Efficient liability law with costly insurance

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6 August 2025

Abstract

This paper examines how insurance considerations should influence the design of liability rules, based on the realistic assumptions that individuals are risk-averse and that private insurance is costly. Empirical evidence indicates that insurance contracts often carry substantial loading factors—ranging from 30% to 40%—and that individuals display marked risk aversion when exposed to uncertain losses. These features have important normative implications for tort law. Under a negligence regime, risk aversion and costly insurance justify raising the standard of care. Under strict liability, the victim's limited access to affordable insurance supports higher damage awards. The analysis advances the argument that courts should not evaluate precautionary behavior solely based on its expected harm reduction, but rather on its insurance value—namely, its capacity to protect risk-averse parties from uncertain losses.

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Keywords: *negligence law, strict liability, insurance*

JEL Code: K13

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[†] I would like to thank two anonymous referees for constructive feedback. I am also grateful to Claude Fluet, Fernando Gomez, Eric Langlais, Avi Tabbach, and seminar participants in Siena, Turin (EALE) and Rome (ISLE) for helpful comments.

1 Introduction

It is widely accepted that courts should not base their decisions on the insurance choices of the parties involved. However, in designing liability rules, the availability of insurance plays a central role. Product liability law, for instance, is explicitly grounded in the assumption that producers are better positioned to purchase insurance and distribute the risk of injury to the public as a "cost of doing business."[1]

This paper builds on the observation that, while insurance is generally available to the parties, it is costly. In most insurance markets, administrative expenses account for 30-40% of the premium. These include underwriting costs (e.g., pricing, marketing, and issuing policies) and loss adjustment expenses (e.g., investigating, defending, adjusting, and settling claims) (see Rejda et al. (2020)). Such costs directly impact liability law, challenging the traditional separation between loss-spreading and deterrence. This traditional view - where insurance manages risk distribution while tort law ensures deterrence- breaks down when private insurance becomes expensive. In response, this paper reconceptualizes the liability system as a dual-function institution that both allocates risk and incentivizes care.

I analyze a standard costly-precautions framework under the realistic assumption that both victims and injurers are risk-averse and have access to costly insurance. The goal is to understand how the liability system, in conjunction with the insurance sector, can optimally manage accident risks.[2] The analysis focuses on the two most common liability regimes: negligence and strict liability.

To draw insights from the theory of insurance demand, I examine a setting in which precautions reduce the *magnitude* rather than the *probability* of harm. For instance, appropriate medical treatment may shorten hospitalization, and proper cap design may mitigate harm from a hot beverage spill.[3]

[1] Justice Traynor in *Escola v Coca Cola Bottling Co., 1944*. Loss spreading is explicitely mentioned in the Restatement (Third) of Product Liability, § 2 cmt. a. For an international perspective, see Cappelletti (2022).

[2] Tort liability and the insurance system have been described as "binary stars," orbiting one another and forming a shared gravitational field (Abraham (2008)).

[3] Under risk neutrality, there is essentially no difference between precautions that reduce the mag-

Leveraging the concept of the risk premium - the amount of money individuals are willing to pay to avoid uncertain losses - the analysis yields clear and intuitive results. First, assuming insurance is unavailable, I show that risk aversion justifies a higher standard of care under negligence. Since compliant injurers are not liable, losses fall on victims; thus, the cost of harm is magnified by risk aversion. The optimal standard increases with the victim's risk aversion and decreases with their income (under decreasing absolute risk aversion, DARA).

When insurance is available but costly, victims purchase partial coverage. In this context, the optimal standard of care depends exclusively on the cost of precautions, the expected reduction in harm, and the insurer's loading factor. Individual risk preferences and income levels become irrelevant for determining the efficient standard of care.

Under strict liability, the distribution of losses depends on the level of damage awards. In the absence of insurance, optimal damages are undercompensatory: they rise with the victim's risk aversion and fall with their income (again, under DARA). When both parties have access to costly insurance, damages remain undercompensatory only if victims can insure at a lower cost than injurers—a plausible assumption that contrasts with Justice Traynor's classic reasoning in *Escola*. In such cases, optimal damages increase with the victim's cost of insurance.

While the risk allocation function of tort law has long been discussed in legal scholarship, formal economic analysis on this issue remains limited. In his seminal work, Shavell (1982) examines whether the availability of first-party and third-party insurance undermines the effectiveness of the liability system. He concludes that it does not: although insurance may weaken incentives to take precautions, the overall outcome remains efficient. Shavell's analysis assumes that precautions reduce the probability of harm rather than its severity, that insurance markets are perfectly competitive, and that insurance is cost-free.[4]

nitude of harm and those that reduce the probability of harm. However, under risk aversion, the two cases can lead to different outcomes, as first noted by Ehrlich and Becker (1972) in a model involving a single agent who can engage in either self-protection (actions that reduce the probability of harm) or self-insurance (actions that reduce the severity of harm). This single-agent problem has inspired a rich body of literature. See Courbage et al. (2013).

[4] A related literature considers the impact of insurance, possibly mandatory, on judgement proof

To simplify the analysis, most contributions addressing risk aversion in tort law assume specific utility functions (and focus on precautions that affect the probability of harm). Greenwood and Ingene (1978) analyzes optimal risk-sharing rules between a polluting firm and its victims using a local approximation approach. Nell and Richter (2003) compare strict liability and negligence under CARA (Constant Absolute Risk Aversion) utility functions, examining the optimal liability rule as the number of victims increases. They demonstrate that neither strict liability nor negligence is efficient in such cases, also in the case in which injurers can buy costly insurance. In Franzoni (2017), I investigate situations where the causal link between conduct and harm is uncertain (i.e., subject to "ambiguity"), using a specifically designed Arrow-Pratt approximation. My findings show that strict liability is preferable to negligence when the injurer has a lower degree of uncertainty aversion than the victim and can make more precise estimates of the probability of harm.

