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**SAFETY MONITORING, CAPITAL  
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RESPONSIBILITY”**

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# Safety Monitoring, Capital Structure, and “Financial Responsibility”\*

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## Abstract

Firms will exert too little preventive care if damages are likely to exceed their equity. This is particularly important for environmental and product liability and motivates the current discussion about extending liability to creditors. We propose a model where the firm can be financed by equity, bank debt or publicly traded debt. There is a moral hazard problem about the choice of care that can be mitigated through stochastic monitoring of its safety standards. We show that the optimal allocation can always be implemented by a liability regime of “financial responsibility”, that is mandatory liability coverage that can be fulfilled either by an insurer or by a lender. We find that the first best can only be achieved if the defendants are fully liable. This result is in contrast to related models which find liability below the level of harm optimal, and we show that the difference is due to the inclusion of safety monitoring. Financial responsibility is strictly superior to lender liability alone or strict liability without extended liability, but their relative ranking may vary.

**Key words:** lender liability, compulsory insurance, choice between private and public debt, limited liability effect.

**JEL classification:** G32, K13, K32.

# 1. Introduction

## 1.1. Motivation

A firm strictly liable for any harm done will generally not choose the efficient care level if there is a possibility that the firm goes bankrupt. Damages large enough to put the firm into bankruptcy - like environmental and product liability or health risks - will be undervalued because some of the losses of the victims will go unclaimed under conventional strict liability. The care level will typically be too low in this case (limited liability effect).<sup>1</sup>For firms facing considerable liability risks, leveraging up the capital structure may become an effective evasion strategy.<sup>2</sup>

Extending liability is a natural regulatory response. Attempts to extend liability are most advanced in the United States where managers, shareholders, holding companies and notably secured creditors are among the groups which have been held liable under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). In Europe, lender liability or mandatory insurance are not yet applied in practice. They are, however, currently being discussed in the wake of initiatives in favor of strict liability for environmental torts throughout the European Union (see Section 2).

If information were perfect, then lender liability as well as mandatory insurance would be fully efficient solutions.<sup>3</sup>In practice, however, there are pervasive problems of asymmetric information between investors and firms, e.g. because investors have difficulties to correctly anticipate environmental risks (adverse selection) or cannot monitor the care level perfectly or without suffering large costs (moral hazard). Under these circumstances, three questions arise: first, if extending liability to third parties is superior even if the agency costs caused by asymmetric information are taken into account. Second, whether lender liability, mandatory insurance or financial responsibility (see below) should be applied. And third, whether liability payments should differ from total harm or not.

Financial responsibility means that the operation of hazardous plants and other businesses is only authorized if the operator shows proof that all liability claims are covered either by an insurance company or by a lender or another sufficiently solvent party. Forms of financial responsibility are legally mandated in the US (under the Resource Conservation and Recovery Act) and in Germany (under the Environmental Liability Act). In both legislations, however, the application seems insufficient and distortions are likely (see Section 2).

We show that financial responsibility can always lead to an allocation which comes arbitrarily close to the first best if (i) the contract between the firm and the lender or insurer assuming residual liability is chosen optimally to reduce the agency costs to the minimum and (ii) if the firm is always held fully liable for the harm done, regardless of whether the damage can be paid out of the firm's reserve or will lead to insolvency and subsequent liability of lenders. Since it leads to the first best, financial responsibility is preferable to all compet-

ing proposals which lead to inefficiencies in important cases. In particular, we demonstrate that both lender liability and standard strict liability without extended liability<sup>4</sup> are strictly inferior proposals. Also, financial responsibility with a total liability below social harm is inefficient.

This finding is in striking contrast to earlier literature on extended liability: In the presence of agency problems like the moral hazard problem studied in our paper, it is usually found that liability should be strictly below the level of harm (see the literature review below), since the following trade-off arises: Raising liability towards the level of harm gives better incentives to internalize the social costs of negligent behavior, but comes at the expense of increasing agency costs.

The optimality of full financial responsibility in our analysis, in contradiction to earlier studies, is explained by two elements which we take into account, and which have widely been ignored in the previous discussion about extended liability. First, our analysis explicitly allows for safety monitoring. We demonstrate that increasing agency costs can be avoided if safety monitoring is applied appropriately, and hence full extended liability dominates reduced extended liability. In the environmental liability discussion, practitioners and lawyers seem to take it for granted that moral hazard problems can be mitigated through monitoring. Big industry insurers and banks have developed considerable competencies in screening environmental risks, in safety consulting and in auditing. In our model, safety monitoring implies that any deviation from a contractually agreed care level can be detected with a probability that is strictly increasing in monitoring expenditures. It is in the manager's self-interest to search for the most efficient monitor, since she fully bears the agency costs caused by moral hazard due to the assumption that capital and insurance markets are competitive. We show that an insurance or loan contract containing both penalties and bonus payments in response to the findings of monitoring solves the limited liability problem.

The second new element leading to the optimality of full financial responsibility is our more complete treatment of possible distortions in the *capital structure*. The preceding literature has only considered the debt-equity choice of firms. By contrast, we allow for a choice among equity, private debt and publicly traded debt. Distinguishing between private or bank debt and publicly floated debt<sup>5</sup> seems more realistic in the light of recent trends towards disintermediation across the industrialized world, and captures the fact that in practice lender liability can only be implemented for large lenders who are geared up to have a special relationship with the borrower. This is, for example, the current legal practice under CERCLA.

As long as firms can escape lender liability issue by issuing publicly traded debt, and as long as such debt issues can be designed to enjoy priority over liability claims - this is for instance easily possible under current US law by issuing secured debt<sup>6</sup> -, lender liability alone cannot solve the limited liability problem. We find indeed that lender liability will

only eliminate distortions between equity and *private debt*, but at the expense of creating *new distortions between insider finance and outsider finance*, since only large creditors can be held liable. Lender liability must be accompanied by measures addressing this bias, notably a guarantee that the equal treatment of all sources of capital can also be carried out in practice. This is the first reason why we argue in favor of financial responsibility for large risks. As will be shown, this implies that firms will opt for self-insurance via deductibles to reduce the agency costs they have to bear if capital markets and insurance markets are competitive.

## 1.2. Related Literature

A number of recent papers have addressed lender liability and compulsory insurance in models with moral hazard. The seminal contribution is Pitchford (1995), who shows that extending liability beyond the manager's *maximum* wealth reduces her effort and social welfare. If lender liability is established and capital markets are competitive, the manager voluntarily invests her total wealth to reduce the agency costs. If the manager's wealth is not sufficient, then the interest rate must increase to fulfill the creditor's participation constraint. But the higher the interest rate, the lower the manager's return in the good state, and the lower her incentive to avoid environmental harm. Pitchford concludes that lender liability should be adjusted as to guarantee that the manager invests her wealth, and that no agency costs exist in equilibrium.

