DIFFERENTIATED BELIEFS IN ACCIDENT MODELS UNDER RISKY ENVIRONMENT

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Gérard Mondello

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A General Accident Model for Risky Activities

Gérard Mondello[1]

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Summary:

The efficiency criterion (the highest level of care at the lowest accident cost) governs the comparison of performance between strict liability and negligence. This view stems from the initial standard accident model which under ideal conditions, ensures equivalence among liability regimes and assumes their potential substitutability. We develop a more general accident model which retains the neutral to risk assumption by assuming divergent views among the parties about the scale of the damages. Efficiency then no longer appears a sufficient relevant criterion to compare liability regimes. Consequently, each belongs to a specific field: Ultra-hazardous activities in the case of strict liability and the remaining areas of negligence.

JEL: D62, K13, K23, K32, Q52, Q58.

Keywords: Tort law, Law & Economics, Unilateral accident model, Risk, Safety, Strict liability, Negligence, Ultra-hazardous activities.

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[1] Université Côte d'Azur, CNRS, GREDEG, France
250, rue Albert Einstein
06560 Valbonne, Sophia Antipolis. France
Tel.: + 33-4-93954327-fax:+ 33-4-93653798,
gerard.mondello@univ-cotedazur.fr

1. Introduction

According to the "*Law and Economics*" literature, liability rules should help to internalize the market failure linked to accident induced by hazardous activities: "*The positive economic theory of tort law holds that tort rules are efficient in the sense of wealth maximizing*" Landes and Posner (1987 p. 16). This view stems from Judge Learned Hand's first use of a cost-benefit analysis in U.S. v. Carroll Towing Co[2]. Subsequently, economists have theoretically developed the law of civil liability under the notion of the "accident model". This reference design is the Standard Accident Model (SAM in the following), which weighs the expected social costs of accidents against the benefits of maintaining risky productions[3]. In other words, this model minimizes the primary cost of an accident, i.e. its prevention, and its expected cost. (Calabresi, 1970).

In its purest version, SAM assumes that potential victims and perpetrators are rational, endowed with Savage's expected utility functions, and risk neutral. By increasing their prevention efforts, the parties improve safety. In the unilateral accident model, victim protection depends only on the potential perpetrator, whereas in the bilateral accident one, victims can partially or fully protect themselves. The simplicity of this model allows comparing the effectiveness of polar liability regimes as strict liability and negligence. Strict liability is the legal liability that obliges a wrongdoer to make good the harm he or she has caused to a victim, without the need to prove negligence or fault. It generally applies to abnormally dangerous activities (storage of explosives or flammable liquids, blasting, accumulation of wastewater, emission of toxic fumes, etc.). Negligence involves the tortfeasor's liability if the court proves that he or she did not act with the necessary due care to protect against the risky activity. To avoid liability, the potential tortfeasor must make costly prevention efforts. In the SAM framework, the private optimal care level chosen by the perpetrator corresponds to the socially first-best level of care. This holds regardless of the liability regime, strict liability, or negligence[4].

This paper develops a model that retains the basic structure of SAM, i.e., the agent's expected utility function, risk neutrality and common knowledge of the prior probability distribution. However, it assumes that the victim and the offender assess the expected harm

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[2] 159 F.2d 169 (2d Cir. 1947).

[3] This representation comes mainly from (Calabresi 1961, Brown 1973, Diamond 1974 A, B, Shavell 1980, 1987 and Posner and Landes 1987 and was developed between the mid 1970s and the mid 1980s).

[4] Shavell (1980) compares strict liability and negligence and shows that if level of activity is considered, strict liability leads tortfeasors to reach the first-best level of care, but negligence does not. Here, we refer only to the simplest case where the production or activity level is equal to 1 that insures equivalence between regimes.

from the hazardous activity differently without requiring the uncertainty framework (ambiguity). SAM is based on a specific cost-benefit model like the usual bilateral externality models[5]. In the overall framework of these models, each agent (polluter and victim) reveals its preferences to a benevolent regulator that aggregates the individual utility functions and computes equilibrium values. In these models, the equilibrium solution equals the marginal social cost of the harm and the marginal benefit of the perpetrator. In the SAM, this process involves determining the socially optimal level of care. In our general accident model based on divergent views about the value of damage between victim and perpetrator we show that:

a) Under strict liability, the injurer's optimum care level diverges from the socially first-best level of care,

b) Under negligence, the judge becomes the key-factor who determines the efficient care level,

In our view, this means that liability regimes are not equivalent and apply to different fields of tort law. Currently, strict liability mainly concerns agents engaged in conducting, using, or overseeing abnormally risky activities (see Cantú, 2001). Innovative technologies may lead to accidents and sudden pollution with unknown consequences. Most of the time, damage occurs without intent or negligence. Negligence falls under less risky activities.

The paper presents in section two a general accident model under risk, the sections three and four are dedicated to analyzing its consequences for strict liability and the negligence rule while section five compares both regimes. A sixth section analyses the consequence of introducing a general accident model under uncertainty with agents having divergent views on damage. We show that adding ambiguity does not add new insight compared to our general accident model. A section seven concludes.

