Environmental Regulation and Civil Liability under Causal Uncertainty: An Empirical Study of the French Legal System

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Abstract

The key question in this paper is to determine whether regulation and regulators information can help solving causal uncertainty problems in liability. A widely held view among Law & Economics scholars is that civil liability alone is not well-suited to cope with environmental accidents, especially where causation is uncertain or costly to establish. Instead of a simple civil liability rule, it is therefore advocated that a regulatory system be implemented combined with a public insurance scheme, or, alternatively, to go for a mix of regulation and civil liability. Such a mix of regulation and civil liability prevails in French law and this article presents an original analysis of French courts decisions concerning cases of environmental accidents for which causation was uncertain and regulators were not able to control for levels of organizational and human care. The dataset covers more than fifty years of trials outcomes from the highest civil and criminal court in France – *Cour de Cassation*. We found evidence that French judges apparently use the informational advantage of regulation (in showing that a particular activity may be of higher risk) to adopt a probabilistic approach to causation, thus increasing the effectiveness of the liability system. Claims that would (probably) be rejected in a liability regime (without regulation), given causal uncertainty are now accepted successfully in courts because the breach of regulation guides the judge (and hence cures his informational deficiency) in the difficulties in proving causation that normally arise in environmental liability cases.

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1. Introduction

The purpose of this paper is to assess whether the use of regulation has on impact on victims' chances of success in environmental civil liability cases when causation cannot be established with absolute certainty. More precisely, the paper aims to answer the questions whether judges tend to use a probabilistic approach to causation when causality is uncertain but some suspects are known, and if so, whether they are deterrent to regulators to apply this probabilistic approach.

Causal uncertainty is often considered as a major defect of ex-post liability rules (Shavell, 1980; 1984; 1985). Indeed the liability deterrence effect depends upon victims' ability to evidence the link between damages and the tortfeasors' activities. As far as environmental hazards and pollution are concerned causal links can hardly be established with absolute certainty when damages are either latent or widespread, and the origin of harm can hardly be established (Faure, 2007). In those cases, the adoption of a probabilistic approach of causation whereby the polluter who increased the most the probability of accident is held liable, may be a desirable solution (Robinson, 1985). However, even if judges adopt a probabilistic approach to causation, the probability of being held liable when an accident occurs remains below one hundred percent, and thus, civil liability fails at providing perfect deterrence (Shavell, 1985). Hence, for those cases, regulation is better than liability rules at addressing environmental hazards and pollution (Rose-Ackerman, 1995; De Geest & Dari-Mattiacci, 2003) because regulatory requirements are prior to damages and causal uncertainty issues therefore vanish.

According to Abraham (2002), informational transfers may occur between regulators and judges or victims, which may provide relevant knowledge to the latter in order to evidence the tortuous act of a suspected tortfeasor or the causation between his behavior and the damages. Given the better ex ante information of the regulator, regulation passes on information to the judge (or to the victims) who must evaluate the behavior of the defendant ex post in a liability case. Yet no empirical study assesses the linkage between environmental regulation and liability rules in such specific cases. Our objective is to fill in this gap by examining the French *Cour de Cassation* trial cases dealing with environmental damages and causal uncertainty. The study relies on data covering all environmental cases between 1956 and 2010. Our empirical study shows that victims increasingly call on breach of regulation and use regulatory expertise to claim damages in environmental cases when causal uncertainty is at stake. In other words, it seems that there is an increasing trend whereby, apparently, the regulator (given his superior informational advantage in cases of causal uncertainty) guides the judge in environmental liability case when causal uncertainty is an issue.

The analysis reveals that, judges tend to accept non-compliance with regulation as evidence of causation – even if causation cannot be established with absolute certainty – and doing so, they overcome the problem of causal uncertainty by sanctioning risky behaviors. Moreover, when regulators carry out environmental impact assessments to design rules and precautionary standards, control emissions levels and set environmental quality levels, they gather relevant information, which may be used by judges, plaintiffs and defendants to evaluate the probability a suspect induced an accident. In doing so, judges adopt a particular interpretation of "causation" that we call "probabilistic causation". Indeed, traditionally, victims have to evidence the causal link between a defendant and the damages to win a case. Hence, if judges accept a breach of regulation or a breach of a general duty of care (reckless behavior according to the "reasonable man" principle) as evidence for causation, they in fact change the meaning of causation itself: even if the causal link cannot be established with certainty, judges would then accept regulatory evidence of a risky behavior as a way to impose liability. Probabilistic models of causal uncertainty may be a useful tool, i.e. when causation cannot be established with absolute certainty, judges will hold liable the potential

injurer, among all potential injurers, who increased the most the probability of an accident. In this perspective, a probabilistic approach to causation remains an all-or-nothing rule. Full liability is assigned to the potential injurer whose acts are assessed to be the most important factor in bringing about the harm.

Judges may consider any breaches in regulation lead to higher accident probability and subsequently lack of breach to lower accident probability. Compliance as no administrative cost is a possible side-effect because courts would provide further incentives to comply with regulation to avoid liability: victims aiming at establishing causation will in fact observe whether the suspected injurer complied with regulation, thus they will increase the probability of being monitored (Posner, 1972, p. 171). In other words, if a breach of regulation is considered as a proof of causation, victims will have incentive to monitor potential tortfeasors and potential torfeasors will have more incentives to comply with regulation to avoid liability even if regulators do not increase the probability of their controls. Hence regulation and liability rules might be socially desirable as legal compliance is favored and judges are better at addressing causal uncertainty.

The rest of this paper is structured as follows: section 2 discusses theoretical and empirical literature on the combined use of regulation and liability rules. In section 3 we briefly describe the French environmental legal system and develop our hypotheses on the role played by regulation to cope with causal uncertainty in liability. In section 4 our database is introduced and our empirical approach is described. Section 5 presents a time series analysis and section 6 presents a logit analysis. Finally, section 7 concludes.

2. Related Literature

Since the seminal paper of Shavell in 1984, the social efficiency of the joint use of ex ante regulation and an ex post liability system and their mutual interactions have been largely studied. For many scholars, the question was whether joint use may help solving judgment proof problems (Shavell, 1984; Schmitz, 2000; Hiriart *et al.*, 2004, Hutchinson & van't Veld, 2005, De Geest & Dari-Mattiacci, 2007). For Innes (2004), judgement-proofness is not a sufficient condition to explain the joint use of regulation and liability. Regulation is desirable whenever causal uncertainty lowers the deterring effect of liability (Boyer & Porrini, 2001). However, the superiority of regulation over liability systems is questionable, first because regulators may lack information about the firm's behavior and second because of regulatory capture risks (Hylton, 2002).

As Innes (2004) emphasizes, under pure regulation regulators have to monitor both the polluter's precautionary level and accident probabilities. If regulators' enforcement costs exhibit scale diseconomies or if the polluters' activity level influence accident probabilities, a liability system remains a desirable complement. In other words, when aspects of care levels are either not observable or difficult to enforce, the joint use of regulation and liability may be desirable (Bhole & Wagner, 2008). Even though facilities' setup is easily monitored, personnel behavior can hardly be so. The existence of observable and non-observable care legitimates the joint use of regulation and liability systems, even if detection is just a probability.

Furthermore, regulatory capture is a problem emphasized as a strong case for judicial action (Boyer & Porrini, 2001; Hiriart *et al.*, 2010). In that vein, judges behave as the last resort levels of regulatory standards monitoring (Angelova *et al.*, 2011). The threat of liability will provide further incentives for regulators to follow the public interest and provide efficient efforts to enforce regulatory standards. But interactions between judges and regulators go both ways: regulators may provide polluters with relevant information about judges'

interpretation of the minimum due care (Kolstad *et al.* 1990). Following Kolstad *et al.* (1990) and Angelova *et al.* (2011) regulation and liability systems are viewed as interconnected issues but seen from a different angle: regulators work as signals and help judges at solving causal uncertainty issues.