Four branches of literature are relevant for our analysis. First, Boyer and Laffont (1997) and Boyd and Ingberman (1997) conclude, like Pitchford, that it might be second best optimal to adjust damages below total harm. Boyer and Laffont's conclusion is based on two effects working in opposite directions: extending liability increases the agent's effort implemented by the principal, but higher agency costs can discourage socially valuable projects. Moreover, they compare lender liability to mandatory insurance, and they prefer (partial) lender liability. This follows from the assumption that the creditor is always better informed than the insurance company, at least with respect to the firm's expected profits.<sup>7</sup>

Boyd and Ingberman (1997) argue that extended liability can reduce social welfare through distortions in investment decisions. They assume that capital investment has two simultaneous effects: it reduces the (unit) costs of production but it also *increases* the value of the firm's assets. Obviously, if the agent is liable for harm, the incentive to decrease the costs of production is reduced by the fact that the expected liability payments are increasing in the amount of the investment. This is already true if only the firm is held liable, and it holds *a fortiori* if liability is extended. Third parties may be discouraged to engage in contractual relationships with the firm,<sup>8</sup> or they may reduce their equity exposure in order to avoid liability payments. This effect is clearly aggravated if proportionate liability for different contracting parties is substituted by joint and several liability, because each party fears that she has to pay if other parties are insolvent.<sup>9</sup> Contrary to Boyer and Laffont, Boyd and Ingberman argue

that mandatory insurance is superior to extended liability.

In clear contrast to these articles, our first contribution is to show that full financial responsibility will always lead to the first best allocation. Full financial responsibility is strictly superior to reduced financial responsibility (liability below the level of harm) once the model accounts for safety monitoring technologies. Moreover, full financial responsibility is always strictly better than either lender liability or strict liability without extended liability. This is explained by our richer account of the capital structure decision. Third, financial responsibility is also better than mandatory insurance alone if different costs of monitoring or distortions in the capital and debt structure are taken into account.

The second strand of literature is more in conflict with Pitchford's analysis. It points out that Pitchford's result crucially depends on the assumption that the manager has all of the *bargaining power* (because capital markets are competitive). In standard principal-agent models, it has been shown that the manager's effort increases in the lender's liability if the lender has the bargaining power.<sup>10</sup> The more the lender's liability is extended, the larger the incentive to reduce the interest rate to improve the manager's care incentive. Heyes (1996) shows that lender liability leads to a decrease in interest rates because the bank internalizes the improvement in incentives for precaution. Balkenborg (1997) extends the analysis by considering variations in the distribution of the bargaining power and shows that the optimal level of lender liability is increasing in the creditor's bargaining power. We follow Pitchford and the papers sketched above, but Heyes' and Balkenborg's results must be kept in mind when drawing practical conclusions. This discussion plays some role in our analysis of the optimal contract allowing almost negligible monitoring costs. This is true under the assumption that the borrower captures all the surplus of investment (the standard assumption in finance models), but would not necessarily hold under a different division of the bargaining power.

The third body of literature emphasizes that there might be excessive incentives for *monitoring*. The basic idea is that monitoring is only socially valuable if it increases the firm's care level, whereas the principal uses monitoring also as a means to reduce the agent's information rent. These effects are demonstrated by Demougin and Fluet (1999). Feess (1999) argues that negligence rules for lenders as applied under CERCLA (see Section 2 below) are strictly inferior to strict liability. In contrast to these papers, monitoring does never lead to excessively high care in our model, which seems to be a reasonable assumption at least for technological safety standards.

Fourth, our model is related to the discussion on mandatory insurance and environmental harm. Jost (1996) emphasizes the benefits of compulsory insurance if insurers can reduce asymmetric information through environmental audits. The regulator observes the insurance contracts and will approve production only if an efficient insurance contract has been signed. Shavell (1986) argued earlier, on a less optimistic note, that the overall effect of mandatory

insurance is ambiguous: on the one hand, it prevents socially inefficient projects. On the other hand, the agent bears no risk under full insurance which reduces care if the insurer cannot contract upon. However, it is in the agent's self-interest to use her total wealth as a deductible to reduce the agency costs, so that she bears part of the risk. If the agent's wealth is high enough to pay the insurance premium in advance (given her maximum deductible), then the effort is the same as without insurance, and mandatory insurance dominates no insurance because investments are only undertaken if they are socially valuable given the suboptimal level of care (Polborn 1999). Polborn's result is confirmed in our model if the manager's wealth is sufficiently high, but does not carry over to the more interesting situation with a wealth-constrained manager.

Lewis and Sappington (1999) is the only prior article also arguing in favor of full financial responsibility, but for very different reasons than ours. Their results are driven by two key assumptions: First, that there are different possible levels of harm, and the level of harm provides a signal for the unobservable effort level that can be exploited in the optimal contract. Second, they assume that the authority grants permission only if the (observable) loan contract is socially optimal, similar to Jost (1996).

We are not aware of theoretical literature analyzing the *capital structure distortions* caused by any regime but financial responsibility, prior to this article. The distortion between insider and outsider lending that we identify should not only appear in the choice of the lending sources, but also distort the involvement of potential insider lenders, that is banks. Our model predicts that creditors should be hesitant to be found closely involved in their borrower's day-to-day operations, because of concerns about future tort liabilities. Kroszner and Strahan (1998) find indeed empirical evidence for this effect, by looking at banks' board membership.<sup>11</sup>In a related paper (Feess and Hege (1999)), we also discuss the choice between financial responsibility, lender liability and strict liability, but follow the conventional assumption that the agency costs of monitoring are increasing in the induced level of care, rather than modelling the stochastic safety monitoring technology explicitly. With the conventional assumption, we find that reduced rather than full liability is optimal, at least in the most interesting case where the manager's wealth is low, and that strict liability may be better than financial responsibility. By contrast, with an explicit monitoring technology, full financial responsibility is always first best. Thus, the inclusion of a true microeconomic model of safety monitoring leads to a much different, and more radical, conclusion.

The paper is organized as follows. Section 2 contains a survey of the current jurisdiction and proposals on lender liability in the United States and the European Union. The model is laid out in Section 3. Section 4 presents the inefficiencies caused by strict liability only and by lender liability, and analyzes the efficiency of financial responsibility. It also looks at whether optimal extended liability should be full or restricted. Section 5 concludes.



## 2. Lender Liability in the United States and in Europe

### 2.1. United States

In the United States, the legal situation and jurisdiction under CERCLA is the most important source of lender liability. According to Section 107(a) CERCLA, *owners and operators* of hazardous plants are jointly and strictly liable. The crucial point is therefore under which circumstances a creditor may be regarded as owner or operator. CERCLA contains a *secured creditor exemption* which excludes creditors from liability as long as they keep property mainly for purposes of securing their loans without getting involved into the management of the borrowing firm.<sup>12</sup> More precisely, the question is under which circumstances the secured creditor exemption applies.

To define activities that do not trigger lender liability, the Environmental Protection Agency (EPA) has published a “Final Rule on Lender Liability under CERCLA”, issued April 29, 1992,<sup>13</sup> which is known as the EPA Rule. However, the US. Court of Appeals for the D.C. Circuit threw out the rule in 1994, holding that the rule surpassed EPA’s regulatory authority.<sup>14</sup> To overcome the uncertainty about the significance of the EPA Rule, the “Asset Conservation, Lender Liability, and Deposit Insurance Protection Act of 1996” (subsequently quoted as “Act”) deems the EPA Rule to have been validly issued, and specifically prohibits any further judicial review of that Rule.

