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## Hazardous Activities and Civil Strict Liability: The Regulator's Dilemma

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## Summary

This paper addresses the conditions for setting up strict civil liability schemes. For that it compares the social efficiency of two main civil liability regimes usually enforced to protect the environment: the strict liability regime and the "capped strict liability scheme". First, it shows that the regulator faces an effective dilemma when he has to enforce one of these schemes. This because the social cost of a severe harm (and the associated optimum care effort) is determined independently of any liability regime. This independency has economic consequences. First, victims and polluters pit one against another about the liability regime that the government should enforce. Hence, financially constrained polluters prefer the ceiling of responsibilities while victims wish to extend the amount of redress under a "standard" strict liability. Economic criteria for enforcing a regime rather than another one are lacking. Second, the paper shows that implementing civil strict liability rules may be done by setting up care standards as for instance in the nuclear or the maritime sectors and demanding to the injurers to comply with them. We show that this goal can be achieved by resorting to some friendly monitoring corresponding to frequent random controls with low fines rather than few controls that should involve heavy fines.

**Keywords:** Environment, Strict Liability, Ex-Ante Regulation, Ex-Post Liability, Judgment-Proof, Environment Law, CERCLA, Environmental Liability

**JEL Classification:** K0, K32,Q01, Q58

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# Hazardous Activities and Civil Strict Liability:

# The Regulator's Dilemma

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## 0. Introduction

Periodically, by their brutal occurrence, anthropogenic harms recalls to us that they are the inevitable and creepy companions of our contemporaneous Societies: the April 2010 massive oil spill in the Mexico Gulf, the Tchernobyl nuclear accident in 1986, the Nigerian Coasts structural oil pollution, the wave of toxic sludge in Kolontar (Hungary) in October 2010, etc. Mostly, because the injurers' wealth is insufficient for repairing the entire externality, Society bears a great share of these unexpected costs. Governments are becoming aware that these ultra-hazard events need urgently these setting up of prevention and mitigation instruments. Among these, the legal instrument occupies a growing place: Environmental legislations intend both prompting the injurers to take effective prevention actions and to gather sufficient funds for repairs.

This paper narrows this huge scope by comparing the social efficiency of two main civil liability regimes usually enforced to protect the environment: strict liability regime and “capped strict liability scheme” that ceils the compensation amount. Our starting point is the acknowledgement that determining the social cost of the harm is independent from the effectively enforced liability regime. Consequently, we put into evidence that if victims and polluters could choose their most preferable liability regime, they would pit one against another about what the government “should” enforce. Obviously, polluters prefer ceiled liability while victims wish “standard” strict liability. Hence, when in position to enforce a liability regime the regulator faces a dilemma: for a given social cost level, he pleases either the (potential) victims or the (potential) injurers. Furthermore, as an unexpected consequence, the paper shows that enforcing care standards may done by friendly monitoring by resorting to low fines and frequent controls rather than criminal heavy fines.

The pioneering works of Summers (1983) and Shavell (1986) emphasized that the limited injurers’ wealth prevent the complete internalization of the harm. Beyond this, Shavell (1986) showed that injurers with limited assets engage in risky activities too often and take too little care. This viewpoint was disputed by Beard (1990): strict liability would involve two opposite effects on injurers' incentives to invest in risk reduction technologies. On one hand, as the expected payment due to liability is less than the real expected damage, the marginal benefit of prevention is too small and the firm will under invest[1] or, conversely could overinvest. Hence, the tort victims effectively subsidize the firm’s pecuniary investments. In a complete information economy and no bankruptcy assumption, Segerson and Tietenberg (1992) show that bank as well as injurer can be considered as liable to generate optimal incentives. This opened the door to vicarious liability involving the liability of the injurer’s financial partners. A rich literature ensued on the moral hazard relationships between the lenders and the injurer and the definition of incentive instruments to minimize the risk of the injurer. By considering the effects of imposing liability on lenders, Pitchford (1995) shows that they have to

[1] See also Friehe (2007).

anticipate future liability, and this leads them to require a higher interest rate in compensation. For Boyer and Laffont (1997) partial bank liability is preferable to complete liability They show this, in a two-period model with preventive effort to be made by the firm in the first period, and possibly accident taking place in the second. They study the impact of bank liability on the safety effort optimality. This way is pursued by Balkenborg (2001) (partial lender liability), Boyer and Porrini (2006) (2008) who explore the relationships of banks and firms under tort law where the decision of the court is random.

The extensions of Beard (1990)'s study the consequence of limited liability. Boyd and Ingberman (1994), Dari-Mattiacci (2006), Friehe (2007) analyze the consequences of bounding strict liability. They show that capping the repairs amount can lead firms to increase their prevention effort and, then, contribute to improve the social welfare that standard strict liability struggles to meet. Recently, Shavell (2005) shows that involving judgment-proof firms to purchase liability insurance can induce them to internalize the risky activities costs. Submitting injurers to mandatory insurance, constitutes a strong incentive to adopt better safety care.

Our paper focuses on the fact that, sometimes, ultra-hazardous harm may be so high that even if the whole financing line ran to ruin, a large part of the damage would remain externalized (for instance after a severe nuclear harm). Hence, the conditions that can reduce the probability of risk matter as more as the repairs question. That explains the importance for parties of the relevant liability regime to enforce and the ways by which the regulator implements the associated optimal safety measures.

In a first part, we define the concrete stakes of the implementation of either a strict liability regime or a capped one by referring to the civil liability of the electro-nuclear industry. A second one defines the structure of the model and shows that the social cost determination is independent from the liability regime. A third part analyzes the enforcement process. A fourth part analyses its legal consequence. A fifth part concludes.

## 1. Standard vs Strict liability regime: The populations' concern

In the eighties, the USA under the CERCLA-Superfund framework[2] enforced strict liability rules. Twenty-five years later, in 2004, Europe followed this way by adopting the European Directive on environmental liability[3]. Under these legal apparatus, injurers have to repair fully the harm they have caused regardless of guilt even if not at fault or negligent and, this, independently of how careful they

[2] Comprehensive Environmental Response, Compensation, and Liability Act of 1980 CERCLA, SUPERFUND, codified in Public Health, 42 USC, §9601 et seq.. CERCLA associates several liability modes: strict liability, "joint and several" and retroactive liability.
[3] Directive 2004/35/CE of the European parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage, Official Journal of the European Union, L143/56, 30/4/04.

acted. Furthermore, strict liability frees the victim of the burden of proving any faulty or negligent behavior from the injurer's side.