Dari-Mattiacci and Langlais (2012) also address harm-reducing precautions, focusing on cases where harm may include a non-pecuniary component and parties have state-dependent utility functions. They analyze the joint problem of optimal precaution and optimal risk sharing - the 'first-best' policy - and show that standard liability rules are necessarily second-best. In contrast, this paper focuses exclusively on fully compensable pecuniary harms and does not attempt to characterize the first-best. Instead, it isolates the effects of risk aversion and costly insurance on the performance of traditional liability rules.

A key issue addressed in the literature is whether the personal characteristics of the parties should influence the design of liability rules.[5] Arlen (1992) focuses on the role of the injurer's wealth, arguing that wealthier defendants should be held to higher standards of care. This argument, as later clarified by Miceli and Segerson (1995), is based on maximizing a utilitarian social welfare function that assigns a positive value to transferring wealth from the rich to the poor. If one sets aside redistributive concerns and considers only Pareto efficiency, wealth has no effect on optimal liability rules -

defendants. See, among others, Shavell (1986), Polborn (1998), and Faure (2006).

[5] This can be taken to the extreme with personalized liability rules. See Guerra and Hlobil (2018) and Ben-Shahar and Porat (2021).

provided that both parties have access to costless insurance. In such cases, perfectly insured parties behave as if they are risk neutral, rendering their income levels and degrees of risk aversion irrelevant. This paper extends that irrelevance result to more realistic settings where insurance is costly and parties are only partially insured. More importantly, it shifts the focus to a different factor that shapes the design of liability rules: the cost of insurance. As noted above, both the optimal standard of care under negligence and the optimal level of damages under strict liability increase with the victim's insurance cost.

In what follows, I first examine the impact of risk aversion on the liability system in the absence of insurance and then introduce the availability of costly insurance.

2 Negligence rule

Let us consider the case in which the risk prospect depends on the precaution level x taken by a party called "injurer."[6] Precaution costs are $c(x)$, with $c' > 0, c'' \geq 0$. Let $h(x)$ be the harm suffered by the victim, with $h' < 0$, $h'' \geq 0$: the greater the precaution taken by the injurer and the smaller the (pecuniary) harm suffered by the victim.

In this section, I consider the case in which the loss falls on the victim as far as the injurer meets the standard of care $\overline{x}$ (the "due care" level). If the injurer does not meet the standard, she has to pay damages equal to $d = h(x)$.[7] The analysis also captures the case in which the injurer is subject to regulatory standards (like emission standards or technology standards) enforced through pecuniary or criminal sanctions.

[6] By referring to an agent as an "injurer," I am implicitly placing the model within a particular legal context. This context defines the scope of causation (A causing B, B causing C, etc.) and assigns responsibility along that chain.

[7] Alternatively, one could assume that damages are equal to the additional harm resulting from the untaken precautions: $d = h(x) - h(\overline{x})$. The latter formulation accounts for the causation requirement of negligence law (see Kahan (1989) and Schweizer (2016)). Since in equilibrium the injurer will meet the standard of care, for our purposes the two formulations are equivalent.

The expected utility of the injurer is:

$$EU_I(x) = \begin{cases} (1-p)\,u(y_I - c(x)) + pu(y_I - c(x) - h(x)) & \text{for } x < \overline{x}, \\ u(y_I - c(x)) & \text{for } x \geq \overline{x}, \end{cases} \tag{1}$$

which can also be written as

$$EU_I(x) = \begin{cases} u(y_I - c(x) - p\ h(x) - RP_I(h(x))) & \text{for } x < \overline{x}, \\ u(y_I - c(x)) & \text{for } x \geq \overline{x}. \end{cases}$$

where y_I is the injurer's income and $RP_I(h(x))$ is the risk premium associated with the prospect of losing $h(x)$ with probability p.

Maximization of EU_I is equivalent to minimization of the injurer's loss

$$L_I(x) = \begin{cases} c(x) + p\ h(x) + RP_I(h(x)), & \text{for } x < \overline{x}, \\ c(x), & \text{for } x \geq \overline{x}. \end{cases}$$

The concept of injurer's loss greatly simplifies the presentation, and I will heavily build on it. In places, however, it will be necessary to go back to the original expected utility formulation.

The expected utility of the victim is

$$EU_V(x) = \begin{cases} v(y_V), & \text{for } x < \overline{x}, \\ (1-p)\,v(y_V) + pv(y_V - h(x)), & \text{for } x \geq \overline{x}, \end{cases} \tag{2}$$

where y_V is the victim's income, p is the accident probability and $h(x)$ the harm suffered.

The maximization of $EU_V(x)$ is equivalent to the minimization of the victim's loss:

$$L_V(x) = \begin{cases} 0 & \text{for } x < \overline{x}, \\ ph(x) + RP_V(h(x)) & \text{for } x \geq \overline{x}, \end{cases}$$

where $RP_V(h(x))$ is the risk premium of the victim.

The injurer will meet the standard of care $\overline{x}$ if

$$\textit{Condition } S\text{:}\;\; c(\overline{x}) < \min_{x} \left(c(x) + ph(x) + RP_I(h(x)) \right)$$

is met. The term on the right hand side represents the injurer's minimal loss when she bears the harm. Condition S is not met when the standard is set to such a high level that bearing liability is actually cheaper than meeting the standard. For our purposes, what matters is that Condition S is met at the optimal standard. In Appendix A1, a simple sufficient condition for S to hold at the optimum is provided. If Condition S is not met at the optimum, the injurer is liable for the harm caused and the analysis of Section 3 below (strict liability) applies.

Let us assume that Condition S is met and that the injurer meets the standard of care $\overline{x}$. The efficient standard is obtained from the minimization of Social Loss (see Appendix A2):

$$SL = L_I(\overline{x}) + L_V(\overline{x}) = c(\overline{x}) + ph(\overline{x}) + RP_V(h(\overline{x})).$$

The optimal standard solves

$$c'(\overline{x}^*) = -ph'(\overline{x}^*) - h'(\overline{x}^*)\, RP'_V(h(\overline{x}^*)). \tag{3}$$

The marginal cost of precaution should be equal to its marginal benefit, which includes the reduction in expected harm and the reduction in the risk borne by the victim.

