economics literature; that literature does not seem to allow for the limited liability that is a standard assumption in financial market models. In the same setting, the analysis shows that the investment in accident prevention is the same in the negligence and strict liability cases and that both are less than the efficient investment. An increase in the due care standard in the negligence rule does not motivate more care. Finally, any increase in economic risk that increases the insolvency risk is shown to dilute the manager's incentive to take care. This result depends on the insolvency risk since direct calculation shows that the manager's accident prevention choice is independent of increases in economic risk in the absence of insolvency risk.

There are a number of directions for further research. Having shown that the various liability rules yield under-investment decisions for a fixed capital structure, it is apparent that the financing decisions are important. One direction for further research would allow for an endogenous financing decision and show that this approach generates a demand for corporate liability insurance.

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