Compared to CERCLA, the European directive framework distinguishes two liability schemes. The first one applies to the dangerous or potentially dangerous occupational activities. These are mainly agricultural or industrial ones that require a license under the Directive on integrated pollution prevention and control (IPPC)[4]. The operator may be held responsible even if not at fault. The second regime applies to all other occupational activities. The operator will be held liable only if at fault or negligent. The scope is limited to species or natural habitats protected by Community legislation under actual damage or imminent threat of damage. CERCLA is restricted to the cleanup of abandoned hazardous waste sites.

The maritime sector and the electro-nuclear industry apply both specific strict liability regimes that ceil the amount of redress. The International Convention on Liability and Compensation for Bunker Oil Pollution Damage of 2001 states the strict liability of ship-owners for all types of pollution damage caused by bunker oil. However, this liability is subject to the limits of applicable national or international regimes not exceeding an amount calculated in accordance with the amended 1976 Convention on Limitation of Liability for Maritime Claims. Concerning the maritime transport, compensation for oil pollution is regulated by the International Convention on Civil Liability for Oil Pollution (CLC) and the International Convention setting up. The Oil Pollution Compensation Fund (Fund Convention) establishes a two-tier liability system built upon the (limited) strict liability for the ship owner and a collectively financed fund which provides supplementary compensation to victims of oil pollution damage who have not obtained full compensation. The full compensation notion does not apply to the environment as a whole, but only to people privately concerned by personal losses in a civil strict liability regulation context.

The nuclear civil liability is ruled by international conventions[5]. These one establish a strict liability regime channeled exclusively to the operators of the nuclear installations. If this liability is absolute, it is limited in time and amount which is set to €1.500M (World Nuclear Association 2009). Hence, the liable agent is exposed to a level of redress substantially lower than the amount of the harm. This faded responsibility should act as an investment incentive for firms. The nuclear operators

[4] These are activities which discharge heavy metals into water or the air, installations producing dangerous chemical substances, waste management activities (including landfills and incinerators) and activities concerning genetically modified organisms and micro-organisms.

[5] IAEA's Vienna Convention of 1963, OECE's Paris Convention on Third Party Liability in the Field of Nuclear Energy of 1960 and the Convention on Supplementary Compensation for Nuclear Damage (CSC) of 1997 amended in 2003 and the OECD Paris (and Brussels) Conventions Amending Protocols of 2004.

are relieved of the burden of potentially ruinous liability claims[6]. However, the internalization process remains structurally incomplete and the victims' rights [7] are seriously impaired.

Under strict cap liability, the potential injurers tend to lower their level of due care (Faure and Hu, 2006), (Faure and Wang 2008)).

At the political level, this analysis is echoed by opponents to the introduction of such liability regimes[8.] This raises the question of the status of potential victims related to the redress question. Generally, literature rather focuses on the polluters' behavior. Hence, liability ceilings are detrimental for victims and can be imposed without considering their welfare. Potential injurers define their optimal level of safety without assessing the consequences for the society[9]. The recent example of India shows the importance of the debate on caps on in the population. Until August 2010, Indian nuclear energy was ruled by a "standard strict liability" regime. India stood out with neither a national nuclear liability legislation, nor membership in one of the international conventions. Hence, the operator is a public firm (Nuclear Power Corporation of India) and the government was fully responsible for compensation in the event of a nuclear hazard. The Indian nuclear industry is expected to grow several folds from the present 4,120 Mw to at least 10,000 megawatts by 2020. This program involves the participation of three major partners: Russia, France and United States. In France and Russia, the State plays the role of insurer for foreign investments. In the US, after an accident, the first $375 million is paid by the insurer(s) of the plant. It is mandatory to insure the plant. Beyond that, up to US$ 10 billion is paid out of a fund jointly contributed by the "operators" as mandated by the Price-Anderson Nuclear Industries Indemnity Act. As a consequence, because of bilateral agreements under Bush administration, USA induces India to adopt a capped liability regime to allow its private firms to operate under a limited liability as required by the US nuclear insurers. Indian Government in 2009 prepared a specific law: 'The Civil Liability for Nuclear Damage Bill 2010' which caps to about $65 million the compensation that foreign nuclear operators would be liable for in the event of a nuclear accident and the Indian government's liability would be limited to about $385 million. However, by March 2010, under the pressure of its opposition, the Indian government withdrew the introduction of the bill and finally adopted it by August 2010. Beyond the effective conclusion, this example shows that opinions are becoming sensitive about how are repaired technological harms.

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6 More explicit still is The "*Exposé des Motifs"* for the 1960 Paris Convention that considers that "unlimited liability could easily lead to the ruin of the operator without affording any substantial contribution to compensation for the damage caused" (*Exposé des Motifs*, Motif 45) or still (Schwartz, 2006:39)

7 See for instance (Boyd 2001, p.47):" *On the other hand, these benefits to regulated industries must be weighed against the obvious drawback of capped liability: namely, that environmental costs above the cap will be uncompensated by responsible parties*."

8 In India, for instance, the Coalition for Nuclear Disarmament and Peace (CNDP), in its Appeal against the Proposed Civil Nuclear Liability [Cap] Bill ask the Indian government to increase the level safety considering the choice for the nuclear energy industry. In http://www.sacw.net/article1288.html

9 Generally, this society is reduced to the injurers' interest. However, Shavell (1982) took into considerations the utility of victims in an insurance model under several liability regimes (negligence and strict liability). He dealt the question of the desirability to sell insurances to injurers.

## 2. The model

We consider two representative agents: a group of victims and a unique polluter. Define the following notation.