A better insight can be obtained by delving in the risk premium expression. Using (2), the optimality condition becomes:

$$\underbrace{c'(\overline{x}^*)}_{\text{marginal cost}} = \underbrace{-ph'(\overline{x}^*)\ \frac{v'(y_V - h(\overline{x}^*))}{(1-p)\,v'(y_V) + pv'(y_V - h(\overline{x}^*))}}_{\text{marginal benefit}} \equiv b'(\overline{x}^*). \tag{4}$$

The marginal benefit of precaution is equal to the amount of income that the victim is willing to pay (ex-ante) to benefit from a reduction in the magnitude of harm. The increase in utility due to the reduction in harm is converted in dollars by dividing it by the marginal utility of income before the accident occurs.

The marginal benefit $b'(x)$ corresponds to the victim's willingness to pay for insurance. We have: $b'(x) \geq ph'(x), b'(x) < h'(x)$, and $b''(x) < 0$.

The following properties can be easily established (see Appendix A3).

Proposition 1 *The optimal standard balances the cost of precaution and the victim's willingness to pay for insurance.*

i) If the victim becomes more averse to risk, the optimal standard increases.

ii) If the probability of harm increases, the optimal standard increases.

iii) If harm uniformly increases given precautions, the optimal standard increases.

iv) When the victim's income increases, the optimal standard decreases if the victim has Decreasing Absolute Risk Aversion.

An efficient standard balances the costs and benefits of precaution. The benefits are evaluated through the victim's willingness to pay for harm reduction, representing their "demand for insurance." This demand is a function of the victim's income and risk aversion. Under the common assumption of Decreasing Absolute Risk Aversion (DARA), the standard should increase in response to a negative income shock. This is because a decline in income makes the individual more averse to risk and increases the benefit of insurance against a fixed loss.[8]

***Discrete example 1*.** Let us consider the case in which the victim's utility function exhibits a constant degree of relative risk aversion equal to 0.3.[9] Let the risk of accident be equal to 1/100 and let the victim's income be equal to \$70,000 per year. Let us consider a precautionary measure that brings down the magnitude of harm, in case of accident, from \$50,000 to nil. The expected value of this measure is 1/100 x

[8] These observations mimic classic results in the theory of insurance demand. See Schlesinger (2013) for a survey.

[9] This is a realistic value consistent with the estimates of Barseghyan et al. (2013), based on insurance choices. Estimates of the degrees of risk aversion under CRRA span a large range, roughly from 0.2 to 4.5, and are affected by a variety of factors that include, among other things, the individuals' age, gender, and education level. US regulators use a conventional value of 1.4 (OMB (2023)).

50,000=\$500. Taking into account the victim's aversion to risk, the insurance value of the precautionary measure is \$583 (so roughly 17% larger than the expected value).[10]

Optimal standard when the victim is insured

Let us suppose that the victim can purchase first-party insurance with loading factor $\lambda_V \geq 0$. Given harm $h(x)$, the victim is offered insurance with a premium $r(\delta)$ that depends on the deductible δ (the amount of harm that remains on the victim's shoulders).[11] Specifically, the premium is

$$r(\delta) = (1 + \lambda_V)\, p\, (h(x) - \delta)\,.$$

The optimal deductible minimizes the victim's loss:

$$\begin{aligned} L_V &= r(\delta) + p\delta + RP_V(\delta) \\ &= (1 + \lambda_V)\, p\, (h(x) - \delta) + p\delta + RP_V(\delta)\,, \end{aligned}$$

where $RP_V(\delta)$ is the risk premium associated to the prospect of losing δ with probability p.

The optimal deductible δ^* solves (at an interior solution):

$$\begin{aligned} -(1 + \lambda_V)\, p + p + \frac{\partial RP_V(\delta^*)}{\partial \delta} &= 0, \text{ i.e.} \\ \frac{\partial RP_V(\delta^*)}{\partial \delta} &= \lambda_V p. \end{aligned} \tag{5}$$

The optimal deductible balances the cost of insurance with the benefit of a reduced risk burden. The higher the loading factor, and the higher the deductible. As far as the loading factor is positive, the victim buys less than full insurance.[12] If the loading factor is very large, $\lambda_V > \frac{1}{p}\frac{\partial RP_V(h(x))}{\partial \delta}$, the victim prefers not to buy insurance and $\delta^* = h(x)$.

[10] This value is relatively insensitive to the probability of harm (the scaling factor is roughly the same with $p = 1/100$ and $p = 1/10,000$).

[11] A share of the harm could also remain on the victim's shoulders due to the deliberate exclusion of specific types of losses.

[12] We cannot have $\delta^* = 0$ because $\frac{\partial RP_V(0)}{\partial \delta} = 0$: for infinitesimal losses, the victim behaves as if he was risk-netural.

The optimal standard $\overline{x}^*$ solves now:

$$\min_{\overline{x}} SL = L_I + L_V = c(\overline{x}) + (1+\lambda_V)\, p\,(h(\overline{x}) - \delta^*) + p\delta^* + RP_V(\delta^*),$$

with

$$\begin{aligned}\frac{\partial SL}{\partial \overline{x}} &= \frac{\partial L_I}{\partial \overline{x}} + \frac{\partial L_V}{\partial \overline{x}} + \frac{\partial L_V}{\partial \delta^*}\frac{\partial \delta^*}{\partial \overline{x}} = \frac{\partial L_I}{\partial \overline{x}} + \frac{\partial L_V}{\partial \overline{x}} \\ &= c'(\overline{x}) + (1+\lambda_V)\, ph'(\overline{x}),\end{aligned}$$

where $\frac{\partial L_V}{\partial \delta^*} = 0$ due to the optimality of δ^*. The optimal standard meets therefore

$$c'(\overline{x}^*) = -ph'(\overline{x}^*)(1+\lambda_V): \tag{6}$$

the benefits of increased precaution now include the saved insurance costs $ph'(\overline{x}^*)\,\lambda_V$.