This paper provides an empirical study in a field mainly filled by theoretical papers. Only two empirical studies precede our work (Viscusi, 1988 and Dewees *et al.*, 1996). Viscusi (1988) observes how breaches of health and safety regulation encourage tortfeasors to settle their cases out of court. Dewees *et al.* (1996) evidence how regulation and liability instruments lowered the number and scope of accidents in the United States. For Dewees *et al.* (1996), regulation is better at reducing pollution than liability systems but may facilitate injurer's detection in civil cases, because victims may call on a breach of regulation to claim damages in environmental civil cases. In other words, regulatory knowledge could be used to prove that the behavior of one suspected tortfeasor increased the probability of the accident. And judges accepting this regulatory knowledge to hold liable a suspected tortfeasor (whereas the causal link cannot be established with certainty) would *de facto* adopt a probabilistic approach to causation. However this is just suggested but has not been proven (Dewees *et al.*, 1996, p. 306). We aim to shed light on this hypothesis.

3. A Glance at the French Environmental Legal System

3.1. Causation in French Environmental Liability

In France, plaintiffs have to establish causal links between the damage they suffered and tortuous deeds (Hinteregger, 2008). Following recent court of cassation decisions, compensations might be granted to plaintiff even when the causation between damage and deeds has not been evidenced but merely suggested due to expositions to unreasonable risks (Van Lang, 2007; Untermaier, 2008; Sintez 2011).[1] In those cases, where damages did not occur yet but risks of catastrophic damages are high, "risk exposure" may lead to liability. And in those cases, non-compliance with regulation is considered as a proof of "unreasonable risk exposure" (Hinteregger, 2008). This is not a reversal of the burden of proof but rather a sanction for potential damage due to negligent behavior (Sintez, 2011, p. 69). Still, "risk exposure" is accepted as a legal ground, only in very specific cases (nuclear risks or imminent risks concerning a large number of potential victims if risks materialize), and awards are low because no damages occurred yet (Sintez, 2011). In other words, this kind of liability for risk (referred to as "preventive liability" in French law) does not apply, explicitly, to environmental cases where damages actually occurred but causation is uncertain.[2] Nevertheless, this concept of "preventive liability" may provide an insight on how regulation may guide judges in deciding liability cases when causation cannot be established with certainty. Indeed, if non-compliance is interpreted as a risk-increasing activity, imposing unreasonable risks to potential victims, judges may also interpret non-compliance has evidence that the non-compliant suspected tortfeasor fairly increased the probability of occurrence of an accident. This leads to *hypothesis 1* (*H1*): if non-compliance is interpreted as a risk increasing activity, judges following a probabilistic approach to causation (which is not

[1] According to Sintez (2011), under certain circumstances, risk exposure is considered as a moral prejudice and can be compensated. He explains that the owner of an oil tank situated in a residential area has been condemned to award local residents because his installation increased the scope of damages of a potential firebreak. Cass. Civ. 2nd, 07/16/1982.

[2] As far as environmental damages are concerned, the French doctrine states that causation has to be established with aboslute certainty. See, Cass. Civ. 2ème ch, 27 October 1975, Gazette du Palais, 1976 (1), Jurisprudence 169.

explicitly stated in French Codes, as far as environmental accidents are concerned) will hold liable non-compliant suspected firms for damages when causation remains uncertain. Here, it is important to remember that the traditional approach to causation imposes to victims to prove the link between damages and the defendant's activity to win the trial. This means that if judges follow a traditional approach to causation, the fact that the defendant did not comply with regulation will not lead to liability if causation cannot be established with certainty.[3] In this case, the defendant will have to pay a fine for not complying with regulation but will not be held liable for the whole damages.[4] Things would be different if judges adopt a probabilistic approach based on non-compliance with regulation. In this case, the non-compliant defendant will be held liable for the whole damages because the fact that he did not comply with regulation is considered as a proof that he fairly increased the probability of accident in such a way that he is likely to have caused the occurrence of this accident. Thus, *hypothesis 1* answers the question whether judges adopt a probabilistic approach to causation and, if so, whether they are deferent to regulators to do so.

3.2. Changes in Regulation and Cooperation-based Regulation

Because we observe the role of regulation in civil cases, and how judges and victims may use regulation to overcome causal uncertainty problems, we provide in this sub-section some information about the major changes in environmental regulation for the last decades. This will help understanding *i*) how victims may use regulatory knowledge to evidence defendants' reckless behaviors and *ii*) why most regulated facilities are more likely to be held liable if judges adopt a probabilistic approach to causation when causal uncertainty is at stake.

The French regulatory system has changed to become more complex and sector specific, especially from 1992 to 2005. The vast majority of environmental laws were enacted and implemented during this period.[5] French environmental regulation has followed a trend toward more differentiation among firms, according to the environmental risks, and more differentiation among the different natural resources (air, water, land) according to their specific characteristics. As far as firms' classification is concerned, most environmentally-unfriendly facilities are subject to the classified facilities Act (hereafter called ICPE facilities) of July 19th 1976.[6] First, ICPE facility owners are liable to domestic and European environmental authorities. Second, for critical ICPE facilities[7], a prior consent procedure has been defined whereby local government authorities consent is required before any business activity is started. Since the Law of February 2nd 1998, regulation of polluting firms is based on the "best available technology not exceeding excessive costs" practice. Moreover, since

[3] In French law, non-compliance leads to liability if the causal link between damages and the non-compliant tortfeasor is certain. But the fact that the suspected injurer did not comply with regulation does not prevent the victim from proving the causal link. For this reason, Sintez (2011) considers that the court of cassation changed, deeply, the interpretation of the concept of causation, when dealing with "imminent risks". Following Sintez (2011), we observe whether the court of cassation also changed its interpretation of causation (from a traditional to a probabilistic approach) when dealing with environmental damages.

[4] This is the French traditional approach to causation. See Savatier, R. (1970).

[5] During this period, 15 out of the 18 laws on water protection were enacted and implemented ; 4 out of the 4 laws on wastes treatment and management ; 15 out of the 21 laws on land pollution ; 14 out of the 25 laws on air pollution, and 4 out of the 4 laws on risks prevention. See Insee. *Enquête Sessi : Réglementations par domaine*. http://www.insee.fr/sessi/enquetes/antipol/eap2006_juridique.pdf.

[6] Loi relative aux Installations Classées pour la Protection de l'Environnement.

[7] Among ICPE facilities subject to authorization we find the riskiest facilities – quarries, nuclear plants – also classified as Seveso (high risk) facilities and IPPC (most polluting) facilities. See The Inspectorate of Classified Installations. http://www.installationsclassees.developpement-durable.gouv.fr/

the implementation of the Seveso II Directive in the French Law (Arrêté of May 10th 2000), environmentally-unfriendly facility owners have to prepare, in cooperation with local government authorities (*préfets*), emergency plans in case of accident (called *POI* and *PPI* in French for Operator Internal Emergency Plans and Competent Authority External Emergency Plans).
The same logic of differentiation applies to the regulation of natural resources. For instance, the Water Act of January 3rd 1992 sets emission limits upon toxic products such as cadmium, lead or arsenic. Those limits are set up by local regulators, according to geographic, demographic and environmental specificities of the local area. Similarly, the Waste Act of July 13th 1992 imposes French firms to store, treat and recycle hazardous wastes, under the control of local regulators.
Finally, since 2005 the core of environmental regulation lies in the Environment Code; government enforcement authorities are in charge of controlling polluting facilities. The Bachelot Act of July 30th 2003 strengthens obligation set on companies according to risks and compliance costs. In this perspective, facilities located in populated areas are subject to more stringent standards than those located in industrial areas. Moreover, cost-effective facilities are subject to more stringent abatement and technical requirements than older or less effective facilities. In other words, the French legislator requires cooperation between relevant authorities and polluting firms, allowing for heterogeneous abatement costs and adjustment to specific geographical situation.