- $D$, the maximum potential damage due to an accident, $D > 0$;
- $e$, the level of care effort, $e \in [0, \infty[$, $e$ decreases the probability of an accident of a major consequence $D$.
- $p(e)$, the probability of a severe harm with $0 < p(e) < 1$; $p'(e) < 0$ and $p''(e) > 0$;
- $y$, the injurer's wealth, $D > y > 0$ (Shavell 1986). This means that the polluter is judgment-proof if some ultra-hazardous event occurs.
- $R$, the level of repairs, $D \geq R \geq 0$;
- $C$, The amount of the ceiling under a capped liability regime, $0 \leq C \leq y < D$.

$U$ is the victims' cost function and $V$ the one of the injurer. Both agent categories are supposed risk-neutral. Let us consider $z(e)$ called 'repair function', $z(e) \in [0, D[$ depends on the liability regime. Furthermore, let us notice the expected cost or disutility functions of the victim $EU^z$ and the injurer $EV^z$, respectfully:

$$EU^z = (D - z(e))\, p(e) + \big(1 - p(e)\big).0 = (D - z(e))\, p(e) \qquad [1]$$

And,

$$EV^z = \big(e + z(e)\big)p(e) + (1 - p(e))e = e + z(e)p(e), \qquad [2]$$

We can establish the following proposition:

**Proposition 1:** *Under the assumption of neutrality to risk of injurers and victims, the social cost function is independent from the enforced strict liability regime.*

**Proof:** The proof helps us keeping presenting the model. Proposition 1 is drawn from Shavell (1982), Shavell (1986) or still, Beard(1990) and is extended to the questioning of liability regimes. The social cost function ($SC^z$) is the sum of the agent's disutility function (or cost function) corresponding to the cost of prevention and the expected cost of compensating a major accident for the polluter and the incurred expected cost the victim, Shavell (1982), Shavell (1986). *In fine,* this corresponds to the sum of the cost of safety $e$ and the expect cost of total damage $Dp(e)$ and this independently of the liability regime:

$$SC^z = EU^z + EV^z = (D - z(e))\, p(e) + e + z(e)p(e) = Dp(e) + e. \qquad [3]$$

To verify the independency from the liability regime, it is sufficient to replace $z(e)$ by the following noticeable values. Precisely, when no liability rule applies (abbreviated as NL), the function is $z(e) = 0$, [3] ensues automatically. Under, the "standard" strict liability (SL), the full ownership of the injurer is engaged minus the share dedicated to safety. Then, $z(e) = y - e$. At last, under the capped strict liability (CL), the amount of repairs is bounded: $z(e) = C, y > C > 0$. The respective functions are respectively for the injurer and the victims:

i) $EV^{NL} = e,$ and $EU^{NL} = D\,p(e)$ for the absolute lack of liability,

ii) $EV^{SL} = (y-e)p(e) + e$, and $(D-y)\,p(e)$ for the strict liability[10],

iii) $EV^{SL} = C\,p(e) + e$, and. $EU^{z} = (D-C)\,p(e)$ for the capped liability.

Then, we can easily check, that, whatever the liability regime,

$$SC^{NL} = SC^{SL} = SC^{CL} = SC = Dp(e) + e \quad [4]$$

**Remark 1:** Under the lack of civil liability rules, the polluter is not held as liable after a severe accident on the ground of civil law. However, this does not mean that the polluter will not make prevention expenses to self-protection, even if he devotes a suboptimal amount of care. Hence, he will spend the amount $e$ for prevention ($e \geq 0$) without being induced to pay for repairs. The regulator wishes to minimize the impact of a severe harm.

**Remark 2:** Under strict liability the responsible polluter should pay for the whole damage he caused ($R = D$). However, he cannot compensate victims fully but in proportion of his own assets. Economic literature calls this situation "limited liability" because redress is bounded by the owner's wealth. After a severe event he will pay back $y - e$ to victims (his initial asset minus the cost of the safety effort). Hence, under a strict liability regime, the victims benefit of a better situation than before because their effective damage is $(D-y)$ and $(D-C)$ under a capped liability regime with $(D-y<(D-C)$.

In spite of [4], the victims and the injurer are sensitive to the nature of the liability regime that can alleviate or weigh down the burden of the social cost. This is shown by proposition 2 (we exclude the lack of any liability for obvious reasons):

**Proposition 2:** *If they could choose the liability regime, the choices of each category may be described as:*

a) *Injurers: The injurer prefers the ceiling of repairs to strict liability in so far that there exists $e \geq 0$ such that $y - C \geq e$, and the reverse for $y - C < e$. He his indifferent for equality.*

b) *The victims prefer strict liability for $y - C > e$ or any scheme that engages the higher amount of the injurer's wealth for repair (in the lack of any another compensation scheme) when $y - C \leq e$.*

***Proof:*** It is sufficient to assess the preferences of each category of agents under the different regimes for cases a) and b).

a) *The injurer's preferences*

If the injurer could express his opinion, he would choose the liability regime that minimizes the safety cost. We can check that for the interval set $e \in [0, y]$:

i) $$EV^{SL}(e) \geq EV^{CL}(e) \Longrightarrow e + (y-e)p(e) \geq e + Cp(e) \Longrightarrow y \geq e + C, \quad [5]$$

(Indifference for equality).

Consequently, the cost of strict liability $EV^{SL}$ is higher than $EV^{CL}$ for $y - C \geq e$ and the injurer prefers the capped liability regime to the strict liability one.

ii) $$EV^{CL}(e) > EV^{SL}(e) \Rightarrow e + Cp(e) > e + (y-e)p(e) \Rightarrow y - C < e. \quad [6]$$

[10] This function is convex and it is studied in appendix 1.

