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Law versus Regulation: A Political Economy Model of Instrument Choice in Environmental Policy*

Marcel Boyer†*, Donatella Porrini*‡

Résumé / Abstract

Nous analysons les conditions sous lesquelles les approches légale et réglementaire peuvent être comparées dans le cadre d'un modèle d'économie politique de l'implémentation de la politique environnementale. La première partie de l'article décrit les caractéristiques essentielles des divers instruments à comparer, à savoir un régime de responsabilité légale élargie aux prêteurs et un régime de réglementation incitative, instruments typiquement utilisés aux États-Unis et en Europe. Dans la deuxième partie, un modèle formel d'économie politique est développé. La possibilité d'une capture de l'agence de réglementation est introduite sous forme réduite par la surévaluation de la valeur sociale de la rente informationnelle des entreprises. Nous montrons qu'un régime de réglementation incitative peut être plus ou moins performant en termes de bien-être qu'un régime de responsabilité élargie, stricte et solidaire. Nous analysons en profondeur trois facteurs principaux de cette comparaison, à savoir le différentiel de coût entre les niveaux faible et élevé de la protection environnementale, le coût social des fonds publics et le facteur de surévaluation.

We analyze the conditions under which a legal intervention can be compared to a regulatory framework in the context of a political economy model of environmental policy. The first part of the paper describes the characteristics of the different instruments we want to compare: first, an assignment of legal liability, focusing on the case of extended lender liability, and second, an incentive regulation framework. We briefly describe the application of those instruments in the United States and Europe. In the second part a formal economy model is presented where the possibility of capture of the regulatory agency is modeled in a reduced-form fashion through an overvaluation of the social value of the informational rent of the firms. We show that compared with an extended, strict, joint and several liability system, a regulatory system may perform better or worse from a welfare point of view. Three factors underlying this comparison are discussed in some depth, namely the differential cost between low and high levels

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of environmental protection activities, the social cost of public funds and the overvaluation factor.

Mots Clés : Politique environnementale, responsabilité élargie, CERCLA, capture des régulateurs, instruments

Keywords: Environmental policy, extended liability, CERCLA, regulatory capture, instruments

1 Introduction

From a law and economics point of view, the regulation of environmentally risky activities is an alternative to a system of liability assignment. "Regulation and tort law are alternative methods (though often used in combination) for preventing accidents. The former requires a potential injurer to take measures to prevent the accident from occurring. The latter seeks to deter the accident by making the potential injurer liable for the costs of accident should it occur." (Landes and Posner, 1984, p. 417). We want here to review and characterize, in an incomplete information political economy framework, the conditions under which an environmental regulation approach is superior to an environmental liability one.

We develop in this paper a formal analysis of the comparison between different policy instruments to implement a given set of environmental protection objectives,[1] including a political economy explanation of the choice of instruments.[2] The first instrument we consider is the assignment of a CERCLA type liability,[3] that is, a strict, retroactive, joint and several liability on the owners and operators of the firm responsible for a catastrophic environmental disaster. More precisely, we model an extended lender liability rule whereby private banks financing the responsible firm are considered as liable operators if the latter is unable to cover the damages and compensation from its own assets. The second instrument in our comparison consists in a regulation framework. After the environmental legislation of the 70s in the United States, the federal government played an extensive role in regulating air pollution, water pollution, hazardous and solid waste disposal, as well as pesticide use, among other environmental risks. More precisely we consider here an incentive regulation system based on a menu of contracts and subject to capture by the regulated firms.

Boyer and Laffont (1999) argue that two types of meaningful comparisons of instruments are possible. In the first type, one considers exogenous constraints on instruments and then various constrained instruments can be compared. In the second type, instruments, equivalent in the complete contracting framework, can be meaningfully compared given some imperfections in the economy outside the control of the social or constitutional planner.[4] The origin of this imperfect control of the social planner must be carefully justified. Otherwise, the results could be simply a direct and uninteresting consequence of artificial constraints on the social planner.

The extended lender liability option

The common law tort system, administered by the courts and governed principally by state law in the United States, provides a mechanism for creating incentives for care and for compensating victims, property losses and health injuries by a strict liability system.[5] Alongside the tort system, there exist a system of private and public insurance both for the liability of firms and for the consequences on individuals. In the 80s, the United States Congress enacted CERCLA and created a Superfund for the quick and effective cleanup of dangerous waste sites.[6] It gave the Environmental Protection Agency (EPA) the power to bring damage actions to recover cleanup costs against the owners and operators of the facility directly responsible for releases.

We want to concentrate here on an important aspect of a liability system that makes all owners and operators retroactively, strictly, jointly and severally liable, namely the extension of liability to the lenders. In spite of a secured interest exemption clause protecting financial institutions holding indicia of ownership on the firm's assets,[7] the United States courts have repeatedly considered secured lenders as owners or operators under CERCLA, insofar as their involvement in the operations of the firm exceeded the level warranted to secure their interest.[8]

A lenders' liability system was defined by the courts decisions, for instance in the following landmark cases involving the bankruptcy of the primary responsible firm: *USA v. Mirabile*,[9] *USA v. Maryland Bank & Trust*,[10] *USA v. Fleet factors*,[11] and *Bergsoe Metal v. East Asiatic*.[12] But these cases appeared to articulate potentially conflicting rules of liability regarding the type and degree of involvement making the lenders jointly liable with the responsible firms.[13] To clarify this confused situation, the EPA issued in 1992 the so called *Final Rule*[14] under which a lender would be liable for cleanup costs if it participated in the management of the borrower's operations by exercising management control over either the day to day operations of the facility or over its environmental compliance efforts. In the years following the EPA's final rule, some court decisions were based on this statement.[15] But in the 1994 case *Kelley v. EPA*,[16] the D.C. Circuit Court of Appeal held that Congress in enacting CERCLA did not give the EPA authority to effect the imposition of liability and therefore invalidated the EPA's final rule.[17]

In 1996, the *Asset Conservation, Lender Liability, and Deposit Insurance Protection Act*[18] clarified the limits of liability for secured creditors by validating the EPA's lender liability rule.

According to this Act, lenders and secured creditors must 'participate in the management of the facility' to be held liable as an 'owner or operator' of a contaminated site and a secured creditor's simple financing transactions should not imply a joint, several, retroactive and strict liability for environmental contamination. But, while the Act provides welcomed relief for secured creditors, it does not completely insulate lenders and fiduciaries from environmental liability and the question remains regarding which precise steps must be taken to ensure a limitation of liability for lenders.[19]

In addition to the lender liability rule developed through the jurisprudence, the CERCLA liability system raises other issues. First, suing all the potentially responsible parties or targeting some 'deep pocket' ones to recover response, cleanup costs and damages, as well as coordinating numerous parties with conflicting interests and finding an agreement on a cost allocation plan may generate very high transaction costs. Second, the involvement of many potentially responsible parties implies that the distribution among polluting parties of the needed compensation costs can create incentive problems such as the allocation of resources to legal strategies rather than to accident prevention.[20]

In addition to this transaction cost problem, the CERCLA liability system was not supported by a significant development in the insurance market.[21] The main problems are the following. The standard insurance policies do not fit the CERCLA retroactive liability system because they do not cover claims made before or after the validity period of the insurance contract. Moreover, because both the premium and the deductible in the policies are extremely high, only a few insurance companies in the United States issue them and many lending institutions opt for selfinsurance.[22]

In Europe, a unified regime of liability for environmental damages is still in the making.[23] The problem of harmonizing different national legal regimes from the standpoint of both market integration and environmental protection that cuts across traditional administrative and legal boundaries raises difficult issues.[24] In this context, the *White Paper on Environmental Liability* of February 2000 aims at determining who should pay for the cleanup and restoration costs of the environmental damage resulting from human acts. The question whether the costs should be paid by society at large through the tax system or by the polluter when it can be identified was answered by the imposition of liability on the party responsible for causing the damage. The EC

opted essentially for a strict (no fault) liability system that is effective only for future damage where polluters can be identified, damage is quantifiable and a causal connection can be shown. Given the general rule that the polluter must always be the first actor a claim is addressed to, the *White Paper* nevertheless recommends a form of extended liability rule. It states that the persons who exercises control (the 'operators') of an activity by which the damage is caused should be the liable party and it specifies that lenders not exercising operational control should not be liable. Furthermore, in the final part of the *White Paper* that deals with the overall economic impact of environmental liability in the European Community, it is stated that the liability system generally protects economic operators in the financial sectors, unless they have operational responsibilities.