Since $\lambda_V p = \frac{\partial RP_V(\delta^*)}{\partial \delta}$ (eq. 5), the marginal benefit of precaution can be rewritten as

$$b'(\overline{x}) = -ph'(\overline{x}) - h'(\overline{x})\frac{\partial RP_V(\delta^*)}{\partial \delta}, \tag{7}$$

where

$$\frac{\partial RP_V(\delta^*)}{\partial \delta} < \frac{\partial RP_V(h(x))}{\partial h(x)}$$

for $\delta^* < h(x)$ (see Appendix A4). The insurance benefit of precaution is now smaller than in eq. (3) because the victim is partially insured (he only loses the deductible δ^*).

Proposition 2 *Insured victim. The optimal standard solves*

$$c'(\overline{x}^*) = -ph'(\overline{x}^*)(1+\lambda_V).$$

The marginal benefit of precaution is equal to the expected reduction in harm and the expected reduction in insurance costs. The optimal standard increases with the first-party insurance loading factor λ_V.

The risk borne by the victim can be mitigated by two means: first-party insurance and injurer's greater precautions. The optimal standard balances these means. If the loading factor becomes very large, $\lambda_V > \frac{1}{p}\frac{\partial RP_V(h(x))}{\partial \delta}$, the victim forfeits insurance and eq. (3) applies.

If affordable insurance is available, the victim's risk preferences and income level become irrelevant to the determination of the efficient level of precaution.[13] Moreover, the generality of the formula allows it to be applied even in contexts where individuals deviate from the assumptions of Expected Utility Theory in their probability judgments. Appendix A5 shows that the formula remains valid when victims are risk-averse and their behavior aligns with Tversky and Kahneman's Generalized Prospect Theory.[14] In short, *the victim's risk assessment is not a factor in determining the efficient precaution level; the only relevant factor is the price of first-party insurance.*

To implement Proposition 2, the lawmaker need only include the savings in insurance costs when calculating the benefits of precaution. As noted above, the insurance loading factor typically falls within the 30–40% range. Accordingly, the marginal benefits of precaution must be adjusted upward by this proportion relative to the benchmark case with costless insurance.

Discrete example 2. Let us consider again the CRRA example. With a 30% loading factor, the optimal deductible is $\delta^* = \$41,031$ (so the victim is insured only for $\$8,969$). The value of the precautionary measure is now equal to \$577. This amount includes the expected harm (\$500), the saved insurance costs (\$27) and the cost of risk bearing (\$50).

[13] In a well known article, Miceli and Segerson (1995) show that efficient tort rules do not depend on the income levels of the parties, under the assumption that insurance is cost free.

[14] Under Prospect Theory, three key effects are observed: (1) extremely unlikely events have a significant impact on welfare; (2) low-probability events are overweighted; and (3) an increase in the probability of harm has little impact on welfare for events that are neither very likely nor very unlikely, a phenomenon known as likelihood insensitivity- see Wakker (2010). Prospect Theory is also compatible with ambiguity aversion - see Teitelbaum (2007).

3 Strict liability

Under strict liability, the injurer is held liable for damages, irrespective of the level of precaution taken. This liability rule is typically applied to specific categories of torts, most notably those involving defective products and harms arising from hazardous or abnormally dangerous activities.

Let us consider now the case in which the lawmaker decides the share k of the harm that should be compensated: $d = kh(x)$, with $k \geq 0$. If $k < 1$, damages undercompensate the victim (for example, by excluding pain and suffering). If $k > 1$, they overcompensate the victim (for example, by entailing a punitive component). To fix ideas, for the time being let us assume that $k \leq 1$ (so, the victim buys insurance against a loss, not a gain).

Given k, the expected utility of the injurer is

$$EU_I(x) = (1-p)\,u(y_I - c(x)) + pu(y_V - c(x) - kh(x)).$$

Maximization of $EU_I(x)$ is equivalent to the minimization of

$$L_I = c(x) + pkh(x) + RP_I(kh(x)),$$

where the $RP_I(kh(x))$ is the risk burden associated with the prospect of losing $kh(x)$ with probability p.

The injurer will therefore select the precaution level x^s that minimizes L_I :

$$c'(x^s) = k\; h'(x^s)\,(p + \; RP_I'(kh(x^s))). \tag{8}$$

Eq. (8) parallels eq. (3). The same comparative statics results apply.

Lemma 1 *The injurer selects the level of precaution x^s that balances the cost of precaution and the damages burden. i) If the injurer becomes more averse to risk, the precaution level x^s increases. ii) If the probability of harm increases, the precaution level x^s increases. iii) If damages uniformly increase given precautions, the precaution* *level x^s increases. iv) When the injurer's income increases, the level of precaution x^s decreases if the injurer has Decreasing Absolute Risk Aversion.*

Let us consider now the optimal level of the damage awards.

The losses for the two parties are:

$$\begin{aligned} L_I &= c\left(x^s\right) + pkh\left(x^s\right) + RP_I\left(kh\left(x^s\right)\right), \\ L_V &= p\left(1-k\right)\ h\left(x^s\right) + RP_V\left(\left(1-k\right)h\left(x^s\right)\right). \end{aligned}$$

Both injurer and victim bear some risk. Social loss is:

$$SL = L_I + L_V = c\left(x^s\right) + ph\left(x^s\right) + RP_I\left(kh\left(x^s\right)\right) + RP_V\left(\left(1-k\right)h\left(x^s\right)\right),$$

where x^s meets eq. (8).

So (omitting arguments),

$$\begin{aligned} \frac{\partial SL}{\partial k} &= \frac{\partial x^s}{\partial k}\frac{\partial L_I}{\partial x} + \frac{\partial x^s}{\partial k}\frac{\partial L_V}{\partial x} + h\left(x^s\right)\ RP_I' - h\left(x^s\right)RP_V' \\ &= \underbrace{\frac{\partial x^s}{\partial k}\left[\left(1-k\right)\ h'\left(x^s\right)\left(p+RP_V'\right)\right]}_{\text{deterrence}} + \underbrace{h\left(x^s\right)\ \left(RP_I' - RP_V'\right)}_{\text{risk shifting}}, \end{aligned} \tag{9}$$

since $\frac{\partial L_I}{\partial x} = 0$.

