The Benefits of Extended Liability*

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Abstract: We characterize the optimal regulation of a firm which undertakes an environmentally risky activity. This firm (the agent) is protected by limited liability and bound by contract to a stakeholder (the principal). A key feature is the non-observability of the level of safety care exerted by the agent. This level of care depends both on the degree of incompleteness of the regulatory contract (i.e., whether private transactions can be controlled or not) and on the allocation of bargaining power between the principal and the agent. Increasing the wealth of the principal that can be seized upon an accident has no value when private transactions are regulated but might strictly improve welfare otherwise. We derive bounds on the principal's wealth so that the second-best complete regulatory outcome can still be achieved with an incomplete regulation if it is supplemented by an ex post extended liability regime. Extensions to the cases of multiple principals and of a ban on regulatory rewards are also analyzed.

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1 Introduction

Extending liability towards deep-pocket stakeholders of firms engaged in environmentally risky activities has been a major building block of recent legislations towards environmental accidents. For instance, under the U.S. 1980 Comprehensive Environmental Response, Compensation, Liability Act (CERCLA), any owner or operator of an environmentally risky venture may be found liable for the losses generated by the firm's activity if the latter is itself judgment-proof, i.e., if its assets cannot cover the cleanup costs of contaminated sites.[1] Despite the international tendency towards strict liability for environmental harm, a general agreement on the rationale for relying on liability rules is still missing.[2] Extending liability towards stakeholders has often been viewed as a successful legal response to finance the remediation of hazardous sites or to indemnify victims (a compensation role). Common sense suggests that it might also foster incentives for prevention by inducing private actors to internalize the environmental concerns of the rest of society (an incentive role). This legal doctrine has nevertheless encountered fierce opposition both among practitioners and scholars. Opponents argue that the benefits of extending liability also come with some costs. On top of the administrative costs of litigation, extended liability might change transactions between risky ventures and their contracting partners. Market structures could be modified accordingly.

This paper gives some theoretical foundations for using a regime of extended liability and, more broadly, analyze how private transactions between principals and their agents are modified accordingly. The key justification for doing so is the *incompleteness of the regulation.* Indeed, the contracts linking the firm to various stakeholders might affect the level of care chosen by the firm and thus impact on the environment. These contracts should thus be regulated in one way or the other. We show in this paper that, even when no such regulation is possible, the threat of extended liability might induce private actors to internalize environmental concerns and design private transactions accordingly.

Designing a complete regulation may be of a tantamount difficulty when the set of partners who contract with the firm performing some hazardous activities and who can

[1]CERCLA Section 107 (a) casts an extremely broad net in defining those persons that can be liable for the costs of responding to a release of hazardous substances: current or former owners or operators of the facility or vessel, those who arranged for treatment or disposal of hazardous substances at a facility, the transporters of the hazardous substances, and more generally anyone involved in the management of hazardous substances. Several cases have illustrated this legal doctrine. In the 1986 *U.S. v. Maryland Bank and Trust* case, for instance, a bank was found liable for cleanup costs as an effective "owner" of the facility at the time the pollution was discovered. More generally, the deep pocket of creditors and other stakeholders has been requested when such partners were contractually tied with judgment-proof firms and involved in a sufficiently close relationship. Strasser and Rodosevich (1993) offer a nice perspective on the principles governing the interpretation of CERCLA. Boyer and Laffont (1996) review the Canadian, the American and the European legal frameworks.

[2]See Faure and Skogh (2003), Chapters 14 and 17.

therefore influence the management of environmental risk is not clearly defined at the design stage.[3] Even if the relevant stakeholders can be found out ex ante, environmental regulators generally do not have the statutory or the auditing rights, or even the expertise, to control the contracts which bind those stakeholders to the firm's management.[4] The regulation of environmental risk in such a context is thus necessarily highly incomplete and leaves these contracts by large uncontrolled. As a result, these contracts may influence care taking in ways which are detrimental to social welfare. Because of this incompleteness, relying ex post on liability might improve welfare by putting the various stakeholders of the firm under the threat of being sanctioned for having wrongly distorted the firm's care taking if a bad environmental performance occurs.

We determine circumstances under which an incomplete regulation can be improved by ex post liability rules. We start with a bare boned model of a vertical relationship between an agent who is subject to environmental risk regulation and liability, and his principal. We first characterize the optimal complete regulation in a moral hazard framework where the agent's level of safety care is non-verifiable but the transaction between the principal and this agent can be controlled. Moral hazard and limited liability[5] force the regulator to leave a socially costly rent to the agent to induce care. Reducing this rent requires a downward distortion of the level care below the first-best.

When the transaction is itself non-verifiable, the regulatory contract is incomplete. This incompleteness may increase significantly the social costs of inducing safety care. To the rent left to the agent to induce care, one must now also add the rent left to his principal so that he designs a private transaction which does not undermine care taking. Increasing the amount of wealth collectable from the principal under a liability regime helps nevertheless reducing these extra agency costs. Extended liability may be a rough substitute for a more complete regulation.

To understand more precisely how this substitution works, note that the regulator faces *two* different moral hazard problems. First, he must induce the cashless agent to exert the proper level of prevention. Second, the regulator must also ensure that the private transaction linking the principal and the agent does not interfere with the regulatory incentives for safety care. If this transaction was regulated, these two problems could be addressed separately. First, the regulator could force the principal to make a payment for the agent's services independent on his environmental performances. Private transactions

[3]For instance, it is often argued that one major problem faced by the Environmental Protection Agency regulators when enforcing the Resource Conservation and Recovery Act (RCRA) for underground storage tanks is that owners are often difficult to locate.

[4]As an example, Boyd (2001, p.21) notes that *"corporate financial auditing is not a traditional strength of environmental regulation"*.

[5]Environmentally risky firms are often small in scale since they conceal assets in order to be insulated from the threat of paying for damages. See Ringleb and Wiggins (1990).

would thus not affect care taking. Second, the regulator could design a convenient set of regulatory rewards and punishments to induce the agent to exert care. Extending the principal's liability would then be useless since, *de facto*, the principal would not interfere with the agent's management of environmental risk.

When private transactions cannot be regulated and a regime of extended liability is used, the principal is concerned with the agent's environmental performances since he may be prosecuted to pay fines following an accident. Part of the benefits from private contracting may be dissipated through these fines. Private contracting is modified accordingly. This is where the distribution of bargaining power in private contracting matters. The higher the principal's bargaining power, the less he will be prone to leave the rent that a cash-constrained agent must receive to exert care. Private contracts are thus designed with an eye on reducing this rent. This calls for reducing the level of care performed by the agent. The unregulated design of private contracting thwarts regulatory incentives.

Anticipating this countervailing effect, an incomplete regulation must induce the principal to design a private contract which gives to the agent the correct incentives for safety care. This can be done by increasing sufficiently fines through a liability regime. However the principal's wealth may not suffice to cover large fines. We characterize a lower bound on the principal's wealth above which the incompleteness of the regulation does not hurt if extended liability is also used. Below this bound, one reaches a third-best outcome characterized by significant care distortions. The principal can still be induced to choose the right private transaction from a social viewpoint but he must also receive a rent to do so. The rents left to both the principal and the agent compound and the social cost of inducing care increases. As a result, the downward distortion in care is exacerbated.

When the agent has most of the bargaining power, he can reap most of the surplus from the transaction with his principal. When this surplus is independent of the agent's environmental performances, contracting has no impact on care taking. Increasing the principal's wealth at stake is then useless. More generally, there is a positive relationship between the wealth needed from a principal to induce care and his bargaining power.

Our paper belongs to a burgeoning literature starting with Pitchford (1995), Heyes (1996) and Boyer and Laffont (1997) who focus on the relationship between a firm and its financiers. Those papers argue that extending liability towards fund providers of risky ventures may not be a panacea. In Pitchford (1995), the competitive financier can only recoup his financial loss in the event of an accident by asking for higher repayments when no accident occurs. This depresses the agent's incentives for exerting safety care. Boyer and Laffont (1997) argue that increasing the financiers' liability can deter participation to projects which are socially valuable. Heyes (1996) shows that increasing liability changes the pool of loan applicants. Earlier critics have shown that extending liability and putting more of the financiers' wealth at stake recovers some value when principals have most of the bargaining power (Balkenborg (2001)) or when the damage technology is more complex than the binary accident-no accident technology used by Pitchford (1995) (Lewis and Sappington (2001a)). These contributions detail how optimal private contracting reacts to liability rules. However, the regulatory response to private contracting discussed there is quite trivial since regulators are concerned only with efficiency and not with rent extraction.[6] In addition, since the only public policies which are available consist of ex post liability rules, it is hard to figure out whether the cost of extending liability comes from this restriction or from some more fundamental economic phenomenon. Instead, we explore optimal regulatory policies when the rents accruing to the private sector are socially costly. In full generality, a regulatory contract policy should involve both fines if an accident occurs and rewards if good environmental performances are observed. This normative approach highlights how agency costs compound when the regulator does not control private transactions. It allows us to characterize conditions on the principal's wealth under which the incompleteness of the regulatory contract can be circumvented.