The *EC White Paper* liability system while similar to the United States system differs from it on many important aspects. First, both of them are based on a strict liability regime in the sense that liability comes from the causal link between the actor and the damage and whether the actor's behavior was proper or negligent is irrelevant. Second, while the CERCLA system is applied retroactively, the *EC White Paper* provides a non-retroactive application.[25] Third, only a mitigated joint and several liability regime is provided in the European case in the sense that a party is allowed to provide convincing arguments that it is only partially liable. Fourth, instead of covering every damage including the damage to natural resources, the European system covers only traditional damages, such as personal injury and damage to property, and the decontamination of sites. Fifth, the objective of the United States system of recovering the environmental damage from liable parties is supported also by the creation of a Superfund while no such fund is established by the *White Paper*. Sixth, the set of actors who can be held liable is the same, namely the 'operators' of the firm, and both systems specify that lenders not exercising operational control should not be held liable, the so called secured interest exemption rule.[26]

The regulation option

An alternative instrument to implement the environmental policy is a regulatory system where an authority or an agency can use a number of ways to control environmental damages and reduce the probability of environmental accidents. The traditional approach is the command

and control procedure of setting and implementing pollution standards. A more recent approach rests on incentive market based instruments, as emission taxation, marketable permits and offset trading.[27]

In the command and control approach based on a mandatory technology or abatement standard, the regulator such the United States Environmental Protection Agency can order the firms to limit their emissions, to emit no more than a specified amount of a pollutant and/or to install a particular abatement technology. The regulator monitors over the time the compliance of firms with the standards and emission limits through the conduct of inspections, actions in federal courts and negotiated settlements with polluters.[28]

The incentive market based instruments are alternative tools that are typically based on the menu of contracts framework or on a system of marketable permits. The latter essentially works in the following way: the regulator grants a plant or public utility a number of permits to emit a given amount of a pollutant; if the facility is able to reduce its emissions, preferably through the use of newer technologies, it can sell its remaining emission permits to another facility that is unable to meet its quota.

Looking at the United States experience, air pollution control under the federal Clean Air Act (1970-1990) followed in its early stages a command and control approach but with the increasing knowledge and experimentation of market based solutions switched to markets of pollution 'rights'. Given that the main goal of the Clean Air Act was the attainment of national ambient air quality standards, the Congress asked the EPA to establish the National Ambient Air Quality Standards (NAAQSs) for pervasive air pollutants. Later on, effluent taxes and marketable emission rights were taken into consideration in order to overcome the shortcomings of the command and control instruments in terms of monitoring, enforcement capabilities, their high level of administrative costs.

In the EC, the European Environmental Agency (EEA) has a limited regulatory role for two reasons. First, the EEA exercises mainly the role of providing objective, comparable and reliable information that member States or the Community at large may use to develop measures to protect the environment, to evaluate the results of said measures, and to educate the public about the state of the environment. Second, the EEA has very limited resources: the agency has a staff of approximately 60 persons and its limited financial resources curtail its capacity

of addressing directly and credible the environmental problems of the Community. Therefore in every single member State, the regulation follows the national legislation and the choice of instruments is specific to each state.

Liability versus regulation

To compare the two policy instruments we can follow a law and economics approach analyzing their impacts in terms of social welfare.[29] This kind of analysis balances the benefits from the risky activities with the costs of precautionary care, the expected level of damages (probability and severity), the administrative expenses associated with these policies, and the net social cost of the informational rents.

A strict liability system is typically applied to risks created by abnormally hazardous activities and against defendants for all injuries caused by their conduct. The victim files an action claiming a causal link between the defendant's conduct and the plaintiff's injury or disease and the system relies on a case by case adjudication. Strict liability regime has the advantage of internalizing environmental risks both from the incentive and the compensation points of view. But it has some practical disadvantages: in many cases the victims are widely dispersed with none of them sufficiently motivated to initiate a legal action, harm may appear only after a long delay, specifically responsible polluters may be difficult to identify, determining the causal link may be difficult, inconsistent verdicts may emerge, delays in court proceedings may be very long and the system may be more profitable for lawyers and experts than for the victims.

On the other hand, a regulation system is typically characterized by a centralized structure. Its advantages are based on the fact that it is well suited to set policies regarding the definition and implementation of standards. The centralized search facilities, the continual oversight of problems and a broad array of regulatory tools can make the regulation system capable of systematically assessing environmental risks and of implementing a comprehensive set of policies. But, regulatory agencies may be not very flexible in adapting to changing conditions and centralized command structure relying on expert advice may be subject to political pressure as well as to collusion and capture by the regulated firms.[30]

We can compare the two policy instruments on the basis of the following features: the level of administrative costs, the magnitude of the damages in case of an environmental accident, the

private knowledge of the parties regarding the causal factors of accident probability and the risk of capture or collusion.

The cost of a liability system includes the administrative expenses incurred by the private and the public parties, namely the cost of optimally controlling the probability of accidents, the legal expenses and the public expenses for maintaining legal institutions. The cost of the regulatory system includes the public expenses for maintaining the regulatory agencies and the private costs of compliance. One advantage of the liability system is that a significant part of the administrative costs is incurred only if a suit occurs. On the other hand the administrative costs of a regulation system are incurred whether or not the harm occurs because the process of regulation is costly by itself and the regulator needs to collect information about the parties, their activities and the risks.

A second element of the comparison refers to who bears the cost of environmental damage. In a regulation system, the costs are usually directly or indirectly covered by the public parties when due care was exercised by the firms according to the standards defined by the regulatory agency. In a liability regime, these costs are imposed on the responsible private parties, if and when a suit occurs, given their capacity to pay and their limited liability. Both systems may require some form of compulsory insurance for the losses in excess of the assets of the firm but the liability system can also rely on an extended liability assignment according to which most or all deep pocket stakeholders (suppliers, partners and financiers) of the firm may be made strictly, jointly and severally responsible for the damages.

A third important element of the comparison is the distribution of knowledge among parties regarding the benefits of activities, the cost of reducing risks and the probability and the severity of accidents. Sometimes the nature of the activities carried out by the firms is such that the private parties have better knowledge of the benefits and costs of reducing risks. In such a case a liability system has the advantage of making the private parties residual claimants of the control of risks while a regulation system suffers from the lack of information leading to overestimation or underestimation of the costs and benefits of the risks (probability and/or severity). But it may also happen that the regulator has better knowledge of those risks because of the possibility of centralizing information and decisions, in particular when a better knowledge of the risk factors requires a special expertise to be shared through different cases and situations.[31]

A fourth relevant feature in the comparison is the possibility of capture and collusion between the enforcers and the parties. The enforcers may be influenced by external pressure in both systems, but one may reasonably argue that the courts are less likely to be captured than the regulating agencies.

On the basis of theses differences between the two policy instruments, we will present in the next section a model based on the stylized features of an extended lender liability system and of an incentive regulation system where the asymmetric information between parties (moral hazard) and the possibility of capture are explicitly present.

2 The model

We consider a two period context where a firm can, in each period, invest an amount F to generate a low profit level of π_L with probability θ or a high profit level of π_H with probability $(1-\theta)$, with expected profit $\bar{\pi} = \theta\pi_L + (1-\theta)\pi_H$.[32] The stochastic revenues are i.i.d. and the discount rate is zero. The firm can choose self-protection activities e that reduce the probability $p(e)$ of a major environmental accident generating damages of $d > \pi_H$. Therefore if a major environmental disaster occurs in period 2, it sends the responsible firm into bankruptcy. We will assume that the self-protection activities are exerted in period 1 and that an accident can happen in period 2 only, if it does occur. The self-protection activities can be at the high level e_h or at the low level e_ℓ; we will assume for simplicity that the cost of the low level e_ℓ is zero and that the (differential) cost of the high level is $\Delta\psi$. Let $p(e_h) = p_h$ and $p(e_\ell) = p_\ell$. We will assume that $\Delta\psi < (p_\ell - p_h)d$ and therefore it is socially optimal in a first best sense that the firm chooses the high level of self-protection activities.

We will assume for simplicity that the firm has no equity and must borrow each period the full amount F in order to remain in business. We consider two regimes. In the first regime, the firm interacts with a private banker who is the residual liable party for environmental damages caused by the firm, that is for damages above the assets of the firm. The firm is assumed to be risk neutral but with limited liability. The bank is assumed to be a deep pocket private bank whose limited liability is irrelevant. In the second regime, the firm interacts with a regulator who is directly responsible for implementing environmental protection policies to maximize welfare but who is subject to capture by the regulated firm. Under the extended lender liability regime,

the firm borrows from the private bank. Under the regulatory regime, we assume for simplicity that the firm borrows from the regulator. Clearly, a real regulator does not finance the firm but in her complex relationship with the firm, she would worry about the financial viability of the firm and also the impact of financial contracts on incentives for self-protection activities. Creating a direct financial link between the regulator and the firm is a reduced form representation of the structural relationship between the regulator, the firm and the financial markets.

We want to concentrate here on the prevention of environmental accidents and so, the information structure we consider is as follows: although the realized profit level is observable by everyone, the level of self-protection activities is a private information of the firm and is therefore observable neither by the regulator nor by the bank. The timing of the interplay between the principal (either the public regulator or the private bank) and the firm is as follows in both regimes considered. The principal offers a financial contract to the firm making explicit the payments to be made in each period if the firm is financed. If the contract is accepted, the firm invests F and chooses the care level e. The profit level of the first period is then observed and a payment is made to the principal according to the financial contract. In period 2, the firm is refinanced or not and if refinanced, it invests F again, the profit level is observed and a catastrophic accident occurs or not. A payment is made to the principal according to the financial contract and, if an accident occurs, cleanup costs are distributed according to the liability system in force.