An increase in damages (for $k<1$): i) reduces the externality that the injurer exerts on the victim ("deterrence"), ii) increases the risk burden of the injurer, iii) reduces the risk burden of the victim.

For $k = 1^-$(full compensation), the deterrent effect vanishes and we get:

$$\lim_{k\to 1^-}\frac{\partial SL}{\partial k} = RP_I'\left(h\left(x^s\right)\right) > 0.$$

Let us briefly consider the case with $k>1$ (over-compensation). We have $\frac{\partial SL}{\partial k}>0$, since an increase in damages increases the risk burdens of both injurer and victim, while it reduces the gain of the overcompensated victim.

These observations prove that optimal damages are undercompensatory: $k^* < 1$ (as first shown by Shavell (1982)). Under expected utility, parties can bear very small losses at a negligible cost. So, under the optimal compensation rule, a positive share of the loss is left on the victim.

This leads us to the next result (proof in Appendix A6).

Proposition 3 *Strict liability. Optimal damages balance deterrence with the optimal allocation of the risk burden.*

i) Optimal damages are undercompensatory: $d^* < h(x^s)$.

ii) If the victim becomes more averse to risk, optimal damages increase.

iii) When the victim's income increases, optimal damages d^* *decrease if the victim has Decreasing Absolute Risk Aversion.*

Proposition 3 highlights the impact of risk aversion on optimal compensation: damages should be less than fully compensatory, they increase with the victim's degree of risk aversion, and they decrease with the victim's income (under DARA).

The impact of an increase in the injurer's degree of risk aversion on optimal damages cannot be signed, as it is mediated by $\frac{\partial x^s}{\partial k}$, the sensitivity of precautions to changes in damages.

Strict liability with insured parties

Let us assume that both the injurer and the victim can purchase insurance.[15] The loading factor for third-party insurance is λ_I, while the loading factor for first-party insurance is λ_V. Each party decides how much insurance to purchase: δ_I is the deductible of the injurer, δ_V the deductible of the victim. The insurance company can observe the precaution level (i.e., the insurance company is involved in "loss control" activities).[16] Again, for the time being let us assume that $k \leq 1$.

[15] In the moves sequence, first the courts set damages, and then parties purchase insurance. So, damages are *not conditional* on whether parties have purchased insurance. Note further that, as shown below, the victim has no incentive to buy insurance coverage in excess of his uncompensated loss: he does not want to be compensated twice for the same harm. The collateral source rule does not apply here.

[16] In an Annex, I show that the main result applies also if the precaution level is not observable and a moral hazard problem arises. In this case, the injurer will opt for a lower insurance coverage.

The loss of the injurer is now

$$L_I = c(x) + p(kh(x) - \delta_I)(1 + \lambda_I) + p\delta_I + RP_I(\delta_I).$$

So, given x, the optimal δ_I should solve

$$\frac{\partial RP_I(\delta_I)}{\partial \delta_I} = \lambda_I\ p. \tag{10}$$

The optimal precaution x^S solves (using 10)

$$\frac{\partial L_I}{\partial x} = c'\left(x^S\right) + h'\left(x^S\right) pk(1 + \lambda_I) = 0,$$

i.e.

$$c'\left(x^S\right) = -pk\ h'\left(x^S\right)(1 + \lambda_I).$$

The marginal benefit of precaution now includes the reduction in expected liability and the reduction in the insurance cost. Clearly, $\frac{\partial x^S}{\partial k} > 0$.

The victim chooses the deductible δ_V^* so that (in line with eq. (10), assuming an interior solution):

$$\frac{\partial RP_V(\delta_V^*)}{\partial \delta_V} = \lambda_V\ p.$$

The optimal compensation k^* should solve

$$\begin{aligned}\min_k SL^S &= L_I + L_V \\ &= c\left(x^S\right) + p\left(kh\left(x^S\right) - \delta_I^*\right)(1 + \lambda_I) + p\delta_I^* + RP_I(\delta_I^*) \\ &+ p\left((1-k)h\left(x^S\right) - \delta_V^*\right)(1 + \lambda_V) + p\delta_V^* + RP_V(\delta_V^*),\end{aligned}$$

with

$$\frac{\partial SL}{\partial k} = \frac{\partial x^S}{\partial k}\frac{\partial L_V}{\partial x} + \frac{\partial L_I}{\partial k} + \frac{\partial L_V}{\partial k}$$
$$= \frac{\partial x^S}{\partial k} ph'\left(x^S\right)(1-k)(1+\lambda_V) + ph\left(x^S\right)(1+\lambda_I)$$
$$- ph\left(x^S\right)(1+\lambda_V),$$

that is

$$\frac{\partial SL}{\partial k} = \underbrace{\frac{\partial x}{\partial k} ph'\left(x^S\right)(1-k)(1+\lambda_V)}_{\text{deterrence}} + \underbrace{ph\left(x^S\right)(\lambda_I - \lambda_V)}_{\text{insurance costs shifting}}. \tag{11}$$

Again, an increase in damages (k) has two effects: on the one hand, it provides the injurer with greater incentives to take precaution. This reduces the externality that the injurer exerts on the victim ("deterrence"). On the other hand, it shifts risk from the victim to the injurer. This induces the injurer to buy extra insurance at cost λ_I, while the victim saves λ_V.

At $k = 1^-$, we have:

$$\lim_{k \to 1^-} \frac{\partial SL}{\partial k} = ph\left(x^S\right)(\lambda_I - \lambda_V),$$

which is positive if $\lambda_I > \lambda_V$. If this is not the case, optimal damages are fully compensatory.

It should be noted here that overcompensatory damages cannot be optimal: for $k > 1$ deterrence is excessive and both injurer and victim have to pay insurance costs.

Proposition 4 *Optimal damages balance deterrence with the optimal allocation of the insurance costs.*

If $\lambda_I \leq \lambda_V$, optimal damages are fully compensatory: $k^* = 1$.

If $\lambda_I > \lambda_V$, optimal damages are under-compensatory: $k^* < 1$. They increase with λ_V .

Optimal damages are under-compensatory when the victim has access to cheaper insurance.