Section 2 presents the model. Section 3 characterizes the optimal regulation when moral hazard on safety care is the only issue. The transaction between the principal and the agent can be fully observed and controlled. In Section 4, we relax this assumption and explore the optimal regulatory policy and its dependence on the allocation of bargaining power between the principal and the agent. In Section 5, we extend the analysis to the case of multiple principals and discuss the case of an institutional constraint banning regulatory rewards. Section 6 concludes. Proofs are relegated to an Appendix.

2 Model

A cashless firm (the agent) exerts an activity that may provoke an accident harming third-parties and/or the environment. This agent is bound by contract to a stakeholder (the principal). The agent's services generate a surplus Π on behalf of the principal.[7] There is a whole range of activities for which our analysis is relevant. For instance, the agent could run underground storage tanks or disposal facilities on behalf of parent firms, dispose wastes collected from clients, or transport hazardous substances on behalf of producers. A financier could also provide capital to the firm in which case Π would be the net value of the agent's project. We should already stress that these different kinds of principals may significantly differ in terms of their available wealth.

The firm's activity being risky, an environmental harm D may occur with probability

[6] A noticeable exception is Boyer and Laffont (1997).

[7] See Boyd and Ingberman (1997) for an earlier model keeping this degree of generality.

$1 - e$. The probability that no accident occurs e is normalized so that it is equal to the agent's level of safety care (or effort). To exert such an effort, the agent incurs a non-monetary cost $\psi(e)$. For technical reasons, we assume that $\psi' > 0$, $\psi'' > 0$, and $\psi''' > 0$ and that the Inada conditions $\psi'(0) = 0$ and $\psi'(1) = +\infty$ hold so that effort is always interior.This effort is not observed neither by the principal nor the regulator.

Without loss of generality, a regulatory scheme stipulates payments z_a and z_n to the agent depending on whether an accident occurs or not. Such a scheme can, for instance, be understood as resulting from the use of ex post liability following a damage (a fine $-z_a > 0$ imposed on the agent if he has enough earnings from the principal's contract, and on the principal if liability is extended) and of an incentive reward ($z_n > 0$) following good environmental performances. Indeed, since the agent has no cash to indemnify harmed third-parties, the principal's contribution may be needed following a damage if the requested fine is too large and cannot be paid by the agent out of the earnings he made from contracting with the principal. Even though they do not a priori target the principal, fines that cannot be paid by the cashless agent end up being paid by the principal if liability is extended and the principal is himself wealthy enough. Since private transactions can undo any allocation of liabilities, it does not really matter who originally bears the fine. This Equivalence Principle is now well-known from the earlier works of Newman and Wright (1990) and Segerson and Tietenberg (1992) and will be used at several places below. In particular, we will argue that the incompleteness of the regulatory contract calls for increasing the fines imposed on the principal/agent pair. With the Equivalence Principle in mind, such an increase in fines can be reinterpreted as relying more on extended liability.

Although our modeling uses the direct monetary nature of rewards and punishments, broader interpretations are available. Bad environmental performances sometimes come also with damages to the fixed capital of the firm and to some stakeholders (like workers). Cost may also be indirect: future regulations might be tightened, environmental audits may be more frequent in the future, the government may refuse authorizations and permits or raises taxes. Rewards may also stem from the firm's gains in reputation vis-à-vis its customers, the government, shareholders and the financial community.[8, 9]

Denoting by (y_n, y_a) the payments made by the principal to the agent in each state of nature, we can rewrite the agent's expected payoff as:

$$U = e(z_n + y_n) + (1 - e)(z_a + y_a) - \psi(e).$$

[8] On the indirect costs and benefits of a good management of environmental risks, see Lesourd and Schilizzi (2001).

[9] Those non-monetary transfers may also be socially costly. For instance, reputation gains may also create switching costs in the relationship between the firm and some of its contractual partners. Similarly, tightening future regulations may reduce entry.

The risk-neutral principal's net benefit from the transaction is thus given by:

$$V = \Pi - ey_n - (1-e)y_a.$$

Since the agent has no cash, what really matters from the regulator's viewpoint is the wealth w collectable from the principal. We will study how the regulatory outcomes and the level of safety care may change with w and ask under which circumstances putting more of the principal's wealth at stake improves welfare. Of course, the principal can engage in a variety of strategies to hide the true value of his assets (accounting manipulations, "flight-by-night" techniques, creating cashless subsidiaries, etc...). We will thus view w as the part of the principal's wealth which can be easily observed and possibly seized when an accident occurs.

The regulator maximizes a social welfare function which takes into account not only the profits of the private sector, the budgetary cost of the regulatory scheme and the cleanup cost or financial amount reimbursed to harmed third-parties. Following Laffont and Tirole (1993), the regulator's objective function can be expressed as:

$$W = U + V - (1+\lambda)((1-e)D + ez_n + (1-e)z_a),$$

where $\lambda > 0$ is the positive cost of public funds.[10] For future reference, it is useful to rewrite the regulator's objective as:

$$W = (1+\lambda)\left(\Pi - (1-e)D - \psi(e)\right) - \lambda\left(U+V\right). \quad (1)$$

This expression stresses the trade-off faced by the regulator in designing an optimal regulation. On the one hand, an efficient level of care maximizes the first bracketed term. On the other hand, inducing such level of effort under moral hazard may require leaving a rent $U + V$ to the private sector. This rent is costly when λ is positive. This trade-off distinguishes our analysis from the previous literature[11] which assumes that rents in the private sector are socially costless. Assuming that rents are socially costly allows us to stress how different contracting modes affect this social cost and to characterize how distortions in the level of care depend on the contracting environment.

Full Control: As a benchmark, let us suppose that both the effort e and the private transaction (y_n, y_a) can be observed and regulated. The regulator's problem becomes:

$$(\mathcal{R}^*) : \max_{\{e,U,V\}} \quad (1+\lambda)(\Pi - (1-e)D - \psi(e)) - \lambda(U+V)$$

[10] We could as well assume that harmed third-parties receive a weight γ in the regulator's objective function so that $W = U + V - \gamma(1-e)D - (1+\lambda)(ez_n + (1-e)z_a)$. This alternative formulation could be useful to capture the often-heard claim that environmental regulatory agencies and judges in environmental litigation put more emphasis on victims when $\gamma > 1$. This would clearly not change our results provided that D is replaced by $D' = \frac{\gamma D}{1+\lambda}$.

[11] Pitchford (1995), Balkenborg (2001) and Lewis and Sappington (2001a).

subject to constraints $U \geq 0$ and $V \geq 0$.

These two constraints ensure participation of the agent and the principal. At the complete information optimum, these participation constraints are obviously binding and the private sector withdraws no rent ($U = V = 0$) from its activity. The first-best effort level e^* is such that the marginal benefit of reducing the likelihood of an accident equals the marginal cost of effort:

$$D = \psi'(e^*). \tag{2}$$

To implement this outcome, the regulator can first impose the standard e^*; second, require the principal to leave the whole surplus of the transaction to the agent by setting $y_a^* = y_n^* = \Pi$; third, force a fixed regulatory payment $z_n^* = z_a^* = -\Pi + \psi(e^*)$ to ensure that the agent breaks even.

Of course, the regulator might not observe all the relevant variables needed to implement this first-best outcome. Either the effort e or both the effort and the private transaction (y_n, y_a) might not be observable and can only be indirectly controlled through the regulatory scheme (z_n, z_a) that the regulator imposes on the sole agent. The analysis of these settings with limited control will be the purpose of the next sections.

3 Moral Hazard in Safety Care

Under moral hazard, neither the regulator nor the principal can observe the agent's effort. Nevertheless, the regulator has still enough instruments to regulate the private transaction. In this complete regulation setting, the regulator can impose the payments made by the principal to the agent for any realization of his environmental performance.

Maximizing his expected profit, the agent chooses an effort satisfying the following moral hazard incentive constraint:

$$z_n + y_n - (z_a + y_a) = \psi'(e). \tag{3}$$

Using (3), the agent's expected utility becomes:

$$U = e(z_n + y_n) + (1 - e)(z_a + y_a) - \psi(e) = R(e) + z_a + y_a.$$

Following Laffont and Martimort (2002, Chapter 4), we will define the agent's limited liability rent as $R(e) = e\psi'(e) - \psi(e)$ which is increasing and convex in e ($R'(e) = e\psi''(e) > 0$ and $R''(e) = e\psi'''(e) + \psi''(e) > 0$). Being cashless, the agent is protected by limited liability in the damage state so that $z_a + y_a \geq 0$. Inducing the agent to undertake a level of safety care e requires thus to leave him a liability rent $R(e)$. We must have:[12,13]

$$U \geq R(e). \tag{4}$$

The principal's participation constraint is:

$$V = \Pi - ey_n - (1-e)y_a = \Pi + ez_n + (1-e)z_a - \psi(e) - U \geq 0. \tag{5}$$

The principal's liability constraint can be written as $\Pi - y_a \geq -w$ or, using (5),

$$V \geq -e(y_n - y_a) - w. \tag{6}$$

Under moral hazard, the regulator's problem becomes therefore:

$$(\mathcal{R}^{SB}) : \max_{\{e,U,V,z_a,z_n\}} \quad (1+\lambda)(\Pi - (1-e)D - \psi(e)) - \lambda(U+V),$$

subject to constraints (4) to (6).