We will characterize and compare three solutions. The benchmark solution will correspond to the case where a benevolent regulator, not subject to capture, chooses the financial contract offered to the firm in order to maximize a utilitarian social welfare function. The second solution will be obtained when a private bank, under an extended lender liability system, chooses and offers a financial contract that maximizes its own expected profit function in which the informational rent of the firm is not present. The third solution will be obtained when the captured regulator chooses the financial contract offered to the firm. In so doing, she maximizes a distorted social welfare function in which the informational rent of the firm will be overvalued. In a sense, there are three possible principals in this context: the benevolent regulator, the captured regulator and the private bank.

3 Moral hazard in environmental protection

Clearly, the asymmetric information structure and the limited liability of the firm makes the internalization of externalities a difficult problem. If a major environmental disaster occurs, the firm will be 'judgment-proof' for damages above its value, that is here, its profit level. Under limited liability, moral hazard variables cannot be costlessly controlled by imposing appropriate penalties on the risk neutral firm and the latter will in general be able to capture an informational rent. Accident-preventing activities by the firm must then be induced by higher rewards rather than stiff penalties since the limited liability constraint imposes a limit on those penalties.

Given that the profit level is observed by all parties, the principal is able to offer a financial contract where the repayment level is a function of the profit level. But because the level of self-protection activities is not observed, the repayment level must be independent of those activities. So we will assume that the financial contract stipulates that in period t, the principal will lend the amount F and ask for repayment levels of R_L^t if realized profit is π_L and R_H^t if realized profit is π_H. A financial contract is therefore a 4-tuple of repayments for loans of F in each period: $(R_L^1, R_H^1, R_L^2, R_H^2)$. The objective function of the principal will depend on the setting, that is, on whether the principal is a benevolent regulator, a captured regulator or a private bank, and whether the principal has priority or not over the firm's profit in case of bankruptcy. We will assume here that if an accident occurs, the firm must pay for the damages at least up to the maximal amount made possible by its limited liability. Since $d > \pi_H$, it means that all its profit will be taken away if an accident occurs and no payment is then made to the principal.

Under our assumptions, the full information first best allocation entails clearly a high level of self-protection activities e_h and a loan/investment F in both periods iff

$$2\bar{\pi} - 2F - p_h d - \Delta\psi \geq 0, \tag{1}$$

a condition which is satisfied if we have a benevolent regulator or a captured regulator. The two regulators differ by their treatment of the firm's informational rent but since the rent is zero under full information, this differential treatment has no impact. In the absence of extended lender liability, the private bank lends in each period iff

$$\max\{\ 2\bar{\pi} - 2F - p_\ell \bar{\pi},\ 2\bar{\pi} - 2F - p_h \bar{\pi} - \Delta\psi\ \} \geq 0, \tag{2}$$

leading to overinvestment because of the partial, rather than full, internalization of the externality. With the extended liability of the deep pocket private bank, the full information first best allocation is also achieved at the Nash equilibrium of the game played by the firm and the bank. The bank's liability induces it to fully internalize the externality and being risk neutral, it prefers the optimal level of effort e_h. Hence, one may suggest that a possible solution to the full internalization of the externality created by environmental accidents is to make the private bank responsible for damages if the judgment-proof firm it finances causes a catastrophic environmental accident.[33]

But when the principal, whether it is the benevolent regulator, the captured regulator or the private bank, suffers from agency problems in its relationship with the firm, the possibility of achieving the first best must be qualified. As mentioned before, we consider in this paper that the firm's profit is observable by the regulators and the private bank but that they all face a moral hazard problem regarding the level of the firm's accident preventing activities. We will characterize first the social optimum to be used as a benchmark. This benchmark corresponds to the case of the benevolent regulator who maximizes the proper social welfare function but in so doing must take into account the private information of the firm regarding its self-protection activities. Next, we will characterize the Nash equilibrium obtained for the game involving the firm and the private bank under the extended lender liability regime. Then, we will characterize the solution obtained when the regulator is captured. Finally, we will compare the three solutions and derive some propositions on the relative social efficiency of the regime of incentive regulation implemented by a captured regulator and the regime of extended lender liability.

The social optimum under moral hazard.

Because of asymmetric information, the full information first best allocation is not achievable anymore. The proper benchmark for our analysis is the social optimum under moral hazard because even the benevolent regulator whose objective is to maximize social welfare must take into account the agency costs. We will assume that the social welfare function (SWF) is utilitarian and that there is a social cost of public funds $(1 + \lambda)$ coming from distortions due to taxation: it costs $(1 + \lambda)T$ to raise T through general taxation.[34] The financial payments made by the

firm to the benevolent regulator acting here as a financier together with the cost F invested by the benevolent regulator will enter the social welfare function with a weight of $(1+\lambda)$, in the first case because they allow a reduction in taxation and in the second case because the investment F must be financed through taxation, directly or indirectly. We will assume also that the expected damage of an accident enters the social welfare function with a weight of $(1+\lambda)$ because the government will have to cover that cost in one way or another and finance it through taxation. Given that the firm's net utility (rent) is not observable by the benevolent regulator, and therefore not taxable, this net utility enters the social welfare function with a weight of 1. It will therefore be efficient that the benevolent regulator recuperates any observable profit of the firm.[35] The firm will be left with its unobservable informational rent which will then have a weight of 1 in the social welfare function. The socially optimal program of the benevolent regulator will therefore minimize the rent left to the firm because of its smaller weight in the social welfare function. The existence of a social cost of public funds is an important and realistic feature of regulatory frameworks. It makes income distribution relevant, although in an unusual sense, for environmental protection. Were that cost equal to zero, the regulator would not care whether the firm makes monopoly profits or capture significant informational rents as long as the efficient production level is realized. The existence of a positive λ together with the assumption of a regulator acting as financier will allow us to develop a tractable yet realistic model of instrument choice in environmental protection policy.

The social optimum under moral hazard maximizes the expected social welfare under the incentive compatibility, limited liability and individual rationality constraints of the privately informed firm. The firm will choose a high level of self-protection activities iff it finds profitable to incur the differential cost $\Delta\psi$, that is, iff its expected net utility in the is larger with $e=e_h$ than with $e=e_\ell$, that is iff:

$$(1-p_h)[\bar{\pi}-(\theta R_L^2+(1-\theta)R_H^2)]-\Delta\psi \geq (1-p_\ell)[\bar{\pi}-(\theta R_L^2+(1-\theta)R_H^2)]$$

which can be rewritten as

$$\bar{\pi}-\theta R_L^2-(1-\theta)R_H^2 \geq \frac{\Delta\psi}{p_\ell-p_h}, \tag{3}$$

which is the incentive compatibility constraint to be satisfied if the principal wants to induce the firm to select e_h. The limited liability constraints of the firm simply require that the repay-

ment levels not exceed the corresponding profit levels. Finally, the firm's individual rationality constraint is that its net utility be non negative (assuming an exogenous utility normalized at zero). The firm's expected net utility is 0 under $e = e_\ell$ and given by its informational rent under $e = e_h$: $\bar{\pi} - \theta R_L^1 - (1-\theta)R_H^1 - \Delta\psi + (1-p_h)\left(\bar{\pi} - \theta R_L^2 - (1-\theta)R_H^2\right)$. Distortions created by the presence of moral hazard will occur only when the combination of the limited liability constraints and the incentive compatibility constraint (3) require to give up a (costly) rent to the firm. The existence of a social cost of public funds requires that $R_L^1 = \pi_L$, $R_H^1 = \pi_H$ and that (3) be satisfied with a strict equality: because $\lambda > 0$, it is socially better to use the profit of the firm to reduce the general distortionary taxes. Therefore, the net utility level or informational rent of the firm is

$$\mathcal{R} \equiv -\Delta\psi + (1-p_h)\frac{\Delta\psi}{p_\ell - p_h} > 0. \tag{4}$$

Under the socially optimal financial contract, the benevolent regulator collects an expected amount of

$$\bar{\pi} + (1-p_h)(\theta R_L^2 + (1-\theta)R_H^2) - p_h[\theta(d - R_L^2) + (1-\theta)(d - R_H^2)] - 2F. \tag{5}$$

Proposition 1: If

$$\frac{\lambda}{1+\lambda}\mathcal{R} + \Delta\psi \leq (p_\ell - p_h)d, \tag{6}$$

the social optimum (the benevolent regulator solution) is characterized by a high level of accident preventing activities and an investment F in both periods iff

$$2\bar{\pi} - 2F - p_h d - \Delta\psi - \frac{\lambda}{1+\lambda}\mathcal{R} \geq 0. \tag{7}$$