2. A general accident model under risk

A general accident model in a risky environment is a model without ambiguity, without Knight uncertainty. All random events may occur with a given probability the sum of which is equal to one. Thus, only risky events are considered and not uncertainty as the literature we analyze in section six. We consider then:

1. Two representative agents, a potential tortfeasor (he, indexed I), and a potential victim (she, indexed V).

[5] See for instance Viner, 1931, Meade, 1952, Baumol and Oates, 1993 and section 2.1 below.

2. Two states of nature: i) An accident occurrence (indexed a) and ii) The "business as usual" situation (no accident) ($\overline{a}$). The set of the states of nature writes as: $A = \{a, \overline{a}.\}$. Let $p(x)$ be the probability of an accident that depends on the care intensity $x, x \geq 0$, where $p'(x) < 0$, $p''(x) \geq 0$, where $1 - p(x)$ is the probability of no accident and $p(0) = 1$.
3. Two moments $\tau, \tau = 0{,}1$, the ex-ante moment $(\tau = 0)$ when the agents make their assessment (potential injurer and victim) and the wrongdoer his level of safety choice and the ex-post situation when the true states of the worlds reveals ($\tau = 1$).
4. Wrongdoer and victim are Savage Expected Utility maximizers and are risk neutral. The injurer chooses the care level $x\ ex\ ante$, $(x \geq 0)$ to limit the cost of an accident risk.
5. Let $u, u > 0$ and $v, v > 0$ respectively be the injurer's and victim's initial wealth. If L is the maximum value of the harm, then by assumption $(u > L)$, and consequently, the injurer is never judgment-proof and could always compensates the damage according to the current liability regime.
6. Let $L_{I\tau=0}(k), L_{V\tau=0}(k)$ (as a simplification we write $\tau = 0\ as\ 0$, $L_{I0}(k), L_{V0}(k)$ respectively be the assessment of damage made by the injurer and the victim, where $L_{I0}(k) \neq L_{V0}(k)$. Thus, each agent makes its own assessment of the cost of damage.
7. $\Psi_\tau(x|k), \phi_\tau(x|k)$ are respectively the perpetrator's and the victim's utility function $(\tau, \tau = 0{,}1)$ under the liability regime, $k = \{(SL),\ (NR)\}$. Considering the states of nature in $A = \{a, \overline{a}.\}$, these functions become $\{\phi_0(x|a,k), \phi_0(x|\,\overline{a},k)\}$ and $\{\Psi_0(x|a,k), \Psi_0(x|\,\overline{a},k)\}$. Each state of nature is associated to an occurrence probability $\{p(x)\ \text{for}\ a\ \text{, and}\ (1 - p(x)\ \text{for}\ \ \overline{a}\ \}$, These functions behave differently according to the current liability regimes restricted to either strict liability (SL) or negligence (NR), (k is the corresponding index: $k = \{(SL), (NR)\}$).
8. By developing we define the agents respective utility functions:

[1] $$\Psi_0(x|k) = u - x - p(x)L_I(k)\ ,$$

[2] $$\phi_0(x|k) = v - p(x)L_V(k)$$

x^0 is the wrongdoer's optimal level of care, where: $\Psi'_0(x|k) = 0$ involves that:

[3] $$p'(\ x^0, k) = -\frac{1}{L_I(k)}$$ (for details see appendix 1)

Since we know the agents' expected utility function, we can deduce the Social Expected Welfare function, $EWS_0(x,k)$ built by aggregating those functions:

[4] $EWS_0(x,k) = \Psi_0(x|k) + \phi_0(x|k) = u + v - \mathrm{x} - p(x)\big(L_I(k) + L_V(k)\big)$

If x^* is the first best social care level, ($x^* > 0$), we can easily see that $x^* \neq x^0$. To show this we need only to determine the first order conditions. Then, maximizing $EWS_0(x,k)$involves that for $x^* > 0$,

[5] $$EWS'_0(x,k) = \Psi'_0(x|k) + \phi'_0(x|k) = 0 \implies$$

$$p'(x^*,k) = \frac{-1}{(L_I(k) + L_V(k))}$$

Now, having defined the global framework, we can study more precisely the involvement for each liability regime. However, before going further, note that as agents assess differently the level of damage, they could also assess different distributions of probability. This will not the case, even, if legitimately they could do so. This assumption about different probability estimation would not add anything to our analysis and complicates it.

3. Strict liability

3.1 Presentation

SAM assumes that the victim and the wrongdoer assess the scale of damages in the same way. How is this agreement achieved? In (Kaplow and Shavell 1996), the perpetrator plays an important role in adjusting the level of care to his or her level of knowledge of the harm. The authors compare the social value of assessing the damage accurately, and the litigants' gain by devoting resources to find evidence of the damage. It follows that the relationship between injurer and victim covers a large spectrum of different situations when parties must assess the damage after an accident:

"*Assessment of damages is often a principal issue in litigation because the primary objective of the plaintiff usually is to collect as much as possible and that of the defendant is to pay as little as possible. Accordingly, litigants frequently devote substantial time and effort attempting to establish the level of harm. In light of this, the question naturally arises concerning the underlying social purpose of accurate determination of harm.*" Kaplow and Shavell (1996, p. 191). (See also Shavell 1987).