That means that if the required cost for risk coverage is $y < e + C$, then the injurer will prefer the standard strict liability regime. This situation deserves some attention because it has been described by Shavell (1986) when injurers with insufficient wealth undertake risky activities. It is typically an adverse selection question.

b) *The victims' preferences*

As above, we compare both costs:

$$EU^{CL}(e) \geq EU^{SL}(e) \Rightarrow (D - C)p(e) \geq \big(D - (y - e)\big)p(e) \Rightarrow \; y - C \geq e \qquad [7]$$

Hence, the same condition that makes the injurer to prefer capped to strict liability induces the overturned effect for victims: they prefer strict liability regime to a capped one. Obviously, for all $e$ such that $y - C < e$, the reverse is true, i.e. the capped regime is preferred to strict liability regime. However, this case has to be considered cautiously. Indeed, under this condition, the victims' uncompensated share is $h(e) = y - (e + C) < 0$. Hence, victims will prefer cap liability regime for all value of $e$ such that for $e \in [0, e^0[$, (where $e^0$ is that value for which $h(e^0) = y - (e^0 + C) = 0$). Beyond this value: $(y - C < e)$, and victims feel indifferent to both regimes because the damage remains uncompensated□

The above propositions are used then to set up the indeterminacy of the regulator's choice.

**Proposition 3**: *From propositions 1and 2, with risk neutral agents, economic criteria for enforcing a strict liability regime (capped or standard) are lacking.*

**Proof:** From the first order conditions concerning the social cost: $e + Dp(e)$, it exists $e^* \geq 0$ such that $SC'(e^*) = 0$, i.e. $p'(e^*) = -\frac{1}{D}$ and $e^* = p'^{-1}\left(-\frac{1}{D}\right)$. $e^*$ is determined independently of any liability regime. The level of $e^*$ is independent from the level of the injurers' wealth. As a result, $e^*$ may be such that either $e^* \geq y$, or $e^* < y$. Obviously, for $e^* \geq y$, the injurer cannot conform to $e^*$ because this level exhaust his own resources. However, this situation cannot be dismissed as such and calls for attention. Concretely, $e^* \geq y$, are these conjectures for which the risk is so high that private firms cannot undertake the project. Overstepping it is under the perfect knowledge that they are unable to meet their liability. However, we have to notice that the regulator has few market-based instruments at his disposal to forbid the activity except to resort to criminal law and prohibiting then the activity.

Then, we consider the case for which: $e^* < y$.

- If $y - C \geq e^*$, the injurer prefers capped liability to strict liability while the victims the reverse and both of them are indifferent if by chance $e^*$, $y - C = e^*$ .
- If $y - C < e^*$, the injurer will prefer strict liability to its ceiling, while the victims are indifferent to both regime because at $C$ and $e^*$ they know that they will receive less than the cap, i.e. $y - e^* < C$. Furthermore, we can ask whether in a regulated economy, concerning ultra-hazardous activities, such a conjecture is realistic, because, as in the nuclear industry or the maritime transport, insufficient funded operators are prohibited to act. Hence, the only relevant situation (from a legal viewpoint) is the case for which $y - C \geq e^*$. Then, for a legal

standard : $e^*$ that minimizes the social cost function, for $y - C \geq e^*$, the regulator can choose neither to favor the injurers nor the victims:

$$EV^{SL}(e^*) > EV^{CL}(e^*) \text{ and } EU^{CL}(e^*) > EU^{SL}(e^*)\square$$

We reach here the announced regulator's dilemma. Indeed, admitting that the regulator could enforce the safety level e*, it remains to him to implement a liability scheme. Then, the dilemma is this. Once the regulator has determined the socially acceptable level of safety effort $e^*$, what liability regime to enforce? If on one hand, he opts for the capped liability regime then he will favor the injurers (because the level of cost is lower for them than with strict liability). On the other hand, the reverse choice (strict liability) means that he favors the victims instead of the injurers. Proposition 2 shows that the victims prefer always a strict liability regime rather than the capped one except for value of $e$ such that $e = e^0$ where they become at most indifferent between them. As a consequence, there is some irrelevancy between the determination of the optimal social of care and the choice of a given civil strict liability regime. This last one cannot be chosen on economic criteria.

These situations are summarized in the following example. We develop a graphical illustration by considering an exponential law of parameter $\lambda > 0$ defined on the care level e (and not on time as usually). The density function is $p(e) = \lambda\, Exp(-\lambda e)$. We can check that it has the required properties with: $p'(e) = -\lambda^2 Exp(-\lambda e) < 0$ and $p''(e) = \lambda^3 Exp(-\lambda e)$. Then, we can conceive the different expectation cost functions described in the analysis, let respectively be these ones: $EV^{SL} = e + (y - e)\lambda Exp(-\lambda e)$ , $EV^{CL} = e + C\lambda\, ExpExp(-\lambda e) SC = e + D\, \lambda ExpExp(-\lambda e)$ , $EU^{SL} = (D - (y - e))\lambda Exp(-\lambda e)$and $EU^{CL} = (D - C)\lambda Exp(-\lambda e)$.

Graphic 1 shows these relationships. On the y-axis, successively one can see the value of damages when $e = 0$ (and $\lambda = 1$), hence, $EV^{SL}(0) = y, SC(0) = D,\ EV^{CL}(0) = C$. On the x-axis are represented the optimum value of care for the injurers and the social planner.

**[Insert Graphic 1]**

Another stake concerns the effective capacity of the regulator to enforce the optimal level of care. Indeed, without any other constraint than the enforced liability regime, the injurer will choose the optimal effort level that minimizes his cost. Indeed, let $e^{CL}$, and $e^{SL}$ be respectively the polluter's optimal safety effort level for, respectively, the capped limited liability and the strict liability regimes. Proposition 4 shows that $e^{CL} < e^{SL} < e^*$.

**Proposition 4**: *Considering neutral to risk injurers, and $y \geq e + C$, then,* $e^{CL} < e^{SL} < e^*$.

Proof in annex 2.

Proposition 4 means that in so far that $y \geq e + C$, the strict liability regime induces higher marginal cost than the capped liability regime.

## 3. Enforcing the optimal social safety effort

According the nature of risks, there are many ways to enforce the socially optimum level of care. Hence, for $e^* \geq y$ (the level of security required is such that it exceeds the wealth of the polluter), the regulator knows that imposing $e^*$ involves stopping the injurer's economic activity. Two cases have to be considered then. If the level of damage is such that it may have irreversible impact on wealth and the environment, then, the precautionary principle should apply as an abstention principle and the risky production (instable molecules in the chemical sector for instance) should be forbidden.

