The Benefits of Extended Liability[*]

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

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 damages. 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 damage generated by the firm's activity if the latter is itself judgement-proof, that is, if its assets cannot cover the clean-up costs and/or compensate harmed third-parties.[1] Extending liability has often been viewed as a successful legal response to finance the clean-up of hazardous sites. Common sense also suggests that it might also foster incentives for safety care by inducing private actors to internalize the environmental concerns of the rest of society. This strategy has nevertheless encountered fierce opposition both among practitioners and scholars. Opponents argue that the benefits of extending liability towards stakeholders also come with some costs. On top of the administrative cost of litigation, extended liability might also change transactions between risky ventures and their contracting partners. Contracting modes and even market structures could be modified accordingly.

This paper challenges this rather dark view of extended liability. We delineate circumstances under which environmental risk regulation is actually improved by extending liability towards stakeholders who have enough wealth. Our analysis is also relevant to understand what are the costs of extended liability towards stakeholders when they are themselves cash-constrained, a real concern of Superfund law which was already stressed by some authors.

We found that the key justification for extending liability towards wealthy stakeholders is the *incompleteness of the regulatory contract*. Indeed, designing an ex ante complete regulation for environmental risk may be of a tantamount difficulty when the set of stakeholders who contract with the firm performing hazardous activities and who therefore influence its care taking is not yet clearly defined ex ante.[2] Even if the relevant stakeholders can be found out, environmental regulators generally do not have the statutory and auditing rights or even the expertise to regulate the contracts which bound those

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[1]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 clean-up costs as an effective "owner" of the facility at the time the pollution was discovered. More generally, the deep pocket of banks and other stakeholders has been requested when such partners are contractually tied with judgement-proof firms and involved in a sufficiently close relationship. Boyer and Laffont (1996) review the Canadian, the American and the European legal frameworks. Klimek (1990) presents Canadian cases. Strasser and Rodosevich (1993) offer a nice perspective on the principles governing the interpretation of CERCLA through multiple cases.

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

stakeholders to the firm's management[3]. Risk regulation in such a context is thus highly incomplete. As a result, the contracts between its stakeholders and the firm may influence care taking in ways which are detrimental to social welfare. Because of this fundamental incompleteness, relying ex post on the legal system in the event of a damage might improve regulatory outcomes since it puts the various stakeholders of the firm under the threat of prosecution. This ex post legal intervention is thus often viewed as a quite attractive institutional solution to have stakeholders internalize the impact of contracting on care taking and social welfare. The theoretical inquiry undertaken by this paper is precisely to determine under which circumstances an incomplete ex ante regulation can be complemented by ex post liability rules to sometimes reach (and otherwise come close) to what a more complete regulation would achieve.

To address these issues, we analyze a principal-agent relationship when the agent may be subject to environmental risk regulation. We first characterize the optimal complete regulation in a moral hazard framework where the agent's level of safety care is nonverifiable. Assuming then that the transaction between the principal and the agent is also nonverifiable and cannot be regulated, we show how this regulatory incompleteness may increase significantly the agency costs of providing safety care. Increasing the amount of wealth which can be seized from the principal under a liability regime helps nevertheless to reduce these extra agency costs. Extending liability and requiring financial responsability from stakeholders may be a rough substitute for a more complete regulation of the private contracts involving the risky venture.

To understand more precisely how this substitution works, note first that, under incomplete contracting, the regulator faces in fact *a double moral hazard* problem. First, he must induce the cashless agent[4] to exert the right level of safety care. Under limited liability, doing so requires to leave some rent to the agent. 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, an hypothetical omnipotent regulator, one could address these two problems separately. This could be easily done by first, forcing the principal to offer to the agent a contract which is independent of his environmental performances; and by, second, designing a convenient set of regulatory rewards and punishments to induce care. Extending the principal's liability would be useless under such a complete regulation since, *de facto*, the principal would not influence at the risk management of environmental risk by the firm.

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[3]For instance, Boyd (2001, p. 21) notes that *"corporate financial auditing is not a tradition strength of environmental regulation"*.

[4]Indeed, environmentally risky firms are often small in scale since they conceal assets in order to be insulated from the threat of paying for damages. This point is now well taken from several empirical studies, most noticeably Ringleb and Wiggins (1990, p.589) who pointed out that *"the incentives to evade liability has led roughly to a 20 percent increase in the number of small corporations in the U.S. economy"*.

Instead, when the private transaction cannot be regulated and a regime of extended liability is used, the principal is concerned by the agent's environmental performances since he may be called upon to pay fines following an accident. Part of the benefits from private contracting may indeed be dissipated through these fines and private contracting is modified accordingly. This is where the distribution of bargaining power in private contracting matters. The more bargaining power the principal has in private contracting, the more costly he finds the rent of a cash-constrained agent. Private contracts are thus designed with an eye on reducing this rent. This in turn reduces the level of care performed by the agent. The unregulated design of private contracting necessarily thwarts regulatory incentives. Anticipating this countervailing effect, an incomplete regulation must induce the principal to design a private contract which implements the correct incentives for safety care from the agent. To do so, the principal must be made residual claimant for social welfare. This can be done by increasing sufficiently fines and rewards. However the principal's wealth may not be enough to pay those fines. We characterize a lower bound on the principal's wealth above which an incomplete regulation can be completed by extended liability on the principal to replicate the second-best outcome that would be achieved with a more complete regulation. When the principal is not so wealthy, the regulatory outcomes moves towards a third-best outcome characterized by significant care distortions. Indeed, the principal can be induced to choose the right private transaction from a social point of view but he has now to receive some rent to do so. The rents left to both the principal and the agent compound and this exacerbates the downward distortion in care.

When the agent has most of the bargaining power, he designs a private transaction which reaps all surplus from his principal. Such a transaction is thus independent of his own environmental performances and does not interfere with regulatory incentives. 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 make him internalize regulatory objectives and his bargaining power when designing in private transaction.

In practice, firms involved in environmentally risky activities are generally part of several contractual relationships involving various stakeholders (be they lenders, customers, suppliers, etc...) who all could be asked for paying fines in the case of judgement-proofness. 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 using the predictions of the one-principal case in those environments. Indeed, implementing the second-best outcome with an incomplete regulation *cum* liability rules requires now to make *each* of those principals residual claimant for social welfare. Far from facilitating this implementation, the presence of multiple stakeholders makes it thus significantly more difficult. We characterize the bound on the principals' aggregate wealth needed to still implement the

second-best regulatory outcomes and discuss how the threat of extended liability may structure the organizational form of the vertical relationship between principals and the agent.