It is particularly difficult to know how ex ante the victim and the offender agree. Kaplow and Shavell (1996) consider that the more accurate the damage assessment, the more due diligence is exercised by the offenders and this depends on both the agents' available information and the resources they spend to acquire it. Then, without a specific incentive to disclose the actual accident costs, the average cost remains the main criterion for choosing the prevention level regardless of the victims' assessments. If this cost is neither observable nor knowable, then the troublemaker and the court need additional information. For instance, drivers adopt careful driving regardless of potential knowledge about damages. However, under strict liability, it is more important to know whether the wrongdoer is solvent than to determine the socially optimal level of care. Of course, the more accurate the assessment of the damages, the closer will be the level of prevention to its optimal level. However, it is of the utmost importance that the victim knows that the court is considering his/her full loss (Shavell, 1987). SAM assumes that the victim is confident that compensation will be complete (as $L_{V0} = L_{V1} = 0$):

[6] $$\phi_0(x) = v - p(x)L_{V0} = v$$

At this point note that:

i) In the SAM, the victim knows that the injurer is never judgment-proof,

ii) All parties agree about the scale of the damages and the distribution of probability of accident,

iii) Ex-ante, the victim is fully aware that the reparations will fully cover his losses.

The SAM framework involves that accepting i) and ii) implicitly validates iii). Then iii) is more important than agreeing or disagreeing about the damages assessment. This is what proposition 1 sets:

Proposition 1: *Under strict liability, with risk-neutral Savage utility-maximizing wrongdoer and victim, the sufficient and necessary condition that allows equating the socially best level of care with the optimal level of care of the perpetrator is that the victim knows with certainty that the perpetrator will fully compensate her losses. This result is independent of whether the parties share the same opinion about the level of damages.*

Proof in appendix 2.

Proposition 1 means that equality between the levels of social and private care in SAM comes first from the victim's certainty that the wrongdoer will always compensate his or her losses, and second, from the certainty that the judge will value them fairly. Proposition 1 says that if the victim feels that the level of compensation does not cover his or her loss then equality does not hold. Then, in a less restrictive unilateral accident model compared to the CAM, even if the agents are risk neutral, under strict liability, the social care level diverges from the private one as corollary 1 shows it:

Corollary 1: *Under strict liability, if the victim knows that reparations may not equal her loss, the socially optimal level of care deviates from the wrongdoer's optimal private level of care.*

Proof: This results from proposition 1.

Proposition 1 and its corollary show that SAM is only a special case of a more general accident model, this is what we show below.

3.2 Discussion

We now consider whether the formation of different beliefs about damages by the parties may violate the foundations of the SAM. We rely on the two-sided negative externality model in which agents' utility functions express their subjectivity. Note that there is no indication that these functions must take on common values or assume similar valuations. Similarly, when considering SAM, there is no indication that the victim and perpetrator should assess the level of loss in the same way. Moreover, as Proposition 1 shows, it does not say whether the victim must or may anticipate whether or not the court will fully compensate his or her injury. Kaplow and Shavell (1996) note that the victim can legitimately consider that her loss will not be fully reimbursed. To simplify the argument, consider that the victim assesses L_{V0} as expected damages. However, she expects that the court will under-evaluate this loss and that she will receive only a ratio$(1-\alpha)$, $0 \leq \alpha \leq 1$ of it, (i.e. she expects to receive $(1-\alpha)L_{V0} \leq L_{V0}$). This means that she believes that a percentage of the loss (αL_{V0}) will remain her burden. Then, the expected social welfare function becomes:

[7] $$ESW_0(x) = \phi_0(x) + \Psi_0(x) = u + v - x - p(x)(L_{I0} + \alpha L_{V0})$$

As that the victim may form beliefs about her estimated damages could lead to think that she prefers ambiguity or is averse to it. This would be tantamount to implicitly introducing uncertainty and contradict the assumption of a risky world. However, the objection does not hold because this assumption does not change the nature of the victim's utility function which remains neutral to risk. In line with the bilateral externality model, here the parties make subjective assessments which result in various levels of care to the socially optimal level (see appendix 1):

[8] $$x^* = x^*(L_{I0} + \alpha L_{V0})$$

and the injurer's optimal level:

[9] $$x^0 = x^0(L_{I0})$$

We can easily check that $x^* > x^0$ and $x^* = x^0$ when $\alpha = 0$ (see appendix 1).

Thus, the assumption of risk neutrality does not preclude the existence of divergent beliefs between the tortfeasor and the potential victim. With respect to SAM, the question to be raised is the following: how is it that the parties assess damages in the same way? We might assume that ex ante, following an unspecified process, they agree on a given value. However, (Kaplow and Shavell, 1996) show that in most cases, agreement is impossible.

4. Negligence rule and divergent views

In negligence, the wrongdoer must compensate the victim if the court finds him or her to be at fault, negligent or reckless. The court must find a causal link between the wrongful conduct and the injury and decide what level of care is required. Therefore, if the wrongdoer is not at fault, the victim suffers harm. Analytically, the social care level which the injurer should respect is $x^* = x^*(L_1)$ (See appendix 1). Then, if the defendant has acted with due care by determining x^0 such that, $x^0 = x^0(L_0) \geq x^*$, the victim will support the entire loss L_{V1}.