Hence, the cooperative process between the regulated industry and the regulator, in line with economic advices[8], enables regulators to obtain information about the organization within the regulated facilities. This, of course, may result in regulatory capture risks[9] but it may provide victims and judges with relevant information about reckless behaviors or organizational mismanagement within a suspected regulated facility in those cases where an accident occurs and causation is uncertain. Indeed, cooperation-based regulation requires polluters to reveal information about costs and organization to obtain desired standards. Thus, if judges adopt a probabilistic approach to causation, they could decide, based on the prior observation of the regulator, that a specific organizational or human misconduct within a suspected firm has increased the probability of an accident. Then, if they adopt a probabilistic approach to causation, they could hold the suspected firm liable for the accident. This might be the case in the French legal system, especially since 2003, because the Bachelot Act (Art. 2) requires local government authority to inform the civil society about the environmental risks imposed by regulated facilities and to explain what will be the emergency plans in case of environmental accidents. Besides, the *Charte de l'Environnement* 2005 states that French residents have a legal right to get regulatory information concerning environmental and industrial risks and their management. Thus, even though regulators cannot directly monitor the daily care within regulated facilities, they can obtain information about the organization within those facilities and victims may use this information to, eventually, prove that the organization was not careful enough when the accident occurred. In other words, the use of regulation might help showing that a suspected regulated facility behaved negligently

[8] Indeed, optimal regulation has to take into account the abatement costs heterogeneity of the regulated facilities and the local specificities – environmental, demographic, economic – of the area where the activity takes place. That is the reason why regulators have to cooperate with facility owners and local residents to acquire information. See Ogus (2004), Viscusi et al. (1995), and Richardson et al. (1982).
[9] With local standards based on private information, regulated firms are incentivized to behave strategically; they will claim either for lower standards in order to minimize compliance costs or claim for stringent ones and use it as an excess compliance strategy. In this context, most regulated industries are more likely to capture the regulator because they interact more often with him than weakly regulated firms. See Pashigian (1984), Kagan (1978) and for an empirical analysis, see Neumann and Nelson (1969).

(negligence is here understood as a breach of a general duty of care, i.e. "unreasonable behavior", which is not concerned by specific regulatory standards and therefore cannot be interpreted as a non-compliance with regulation[10]). This leads to a second hypothesis (*H2*): if victims can win a trial when causation is uncertain simply by proving that the suspected defendant behaved negligently, this means that judges have adopted a probabilistic approach to causation, as a general means to overcome causal uncertainty problems. But if victims can win a trial when causation is uncertain only by using regulatory reports on the suspected facility to prove its negligent behavior, this means that judges have adopted a probabilistic approach to causation based on regulation – third hypothesis that will be tested (*H3*). In this case, this would mean that judges are deferent to regulators when they have to decide whether a compliant suspected tortfeasor behaved in a way that increased the probability of accident and may therefore be held liable. Again, as for *hypothesis 1*, the fact that judges hold liable a negligent defendant even though causation cannot be established would be a remarkable, non trivial, fact because this would mean that they sanction behaviors that increased the likelihood of accidents even if the causal link between those behaviors and damages cannot be established.

3.3. Reliance on regulatory expertise

Victims in environmental liability cases often have problems in proving causation. Thus, they will rely on experts to establish that a suspected facility increased the risks of accidents. These experts are not always private experts paid by victims, but often government institutions that examine within the framework of establishment of standards for regulation what the likelihood is that a particular activity would cause damages to the victims.
Several public and independent agencies monitor hazardous emissions released in the atmosphere and rivers; control, water soil and air quality and publish reports. For instance, the BRGM[11] or the INERIS[12] control for water, soil and air quality and publish reports available to the public. Public regional agencies called DREAL[13] also provide studies on land contamination. These expertise and reports may facilitate fulfillment of victims' burden of proof; damages may be evidenced with temporary increases of some emissions seemingly related to specific facilities. These scientific evidences, which are hence gathered within the regulatory framework, shed light on the potentially hazardous nature of the activity (and thus also on the propensity to cause damage to the victim). Hence, this information might be used by plaintiffs and could guide the decision making of the judge. For these reasons, availability of such reports should help solving problems of causal uncertainty – fourth hypothesis to be tested (*H4*). This hypothesis sheds light on the question whether judges consider that regulatory scientific expertise provide sufficient information to decide whether a suspected polluter should be held liable, even though causation remains uncertain. Again, this hypothesis is about judges' deference to regulators and concerns a potential probabilistic approach to causation since only cases where causal uncertainty remains at the end of the trial are observed in our database.

A last hypothesis (*H5*) to be derived from our economic analysis of the French regulatory

[10] From a Law & Economics perspective, negligence can be interpreted as the "unobservable dimension of care", i.e. the components of care that cannot be monitored *ex ante* by regulators, such as daily behaviors within the firm. On the distinction between "observable" and "unobservable" care, see Bhole & Wagner (2008).
[11] Bureau de Recherche Géologique et Minière (Bureau of Geological and Mining Research)
[12] Institut National de l'Environnement Industriel et des Risques (National Institute for Industrial Environment and Risks).
[13] Regional Departments of the Environment, Planning and Housing.

system. ICPE plants are required to provide more information about how they operate and their emissions releases; prior declaration ICPE facilities are controlled every three years and prior authorization ICPE (High risk Seveso facilities and IPPC facilities) facilities are controlled on a yearly basis; consequently victims should be at greater ease whenever polluting firms are subject to the ICPE facility Act. Evidence of non-compliance with regulatory provisions may be used to prove that ICPE facilities have increased the damages probability. Given that judges adopt a probabilistic approach to causation legal battles must be more easily won when suspected firms are ICPE ones. Claimants' chances of success should be even greater if judges are willing to tame regulatory capture since ICPE facilities are more regulated than other firms and may have more room to influence regulations.

4. Empirical approach

As section 3 puts it, regulators may provide victims and judges with relevant information regarding the chain of causation between damages and suspected tortfeasors, granted that judges adopt a more flexible interpretation of causation i.e. probabilistic causation.
To observe whether judges rely on statistical and scientific evidence provided by regulators we study the decisions of the highest civil court in France – the *Cour de Cassation* – when causation is uncertain in environmental lawsuits. Our database comprises all litigations concerning environmental accidents between 1956 and 2010. Our database is constructed on two French official legal search engines[14] that list all cases before the *Cour de Cassation* and the most important case law in lowest courts. We used the following keywords[15] to collect information on environmental and pollution cases: pollution, *trouble de voisinage* (nuisance to neighborhood), environmental damage, environmental risk, environmental loss, ecological risk, ecological loss, ICPE, Seveso, IPPC, and risk prevention. We obtained 3206 different cases[16]; out of these 3206 cases 615 decisions are related to an environmental accident or damages. Causal uncertainty was the main issue only in 135 out of these 615 cases.

All the variables presented in the following sub-sections are originally dummy variables noted "*1*" when present in cases and "*0*" otherwise. We run two regressions. Regression #1 is a time series analysis and cases are aggregated on a yearly basis. Regression #2 is a logit analysis.

4.1. Dependent variable: Victims' success

We analyze victims' rate of success and its evolution over time. Although not all formal successes are equal in their degree of success from the victim's perspective, a win by the victim is easily observable and is often used in the legal literature as a proxy for success. In our dataset victims won 88 cases over the 135 relevant cases.[17]

4.2. Explanatory variables

[14] Lamyline and Dalloz, www.lamyline.fr ; www.dalloz.fr .
[15] Before the 1970s, very few cases have been found and they have been selected with the keyword *"trouble de voisinage"*. It seems obvious because of the relatively recent use of the word *"environment"*.
[16] Most of the 3206 cases were not directly related to environmental accidents although they contained one or more keywords. For instance, more than 300 cases were concerned with environmental taxation, more than thousand cases were concerned with *"trouble de voisinage"* where pollution was not an issue.
[17] Cases concerning causal uncertainty are also more accepted by courts today than in 1956. See appendix.