As far as lender liability as *owner* is concerned, creditors are held liable for the clean-up of contaminated land plots on which they foreclose in the process of a default. Rational creditors, however, will not use the option to foreclose on land if its value including clean-up costs is negative. This implies that creditors are held liable only for the minimum of the residual face value of their debt outstanding and the clean-up costs. In other words, lender liability as owner appears to be tantamount to a partial liability which in effect reverts the priority between secured creditors and clean-up charges.<sup>15</sup>

According to the EPA Rule, lender liability as *operator* requires that the creditor is involved in the day-to-day-management of the insolvent firm. Interestingly, it is neither necessary nor sufficient that the creditor participates in the environment-related management decisions. The courts seem generally to agree with this principle. For example, in *US v. Mirabile*, Mellon Bank has been held liable because an employee of its commercial loan division was also a member of the board of directors of the firm and hence not only involved in its financial affairs, but also participating in its day-to-day management.<sup>16</sup>

The best-known decision is probably *US v. Fleet Factors Corporation*. The EPA was suing Fleet Factors Corporation, a creditor of Swainsboro Print Works (SPW), for clean-up costs of a harm discovered after the bankruptcy of SPW. In this case, an earlier decision that the management participation of Fleet did not infringe on the secured creditor exemption was overruled by the 11th Circuit who argued that the “*capacity to influence*” day-to-day

management decisions may suffice for an infringement of the secured creditor exemption. The court, however, restricted this explicitly to situations where the management participation would have been appropriate, given Fleet’s role for SPW. The secured creditor exemption may not be used to create a loophole for liability exemptions due to ignorance, in situations where creditors are responsible for strategic decisions of the borrower. This, so the court, was necessary to provide creditors with incentives to carry out environmental audits and to incorporate aspects of environmental safety into the process of credit approval.<sup>17</sup>

Since we restrict our attention to strict liability of lenders, a remark concerning the possibility to apply a *negligence rule for lenders* (while upholding strict liability for the insolvent borrower) should be added. Although lenders are strictly liable under CERCLA if they are liable as owners or as operators, the legal status quo contains elements of a negligence rule for lenders. In particular, the EPA rejects the liability of a lender as operator if the participation in the environment-related day-to-day management is deemed “reasonable”. Like the 11th Circuit, the EPA emphasizes that otherwise creditors would face undesirable incentives to refrain from socially valuable environmental audits for fear to infringe on the secured creditor exemption. However, our paper deals with the comparison of financial responsibility to different kinds of strict liability, so that the concept of negligence for lenders is beyond the scope of the present model.<sup>18</sup>

The concept of financial responsibility suggested in this paper is already applied under the Resource Conservation and Recovery Act (RCRA) where the owners and operators of landfills and underground petroleum storage tanks must prove “adequate” levels of capital as a precondition to get approval. The same holds for the Oil Pollution Act of 1990, that requires financial responsibility for tankers, offshore pipelines, and oil and gas terminals.<sup>19</sup> Under RCRA, there are different possibilities for demonstrating financial responsibility, namely Corporate and Local Government Financial Tests, Trust Funds, Letters of Credit and Insurance that differ in important respects.<sup>20</sup> The main problem with RCRA is that the different mechanisms are not equally efficient, and that firms are allowed to choose which mechanism they prefer.<sup>21</sup> First, letters of credit and surety bonds can be withdrawn by their issuers before environmental losses are detected. Second, the schedule of payments under the trust fund mechanism does not make sure that the money is sufficient if harm occurs before the end of the pay-in period. Boyd (1996) concludes that there are important loopholes that decrease the power of financial responsibility under RCRA.

## 2.2. European Union

Environmental liability varies considerably among the members of the European Union, and the drafts about a harmonized environmental liability legislation that are circulating disagree substantially.<sup>22</sup>

In 1996, a comprehensive study mandated by the European Commission on the harmo-

nization of environmental liability has been published.<sup>23</sup> While some countries like Germany and the Netherlands have moved to strict liability, other countries like Italy and France restrict strict liability to a few groups of risks (in France e.g. for neighborhood disturbance). The drafts for a unionwide harmonization advocate strict liability.<sup>24</sup>

Lender liability is a theoretical possibility in most member countries if creditors foreclose on property or are actively involved in management decisions. All attempts to sue creditors have failed so far, however.<sup>25</sup> All country reports agree that lender liability is very unlikely to gain significance. Only British and German banks voice some anxiety about this prospect. The “Final Report” for the European Commission discusses the problem of insolvency and emphasizes that shifting of environmental risk to companies with little equity endowment must be avoided, but it remains unclear to what groups of financiers liability would extend. On the whole, the drafts and the comments support the conclusion that lender liability would play a minor role in a harmonized environmental liability code in the European Union.

Most member countries do not require compulsory insurance for environmental damage.<sup>26</sup> In Finland, insurance is compulsory for operators of nuclear installations and for owners of ships carrying more than 2000 tons of oil. In Sweden, activities which are required to be licensed under the Environmental Protection Act 1969 have to contribute to a compulsory insurance fund run by a group of insurance companies in accordance with the Ordinance of July 1, 1989 (Environment Civil Liability Damage Fund).

Analogously to RCRA, Article 19 of the German Environmental Liability Law 1990 requires compulsory coverage for all hazardous plants listed in an appendix (“Anhang II”) that can be proven either by insurance companies or by banks. Unfortunately, lobbying from industry and banks has had the effect of putting this part of the law on hold for an unforeseeable future. The situation in the Netherlands is very similar: the Environmental Control Act 1979 and the Soil Protection Act 1994 provide that liability insurance can be made compulsory for activities that can cause deleterious environmental damage. The European Commission seems to give preference to industry specific Superfund models rather than compulsory insurance for fear that the latter might lead to higher costs.<sup>27</sup> Most of the comments from member state governments, the insurance industry and manufacturers show strong resistance against the idea of compulsory insurance.

To summarize, neither in single member countries nor on a unionwide level has the insolvency problem been solved or been addressed in a satisfactory manner; compulsory insurance requirement is nowhere implemented and lender liability plays no role.

### 3. The Model

A risk-neutral manager owns a project which carries an environmental risk. The manager needs to raise  $I$  to finance the initial investment outlays. The manager has unobservable initial wealth  $W$  and has a choice between equity (her own money), publicly floated debt

and private debt to finance  $I$ . Let  $I_D$  be the part financed by debt and  $E = I - I_D$  be the part financed by equity. All financial variables are expressed as present values when the financial structure is chosen. The project yields a random pre-tax cash flow  $x$  distributed with the cumulative distribution function  $F(x)$  over the positive interval. Capital markets are competitive. In case of publicly floated debt, the investment is equally split up among a large number of investors. For the capital structure decision, we invoke a standard static trade-off model<sup>28</sup>: On the one hand, the firm needs to pay a corporate tax rate of  $\tau$  on the fraction of its cash flow belonging to shareholders, but not on the part owed to debtholders. On the other hand, the higher its financial leverage, the higher the probability that the firm faces bankruptcy with an ensuing loss of bankruptcy costs.