Second, regulatory policies are often even more incomplete than suggested so far. In some institutional contexts, regulatory rewards for firms having good environmental performances are banned and only ex post fines when bad performances arise are feasible. Such institutional frameworks come closer to the use of a pure liability regime. We first show that this absence of regulatory reward may not be an obstacle to the implementation of the second-best outcome if the agent has all bargaining power in designing private transactions. Second, we argue that raising the principal's liability might still help to improve social welfare and the level of care in those contexts.

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) argued that increasing the financiers' liability can deter them from participating to projects which nevertheless would be socially valuable. Heyes (1996) showed 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 in this paper is quite trivial since regulators are concerned only with efficiency and not by rent extraction as in our model below.[5] Also, 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 (if any) comes from the incompleteness of the regulatory policies under scrutiny 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, regulatory policies should involve both fines if an accident occurs and rewards if good environmental performances are realized. This more normative environment highlights how agency costs compound when the regulator does not control private transactions. It also allows us to also characterize conditions on the principal's wealth under which the incompleteness of the regulatory contract can be circumvented. Starting from this benchmark, we then analyze the impact of statutory

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

restrictions on transfers and discuss under which condition our results can be extended.

Section 2 presents the model. Section 3 solves for 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 depending on the allocation of bargaining power between the principal and the agent at the time of designing the private transaction. In Section 5, we provide some analogies which may be useful to understand how regulatory and private contracts interact. Section 6 extends our framework to the case of multiple principals. Section 7 discusses the case of an institutional constraint banning regulatory rewards. Section 8 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 damaging the environment. There is a whole range of such activities for which our analysis is relevant, for instance running underground storage tanks or disposal facilities, producing animal wastes, or transporting hazardous substances.

To run his project, the agent needs I units of capital which are supplied by a principal. This principal may be an outside lender, a group of shareholders or even a parent unit. We won't be too explicit on the exact nature of this principal even though we already stress that those different kinds of principals may significantly differ in terms of their available wealth. Net of the investment I, the project generates a cash flow Π which accrues to the principal.[6] In more general contexts the principal may not be financier but buy some services from the agent. Π can be viewed as the surplus of the transaction linking the principal and the agent.[7]

We are interested in the joint design of regulatory schemes and private transactions between the principal and the agent under various institutional and contractual settings.

The firm's activity being risky, an environmental damage D may occur with probability $1-e$, where e is the agent's level of safety care (or effort) normalized so that it corresponds to the probability of a good environmental performance. To exert such an effort, the agent must incur a non-monetary cost $\psi(e)$.[8] For technical reasons, we assume that $\psi' > 0$, $\psi'' > 0$, and $\psi''' > 0$ and that the Inada conditions $\psi'(0) = 0$ and $\psi'(1) = +\infty$ both hold

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[6]Given that the cash-flow of the project is contractible, it is only a matter of accounting convention to have the principal enjoy it rather than the agent himself.

[7]A relevant example is the following. Under Superfund law, liability can be extended from the operators of disposal facilities to the original generators of waste.

[8]We comment in Footnote 15 below on the case of a monetary cost of effort.

so that effort is always interior in all circumstances below.[9]

In the most complete contracting environment, a regulatory scheme stipulates transfers 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 in case of a damage (the fine $z_a < 0$) and of an incentive reward ($z_n > 0$) to the agent following good environmental performances.[10]

Denoting by (y_n, y_a) the shares of the private surplus left by the principal to the agent, the agent's expected payoff can be rewritten as:

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

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

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

By assumption, the agent has no wealth to compensate harmed third-parties following a damage. Faced with such a potentially judgement-proof agent, the principal's financial contribution may be necessary in the event of a damage. Even though fines and rewards do not a priori target the principal, a fine that cannot be paid by the cashless agent ends up being paid by the (more) wealthy principal if liability is vertically extended.[11]

Since the agent has no cash, what really matters from the regulator's viewpoint is how much wealth w is thus available from the principal. We will study how regulatory outcomes and safety care may change with w and ask under which circumstances putting more of the principal's wealth at stake improves social welfare. Of course, the principal can engage in a variety of strategies aimed at hiding the true value of his assets (accounting manipulations, "flight-by-night" techniques, creating cashless subsidiaries, etc...).[12] We will thus view w as the principal's wealth which can be easily observed and possibly seized when an accident occurs. The existence of those asset manipulations suggest that, in practice, the efficiency of a regime of extended liability may be limited by the size of the principal's asset holdings.

The risk-neutral regulator maximizes a social welfare function which takes into account not only the profits made by the firm and its principal but also the budgetary cost of the

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[9]In Section 6 and only for numerical purposes, we use a quadratic disutility function, still focusing on interior solutions.

[10]We investigate in Section 7 the case where those rewards are actually banned.

[11]Since the share of the surplus y_a left to the agent in the event of a damage can be adjusted to cover the loss z_a accruing to the coalition that he forms with the principal, it does not really matter who bears the fine. This Equivalence Principle is now well known from the earlier work of Newman and Wright (1990) and Segerson and Tietenberg (1992) and we will use it at several places in the interpretation of our results.

[12]This is particularly true since, as we will see below, the principal may obtain some rent from being cash-constrained.

regulatory scheme and the cleaning-up cost or financial amount reimbursed to harmed third-parties. Following Laffont and Tirole (1993), the regulator's objective function can be expresse as follows:

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

where $\lambda > 0$ is the positive cost of public funds.[13] For future reference, it is useful to rewrite the regulator's objective as:

$$W = (1 + \lambda)\{\Pi - (1 - e)D - \psi(e)\} - \lambda\{U + V\}.$$

This expression stresses the trade-off faced by the regulator in designing an optimal regulation. On the one hand, an efficient level of safety care maximizes the first bracketed term. On the other hand, inducing such level of effort in a moral hazard setting may require leaving too much rent $U + V$ to the private sector and this is costly when public funds are costly. This trade-off distinguishes our analysis from most of the previous literature, most noticeably Pitchford (1995), Balkenborg (2001) and Lewis and Sappington (2001a), who assume that rents are socially costless.[14] Assuming that rents are socially costly allows us to stress how different contracting modes affect this social cost.

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

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

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

where the latter two constraints ensure participation by respectively the agent and the principal.

At the complete information optimum, both constraints are obviously binding and the private sector withdraws no rent ($U = V = 0$). The first-best effort level e^* is such that the marginal benefit of reducing the likelihood of a damage equals the marginal cost of effort:

$$D = \psi'(e^*). \tag{1}$$

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[13]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 conveniently scaled up to fit the formulation in the text.

