Tort Liability and Probability Weighting Function according to Prospect Theory

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Abstract

This paper analyzes unilateral tort liability assuming that the tort-feasor weights probabilities similar to Prospect Theory, thus, the tort-feasor underestimates very high probabilities and overestimates very low ones. The results with a precise standard of due care are: (a) Probability weighting decreases the marginal benefits of taking care, thus, the tort feasor may choose too little care. (b) Whereas a negligence rule not always causes underdeterrence with probability weighting, strict liability does. With a vague standard of due care, results are more ambiguous. Probability weighting tends to reduce overdeterrence and might even induce efficient care. Still, a corner solution with even more excessive care is possible. In contrast to strict liability, a negligence rule provides certainty, which is valuable and affects a tort-feasor’s behaviour.

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1. Introduction

This paper analyzes tort feasor’s incentives to take care with a negligence rule and with strict liability assuming that a tortfeasor weights probabilities according to Prospect Theory (Kahneman and Tversky, 1979). The probability weighting function takes into account that individuals overrate (very) small probabilities, but underrate (very) large ones. There are two other important elements of Prospect Theory: loss aversion and risk-seeking behaviour with losses. Loss aversion means that a negative deviation to a certain reference point, a loss, counts more than a positive deviation (gain) even though in absolute terms they are the same. All three elements seem to describe empirical decision-making better than the standard approach in economics and also in law and economics which is based on Expected Utility Theory (EU-model).

In what follows, we exclude loss aversion and risk-seeking behaviour with losses for two reasons. First, a simultaneous analysis of all three elements turns out to be too complicated at this point of time. Second, a separate analysis of the single elements shows results which are not too much different to the Expected Utility case (Bigus, 2005). With loss aversion of tort feasors the definition of loss matters. If only damage payments are considered as a loss we obtain similar results to Expected Utility Theory considering the incentive effect. If both liability payments and costs of care are considered as a loss even strict liability induces efficient care different to the case of risk aversion in Expected Utility Theory. Similar to Expected Utility Theory, risk-seeking behaviour with losses generally induces a tort feasor to “gamble”, that is, to spend too little care under strict liability and possibly even under a negligence rule.

Surprisingly, even though there is a vast literature on the economics of tort law, new models of decision-making have hardly been incorporated yet (Shavell, 1987 and 2004). To our best knowledge, Behavioral Law and Economics has not addressed the link between Prospect Theory and tort law yet (Sunstein, 2000).1 Apparently, only Eide (2005) and Teitelbaum (2006) investigate how Rank Dependent Expected Utility (RDEU) and Choquet Expected Utility (CEU), respectively, affect the economics of various liability rules.2 The RDEU-concept is mainly based on the work of Quiggin

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1 In the most relevant book on Behavioural Law and Economics edited by Sunstein (2000) there is only a contribution on “Assessing punitive damages”, written by Sunstein, Kahneman and Schkade.

2 Eide and Teitelbaum mainly look at the issue of ambiguity and ambiguity aversion. Segal and Stein (2006) examine how ambiguity aversion may affect the criminal process and how it may foil criminal justice.
(1982), Yaari (1987) and Segal (1987), the CEO-concept on Schmeidler (1989). Both, RDEU and CEU-concept change probabilities of the EU-model into probability weights. However, neither Eide nor Teitelbaum address vague standards or the important discontinuities of the probability weighting function suggested by the work of Kahneman and Tversky (1979). Posner (2003) assumes that people treat accident probabilities below the threshold as though they were zero, whereas I follow the approach of Kahneman and Tversky (1979) who suggest that very small probabilities might be overestimated.

We derive the following results: (1) If we consider possible damage payments as losses, both risk-seeking and probability weighting might induce the tort feasor to take less care than in the EU-model. This holds for strict liability and for a negligence rule with a precise standard of due care. (2) A negligence rule might still induce efficient solutions, however, a strict liability rule will induce too little care. (3) Often, the standard of due care is not precisely defined. With a vague standard, probability weighting mitigates the problem of overdeterrence that exists with the EU-model, but there might be an opposite second effect which induces the tort feasor to choose a care level where there is no liability for sure but which is inefficiently high. The overall outcome is not clear.