If (6) is not satisfied, the social optimum is characterized by a low level of accident preventing activities and an investment in both periods iff

$$2\bar{\pi} - 2F - p_\ell d \geq 0. \quad \| \tag{8}$$

Proof: Let us first derive the social welfare when e_h is induced. We must solve the following program

$$\left.\begin{array}{l} \text{Max } \{(1+\lambda)[\theta R_L^1 + (1-\theta)R_H^1 + (1-p_h)(\theta R_L^2 + (1-\theta)R_H^2) - 2F] \\ \quad -(1+\lambda)p_h(d - \bar{\pi}) \\ \quad\quad +[(\bar{\pi} - \theta R_L^1 - (1-\theta)R_H^1 - \Delta\psi) + (1-p_h)(\bar{\pi} - \theta R_L^2 - (1-\theta)R_H^2)]\} \end{array}\right\} \tag{9}$$

subject to the incentive compatibility condition (3) and the individual rationality condition

$$\bar{\pi} - \theta R_L^1 - (1-\theta)R_H^1 - \Delta\psi + (1-p_h)(\bar{\pi} - \theta R_L^2 - (1-\theta)R_H^2) \geq 0. \tag{10}$$

The solution entails $\theta R_L^1 + (1-\theta)R_H^1 = \bar{\pi}$ and (3) satisfied with a strict equality because of the different weights in the SWF. Accordingly, the social welfare (9) can be written as

$$(1+\lambda)[\bar{\pi} - 2F + (1-p_h)(\bar{\pi} - \frac{\Delta\psi}{p_\ell - p_h}) - p_h(d-\bar{\pi})] + [(1-p_h)\frac{\Delta\psi}{p_\ell - p_h} - \Delta\psi],$$

hence as

$$(1+\lambda)[2\bar{\pi} - 2F - p_h d - \Delta\psi] - \lambda[(1-p_h)\frac{\Delta\psi}{p_\ell - p_h} - \Delta\psi],$$

that is,

$$(1+\lambda)[2\bar{\pi} - 2F - p_h d - \Delta\psi] - \lambda\mathcal{R}. \tag{11}$$

Therefore, investment should take place if (7) is satisfied. If $e = e_\ell$, no rent is left to the firm, the social welfare becomes

$$(1+\lambda)(2\bar{\pi} - 2F - p_\ell d) \tag{12}$$

and investment must take place in both periods if (12) is positive. Comparing the social welfare levels (11) and (12), we obtain that $e = e_h$ must be induced if

$$\frac{\lambda}{1+\lambda}\mathcal{R} + \Delta\psi \leq (p_\ell - p_h)d, \tag{13}$$

where the right hand side is the incremental value and the left hand side is the incremental cost, including the social cost of the informational rent, of the high level of accident preventing activities. This completes the proof. $\diamondsuit$

Proposition 1 differs from the first best full information rule because of the presence of $\mathcal{R}$, the rent to be given up to the firm when the benevolent regulator wants to induce a high level of accident prevention activities. The benevolent regulator cannot avoid giving up that rent to induce a high level of accident preventing activities and will therefore take into account the net social cost of that rent, namely $\lambda\mathcal{R}$. If that cost is large, the benevolent regulator may prefer, in maximizing the SWF, to induce a low level of care e_ℓ generating a high probability p_ℓ of environmental accidents. It may even turn out that the firm will not be financed by the benevolent regulator even if it would be in a full information context. Both when making the

investment decision and deciding on the optimal level of care activities, the social cost of this rent must be accounted for. As λ decreases, the net social cost of the firm's informational rent decreases and condition (13) converges to the condition for $e = e_h$ under full information. As λ increases, the net social cost of giving up a rent to the firm goes up and condition (13) converges to the condition, to be derived below, for $e = e_h$ under extended lender liability since $\lambda/(1+\lambda)$ converges to 1 as $\lambda \to \infty$.

The Nash equilibrium when the firm faces a private bank.

We now consider the case where the firm faces a private banker who is liable for environmental damages caused by the firm when the latter is unable to cover those damages from its assets, here its profits. Clearly as in the above case of a benevolent regulator acting as financier, the private bank can offer a care-inducing contract to the firm but in so doing will concede a rent to the firm as expressed by (3). Otherwise, the bank can capture the whole profit. The bank's expected profit under a contract inducing a high level of care activities e_h is, using (3),

$$\bar{\pi} + (1 - p_h)(\bar{\pi} - \frac{\Delta\psi}{p_\ell - p_h}) - p_h(d - \bar{\pi}) - 2F$$

that is

$$2\bar{\pi} - 2F - p_h d - (1 - p_h)\frac{\Delta\psi}{p_\ell - p_h}, \tag{14}$$

while under the alternative contract inducing the low level of care e_ℓ, its profit is

$$2\bar{\pi} - 2F - p_\ell d. \tag{15}$$

Proposition 2: Under extended lender liability, the private bank induces a high level of accident preventing activities less often than the benevolent regulator does. When the bank decides to induce $e = e_h$ conceding a rent $\mathcal{R}$ to the firm, it lends less often than the benevolent regulator does. When, in spite of lender liability, the bank opts to induce the low level of care activities e_ℓ leaving no rent to the firm, it lends as often as the benevolent regulator does in that case. ‖

Proof: Comparing (14) and (15), the private bank opts for inducing $e = e_h$ iff

$$\mathcal{R} + \Delta\psi < (p_\ell - p_h)d \tag{16}$$

while the benevolent regulator induces such a level of care when (13) is satisfied. Comparing the two conditions shows that the private bank opts for the low level of care activities more often

because

$$\frac{\lambda}{1+\lambda}\mathcal{R} + \Delta\psi < \mathcal{R} + \Delta\psi.$$

Considering (14) and using (4), the private bank will lend with e_h iff

$$2\bar{\pi} - 2F - p_h d - \Delta\psi - \mathcal{R} \geq 0. \tag{17}$$

Comparing (17) and (7), obtained in the case of the benevolent regulator, shows that the private bank lends less often than the benevolent regulator does. Similarly, since (15) and (8) are the same then the private bank lends as often as the benevolent regulator does in that case since no rent is left to the firm and the bank internalizes completely the cost of an accident. $\diamondsuit$

The intuition behind Proposition 2 is that under the extended lender liability, the cost of an accident for the bank is the same as for the benevolent regulator and so the comparison between the two solutions rests on their different evaluation of the firm's rent when $e = e_h$ is induced. For the bank, the cost of the rent is equal to the value of the rent itself $\mathcal{R}$ while for the benevolent regulator the net cost is smaller, namely $\frac{\lambda}{1+\lambda}\mathcal{R}$, because she considers the social value of that rent in the SWF. This makes the bank less willing than the benevolent regulator not only to lend but also to induce a high level of accident preventing activities. Hence this unavoidable informational rent leads to insufficient financing and too little care activities induced by the bank. If the bank chooses to induce $e = e_\ell$, there is no rent and therefore the bank lends as often as the benevolent regulator.

The biased optimum when the regulator is captured

If the regulator is captured, she will in a sense benefit from the firm's rent one way or another, that is, through bribes, collusive interests, perks, future employment opportunities and so on. It will be as if she puts too much weight (overvaluation) on the firm's informational rent in the objective function, that is, as if she undervalues the social cost of that rent in comparison with the benchmark case of the benevolent regulator. This will make the captured regulator less keen to reduce this rent to its minimum.

We will assume that the rent $\mathcal{R}$ of the firm, when $e = e_h$ is induced, enters the captured regulator's objective function with a weight of K, where $1 < K < (1 + \lambda)$. The captured regulator's objective function is a biased version of the social welfare function, namely when e_h

is induced,

$$(1+\lambda)[\bar{\pi} - 2F + (1-p_h)(\bar{\pi} - \frac{\Delta\psi}{p_\ell - p_h}) - p_h(d-\bar{\pi})] + K\mathcal{R},$$

that is, using (3),

$$(1+\lambda)[2\bar{\pi} - 2F - p_h d - \Delta\psi] - (1+\lambda-K)\mathcal{R} \tag{18}$$

and, when e_ℓ is induced,

$$(1+\lambda)[2\bar{\pi} - 2F - p_\ell d]. \tag{19}$$

We have:

Proposition 3: The captured regulator induces a high level of accident preventing activities more often than the benevolent regulator does. When she induces $e = e_h$ conceding a rent to the firm, she lends more often than called for, conditionally on $e = e_h$, by the second best optimal investment rule. When the captured regulator induces a low level of accident preventing activities e_ℓ leaving no rent to the firm, she lends as often as called for, conditionally on $e = e_\ell$, by the second best optimal investment rule. ‖

Proof: Comparing (18) and (19), we obtain that the captured regulator induces $e = e_h$ iff

$$\frac{1+\lambda-K}{1+\lambda}\mathcal{R} + \Delta\psi < (p_\ell - p_h)d$$

which compared with (6) shows that the captured regulator induces e_h too often since

$$\frac{1+\lambda-K}{1+\lambda}\mathcal{R} + \Delta\psi < \frac{\lambda}{1+\lambda}\mathcal{R} + \Delta\psi.$$

When e_h is induced, the captured regulator's objective function (18) is positive iff

$$2\bar{\pi} - 2F - p_h d - \Delta\psi - \frac{1+\lambda-K}{1+\lambda}\mathcal{R} \geq 0.$$