However, the government may consider that in spite of dangers, the risky activity is worthy for the economy. He faces then a kind of dilemma. He cannot enforce $e^*$ and he knows that the level chosen by the injurers will be either $e^{SL}$ if he chooses a strict liability regime or $e^{CL}$ if he settles a cap with $e^* > e^{SL} > e^{CL}$. However, the government has to implement $e^*$ and he has to find some device to achieve this objective.

Now, let $g, g > 0$ be the polluter's total receipt, and $E\Pi^{SL}(e) = g - EV^{SL}(e)$ and, $E\Pi^{CL}(e) = g - EV^{CL}(e)$ be the net expected payoff functions under, respectfully, a strict or a capped liability regime. By fixing, $e^*$, the expected net payoff of the injurer will be $E\Pi^{SL}(e^*) = g - EV^{SL}(e^*)$ and $E\Pi^{SL}(e^*) = g - EV^{CL}(e^*)$, with naturally, $E\Pi^{SL}(e^*) \leq E\Pi^{SL}(e^*)$. At this level, if the injurer is forced to apply $e^*$, he will go on producing if $E\Pi^{SL}(e^*) > 0$. The following table summarizes the different conjectures:

| | | |
|---|---|---|
| $E\Pi^{CL}(e^*) > 0$<br>$E\Pi^{L}(e^*) \geq 0$ | $E\Pi^{CL}(e^*) > 0$<br>$E\Pi^{SL}(e^*) \leq 0$ | $E\Pi^{CL}(e^*) < 0$<br>$E\Pi^{SL}(e^*) < 0$ |
| Can comply for all Liability scheme "usual" hazardous activities | Can comply only under Capped liability scheme (nuclear industry, maritime sector) | Injurer resigns<br>Ultra-hazardous activities |
| (a) | (b) | (c) |

Table 1

Before going further, it is necessary to summarize the conditions for which these instruments have to be designed. First, the socially desired care level $e^*$has to be such that $e^* < y$ and, second, $g - EV^{SL}(e^*) \geq 0$ or/and $g - EV^{CL}(e^*) > 0$. The problem is then to define an instrument such that, the injurer is induced to move from his equilibrium position $e^{SL}$ or $e^{CL}$ towards $e^*$. If these conditions are not met, either the government should definitively stop the production (precautionary principle) or accept that production will be achieved out of social efficiency criteria. This may be the case under exceptional conditions as war time for instance.

Symmetric information between the injurer and the regulator following is assumed. This means that when the regulator seeks for information about the injurer, no screen prevents him to access to full detail. However, the knowledge is not automatic and if the injurer knows that the regulator's monitoring present failures, he can cheat. If, because the government cannot impose $e^*$ but allows the polluter to produce, then he will achieve a "risk surplus" equivalent to:

$\Delta\Pi = E\Pi(e^{SL}) - E\Pi(e^*)$ or $\Delta\Pi = E\Pi(e^{CL}) - E\Pi(e^*)$ following that the regime SL or CP. Naturally, because $e^* > e^{CL}$, then $E\Pi(e^{SL}) > E\Pi(e^*)$ and $\Delta\Pi > 0$. Because the harm occurs randomly, the regulator does not dispose of market based instrument to regulate *ex-ante* the pollution level as under "standard" pollution problems which use of taxes, tradable permits, etc. to induce the polluter to adopt the optimum safety level $e^*$. However, the regulator can use coercion instruments by resorting to administrative law inducing the polluter to comply with $e^*$. Here, coercion is only a complement and not a substitute to enforce strict liability rules compatible with the socially desired level of care.

Hence, the level of fine does not need to be high to induce the polluter to reach the first best social level of care. However, before going further, let us note that, implicitly, resorting to coercion is made on two levels. The first one is explicit and concerns mainly the definition of the fine level while the second one is truly implicit and consists in threatening the polluter to jail or personal bankrupt. The threat will become effective, if, in spite of warning, he does not comply with the regulator requirement. To enforce $e^*$, the regulator may resort to a systematic control of the polluter's installations. This may be the case with very low monitoring or control costs. We consider these costs as endogenous, included in the fine paid by the polluter if negligent. Let $\wp$ the probability of no control from the regulator side and $(1-\wp)$ the one of control with naturally, $1 \geq \wp \geq 0$. Hence, the higher $(1-\wp)$ is, the higher the monitoring of the injurer by the regulator. We can now set up proposition 4.

**Proposition 5:** *Under the assumption of symmetric information, under the conditions that the injurer's benefit is either: i) $E\Pi^{CL}(e^*) > 0$ and $E\Pi^{L}(e^*) \geq 0$, or ii) $E\Pi^{CL}(e^*) > 0$ and $E\Pi^{SL}(e^*) \leq 0$, (but not $E\Pi^{CL}(e^*) < 0$ and $E\Pi^{SL}(e^*) < 0$), if the regulator establishes a level of fine $F^*$ such that $F^* > \frac{\wp}{(1-\wp)}\Delta\Pi^k$, then a rational injurer will adopt the desired social care level $e^*$.*

**Proof :**

- Conditions i) and ii) mean that the activity is profitable under at least one given liability regime. They correspond to the case (a) and (b) of table 1. Under iii), it is obvious that no injurer has interest to undertake the activity. Here, the goal is to show how a fine, even weak, may threaten the injurer to induce him to adopt the efficient safety level.
- The injurer's choice is either to comply immediately with the required level, in this case $E\Pi(e^*|c) = \Pi(e^*)$ where $c$ means compliance. If the polluter's chooses to not comply, his expected payoff will be:
- $E\Pi(e^k|\overline{c}) = \wp E\Pi(e^k|\overline{c}) + (1-\wp)E\Pi(e^*|\overline{c})$ where $\overline{c}$ corresponds to the non-compliance and $k = \{SL, CL\}$. Indeed, if the regulator does not exert control, the injurer's payoff will be $E\Pi(e^k|\overline{c}) = E\Pi(e^k)$, $(\wp = 1)$. If the control is done, and if the injurer do not comply, this