We summarize this optimization in the next proposition.

Proposition 1 *Assume that there is moral hazard on safety care but that the private transaction can be regulated. The optimal regulatory policy induces a second-best effort level e^{SB} such that $e^{SB} < e^*$ and:*

$$D = \psi'(e^{SB}) + \frac{\lambda}{1+\lambda} e^{SB} \psi''(e^{SB}). \tag{7}$$

The principal's limited liability constraint (6) can be satisfied at no cost by giving to the agent all the surplus from his relationship with the principal whatever the agent's environmental performance, $y_n^{SB} = y_a^{SB} = \Pi$. The agent's and the principal's payoffs are respectively $U^{SB} = R(e^{SB})$ and $V^{SB} = 0$.

[12] For any $e \geq 0$, $R(e) \geq 0$ and the agent's participation constraint is implied by (4). Had the agent owned assets of value l, (4) would have to be replaced by $U \geq R(e) - l$. In that case, the participation constraint may be binding for l large enough, meaning that the first-best level of care can still be implemented at no cost. For intermediate levels of l, both the participation and the limited liability constraints may be simultaneously binding. This leads to a constrained optimum where, despite making zero profit, the agent no longer exerts the first-best effort. The number of relevant cases in the analysis is thus simplified by our assumption that the agent has no wealth.

[13] Our model could be easily modified when the cost of effort may be monetary. This alternative assumption would capture the fact that investments in safety care are a component of the firm's costs which is not easily verifiable. The firm's liability constraint is now $z_a + y_a \geq \psi(e)$ and (4) becomes $U \geq \hat{R}(e) = e\psi'(e)$. We have $\hat{R}'(e) > R'(e)$ and the second-best effort is greater with a monetary disutility. Intuitively, by reducing the effort, the regulator relaxes now also the firm's liability constraint. Although expressions differ, insights are similar to those obtained with a non-monetary cost.

Under moral hazard, the regulator faces a trade-off between inducing a level of effort close to the first-best e^* and giving a socially costly rent $R(e^*)$ to the agent, the only way of inducing this effort. Reducing the effort below the first-best e^* reduces this rent.

Implementation: When the private transaction is regulated, the regulator extracts all the principal's profit. To this end, the regulator has several possibilities obtained by combining the payments y_n and y_a so that, in expectation, the principal's profit is zero. One such combination is particularly attractive in view of the analysis of the next section. When $y_n^{SB} = y_a^{SB} = \Pi$ so that $V^{SB} = 0$, everything happens as if the agent had full bargaining power in transacting with the principal. Since this private transaction does not depend on the agent's environmental performances, it does not perturb the agent's incentives and the level of care depends only on the regulatory transfers. ■

With this implementation, the principal is actually quite passive and does not interfere with risk management. There is thus a complete dichotomy between the design of the private transaction and the provision of incentives for safety care to the agent. Since the principal remains passive, his liability constraint plays no role whatsoever. In addition, $z_a = -\pi$ leaves a rent $U = R\left(e^{SB}\right)$ to the agent.

Corollary 1 *Assume that there is only moral hazard on safety care and that the private transaction is regulated. Increasing the principal's collectable wealth w has no value.*

For further reference, we note that the power of the regulatory scheme in the full control environment can be defined as :

$$z_n^{SB} - z_a^{SB} = \psi'(e^{SB}) = D - \frac{\lambda}{1+\lambda} e^{SB} \psi''(e^{SB}) < D.$$

This incentive power is less than the size of the harm done because effort is distorted downwards below the first-best. In the next section, we will see how the power of regulatory incentives changes when the private transaction is no longer regulated.

4 Non-Observable Private Transaction

In practice, environmental regulators do not have the expertise and the monitoring technology necessary to audit and control the full set of contracts involving the firm. Regulators can certainly determinate whether a given firm threatens the environment with its activities. However, they may find hard to ascertain the whole set of stakeholders (suppliers, customers, lenders, etc..) who are bound by contracts with the firm, even though these transactions may significantly affect the management of environmental risk.

In such incomplete regulatory settings, only the agent can be targeted ex ante with a regulatory scheme. This regulation can be supplemented by an ex post liability rule which may impose a fine on the principal/agent pair in the event of a damage once the involvement (be it direct or indirect) of the principal has been proved.[14] Of course, if it is large enough, this fine ends up being paid by the wealthy principal since the agent is cashless and the payments he gets from contracting may not suffice to pay the fine.

An incomplete regulation might restore some role for the principal's wealth. The results below on the benefits of extending liability can thus be interpreted as saying that an incomplete ex ante regulation supplemented by an ex post liability rule sometimes achieves what a complete ex ante regulation would have done.

To capture the fact that private transactions are not regulated, the relationship between the agent and his two masters (the regulator and the principal) is now modeled as a common agency game under moral hazard along the lines of Bernheim and Whinston (1986), with the special feature that the regulator remains a Stackelberg leader and that the regulatory contract is publicly observable. The time line unfolds as follows:

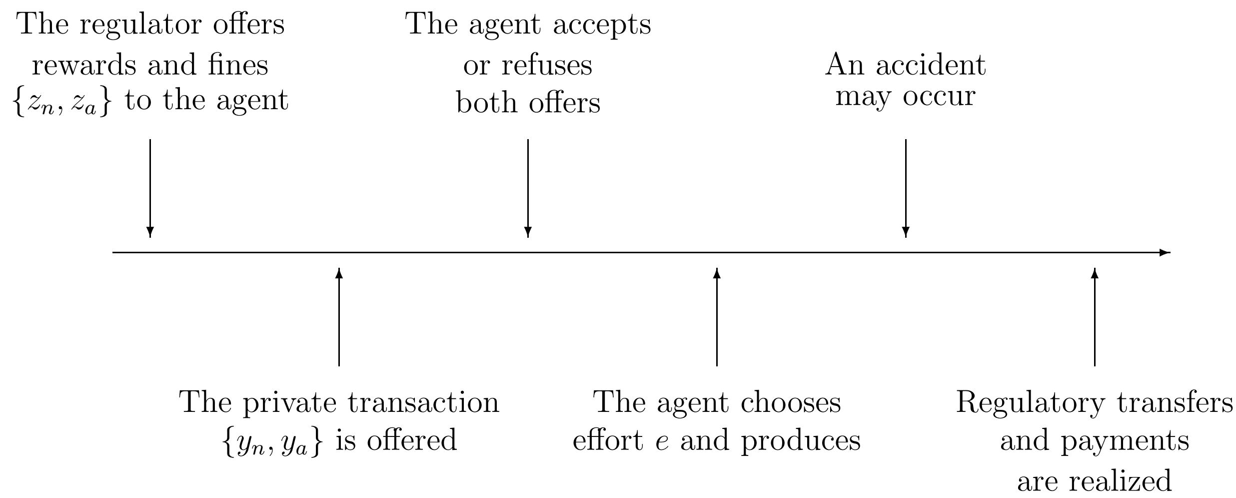

Figure 1: Timing with a non-observable transaction.

The agent must accept both contracts to produce since risk regulation is mandatory. We solve for the Perfect Bayesian Equilibrium of that game by backward induction.

The design of the private transaction depends on the respective bargaining power of the principal and the agent. For instance, lenders may have quite different bargaining positions in negotiating loans with their borrowers. These principals may either compete

[14]The implicit assumption here is that, although it is prohibitively costly to determine ex ante the contractual partners of the firm (because these contractual relationships might not even be already signed), finding these partners ex post through litigation is not as costly.

head-to-head for the right to serve the agent or they may have developed close knitted customer relationships which give them monopoly power with their clients.[15] When the project is financed by a parent firm which is in a unique relationship with its subsidiary (maybe because some specific investments have already been sunk in the past), the principal might have most of the bargaining power. We capture these different patterns in the distribution of bargaining power by introducing a parameter $\alpha \in [0, 1]$ (resp. $1 - \alpha$) which reflects the weight given to the principal (resp. the agent) at the contracting stage.

Note that the feasible regulatory payments z_a are necessarily bounded from below as a result of both the agent's and the principal's limited liability constraints. Indeed, these two liability constraints (respectively $\Pi - y_a \geq -w$ and $y_a + z_a \geq 0$) altogether imply that the following aggregate liability constraint of the principal/agent pair must hold:[16]

$$\Pi + z_a \geq -w. \tag{8}$$

To have a non-trivial continuation equilibrium of the game, fines should thus be small enough so that this condition always holds. Intuitively, the maximum fine cannot exceed the amount collectable from the principal/agent pair, i.e., the value of the transaction plus the principal's wealth. By increasing fines if an accident occurs, the regulator may force the principal to increase the payment to the agent to keep him solvent. However, doing so is only possible when the principal is himself wealthy enough.

Given that the principal has a bargaining weight α at the contracting stage, the optimal private transaction solves:

$$(\mathcal{SP}_\beta) : \max_{\{e, U, y_n, y_a\}} (\Pi + e z_n + (1 - e) z_a - \psi(e) - U) + \beta U$$

subject to constraints (4) to (6),

where $\beta = \frac{1-\alpha}{\alpha}$ is the relative bargaining power of the agent. In solving $(\mathcal{SP}_\beta)$, we will distinguish between the cases where either the agent ($\beta \geq 1$) or the principal ($\beta < 1$) has most of the bargaining power.