Let  $b$  be the bankruptcy costs. Suppose debt with a face value of  $\delta(I_D) \geq I_D$  is issued, where  $\delta$  is a strictly increasing function of  $I_D$ . Therefore, the capital structure decision is captured by the level of debt funding  $I_D$ . The firm goes bankrupt if  $x < F(\delta(I_D))$ .

Therefore, according to the static trade-off model, the manager's capital structure decision maximizes the expected after-tax cash flow, denoted by  $R$ :

$$\max_{I_D} R = E[x - \tau(x - \delta(I_D))] - bF(\delta(I_D)),$$

where  $E[\cdot]$  is the mathematical expectations operator. We write this objective function as  $R(I_D)$  for short, and we assume that  $R(I_D)$  is a strictly concave function of  $I_D$ . In the absence of any distortion, we denote the debt financing level that maximizes the firm value by  $I_D^f$  i.e.

$$I_D^f = \arg \max R(I_D)$$

is the optimal capital structure which we assume to be a unique and internal optimum.<sup>29</sup> Assume that  $W \geq I - I_D^f$ .

There is an additional cost of choosing bank debt over public debt represented by  $c \gtrless 0$ . Thus, in the absence of any environmental risk, the manager prefers bank debt over public debt whenever the cost is negative ( $c < 0$ ). By construction of our model, mixing public and private debt is never better than either pure bank debt or public debt financing.

The environmental risk is captured by the possibility that some harm with a monetary loss of  $D > 0$  arrives. We suppose that  $D > x^{\max} + b$ , the highest possible return realization, so that the accident will always lead to bankruptcy, and that the manager will never voluntarily insure the accident risk just to avoid bankruptcy. Harm  $D$  occurs with probability  $p(e) > 0$  which depends on the manager's unobservable care level  $e$ . As usual,  $e$  expresses at the same time the cost of care.  $p(e)$  is strictly decreasing in the care level, but at a decreasing rate:  $\frac{dp(e)}{de} < 0$ ;  $\frac{d^2p(e)}{de^2} > 0$ . Hence, if there is no monitoring (see below), total social surplus can be written as

$$SW = R(I_D) - I - p(e)D - e \tag{3.1}$$

which means that the optimal care level is independently of the capital and debt structure given by  $-\frac{dp}{de}D = 1$ . If harm  $D$  arrives, then the firm is held liable by the court for damages in the amount of  $L$ . We do not consider negligence rules in this paper, so the firm has to come up for  $L$  whenever the harm is done. We assume that damages have strict priority over equity, but that debt is secured and is prior to damages. We assume that the manager's wealth which is not invested into the firm is protected through limited shareholder liability.

Note that the first best investment decision is to invest if and only if expression (3.1) is positive.

In view of the insolvency problem, we consider three liability regimes:

(i) (Un-extended) *Strict Liability*: liability is neither extended to third parties nor is insurance coverage required to get a permission for the project. This situation serves as the benchmark case.

(ii) *Lender Liability* without financial responsibility: strict liability is extended to bank creditors. Lender liability does not extend to public creditors, since transaction costs would be prohibitively high, and since nothing can be gained by extending liability to parties that have no close relationship to the manager.

(iii) *Financial Responsibility*: As explained in the introduction, this means that the investment is permitted only if the manager shows proof that  $D$  is fully covered by either her own wealth, an insurance company, or a lender.

Thus, the problem of the regulator is to choose ex ante among these three liability regimes and to define total liability payments  $L \geq 0$ . Insurance is available on a competitive insurance market.

Next, we turn to the possibility of *monitoring*. If there is extended liability (lender liability or financial responsibility), then the manager will ultimately bear a larger fraction of the damages  $L$  than what she can pay before insolvency becomes effective: she will have to pay higher risk premia for credit or higher insurance premia. Since the care level chosen by the manager is unobservable, and the manager is ex post protected by limited liability, she would choose too low a level of care compared to her ex ante optimal level. The manager is looking for a bonding device to increase the care level  $e$  when signing contracts with lenders and insurers. Such a bonding device is available in form of monitoring: lenders and insurers may perform environmental audits on the firm to make sure that the level of care written into the debt or insurance contract ( $e^*$ ) is maintained. The higher the level of monitoring, the higher the probability that a deviation from  $e^*$  is detected by banks or insurers. Monitoring mitigates the moral hazard problem, but it has a cost. We remain agnostic about the question whether banks or insurers are the better monitors, and assume for simplicity that banks and insurers have the same monitoring technology. We denote by  $m$  the monitoring costs of banks and insurance companies, and assume that the probability of detecting a deviation from the committed care level is  $q(m)$ , where  $\frac{dq}{dm} > 0$ ,  $\frac{d^2q}{d(m)^2} < 0$ ,  $q < 1 \forall m$ . Our model could easily

accommodate for a difference between banks' and insurers' monitoring technology. In this case, the capital structure decision would be in many cases biased in favor of bank debt in order to preserve the option of choosing a cheaper bank monitor, but qualitatively all results remain unchanged. <sup>30</sup>To avoid double moral hazard problems, we assume that the monitor can credibly commit to a level of auditing. Moreover, we assume that duplication of auditing efforts is inefficient, i.e. if both the bank and the insurance company audit, then their total costs are higher than if one of the two were to assume all the auditing.

If the manager and a third party (insurer or lender) agree upon a positive level of monitoring, then total social surplus is

$$R(I_D) - I - p(e)D - e - m \quad (3.2)$$

Since monitoring costs accrue as additional costs, the surplus (3.2) is always only constrained efficient as compared to the first best surplus in expression (3.1).

## 4. Analysis of Liability Regimes

### 4.1. Strict liability

In this section, we demonstrate which distortions are caused by the insolvency problem if there is no extended liability. First note that there is no distortion between private and public debt, since lenders bear no risk. If the regulator chooses  $L = D$ , then the manager's objective function is<sup>31</sup>

$$M^{SL} = [1 - p(e)] [R(I_D) - I_D] - E - e \quad (4.1)$$

where  $E = I - I_D$  is the manager's equity participation. Without accident, the manager gets  $R(I_D) - I_D$ , otherwise she goes bankrupt. The first order condition for  $I_D$  is given by<sup>32</sup>

$$\frac{dR}{dI_D^{SL}} = 1 \quad (4.2)$$

Comparing  $I_D^{SL}$  to the first best debt level  $I_D^f$  shows immediately that the debt level is too high, because debt is prior to damages and hence the part of harm borne by victims is the higher the higher the level of debt.

Recall that the optimal capital structure decision reflects the trade-off between tax advantages and expected financial distress costs of debt. While this is hidden in our convenient expected value variable  $R$ , this becomes important when we turn to the capital structure distortions created by the liability rule.