involves a cost of $E\Pi(e^*|\bar{c}) = (E\Pi(e^*) - F$ with a probability $(1-\wp)$, (where $F$ is the amount of the fine for no-compliance). This expression writes too:

$$E\Pi(e^k|\bar{c}) = \wp E\Pi(e^k) + (1-\wp)(E\Pi(e^*) - F),\ k = \{SL, CL\}.$$

Putting it otherwise, $\wp E\Pi(e^k)$ means that the injurer expects to win $E\Pi(e^k)$ with a probability $\wp$ and $(E\Pi(e^*) - F)$ with a probability $(1-\wp)$. Hence, one may consider that the injurer will be indifferent to both situations (comply for the safety level $e^*$ or not), if the following relationship is verified:

$$E\Pi(e^k|\bar{c}) = E\Pi(e^*|c)$$

or, still,

$$\wp E\Pi(e^k) + (1-\wp)(E\Pi(e^*) - F) = E\Pi(e^*),$$

That is to say, the payoff of no complying should be equal to the one of conforming, and, after developing:

$$F = \frac{\wp}{(1-\wp)}\left(E\Pi(e^*) - E\Pi(e^k)\right) = \frac{\wp}{(1-\wp)}\Delta\Pi^k,$$

Reaching this point we have to note that the injurer is facing the following choice. If he complies with the regulator's standard then he will gain $\Pi(e^*)$ with a probability equal to 1. Or, if he does not, either the regulator exerts control and he will gain less than in the previous situation($(\Pi(e^*) - F)$), or he wins the bet and gets $\Pi(e^*)$. The bet depends on the intensity of the control. We have to note that if $\wp = 1/2$ then the expected gain is the net surplus of the risk taker, but this one is not certain as in the case in which the regulator does not exert any control. The higher the probability of a control is, the lesser the level of the fine. Hence, as the control increases, the level of the expected gain is less than the risk taker surplus. To discourage the temptation of cheating behavior the regulator could consider $F^*$ such that $F^* > F > 0$, with $F^* = F + \varepsilon$, $\varepsilon > 0$. Hence, the injurer will be led to adopt the desired social care level. $F^*$ has to be lump sum and not proportional to the level of sub-optimal care effort, (i.e. a decreasing fine associated to the effort level $e^*$). Indeed, with lump-sum fine, even if the injurer increases its effort level, but stay short of $e^*$, he will be forced to supply $e^*$ and will be fined at $F^*$. Consequently, it is of no interest for him to undersize his safety investment. There is an inverse relationship between the probability of frequency of control and the level of the fine. This may have impact on the cost of control. Indeed, very few frequent controls may induce the regulatory agency to spend heavy check costs. Hence, looking at the ratio $\frac{\wp}{(1-\wp)}$ and its evolution can help understanding different enforcement styles. This point will be dealt in the next section.

## 4. Legal considerations and others

Administrative requirements for environmental prevention and liability rules are associated. Generally, these are regulatory agencies that enforce environmental laws and rules. For instance, quality of water is managed by water regulatory agencies, wildlife, landscape etc. by environmental agencies etc. These agencies dispose of a wide range of enforcing instruments. Pollution control legislation typically provides for licenses, authorizations, etc. and the use of prosecution powers are only a small element of this set of mechanisms. Sanctions can be either explicit, for instance, fines the cessation or restriction of previously authorized activities or implicit by a step by step process which can lead to prosecution. These elements are activated to impose the optimal social level of prevention. This range of means may supported by our model. Indeed, let us consider $k = \frac{p}{(1-p)}$. This ratio may express the policy choice of the regulator. For instance, $k \to 0$ means frequent control and a high incentive to adopt the optimal social safety effort $e^*$. This may be considered as a friendly monitoring. The frequent controls induce the injurer to adopt almost "naturally" the correct preventive actions. This process describes the working of regulatory agencies that accompany the working of dangerous facilities or activities. The permanent threat of non-criminal sanctions is a deterrent instrument to oppose to the deviation temptation.

Conversely, few controls should call for high sanctions. This is seldom the case in concrete situations because if the probability of not being controlled is high ($k \to 1$) , then, the fine should be almost infinite. This matter of fact enlightens the traditional distinction between routine cases of environmental harm and crimes. The first one results from general activities while the second one are committed with a view to personal or business advantage. The former case civil penalties are administered through civil or administrative means (such as standardized 'fines' for breaches of license conditions) while criminal sanctions are associated to the worst type of offences (Woods and Macrory, (2003)).

**[insert scheme 1]**

These relationships are figured in the scheme 1 that shows the consequences of different policies from the regulator side. When controls are frequent, the regulator plays an educative role and his coercion role increases with decreasing controls. For values of *k* below ½, relationships between the polluter and the regulator are discontinuous, but the injurer knows that the control can be frequent and the inducement to default not high. The situation changes for few or very few controls. The only way for the regulator to deter cheating behaviors or to induce agents to comply with the required safety effort is to fine heavily the polluter. Very low probability of control calls for very high fine level.

## 5. Conclusion

It has been shown that the regulator faces an effective dilemma because the social cost determination of a severe harm (and the associated optimum care effort) is determined independently from the liability regimes. The key of indecision lies in the opposite preference about the liability scheme between injurers and victims. For a given social optimum level of safety effort, injurers prefer the ceiling of repairs and victims a standard strict liability regime. This last one extends the repairs to the integrality of the injurers' wealth. Hence, enforcing a specific scheme rather than another one involves that the regulator favors a category against another one.