This paper assumes that tort feasors do not act rationally in the sense of Expected Utility Theory. Empirical evidence suggests that individuals do not necessarily follow this concept of rationality. Still, one might argue that institutional actors may provide mechanisms to induce their agents to behave rationally and to learn over time. Yet, the evidence for this claim is mixed at best and shows that even institutional actors might be subject to bounded rationality (see e.g., Odean, 1998). Rabin (1998) points out that learning effects in reality are considerably more limited than economists usually assume. Still, the paper may rather address cases where individuals are tort feasors rather than institutions and where torts happen rather rarely such that learning is hardly possible. Thus, the paper may apply to individual’s liability for car accidents rather than to product liability of firms.

Section 2 investigates the impact of the probability weighting function with a precise standard of due. Section 3 assumes a vague standard of due care. Section 4 concludes.

3 However, Eide (2005) analyzes also the case of bilateral accidents whereas we — as most of the literature on tort feasors’ liability — stick to the unilateral case. Teitelbaum (2006) examines unilateral accidents as well and stresses the issue of ambiguity (Knightian uncertainty) where people do not fully trust the subjective probability distribution and might be ambiguity loving or ambiguity averse.
2. **Probability weighting function: precise standard of due care**

2.1 *Assumptions and first-best-solution*

Let us assume that a risk-neutral individual (injurer) may cause an accident which induces a harm of \( D \) to the risk-neutral victim. The injurer is held liable.\(^4\) Liability is unlimited. The probability of damage, \( p \), depends on the injurer’s level of precaution, \( x \):

\[
(1) \quad p = p(x) = \frac{1}{1+x} \quad \text{with} \ x \geq 0.
\]

Following the literature (e.g., Shavell, 1987) we assume that the probability of damage decreases as the injurer’s level of precaution increases, however, at diminishing rates \( (p'(x) < 0; \ p''(x) > 0) \). For illustrative purposes we will use the specification of \( p(x) \) in (1), however, we also show more general results.

*Fig. 1: Probability of damage depending on the injurer’s level of precaution*

The injurer bears direct costs of precaution which, for simplicity, equal the level of precaution, \( x \). Thus, the direct costs increase linearly with the level of precaution. Let us assume that the law-feasor is rational in the sense of Expected Utility Theory. The social costs of an accident are then reflected by:

\[
(2) \quad SC = p(x)D + x.
\]

With the socially desirable level of precaution, \( x = x^* \), marginal gains equal marginal costs. Thus,

\[
(3) \quad SC'(x) = 0 \quad \text{for} \ x = x^* \quad \text{with} \ x^* = \sqrt{D} - 1.\(^5\)
\]

\(^4\) Following the law and economics literature (Shavell, 1987 and 2004) we assume that the victim will sue for sure.
Obviously, both a strict liability regime and a negligence rule defining the due standard of care to be \( x^* \) will induce an injurer to choose the efficient level of precaution if he decides on the basis of Expected Utility Theory.

However, will the injurer choose the efficient level of precaution if the injurer takes decision based on the probability weighting function of Prospect Theory? The answer to this question also depends on the characteristics of the liability regime. We start with a negligence rule where the injurer is only held liable if he does not perform an efficient standard of due care, thus, if he chooses care levels below \( x^* \).

2.2 The impact of probability weighting

2.2.1 An illustration of the certainty effect

The probability weighting function of Prospect Theory implies that people value certain events, independently of their risk attitude. We want to illustrate this certainty effect with one famous paradox by Allais (1953).\(^6\) Imagine A and B are uncertain prospects with a certain outcome distribution where A grants 100 Mio.€ for sure and B 500 Mio.€, 100 Mio.€ and 0€ with probabilities of 10%, 89% and 1%, respectively. We can also write:

\[
A: (100 \text{ Mio.}, 100\%), \quad B: (500 \text{ Mio.}, 10\%; 100 \text{ Mio.}, 89\%; 0, 1\%).
\]

Subtracting a payoff of (100 Mio., 89%), we obtain the prospects A' and B':

\[
A': (100 \text{ Mio.}, 11\%), \quad B': (500 \text{ Mio.}, 10\%; 0, 1\%)
\]

When a decision maker prefers A to B, then – according to the independence axiom of Expected Utility Theory – she should also prefer A' to B'. Allais, however, claimed, that most human beings are likely to prefer A to B, while preferring B' to A'. Experimental studies confirm the preference reversal.\(^7\) It seems like that the difference between 99% and 100% matters but not the one between 10% and 11%. People tend to value certainty especially when there are high payoffs to gain or to lose. Thus, the certainty effect might be especially relevant in accident cases with large damages.