We focus on three types of variables that might affect the victims' chance of success: *i)* regulatory information that may be useful for victims and judges to establish causation or to assess the probability that a suspected injurer actually caused the damages, *ii)* the search for negligence – careless behavior or organization – as proof of a breach of general duty of care that in turn may be considered as an evidence for suspected injurer responsibility on a probabilistic approach to causation, and *iii)* the category of pollution i.e. the resource originally damaged by the accident or by the firm's emissions.

4.2.1. Regulatory information

The first set of explanatory variables describes regulatory information that the claimant may use and judges may accept when confronted to causal uncertainty. As explained in section 3, three variables are available: breach of regulatory provisions, availability of scientific reports and suspected injurer's identity.

i) Breach of regulatory provisions: victims mention this motive to support their claim that suspected firms did not comply with environmental regulation and consequently caused damages. If judges accept this ground to convict suspected firms we could conclude that they relied on regulatory information to establish a probabilistic chain of causation. Indeed, judges would condemn non-compliants when causation is uncertain; breach of regulation would be viewed as an influential factor in the accident probability. In these case judges would have been considered as having adopted a probabilistic approach to causation based on regulatory standards.

ii) Availability of scientific reports: victims can use the scientific information released by regulatory agencies to provide evidence either that suspected firms has emitted hazardous products that caused damages or that firms geographical position is evidence of damage liability. For instance, with excess fish deaths, previous scientific analysis of rivers hazardous products contents may help to reveal the geographical origin of emissions. Where reports are accepted as legal evidence against suspected firms that would suggests judges are aware of the informational role that regulators can play to establish causation. Moreover if judges' decisions rely on statistical observations to solve causal uncertainty this would evidence that judges have adopted a probabilistic approach to causation.

iii) Injurer's identity: in our database injurers may be either small or individual firms, medium firms, large firms, ICPE or state-owned firms and officials with specific authorities over hazardous activities (e.g. mayors are in charge of water treatment within relevant area). According to the defendant identity, courts could make different decisions in order to reduce regulatory capture risks that are more likely to occur when dealing with large firms and/or to adopt a probabilistic approach to causation: the more regulated facilities should be held liable more often than others if judges rely on breach of regulation to establish causation.

The cooperation mechanisms between regulation authorities and regulated firms increase regulatory capture risks (Laffont, 1990; Hawkins, 1983) and are likely to favor the most heavily regulated and large firms that operate several regulated plants at the same time because they have more interactions with the legislator than small ones (Pashigian, 1984). Empirical studies suggest that environmental, health and safety regulation may benefit large firms to erect barriers to entry against smaller competitors (Neuman & Nelson, 1969). Besides, regulators may be reluctant at punishing big companies because of bad economic consequences in case they leave the market (Kagan, 1978). Thus courts' severity against

ICPE facilities and big companies could be interpreted as a willingness to control regulatory capture. That attitude may be even more desirable when suspected polluters are state-owned firms or officials, because of the high capture risk. In this perspective regulators and state-owned companies would have common political interests in case they can influence each other's career and/or common economic interests in case they share a willingness to develop the regional industry under the scope of regulators power.
In addition to this, ICPE facilities are theoretically more dangerous than others. Greater courts' severity against ICPE facilities when causation is uncertain might lead us to conclude that courts rely on the regulators' classification of risks in order to assess the probability that suspected firms originated accidents.

4.2.2. Negligence

Plaintiffs invoke negligence when damages are supposed to result because of careless organization (understaffing, required excess work time, inadequate delegation of power) or individual misconduct (inadequate skills, reckless behavior). These aspects of care are not subject to regulatory standards, *per se*, but may lead to liability according to the Article 1382 of the French Civil Code.[18] Should the detection of a lack of care increase victims' chance of success, that would be interpreted as courts' reliance on probabilistic causation based upon what it considered as "reasonable behavior" and "state-of-the-art organization".
As for the breach of regulatory provisions, the negligence variable may help to assess whether judges punish gross-negligent or riskiest polluters when courts face causal uncertainty.
Under this category, a sub-category has been done: "Negligence evidenced by regulatory information". This variable represents the cases where victims invoked negligence and use regulatory reports about the regulated firm – e.g. information about the organization within the firm, maximum and minimum number of employees who can work at the same time, emergency plans – to prove that the firm was negligent. This variable, compared to the "negligence variable" may help to assess whether judges rely ultimately on regulation to establish negligence, when and if they adopt a probabilistic approach to causation.

4.2.3. Categories of pollution

Pollution is broken down into four categories: water, soil, air and noise pollution. We believe that adopting a probabilistic approach to causation may have different deterring effect depending upon the pollution category. Probabilistic causation may be an efficient way to address uncertainty insofar as polluters are incentivized to consider costs they impose upon society either under strict liability or under negligence. Thus probabilistic causation is desirable if polluters have a direct influence either on the scope or on the probability of damages – in that case a greater probability of sanction would lead to more care –; and if the benefits of such additional care action exceed costs of over-deterrence due to courts erroneous decisions (Shavell, 1987, p. 115-126).

Regarding water pollution, damages may result in biodiversity losses and increased risks of disease overcoming local areas (e.g. river pollution from an upstream industry may have harmful consequences downstream, so damages may be widespread over a large population). Polluting firms have a direct control over their emissions and damages thereby. In these perspectives polluting firms will not be over-deterred with a probabilistic approach to causation because expected damages are likely to be very large compared to additional costs

[18] Article 1382, Civil Code: Any act of a person which causes damage to another makes him by whose fault the damage occurred liable to make reparation for the damage.

of care. A similar conclusion can be drawn for soil pollution. Causal uncertainty surfaces when the origin of damage may either be new owners or former operators. Former operators or new owners subject to strict liability rules will not be over-deterred but rather encouraged to disclose information. Initial operators subject to a liability rule will be encouraged to decontaminate their property before selling it; new owners subject to a liability rule will be encouraged to control soil quality before buying it. A probabilistic approach to causation may encourage revelation of all relevant information about land quality. Thus probabilistic causation is expected to encourage socially desirable care.

For air and noise pollution, a probabilistic approach to causation is irrelevant. The risk of error is high for two reasons: first, noise damages are small especially when compared to expected water or air damages; second, noise damages are cumulative. In this case, polluters subject to probabilistic causation might be over-deterred when additional care costs exceed benefits.
For air pollution a probabilistic approach to causation is expected to be worse than for noise. Just like for noise pollution, damages can hardly be evaluated. Just like for noise pollution hazardous air pollutants are volatile and cumulative.
The greater the uncertainty about the pollution source the greater the probability of courts' error. Suspected polluters held liable for global damages and not just for the damage they generated will be over-deterred.

In other words, courts should adopt a probabilistic approach to causation (i.e. an all-or-nothing rule based on the comparative influence of each potential injurers on the occurrence of an accident) for water and soil pollution and reject it for noise and air pollution.

We can summarize our four hypotheses to be tested as follows:

H1. Non-compliance with environmental regulation increases the accident probability. When judges adopt a probabilistic approach to causation based on regulation, liability would be positively related to non-compliance with environmental regulation.

H2. Negligence (i.e. careless organizational behavior) increases the accident probability if judges adopt a general probabilistic approach to causation and has no effect is judges adopt a probabilistic approach to causation based only on regulatory knowledge.

H3. Negligence evidenced by regulatory information increases the accident probability. When judges adopt a probabilistic approach to causation that is only based on regulators' superior information about the regulated firm.

H4. Environmental reports should alleviate claimants' burden of proof. When these reports are available, victims might have greater chances of legal success if judges adopt a probabilistic approach to causation based on regulatory scientific expertise.