Since $\frac{1+\lambda-K}{1+\lambda} < \frac{\lambda}{1+\lambda}$, the social cost of the rent is undervalued and therefore, the capture of the regulator leads to overinvestment, conditionally on $e = e_h$, in the environmentally risky activities. When e_ℓ is induced, we observe from (12) and (19) that the investment rules of the captured regulator and of the benevolent regulator are the same. ♢

4 The choice of instruments

Let SWF^{CR} be the value of the SWF (9) with the solution, level of care activities and investment rule, implemented by the captured regulator, as defined in proposition 3. Let SWF^{PB} be the

value of the SWF with the solution, level of care activities and investment rule, implemented by the private bank under extended lender liability, as defined in proposition 2. Let us define the correspondences Ω, Φ, Γ as follows:

$$\begin{aligned} \text{SWF}^{CR} &> \text{SWF}^{PB} \quad \text{iff} \quad \Delta\psi \in \Omega(\lambda) \\ \text{SWF}^{CR} &= \text{SWF}^{PB} \quad \text{iff} \quad \Delta\psi \in \Phi(\lambda) \\ \text{SWF}^{CR} &< \text{SWF}^{PB} \quad \text{iff} \quad \Delta\psi \in \Gamma(\lambda). \end{aligned}$$

We now turn to the characterization and illustration of those correspondences.[36] But first, let us recall the main result of our analysis so far.

When $e = e_\ell$ is induced, the investment rules are the same in the three cases considered, namely the benevolent regulator, the private bank and the captured regulator.

When the benevolent regulator is the principal, we obtain that the probability that $e = e_h$ will be induced is the probability that $\frac{\lambda}{1+\lambda}\mathcal{R} + \Delta\psi$ is less than $(p_\ell - p_h)d$ and the probability that an investment $2F$ will be made in the firm is the probability that $\frac{\lambda}{1+\lambda}\mathcal{R} + \Delta\psi$ is smaller than $2\bar{\pi} - 2F - p_h d$. This is the benchmark case corresponding to the second best solution, that is, the social optimum under moral hazard.

When the private bank is the principal, the probability that $e = e_h$ will be induced is now the probability that $\mathcal{R} + \Delta\psi$ is less than $(p_\ell - p_h)d$ and the probability that an investment $2F$ will be made in the firm is now the probability that $\mathcal{R} + \Delta\psi$ is smaller than $2\bar{\pi} - 2F - p_h d$. Compared with the benchmark case, this solution represents a loss of social welfare because of <u>not enough</u> incentive for care, hence too many accidents, and <u>not enough</u> investment in the environmentally risky operations of the firm. The loss in welfare is due to the bank's <u>overvaluation</u> of the net social cost of the informational rent captured by the firm, that is to the bank's failure to consider the social value of the rent.

When the captured regulator is the principal, we then obtain that the probability that $e = e_h$ will be induced is the probability that $\frac{1+\lambda-K}{1+\lambda}\mathcal{R} + \Delta\psi$ is less than $(p_\ell - p_h)d$ and the probability that an investment $2F$ will be made in the firm is then the probability that $\frac{1+\lambda-K}{1+\lambda}\mathcal{R} + \Delta\psi$ is smaller than $2\bar{\pi} - 2F - p_h d$. Again, compared with the benchmark case, this solution represents a loss of social welfare because of <u>too much</u> incentive for care, hence too few accidents (conditional on the level of financing), and <u>too much</u> investment in the environmentally risky operations of

the firm. The loss in welfare is due to the captured regulator's undervaluation of the net social cost of the informational rent captured by the firm, that is the captured regulator's overweighing of the social value of the rent.

The investment rules in the three contexts are the same if $e = e_\ell$ is induced. But they differ if $e = e_h$ is induced. Moreover the conditions under which e_h is induced differ between the three contexts.

- In the benevolent regulator (BR) solution:

  $e = e_h$ iff

  $$\frac{\lambda}{1+\lambda}\mathcal{R} + \Delta\psi \leq (p_\ell - p_h)d,$$

  that is, using (4), iff

  $$\Delta\psi \leq \frac{(1+\lambda)(p_\ell - p_h)d}{1 + \lambda\frac{1-p_h}{p_\ell - p_h}}. \tag{20}$$

  Investment $2F$ will take place iff

  $$2\bar{\pi} - 2F - p_h d - \Delta\psi - \frac{\lambda}{1+\lambda}\mathcal{R} \geq 0,$$

  that is, iff

  $$\Delta\psi \leq \frac{(1+\lambda)(2\bar{\pi} - 2F - p_h d)}{1 + \lambda\frac{1-p_h}{p_\ell - p_h}}. \tag{21}$$

- In the private bank (PB) solution:

  $e = e_h$ iff

  $$\mathcal{R} + \Delta\psi \leq (p_\ell - p_h)d,$$

  that is, iff

  $$\Delta\psi \leq \frac{(p_\ell - p_h)^2 d}{1 - p_h}. \tag{22}$$

  Investment $2F$ will take place iff

  $$2\bar{\pi} - 2F - p_h d - \Delta\psi - \mathcal{R} \geq 0,$$

  that is, iff

  $$\Delta\psi \leq \frac{(p_\ell - p_h)(2\bar{\pi} - 2F - p_h d)}{1 - p_h}. \tag{23}$$

- In the captured regulator (CR) solution:

  $e = e_h$ iff

  $$\frac{1+\lambda-K}{1+\lambda}\mathcal{R} + \Delta\psi \leq (p_\ell - p_h)d,$$

  that is, iff

  $$\Delta\psi \leq \frac{(1+\lambda)(p_\ell - p_h)d}{K + \frac{(1-p_h)(1+\lambda-K)}{p_\ell - p_h}}. \tag{24}$$

  Investment $2F$ will take place iff

  $$2\bar{\pi} - 2F - p_h d - \Delta\psi - \frac{1+\lambda-K}{1+\lambda}\mathcal{R} \geq 0,$$

  that is, iff

  $$\Delta\psi \leq \frac{(1+\lambda)(2\bar{\pi} - 2F - p_h d)}{K + \frac{(1-p_h)(1+\lambda-K)}{p_\ell - p_h}}. \tag{25}$$

Suppose that $\lambda = 0$. In that case, the BR implements the first best solution since, although the firm can capture an informational rent, that rent has no social cost. So the BR induces e_h since by assumption $\Delta\psi < (p_\ell - p_h)d$ and finances the firm iff $2\bar{\pi} - 2F - p_h d - \Delta\psi \geq 0$. The PB solution is independent of the value of λ. Using (4), we obtain that the PB induces e_h, leaving a rent $\mathcal{R}$ to the firm, iff

$$\Delta\psi \leq \frac{p_\ell - p_h}{1 - p_h}(p_\ell - p_h)d.$$

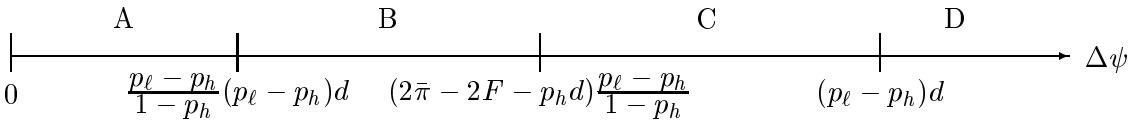
Otherwise, the PB induces e_ℓ, leaving no rent to the firm. Conditionally on $e = e_\ell$, the private bank lends as often as called for by the first best rule since there is no rent. The social loss in welfare in this case is the welfare loss due to inducing e_ℓ rather than e_h. Moreover, even when the PB prefers to induce e_h, it does not follow that it finances the firm. In fact, if

$$\Delta\psi > (2\bar{\pi} - 2F - p_h d)\frac{p_\ell - p_h}{1 - p_h},$$

the PB will not finance the firm with $e = e_h$, contrary to the first best rule. It may still finance the firm with $e = e_\ell$. But $(2\bar{\pi} - 2F - p_h d)\frac{p_\ell - p_h}{1-p_h} > \frac{p_\ell - p_h}{1-p_h}(p_\ell - p_h)d$, as in Figure 1 below, iff $2\bar{\pi} - 2F - p_\ell d > 0$. Otherwise, we have Figure 2.