Without any ex-ante coordination process the parties cannot agree about the expected damages assessment. After an accident occurrence, before the court gives its judgement, the parties' estimate the effective damage as:

$$\tilde{L}_{\tau=1} = \{L_{I1,}L_{V1}\}, \text{with } L_{I1} \neq L_{V1}$$

After the court's judgement where d' is the value of the damages decided by the judge, and both agents then J_1 express their assessed loss levels:

$$J_1 = \begin{cases} \{L_{I1} - d', L_{V1} - d'\}, & x < x^*, \qquad (a) \\ \{0, L_{V1}\}, & x \geq x^* \qquad (b) \end{cases}$$

Then, if $x < x^*$, the wrongdoer is held liable by the Court and bears the damages burden, i.e. d'. This value does not correspond to both parties' initial forecasts. Implicitly, we consider that $L_{I1} < L_{V1}$ are the damages levels being claimed by the parties after an accident. The perpetrator minimizes them, and the victim inflates them.

Using the same argument, if $x \geq x^*$, the injurer is cleared of any liability and the victim will bear the whole loss. Facing any lack of consensus about the damages, how can the socially optimal care level be determined ex-ante? There is a methodological difficulty related to establishing the due care that should be brought ex-ante. Indeed, in the real world, even if courts use the probabilistic approach adopted by Judge Learned Hand, the parties know the due care level afterwards. In the SAM, this difficulty does not arise. The injurer "naturally" chooses the right care level by choosing the prevention level which maximizes his own payoff. Since this solution corresponds to the individual and optimal choice of care under strict liability, this level is ipso-facto the socially first-best care level. Furthermore, the victim knows that if the judge designates the perpetrator as faulty, her loss will be fully compensated. Under negligence, the injurer's expected payoff function expresses as:

[10] $$\Psi_0(x) = \begin{cases} u - x - L_{I0}p(x) & if\ x < x^* \\ u - x & if\ x \geq x^* \end{cases}$$

While the victim's expected utility function is:

[11] $$\phi_0(x) = \begin{cases} v - (\alpha L_{V0})p(x) & if\ x < x^*,\ (a) \\ v - L_{V0}p(x) & if\ x \geq x^*,\ (b) \end{cases}$$

Equation (a) in [11] is the victim's forecast about damages compared to the court's predictions. Then, even if the court finds the injurer liable, the victim considers that the compensation does not equate with her loss. Then, the expected welfare function becomes:

[12] $$ESW_0(x) = \begin{cases} v + u - x - p(x)(L_{I0} + \alpha L_{V0}) & if\ x < x^* \\ v + u - x - L_{V0}p(x) & if\ x \geq x^* \end{cases}$$

Naturally, this program allows two workable solutions depending on whether $x < x^*$ or $x \geq x^*$:

[13] $$x_v^* = \begin{cases} x_1^* = x^*(L_{I0} + \alpha L_{V0}) & if\ x < x^* \\ x_2^* = x^*(L_{V0}) & if\ x \geq x^* \end{cases}$$

Indeed, if the court exonerates the injurer from any liability, the victim bears the reparations burden, and her assessment of the loss defines the first-best care level. Considering [13], the injurer faces three care levels including his own optimal level of care $x^0 = x^0(L_{I0})$. These values correspond to the following set: $\{x^0, x_1^*, x_2^*\}$. Then, what level should the injurer choose? If the injurer chooses x_1^* rather than x_2^* (because $x_1^* < x_2^*$), this means that the injurer believes that the judge will choose x_1^* as the socially first-best care level. However, the injurer could equally believe that the judge will choose x_2^*. Therefore, knowing x_1^* and x_2^* does not prevent the injurer to be involved in liability if he chooses x_1^* (when $x_1^* < x_2^*$). However, having chosen x_2^* which is the victim's assessment, involves escaping to any responsibility. However, the victim is likely to over-estimate her losses, and the inequality is verified in the following injurer payoff equation:

$$u - x_1^* - p(x_1^*)(L_{I0} + \alpha L_{V0}) > u - x_2^*$$

Putting it differently, choosing x_1^* (and accepting the risk of paying $L_{I0} + \alpha L_{V0}$ rather than x_2^*) could increase the injurer's expected profit. This result is due to both the assumption of risk-neutrality and the low probability of an accident $p(x_1^*)$ such that $\Psi_0(x_1^*) > \Psi_0(x_2^*)$. Here, the injurer does not implement the care level that maximizes his expected payoff because he will take account of his own assessment of the damages. He will choose $x_v^*, v = 1{,}2$ as the second-best option based on the believe that the court might find him liable. Then, because of the existence of two potential social care levels under negligence, there is no structural link to the strict liability regime as assumed in the SAM.