This dilemma is not an ideological matter in which a "green" regulator would enforce strict liability while a "liberal" one would favor polluters. In fact, choosing a capped strict liability regime may be done on "technical" or strategic reasons. For instance, if strict liability involves negative payoff for the injurers and if the production is considered as vital for the economy, then capping the repairs guarantees the production effectiveness. This leads us to the second point analyzed in this paper i.e. the way by which the optimal level of care is enforced in a symmetric information context. Hence, the regulator can choose to monitor closely the injurer with quite low fines for no compliance. As controls are less frequent, cheating deterrence involves higher level fines. As a consequence, ideally, if controls are numerous, the enforcement of the optimal level could be achieved with very low fine threat. This puts into perspective the relationships between administrative control, criminal law and the enforcement of strict liability regimes. It seems that administrative coercion is necessary to enforce the relevant (optimal) level of care and the resort to criminal law with heavy sanction should be quite exceptional and punish only crimes to the environment. However, a "friendly" monitoring corresponding to repeated control with mandatory compliance to the optimal level of care effort, in certain circumstances, may bring essential information to the regulator. However, for very sensitive sectors, gathering information may be either too costly or impossible and, consequently, defining incentives tools is necessary. Another direction to deal with concerns the introduction of insurance policies as it is compulsory in many environmental or energetic sectors (risky facilities, maritime transportation of oil, nuclear industry…). this paper has been written under the assumption of symmetric information between the injurer and the regulatory institution. This assumption should be relaxed in a new contribution.

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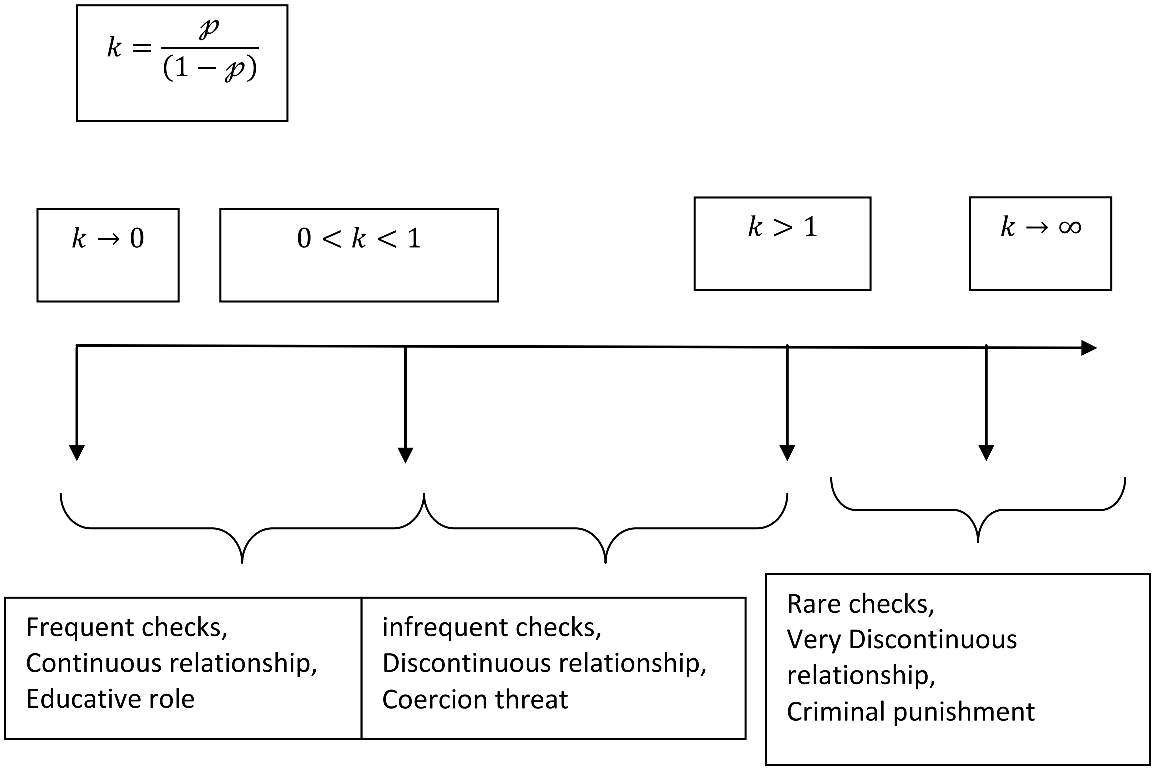
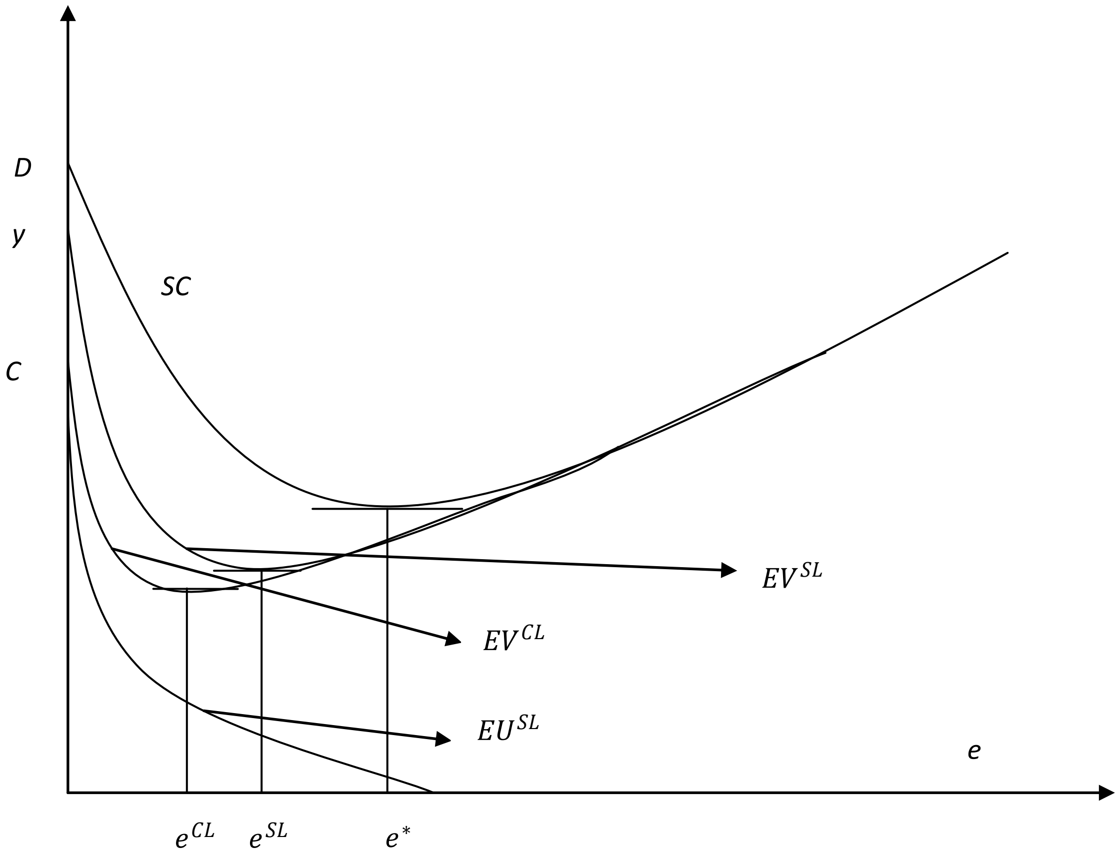