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\(^5\) Since we assume the level of precaution to be non-negative: \( x \geq 0 \), there is only a solution if \( D > 1 \). For convenience, we assume that this case holds. The second-order condition is met because of (1). For simplicity, we do not address the second-order conditions in the following. They are met, though.

\(^6\) See Allais (1953), p. 526f.

\(^7\) See, for instance, McCrimmon and Larsson (1979).
2.2.2 Probability weighting with a precise standard of due care

Prospect Theory suggests that individuals do not directly consider the probability of a state of nature occurring \( p_j \). Rather, they perceive a different weight according to a weighting function \( \omega(p_j) \). Based on robust empirical evidence, Kahneman and Tversky (1979: 280-284) attach the following characteristics to the weighting function:\(^8\)

(a) The weighting function increases monotonically with the probability \( p \). It holds \( \omega(p=1) = 1 \) and \( \omega(p=0) = 0 \). The weighting function is not continuous in \( p=0 \) and \( p=1 \).\(^9\)

(b) Small probabilities are overestimated, big ones are underestimated: \( \omega(p) > p \) and \( \omega(p) < p \), respectively.

Figure 2 shows the weighting function and its relation to the (original) probabilities.

Fig. 2: Probability weighting function \( \omega(p) \) (solid line) according to Prospect Theory

According to the weighting function, small probabilities are overestimated, big ones are underestimated. Thus, in the continuous part the weighting function increases at lower rates than the original probability. Note the discontinuities with \( p = 0 \) and \( p = 1 \). This is due to a so-called certainty effect: there is a “jump” in perceived probability if events certainly will happen or certainly will not. With \( p \to 1 \), this certainty effect has a value on its own.

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8 Allais (1953), pp. 508, 513 already mentions this idea.
9 The weighting function has some additional features that, on first sight, do not directly affect tortfeasor’s liability: (a) subcertainty for complementary events: \( \omega(p) + \omega(1-p) < 1 \), (b) subadditivity for small probabilities: \( \omega(rp) > r \omega(p) \) for \( r \in (0,1) \) and (c) subproportionality: \( \omega(p \cdot q) < \omega(r \cdot p \cdot q) \), for \( r, q \in (0,1) \).
We approximate the weighting function by the following function:\(^{11}\)

\[
\omega(p) = \begin{cases} 
0 & , p = 0 \\
\beta p + \alpha & , 0 < p < 1 \\
1 & , p = 1.
\end{cases}
\]

What does this mean for injurer’s liability? We have to consider discontinuities for \(p = 0\) and \(p = 1\), that is, for \(x = \infty\) and \(x = 0\), respectively, in case of strict liability, and for \(x = x^*\) and \(x = 0\), respectively, in case of a negligence rule with an efficient standard of due care. With a negligence rule, the injurer’s cost function is reflected by (general formula and formula with specification of \(p(x)\) according to (1)):

\[
C(x) = \begin{cases} 
D & , x = 0 \\
x + \left[ \beta p(x) + \alpha \right] D & , 0 < x < x^* \\
x & , x \geq x^*,
\end{cases}
\]

respectively. Zero effort \((x = 0)\) cannot be optimal, since a marginal increase in effort will reduce the weighted probability considerably (there is a discontinuity!). In contrast to the standard tort model without probability weighting there are now two local minima due to the discontinuity for \(x = x^*\), which implies a damage probability of \(p = 0\). The global cost minimum is located at \(x = \hat{x} = \sqrt{\beta D} - 1 < x^*\), if holds:

\[
C(x = \hat{x}) = 2\sqrt{\beta D} - 1 + \alpha D < C(x = x^*) = x^* = \sqrt{D} - 1
\]

or if \(\beta < \hat{\beta} = \left(\frac{\sqrt{D} - \alpha D}{4D}\right)^2\),

that is, if the slope of the probability weighting function is sufficiently small. With strict liability, the cost function equals \(C(x) = x + \left[ \beta / (1 + x) + \alpha \right] D\) and the injurer chooses the individual optimum \(\hat{x}\) which implies underdeterrence. Note that with strict liability there is no discontinuity, and thus, no certainty effect, since there is always a

\(^{11}\) Tversky and Kahneman (1992), p. 309, suggest the following approximation for the weighting function: \(\omega(p) = \frac{p^\gamma}{(p^\gamma + (1 - p)\gamma)}\), for \(0 < \gamma \leq 1\) and Prelec (1998) suggests \(\omega(p) = e^{-\ln(p)^\gamma}\), for \(0 < \gamma \leq 1\). However, the formal analysis becomes messy with these functions, we do not end up with clear results. Thus, we suggest the approximation given in (4).