5. Comparing Strict liability and Negligence rule

Reaching this step the comparison between both regimes is inevitable. Then, under strict liability we recall that the expected social welfare function becomes:

[7] $ESW_0(x) = \phi_0(x) + \Psi_0(x) = u + v - x - p(x)(L_{I0} + \alpha L_{V0})$ (With $0 \leq \alpha, \alpha \leq 1$),

and under the negligence rule from [14], considering $(L_{V0} - d) = \alpha L_{V0}$, we get:

[12] $$ESW_0(x) = \begin{cases} v + u - x - p(x)(L_{I0} + \alpha L_{V0}) & if\ x < x^*\ (a) \\ v + u - x - L_{V0}p(x) & if\ x \geq x^*\ (b) \end{cases}$$

We notice that for $x < x^*$, if $d = \alpha\, L_{V0}$, then from [7] and (a) from [12] match in such a way that both socially first best care level are identical:

[13] $x^* = x_1^* = x^*(L_{I0} + \alpha L_{V0})$ for $x < x^*$

However, this is not the case, when $x \geq x^*$, there the victim bears the whole loss under negligence. Then, the social welfare is (b) from [12]. It follows that formally, there, the social optimal care level should be:

$$x_2^* = x^*(L_{V0})$$

A methodological shortcut might encourage solving the question by considering that the injurer should, in both cases, grant the level of prevention to the victim's estimate of damage, i.e., $x_2^* = x^*(L_{V0})$. This solution, although attractive, is far from being a viable one because it could involve a too high care level for the injurer's resource such that $(u - x_2^* - p(x_2^*)L_{V0} < 0)$, then, the incentive to continue activity is zero.

With the hypothesis of divergent expectations, which is common to all cost-benefit models (Proposition 1) where it takes the form of divergent utility functions, the injurer under a strict liability regime has no choice but to implement the level that maximizes his profit function because he has no information on the victims' assessment of the level of damage. This applies to both liability regimes. It turns out that, having no knowledge of the level of prevention required by the victim, the tortfeasor can only implement the level that minimizes his accident cost function (and maximizes his utility level). This situation calls for the following remarks.

First, considering a more general accident model than the basic one implies that the perpetrator no longer "spontaneously" establishes the socially optimal level of care. Secondly, knowing that the virtual regulator cannot operate directly concerning private accident relationship between perpetrator and victim, who can establish it?

Second, in our general model, the judge is at the heart of the process of determining responsibility. Consequently, the notions of errors of judgment in relation to the socially optimal level of prevention do not have the same meaning as in the standard model. In the context of strict liability, whatever the level of prevention, the judge will limit himself or herself to determining the amount of compensation. In the case of negligence, the victim will be considered (i) imperfectly compensated after the occurrence of an accident if the judge considers the diligence of the author of the damage to be insufficient, or (ii) not compensated at all if the judge considers it to be sufficient. In this case, the victim will bear the full cost of the damage. It is therefore difficult to assess which system is more effective than another in terms of prevention.

To answer this question, the comparison of equations [7] and [12] shows that, considering both regimes, the optimal levels of social prevention match when the wrongdoer does not provide an adequate level of prevention under negligence and is placed "as" if he were subject to strict liability.

Does this comparison leads inferring the superiority of strict liability on negligence? In fact, the social cost of the accident is based on the evaluation of the victim's potential losses. As Polinski and Shavell (1996) show it, the victim's losses can be overestimated. However, they are the result of her ex-ante subjectivity and there is no endogenous way to make them objective. The victim's assessment about her anticipated losses raises the same questions as the assessment of the damage by the injurer. The only factor that would make it possible to choose strict liability regime over negligence is that, in the generalized risk model, the occurrence of an accident leads to even partial compensation of the victims.

6. The impact of uncertainty/ambiguity on the SAM accident model

From the mid-2000s, Bigus (2006), Teitelbaum (2007) introduced ambiguity insights in the SAM fundamental structures. Several contributors completed these attempts (Langlais(2012), Franzoni (2013) and Franzoni (2015), Mondello (2012), Lampach and Spaeter (2016)). For instance, Langlais (2012) Franzoni (2013) and Franzoni (2015) consider a social welfare function built from the tortfeasor and the victim's preferences. For Franzoni, the agents' utility functions come from Klibanof and al. (2005)'s model (smooth ambiguity). He does not consider ambiguity aversion as a cognitive bias, but a genuine component of welfare as Ellsberg (1961). Chakravarty and Kelsey (2016) analyze the welfare implications of tort rules in a bilateral accident model where both injurer and victim, each Neo-capacity utility maximizer, invest in care. Both agents derive utility from an unobservable action, which may lead to the accident. When the agents only choose the level of care, under negligence, ambiguity-averse agents are more likely to choose the optimal amount of care. Second, when agents choose care and the unobservable action, they propose a system of negligence, plus punitive damages which give optimal level of both care and unobserved action by injurers and victims.

Langlais (2012) also keeps the aggregation of agents' preferences. He shows that Knight's uncertainty leads to a socially inefficient care level, and he considers a global non-insurable risk where the polluters invest in reducing risk technologies. Compared to victims, the polluter feels a lesser degree of risk aversion and ambiguity. Then, his estimate of the prejudice likelihood also corresponds to a lower ambiguity degree. Langlais' model is based on supposed pessimistic and risk-averse agents. Agents are maximizers Rank Dependent Expected Utility; he is close with Bigus (2005)'s work. He shows that the required security level is higher than in a neutral to risk economy and that no liability regime is significantly efficient.