Scheme 1

The relationships between the Regulatory Agency and the injurer




Graphic 1

## Appendix 1

Study of the function

$\varphi(e) = e + (y-e)p(e)$

$e \in [0, y[$ and $1 \geq p(e) > 0$. Furthermore, by assumption, $p'(e) > 0$, and $p''(e) < 0$ with $\lim_{e\to 0} p(e) = 1$.

- Study to the limits of $\varphi(e)$:

$$\lim_{e\to 0} \varphi(e) = \lim_{e\to 0}\{e + (y-e)p(e)\} = y$$
$$\lim_{e\to y} \varphi(e) = \lim_{e\to y}\{e + (y-e)p(e)\} = y$$
$$\varphi'(e) = \left(e + (y-e)p(e)\right)' = 1 + yp'(e) - ep'(e) - p(e)$$

- Study of $\varphi'(e)$:
  As it is difficult to define values $e^*$ such that $\varphi'(e^*) = 0$, we study its behavior on $e \in [0, y[$.
- $\lim_{e\to 0} \varphi'(e) = \lim_{e\to 0}\{1 + yp'(e) - ep'(e) - p(e)\} = (y-e)p'(e) = yp'(e) < 0$
- $\lim_{e\to y} \varphi'(e) = \lim_{e\to y}\{1 + yp'(e) - ep'(e) - p(e)\} = \lim_{e\to y}\{1 - p(e)\} > 0$

  Conditions for having
  - $1 + yp'(e) - ep'(e) - p(e) > 0$

    $1 - p(e) > (e-y)p'(e) > 0$

  We see here that as $e$ increases $1 - p(e)$ increases because $p(e)$ decreases, however, as $e$ increases, $(e-y)$ decreases (for $e < y$) and is negative while $p'(e)$ is negative, and their product is positive.

  For low value of $e$, this relationship is verified:

$$0 < 1 - p(e) < (e-y)p'(e)$$

  As a consequence, there is $e^*$ which cancels $1 + yp'(e) - ep'(e) - p(e)$. For right values of $e^* < e$, the function is increasing and decreasing on the left hand side $e^* > e$.

## Appendix 2

Demonstration of proposition 4.

- (a) Demonstration that $e^{SL} \geq e^{CL}$

For that we assume the reverse, $e^{SL} < e^{CL}$. Hence, let us consider $EU^{SL} = e + (y-e)p(e)$ and $EU^{CL} = e + C\,p(e)$. Then,

$$p(e) = \frac{EU^{CL} - e}{C}$$

We replace this value in $EU^{SL}$, and,

$$EU^{SL} = e + (y-e)\left(\frac{EU^{CL} - e}{C}\right)$$

Let us take the first order derivative of $EU^{SL}{}'$, and we look for the value of this function for $e^{CL}$ that makes $EU^{CL'}(e^{CL}) = 0$:

$$EU^{SL'}(e^{CL}) = 1 - \frac{y}{C} - \frac{EU^{CL}}{C} + \frac{2}{C}e^{CL}$$

If , $e^{SL} \leq e^{CL}$ then, $e^{CL}$ is situated in the increasing part of $EU^{SL'}$, this involves that $1 - \frac{y}{C} - \frac{EU^{CL}}{C} + \frac{2}{C}e^{CL}$ should be positive or null. If,

$$1 - \frac{y}{C} - \frac{EU^{CL}}{C} + \frac{2}{C}e^{CL} > 0$$

Then,

$$1 - \frac{y}{C} - \frac{EU^{CL}}{C} + \frac{e^{CL}}{C} > \frac{EU^{CL}}{C} - \frac{e^{CL}}{C} = \frac{C\,p(e^{CL})}{C}$$, (This by the definition of $EU^{CL}$).

And,

$$C - y + e^{CL} > C\,p(e^{CL})$$

The domain of definition for $e^{CL}$ involves that $C + e^{CL} < y$ and, then $C - y + e^{CL} < 0$ and is $C\, p[e^{CL}] > 0$ which is positive, $C - y + e^{CL} > C\, p(e^{CL})$ is a contradiction, then $e^{SL} \geq e^{CL}$.

- (b) Demonstration that $e^{SL} \leq e^*$

We compare $SC = e + Dp(e)$ and $EU^{SL} = e + (y - e)p(e)$.

As before, we draw:

$$p(e) = \frac{SC - e}{D}$$

But this time, we look for $e^{SL}$, $e^{SL} < e^*$ and proceeding as above, we get:

$$EU^{SL'}(e^*) = 1 - \frac{y}{D} - \frac{SC}{D} + \frac{2}{D}e^*$$

If $e^{SL} < e^*$, then $EU^{SL'}(e^*)$ should be positive which is the case:

$$1 - \frac{y}{D} - \frac{SC}{D} + \frac{2}{D}e^* > 0,$$

Because

$$1 - \frac{y}{D} + \frac{e^*}{D} > \frac{SC}{D}$$

And

$$D - y + e^* > D\, p(e^*) > 0 \text{ or,}$$

$$D\big(1 - p(e^*)\big) > y - e^* > 0$$

$p(e^*)$ is very small, and $\big(1 - p(e^*)\big)$ near from 1, then the relationship is verified.

- (c) Demonstration that $e^{CL} \leq e^*$

This results from the relationships studied en (a) and (b).

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