4.1 Dominant Agent

The solution to $(\mathcal{SP}_\beta)$ depends now on how large the fine is.

[15]See Sharpe (1990) and Rajan (1992) for models of relational banking developing this argument.

[16]Reciprocally, when (8) holds, one can find y_a such that both the principal's and the agent's liability constraint hold. y_a is then determined by the allocation of bargaining power in private contracting.

Lemma 1 *Assume that the agent has most of the bargaining power in designing the private transaction ($\beta \geq 1$). The optimal transaction is such that the principal's participation constraint (6) is binding.*

- **Small fines:** *For $-z_a \leq \Pi$, the effort is efficient from the point of view of the principal/agent coalition:*

$$z_n - z_a = \psi'(e); \tag{9}$$

- **Large fines:** *For $\Pi + w \geq -z_a > \Pi$, the effort is inefficiently low from the point of view of the principal/agent coalition. It is uniquely defined by:*

$$\Pi + z_a + e(z_n - z_a - \psi'(e)) = 0. \tag{10}$$

To understand the solution to $(\mathcal{SP}_\beta)$, it is useful to rewrite the principal's participation constraint (6) as:

$$\Pi + ez_n + (1-e)z_a - \psi(e) \geq U = R(e) + y_a + z_a. \tag{11}$$

This feasibility condition simply says that the whole surplus of the principal/agent coalition (on the l.h.s.) must cover the limited liability rent of the agent (on the r.h.s.) plus all transfers he receives from his two masters in the event of an accident. Constraint (11) binds at the optimum of $(\mathcal{SP}_\beta)$ as soon as the agent has most of the bargaining power and pushes therefore the principal down to his reservation value. Moreover, raising z_a increases the right-hand side of (11) and hardens this constraint.

Think first of the case of a small fine which is less than Π. Since the agent has most of the bargaining power, he pockets all that surplus and can thus pay the fine by himself. This is akin to a regime where only the agent is under the threat of liability. All the principal's profit is extracted with a flat contract such that $y_n = y_a = \Pi$, and the agent's own limited liability constraint is still satisfied because $z_a + \Pi > 0$. The agent's private incentives to exert effort are aligned with those of the principal/agent pair as a whole. Moral hazard does not affect private contracting. Condition (9) says then that the marginal cost of effort equals its marginal benefit for the principal/agent coalition. The effort is efficient from this coalition's viewpoint.

If the fine $-z_a$ is too large, this flat contract no longer works. The principal's wealth is now needed to pay the fine and we are in a regime of extended liability.[17] To break-even, the principal must then recoup this liability payment by diminishing the payment left to

[17] One can again use the Equivalence Principle here. Consider simply that the agent pays himself the fine but requests a higher payment y_a to avoid bankruptcy.

the agent following a good environmental performance. For such a large fine, the agent's limited liability creates some perverse incentives since $y_n < y_a$. From (3), the agent's effort is below its efficient level from this coalition's viewpoint.

4.2 Dominant Principal

Lemma 2 *Assume that the principal has most of the bargaining power in private contracting ($\beta \in (0,1)$). The optimal private transaction induces a level of safety care e which is lower than the efficient level from the principal/agent coalition's viewpoint:*

$$z_n - z_a = \psi'(e) + (1-\beta)e\psi''(e). \tag{12}$$

The agent obtains a rent $U = R(e)$. The principal's expected utility is:[18]

$$V = \Pi + z_a + (1-\beta)e^2\psi''(e) \geq 0. \tag{13}$$

Since the agent's effort is not observed by the principal, the principal must give him a liability rent to induce some positive effort. However, this rent is costly when $\beta \in (0,1)$ and the cost increases as more of the bargaining power goes to the principal.

Condition (12) characterizes an important trade-off. On the one hand, efficiency within the principal/agent coalition calls for choosing a level of effort such that the marginal disutility of effort $\psi'(e)$ is equal to the marginal benefit $z_n - z_a$ accruing to the coalition as a whole. This efficient level of effort would be chosen if care were observable within the coalition. On the other hand, inducing such a high level of effort requires giving more rent to the agent. The marginal limited liability rent $R'(e) = e\psi''(e)$ left to the agent adds up to the marginal disutility of effort to assess the cost of marginally increasing effort within the coalition. This limited liability term has to be weighted by the relative bargaining power of the agent. In bilateral monopoly settings where β is close to one, the private transaction maximizes the overall surplus and its distribution between the principal and the agent is almost irrelevant. The effort level is then almost efficient. Starting from this benchmark, the agent's rent is viewed as more costly within the coalition and effort distortions due to private contracting are increased as the agent's bargaining weight decreases.

Using (3) and (12), we immediately get:

$$y_n - y_a = -(1-\beta)e\psi''(e) < 0. \tag{14}$$

[18]Condition (13) requires that z_a cannot be too negative. Otherwise the principal prefers not to sign any contract.

It could seem quite surprising that the principal reduces the agent's payment following a good environmental performance. The private transaction somewhat countervails regulatory incentives. Indeed, since some rent has to be left to the agent by a principal who cannot observe the agent's effort, the principal offers a marginal contribution $y_n - y_a$ to reduce the likelihood of a damage which is less than what it is worth to him. So doing reduces effort and thus the liability rent of the agent. Since the principal does not value *per se* a good environmental performance, the marginal contribution is negative.[19]

This contract increases the probability of an accident compared with the flat scheme derived when transactions are regulated. Harmed third-parties could initiate litigation to denounce this contract as providing incentives for reducing care if this contract was observable. Those contracts could thus be viewed as being criminal acts. That could trigger further sanctions for the principal, most noticeably non-pecuniary ones like imprisonment and the associated reputation loss. However, providing evidences that such a contract is criminal is not as clear as it appears. Suppose indeed that the principal receives $\Pi + \Delta$ (where $\Delta > 0$) in states positively correlated with a bad environmental performance.[20] Then, the fact that y_a is greater than y_n might reflect only the existing incentives for improving gains from trade. It may be hard to disentangle this incentive effect from the desire of the principal to dilute regulatory incentives. The private transaction can then hardly be viewed as being criminal.

In our context, the non-observability of the transaction countervails incentives for care. The general idea here is that part of the regulatory incentives is diluted when private transactions remain unregulated. Indeed, because of their common desire to extract the agent's liability rent, both the regulator and the principal create a wedge between their marginal benefit of increasing the agent's effort and the marginal cost of doing so. When the principal considers modifying his transaction with the agent to extract his rent, he does not take into account the impact of his decision on social welfare as a whole but only on his own profit. Hence, there is a negative externality between both masters of the firm. This leads to too little effort in equilibrium. Adding up agency costs in each bilateral relationship in which the agent is involved will exacerbate distortions when both the agent and the principal are cash-constrained as we will see below.[21]

[19] The principal could also suffer from a loss L in the event of an accident. This loss could be due to the fact that assets are specific and have thus a lower resale value following the agent's bankruptcy. It may also come from the fact that an accident may disrupt the production process and reduce the return on investment expected by the principal. The results would then be slightly different although similar in spirit. Indeed, (14) would be replaced by $y_n - y_a = L - (1-\beta)e\psi''(e) < L$. The agent may receive a greater payment when there is no accident although the power of incentives of this private transaction is still less than L, i.e., less than the principal's valuation for avoiding an accident.

[20] This may be the case if the agent's care is a substitute for his cost-reducing effort.

[21] This negative externality reminds of the double marginalization distortions that arises when two monopolists sell complement goods and do not coordinate their prices (see Tirole (1988, Chapter 4)).

4.3 Regulatory Response

Perverse incentives due to private contracting always arise whatever the allocation of bargaining power. When the agent is dominant, they might come from the principal's desire to recoup the liability payment so that he can break even. When the principal is dominant, those incentives come from his desire to extract liability rent from the agent. Whatever this allocation, the regulator must undo these countervailing incentives or, at worst, limit their impact. To show how this can be done, let us move backwards and find the optimal regulatory scheme. Given the continuation of the game described above, the regulator's problem is now:

$$(\mathcal{R}) : \max_{\{e,U,V,z_a,z_n\}} (1+\lambda)(\Pi - (1-e)D - \psi(e)) - \lambda(U+V)$$

subject to constraints (4), (8) and either (11) or (13),

where (8) and (11)/(13) are respectively the principal's limited liability and participation constraints once the outcome of private contracting is taken into account.[22]

4.3.1 Dominant Agent

Proposition 2 *Assume that the agent has most of the bargaining power ($\beta \geq 1$). The optimal regulation still implements the second-best outcome with effort e^{SB} and leaves to the agent and the principal the rents $U^{SB} = R(e^{SB})$ and $V^{SB} = 0$.*

When the transaction cannot be regulated, the regulator faces a double incentive problem. First, he must induce the correct level of care from the agent, typically the level found in Proposition 1. Second, he must induce the choice of a private transaction which has no impact on care. If the agent has most of the bargaining power, the regulator can easily achieve this outcome. First, remember that the regulator also wants to extract, even though it is indirectly, the principal's profit. When he is dominant, the agent is very well suited to do so on the regulator's behalf. Provided that the fine is not too large, the agent remains solvent and his private incentives to exert care are not modified by private contracting. There is no extra agency cost induced by private contracting. Implementing a given level of effort costs the same as if the transaction could be regulated.