It might be argued here that, even if injurer and victim have access to the same insurance market, the loading factor for the injurer is likely to be higher. This is because third-party insurance costs account for loss-control activities and for larger loss adjustment expenses (due to the defence costs associated with litigation and settlement negotiation).[17]

4 Conclusions

This paper adopts an efficiency-oriented approach, proposing that standards of care and damage awards should be structured to maximize the overall welfare of the parties involved. The central aim is to identify those features of the liability system that rational parties would mutually endorse ex ante. Within this framework, victims are conceptualized as expressing a demand for insurance - a demand met not only through private insurance markets but also, in part, through the tort system itself.

The analysis yields clear policy implications: to properly account for victims' risk aversion and the cost of insurance, courts should adopt higher standards of care in negligence regimes and increase damage awards under strict liability. While this reasoning applies broadly across tort law, it is particularly salient in the context of product liability, where competitive market forces enhance the alignment between legal incentives and efficient risk distribution.

[17] See Harrington and Niehaus (2012), p. 146.

Appendix

A1. Condition S. The injurer prefers to meet the standard of care $\overline{x}$ if

$$c(\overline{x}) < c(x^s) + ph(x^s) + RP_I(h(x^s)),$$

where

$$x^s = \arg\min\left[c(x^s) + ph(x^s) + RP_I(h(x^s))\right].$$

In turn, if the injurer is not liable, the optimal standard $\overline{x}^*$ should meet:

$$\overline{x}^* = \arg\min\left[c(\overline{x}) + ph(\overline{x}) + RP_V(h(\overline{x}))\right].$$

If the Condition:

$$RP_V(h(x^s)) < RP_I(h(x^s)) \tag{12}$$

is met, we have

$$\begin{gathered} c(\overline{x}^*) < c(\overline{x}^*) + ph(\overline{x}^*) + RP_V(h(\overline{x}^*)) < \\ c(x^s) + ph(x^s) + RP_V(h(x^s)) < c(x^s) + ph(x^s) + RP_I(h(x^s)). \end{gathered}$$

So, if Condition (12) is met, the injurer meets the optimal standard $\overline{x}^*$.

A2. The Pareto efficient negligence standard $\overline{x}^*$ is obtained from

$$\begin{aligned} &\max_x EU_V(x) = (1-p)\,v(y_V - t) + pv(y_V - t - h(x)) \\ &s.t.\quad EU_I(x) = u(y_I - c(x) + t) = k_I, \end{aligned}$$

where t is an ex-ante transfer from the victim to the injurer and k_I a constant.

This maximization problem can be rewritten as

$$\begin{aligned} &\max\nolimits_x v(y_V - t - ph(x) - RP_V(h(x))) \\ &s.t.\ y_I - c(x) + t = u^{-1}(k_I) \equiv k_{2.} \end{aligned}$$

Since v is monotonic, the problem can be we written as (substituting for t) :

$$\max_x\ y_V - k_2 + y_I - c(x) - ph(x) - RP_V(h(x)). \tag{13}$$

Maximization of (13) is equivalent to the minimization of the Social Loss

$$SL = c(x) + ph(x) + RP_V(h(x)).$$

A3. From (4), optimal standard should meet

$$c'(\overline{x}^*) = -h'(\overline{x}^*)\frac{1}{1+\frac{(1-p)}{p}\frac{u'(y_V)}{u'(y_V - h(\overline{x}^*))}}. \tag{14}$$

If the victims' utility function u is replaced by the function $v(y) = \varphi(u(y))$, with $\varphi' > 0$, $\varphi'' < 0$, then the optimal standard should meet

$$c'(\overline{x}^*) = -h'(\overline{x}^*)\frac{1}{1+\frac{(1-p)}{p}\frac{\varphi'(u(y))u'(y_V)}{\varphi'(u((y_V - h(\overline{x}^*))))u'(y_V - h(\overline{x}^*))}} \tag{15}$$

For any $\overline{x}^*$, the RHS of eq. (15) is larger than the RHS of (14) since $\varphi'(u(y)) < \varphi'(u(y_V - h(\overline{x}^*)))$, due to the concavity of φ. So, if victims become more averse to risk, the optimal standard should increase. If the victim becomes infinitely averse to risk, the marginal benefit converges to $-h'(\overline{x}^*)$: the victim behaves as if the accident were to happen for sure. ii) From eq. (14), it is clear that the marginal benefit of precaution increases if p increases. iii) Let the harm be equal to $h(x)+z$, where z is the baseline harm (a level of harm independent of the precaution level). As z increases, the marginal utility in the adverse state increases, and so does the demand for insurance. iv) From (14), it can be seen that the marginal benefit of precaution decreases with the victims' income if $\frac{u'(y_V)}{u'(y_V - h(\overline{x}^*))}$ increases in y_V, which is the case if, and only if: $u''(y_V)u'(y_V - h(\overline{x}^*)) - u'(y_V)u''(y_V - h(\overline{x}^*)) > 0$, i.e., $\frac{u'(y_V - h(\overline{x}^*))}{u''(y_V - h(\overline{x}^*))} > \frac{u'(y_V)}{u''(y_V)}$, which is met if the victims has DARA.

A4. With insurance, optimal standard should meet (from 7),

$$c'(\overline{x}^*) = -h'(\overline{x}^*)\frac{1}{1+\frac{(1-p)}{p}\frac{u'(y_V)}{u'(y_V - \delta^*)}}. \tag{16}$$

Since $\delta^* \leq h(x)$, for any x, the RHS of (16) is less than the RHS of (14).

A5. Prospect theory. Let us suppose that the victim weights the probability of harm through an S-shaped function $\pi(p)$, with $\pi'(p) > 0$. The S-shaped function captures the salient features of prospect theory: i) extremely unlikely events have a significant impact on the victim's welfare (impossibility effect), ii) low probability events have an overweighted impact on welfare (overweighting of unlikely events), iii) for events that are neither very likely nor very unlikely, an increase in the probability of harm has little impact on welfare (likelihood insensitivity). I retain the assumption of risk aversion - otherwise victims would not buy insurance.