H5. Where suspected companies are ICPE ones, victims should have greater chances to win legal battles.

5. Evidence of Courts' use of regulators' information

5.1. From a time series perspective

From a time series perspective, are courts more severe vis-à-vis fault and negligence than they were in the past? To address this problem our five hypotheses are tested with a time series analysis. The five variables under test are the following ones: non-compliance with regulation (REG), careless organization or behavior (ORGA), availability of environmental reports made by regulators (EXPERT_REG), availability of other environmental reports, made by victims themselves, NGOs or by experts mandated by the court (EXPERT_NONREG) and existence of an ICPE (ICPE). Variables are expressed in percentage and time aggregated[19].
We use time series regression[20] and test the following relationship:

$$VICT_t = \beta_0 + \beta_1 REG_t + \beta_2 ORGA_t + \beta_3 EXPERT\_REG_t + \beta_4 EXPERT\_NONREG_t + \beta_5 ICPE_t + \beta_6 TREND_t + \varepsilon_t,$$

where $VICT_t$ represents victims' rate of success for the year *t*, TREND is an additional time trend used to represent the changes over time.[21]

First, since 1976 the compliance rate increased.[22] From the victims' perspective, the rate of success sharply decreased from 1976 to 1989, as non-compliance became less patent in courts' eyes (see *Figure 1*). Second, before 1986, non-compliance with regulation was the most important factor and was mentioned in seventy percent of cases (see *Figure 1*). At that time, environmental reports were present only in 20% of cases and organizational misconduct was invoked in less than 5% of cases. In other words, courts only regarded compliance with regulation to establish causation. That may have resulted in a compliance strategy leading to an immediate fall in victims' rate of success. As of 1986, values observed for EXPERT and ORGA variables have increased, resulting in a change of pattern. Since 1986, these two variables are correlated with victims' rate of success. In other words, courts changed their decisions and accepted scientific measures (EXPERT variables) and negligence (ORGA variable) only since 1986 as evidence of probabilistic causation.[23] This change in judges' decisions seems to follow the evolution of regulation, i.e. when regulation is more precise, the availability of reports increases and it is easier for victims to prove negligence, that is the reason why the reliance on these two variables is more important in 2010 than in 1956. *Table 1* summarizes statistics of the aggregated variables.

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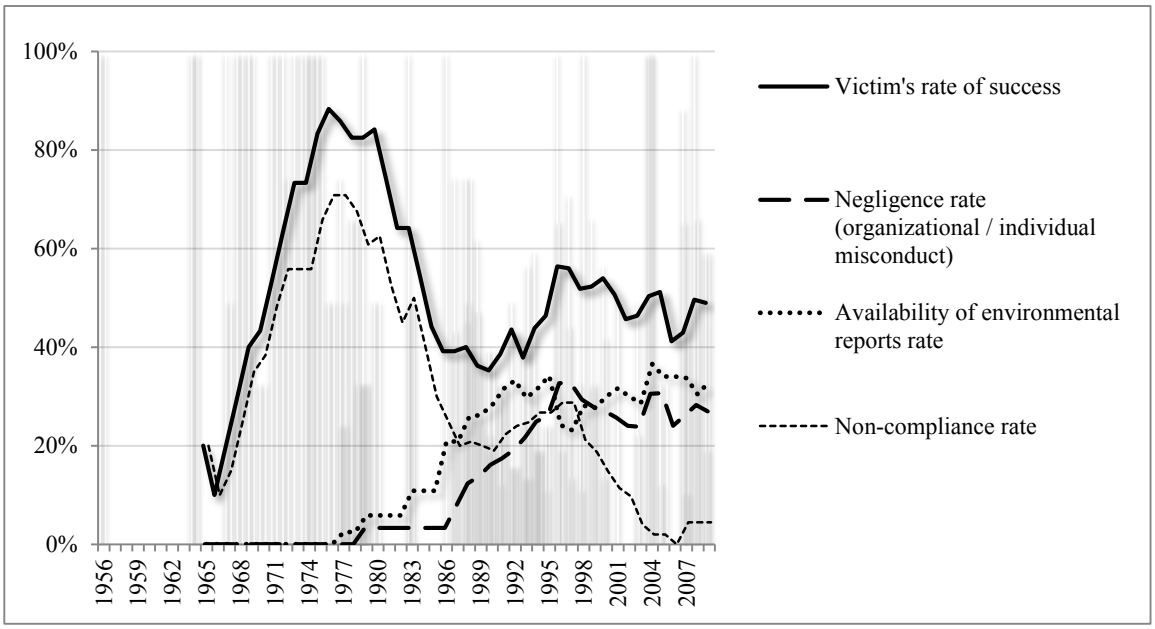
[19] For instance, during year 1992, the victims won 50% of their trials, they invoked careless organization in 17% of the cases and in 25% of the cases scientific environmental reports were available. 17% of the cases concerned suspected injurers who did not comply with regulation and an ICPE facility was suspected in 14% of the cases.
[20] Tests are computed on Stata 10 and SPSS. Results are the same with both softwares. For more details on the diagnostics, see Appendix.
[21] The variables have two different trends: before and after 1986. TREND represents this change in trend; it has the value 0 before 1986 and the value "t-1986" for the years "t" after 1986.
[22] 07/19/1976: entry into force of the ICPE Act.
[23] From an econometric point of view, the year 1986 appears to be a structural change so we created a dummy variable noted "*1*" after 1986 and "*0*" before that we combine with the variables ORGA, EXPERT_REG and EXPERT_NONREG. See Appendix. For a complete discussion on structural changes, see Gujarati & Porter (2009), p. 285-288.

Figure 1. Determinants of victims' rate of success under causal uncertainty



Note: "Availability of environmental reports rate" represents the annual rate of use of scientific reports. Those reports may have been provided by regulators or any other experts. Thus it combines both "EXPERT_REG" and "EXPERT_NONREG" variables.

Table 1. Summary statistics of the aggregated variables.

Variables	Definition	Period 1956-2010 Mean
Victim's rate of success	Annual rate of success	.49
Regulation (REG)	Non-compliance rate (part of annual cases)	.29
Organizational care (*after 1986*) (ORGA)	Rate of victims claiming for organizational/individual misconduct (part of annual cases)	.30
Regulatory expertise (*after 1986*) (EXPERT_REG)	Rate of availability of environmental reports made by regulators (part of annual cases)	.11
Non regulatory expertise (*after 1986*) (EXPERT_NONREG)	Rate of availability of environmental reports made by NGOs, private experts or experts mandated by the court	0.8
ICPE	Part of ICPE among injurers (per year)	.08

5.2 Econometric results

Table 2 presents our results of time series analysis.
The results of the regression and the predicted probabilities are presented in *table 2*. All the coefficients are statistically significant at level 99% or higher except ICPE that is only significant at 95%.

Our results are in line with our predictions. All the four variables increase the victims' rate of success; this evidences that courts adopt a probabilistic approach to causation.

Table 2. Results of the time series regression

	Victim's rate of success: Period 1956-2010		
Variables	Coefficients	Predicted probabilities[a]	
Non-compliance with regulation (REG)	0.487***	*28%*	
	(0.044)		
Negligence (organizational/individual misconduct) (ORGA) *after 1986*	0.414***	*7%*	
	(0.084)		
Regulatory reports and expertise (EXPERT_REG) *after 1986*	0.826**	*31%*	
	(0.082)		
Other environmental reports and expertise (EXPERT_NONREG) *after 1986*	0.271***	*6%*	
	(0.052)		
Suspected injurer is an ICPE (ICPE)	0.140*	*5%*	
	(0.067)		
Change in trend (TREND)	-0.014***		
	(0.002)		
Constant	0.322***		
	(0.045)		
Observations (number of years)	*54*		
R^2	0.6320		
F-statistic	56.26 (0.0000)		
Tests	χ^2	*df*	*p*
White test	15.73	14	0.3299
Breusch Godfrey test	0.467	1	0.4942
Durbin-Watson *d*-statistic	1.9560		
Augmented Dickey-Fuller[b] test (*on residuals*)	*Z*(t)		*p*
	-4.355		0.0004

Standard errors in parentheses
Significant at: *** p<0.001, ** p<0.01, * p<0.5.
[a] Change in victims' rate of success when the rate of the explanatory variable raises by 1% (compared to its mean value)
[b] ADF critical value at 1% is -3.730 so we reject the null hypothesis that residuals have a unit root.