FIGURE 1

$(\lambda = 0 \text{ and } 2\bar{\pi} - 2F - p_\ell d > 0)$

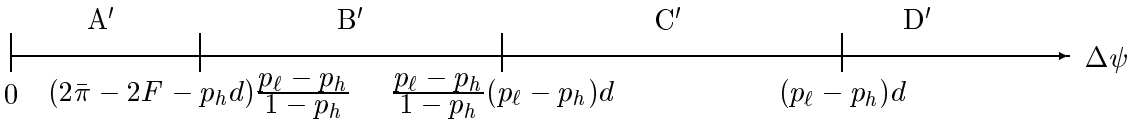


- In A, we have $e^{PB} = e_h$ and $e^{BR} = e_h$, and financing occurs in both the BR and PB solutions: no welfare loss in the PB solution.
- In B and C, we have $e^{PB} = e_\ell$ and $e^{BR} = e_h$, and financing occurs in both the BR and PB solutions: the welfare loss in the PB solution corresponds to the higher than efficient level of accidents.
- In D, we have $e^{PB} = e_\ell$ and $e^{BR} = e_\ell$, and financing occurs in both the BR and PB solutions, since $2\bar{\pi} - 2F - p_\ell d \geq 0$, independently of $\Delta\psi$ which is not paid since $e = e_\ell$: there is no welfare loss in the PB solution.[37]

If $2\bar{\pi} - 2F - p_\ell d < 0$, then we have the following:

FIGURE 2

$(\lambda = 0 \text{ and } 2\bar{\pi} - 2F - p_\ell d < 0)$



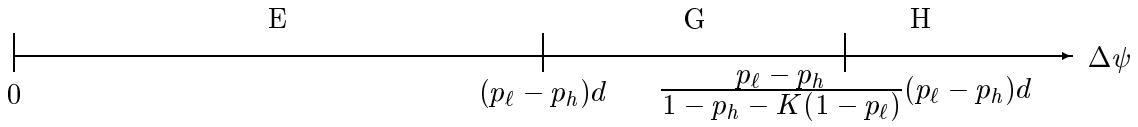
- In A′, we have $e^{PB} = e_h$ and $e^{BR} = e_h$, and financing occurs in both the BR and PB solutions: no welfare loss in the PB solution.
- In B′, we have $e^{PB} = e_h$ and $e^{BR} = e_h$, but financing occurs only in the BR solution: the welfare loss in the PB solution corresponds to not realizing the investment.
- In C′, we have $e^{PB} = e_\ell$ and $e^{BR} = e_h$, but financing occurs only in the BR solution: again the welfare loss in the PB solution corresponds to not realizing the investment.

- In D′, we have $e^{PB} = e_\ell$ and $e^{BR} = e_\ell$, and financing occurs in neither the BR nor the PB solutions: no welfare loss in the PB solution.

Similarly, comparing the solutions under BR and CR for the case $2\bar{\pi} - 2F - p_\ell d > 0$, we obtain:

FIGURE 3

($\lambda = 0$ and $2\bar{\pi} - 2F - p_\ell d > 0$)



- In E, we have $e^{CR} = e_h$ and $e^{BR} = e_h$, and financing occurs in both the BR and CR solutions: no welfare loss in the CR solution.

- In G, we have $e^{CR} = e_h$, leaving a rent to the firm, and $e^{BR} = e_\ell$, leaving no rent to the firm, and financing occurs in both the CR and the BR solutions. The welfare loss in the CR solution corresponds to a level of accidents that is too low (from the level of care e_h generating a rent for the firm) !

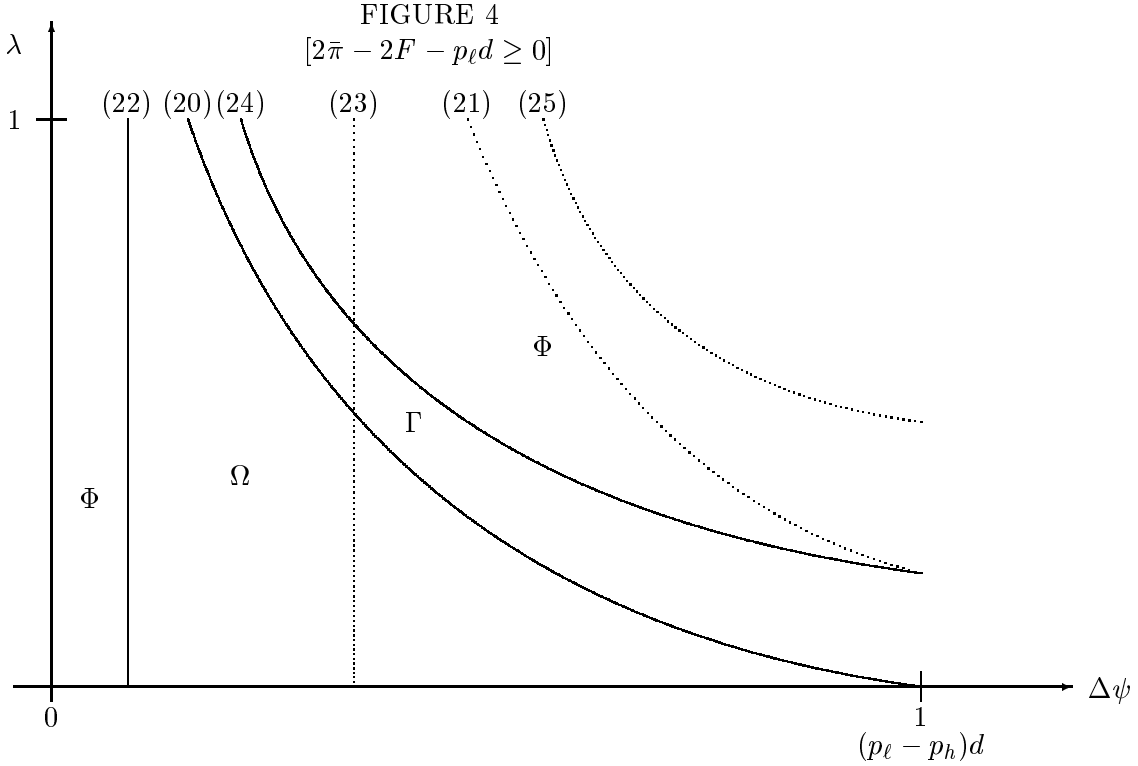
- In H, we have $e^{CR} = e_\ell$ and $e^{BR} = e_\ell$, and financing in both the CR and the BR solutions: no welfare loss in the CR solution.

Rather than proceed with a general analysis of the cases with $\lambda > 0$, let us consider the following illustrative numerical example:

$$\pi_L = 5,\ \pi_H = 10,\ \theta = 0.5,\ F = 5,\ p_\ell = 0.1,\ p_h = 0.05,\ d = 20,\ K = 1.2$$

for which $\bar{\pi} = 7.5$ and $(p_\ell - p_h)d = 1$. For this case, we can graph the frontiers (20) to (25) as on Figure 4, for $(\Delta\psi, \lambda) \in \{(0,0),\ (1,1)\}$.

FIGURE 4
$[2\bar{\pi} - 2F - p_\ell d \geq 0]$



Conditions (20), (22) and (24) relate to the decision about the level of care activities, namely $e^{BR} = e_h$ iff $\Delta\psi$ is to the left of (20) for a given λ, that is, iff λ is below (20) for a given $\Delta\psi$, $e^{PB} = e_h$ iff $\Delta\psi$ is to the left of (22), irrespective of the value of λ, and $e^{CR} = e_h$ iff $\Delta\psi$ is to the left of (24) for a given λ, that is, iff λ is below (24) for a given $\Delta\psi$. Conditions (21), (23) and (25) relate to the decision about the investment in the firm, namely BR invests with e_h iff $\Delta\psi$ is to the left of (21), PB invests with e_h iff $\Delta\psi$ is to the left of (23) and CR invests with e_h iff $\Delta\psi$ is to the left of (25). Therefore, for the example considered, all three principals invest if indeed they decide to induce e_h from the firm. When they induce e_ℓ, they all follow the same rule since there is then no rent left to the firm, namely they all invest iff $2\bar{\pi} - 2F - p_\ell d \geq 0$. If we assume that this last condition is satisfied, then there will always be investment in the firm. The difference between the three solutions comes from the different decisions regarding the inducement of care activities. Consider Figure 4. For a situation $(\Delta\psi, \lambda)$ to the left of (22), all three principals induce e_h and invest in the firm: the three solutions are the same. For a

situation $(\Delta\psi, \lambda)$ between (22) and (20), $e^{BR} = e^{CR} = e_h$ but $e^{PB} = e_\ell$, while they all invest in the firm: in this region, the captured regulator solution is preferred to the private bank solution. For a situation $(\Delta\psi, \lambda)$ between (20) and (24), $e^{BR} = e^{PB} = e_\ell$ but $e^{CR} = e_h$, while they all invest in the firm: in this region, the private bank solution is preferred to the captured regulator solution, even if there will be more accidents in the former solution. The larger number, more precisely the higher probability, of accidents is more than compensated by the fact that there is no (costly) rent left to the firm. Finally for a situation $(\Delta\psi, \lambda)$ above (24), all three principals induce e_ℓ and invest in the firm: the three solutions are the same. Therefore:

Proposition 4: If $2\bar{\pi} - 2F - p_\ell d \geq 0$, that is, if the firm is socially profitable with a low level of care, then the 'extended lender liability' regime and the 'regulator subject to capture' regime are equivalent instruments for implementing the environmental policy if the differential cost between high and low levels of accident prevention activities is relatively small or relatively large (as a function of the social cost of public funds λ), that is, if

$$\Delta\psi \in \Phi(\lambda) \equiv \left[0,\ \frac{(p_\ell - p_h)^2 d}{1 - p_h}\right] \bigcup \left[\frac{(1+\lambda)(p_\ell - p_h)d}{K + \frac{(1-p_h)(1+\lambda-K)}{p_\ell - p_h}},\ \infty\right] \bigcup \{\frac{(1+\lambda)(p_\ell - p_h)d}{1 + \lambda\frac{1-p_h}{p_\ell - p_h}}\}.$$

The 'regulator subject to capture' regime is a better instrument if the differential cost between high and low levels of accident prevention activities is in the lower intermediate range, that is, if

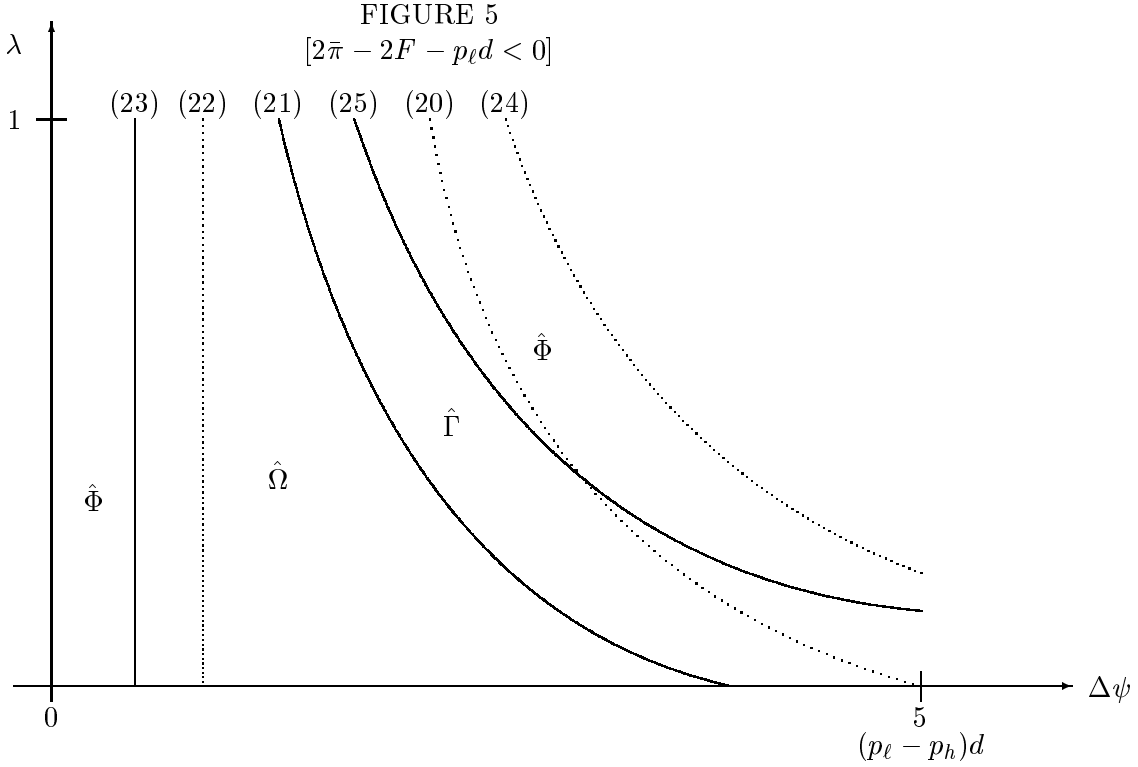
$$\Delta\psi \in \Omega(\lambda) \equiv \left(\frac{(p_\ell - p_h)^2 d}{1 - p_h},\ \frac{(1+\lambda)(p_\ell - p_h)d}{1 + \lambda\frac{1-p_h}{p_\ell - p_h}}\right).$$

The 'extended lender liability' regime is a better instrument if the differential cost between high and low levels of accident prevention activities is in the higher intermediate range, that is, if

$$\Delta\psi \in \Gamma(\lambda) \equiv \left(\frac{(1+\lambda)(p_\ell - p_h)d}{1 + \lambda\frac{1-p_h}{p_\ell - p_h}},\ \frac{(1+\lambda)(p_\ell - p_h)d}{K + \frac{(1-p_h)(1+\lambda-K)}{p_\ell - p_h}}\right). \quad \|$$

If investing in the firm is not socially desirable or profitable unless $e = e_h$ is induced, that is, if $2\bar{\pi} - 2F - p_\ell d < 0$, we obtain a configuration represented in Figure 5, where $p_\ell = 0.3$, for $(\Delta\psi, \lambda) \in \{(0,0),\ (5,1)\}$.

FIGURE 5
$[2\bar{\pi} - 2F - p_\ell d < 0]$



We observe the following. For a situation $(\Delta\psi, \lambda)$ to the left of (23), all three principals prefer to induce e_h and invest in the firm: the three solutions are the same. To the right of (23), the private bank does not invest anymore because $\Delta\psi$ is too high. For a situation $(\Delta\psi, \lambda)$ between (23) and (21), $e^{BR} = e^{CR} = e_h$ and both invest in the firm: in this region, the captured regulator solution is preferred to the private bank solution. To the right of (21), the benevolent regulator does not invest anymore. Although she would prefer to induce e_h [for $(\Delta\psi, \lambda)$ between (21) and (20)], $\Delta\psi$ is too high and therefore the rent to be left to the firm is too costly. Note that as expected, the no investment trigger value is decreasing in λ: the higher the social cost of public funds, the faster the benevolent regulator stops investing as the differential cost $\Delta\psi$ increases. For a situation $(\Delta\psi, \lambda)$ between (21) and (25), $e^{CR} = e_h$ and the captured regulator is the only principal still interested in investing in the firm: in this region, the private bank solution is preferred to the captured regulator solution. Even if the captured regulator induces the high level of care activities, her decision to invest in the firm is due to her undervaluation of the social

cost of the rent left to the firm. In this region of parameter space, it is socially better not to finance the firm. Finally for a situation $(\Delta\psi, \lambda)$ above (25), none of the three principals invest in the firm: the three solutions are the same. We obtain a comparison similar to the case of proposition 4 but with different boundaries. We have:

Proposition 5: If $2\bar{\pi} - 2F - p_\ell d \leq 0$, that is, if the firm is socially profitable only with a high level of care, then the 'extended lender liability' regime and the 'regulator subject to capture' regime are equivalent instruments for implementing the environmental policy if the differential cost between high and low levels of accident prevention activities is relatively small or relatively large, that is, if

$$\Delta\psi \in \hat{\Phi}(\lambda) \equiv \left[0, \frac{(p_\ell - p_h)(2\bar{\pi} - 2F - p_h d)}{1 - p_h}\right] \bigcup \left[\frac{(1+\lambda)(2\bar{\pi} - 2F - p_h d)}{K + \frac{(1-p_h)(1+\lambda-K)}{p_\ell - p_h}}, \infty\right] \bigcup \left\{\frac{(1+\lambda)(2\bar{\pi} - 2F - p_h d)}{1 + \lambda\frac{1-p_h}{p_\ell - p_h}}\right\}.$$

The 'regulator subject to capture' regime is a better instrument if the differential cost between high and low levels of accident prevention activities is in the lower intermediate range, that is, if

$$\Delta\psi \in \hat{\Omega}(\lambda) \equiv \left(\frac{(p_\ell - p_h)(2\bar{\pi} - 2F - p_h d)}{1 - p_h}, \frac{(1+\lambda)(2\bar{\pi} - 2F - p_h d)}{1 + \lambda\frac{1-p_h}{p_\ell - p_h}}\right).$$

The 'extended lender liability' regime is a better instrument if the differential cost between high and low levels of accident prevention activities is in the higher intermediate range, that is, if

$$\Delta\psi \in \hat{\Gamma}(\lambda) \equiv \left(\frac{(1+\lambda)(2\bar{\pi} - 2F - p_h d)}{1 + \lambda\frac{1-p_h}{p_\ell - p_h}}, \frac{(1+\lambda)(2\bar{\pi} - 2F - p_h d)}{K + \frac{(1-p_h)(1+\lambda-K)}{p_\ell - p_h}}\right). \quad \|$$

Proposition 6: The region in $(\Delta\psi, \lambda)$-space over which the captured regulator solution is better than the extended lender liability solution is independent of K while the region in $(\Delta\psi, \lambda)$-space over which the captured regulator solution is worse than the extended lender liability solution is expanding with K. $\|$

5 Conclusion and policy implications

We analyzed in this paper a simple model allowing a comparison between different instruments for implementing an efficient environmental protection policy. More precisely, we considered a moral hazard context in which firms can take preventing actions to reduce the probability of environmental disasters. Those actions being a private information of the firm concerned will give rise to informational rents whose net social cost is positive because of the existence of a social cost of public funds. We first characterized the optimal rules a benevolent welfare maximizing regulator would choose regarding the level of care activities a given firm should be exercising and the condition for financing the firm. Those rules differ from the first best rules because the maximization of social welfare requires that the regulator minimizes the informational rent of the firm. We then compared the benevolent regulator solution rules to those rules a private bank would apply under the extended lender liability of the CERCLA type and to those rules a captured regulator, overestimating the contribution of the informational rent of the firm to social welfare, would choose.