[14]Alternatively, this amounts to assuming that $\lambda = 0$.

To implement this outcome, the regulator can first impose a standard on the level of safety care;[15] 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 payment $z_n^* = z_a^* = -\Pi + \psi(e^*)$ from the agent to the regulator to ensure that the agent ends up making zero profit.

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

3   Moral Hazard in Safety Care

Let us first assume that neither the regulator nor the principal can observe the agent's effort which is now a moral hazard variable. Nevertheless, the regulator has still enough instruments to regulate the private transaction between the principal and the agent. This means that the regulator can impose which shares of the surplus generated by the private transaction should be left 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:

$$z_n + y_n - (z_a + y_a) = \psi'(e). \tag{2}$$

Using (2), the agent's expected utility becomes:

$$U = R(e) + z_a + y_a,$$

where the agent's limited liability rent $R(e) = e\psi'(e) - \psi(e)$ is increasing and convex in e ($R'(e) = e\psi''(e) > 0$ and $R''(e) = e\psi'''(e) + \psi''(e) > 0$). Because the agent has no cash, he 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

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[15]Any deviation away from that standard would be observed and heavily punished.

$R(e)$.[16] We must have:[17] [18]

$$U \geq R(e). \tag{3}$$

The principal's participation constraint is

$$V = \Pi - ey_n - (1-e)y_a = \Pi + ez_n + (1-e)z_a - \psi(e) - U \geq 0. \tag{4}$$

The principal's liability constraint can be written as $\Pi - y_a \geq -w$ or, using the expression of V,

$$V \geq -e(y_n - y_a) - w. \tag{5}$$

Under moral hazard, the regulator's problem becomes

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

subject to constraints (3) to (5).

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:*

$$D = \psi'(e^{SB}) + \frac{\lambda}{1+\lambda}e^{SB}\psi''(e^{SB}). \tag{6}$$

The principal's limited liability constraint (5) 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 $V^{SB} = 0$.

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[16]See Laffont and Martimort (2002, Chapter 4).

[17]For any $e \geq 0$, $R(e) \geq 0$ and the agent's participation constraint is implied by (3). Had the agent owned assets of value l, (3) would have to be be replaced by $U \geq R(e) - l$. In that case, the particip ation constraint may be binding for l large enough meaning that the first-best level of care can still be implemented costlessly. For intermediate levels of l, both the agent's participation constraint and his limited liability one may be simultaneously binding leading to constrained optima where despite having zero expected payoff, 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 asset to start with.

[18]Our model could be modified to account for the fact that 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 (3) would become

$$U \geq \hat{R}(e) = e\psi'(e).$$

Of course, $\hat{R}'(e) > R'(e)$ and the second-best effort is lower in this environment than with a non-monetary disutility. Intuitively, by reducing effort, the regulator relaxes now the firm's liability constraint. Although expressions differ, insights are similar to what we get in the case of 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 up a socially costly rent $R(e^*)$ to the agent, the only way of inducing this effort. Reducing the effort below the first-best e^* is thus optimal.

Implementation: When the private transaction is regulated, the regulator pushes the principal's expected utility down to his reservation value. To do so, the regulator has several possibilities, among which the following one is particularly attractive in view of the analysis forthcoming in the next section. By imposing that the principal leaves all surplus of the transaction to the agent in all circumstances, $y_n^{SB} = y_a^{SB} = \Pi$ so that $V^{SB} = 0$, everything happens as if the agent had full bargaining power in transacting with the principal. Then the private transaction does not perturb the agent's incentives and the level of care he chooses depends only on the regulatory transfers. ∎

With this implementation, the principal is quite passive and does not interfere with the optimal regulation. 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.

Corollary 1 *Assume that there is only moral hazard on care and that the private transaction is regulated. Increasing the principal's liability is irrelevant.*

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

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

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

4   Non-Observable Private Transaction

In practice, environmental regulators generally do not have the expertise and monitoring technology necessary to control the full set of transactions in which the firm is involved. Those regulators can certainly determinate whether a given firm threatens the environment with its activities but they may find hard to uncover the whole set of stakeholders (suppliers, customers, lenders, etc..) who are bound by contracts with the firm when the risky activity is undertaken even though those transactions may significantly affect the management of environmental risk.

In such incomplete regulatory settings, only the agent can be targeted ex ante with regulatory rewards and punishments. This regulation can be completed 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. Of course, this fine ends up being paid by the wealthy principal since the agent has, by assumption, no cash.

As we will see, this incompleteness of the regulatory contract restores 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 might sometimes achieve (and otherwise approximate) what a more complete ex ante regulation would have done.

To capture the regulator's loss of control due to 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 multi-principal game under moral hazard along the lines of Bernheim and Whinston (1986), with the special feature that the regulator remains a Stackelberg leader of this game. The time line unfolds as follows:

The regulator offers rewards and fines $\{z_n, z_a\}$

The agent accepts or refuses both offers

An accident may occur

The financial contract $\{y_n, y_a\}$ is offered

The agent chooses effort e and produces

Regulatory transfers and repayments are realized
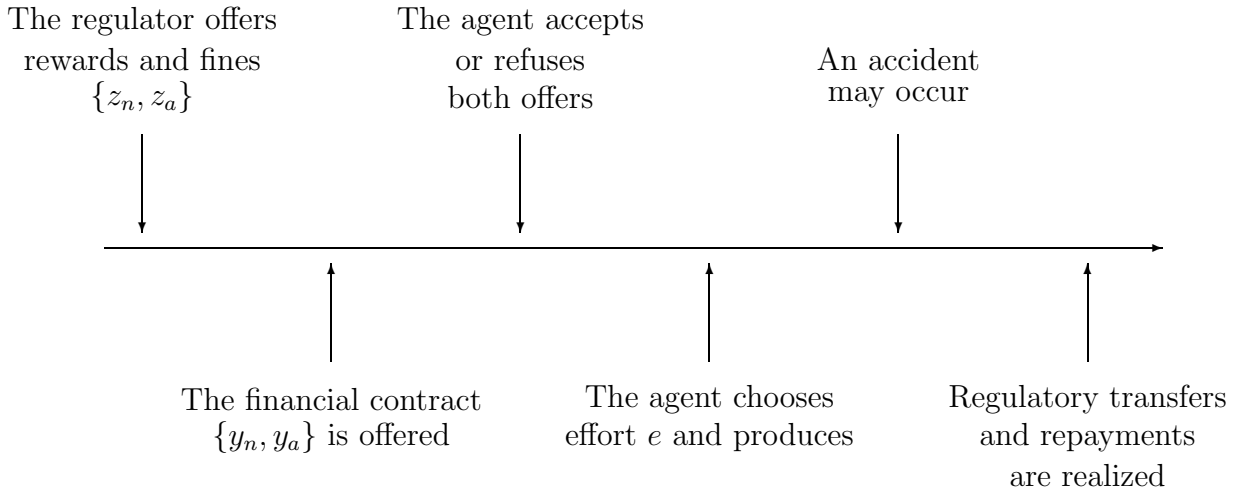
Figure 1: Timing with a non-observable transaction.