Moreover, the FOC for effort is

$$-\frac{dp}{de^{SL}} [R(I_D^{SL}) - I_D] = 1 \quad (4.3)$$

Hence,  $e^{SL} < e^f$ , and the distortion is increasing in the level of debt. This is the well-known limited liability effect: the safety level is too low whenever harm exceeds the firm's solvency, and this is aggravated by the incentive to increase the leverage.

Moreover, the manager would clearly have an incentive to *overinvest*: From the social planner's point of view, the investment should only be undertaken if expression (3.1) is positive. Under strict liability, however, the manager would always undertake the project if  $M^{SL}$ , i.e. if (4.1) is positive. Comparison of (3.1) and (4.1) shows that inefficient investment is undertaken if

$$[1 - p(e^{SL})] [R(I_D^{SL}) - I_D^{SL}] - E - e > 0 > R(I_D^f) - I - p(e^f)D - e^f. \quad (4.4)$$

Condition (4.4) is likely to be satisfied for projects with a positive monetary value  $R(I_D^f) - I$ , and a large accident risk  $D$ .

Nothing would change and nothing could be gained by setting  $L > D$ , because the manager goes bankrupt anyway if an accident happens.<sup>33</sup> Note that monitoring plays no role under un-extended strict liability, because (i) the manager has no incentive to insure the environmental risk and (ii) the lender does not care about the risk because debt is prior to damages. It follows that strict liability only leads to too low a care level and to a distortion in the debt-equity ratio, whereas the debt structure remains unaffected. We summarize:

**Proposition 1.** *Under strict liability, the care level will be too low and leverage will be too high. Investment incentives are distorted, and there is too much investment into projects with large accident risks.*

## 4.2. Financial Responsibility

Under financial responsibility the regulator grants permission for the investment project if and only if the manager shows proof that all damages  $L$  are fully covered. To analyze the privately optimal effort and capital structure, we proceed by distinguishing cases according to whether the manager has enough wealth to self-insure (Section 4.2.1) or not (4.2.2).

### 4.2.1. Sufficient Wealth of the Manager

In the first step, we look at the case where  $W \geq D - R(I_D^f) + I$ , i.e. harm could be covered from the manager's net wealth if investment is carried out optimally. We prove that full liability is then optimal,  $L = D$ . In this case, financial responsibility avoids not only distortions in the capital structure, but also leads to the first best level of care without monitoring. Since both capital markets and insurance markets are competitive, it is in the manager's self-interest to use  $W$  as a liability deposit to avoid the moral hazard problem. Suppose the manager deposits a part of her wealth equal to  $D + I - R(I_D)$ , so that she can definitely pay for total damages. Her objective function is then to maximize

$$M_W^{FR}(e) = R(I_D) - I - p(e)D - e \quad (4.5)$$

Here,  $M_W^{FR}(e)$  denotes the manager's utility under financial responsibility if she is wealthy. Since this objective function is identical to the social surplus defined in (3.1), it follows that  $e_W^{FR} = e^f$ . Note that the risk borne by the manager is independent of the capital structure, so that she also chooses the efficient level of debt. Obviously, the manager's expected utility is lower in each other case, because she has to bear the total welfare loss if capital and insurance markets are competitive, and if it is not possible to externalize part of the harm to victims. Without monitoring, it is clear that she would choose  $e < e^f$  because of the moral hazard problem, and that she had to pay accordingly high insurance premia or interest rates. With monitoring, it could be possible to commit to the efficient care level  $e^f$ , but she would have to additionally bear the monitoring costs  $m$ . Hence, financial responsibility leads to a first best without monitoring whenever the manager's initial wealth is sufficiently high.

#### 4.2.2. Low Wealth of the Manager

In the second step, we turn to the more interesting case where  $W < D - R(I_D^f) + I$ . A first point to note is that the optimal capital and debt structure is chosen independently of the manager's wealth  $W$ , because the total liability risk is always  $L$ , and cannot be reduced by increasing the level of (public) debt. The crucial point is hence whether the manager prefers to be monitored or not.

(i) *No monitoring.* First suppose the manager chooses  $e$  without being monitored. To minimize the moral hazard problem, it is again in the manager's self-interest to deposit her total wealth, so that the insurer or bank (henceforth insurer for short) has to pay only  $L + I - R(I_D^f) - W$  if an accident happens.<sup>34</sup> This implies that the insurer requires an insurance premium  $r$  if its participation constraint is to be satisfied. We will determine  $r$  below:  $r$  depends on the equilibrium, but it is part of the initial contract, and hence already given when the manager chooses the care level  $e$  to maximize

$$M_C^{FR}(e) = [1 - p(e)] \left[ R(I_D^f) + W - E - (1 + r)I_D^f \right] - e \quad (4.6)$$

because the agency costs are minimized when the contract specifies that the manager's utility is zero if an accident occurs. The FOC determining the manager's effort  $e_C^{FR}$  is<sup>35</sup>

$$-\frac{dp}{de} \left[ R(I_D^f) + W - E - (1 + r)I_D^f \right] = 1$$

Clearly,  $e_C^{FR} < e^f$  since  $R(I_D^f) + W - E - (1 + r)I_D^f < D$ . The insurance premium  $r$  is given by the lender's (or insurer's) participation constraint, i.e. by

$$r = \frac{p(e_C^{FR})}{1 - p(e_C^{FR})} \frac{\left[ L + I - R(I_D^f) - W \right]}{I_D^f} \quad (4.7)$$



Clearly, a capital structure choice of  $I_D^f$  maximizes the manager's net wealth.

We now analyze if full liability is also optimal if the manager has low wealth. Setting  $L = D$ , and substituting  $r$  into the manager's objective function shows that her expected utility is simply

$$M_C^{FR} = R(I_D^f) + W - I - p(e_C^{FR})D - e_C^{FR} \quad (4.8)$$

The manager's payoff function (4.8) shows that the manager would actually prefer to choose  $e^f$  instead of  $e_C^{FR}$  because, in expectation, she has to bear total damages. Note that nothing would change if the manager decided to insure herself instead of asking the lender to cover her insolvency risk: as before, she would invest her total wealth as a deductible, and the insurance premium would have to fulfill the insurer's participation constraint. Thus, there is no difference between coverage through lenders or insurance companies, due to the fact that in both cases, the manager prefers to deposit all of her wealth  $W$  as a bond which is last if harm  $D$  occurs.

Therefore, *if* it were ever optimal for the manager not to include monitoring in the initial contract, our model would exactly replicate the well-known result found by Pitchford (1995): the manager's level of care would be *decreasing* in  $L$  whenever  $L$  cannot fully be covered out of the manager's wealth. In this case, the damages that maximize social welfare are  $L = W + R(I_D^f) - I < D$ . Hence, reduced liability ( $L < D$ ) would be optimal.

The interesting point, however, is that once the possibility of safety monitoring is taken into account, this situation is not the relevant one. As we will argue next, this trade-off is then purely *hypothetical* since the agency costs of monitoring can be reduced to an arbitrarily small amount, provided the contract with the monitor (insurance or bank lender) is optimally designed.