In what follows we focus on Teitelbaum (2007)'s paper that initiated the introduction of ambiguity in the SAM. This author proposed a new model that shares little with the CAM. Indeed, he assumes that injurer is a Choquet Expected Utility maximizer (CEU). This means that the latter is no longer neutral to risk, but that he expresses his ambiguous and optimistic/pessimistic views about an "official" probability distribution of risk, while the victim is supposed to be neutral to risk. The CEU is also called Neo-capacity utility function. This function comes from the ambiguity theory reformulation made by Chateauneuf, Eichberger, and Grant (2007) among others. As a result, the injurer attributes specific weights to extreme events that involve distinguishing a maximum and a minimum utility level plus and utility expectancy. These weights express his degree of aversion/preference for ambiguity and its degree of optimism/pessimism. The social accident cost function expresses risk neutrality. Then, the first-best level of care that the injurer chooses is not socially optimal and this breaks equivalence between strict liability and negligence rule. Indeed, the injurer's level of care decreases with ambiguity if he is optimistic and decreases with his optimism degree. The relationship varies in the opposite with decreasing ambiguity and pessimism. As pessimism leads to more precaution, negligence rule seems superior to strict liability.

Teitelbaum's model is based on the difference between the determination (setting) of the socially optimal level of prevention by a rational planner and the level of prevention actually implemented by the injurer. The status of the level determined by the regulator is questionable. Indeed, on the one hand, Teitelbaum is aware that in doing so he is breaking with one of the foundations of the basic model as indicated in the first sentence of footnote 27 of his article: « *In contrast to the standard model, in the present model minimizing total accident costs is not necessarily equivalent to maximizing the sum of the utilities of the injurer and the victim.* » (Teitelbaum, 2007, p.446, fn.27). As a result, the regulator's choice could be arbitrary. Recognizing this problem, Teitelbaum proposes in his Appendix B a procedure for an "objective" determination of this level: « *However, c* is the level of care that would be chosen by a rational social planner as part of a Pareto-optimal allocation (x* in our notation (note of the author))(see Appendix B). Accordingly, I maintain that minimizing total accident costs is the appropriate social goal*."

However, Teitelbaum fails to demonstrate that the first-best level of care comes from the aggregation of agents' preference. For instance, the victim's assessment of damage lacks fully. Consequently, Teitelbaum does not introduce ambiguity in the canonical accident model but in a different where the regulator's utility function is not built by aggregating the agents preference.

Here we develop the beliefs of both agents about major damages under the radical uncertainty chosen by Teitelbaum but applied to damage assessment. It appears that uncertainty is unnecessary to show the limits of CAM that can be reached by the generalized standard risky model with heterogenous assessment. We begin by showing the foundation of ambiguity theory leading to conceiving the neo-additive capacities. Then, let $\mathcal{E}$ be the finite set of the states of nature that corresponds to a maximum damage involved in a major accident. $\mathcal{E}$ is included in the σ-algebra of $\mathcal{E}$. We define a set of A issues (value of damages) and a set of simple functions Φ that verify the following point-to point mapping: $\Phi = \{f: \mathcal{E} \to A\}$. These ones map the damage set in $A, A \subset \mathbb{R}$, such that for each element $a_v \in A$, (a_v is also called an act), we define the following ordering between the acts: $a_1 \geq a_2 \ldots \geq a_n$. Then, if $E_p(a)$ is the expected value of damage, now, the damage function writes as:

[14] $$E_p(a) = \int_{\overline{d}}^{l} a\, p(a) da$$

(Where l and $\overline{d}$ are defined below).

And the neo-additive capacity is (see appendix 1 for details):

[15] $$\mu(A \,/\, p, \delta, \beta) = \begin{cases} 0 \; for \; A = \emptyset \\ \delta\beta\nu_0(A) + \delta(1-\beta)\nu_1(A) + (1-\delta)p(A) \; for \; \emptyset \subsetneq A \subsetneq \mathcal{E} \\ 1 \; for \; A = \mathcal{E} \end{cases}$$

For $\beta, \delta \in [0,1]$.

Let $\nu_0(A) = \mathrm{Inf}(f) = \overline{d}$ be the lowest damage cost and $\nu_1(A) = \mathrm{Sup}(f) = l$), the highest one. The values δ and β represent the weight that the injurer allocates to the extreme events. Here δ is the preference for ambiguity and $\beta$the pessimism degree[6]. Then for $\emptyset \subsetneq A \subsetneq \mathcal{E}$ the neo-additive capacity is:

[16] $$\mu(.) = \delta\beta L + \delta(1-\beta)\overline{d} + (1-\delta)p(A)$$

We obtain a Choquet's integral by integrating the capacity $\mu(.)$ that represents the expected costs related to a major accident:

[17] $$V_p(A/p, \delta, \beta) = \delta\beta L + \delta(1-\beta)\overline{d} + (1-\delta)E_p(a)$$

Hence, the Choquet integral of a neo-additive capacity consists of the following elements, i) The maximum value of the costs associated with a major accident (L), ii) Their minimum ($\overline{d}$), iii) Their expected value $\left(E_p(a)\right)$.