The agent has to accept both contracts simultaneously since risk regulation is mandatory.[19] We solve for the Perfect Bayesian Equilibrium of that game by backward induction.

Of course, the design of the private transaction depends on the respective bargaining power of the principal and the agent. For instance, in the case where those principals are financiers, the finance literature has stressed that lenders may have quite different

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[19]In the vocabulary of Bernheim and Whinston (1986), we thus develop a model of *intrinsic common agency*.

bargaining positions in negotiating loans with their borrowers. Those principals may either compete head-to-head for the right to serve the agent or they may have developed close knitted customer relationships which put them in a unique monopoly relationship with their clients.[20] When the project is financed by a parent which is in a unique relationship with its subsidiary (maybe because specific investments have already been sunk in the past), the principal is probably best modeled as having all bargaining power in dealing with the agent. 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.

As a preliminary step and before describing the optimization problem, 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, $\Pi - y_a \geq -w$ and $y_a + z_a \geq 0$ altogether imply the following aggregate liability constraint of the principal/agent pair:

$$\Pi + z_a \geq -w. \tag{7}$$

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 total liabilities available to the principal/agent pair, i.e., the net value of the transaction plus the principal's wealth. By increasing fines if an accident occurs, the regulator may force the principal to give up more of the surplus in order to keep the agent solvent. However, doing so is only possible when the principal has himself enough wealth.

Given that the principal has a 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 (3) to (5),

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

4.1   Dominant Agent

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

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

Lemma 1 *Assume that the agent has most of the bargaining power in designing the private transaction (i.e., $\beta \geq 1$), the optimal transaction is such that the principal's participation constraint (5) is binding and:*

- **Small fines:** *For $-z_a \leq \Pi$, the effort chosen by the agent is efficient from the point of view of the coalition he forms with the principal:*

$$z_n - z_a = \psi'(e); \tag{8}$$

- **Large fines:** *For $\Pi + w \geq -z_a \geq \Pi$, the effort chosen by the agent is inefficiently low and uniquely defined by*

$$\Pi + z_a + e(z_n - z_a - \psi'(e)) = 0. \tag{9}$$

To understand the solution to this problem, it is useful to rewrite the principal's participation constraint (5) as:

$$\Pi + ez_n + (1 - e)z_a - \psi(e) \geq U = R(e) + y_a + z_a. \tag{10}$$

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. The size of the regulatory fine $-z_a$ impacts on how costly it is to satisfy this constraint. Constraint (10) 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.

Think first of the case of a small fine which can be covered by the project's value Π. Since the agent has most of the bargaining power, he pockets that value and can thus pay that fine by himself. All the principal's expected profit can be extracted with a flat contract such that $y_n = y_a = \Pi$, and the agent's own limited liability constraint remains indeed satisfied, i.e., $z_a + \Pi > 0$. Since the principal's wealth is not needed to cover the fine, the agent's private incentives to exert effort are aligned with those of the principal/agent pair as a whole. Moral hazard is not an issue in private contracting. Condition (8) says then that the marginal cost of effort equals its marginal benefit for the coalition, i.e., the effort is efficient from the principal/agent pair's viewpoint.

If the fine $-z_a$ is instead sufficiently large, this flat contract no longer works. The principal's wealth is now needed to pay the fine. The agent requests a higher share of the surplus y_a from his principal to avoid bankruptcy. To break-even, the principal must then recoup this extra payment by diminishing the share of the surplus left to the agent when there is no accident. In that case, the agent's limited liability creates perverse incentives since $y_n < y_a$ and, from (2), the agent's effort is below its efficient level from the coalition's viewpoint.

4.2 Dominant Principal

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

$$z_n - z_a = \psi'(e) + (1 - \beta)e\psi''(e). \tag{11}$$

The agent obtains a rent $U = R(e)$. The principal's expected utility is:[21]

$$V = \Pi + z_a + (1 - \beta)e^2\psi''(e) \geq 0. \tag{12}$$

Since the agent's effort is not observable by the principal, the principal must give up a liability rent to the agent in order to induce some positive effort. However, this rent is costly when $\beta \in (0,1)$ and that cost increases as β goes to zero.

Condition (11) characterizes an important trade-off in designing the private transaction. On the one hand, efficiency within the principal/agent pair calls for choosing a level of effort such that the marginal disutility of effort $\psi'(e)$ is equal to the marginal benefit $z_n - z_a$ which accrues to the coalition as a whole when the probability of an accident decreases marginally. This efficient level of effort would be chosen if care were verifiable within the coalition. On the other hand, inducing such a high level of effort requires giving up a larger share of the transaction surplus 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 increasing marginally effort in the coalition. Of course, this limited liability term has to be weighted by the relative bargaining weight of the agent. In bilateral monopoly settings where β is close to one, all that matters for the coalition is to maximize the overall surplus and its distribution between the principal and the agent is irrelevant. The effort level is then almost efficient. Starting from this benchmark and as the agent's weight decreases, the agent's rent is viewed as more costly within the coalition and effort distortions are increased.

Using (2) and (11), we immediately get that:

$$y_n - y_a = -(1 - \beta)e\psi''(e) < 0. \tag{13}$$

It seems a priori quite supervising that, at the optimal response to the regulatory contract, the principal leaves to the agent a lower share of the surplus following a good

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[21]Condition (12) requires that z_a cannot be too negative otherwise the principal prefers not to sign any contract.

environmental performance. Therefore, the design of the private transaction somewhat countervails regulatory incentives. This captures the fact that, 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. Since the principal does not value *per se* a good environmental performance, the marginal contribution is here negative.

Of course such a private scheme increases the probability of a damage and would thus be problematic if it was observable. Note however that this is precisely because the transaction is not observable by the regulator that this countervailing effect arises. The general idea here is that part of the regulatory incentives get diluted when private transactions remain unregulated.[22]

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 this 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 low a level of 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.