(ii) *Monitoring.* Now suppose the manager prefers to be monitored. Let  $e_m^{FR}$  be the optimal care level in this case. Obviously, it is in the manager's self-interest to agree upon a loan contract where she loses all her money whenever a deviation from  $e_m^{FR}$  is detected, because this is the cheapest way of implementing the desired care level. Moreover, the manager would like to commit to the care level  $e_m^{FR}$  which minimizes the total costs borne by her and the creditor (or an insurer).

For the following analysis, we consider only one class of insurance contracts, which takes into account the effort incentives of the manager. This class of contracts which, as will be shown, includes the optimal contract, can be characterized as follows:

- (i) The manager is audited with some probability  $q$  which depends on the monitoring expenditure  $m$ ,  $q(m)$ .
  - (a) If the manager is caught deviating from the contractual effort level  $e_m^{FR}$ , i.e if the manager chooses  $e < e_m^{FR}$ , then she loses everything - this is the harshest possible

punishment under limited liability.

(b) If the manger is found compliant with the safety standard,  $e \geq e_m^{FR}$ , then the manager receives a *bonus payment* of  $\Pi > 0$ .

(ii) If an accident occurs, the manager loses again everything.

(iii) If no accident occurs and the manager is not monitored, the manager pays an insurance premium  $r^*$  and keeps the remainder.  $r^*$  is in principle determined as in (4.7), but has to take into account the bonus payment  $\Pi^*$  if the manger is monitored and found compliant. The actuarially fair insurance premium, assuming that the manager will not deviate from the equilibrium behavior, is:

$$r^* = \frac{1}{1 - p(e_m^{FR})} \frac{p(e_m^{FR}) \left( L + I - R(I_D^f) - W \right) + (1 - p(e_m^{FR}))q(m)\Pi^*}{I_D^f}. \quad (4.9)$$

With this contract, we can next turn to the manager's incentives.

The manager gains nothing by choosing  $e > e_m^{FR}$ , so  $e_m^{FR}$  will be the manager's choice of effort if the manager complies:

$$e_m^{FR} = \arg \max \left\{ [1 - p(e)] \left( R(I_D^f) + W - E - (1 + r^*)I_D^f + q(m)\Pi^* \right) - e - m \right\} \quad (4.10)$$

Let  $e^v$  (for "violation") denote the manager's choice of effort if it pays off to deviate, i.e.  $e^v$  is the best deviation policy, which in turn depends on  $r^*$ . That is,  $e^v$  maximizes:

$$e^v = \arg \max \left\{ [1 - p(e)] (1 - q(m)) \left( R(I_D^f) + W - E - (1 + r^*)I_D^f \right) - e - m \right\} \quad (4.11)$$

The manager's expected utility can be summarized as:

$$M_m^{FR}(e) = \begin{cases} [1 - p(e)] \left( R(I_D^f) + W - E - (1 + r^*)I_D^f + q(m)\Pi^* \right) - e - m & \text{for } e \geq e_m^{FR} \\ [1 - p(e)] (1 - q(m)) \left( R(I_D^f) + W - E - (1 + r^*)I_D^f \right) - e - m & \text{otherwise} \end{cases} \quad (4.12)$$

The incentive compatibility condition for the manager guaranteeing that she actually prefers  $e_m^{FR}$  over  $e^v$  can be written as

$$e_m^{FR} - e^v \leq \left( R(I_D^f) + W - E - (1 + r^*)I_D^f \right) \left[ (1 - p(e_m^{FR})) - (1 - p(e^v)) (1 - q(m)) \right] + (1 - p(e_m^{FR})) q(m)\Pi^* \quad (4.13)$$

The incentive condition (4.13) determines the minimum detection probability  $q(m)$  (leading to corresponding costs of  $m$ ) such that  $e_m^{FR}$  is preferred by the manager. Inequality (4.13) shows that it is the more likely that monitoring is chosen, (i) the more efficient the monitoring technology (the higher  $q(m)$  for given  $m$ ), (ii) the higher the manager's wealth and the project's return, and (iii) the lower the insurance premium required to fulfill the insurer's participation constraint.

**Proposition 2 (Optimal Insurance Contract).** *Suppose the manager's wealth is low,  $W < D - R(I_D^f) + I$ . Then the optimal contract under financial responsibility will be such that:*

1. The insurance premium is

$$r^* = \frac{R(I_D^f) + W - I}{I_D^f}. \quad (4.14)$$

2. The bonus if the manager is found compliant is

$$\Pi^* = \frac{1}{q(m)} \frac{1}{1 - p(e^*)} \left( \left[ R(I_D^f) + W - I \right] - p(e^*)L \right) \quad (4.15)$$

3. The optimal monitoring probability  $q(m)$  and monitoring costs  $m$  can be chosen arbitrarily close to zero,  $q(m) \approx 0$  and  $m \approx 0$ .

**Proof:** See the Appendix.

With this optimal contract, we can immediately conclude that financial responsibility comes arbitrarily close to the first best allocation. Note that the manager always chooses the privately optimal level of care if she prefers to be monitored. With these insights, the following result is immediate:

**Proposition 3 (Optimal Liability Rule).** *The optimal liability regime is full liability,  $L = D$ . This liability rule will always achieve the first best allocation as long as firms choose the optimal insurance contract laid out in Proposition 2.*

Proposition 3 is an immediate consequence of the fact that the optimal contract can come arbitrarily close to the first best allocation,  $e_m^{FR} = e^*$ . But then, since  $e_m^{FR}$  is strictly increasing in  $L$ , the choice of  $L$  should be such that  $e_m^{FR} = e^*$  is chosen. This is precisely the case if  $L = D$ , i.e. if the court decides on full liability, since then the manager's objective function under the optimal contract coincides just with the maximization of the social surplus. We wish to emphasize that it is exactly the bonus payment that allows for a first best even with positive monitoring costs and limited wealth.

Another point to note is that it can never be a subgame perfect strategy for the manager to *sign and violate* a monitoring contract, because her expected utility is strictly lower than without monitoring (the only advantage of being monitored is the possibility to credibly commit to  $e^L$ ). Hence, only  $e_C^{FR}$  and  $e_m^{FR}$  are possible effort levels in a subgame perfect equilibrium. With monitoring, the manager's expected utility is

$$M_M^{FR} = R(I_D^f) + W - I - p(e_m^{FR})L - e_m^{FR} - m \quad (4.16)$$

where  $m$  is the minimal monitoring level that fulfills Inequality (4.13) above. It follows that, in case of private debt, the manager chooses monitoring if

$$p(e_m^{FR})L + e_m^{FR} + m \leq p(e_C^{FR})L + e_C^{FR} \quad (4.17)$$

We can summarize the findings on financial responsibility as:

**Proposition 4.** (i) If  $W \geq D + I - R(I_D^f)$ , then the first best can be reached if the liability regime is financial responsibility and if the regulator chooses  $L = D$ .

(ii) If  $W < D + I - R(I_D^f)$ , then the first best can be reached if the liability regime is financial responsibility and if the regulator chooses  $L = D$ . Under the optimal allocation, the optimal insurance contract of Proposition 2 is chosen and the firm will be monitored with an arbitrary small probability  $q$  and negligible monitoring costs  $m$ .