Considering the tortfeasor and the victim, we limit the analysis to their accident cost function to simplify the writing of their optimization program. Then, their respective situation is the following one:

[6] See Teitelbaum(2007) for a more precise explanation about this point.

The victim: Let, respectively be δ and γ, the degree of ambiguity aversion and the level of pessimism with $1-\gamma$ the optimism level ($1 \geq \delta,\gamma \geq 0$). Considering that $\overline{d}=0$, her neo-additive capacity, expresses as:

[18] $$V_p(.) = \delta\gamma\alpha L_V + (1-\delta)p(x)\alpha L_V$$

(Here $E_p(x) = p(x)\alpha L_V + \big(1-p(x)\big)0 = p(x)\alpha L_V$).

Here, the victim does not know if the amount the judge considers the perpetrator as liable, whether she will pay a part of the repairs αL_V or not at all. Her neo-additive capacity depends on both her pessimism and ambiguity levels. If her pessimism is absolute ($\gamma = 1$), then, $V_p(.) = \big[\delta\big(1-p(x)\big) + p(x)\big]\alpha L_V$, this means that her estimation compared to the mean of her expected loss $\alpha L_V\, p(x)$, is increased by a factor $\delta\big(1-p(x)\big)$.

The injurer: Let, respectively be λ and μ, the injurer's degree of ambiguity aversion and the level of optimism with $(1-\mu)$ his pessimism level ($1 \geq \lambda,\mu \geq 0$), his neo-additive capacity, expresses as:

[19] $$I_p(.) = \lambda\mu L_I + x + (1-\lambda)\, p(x) L_I$$

Comparing with the injurer's expected cost, $p(x)L_I$ the condition for minoring the expected accident cost, i.e. $I_p(.) \leq\ x + p(x)L_I$ is that: $\mu L_I \leq\ p(x)L_I$ or still $\mu <\ p(x)$ and this means that his level of pessimism must be below the probability of an accident.

With λ different from 1, the injurer intends to define $x^{00} \geq 0$ the level of safety i.e. considering the first order conditions: $I'_p(x^{00}) = 0$ or,

[20]

$$p'(x^{00}) = \frac{-1}{(1-\lambda)L_I}$$

We dispose of the whole tools to build the Social Expected cost function by aggregating the agents' accident cost function:

[21] $$ESC_p(.) = \delta\gamma L_V + \lambda\mu L_I + x + p(x)[(1-\lambda)\, L_I + (1-\delta)\alpha L_V]$$

Then, it is easy to determine the first-best care level, which expresses as $x^{**} \geq 0$, such that, $ESC'_p(x^{**}) = 0$, or,

[22]

$$p'(x^{**}) = \frac{-1}{[(1-\lambda)\, L_I +\ (1-\delta)\alpha L_V]}$$

Consequently, we can check the discrepancy between the injurer's optimal level of care, and the social first-best care level. This result is not due to the introduction of uncertainty but from the different assessment of damage by the victim and the injurer. Furthermore, the victim knows that she will not be fully compensated for her loss. It is easy to see that if $\lambda = \delta = 0$, then $p'(x^{**}) = p'(x^{*})$, i.e. we find the result reached with the global accident model we defined above.

This result confirms that the nature of uncertainty (risk or radical uncertainty) is not a factor that breaks the main result of SAM: the injurer naturally chooses the socially first best of care by settling his optimal care level. Considering a global accident model under risk but with divergent opinion between potential tortfeasor and victim is sufficient. We do not push further the analysis concerning the equivalence of strict liability and the negligence rule, it easy to understand that they do not match in the general case.

7. Conclusion: Methodological consequences

Introducing uncertainty makes more realistic the "Law & Economics" tort law analysis but does not bring new insight to enlarge the SAM. This contribution shows that the standard accident model comes from strong assumption derived from a more general model. What would have been the theoretical consequences of comparing liability regimes if its authors had proposed a global framework? Regardless of the liability regime, if the parties assess the costs of damages differently, and/or if the victim knows that the damages will not compensate for her loss, then the optimal social and private levels of prevention do not match. Similarly, in the context of negligence, this leads to the judge alone choosing the level of care that the wrongdoer should have applied to the activity, as in the real world.

This raises the question of the meaning of comparing liability regimes on the basis of their respective performances. Thus, while economic efficiency is one criterion to be considered, it is not the only one when decision-makers must choose a liability regime. This contradicts the SAM where strict liability and negligence may be perfect substitutes. This view is also assumed by the many contributions which consider the effectiveness criterion to be the main factor for evaluating the regimes. None of this question the efficiency concept itself; it is relevant to assess the impact of a legal decision and must preserve both fairness and economic sustainability. However, the efficiency concept should be applied to the relevant field of each regime.