Implementation: This outcome is easily implemented with the regulatory transfers $z_a^C = -\Pi$ and $z_n^C = -\Pi + \psi'(e^{SB})$. Then, the agent's extracts all the principal's rent in

[22] The principal's participation constraint takes different expressions depending on whether he is dominant or not.

each state of nature $y_a^C = y_n^C = \Pi$. With this scheme, the regulator puts the principal-agent coalition in the range of small fines. ¿From Lemma 1, moral hazard within the coalition is then costless. This avoids any extra effort distortion due to private contracting under moral hazard. The second-best outcome can still be implemented. ■

4.3.2 Dominant Principal

For future references, we define the third-best level of care e^{TB} as:

$$D = \psi'(e^{TB}) + \frac{\lambda}{1+\lambda}((3-\beta)e^{TB}\psi''(e^{TB}) + (1-\beta)(e^{TB})^2\psi'''(e^{TB})), \tag{15}$$

and the wealth levels $\underline{w} = (1-\beta)(e^{TB})^2\psi''(e^{TB})$ and $\bar{w} = (1-\beta)(e^{SB})^2\psi''(e^{SB})$. Note that $e^{TB} < e^{SB}$ and $\underline{w} < \bar{w}$ since $x^2\psi''(x)$ is an increasing function of x.

Proposition 3 *Assume that the principal has most of the bargaining power ($\beta \in (0,1]$). Three possible regulatory regimes may arise depending on the principal's wealth.*

- **Shallow pocket:** *When $w < \underline{w}$, the optimal regulation implements the third-best level of effort e^{TB} which is strictly less than e^{SB}.*

  The principal's limited liability constraint is binding and the principal gets a strictly positive payoff $V^{TB} = (1-\beta)(e^{TB})^2\psi''(e^{TB}) - w > 0$. The agent gets $U^{TB} = R(e^{TB})$.

- **Intermediate pockets**: *When $w \in [\underline{w}, \bar{w}]$, the optimal regulation implements a constrained level of effort e^C defined by:*

  $$w = (1-\beta)(e^C)^2\psi''(e^C). \tag{16}$$

  The effort e^C increases with w and describes the whole interval $[e^{TB}, e^{SB}]$ as w varies in $[\underline{w}, \bar{w}]$.

  The principal's participation and limited liability constraints are both binding and the principal gets zero expected payoff $V^C = 0$. The agent gets a rent $U^C = R(e^C)$.

- **Deep pockets**: *When $w > \bar{w}$, the optimal regulation implements the second-best level of effort e^{SB}.*

  The principal's limited liability constraint is slack and the principal gets zero expected payoff. The agent gets a rent $U^{SB} = R(e^{SB})$.

Implementing the second-best outcome is more difficult with a dominant principal than with a dominant agent. To see that, consider the extreme case where the principal has in fact all bargaining power ($\beta = 0$).

If regulatory transfers were directly targeted to the principal, standard moral hazard theory teaches us that the risk-neutral principal could be made residual claimant for the impact of any private transaction on the environment.[23] As long as it would not violate the principal's liability constraint, this implicit delegation of the regulatory authority to the private sector would be costless.

A first difference between this ideal setting and ours comes from the fact that, when the transaction is not regulated, only the agent receives regulatory rewards. Following the logic of the Equivalence Principle, this is only a minor difference since the private transaction can redistribute transfers between the principal and the agent. An indirect perfect delegation is therefore still possible when the principal is wealthy enough. To do so, the regulator must simultaneously align the principal's incentives to induce effort with the socially optimal ones and extract (although indirectly through the regulatory scheme imposed on the agent) his profit. Aligning incentives requires modifying the regulatory scheme to undo the dilution of incentives which arises under private contracting. The new regulatory scheme must be sufficiently high-powered so that, despite the countervailing power of the private transaction, the agent ends up exerting the same second-best effort as if the transaction was regulated. This requires that the principal bears more risk. In particular, the fine in the event of an accident increases and the principal may be himself insolvent if his wealth is small.

When he is cash-constrained, the principal must receive a rent to implement the proper transaction. This is again socially costly. The regulator must distort incentives to reduce this extra agency cost. This compounding of agency costs along the principal/agent hierarchy requires to distort care below its second-best level.

Implementation: For a given bargaining power tilted in favor of the principal, let us see in more details how the second-best outcome can still be implemented.

First, inducing e^{SB} requires that the new regulatory scheme (z_n^{TB}, z_a^{TB}) now offered by the regulator satisfies:

$$z_n^{TB} - z_a^{TB} = D + \left(1 - \beta - \frac{\lambda}{1+\lambda}\right) e^{SB}\psi''(e^{SB}) > z_n^{SB} - z_a^{SB}. \tag{17}$$

Indeed, taking into account the countervailing incentives as defined in (14), private contracting induces the agent to choose an effort level which satisfies:

$$\psi'(e) + (1-\beta)e\psi''(e) = z_n^{TB} - z_a^{TB}. \tag{18}$$

This equation admits a unique solution $e = e^{SB}$.

Since part of the incentives are dissipated through private contracting, the socially optimal level of care e^{SB} can only be obtained if the regulatory scheme is higher powered

[23]See Laffont and Martimort (2002, Chapter 4) for instance.

than when transactions are observable. The incentive power $z_n^{TB} - z_a^{TB}$ may now exceed D (at least when β is small) and the optimal policy then relies on *punitive* fines.[24]

Second, to extract the whole principal's expected benefit from contracting, the regulator must set rewards and fines so that:

$$V = \Pi + z_a^{TB} + e^{SB}(z_n^{TB} - z_a^{TB} - \psi'(e^{SB})) = 0. \tag{19}$$

Solving the system (17) and (19) gives the values z_n^{TB} and z_a^{TB} used by the regulator to implicitly and costlessly delegate regulatory authority to the principal. Those expressions show that the fine $-z_a^{TB}$ has to be sufficiently large to do so. Such a fine will conflict with the aggregate limited liability constraint (8) when the principal is not wealthy enough. ■

We also see on (17) that the incentive power of the regulatory contract $\left(z_n^{TB}, z_a^{TB}\right)$ increases as $1-\beta$ increases or as λ decreases. Punitive fines are less attractive when the principal's bargaining power diminishes because the countervailing power of the private transaction itself diminishes. Also, when the social cost of the agent's rent is small enough and e^{SB} is close to the first-best e^*, the regulation must be more punitive to undo the significant dilution of incentives coming from the private transaction.

The above analysis shows the practical importance of imposing cash requirements on stakeholders contracting with the firm. In practice, regulatory policies have often similar features. For instance, various rules are imposed on stakeholders to demonstrate financial responsibility. This has been the case for RCRA since an amendment passed in 1984 imposed that underground storage tank owners hold liabilities or purchase liability insurance from third-parties to compensate victims in an amount up to 1 million US dollars. As shown in our analysis, this kind of policies guarantees that the owner/operator hierarchy fully internalizes the costs of storage tank hazards so that an efficient level of prevention is performed even in the case of an incomplete environmental regulation. Finally, the compensations for the victims of oil spills come from an international fund[25] financed by oil companies upon request of the member States. The decisions of these States to increase the required contributions of oil companies following the *Prestige* 2002 accident has often been viewed as providing incentives to these companies for better delegating oil transport to the safer shippers.

4.4 A Useful Analogy

Consider the case where the principal has all bargaining power. To understand how the liability rents of the agent and the principal compound, it is useful to see their coalition

[24] According to Shavell (2004), "*it is conventional to refer to damages that are greater than losses as punitive*".

[25] The International Oil Pollution Compensation Funds.

as a merged agent who, once the agency problem within the coalition is already solved, behaves as having a *virtual utility function* given by:

$$\Pi + z_a + e(z_n - z_a) - \psi(e) - R(e).$$

In terms of its safety care choice, this coalition has a *virtual disutility* of effort $\phi(e) = \psi(e) + R(e) = e\psi'(e)$. The corresponding virtual liability rent that must be given up by the regulator to this coalition to induce an effort e is thus:

$$\mathcal{R}(e) = e\phi'(e) - \phi(e) = e^2\psi''(e).$$

This virtual liability rent is precisely the rent that must be taken from the principal to be sure that it is costless to delegate regulatory authority to the private sector. The principal must be able to post ex ante a bond equal to this virtual rent for a costless delegation of the regulatory authority to take place. If the principal cannot post such a bond, distortions arise.

Recasting the results of Propositions 2 and 3: when $w \geq \bar{w} = \mathcal{R}(e^{SB})$, the principal is wealthy enough to post this bond; when $\bar{w} > w > \mathcal{R}(e^{TB}) = \underline{w}$, we have a constrained regime where effort is distorted but positively linked to the principal's wealth w; lastly, when $w \leq \underline{w}$, a liability rent must be given up to the principal.