This is a remarkable finding given the fact that, according to the French doctrine, the standard of proof requires the demonstration of absolute certainty of the causal link. And yet, our results show that courts tend to relax the burden of proof of causation in the field of

environmental accidents.[24] Indeed, courts admit that causation can be assumed in the presence of "sufficient probability",[25] where sufficient probability is defined as serious, precise and concordant presumption.[26] In this perspective, it is worth noticing that fault, being either non-compliance with regulation or negligent behavior, is now more often considered as a proof of causation with a "sufficient probability" (non-compliance and negligence variables both increase victims' rate of success even if causation cannot be established with absolute certainty). In fact, judges do not consider fault as a proof of causation, per se, but accept is as "sufficient" evidence if it can be proven that this fault was a necessary condition, among others, for the accident to occur. For instance, a farmer whose cattle died after a contamination from copper sulfate succeed in a trial against a suspected firm after he provided regulatory evidence that this firm was emitting important quantity of copper sulfate – above the regulatory limit – at the time of the contamination.[27]

Nevertheless, courts appear to be more likely to adopt a probabilistic approach to causation in the presence of a breach of regulation than in the presence of a negligent behavior (a one percent increase in the non-compliance rate raises victims' rate of success by 28 percent whereas a one percent increase in the negligence rate raises victims' rate of success by only 7 percent). Thus, it seems that judges are deferent to regulators when adopting a probabilistic approach to causation.

The fact that regulatory expertise increases victims' chance of success seems to confirm this conclusion. Indeed, when victims can use regulatory reports and expertise to evidence the probability that a suspected injurer actually caused the damage, they are more successful than when they can only rely on their own experts, on NGOs reports or on experts mandated by the court (A one percent increase in the availability of environmental reports made by regulators raises victims' success by 31 percent, whereas reports done by other experts raises victims' rate of success by only 6%). For instance, a farmer complained against a suspected polluter arguing that his cattle died after the pollution of his puddle by pesticide.

Regulators' expertise showed that this cause was "probable" even though it was not only possible cause. Based on this expertise, judges decided to hold the suspected polluter liable for the whole damages.[28] In the same vein, judges ruled in favor of a farmer whose cattle died because of contamination by pollutants based on the fact that regulatory experts said that there was a "possible correlation" between the death of the cattle and the pollutants.[29] Again this finding is important given the fact that legal scholars are often skeptical about the use of "scientific evidence" to establish causation.[30] Indeed, our results show that courts accept scientific evidence as a way to adopt a probabilistic approach to causation only of those evidence come from regulators.

Though, the fact that regulatory expertise and reports are more "victims oriented" might be surprising because scientific reports should be, by definition, objective evaluations of the environmental quality. However, it appears that regulators are more precise and severe today, when conducting environmental impact assessments and this might be favorable to victims. For instance, regulators observed that a company in charge of drinking water production did not comply with maximum pesticide concentration in water (0.10µ/mg); the water contained 0.11µ pesticide by milligram, and consumers used this information to successfully sue the

[24] It seems that courts dealing with environmental cases follow an existing trend toward easing the burden of causation. Indeed, the proof of causation is already based on scientific probability in some domains such as medical products liability and medical malpractice. See Viney, G., & Jourdain, P. (2006).

[25] CA Pau, 14 October 2002.

[26] Art. 1353 Civil Code.

[27] CA Douai, 3e ch., 29 June 2006.

[28] Cass. Civ. 2e ch., 23 January 2003, n°00-20.932.

[29] CA Caen, 13 January 2005, n°03/01273.

[30] See Rougé-Maillart, C. (2005).

company.[31] Hence, the greater reliability of regulatory expertise appears to be favorable to victims going to trial. For this reason, it seems obvious that the most regulated facilities have more chances to be held liable by courts than other suspected injurers, since they are more subject to regulatory expertise (the results regarding ICPE facilities confirm this conclusion since victims' rate of success increases by 5% when the suspected injurer is an ICPE facility).

These econometric results lead to the following conclusion: technical feasibility of environmental reports and prospective legal interpretation of causation seem to alleviate the burden of the proof of causation. First, as technology enables to trace back emissions and measure environmental and health impact, courts could more easily prove causation. Second, a prospective interpretation of causation may evidence that judges are aware of the informational role that the regulators can play to help solving causal uncertainty.
Hence, it seems that judges follow the regulatory standard to the extent that when regulation has been violated, this will indicate finding of liability and even when there is compliance, in case of a high risk activity, the judges consider the regulated nature of the activity as an indication that the particular activity may have caused the harm and thus apply a probabilistic approach to causation.

6. Efficient use of regulators knowledge

6. 1. A logit analysis

The interactions between regulation and liability may have adverse effect when courts prefer granting compensation rather than encouraging efficient care measures. Courts may have the tendency to use the liability system for compensation reasons and hence award compensation to victims also in cases, which would not merit liability (because of lacking causation). In that case courts may overallocate liability to defendants and overdeterrence would be the result. Thus, as aforementioned in section 4.2.2 and 4.2.3, relying on regulators information would be useful when courts adopt a probabilistic approach to promote desirable care measures and prevent over-deterrence effects.
Courts' decisions will depend upon the nature of polluted resources, suspected firms' identity, and locational specificities. Damages are expected to be high when facilities are situated in populated areas or close to other hazardous facilities. Populated areas and industrial park areas will be considered as areas under severe risks.
A probabilistic approach is desirable when the reduction of expected damages is above courts' decisions costs. The net benefit of a probabilistic approach – difference between reduction of expected damages and courts' decisions costs – is expected to be higher for areas under severe risks than for other ones.
Note that areas under severe risk are easily identified under the French legal system. Environmental agencies[32] classify French regions according the number of dangerous firms, population density, and distance to major rivers. With that classification, *la Seine Maritime, les Bouches du Rhône, la Gironde and la Loire Atlantique* regions are considered as the most dangerous regions. In these regions courts have jurisdiction over 14,5% of the most dangerous

[31] CA Reims, 1e ch. civ., 20 December 2006.
[32] Ministère de l'Ecologie du Développement Durable du Transport et du Logement. *Répartition des sites ICPE et Seveso.*
http://www.statistiques.developpement-durable.gouv.fr/lessentiel/article/333/1200/repartition-spatiale-installations-classees-soumises.html

facilities subject to regulation – i.e. 174 out of the 1204 plants classified as the most dangerous ones.
Locational specificities are not directly observable. However information about territorial jurisdiction of courts is used as the proxy variable for regions under severe risks. This dummy variable is called "risky region" ("1" when courts are situated in a regions with severe risks, "0" otherwise).

6.2. Econometric results of the logit analysis

The efficient use of regulators' information by courts is subject to three variables: polluter identity, polluted resource category, and specific regulator knowledge – i.e. compliance and non-compliance with regulation and region under severe risk or not.
Under the logit regression test, qualitative data are still dummy variables and are not aggregated.
We run a bivariate logistic regression model where predicted impacts of variables are compared to a baseline situation. The baseline situation as follows:

Water pollution suspectedly caused by a medium-size firm complying with environmental regulation situated in a low risk region.