It is worth noticing that perverse incentives through private contracting arise whatever the allocation of bargaining power but for different reasons. When this is the agent who is dominant, perverse incentives come from the principal's desire to recoup the liability payment. When the principal has most of the bargaining power, those incentives come from the desire of the principal to extract some rent from the agent.

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[22]Of course, the principal could also incur a loss L in the event of a damage. This loss may be, for instance, due to the fact that assets are specific and have thus a lower resale value following bankruptcy than their value in the bilateral principal/agent's relationship. 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 result would then be slightly different although similar in spirit. Indeed, (13) would be replaced by the condition:

$$y_n - y_a = L - (1 - \beta)e\psi''(e) < L.$$

In that case, the agent may receive a larger share of the surplus when there is no accident although the power of incentives of this private transaction is still less than the principal's valuation for avoiding a damage.

4.3 Regulatory Response

Whatever the allocation of bargaining power in private contracting, the regulator must anticipate that part of the regulatory incentives may be diluted through private contracting. The regulator must thus find ways to undo this effect or, at worst, to limit its 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 (3), (7) and either (10) or (12),

where (7) and (10)/(12) are respectively the principal's limited liability and participation constraints once the outcome of private contracting is taken into account. Note that the principal's participation takes different expressions depending on whether the principal or the agent is dominant.

Proposition 2 *Assume that the principal has less bargaining power than the agent in designing the private transaction (i.e., $\beta \geq 1$), then the optimal regulation still implements the second-best outcome with effort e^{SB} and gives to the agent and the principal respectively the rents $U^{SB} = R(e^{SB})$ and $V^{SB} = 0$.*

To build intuition, note that, under restricted control, the regulator faces now a double moral hazard problem. First, he must induce the correct level of care from the agent, typically that found in Proposition 1. Second, he must incite the principal to choose the "right" private transaction. If the agent has most of the bargaining power, the regulator can easily achieve this outcome. First, remember that the regulator also wants, even though it is indirectly, to extract the principal's expected benefits from contracting. When the agent has most of the bargaining power, he is very well suited to extract all the principal's profit on the regulator's behalf. Provided that the fine $-z_a^C$ is not too large, the agent remains solvent and his private incentives to exert care will not be modified by private contracting. There is no extra agency cost induced by private contracting and implementing a given effort costs the same as if the regulator could regulate the transaction.

Implementation: This outcome is easily implemented with the regulatory transfers $z_a^C = -\Pi$ and $z_n^C = -\Pi + \psi'(e^{SB})$ which yield $y_a^C = y_n^C = \Pi$. With this scheme, the regulator puts the principal-agent pair 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 and helps to replicate the second-best outcome.
∎

Let now turn to the case of a dominant principal. For future references, let define also a level of care e^{TB} such that:

$$D = \psi'(e^{TB}) + \frac{\lambda}{1+\lambda}((3-\beta)e^{TB}\psi''(e^{TB}) + (1-\beta)(e^{TB})^2\psi'''(e^{TB})), \qquad (14)$$

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 more bargaining power than the agent in designing the private transaction (i.e., $\beta \in (0,1]$). Three possible regulatory regimes may arise depending on how deep the principal's pocket is.*

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

  $$w = (1-\beta)(e^C)^2\psi''(e^C). \qquad (15)$$

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

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

- **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 $U^{SB} = R(e^{SB})$.

When the principal has most of the bargaining power, implementing the second-best outcome becomes less trivial than when this is the agent who has most of the bargaining power. To see how the regulatory scheme can be designed to do so and what are the difficulties otherwise, consider the extreme case where the principal has in fact all bargaining power (i.e., $\beta = 0$).

If regulatory transfers directly targeted to the principal could be used, standard moral hazard theory teaches us that the risk-neutral principal could be made residual claimant for the impact of designing any private transaction on social welfare. As long as it does not violate the principal's own liability constraint, there would be an implicit delegation of the regulatory authority to the private sector would then 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 and fines. This is only a minor difference since the private transaction can be designed to redistribute transfers between the principal and the agent and undo this extreme allocation of rewards and fines.[23] Perfect delegation is therefore still possible when the principal has enough wealth. To reach this outcome, the regulator must simultaneously align the principal's incentives to induce effort with his own ones and extract (although indirectly through the regulatory scheme imposed on the agent) the socially costly principal's rent. Aligning the social incentives to provide effort with those induced by the principal requires to modify the regulatory scheme to undo the dilution of incentives which arises under private contracting. The modified regulatory scheme must be sufficiently high powered so that, despite the countervailing power of the private transaction, the agent ends up exerting the second-best effort as of the transaction is regulated. This requires having the principal bear more risk. In particular, the fine in the event of an accident increases and the risk of having the principal being himself insolvent if he has not enough wealth increases.

When he is himself cash-constrained, the principal must also receive a rent to implement the right transaction. This is again socially costly from the regulator's viewpoint. The regulator must distort incentives to reduce this new agency cost. This compounding of agency costs along the principal/agent hierarchy requires to move to a third-best level of care which is below its second-best value.

Implementation: For a given bargaining power tilted in favor of the principal, let us see in more details how the second-best outcome can be implemented. First, to induce the second-best level of care after private contracting, the following condition must thus be satisfied by the new regulatory scheme (z_n^{TB}, z_a^{TB}) now offered by the regulator:

$$z_n^{TB} - z_a^{TB} = D + \left(1 - \beta - \frac{\lambda}{1+\lambda}\right) e^{SB} \psi''(e^{SB}) > z_n^{SB} - z_a^{SB}. \tag{16}$$

Indeed, taking into account the countervailing impact of the private transaction as defined in (13), private contracting induces the agent to choose an effort level which satisfies:

$$\psi'(e) + (1 - \beta)e\psi''(e) = z_n^{TB} - z_a^{TB}. \tag{17}$$

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

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[23]Again, the Equivalence Principle applies here also.

Since some of the incentives for care provision are dissipated through private contracting, the socially optimal level of care e^{SB} can only be obtained if the coalition's benefit from implementing an effort is sufficiently raised. The regulatory scheme is thus higher powered when transactions are non-observable than otherwise.

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

$$V = \Pi + z_a^{TB} + e^{SB}(z_n^{TB} - z_a^{TB} - \psi'(e^{SB})) = 0. \tag{18}$$

Solving equations (16) and (18) yields the values z_n^{TB} and z_a^{TB} used by the regulator to implicitly and costlessly delegate regulatory authority to the principal. It should be clear on those expressions that the fine $-z_a^{TB}$ may have to be sufficiently large to do so. Such a large fine conflicts then with the principal's own limited liability constraint (7) when he is not wealthy enough. ∎

In practice, regulatory policies are sometimes complemented by a requirement imposed on stakeholders to demonstrate financial responsability. This is for instance the case for RCRA since an amendment passed in 1984 which 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 helps to guarantee that the owner/operator hierarchy fully internalizes the costs of tank hazards so that an efficient level of prevention is performed even in the case of an incomplete environmental regulation.