4.5 Bargaining Power and Liability

We investigate now the relationship between the principal's wealth needed to achieve the second-best outcome even under an incomplete regulation and the allocation of bargaining power. We already know from Proposition 3 that, for a given allocation, there is a positive relationship between the principal's wealth and the level of care. When the principal has most of the bargaining power but is cash-constrained, an increase in the amount collectable for damages relaxes his binding liability constraint and improves strictly welfare. This better aligns the principal's private incentives to induce care with the socially optimal ones. It also strictly increases the level of care when w lies in the interval $[\underline{w}, \bar{w}]$ since effort is positively linked to the available wealth when the principal has an "intermediate" pocket. In this case, full extraction of the principal's rent is still possible, but obtained at the cost of decreasing the effort below the second-best level.

Let us now fix the principal's wealth and vary his bargaining power within the coalition.

Corollary 2 *There exists $\beta^*(w) = \max\{0, 1 - \frac{w}{(e^{SB})^2\psi''(e^{SB})}\} < 1$ such that, for $\beta \geq \beta^*(w)$, the second-best regulation can be implemented even under an incomplete regulation. Extending the principal's liability by raising w has no value.*

By increasing the principal's wealth collectable for damages, one weakens the principal's bargaining position vis à vis the agent. Indeed, even when the principal is dominant, the regulator can raise fines up to the point where the principal has to leave most of the surplus from the transaction to avoid the agent's bankruptcy; exactly as if the principal had less bargaining power. The principal's liability can thus be viewed as a substitute for his own bargaining power.[26]

As λ diminishes, e^{SB} increases towards the first-best level e^* and thus $\beta^*(w)$ also increases. When the social cost of the rent diminishes, the punitive content of regulatory schemes must increase since the countervailing power of the private transaction is more significant, as it can be seen from the r.h.s. of (14) which decreases with e. For a given allocation of bargaining power, it becomes more valuable to increase the collectable wealth to raise welfare.

¿From a policy perspective, it is important to stress a few cases where extended liability may certainly be beneficial. Financiers who have developed a unique relationship with firms are the best targets for that policy. Also, extended liability may be particularly useful in transportation where agents are highly competitive.

5 Extensions

5.1 Affiliated Principals

On top of the polar cases where principals are fully competitive and where they hold a monopoly position vis-à-vis their agent, there is a whole range of possible organizational structures where a single agent deals in fact with several principals without having bargaining power with any of them. Boyd and Ingberman (2001) coined the expression of *affiliated principals* to characterize such settings. For instance, one may think of those principals as n ($n \geq 2$) different lenders bringing each a fraction $\frac{I}{n}$ of the overall investment of the firm. Those principals could also be n polluting contractors affiliated via the firm which disposes or transports pollutants on their behalf.

Although such settings seem at first glance akin to a reduction of each principal's bargaining power vis-à-vis the agent, one has to be cautious in generalizing the predictions of the one-principal model. Indeed, implementing the second-best outcome with an incomplete regulation cum liability rules requires now to make *each* of these principals residual

[26]Note that extending the principal's liability may still be irrelevant when the principal has most of the bargaining power but the distribution of bargaining power is quite even (β close to 1 from below). The principal's liability constraint is then automatically satisfied when his participation constraint holds. Also, when the principal's bargaining power is small enough, extending liability is irrelevant since the second-best outcome can already be achieved by regulating only the agent.

claimant for the harm done. Far from facilitating this implementation, the presence of multiple stakeholders makes it more difficult. We characterize below the bound on the principals' aggregate wealth which is now needed to implement the second-best outcome and show that it increases with the number of principals.

To make things simpler, we assume that principals are symmetric. Each pockets $\frac{\Pi}{n}$ of the gains from trade and holds assets worth $\frac{w}{n}$.[27]

Let us denote by (y_n^i, y_a^i) the contract offered by principal i ($i \in \{1, .., n\}$). The agent's incentive constraint can now be written as:

$$z_n + \sum_{i=1}^{n} y_n^i - (z_a + \sum_{i=1}^{n} y_a^i) = \psi'(e); \tag{20}$$

and his limited liability constraint as:

$$z_a + \sum_{i=1}^{n} y_a^i \geq 0. \tag{21}$$

For a given regulatory scheme, the Nash equilibrium in contracts among the n non-cooperating principals leads to an effort level given by:[28]

$$z_n - z_a = \psi'(e) + ne\psi''(e). \tag{22}$$

In this non-cooperative setting, a given principal does not take into account the impact of his own desire to reduce the rent of the agent on the surplus of the bilateral relationships involving this agent with other principals. Each principal individually countervails the regulatory incentives and sets a negative marginal reward:

$$y_n^i - y_a^i = -e\psi''(e) < 0. \tag{23}$$

Just like in the single principal case, each principal chooses a bilateral contract with the agent with an incentive power which is his own marginal valuation for the agent's effort (here again zero because principals do not care directly about a damage) minus the marginal cost of the agent's rent. As those distortions add up in a non-cooperative equilibrium, there is an excessive reduction of the agent's rent. The agent's effort ends up being significantly downward distorted below the effort that would be obtained had principals jointly designed his incentives. There is free-riding among the principals over

[27] Boyd and Ingberman (2001) argue that, because liability on affiliated contractors is joint and several, asymmetric principals will not be affiliated altogether. According to these authors, the threat that wealthy principals have to subsidize shallow-pocket ones in the event of a damage makes them separate from each other, so that affiliated structures should form with principals having comparable wealth.

[28] See the Appendix for details. For simplicity, we assume that the n principals are needed so that we model a game of intrinsic common agency. This is for instance the case if each principal is a lender who faces a capacity constraint and can only finance a fraction $\frac{1}{n}$ of the project.

the provision of incentives to the agent. Affiliation of the principals thus worsens the countervailing effect of private transactions on regulatory incentives.

Let us assume that liability is joint and several[29] so that symmetric principals end up sharing equally fines in the event of an accident. Each principal gets a profit worth:

$$V = \frac{\Pi + z_a}{n} + e^2\psi''(e) \geq 0. \tag{24}$$

Without embarking on a full-fledged analysis similar to Section 4, let us determine the conditions under which delegation of the regulatory authority to the private sector is costless and what happens when, instead, the liability constraint of each principal binds.

To implement the second-best outcome e^{SB}, the regulator must now undo the severe dilution of incentives that results from the principals' non-cooperative behavior. This can be done by offering a very high-powered regulatory scheme (z_n^M, z_a^M) such that:[30]

$$z_n^M - z_a^M = D + \left(n - \frac{\lambda}{1+\lambda}\right) e^{SB}\psi''(e^{SB}) > z_n^{TB} - z_a^{TB}. \tag{25}$$

The regulatory policy is more punitive with affiliated principals than with a single stakeholder and the punitive content increases with the number of principals involved.

To extract each principal's profit without hitting his liability constraint, we must have:

$$-z_a^M = \Pi + n(e^{SB})^2\psi''(e^{SB}) < \Pi + w. \tag{26}$$

This r.h.s inequality is more stringent as n increases. It is more difficult to ensure costless delegation of the regulatory authority as more principals contract with the agent. Intuitively, a costless delegation requires now that each principal posts a bond equal to the rent withdrawn from contracting independently with the agent. This bond is exactly the virtual rent obtained by the merged entity that this principal forms with the agent. With multiple principals, those rents add up and make it more difficult to satisfy the aggregate liability constraint of the principals. The minimal aggregate wealth $\bar{w}(n) = n(e^{SB})^2\psi''(e^{SB})$ above which delegation is costless increases linearly with n.

Let us now turn to the polar case where the limited liability constraint of each principal is binding. To induce an effort e, each principal must now get a rent worth:

$$V = e^2\psi''(e) - \frac{w}{n} > 0. \tag{27}$$

Using symmetry, the regulator's problem becomes:

$$(\mathcal{R}^M) : \max_{\{e,U,V\}} (1+\lambda)(\Pi - (1-e)D - \psi(e)) - \lambda(U + nV)$$

[29] One of the principals is then held liable for the whole damage caused by the agent and threatens the $n-1$ others with litigation to share equally the financial burden.

[30] Where the superscript M is meant for multiple principals.

subject to constraints (4) and (27).

The optimal effort level e^M in this environment with affiliated principals becomes:

$$D = \psi'(e^M) + \frac{\lambda}{1+\lambda}((2n+1)e^M\psi''(e^M) + n(e^M)^2\psi'''(e^M)). \tag{28}$$

Taking for instance the case where $\psi(e) = \frac{e^2}{2}$ and making the dependence of e^M on n explicit, we observe that $e^M(n)$ decreases with n due to free-riding among principals in providing incentives to the agent. The liability constraint of each principal is now binding when:

$$w < \underline{w}(n) = n(e^M(n))^2 = \frac{nD^2}{\left(1 + \frac{\lambda}{1+\lambda}(2n+1)\right)^2}. \tag{29}$$

It is easy to check that $\underline{w}(n)$ is inversely U-shaped in n. There are two effects at work here. First, as we saw above, the aggregate wealth of the principals must be lower than n times the rent obtained by each of them from his relationship with the agent in order to create a liability problem. This first effect tends to increase the bound $\underline{w}(n)$. Second, as more principals get involved, the equilibrium effort of the agent diminishes because of free-riding and the rent that each principal gets from his relationship with the agent decreases. This makes it somewhat harder to satisfy (29) so that principals are less likely to have a shallow pocket. This second effect dominates for n large enough. As a result of those two effects, $\underline{w}(n)$ achieves its maximum at $n = 3$ when the cost of public funds λ is close to .3, a value commonly accepted. Principals find it easier to be shallow-pocketed and thus to earn a positive liability rent in affiliated structures involving such a small number of principals. Exactly as principals may reduce the size of their collectable wealth to escape liability payments and earn a liability rent, they may also choose to be affiliated with only a few other principals.[31]

5.2 Ban on Regulatory Rewards

In the U.S., the statutory ability of environmental agencies for using transfers with regulated firms (both at the Federal and at the State levels) is often more limited than assumed so far. Although fines are feasible, financial rewards for good environmental performances may not always be authorized.[32] This extra incompleteness of the regulatory scheme puts certainly some constraints on the delegation of regulatory objectives to the private sector. Sticking to this real world institutional setting amounts to forcing $z_n = 0$.