Water pollution: is a reference variable to test the adoption of a probabilistic approach to causation when the expected benefits (additional care) are likely to exceed expected costs (court's errors and over-deterrence). We believe that victims' chance of success should be lower for air and noise pollution because risks of errors are high and may lead to great over-deterrence.[33]

Medium-size firms polluting rivers: accounts for more than 15% of cases under our scrutiny. Compared to small-size firms, medium-size companies may generate more pollution and spend more money to prevent damages. Compared to large-size firms, medium-size firms generate lower pollution and can more hardly capture regulators. The medium-size firm scenario allows testing victims' chances of success against dangerous firms and small firms.
Compliance with regulation and regions with low risk level: are used to evaluate courts' severity when regulators' knowledge evidences that suspected firms greatly increased damages probability.

Victims' probability of success is tested with the following equation, where SMALL, ICPE and PUBLIC stand for small firms, ICPE facilities and large firms and state-owned firms or officials, respectively, REG and RISKY_DPT stand for breach of compliance and nature of the region respectively and SOIL, NOISE and AIR are pollution categories:

$$L_{VICT} = \ln\left(\frac{P_{VICT}}{1-P_{VICT}}\right) = \beta_0 + \beta_1 SMALL + \beta_2 ICPE + \beta_3 PUBLIC + \beta_4 REG + \beta_5 RISKY\_DPT + \beta_6 SOIL + \beta_7 NOISE + \beta_8 AIR + \varepsilon$$

Table 3 provides summary statistics of the dummy variables over the period 1956-2010. Note first, that victims won 65 percent of the cases. Given this high success rate, courts apparently have the tendency of using (breaches of) regulation to allocate liability to defendants also in

[33] See section 4.2.3.

cases of causal uncertainty. ICPE and state-owned firms or officials are present only in 9% and 8% of cases. By contrast 40% of cases concerned non-compliant firms and 20% concerned firms situated in a region with high risks. These two variables have a significant importance.
Regarding pollution categories, our dataset is well balanced. A comparative approach will allow testing the adoption a probabilistic to causation by courts.

Econometric results (*table 4*) suggest that SMALL and ICPE variables are not significant ones. In other words, courts do not ease the burden of precaution for dangerous firms. Their decisions do not depend upon the nature of firms, nature of expected damages and level of abatement costs. This conclusion sharply contrasts with the time series regression results. Remember that the presence of ICPE facilities was found to significantly increase victims' chance of success. This is the fact because courts are seemingly more prone to adopt a probabilistic approach to causation in cases situated in regions under severe risk rather than in regions with low risk levels. Since ICPE facilities are situated in regions under severe risk, courts are seemingly more prone to adopt a probabilistic approach to causation when cases imply ICPE facilities.

Table 3. Summary statistics of the outcomes with logistic regression

Variables	Mean value
The victim wins	.65
Polluter's identity	
Medium firm (*reference variable*)	.31
Small firm	.52
ICPE or large firm	.09
State-owned firm or official	.08
Regulators' knowledge	
Non compliance with regulation	.4
Risky region	.20
Polluted resource	
Water (*reference variable*)	.31
Soil	.15
Noise	.2
Air	.34

Tableau 4. Results of the logistic regression

Variables	Coefficients (*log odds*)	Predicted probabilities[a]
Polluter's identity		
Medium firm (*reference variable*)		
Small firm	-0.943 (0.607)	-16%
ICPE or large firm	0.788 (1.550)	10%
State-owned firm or official	2.228* (1.340)	19%
Regulatory knowledge		
Non-compliance with regulation	2.811*** (0.615)	39%
Risky region	1.819** (0.779)	20%
Polluted resource		
Water (*reference variable*)		
Soil	2.595** (1.174)	26%
Noise	-1.114* (0.621)	-19%
Air	-1.902** (0.795)	-39%
Constant	0.108 (0.589)	
Cases	*135*	
Victim wins (Victim = 1)	*88*	
Tests[b]	χ^2	*df*	*p*
Overall model evaluation			
Likelihood ratio test (LR test)	75.61	8	0.0000
Score test (Lagrange test)	66.15	8	0.0000
Wald test	35.28	8	0.0000
Goodness of fit[c]			
Hosmer & Lemeshow	2.38	8	0.9670
c-statistic[d]	82.96%		

Standard errors in parentheses.
Significant at : ***p<0.001, ** p<0.01, * p<0.05.
[a] Change in the victim's probability of success, compared to the reference situation (i.e. when the explanatory variable changes from *0* to *1*).
[b] We provide tests considered as fundamental and sufficient by Peng, C.-Y., Lee, K. L., & Ingersoll, G. M. (2002). An Introduction to Logistic Regression Analysis and Reporting. *The Journal of Educational Research , 96* (1), 1-13.
[c] Two additional descriptive measures of goodness-of-fit might be added : Cox & Snell R^2 = 0.429 ; Nagelkerke R^2 = 0.591.
[d] *C*-statistic means that the model assigned the correct actual outcome in 82.96% of all trials.

For courts, polluter identity matters only when polluters are state-owned companies (hereafter SOC) or officials. Victims' chances of success against SOC are 19 percent higher in such cases than against medium-size companies. This suggests that courts are apply a more severe probabilistic approach when dealing with SOC. This might be due to the fact that SOC are in charge of hazardous activities (e.g. nuclear waste management for instance) or potentially harmful activities (e.g. water treatment for instance). In this case, easing the burden of proof against state-owned companies could be desirable as it provides incentives to take more care. Additionally, courts greater severity against SOC could be desirable as the risk of regulatory capture is high for SOCs.

Second, our econometric results suggest that when regulatory information is available, in litigation where causation is uncertain, victims' chance of success increase. Law breaches increase victims' chance of success by 39 percent; accidents in regions under severe risk increase victims' chance of success by 36 percent. These results are in line with our prediction. The data seem to indicate that courts are more likely to accept a probabilistic causation, and that probabilistic causation is based on regulator knowledge, when over-deterrence costs are low and additional care benefits are high.

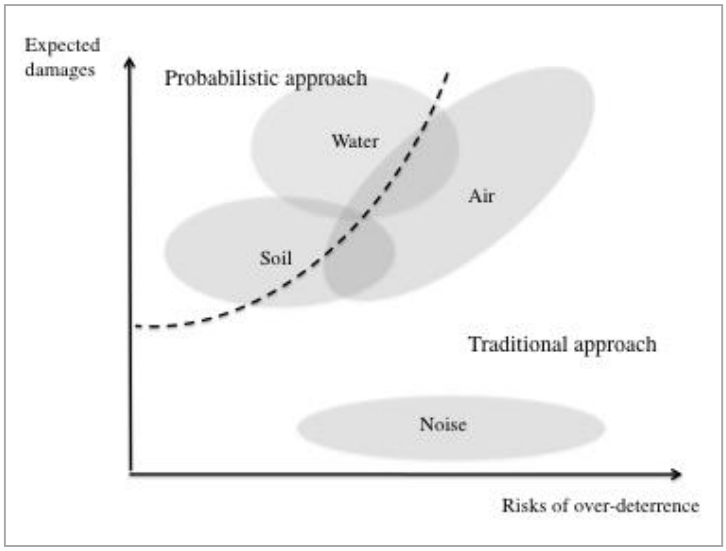
Third, our econometric results suggest that victims' chances to win are lower in air and noise pollution case than in soil or water pollution cases. Although our data cannot provide a clear explanation of this phenomenon, we could interpret the results as follows: for air pollution, over-deterrence risks are high due to the nature of pollution (see section 4.2.3 for more details). In this case, error and over-deterrence costs may be far above additional care benefits. For water pollution cases, victims' chances of success are 39 percent higher than for air pollution cases. For noise pollution, courts apparently hesitate at convicting suspected firms when they have no certainty about the noise source. Again, this result could be interpreted as follows: when noise damages are relatively low, not compensating victims is better than convicting potential polluters that would eventually be over-deterred.