4.4   Bargaining Power and Liability

In this section, we investigate the relationship between the principal's wealth needed to achieve the second-best outcome and the allocation of bargaining power. We already know from Proposition 3 that, for a given allocation of the bargaining power, there is a positive relationship between the wealth available from the principal and safety care. When the principal has most of the bargaining power but is cash-constrained (cases corresponding to a shallow or an intermediate pocket), increasing the funds available for liability payments relaxes his binding liability constraint and improves strictly welfare. Raising the amount of cash w available from the principal allows to better align the principal's private incentives with those of the regulator. This also strictly increases effort when w lies in the interval $[\underline{w}, \bar{w}]$ since effort is positively linked to the available wealth only when the principal has an "intermediate" pocket. In that case, full extraction of the principal's rent is still possible but is obtained at the cost of decreasing the effort level below the second-best.

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

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

By making more of the principal's wealth available for liability payments, one weakens the principal's bargaining position vis à vis the agent. Indeed, even when the principal has most of the bargaining power, 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 liabilities can thus be viewed as substitutes for the agent's lack of bargaining power.

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 his liabilities is irrelevant since the second-best outcome can already be achieved by regulating only the agent.

5   Useful Analogies

To better understand some of the results found above, it might be useful to have in mind two analogies.

5.1   Merged Agent

Let us now focus on the case where the principal has all bargaining power. To better understand how the liability rents of the agent and the principal compound, it is useful to see their coalition as a merged agent who, once the agency problem within the coalition is 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 choice of care, this coalition has a *virtual disutility* of effort $\phi(e) = \psi(e) + R(e) = e\psi'(e)$. The corresponding liability rent that must be given up by the regulator to that 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 make sure that it is costless to delegate regulatory authority to the private sector.

Intuitively, 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 bound, distortions arise.

Recasting the results of Propositions 2 and 3: When $w \geq \bar{w} = \mathcal{R}(e^{SB})$, the principal has enough wealth 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.

5.2   Nonlinear Pricing

There is also an analogy between our results and the literature on two-part pricing by a monopoly. Let us first think of a single monopolist selling a good to a customer. If two-part tariffs are feasible, it is well-known that the first-best can be achieved simply by selling each unit at marginal cost and reaping off all consumer's surplus with a fixed-fee. This is analogous to what would happen in our framework if the regulator could fully control the private transaction and the firm faces no liability constraint whatsoever. With a marginal reward $z_n^* - z_a^* = D = \psi'(e^*)$ and a fee $z_a^* = -R(e^*)$, the regulator would achieve indeed the first-best. Introducing a liability constraint on the agent requires to increase the agent's marginal reward $z_n - z_a$ following a good environmental performance and this gives him some positive rent. This rent is akin to the surplus that the consumer gets in the monopoly story when the monopolist is restricted to use an uniform price. The reward and the uniform price play thus both an allocative and a distributive role. Just like the uniform price is set above marginal cost to extract the consumer's surplus, the marginal reward is below the damage level and effort is below the first-best to reduce the agent's rent.

Let us think now of the regulator and the principal as two monopolists selling complementary goods.[24] That the regulator can control the private transaction in our framework amounts to assuming that the first monopolist imposes the unit price charged by the second one. Everything happens then as if the two monopolists had merged and the only inefficiency comes from the impossibility to charge a positive fixed-fee to the final consumer. When instead, the second monopoly can choose its unit price independently, distortions may arise. This second monopolist can certainly undo any such fee imposed by the first one and still charge a marginal price equal to marginal cost. The first monopoly can then achieve the integrated profit by inducing the second one to pay for the fee he asks from the customer, i.e., to pay an amount equal to the second monopoly's profit.

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[24]Although the traditional IO textbook presentation of this multiproduct monopolists setting assumes that monopolists act simultaneously fixed-fees, let us think of them as acting sequentially to fit with the timing of our contracting model.

Indeed, imposing a limited liability on the principal in our context is just like imposing a constraint on the fixed-fee that can be charged by the second monopoly to the customer. This leads of course to adding inefficiencies exactly as in Spengler (1950)'s seminal paper. This is analogous to the case where a third-best effort is implemented in our framework.

When the second monopolist faces a competitive fringe and is thus forced to charge a uniform price equal to marginal cost, it is well known that the profit of the integrated structure can again be realized by the first monopolist. This competitive environment is akin to the case where the agent has all bargaining power in designing private transactions, leading to the implementation of the second-best effort.

6 Multiple Principals

In between the case where principals are fully competitive and the case where they hold a monopoly position vis-à-vis their agent, there is a whole range of possible market structures where a single agent deals in fact with several principals at the same time without having bargaining power with any of them. This is the case when n ($n \geq 2$) principals are *affiliated* to the same agent to use an expression coined by Boyd and Ingberman (2001). For instance, one may think of n different lenders bringing each a fraction $\frac{I}{n}$ of the overall investment of the firm. Those principals could also be polluting contractors affiliated via the firm which disposes or transports pollutants on their behalf.

To make things simpler, we assume that principals are all symmetric, pocket each a fraction $\frac{\Pi}{n}$ of the project value and hold assets worth $\frac{w}{n}$.[25]

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 be written then as

$$z_n + \sum_{i=1}^n y_n^i - (z_a + \sum_{i=1}^n y_a^i) = \psi'(e); \tag{19}$$

and his limited liability constraint as:

$$z_a + \sum_{i=1}^n y_a^i \geq 0. \tag{20}$$

We show in the Appendix that, for a given regulatory scheme, the Nash equilibrium in

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

contracts among the n non-cooperating principals leads to an effort level given by[26]

$$z_n - z_a = \psi'(e) + ne\psi''(e). \tag{21}$$

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 each of the other principals. There is an excessive reduction of the agent's rent due to this non-cooperative behavior among principals. The agent's effort ends up being downward distorted significantly below what would be obtained had principals jointly designed the agent's incentives. There is free-riding among the principals over the provision of incentives to the agent. Affiliation of the principals worsens thus the countervailing effect of private transactions on regulatory incentives.