The insurance company charges a premium:

$$r(\delta) = (1 + \lambda_V) p (h(x) - \delta).$$

The optimal deductible minimizes the victim's loss:

$$\begin{aligned} L_V &= r(\delta) + \pi(p)\delta + RP_V(\pi(p), \delta) \\ &= (1 + \lambda_V) p (h(x) - \delta) + \pi(p)\delta + RP_V(\pi(p), \delta), \end{aligned}$$

where $RP_V(\pi(p), \delta)$ is the risk premium associated to the prospect of losing δ with weighted probability $\pi(p)$.

The optimal deductible δ^* solves:

$$-(1 + \lambda_V) p + \pi(p) + \frac{\partial RP_V(\delta^*)}{\partial \delta} = \tag{17}$$

$$-\lambda_V p + (\pi(p) - p) + \frac{\partial RP_V(\delta^*)}{\partial \delta} = 0. \tag{18}$$

If the victim overweights risk, $\pi(p) > p$, insurance becomes more appealing (lower deductible δ^*).

The optimal standard $\overline{x}^*$ solves now:

$$\min_{\overline{x}} SL = L_I + L_V = c(\overline{x}) + (1 + \lambda_V) p (h(x) - \delta^*) + \pi(p)\delta^* + RP_V(\pi(p), \delta^*),$$

and again

$$\begin{aligned}\frac{\partial SL}{\partial \overline{x}} &= \frac{\partial L_I}{\partial \overline{x}} + \frac{\partial L_V}{\partial \overline{x}} + \frac{\partial L_V}{\partial \delta^*}\frac{\partial \delta^*}{\partial \overline{x}} = \frac{\partial L_I}{\partial \overline{x}} + \frac{\partial L_V}{\partial \overline{x}} \\ &= c'(\overline{x}) + (1+\lambda_V)\, ph'(\overline{x}),\end{aligned}$$

where $\frac{\partial L_V}{\partial \delta^*} = 0$ due to the optimality of δ^*. So, after all, the way in which the victim assesses the risk prospect does not affect the optimal negligence standard.

A6. Optimal damages are obtained from

$$\begin{aligned} &\max EU_V(x) = (1-p)\, v(y_V - t) + pv(y_V - t - (1-k)\, h(x)) \\ &s.t. \quad EU_I(x) = (1-p)\, u(y_I - c(x^s) + t) + pu(y_V - c(x^s) - kh(x^s) + t) = c_I, \\ &\qquad\qquad x^s = \arg\max EU_I(x).\end{aligned}$$

The Lagrangian is

$$\mathcal{L} = EU_V(k,t) + \lambda\left[EU_I(k,t) - c_I\right],$$

and the optimal solution solves

$$\begin{aligned}\tfrac{\partial \mathcal{L}}{\partial k} &= \tfrac{\partial EU_V(x)}{\partial k} + \lambda\left[\tfrac{\partial EU_I(x)}{\partial k}\right] = 0, \\ \tfrac{\partial \mathcal{L}}{\partial t} &= \tfrac{\partial EU_V(x)}{\partial t} + \lambda\left[\tfrac{\partial EU_I(x)}{\partial t}\right] = 0, \\ \tfrac{\partial \mathcal{L}}{\partial \lambda} &= EU_I(x) - c_I = 0.\end{aligned}$$

Solving for λ the first two equations yields:

$$\lambda = -\frac{\frac{\partial EU_V(x)}{\partial k}}{\frac{\partial EU_I(x)}{\partial k}} = -\frac{\frac{\partial EU_V(x)}{\partial t}}{\frac{\partial EU_I(x)}{\partial t}}.$$

or

$$\left.\frac{\partial t}{\partial k}\right|_V = \frac{\frac{\partial EU_V(x)}{\partial k}}{\frac{\partial EU_V(x)}{\partial t}} = \frac{\frac{\partial EU_I(x)}{\partial k}}{\frac{\partial EU_I(x)}{\partial t}} = \left.\frac{\partial t}{\partial k}\right|_I.$$

The term on the RHS measures how much money the victim is willing to pay to get additional insurance (an increase in damages); the RHS how much money the injurer is demanding to provide additional insurance.

By differentiation, we get (omitting arguments)

$$\frac{pv'(y_V-t-(1-k)h)h+\frac{\partial x^s}{\partial k}\frac{\partial EU_V}{\partial x}}{(1-p)v'(y_V-t)+pv'(y_V-t-(1-k)h)}=\frac{pu'(y_V-c-kh+t)h-\frac{\partial x^s}{\partial k}\frac{\partial EU_I}{\partial x}}{(1-p)u'(y_I-c(x^s)+t)+pu'(y_V-c(x^s)-kh+t)}$$

where $\frac{\partial EU_I(x)}{\partial x^s}=0$ because x^s is optimally chosen by the injurer. This yields

$$\frac{pv'(-)\ \ h-\frac{\partial x^s}{\partial k}pv'(-)\ \ (1-k)\,h'}{(1-p)\,v'(+)+pv'(-)}=\frac{p\ u'(-)\,h}{(1-p)\,u'(+)+pu'(-)},$$

where $(-)$ represents the payoff when the accident occurs and $(+)$ the payoff when the accident does not occur. The latter equation can be rewritten as

$$\frac{\frac{\partial x^s}{\partial k}h'\ pv'(-)\,(1-k)}{(1-p)\,v'(+)+pv'(-)}+h\left[\frac{p\ u'(-)}{(1-p)\,u'(+)+pu'(-)}-\frac{pv'(-)}{(1-p)\,v'(+)+pv'(-)}\right]=0, \quad (19)$$

which is the same as eq. (9) of the body. The first term is the "externality effect:" an increase in k induces an increase in the precaution and thus a reduction of the loss suffered by the victim. The second term (in square brackets) captures the shift in the risk burden: an increase in k raises the burden of the injurer and reduces that of the victim.