### 4.3. Lender Liability

Now consider the effect of lender liability that is not backed up by the requirement to prove mandatory coverage, irrespective of the financial structure. For the reasons explained above, we assume that lender liability extends only to bank creditors, not to public creditors. Recall that the efficient debt structure choice would be to prefer bank debt whenever  $c < 0$ . Moreover, bank debt could be socially preferable if we allowed for the possibility that the bank's monitoring technology might be superior to that of insurance companies. The capital structure decision will now be distorted because of the unequal treatment of private and public debt: Only bank financed firms have to fully internalize the environmental risk. Two distortions can emerge: first, public debt firms will use too much debt and exercise too little care because of the lacking imposition of social costs. Second, some firms which should use bank debt because of  $c < 0$  will now find it privately optimal to switch to public debt to free ride on (parts of) the social costs of their activities. This is the *debt structure bias* of lender liability.

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Suppose the firm continues to use bank debt in spite of this handicap. Then everything is identical to financial responsibility: the manager uses her initial wealth as deductible, and chooses  $e_m^{FR}$  (since the optimal monitoring contract is always better for the manager).

On the other hand, if the firm uses public debt, its objective function is the same as under strict liability only, because liability is not extended to third parties. Therefore, as long as the cost advantage of bank debt  $c$  is small, the possibility to evade liability by choosing dispersed public debt will dominate, and the outcome is comparable to strict liability.

To summarize, which of the two debt alternatives the manager prefers depends on the cost difference between bank and public debt, i.e. on  $c$ . We find:

**Proposition 5.** *With lender liability, the capital structure will be biased in favor of publicly floated debt.*

(i) If bank debt is more expensive (i.e. if  $c$  is positive) or if the cost advantage of bank debt is relatively small (i.e. if  $c$  is negative but close to zero), then public debt is always preferred and the same distortions as under strict liability arise: underprovision of care, overleverage, and overinvestment.

(ii) If bank debt is substantially less costly,  $c < 0$  and the value of  $c$  is large, then bank debt will be preferred and the first best can be achieved, as under financial responsibility.

Since we are not stating a formal proof of Proposition 5, we want to at least append a solid intuition how this finding can be proven. Suppose bank debt is the more attractive source of financing, i.e.  $c < 0$ . In economic terms, since the choice of public debt effectively reinstates the strict liability regime, this gives the manager a *free put option* on a part of the damages, namely the fraction that is not covered by the liquidation process of the firm after creditors are paid off,  $R(I_D) - I$ . Since option theory tells that such an option is always valuable, the manager will use it as long as the use of this option is not too costly. This is expressed in Proposition 5.

#### 4.4. Comparison of the Liability Rules

The main result of our analysis is that financial responsibility either leads to the first best allocation or comes arbitrarily close to that if the regulator requires full liability,  $L = D$ . This finding is strikingly different from the view held by the proponents of reduced liability,  $L < D$ , (for these proponents, see the references in Section 1.2). This difference is explained by the fact that our contract proposes the optimal combination of stick-and-carrot elements, or of contract penalties and bonus payments in response to the findings of the monitoring: The proponents of restricted liability argue that in the presence of agency costs, the trade-off between improving the risk internalization (by increasing  $L$  toward  $D$ ) and the rising agency costs leads to an internal optimum. In our model, safety monitoring is introduced, and we show that with the optimal contract, almost no agency costs  $m$  (for monitoring the manager) are required. It follows that full liability ( $L = D$ ) is optimal.

By contrast, both strict liability alone and lender liability lead to distortions: The limited liability effect is present under strict liability, but also, as discussed in the last subsection, under lender liability, at least as long as banks are not substantially more cost efficient. This leads to underprovision of care, to overleverage, and to overinvestment.

Finally, we can compare the relative inefficiencies caused by strict liability and lender liability. In fact, the relative ranking between strict liability and lender liability is ambiguous. On the one hand, for firms which prefer bank debt under both regimes, efficiency is improved through lender liability because they are now internalizing the environmental risk in their investment and care decisions. On the other hand, for firms which prefer bank debt under strict liability but are induced to switch to public debt, efficiency will deteriorate because the environmental risk will still only be partially internalized, and there will be an additional

loss from using a less preferable capital structure. Finally, firms preferring public debt under both regimes will see no change in their incentives.

## 5. Conclusion

We compared financial responsibility, strict liability without extension, and lender liability in a model where the manager can finance the project through equity (out of her wealth), publicly floated debt and bank debt. Lenders and insurers can perform audits to mitigate the moral hazard problem with respect to the manager's effort.

We demonstrate that financial responsibility is superior to each other regime. Under financial responsibility, the efficient care level is chosen, and the agency costs of monitoring can be reduced to a negligible quantity, if contracts are optimized. The social welfare can then attain the first best.

There are three driving forces behind our findings. First, the manager voluntarily invests her total wealth as deductible and insurance premium to reduce agency costs. Second, financial responsibility avoids distortions in the capital structure. Third, the agent chooses the optimal monitor independently of the capital structure. If partial liability is applied instead, distortions in the capital or debt structure are inevitable: the lower the level of extended liability, the higher the bias towards debt instead of equity. However, the higher the level of lender liability, the higher the incentive to substitute bank credits by publicly floated debt. These distortions together with well developed monitoring technologies lead to the conclusion that financial responsibility is referable.

Certainly, one may remain skeptical whether the reduction of monitoring costs to an arbitrarily small amount is possible in practice. In our view, this feature of the optimal contract nonetheless captures an important aspect of the reality of environmental audits: Since firms so often voluntarily engage in contracts with their insurers where they are routinely monitored, they demonstrate *by revealed preferences* that in practice, the benefit of implementing the efficient care level typically more than dominates the additional agency costs of continuous safety monitoring.

## Appendix

### Proof of Proposition 2.

Since the insurance market is competitive, for each choice of bonus  $\Pi^*$  the competitive (or fair) premium  $r^*$  will be such that the manager expects a surplus, conditional on there being no accident, of

$$B = R(I_D^f) + W - E - (1 + r)I_D^f.$$

where

$$r = \frac{p(e)}{1 - p(e)} \frac{[L + I - R(I_D^f) - W]}{I_D^f}$$

Hence the manager maximizes, irrespective of the choice of  $\Pi^*$ ,

$$e = \arg \max (1 - p(e))(1 - q(m))B - e. \quad (5.1)$$

The solution of (5.1) is  $e_m^{FR}$ . Consider then  $e^v$ . if  $\Pi^*$  is chosen as in (4.15), then  $r^*$  as in (4.14), hence the manager retains zero if not audited and there is no accident. As a consequence,  $e^v$  maximizes

$$e^v = \arg \max \{-e - m\},$$

hence the best deviation strategy is to choose the lowest feasible effort. Therefore, any monitoring policy which gives the manager a positive payoff iff  $e_m^{FR}$  is chosen. But this is the case since  $B > 0$ . It remains to choose the optimal  $\Pi^*$ . Consider all pairs  $(q, \Pi^*)$  such that the ensuing fair premium  $r^*$  satisfies (4.9). Straightforward calculation gives that these pairs satisfy the condition:

$$q\Pi^* = \frac{1}{1 - p(e^*)} \left( [R(I_D^f) + W - I] - p(e^*)L \right) \quad (5.2)$$