In this context, it is still true that each principal individually countervails the regulatory incentives and sets a negative marginal reward

$$y_n^i - y_a^i = -e\psi''(e) < 0. \tag{22}$$

Now each principal chooses an incentive power of his bilateral contract with the agent which is his own marginal valuation for the agent's effort (here again zero) minus the marginal cost of the agent's rent.

Let us assume that liability is joint and several[27] so that symmetric principals end up sharing equally fines in case of an accident. Each principal gets thus an expected profit worth

$$V = \frac{\Pi + z_a}{n} + e^2\psi''(e) \geq 0. \tag{23}$$

Without embarking on a whole full-fledged analysis similar to Section 4, let us determine under which conditions 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 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

$$z_n^M - z_a^M = D + \left(n - \frac{\lambda}{1 + \lambda}\right) e^{SB}\psi''(e^{SB}) > z_n^{TB} - z_a^{TB}. \tag{24}$$

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

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

To extract each of the principals' surplus without hitting their liability constraint, it must also be that

$$-z_a^M = \Pi + n(e^{SB})^2 \psi''(e^{SB}) < \Pi + w. \tag{25}$$

This r.h.s inequality is more stringent as n increases. It becomes more difficult to ensure a costless delegation of the regulatory authority as more principals contract with the agent. Intuitively, this costless delegation requires now that each principal posts a bond equal to the rent he withdraws 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 to strengthen 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 turn now to the other polar case where the limited liability constraint of each of those principals is the only binding constraint. Then, each principal must get a rent

$$V = e^2 \psi''(e) - \frac{w}{n} > 0. \tag{26}$$

Using the symmetry among principals, the regulator's problem becomes now:

$$(\mathcal{R}^M)^{28} : \max_{\{e,U,V\}} (1 + \lambda)(\Pi - (1 - e)D - \psi(e)) - \lambda(U + nV)$$

subject to constraints (3) and (26).

The optimal effort level e^M in this multiprincipal environment becomes:

$$D = \psi'(e^M) + \frac{\lambda}{1 + \lambda}((2n + 1)e^M \psi''(e^M) + n(e^M)^2 \psi'''(e^M)). \tag{27}$$

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 the number of principals involved. This captures the free-riding problem among these principals. Moreover, the liability constraint of each principal is now binding when:

$$w < \underline{w}(n) = n(e^M(n))^2 = \frac{nD^2}{\left(1 + \frac{\lambda}{1+\lambda}(2n + 1)\right)^2}. \tag{28}$$

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 that each of them obtains from his relationship with the agent to create a liability problem. This tends to increase $\underline{w}(n)$. Second, as more principals get involved, the equilibrium effort of the agent diminishes because of free-riding among the principals and the rent that each principal gets from his relationship with the agent decreases. This effect

dominates for n large enough. Interestingly, $\underline{w}(n)$ achieves its maximum around $n = 3$ when the cost of public funds λ is close to .3 as commonly accepted. This means that the principals' liability constraint is easier to satisfy for a structure having few principals. One should thus expect that an increase in the seizeable wealth of those principals has less impact for those intermediate market structures.

For $w \in [\underline{w}(n), \bar{w}(n)]$, we are in the case where the effort level is constrained by the principals' limited wealth. Typically, the constrained effort level $e^C(n)$ solves now:

$$ne^C(n)\psi''(e^C(n)) = w.$$

For those principals with intermediate pockets, raising their seizeable wealth increases again welfare and effort.

7 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 level) is often more limited than what we have assumed so far. Although fines are feasible, rewards for good economic performances may not always be. This extra incompleteness of the regulatory scheme puts some constraints on how the regulator can delegate regulatory objectives to the private sector. In our context, sticking to this real world institutional setting amounts to set $z_n = 0$. In that case, the fine $-z_a$ plays two roles at the same time; on the one hand inducing effort and on the other hand shifting rent away from the private sector when those rents are costly (remember that $\lambda > 0$).

Let us focus on the case of a dominant firm which has attracted much of the focus in the recent literature.[29] We know from Lemma 1 that this firm faces a liability problem when the fine cannot be covered with the value of the transaction (i.e., $-z_a > \Pi$) and that the principal's assets are called for in that case. We know also that the effort level is determined by the principal's zero profit condition (10) which is rewritten taking into account the ban on regulatory rewards as:

$$\Pi + z_a(1 - e) - e\psi'(e) = 0 \tag{29}$$

The regulator wants now to optimize an objective which can be rewritten as:

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

subject to constraints (7) and (29).

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

When the principal is a deep-pocket, the aggregate liability constraint (7) is not binding. Inserting the value of the optimal fine which saturates (29) into the regulator's objective function and optimizing, one finds that the corresponding optimal effort e^W is still equal to the second-best level $e^W = e^{SB}$. The optimal fine is given by $-z_a^W = \frac{\Pi - e^{SB}\psi'(e^{SB})}{1 - e^{SB}}$ which is greater than the project value Π so that the principal's assets are called for when $-z_a^W > \Pi$ or $\Pi > \psi'(e^{SB})$. Even when D is bigger than Π, this inequality might still hold because the second-best effort is distorted below its first-best level when public funds are costly. This stands in sharp contrast with the case of costless public funds.

When instead $\lambda = 0$, the regulator is only concerned with efficiency and he would like to set a fine $-z_a$ which implements the first-best level of effort e^*. This can certainly not be done with a small fine $-z_a < \Pi$ when $\Pi < D$ since from Lemma 1 the effort chosen by the agent would be such that $\psi'(e) = -z_a < D = \psi'(e^*)$ and thus too low. On the other hand, a large fine $-z_a > \Pi$ would lead to choosing an effort given by (29) and again this effort would be inefficient.

Interestingly, when public funds are costly, the regulator may find it possible to implement the second-best policy even with a ban on rewards because this second-best policy corresponds to a lower level of care.

The case of a deep pocket principal arises when $\Pi + w > -z_a^W$, i.e., when:

$$w \geq \bar{w}^W = \frac{e^{SB}(\Pi - \psi'(e^{SB}))}{1 - e^{SB}} > 0.$$

It is striking to see that the implementation of the second-best outcome remains feasible even if the regulatory contract is quite incomplete. Regulatory rewards are not needed to do so if the principal's liability constraint is not an issue. The regulator can still use the fine z_a to align the objective of the principal/agent pair with social welfare.