If the level of harm were insensitive to precautions ($h'=0$), then only the optimal risk allocation would matter and optimal damages would yield:

$$\frac{p\ u'(-)}{(1-p)\,u'(+)+pu'(-)}=\frac{pv'(-)}{(1-p)\,v'(+)+pv'(-)},$$

that is

$$\frac{u'(-)}{u'(+)}=\frac{v'(-)}{v'(+)}.$$

The ratio of the marginal utilities of money in the accident and non-accident states would be the same for both parties.

If $k\to 1^-$, the victim is perfectly insured ($v'(-)=v'(+)$) and the externality effect vanishes. We get

$$\lim_{k-1^-}\left.\frac{\partial t}{\partial k}\right|_V=h\,(x^s)\,,$$

the price the victim is willing to pay to increase k is just the expected value of the loss. When the risk is very small, the victim behaves like a risk-neutral agent. Thus

$$\left.\frac{\partial t}{\partial k}\right|_I = h(x)\,\frac{p\ u'(-)}{(1-p)\,u'(+)+pu'(-)} > \left.\frac{\partial t}{\partial k}\right|_V = h(x):$$

the injurer is willing to pay a price greater than $h(x)$ to relinquish the risk: $k=1$ cannot be optimal.

Eq. (19) can be rewritten as:

$$\frac{pv'(-)}{(1-p)\,v'(+)+pv'(-)}\left[h(x)-\frac{\partial x^s}{\partial k}(1-k)\,h'(x)\right] = \frac{pu'(-)\,h(x^s)}{(1-p)\,u'(+)+pu'(-)}. \tag{20}$$

At the optimum, $\left[h(x)-\frac{\partial x^s}{\partial k}(1-k)\,h'(x)\right]$ has to be positive.

We can then observe that, if the victim becomes more averse to risk (v is subject to a concave transformation), the LHS of (20) increases and optimal damages increase. Similarly, under DARA, when the victim's income increases, optimal damages increase.

Annex

Insurance with moral hazard. Let us consider the case of strict liability, where the share of the loss that falls on the injurer is $kh(x)$ and the share that falls on the victim is $(1-k)\,h(x)$. The injurer purchases third party insurance with coverage $z\ kh(x)$. The share of the harm that remains on the injurer's shoulders is $(1-z)\ k\,h(x)$. The level of care x is not observable.

The premium charged by the insurance company is $q = z\ pkh(x)(1+\lambda_I)$. An injurer insured with coverage z will take precautions x^I that minimize

$$L_I = c(x) + q + p(1-z)\,kh(x) + RP_I((1-z)\,kh(x)).$$

Thus, x^I will solve

$$c'\left(x^I\right) + (1-z)\,kh'\left(x^I\right)\left(p + RP_I'\left((1-z)\,kh\left(x^I\right)\right)\right) = 0, \tag{21}$$

with $\frac{\partial x^I}{\partial z} < 0$.

Let $x(z)$ be the optimal care level given z. The optimal coinsurance contract minimizes:

$$L_I = c(x(z)) + pz\ kh(x(z))(1+\lambda_I) + p(1-z)\,kh(x(z)) + RP_I((1-z)\,kh(x(z))),$$

where, accounting for (21) and omitting arguments,

$$\begin{aligned}\frac{\partial L_I}{\partial z} &= pkh\lambda_I - khRP_I' + x'\left(c' + pzkh'(1+\lambda_I) + p(1-z)\,kh' + (1-z)\,kh'RP_I'\right)\\ &= kh\left(p\lambda_I - RP_I'\right) + pzkh'x'(1+\lambda_I).\end{aligned}$$

The optimal z^I solves

$$kh\left(RP_I' - p\lambda_I\right) = pz^I k\ x'h'(1+\lambda_I). \tag{22}$$

Due to the moral hazard problem, the injurer takes suboptimal insurance (note that the RHS of (22) is positive).

The loss for the victim is

$$L_V = pz^V\ (1-k)\,h(x^s)(1+\lambda_V) + p\left(1-z^V\right)(1-k)\,h(x^s) + RP_V\left(\left(1-z^V\right)(1-k)\,h(x^s)\right).$$

For the victim, the optimal coinsurance contract z^V is such that (again, omitting the argument):

$$p\lambda_V = RP'_V. \tag{23}$$

Optimal damages, k^*, should minimize social loss:

$$SL = L_I + L_V,$$

with

$$\begin{aligned}
\frac{\partial SL}{\partial k} &= \left.\frac{\partial SL}{\partial k}\right|_z + \frac{\partial SL}{\partial z}\frac{\partial z}{\partial k} \\
&= ph\left(x^s\right) + pz^I h\left(x^s\right)\lambda_I + \left(1 - z^I\right) h\left(x^s\right) RP'_I\left(\left(1 - z^I\right) kh\left(x^s\right)\right) \\
&- ph\left(x^s\right) - pz^V h\left(x^s\right)\lambda_V + RP_V\left(\left(1 - z_V\right)\left(1 - k\right) h\left(x^s\right)\right) \\
&+ \frac{\partial x}{\partial k} h'\left(x^s\right)\left(1 - k\right)\left[p + p\left(1 - z_V\right)\lambda_V + \left(1 - z_V\right) RP'_V\left(\left(1 - z_V\right)\left(1 - k\right)\left(x^s\right)\right)\right].
\end{aligned}$$

Using (21) and (23), we get:

$$\frac{\partial SL}{\partial k} = ph\left(x^s\right)\left(\lambda_I - \lambda_V\right) + \frac{\partial x}{\partial k} h'\left(x^s\right)\left(1 - k\right) p\left[1 + \lambda_V\right],$$

which replicates eq. (11). Here, however, it is harder to pin down the effect of k on x, because it is mediated by a change in z. Still, it can be seen that:

i) if $k \to 1$, the externality effect vanishes and $\frac{\partial SL}{\partial k} > 0$ if and only if $\lambda_I > \lambda_V$;

ii) at an interior solution, with $\lambda_I > \lambda_V$, we have $\frac{\partial SL}{\partial k} = 0$ and $\frac{\partial k^*}{\partial \lambda_V} = -\frac{\partial \frac{\partial SL}{\partial k} / \partial \lambda_V}{\partial^2 SL / \partial k^2} > 0$.

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