Then, considering the different assessments of damage by the parties suggest significant changes in the area of liability regime comparison. Most significant is that fault-based liability (negligence) and no-fault based liability (strict liability) are not substitutable but complementary regimes. As already specified by the judges' and lawyers' practice, strict liability and the negligence rule apply to different areas. Strict liability is related to ultra-dangerous activities which could inflict huge harm on the victim and where proving owner or manager liability is long and costly (e.g. industrial accidents, road accidents, heavy industry accidents, energy related accidents, major pollution incidents, etc.). Economic tort law, by promoting the standard model tends to make both regimes substitutable. However, negligence applies to activities with limited risk and strict liability to hazardous activities, no-bridge can be built between them. This distinction has been used by jurists and legislators since the late 19th and early 20th centuries. Jurisprudence and legislation tend to confirm this situation. Rather than attempting to assess which regime works better, we should examine the conditions for improving the application of these regimes to the areas where they apply.

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Appendix 1

A generic calculus

Let A, B be two positive numbers such that $A > B$. Consider the following two functions which we call "expected cost functions":

1. $v(x) = x + p(x)A$ and $w(x) = x + p(x)B$
2. $p(x)$ is a probability density with $p'(x) < 0$ and $p''(x) > 0$, this means that the derivative $p'(x)$ is an increasing function.
3. From the first order condition, we get x^A and x^B which we assume to be positive such that:

$$p'(x^A) = -\frac{1}{A}$$
$$p'(x^B) = -\frac{1}{B}$$

As $A > B$, it follows that $x^A > x^B$. Indeed, $\frac{1}{A} < \frac{1}{B}$ and, obviously,

$$p'(x^A) = -\frac{1}{A} > p'(x^B) = -\frac{1}{B},$$

then, since $p'(x)$ is increasing,

$$x^A > x^B$$

This methodology and this result are generic in our paper.
Then, we will write the solution as:

$$x^A = x^A(A) \text{ and } x^B = x^B(B)$$

Appendix 2

Proof of Proposition 1

This demonstration complements Shavell (1982) and is conducted in two stages. We first prove necessity and then sufficiency. However, note that L_1 is the court's assessment of the damages and d is the compensation level it requires from the defendant, with $L_1 = d'$.

a) Necessity

To prove necessity, consider that following an accident, the judge assesses an amount L_1 to be the cost of the accident that is at odds with the victim's estimate L_{V1} (with $L_{V1} \neq L_1$).

i) However, let us consider that ex ante, the victim believes that the judge's assessment corresponds to what she believes to be full compensation.:

$$L_{V0} = d.$$

Then, ex-ante, her expected utility function will be:

$$\phi_0(x) = v - p(x)(L_{V0} - d) = v - p(x)0 = v$$

Consequently, considering that the injurer's utility remains unchanged, the expected social welfare function is:

$$EW_0(x) = \max_{x \geq 0}\{\Psi_0(x) + \phi_0(x)\} = u + v - x - p(x)L_{I0}$$

The equilibrium condition corresponds to the *standard* model where:
$x^* = x^*(L_{I0})$ and $x^0 = x^0(L_{I0})$ with $x^* = x^0$ (see appendix 1).

ii) Now consider that, **ex-ante,** the victim knows that, after an accident, the judge's assessment is different from hers $L_{V0} \neq L_1$. She assesses the level of compensation as $L_1 = d$[7]. Then, her expected utility function becomes:

$$\phi_0(x) = v - p(x)(L_{V0} - d)$$

and the expected social welfare function is :

$$EW_0(x) = \max_{x \geq 0}\{\Psi_0(x) + \phi_0(x)\} = u + v - x - p(x)\big(L_{I0} + (L_{V0} - d)\big)$$

It follows that the socially optimal prevention, x^* should be:

$$x^* = x^*\big(L_{I0} + (L_{V0} - d)\big)$$

Since the perpetrator's optimal level of prevention is $x^0 = x^0(L_{I\tau=0})$, it follows that $x^* \neq x^0$. As $L_{I0} + (L_{V0} - d) > L_{I0}$ because by assumption $(L_{V0} - d) > 0$, then in accordance with Appendix 1, $x^* > x^0$.
Then, by i) and ii) the necessary condition is proved.

b) Sufficiency

Victim and injurer assess the damages $L_{V0} \neq L_{I0}$ differently. However, since the victim knows that the court forces the injurer to compensate the damage caused in full:

$$\forall L_1 > 0, L_1 = L_{V1} \text{ and } \exists d' > 0: L_1 = d', \text{then } L_{V1} = d'$$

Consequently, as in i) in a) above, the victim feels confident that her expected utility is constant before and after the accident:

$$\phi_0(x) = v - p(x)(L_{V0} - d) = v - p(x)0 = v$$

This result is independent of the existence of a divergence between injurer and victim about the damages. Indeed, we would get the same result if they agreed i.e. $L_{V\tau=0} = L_{I\tau=0} = L$ as in the SAM.
Obviously, as before,

$$EW_0(x) = \max_{x \geq 0}\{\Psi_0(x) + \phi_0(x)\} = u + v - x - p(x)L_{I0}$$

and $x^* = x^*(L_{I0}), x^0 = x^0(L_{I0})$ with $x^* = x^0$.

Consequently, we need only to show that ex-ante, the victim's belief about full compensation is sufficient to induce her to believe that her expected utility function will remain constant.

QED

[7] To make things realistic, she may estimate that her loss will be x% compared to her effective compensation.

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