However, victims' chances of success are 26% higher for soil pollution than in the baseline scenario. That suggests that over-deterrence costs are well below the additional care benefits in the courts' eyes.[34]

In brief, courts apparently adopt a probabilistic causation approach and ease the burden of the proof when *i)* pollution is under the direct control of suspected polluters and *ii)* the reduction in expected damages is above over-deterrence costs. *Figure 2* illustrates the French judges' courts approach to causation.

[34] This result is in line with the concept of "cheapest evidence avoider" of Porat & Stein (1997).

Figure 2. French judges' approach to causation



6.3. Limitations of the study

Our study focuses on cases adjudicated by the *Cour de Cassation*, raising a selection bias for two reasons. First, out of courts settlements are neglected in our analysis; therefore private bargaining was not observed (Priest & Klein, 1984). Therefore our analysis focuses on high expected damages. Second there may be a selection bias; our analysis concentrates on the *Cour de Cassation* case law and disregards lower level courts. Hence, our sample might be considered as biased since only complex or financially significant cases are finally within the scope of our analysis (Clermont & Eisenberg, 1998).

In addition to this, 30% of cases are declared as "non admissible" ones by the *Cour de Cassation*. For the 70% remaining cases, the *Cour de Cassation* is more prone to confirm than to reject lower-level courts decisions. Since 78% of cases decided over by the *Cour de Cassation* are brought by victims, victims' chances of success might be over-represented in highest-level courts compared to lower-level jurisdictions (Eisenberg, Fisher, & Rosen-Zvi, 2011).

Notwithstanding selection bias, the study shows the role of civil judges of the highest jurisdiction in preventing environmental accidents and shows that this pattern has significant features beyond chance outcomes. The outcomes of cases in the *Cour de Cassation* are especially important because they are both final and can be expected to have the most influence on lower courts and on other actors in the system of environmental regulation.

7. Conclusion

The present empirical analysis provides evidences that the French *Cour de Cassation* has adopted a probabilistic approach to causation – a result in line with mainstream economics – based on regulatory knowledge. We observe that thanks to regulation a civil liability rule allows the *Cour de Cassation* to overcome uncertainty problems. In this perspective, the *Cour de Cassation* is found to adopt a probabilistic approach to causation only for specific cases (i.e. for water and soil pollution cases). Moreover, it appears that judges are deferent to

regulators when deciding whether they adopt a probabilistic or a traditional approach to causation.

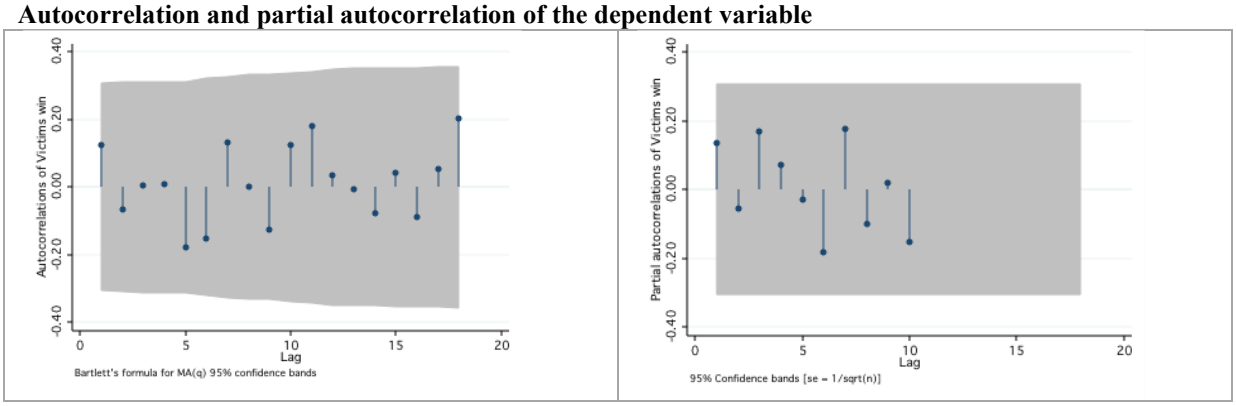
Finally, our analysis focuses on the French highest-level court whose decisions will influence lower-level jurisdictions – a positive element that should not neglect selections biases that such an analysis imply.

Appendix

1. Autocorrelation and partial autocorrelation

The dependent variable has no autocorrelation nor partial autocorrelation. So there is no need to use autoregressive models.

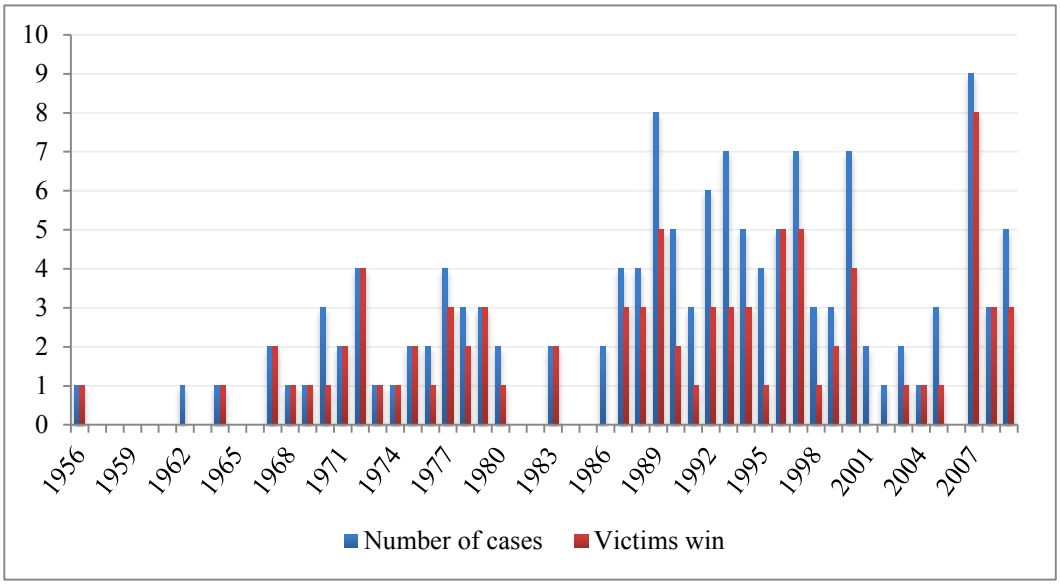
Autocorrelation and partial autocorrelation of the dependent variable



2. Gaps in the time series

However, in the figure below, we can see "gaps" in the time series. Moreover, there are more cases in the last two decades than before. To cope with these two issues, we added a Kalman filter on the regression and we weighted the importance of each observation (i.e. year) according to the number of cases judged during this year.

Cases by year



3. Structural change

As observed in figure 1, the trend of the variables ORGA and EXPERT change after 1986. We ran a Chow test on these variables. The test has been done as follows:

$$VICT = \beta_1 REG + \beta_2 ORGA + \beta_3 EXPERT\_REG + \beta_4 EXPERT\_NONREG + \beta_5 ICPE + + \beta_6 BREAK + \beta_7 BREAK\_ORGA + \beta_8 BREAK\_EXPERT\_REG + \beta_9 BREAK\_EXPERT\_NONREG + \varepsilon$$

where, BREAK is a dummy variable noted 1 after 1986 and 0 otherwise, and BREAK_ORGA, BREAK_EXPERT_REG and BREAK_EXPERT_NONREG are the interactions terms.

We tested the null hypothesis that the interactions terms and the dummy variable have coefficients equal to 0, and got the following result:

F(4,32) = 2.36
Prob > F = 0.0742

So we rejected the null hypothesis and concluded that year 1986 causes a break in the coefficients of these variables.

To take into account the change of the victims' rate of success over time, we also added a time trend (TREND) defined as follows:

TREND = t-1986, if t>1986, where t represents the year of the judgment.

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