The comparison of the three sets of rules led us to identify the region in the $(\Delta\psi, \lambda)$-space where the captured regulator rules and the CERCLA-liable private bank rules are equivalent to the benevolent regulator rules, the region where the captured regulator rules are better in terms of social welfare attained to the CERCLA-liable private bank rules, and finally the region where the CERCLA-liable private bank rules are better.

Our main results are summarized in proposition 4 for the case where the firm is socially profitable when the level of care is high or low and in proposition 5 for the case where the firm is socially profitable only if the level of care is high. In general, the captured regulator solution is better if the deterministic characteristic location of the economy in the $(\Delta\psi, \lambda)$-space falls in the lower intermediate range, that is if $\Delta\psi \in \Omega(\lambda)$ [or $\Delta\psi \in \hat{\Omega}(\lambda)$] and the CERCLA-liable private bank solution is better if the deterministic characteristic location of the economy falls in the higher intermediate range, that is if $\Delta\psi \in \Gamma(\lambda)$ [or $\Delta\psi \in \hat{\Gamma}(\lambda)$]. It is interesting to note that the former region is independent of the capture parameter K while the latter region is expanding with increases in K: if the captured regulator's overestimation of the contribution of the informational rent to social welfare increases, within its reasonable interval, then the upper

boundary of the region in $(\Delta\psi, \lambda)$-space where the CERCLA-liable private bank solution rules are better than the captured regulator's rules [condition (24) in proposition 4 and condition (25) in proposition 5] moves up.

The main conclusion of this paper is therefore that choosing between a regulation framework and a legal framework to implement an environmental protection policy is not an easy matter. But our analysis provides some preliminary steps in determining a way to analyze such a choice. So the answer to the question regarding which instruments should be employed by the policy makers is that a case by case examination is required. But, some of the important determinants of the relative efficiency with which different policy instruments maximize social welfare function have been characterized.

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NOTES

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1. See Cropper and Oates (1992), Segerson (1996) and Lewis (1996).

2. See Buchanan and Tullock (1975), Yohe (1976), Boyer (1979), Noll (1983), Hahn (1990), Laffont (1995) and Boyer and Laffont (1999).

3. CERCLA: Comprehensive Environmental Response, Compensation and Liability Act 1980, 1985, 1996.

4. This is the case in Buchanan's (1969) example of a polluting monopolist when the subsidies required to correct the monopolistic behavior are not available: Pigouvian taxes are then dominated by a quota which implements the second best tax.

5. See Calabresi (1970), Landes and Posner (1984, 1987), Shavell (1987), Menell (1991) and Boyer, Lewis and Liu (2000).

6. The Superfund enabled the government to begin the cleanup of priority sites placed on the National Priority List (NPL) with money generated principally by taxes on crude oil, corporate income, petrochemical feed stocks, and motor fuels.

7. 'The term "owner or operator" does not include a person, who, without participating in the management of a vessel or facility, holds indicia of ownership primarily to protect his security interest in the vessel or facility' (42 USAC., par. 9601, (21), 1988)

8. See Strasser and Rodosevitch (1993), Pitchford (1995), Heyes (1996), Boyer and Laffont (1996, 1997), Boyd and Ingberman (1997), Dionne and Spaeter (1998), Gobert and Poitevin (1998) and Gobert (1999).

9. 15, Environmental Law Reports 20,994 (E.D. Pa 1985).

10. 632 F. Supp. 573 (d. Md. 1986).

11. 901 F. 2d 1550 (11th Circuit 1990) cert. denied, 498 USA 1046 (1991).

12. 910 F. 2d 668 (9th Circuit 1990).

13. See Chadd et alii (1991).

14. *National Oil and Hazardous Substances Pollution Contingency Plan; Lender Liability under CERCLA Final Rule*, 57 Fed. Reg. 18, 344 (1992), codified at 40 C.F.R. § 300.1100 to 1105 (1992).

15. *Publicker Indus., Inc. v. USA (In re Cuyahoga Equip. Corp.)*, 980 F. 2d 110, 118-119 (2d Cir. 1992); *Kelley ex rel. Mich. Natural Resources Comm'n v. Tisconia*, 810 F. Supp. 901, 907 (W.D. Mich. 1993); *Ashaland Oil, Inc. v. Sonford Prods. Corp.*, 810, F. Supp. 1057, 1060 (d. Minn. 1993), and others.
16. *Kelley v. USEPA*, 15 F. 3d 1100 (DC circuit 1994), cert. denied; *American Bankers Assoc. and Others v. Kelley*, 115 S. Ct. 900 (1995).
17. See Simons (1994).
18. H11766 Subtitle E, §§ 2501 to 2505 - Asset Conservation, Lender Liability, and Deposit Insurance Protection Act of 1996 (HR 3610).
19. See Henderson (1997).
20. See Kornhauser and Revesz (1994).
21. See Staton (1993).
22. For more on this issue, see *A. Johnson & Co. v. Aetna Casualty & Sur. Co.*, 933 F.2d 66 (1st Cir. 1991); *USA Fidelity & Guar. Co. v. George W. Whitesides Co.*, 932 F..2d 1169 (6th Cir. 1991).
23. In 1993, the European Commission published the *Green Paper on Remedying Environmental Damage* (COM (93) 47 final, Brussels, 14 may 1993, OJ 1993 C 149/12). It presented the broad concepts on which a liability system could be built and contained a description of the issues relevant to designing a Community-wide liability system. It led to discussions on the future EC liability regime through a debate aimed at collecting the opinions of the interested sectors and parties. It focused on the liability criteria, the definition of environmental damage, the right of non governmental organizations to bring legal actions (the legal standing doctrine), the insurability of environmental damage, the limitations of liability, the problem of reinstatement of the environment, the possibility of compensation funds financed by industries. In the same year, the Commission explored the possibility of joining the 1993 Council of Europe Lugano Convention, but a decision did not follow because of the intention to issue a specific White Paper and a Directive proposal. In November 1997, the *Working Paper on Environmental Liability* outlined the key elements of a proposed Directive on environmental liability and in October 1998, a commitment to adopt a White Paper on Environmental Liability was stated (Commission Decision 2176/98 (24/9/98), *Towards Sustainability*, OJ 1998 L 2 75/12). The

Commission published a detailed environmental liability model for the EC in March 1999.

24. See Bianchi (1994) and Poli (1999).
25. The European Commission justifies in the *White Paper* the choice of such a system as follows: first, the 'polluter pays principle' is more efficiently applied if the polluter must pay for the damages regardless of fault; second, the operator of an hazardous activity should bear the risk inherent in it; third, it can be difficult for the victims to prove the fault of the operator because of a lack of knowledge; fourth, a non-retroactive system allows a quicker consensus by restricting attention on care for future accident prevention only.
26. See Boyer and Porrini (2000).
27. Boyer and Laffont (1999) develop a theoretical model where the emergence of incentive market based instruments is obtained endogenously rather than simply assumed.
28. See Cole and Grossman (1999).
29. See Cooter and Ulen (1999), Posner (1998), Chiancone and Porrini (1998).
30. See Laffont and Martimort (1999) and Boyer and Laffont (1999).
31. Considering the three elements, Shavell (1984) affirms that administrative costs and differences in knowledge favor liability, while incapacity to pay (or limited liability) and the probability of escaping suit favor regulation. In general, a liability system is more efficient when private parties possess better information and when accident has a low probability of occurrence. Regulation is better when harm is usually large, spread over many victims or takes a long time to show up, when accidents are not very rare events, and when standards or requirements are easy to find and control.
32. This framework is similar to the one proposed by Boyer and Laffont (1997). Although there is no direct role played in our current paper by the two period feature of the model, we elected to remain close to the Boyer-Laffont framework in order to reach a more integrated compared analysis with their paper and also with our forthcoming paper on the choice of instruments under adverse selection, where the multi period feature is essential.
33. This corresponds to the basic reasoning of the judge in the *Fleet Factors* case.
34. The value of λ is non negligible and considered to be of the order of 0.3 in developed countries and higher in developing ones. See Jones, Tandon and Vogelsang (1990, chapter 3).
35. Clearly the benevolent regulator as financier, as it will be the case for the other principals, has

market power in such a context but, increasing the firm's exogenous reservation utility would be equivalent to increasing the competitiveness of the lending market. No important result depends on this simplifying assumption of a zero reservation utility. Hence the approach taken here is more general than it may appear at first sight.

36. Although we concentrate here on $\Delta\psi$ and λ as variables and consider all other variables as parameters $(p_\ell, p_h, d, \pi_L, \pi_H, \theta, F, K)$, we could of course consider changes in any other parameters of the model.

37. Stricto sensu this case is ruled out if we stick to our assumption that $\Delta\psi < (p_\ell - p_h)d$.

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