Hence all pairs  $(q, \Pi^*)$  where the product  $q \cdot \Pi^*$  is equal to the RHS of (5.2) will make sure that the manager prefers the first best care level  $e^*$  over any other care level. But then consider a sequence where  $\Pi^* \rightarrow \infty$ : all pairs  $(q, \Pi^*)$  satisfying (5.2) along this sequence must have as limit point:  $q \rightarrow 0$ . It follows that if  $q$  can be chosen arbitrarily close to zero, then the monitoring costs can be chosen arbitrarily close to zero. Thus, in the limit the optimal care level  $e_m^{FR}$  will be the maximizer of

$$e_m^{FR} = \arg \max \left\{ R(I_D^f) - I - p(e)D - e \right\}$$

and hence  $e_m^{FR} \rightarrow e^*$  as  $\Pi^* \rightarrow \infty$ , so the first best allocation can be achieved. ■

## Notes

1. (1) See Summers (1983), Schwartz (1985) and Shavell (1986). Beard (1990) and Posey (1993) extend the discussion to care costs that reduce the coverage of the defendant and Kornhauser and Revesz (1990) discuss the problem of multiple tortfeasors.  
(2) Ringleb and Wiggins (1990) indeed find that firms attempt to avoid liability by shielding assets through divestiture. Their analysis suggests that the incentive to avoid liability led to a 20% increase in the number of small corporations between 1967 and 1980; see also Wiggins and Ringleb (1992) for a theoretical analysis.  
(3) See e.g. Shavell (1987).  
(4) Strict liability without extended liability means that no other party, like lenders, assumes liability in the case of insolvency.  
(5) This distinction has received a lot of attention recently in the theory of corporate finance in the wake of the trend of financial markets toward direct placements of debt. See e.g. Diamond (1991), Rajan (1992), Chemmanur and Fulghieri (1994) and Bolton and Scharfstein (1996).  
(6) Basically, in U.S. bankruptcy proceedings, claims of the Environmental Protection Agency (EPA) for the clean-up of toxic property are ranked as administrative expenses. That is, they are junior to secured claims, but senior to all unsecured claims; see *in re. Chateaugay Corporation* 994 F.2d 997 (2nd Circuit Court 1991); *in re. Hemingway Transport, Inc.*, 993 F.2d 915 (1st Circuit Court) and *Pennsylvania vs. Conroy*, no. 93-3284 (3rd Circuit Court 1994).  
(7) Boyer and Laffont analyze a rich model that consists of two periods and moral hazard (with respect to care) as well as adverse selection (with respect to the expected revenue). To make our point, however, the trade-off between internalization and agency costs with the conclusion of liability below harm is the most important result.  
(8) Though Boyd and Ingberman focus on purchasers of inputs, their analysis is more general.  
(9) See Boyd and Ingberman (1996). Endres and Lüdeke (1998) derive arguments for partial liability in a somewhat different environment.  
(10) See e.g. Newman and Wright (1992) and Demougin and Fluet (1999). Shavell (1997) demonstrates that the optimal level of extended liability might well be above total harm (punitive damages) if the principal has the bargaining power.  
(11) In a different context, Gompers and Lerner (1999) report that concerns about liability prevent limited partners in venture capital firms to follow closely their investment.  
(12) 42 USC 9601(20)(A).  
(13) Published at 57 Fed. Reg. 18, 344 and found in 40 C.F.R. § 300.1100.  
(14) *In re. Kelley v. EPA*. See also Buente et.al (1996), and Phillips (1996).



- (15) See e.g. *in re. T.P.Long Chemical, Inc.* 45 B.R.278 (US Bankruptcy Court N.D. Ohio 1985); *US v. Mirabile* (E.D.Pa. 1985), 15 ELR 20994; *US v. Maryland Bank&Trust Co.* 643 F. Supp 573 (D.Md.1986), *Guidice v. BFG Electroplating and Mfg. Co., Inc.*, 732 F. Supp 556 (W.D.Pa. 1989) and *Ashland Oil, Inc.v. Sonford Products Corporation*, 810 F. Supp 1057 (D.Minnisota 1993).
- (16) The same argument is *in re. Bergsoe Metal Corp.* 910 F2d 668 (9th Circuit 1990).
- (17) *Factors Corporation*, 901 F2d 1550-9 (11th Circuit. 1990). See also Greenberg and Shaw (1988, 1230); Clanton (1992, 200-204); Strasser and Rodosevich (1993, 524).
- (18) A discussion of this point is in Feess (1999).
- (19) 33 U.S.C. §2716.
- (20) See 40 CFR 258, subpart G.
- (21) See Boyd (1996) for an economic analysis of the different mechanisms to prove financial responsibility under RCRA.
- (22) Commission of the European Communities: “Communication from the Commission to the Council and Parliament and the Economic and Social Committee: Green Paper on Remedying Environmental Damage”, Brussels, May 14, 1993.
- (23) See “Study of Civil Liability Systems for Remedying Environmental Damage. Final Report” (cited as “Final Report”); “Economic Aspects of Liability and Joint Compensation Systems for Remedying Environmental Damage. Main Report” (cited as “Main Report”); “Economic Aspects of Liability and Joint Compensation Systems for Remedying Environmental Damage. Volume II: Topic Papers.” (cited as “Topic Papers”).
- (24) See e.g. Commission of the European Communities 1993, 13-18.
- (25) See Final Report, 168-178 and the Topic Papers.
- (26) See Final Report 369-374 and the country reports in “Topic Papers”.
- (27) See e.g. Commission of the European Communities (1993, 36). See Lidgren and Skogh (1996) for a comparison of insurance and funds.
- (28) See Myers (1977) for this theory, which is also the leading capital structure model in most corporate finance textbooks.
- (29) The optimal capital structure is treated exogenous because we are only interested in distortions caused by limited liability.
- (30) In reality, either banks or insurance companies might have the superior auditing technology. On the one hand, insurance companies have great experience in environmental monitoring, but on the other hand, it has been common bank practice for years to assess the environmental risks of potential borrowers.
- (31) If bank debt is superior to public debt,  $c < 0$  must be added.
- (32) Subscripts  $SL$  denote the case with strict liability only.
- (33) The effects of punitive damages would be somewhat more complicated if we allowed for different levels of harm, some of which above and some of which below the

insolvency threshold; see Innes (1999), and Lewis and Sappington (1999).

(34) If  $L$  is so low that  $W \geq L - R(I_D^f) + I$ , then the manager covers herself, but chooses  $e < e^f$  as  $L < D$ .

(35)  $e_C^{FR}$  is the effort in case of *financial responsibility* if wealth is constrained (low), and if the manager prefers not to be monitored.

(36) Of course, one must take into account that care and the leverage will endogenously be adjusted after a switch in capital structure.

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