[31]For $w \in [\underline{w}(n), \bar{w}(n)]$, the effort level is constrained by the principals' limited wealth. The constrained effort level $e^C(n)$ decreases with n and solves now $ne^C(n)\psi''(e^C(n)) = w$. For those principals with intermediate pockets, raising their collectable wealth increases again welfare and effort.

[32]However, indirect rewards from good environmental performances can still be present as we argued while presenting the model in Section 2.

Let us first consider the case of a dominant agent which has attracted much of the attention in the literature.[33] First, it may be that $\Pi \geq \psi'(e^{SB})$ if the second-best effort e^{SB} is sufficiently distorted below the first-best e^* even if the level of harm D is much greater than Π.[34] There is a simple way for the regulator to implement the second-best level of effort e^{SB} even in the absence of rewards. Suppose that the regulator imposes a fine $-z_a^{SB} = \psi'(e^{SB})$. The agent having all bargaining power offers a flat contract to the principal $y_a = y_n = \Pi$ which extracts all surplus from the transaction and does not perturb incentives. The surplus pocketed by the agent is enough to cover the fine and the agent chooses the second-best level of effort.

Suppose now that $\Pi < \psi'(e^{SB})$. By choosing the fine $-z_a^W = \Pi$, the regulator can implement a level of effort e^W such that $\Pi = \psi'(e^W)$. Note that $e^W < e^{SB}$ so that, by concavity of welfare in e, raising effort above e^W would improve welfare. Can the regulator improve on this outcome? Raising the fine may a priori foster care but it requires also using the principal's wealth and this introduces countervailing incentives. From Lemma 1, the effort level is indeed given by the principal's zero profit condition. This condition can be rewritten taking into account the ban on rewards as:

$$\Pi + (1 - e)z_a - e\psi'(e) = 0. \tag{30}$$

This expression defines the fine as a function of the effort level implemented $-z_a = H(e) = \frac{\Pi - e\psi'(e)}{1-e}$. Differentiating with respect to e, we find $H'(e) = \frac{\Pi - \psi'(e) - e(1-e)\psi'(e)}{(1-e)^2}$ and thus $H'(e^W) < 0$. Therefore, raising the fine above Π decreases the effort level below e^W and reduces also welfare. We recover here Pitchford (1995)'s result that extended liability may be costly when the principal has no bargaining power. His result extends thus to the second-best environment considered in our paper.

Consider now the case of a dominant principal and for simplicity assume that he has all bargaining power ($\beta = 0$). Taking into account the ban on rewards and using Lemma 2, the effort satisfies:

$$-z_a = \psi'(e) + e\psi''(e). \tag{31}$$

Using (1) and setting $z_n = 0$, the regulator's problem can now be written as:

$$(\mathcal{R}^L) : \max_{\{e, z_a\}} \quad \Pi - \psi(e) - (1 + \lambda)(1 - e)D - \lambda z_a(1 - e)$$

subject to constraints (8), (13) and (31).

[33]See Pitchford (1995, 2001) and Lewis and Sappington (2001a) for instance.

[34]Even if the cost of public funds λ is close to zero, a very convex disutility of effort ($\psi''(\cdot)$ large) is enough to guarantee that this case is relevant. This case never arises in the analysis of Pitchford (1995) because the second-best level of effort remains equal to the first-best when $\lambda = 0$.

The fine $-z_a$ plays now two roles at the same time: first, inducing effort and, second, shifting rents away from the private sector since those rents are costly when $\lambda > 0$.

When Π and w are small enough, the optimal effort e^W is obtained by using (31) and binding (8):

$$\Pi + w = \psi'(e^W) + e^W \psi''(e^W). \tag{32}$$

Raising the principal's liability w increases the level of care and improves welfare.

6 Conclusion

Extending liability towards principals linked through contracts with an agent involved in environmentally risky activities may improve welfare when private contracts cannot be regulated. Even with such incomplete regulation, the management of environmental risk can in fact be indirectly delegated to the private sector but it requires increasing fines and rewards. This is of course easier when part of these large ex post fines are paid by principals. Otherwise, the optimal regulation may take into account an extra agency cost of delegation and calls for strong distortions in the level of precautionary care undertaken by the agent. Increasing the wealth of principals that can be collected helps thus improving this implicit delegation and moves the level of care towards the second-best level. This result holds under a broad range of possible values of the principal's bargaining power but also for more complex organizations involving multiple principals jointly contracting with the agent or when regulatory rewards are banned.

The fact that rewards and fines are increased under an incomplete regulation gives significant discretionary power to regulators and thus increases the scope for capture.[35] One possible response to this threat of capture is to limit the regulator's discretion by reducing either punishments or rewards. In the first case, extending liability may then be less attractive. In the second case, banning rewards in the event of good environmental performances still leaves some scope for extending liability as shown above. A second possible response to the threat of capture is to separate ex ante regulation from ex post litigation. In our model, the two aspects of risk control have been merged and viewed as a single incentive contract offered by a merged entity. Hiriart, Martimort and Pouyet (2005a) give a more active role to regulators and judges by allowing them to monitor care either ex ante or ex post. They show that splitting these monitoring tasks helps reducing the threat of capture.

[35] It is indeed well known that high-powered incentive schemes may be particularly prone to regulatory capture. See Laffont and Tirole (1993, Chapter 11). On this issue of capture, see Boyer and Porrini (2004) who compare a captured regulation with an uncorruptible liability regime.

Another assumption that should be relaxed is the fact that the regulator knows the size of the principals' wealth. Because principals may hide assets in various ways, asymmetric information on wealth may arise. The implicit delegation of regulatory authority to the private sector becomes more difficult because it is not known whether principals have enough assets to manage risk efficiently.[36] To the agency costs of moral hazard, one must now add also the rent that wealthy principals may withdraw from their assets hiding. This may tighten the bound on wealth above which the implicit delegation of regulatory authority to the private sector is costless and make extended liability less attractive. On the other hand, asymmetric information on wealth requires to develop a whole legal arsenal to unveil assets. Extending liability through a legal procedure may be quite attractive in this respect.[37]

It would also be worth introducing into our framework a substitutability between care and cost minimizing effort.[38] Increasing care raises cost and reduces thereby the gains from trade with the principal. This countervailing effect might certainly influence the kind of contracts signed with principals. Principals may want to write contracts which induce even more countervailing incentives for the agent compared to our setting which does not include such substitutability in efforts. This effect should reinforce our previous findings. When principals have most of the bargaining power, the regulator should design an ex ante regulatory contract with even higher-powered incentives. Indeed, the regulator must now undo not only the desire of principals to extract the firm's liability rent but also their desire to divert the firm's effort towards more productive activities. These are issues that we plan to explore in future works.

References

Bernheim, D. and M. Whinston, 1986, "Common Agency," *Econometrica*, 54: 923-42.

Balkenborg, D., 2001, "How Liable Should the Lender Be? The Case of judgment-Proof Firms and Environmental Risks: Comment," *American Economic Review*, 91: 731-738.

Boyd, J., 2001, "Financial Responsability for Environmental Obligations: Are Bonding and Assurance Rules Fulfilling Their Promise?" Dicussion Paper 01-42 Resources for the Future.

[36]For moral hazard models where liabilities are also private information, see Lewis and Sappington (2000 and 2001b).

[37]See Hiriart, Martimort and Pouyet (2005b).

[38]Dionne and Spaeter (2003) and Laffont (1995) analyze such settings.

Boyd, J. and D. Ingberman, 1997, "The Search for Deep Pockets: Is "Extended Liability" Expensive Liability?" *Journal of Law, Economics and Organization,* 13: 232-258.

Boyd, J. and D. Ingberman, 2001, "The Vertical Extension of Environmental Liability through Chains of Ownership, Contract and Supply," in A. Heyes ed. *The Law and Economics of the Environment,* 44-70. Edward Elgar.

Boyer, M. and J.J. Laffont, 1996, "Environmental Protection, Producer Insolvency and Lender Liability," in A. Xepapadeas ed. *Economic Policy for the Environment and Natural Resources,* 1-29. Edward Elgar.

Boyer, M. and J.J. Laffont, 1997, "Environmental Risk and Bank Liability," *European Economic Review*, 41: 1427-1459.