When instead $w < \bar{w}^W$, the principal's liability constraint is binding and the constrained effort level e^C is determined by (29):

$$w = \frac{e^C(\Pi - \psi'(e^C))}{1 - e^C}.$$

It can be checked that the r.h.s. above is an increasing function of the effort level over the interval $[0, e^{SB}]$ if $\Pi > \psi'(e^{SB}) + e^{SB}psi''(e^{SB})$. Raising the liability of the principal even when he has no bargaining power increases then the level of care and moves it closer to the second-best level e^{SB}. This result stands again in sharp contrast with Pitchford (1995) who argues that extended liability may worsen welfare when principals are competitive. The difference between his results and ours comes again from the fact that the welfare criterion he uses is based on efficiency only (which amounts to setting $\lambda = 0$ and thus $e^{SB} = e^*$ in our framework) so that the inequality above can never hold in his framework when the damage $D = \psi'(e^*)$ is greater than Π.

8   Conclusion

In this paper, we have stressed that the benefits of extending liability towards principals linked through contracts with an environmentally risky venture come from the fact that the regulatory contract is actually incomplete. When private transactions cannot be regulated, the regulator looks for rewards and fines which delegate in the least costly possible way the control of risk to the private sector. Putting more of the principals' wealth at stake may then sometimes strictly improve this implicit delegation of regulatory authority. That result holds under a broad set of allocations of the bargaining power between the principal and his agent and under a variety of institutional settings.

It is striking to see that some forms of incompleteness in the regulatory contract can sometimes be circumvented by offering regulatory rewards and fines which are higher-powered than if private transactions could be regulated. By exerting their discretion, risk regulators impose on the private sector either harsh fines or large rewards. This suggests that the stake for capture of those "incomplete" regulatory policies also increases significantly with respect to the case where private transactions are regulated. When capture is a serious concern, the optimal policy is more likely to limit the regulator's discretion, making large rewards and harsh punishments less attractive. The true scope for extending liability is such an environment should be assessed in future research. [30]

One institutional way of reducing the regulator's discretion often found in practice is to prohibit rewards to the firm for good environmental performances. This constraint should be derived from basic principles rather than assumed as we did above. In this respect, it is striking to note that if the impossibility of writing a complete contingent regulatory scheme comes from the impossibility to foresee some contingencies (a standard assumption used generally to justify incomplete contracting of this sort) one should also impose this constraint on the principal himself.[31] In this paper, we gave to the regulator and the principal the same contractual possibilities but, certainly, investing who between the regulator and the principal is better able to contract with the agent (may be because of a comparative advantage in monitoring care) is an issue worth exploring.

A last quite restrictive assumption that we also made above is that the regulator knows the size of assets available from the principal at the time of designing the optimal regulatory scheme. This hypothesis could be relaxed. Asymmetric information on wealth is likely to make the implicit delegation of regulatory authority to the private sector rather difficult because it is not known whether principals have enough assets to manage risk

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[30]On the articulation between a regime of ex post liability and an ex ante regulatory intervention subject to capture, see Boyer and Porrini (2001).

[31]This is not what is assumed by the previous literature (see Pitchford (1995), Balkenborg (2001) and Lewis and Sappington (2001a) which supposes that no complete regulatory contract can be passed whereas stakeholders can do so.

efficiently.[32] Extended liability appears certainly less attractive in such a framework. The relevant policy tools which may then be used remain to be characterized.

Finally, it would be worth introducing into our framework some interactions between the level of care chosen and the agent's cost function endogenizing thus the value of the project.[33] Typically, more care might increase the firm's cost and has thus an impact on the kind of contracts signed with principals. This is particularly true when the private transaction takes place under asymmetric information on technology since then the liability rent of the agent due to moral hazard may interact with his adverse selection rent and affects the cost of implicitly delegating regulatory authority to the principal.[34] These are issues that we plan to explore in future works.

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

[33]On this issue see Dionne and Spaeter (2003) for a pure moral hazard model where cost-saving investment and care are substitutes and Laffont (1995) for a model with adverse selection on the cost function.

[34]See Laffont and Martimort (2002, Chapter 7) for examples of such interactions.

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Appendices

• **Proof of Proposition 1:** The proof is straightforward: we first find the optimal effort neglecting constraint (5) and then, we check that there exists values of (y_n, y_a) which satisfy (5).

First step. The regulator wants to reduce U and V as much as possible since $\lambda > 0$. Both (3) and (4) are thus binding. Inserting $U = R(e)$ into the objective function which becomes a strictly concave function of e and optimizing, we find (6).

To satisfy (5), one possibility (among others) is to set $y_n^{SB} = y_a^{SB} = \Pi$. With those values, the moral hazard constraint (2) 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 2:** We neglect (4) and (5) which will be satisfied with a convenient choice of z_n and z_a by the regulator. Of course, (3) must be binding since the agent's limited liability rent is privately costly for the financier. Hence, $y_a + z_a = 0$. Inserting $U = R(e)$ into the financier's objective which becomes strictly concave in e, we obtain the first-order condition (11). ∎

• **Proof of Lemma 1:** First, observe that (10) must be binding at the optimum if we want to maximize the agent's payoff. This can be done by raising y_a as long as (5) is satisfied, i.e., as long as $y_a \leq \Pi + w$.

Two cases must be distinguished depending on whether the effort e (such that $\psi'(e) = z_n - z_a$), which maximizes the complete information aggregate payoff of the coalition, satisfies (10) 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 all bargaining power, $y_a = \Pi$. Given that $y_a + z_a \geq 0$ must be satisfied, this case can only occur when $z_a \geq -\Pi$, i.e., for small fines.

When $-\Pi > z_a \geq -\Pi - w$, we are in the case of strong fines, the solution to $(\mathcal{SP}_\alpha)$ is no longer interior and is constrained by equation (10). Of course, z_a must not be too negative otherwise the constrained set defined by (10) is empty. This is ensured when

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

where e_∞ is defined as:

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

When the constrained set is non-empty, the optimal effort is obtained when $y_a + z_a = 0$ and we find that it solves (9). 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 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 (7) 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 (3) 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 (14). This regime occurs as long as $\underline{w} > w$.

Let us assume, on the contrary, that (12) is binding and (7) is slack. Then, since (3) 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 $\bar{w} < w$.

Finally, for $\bar{w} \geq w \geq \underline{w}$, both (7) and (12) 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 (19), we get

$$U \geq z_a + \sum_{j=1}^{n} y_a^j + R(e) \geq R(e) \tag{30}$$

where the inequality follows from (20).

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 (30).

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

$$z_n + \sum_{j \neq i} y_n^j - \left(z_a + \sum_{j \neq i} y_a^j \right) = \psi'(e) + e\psi''(e). \tag{31}$$

Summing those equations for all i and taking into account (19) yields then (21). Finally, using again (31), we get (22). ∎