Boyer, M. and D. Porrini, 2004, "Modelling the Choice Between Regulation and Liability in Terms of Social Welfare," *Canadian Journal of Economics*, 37: 590-612.

Dionne, G. and S. Spaeter, 2003, "Environmental Risks and Extended Liability: The Case of Green Technologies," *Journal of Public Economics*, 87: 1025-1060.

Faure, M. and G. Skogh, 2003, *The Economic analysis of Environmental Policy and Law,* Edward Elgar Publishing.

Heyes, A., 1996, "Lender Penalty for Environmental Damage and the Equilibrium Cost of Capital," *Economica*, 63: 311-323.

Hiriart, Y., D. Martimort and J. Pouyet, 2005a, "The Public Management of Risk: Separating Ex Ante and Ex Post Monitors," mimeo IDEI.

Hiriart, Y., D. Martimort and J. Pouyet, 2005b, "The Regulator and the Judge: Complements or Substitutes in the Control of Risky Activities," mimeo IDEI.

Laffont, J.J., 1995, "Regulation, Moral Hazard and Insurance of Environmental Risks," *Journal of Public Economics*, 58: 319-336.

Laffont, J.J., and D. Martimort, 2002, *The Theory of Incentives: The Principal-Agent Model,* Princeton University Press.

Laffont, J.J., and J. Tirole, 1993, *A Theory of Incentives in Procurement and Regulation,* The MIT Press.

Lesourd, J.B., and G. Schilizzi, 2001, *The Environment in Corporate Management,* Edward Elgar.

Lewis, T., and D. Sappington, 2000, "Contracting Wealth-Constrained Agents," *International Economic Review*, 41: 743-767.

Lewis, T., and D. Sappington, 2001a, "How Liable Should the Lender Be? The Case of Judgment-Proof Firms and Environmental Risks: Comment," *American Economic Review*, 91: 724-730.

Lewis, T., and D. Sappington, 2001b, "Optimal Contracting with Private Knowledge of Wealth and Ability," *Review of Economic Studies*, 68: 21-45.

Newman, H., and D. Wright 1990, "Strict Liability in a Principal-Agent Model," *International Review of Law and Economics*, 10: 219-231.

Pitchford, R., 1995, "How Liable Should the Lender Be? The Case of judgment-Proof Firms and Environmental Risks," *American Economic Review*, 85: 1171-1186.

Pitchford, R., 2001, "How Liable Should a Lender be? The Case of Judgment-Proof Firms and Environmental Risks: Reply," *American Economic Review*, 91: 739-745.

Rajan, R., 1992, "Insiders and Outsiders:The Choice Between Informed and Arm's Length Debt," *Journal of Finance*, 47: 1367-1400.

Ringleb, A. and S. Wiggins, 1990, "Liability and Large Scale, Long-Term Hazards," *Journal of Political Economy*, 98: 574-595.

Sharpe, S., 1990, "Asymmetric Information, Bank Lending and Implicit Contracts: A Stylized Model of Customer Relationship," *Journal of Finance*, 45: 1069-1087.

Shavell, S., 2004, *Foundations of Economic Analysis of Law*, Harvard University Press.

Segerson, K. and T. Tietenberg, 1992, "The Structure of Penalties in Environmental Enforcement: An Economic Analysis," *Journal of Environmental Economics and Management*, 23: 179-200.

Strasser, K. and D. Rodosevich, 1993, "Seeing the Forest for the Trees in CERCLA Liability," *Yale Journal on Regulation*, 10: 493-560.

Tirole, J., 1988, *The Theory of Industrial Organization*, MIT Press.

Appendices

• **Proof of Proposition 1:** The proof is straightforward: we first find the optimal effort neglecting constraint (6) and then, we check that there exists values of (y_n, y_a) which satisfy (6).

First step. The regulator wants to reduce U and V as much as possible since $\lambda > 0$. Both (4) and (5) are thus binding. Inserting $U = R(e)$ into the objective function which becomes a strictly concave function of e and optimizing, we find (7).

Second step. To satisfy (6), one possibility (among others) is to set $y_n^{SB} = y_a^{SB} = \Pi$. With those values, the moral hazard constraint (3) becomes:

$$z_n^{SB} - z_a^{SB} = \psi'(e^{SB}) = D - \frac{\lambda}{1+\lambda} e^{SB} \psi''(e^{SB}) < D.$$

With the agent's limited liability constraint $y_a + z_a \geq 0$ being binding, we finally obtain $z_a^{SB} = -y_a^{SB} = -\Pi$ and all transfers are defined. ■

• **Proof of Corollary 1:** Direct from the text. ■

• **Proof of Lemma 1:** First, we observe that (11) must be binding at the optimum when the agent is dominant. This can be done by raising y_a as long as (6) is satisfied, i.e., as long as $y_a \leq \Pi + w$.

Two cases must be distinguished depending on whether the effort e which maximizes the complete information total payoff of the coalition (such that $\psi'(e) = z_n - z_a$), satisfies (11) or not. This is the case when for this value of e:

$$\Pi + z_a + e(z_n - z_a) - \psi(e) \geq R(e) + y_a + z_a,$$

or $\Pi - y_a \geq 0$. Of course, since the agent has most of the bargaining power, he chooses $y_a = \Pi$. Given that $y_a + z_a \geq 0$ must be satisfied, this case can only occur when $-z_a \leq \Pi$, i.e., for small fines.

When $\Pi < -z_a \leq \Pi + w$, we are in the case of strong fines, the effort solution to $(\mathcal{SP}_\alpha)$ is no longer interior and efficient, and is constrained by equation (11). Of course, z_a must not be too negative otherwise the constrained set defined by (11) is empty. This is ensured when

$$\Pi + z_a + e_\infty^2 \psi''(e_\infty) \geq 0,$$

where e_∞ is defined implicitly as

$$z_n - z_a = \psi'(e_\infty) + e_\infty \psi''(e_\infty).$$

Note that the regulator should not choose z_n and z_a such that the constrained set of $(\mathcal{SP}_\beta)$ is empty since then the market for private transactions would break down. When the constrained set is non-empty, the optimal effort is obtained when $y_a + z_a = 0$ and we find that it solves (10). Note that $z_n - z_a = \psi'(e) - \frac{\Pi + z_a}{e} > \psi'(e)$. Hence the effort no longer maximizes the complete information aggregrate payoff of the coalition. ■

• **Proof of Lemma 2:** We neglect (5) and (6) which will be satisfied with a convenient choice of z_n and z_a by the regulator. Of course, (4) must be binding since the agent's limited liability rent is privately costly for the principal. Hence, $y_a + z_a = 0$. Inserting $U = R(e)$ into the principal's objective which becomes strictly concave in e, we obtain the first-order condition (12). ■

• **Proof of Proposition 2:** It is obvious to check that $y_n = y_a = \Pi = -z_a$ maximizes the agent's expected utility, extracts the principal's rent, and induces an effort e such that $\psi'(e) = z_n - z_a$. For z_n^C and z_a^C proposed in the text, e^{SB} is chosen. ■

• **Proof of Proposition 3:** Let us first find the regime where only (8) is binding. Then, $V = (1-\beta)e^2\psi''(e) - w$ and inserting this value into the regulator's objective function along with the other binding constraint (4) yields an objective function which is strictly concave in e:

$$(1+\lambda)(\Pi - D(1-e) - \psi(e)) - \lambda(R(e) + (1-\beta)e^2\psi''(e) - w).$$

Optimizing with respect to e yields (15). This regime occurs as long as $w < \underline{w}$.

Let us assume, on the contrary, that (13) is binding and (8) is slack. Then, since (4) remains binding, the objective function of the regulator becomes:

$$(1+\lambda)(\Pi - D(1-e) - \psi(e)) - \lambda R(e),$$

which is maximized for e^{SB}. Since $(e^2\psi''(e))' > 0$, it is straightforward to check that $e^{TB} < e^{SB}$. This regime occurs as long as $w > \bar{w}$.

Finally, for $\bar{w} \geq w \geq \underline{w}$, both (8) and (13) are binding and $w = (1-\beta)e^2\psi''(e)$. As w increases, the optimal effort describes the whole interval $[e^{TB}, e^{SB}]$. ■

• **Proof of Corollary 2:** Direct from the text. ■

• **Nash Equilibrium Among Principals:** From (20), we get

$$U \geq z_a + \sum_{j=1}^{n} y_a^j + R(e) \geq R(e), \tag{33}$$

where the inequality follows from (21).

At a best response, principal i wants to solve:

$$(\mathcal{SP}_i) : \max_{\{e,U,\}} \Pi + e\left(z_n + \sum_{j\neq i} y_n^j\right) + (1-e)\left(z_a + \sum_{j\neq i} y_a^j\right) - \psi(e) - U$$

subject to (33).

The constraint is binding and thus, principal i wants to induce an effort level i such that

$$z_n + \sum_{j \neq i} y_n^j - \left(z_a + \sum_{j \neq i} y_a^j \right) = \psi'(e) + e\psi''(e). \tag{34}$$

Summing those equations for all i and taking into account (20) yields then (22). Finally, using again (34), we get (23). ■