\(^{12}\) This condition makes sure that \(\omega(p) < 1\) holds, if \(p \to 1\). Based on the evidence provided by Tversky and Kahneman (1992) and their approximation for the weighting function and for \(\gamma\) (see footnote before), we can imagine values between 0.02 – 0.1 for \(\alpha\), and values between 0.5 – 0.9 for \(\beta\) (note, however, that the “original” weighting function is not linear).
small probability to be held liable. As opposed to a negligence rule, there is only one local cost minimum.

**Result 1:**

(1) The wrong estimation of probabilities decreases the *marginal* benefits of taking care, thus the injurer may have less incentives to take care and may choose the suboptimal level $\hat{x}$ if (6) holds.\(^\text{13}\) Note that without probability weighting ($\beta = 1, \alpha = 0$) the injurer would always choose the efficient level $x^*$. (2) Whereas a negligence rule not always causes underdeterrence, strict liability does. Without probability weighting, strict liability would induce an efficient care level.

Due to the weighting function *perceived* probabilities decrease at lower rates than real probabilities as the care level increases. Thus, perceived expected damages also decrease at lower rates. The marginal costs of taking care are not affected by the weighting function, they are certain (it holds $\omega(p=1) = 1$). Thus, with a negligence rule the individually optimal level is lower than in the case without the weighting function.

This effect might be stronger if we take into account the *convex slope* of the probability weighting function. In (4), we approximate the weighting function of Prospect Theory by a linear function. However, a convex slope indicates that marginal probability weights $\omega(p)$ increase more the higher is the “true” probability $p$. Thus, marginal changes of small probabilities are perceived to be less important than changes of big ones (except for the discontinuity at $p = 0$). This suggests that the perceived marginal benefits of additional precaution decrease as well and that the local optimum for $0 < x < x^*$ may be even lower than $\hat{x}$. Unfortunately, with the weighting functions suggested by Tversky and Kahneman (1992) and Prelec (1998), we do not end up with closed form solutions.\(^\text{14}\)

It is worth noticing that strict liability generally induces too little care if injurers decide according to Prospect Theory. Thus, many scenarios in which strict liability is regarded to be preferable to a negligence regime have to be reconsidered, for instance scenarios, where the risk of an activity or of a product is substantial but difficult to assess and if potential injurers can much better reduce risk than users (Shavell, 2004: 219).

\(^\text{13}\) This is a general result as one can see from the formula on the left hand side in (5). The marginal *perceived* benefits of additional precaution are lower than in the Expected Utility case (with $\beta = 1, \alpha = 0$).

\(^\text{14}\) See footnote 11.
3. **Probability weighting with a vague standard of due care**

We assume that there is no weighting with regard to the probability that a damage occurs \( \left( p \right) \). We do so to single out the effect of probability weighting on a vague standard level of due care.

With a precise standard the injurer’s knows exactly ex ante when he crosses the sharp line between liability and no liability. However, in reality this line often is not very clear, it is rather fuzzy. Often, a court decides *ex post* whether the injurer has met the standard level of due care.\(^{15}\) Figure 3 illustrates the zone of care levels where it is not clear *ex ante* whether the injurer meets the due level or not.

**Fig. 3: Vague standard of due care**

![Diagram showing the zone of care levels](image)

If the level of precaution does not exceed \( x_L \), the injurer knows *ex ante* that he will be held liable for sure. With a care level of at least \( x_H \), he certainly will not be held liable. In the range in-between, \( x_L < x < x_H \), the injurer does not know for sure *ex ante* how the court will decide *ex post*. We can capture this uncertainty by a probability function \( F = F(x) \). When there is no additional information the principle of insufficient reason suggests a uniform distribution of \( F(x) \) with the following characteristics:

\[
F(x) = \begin{cases} 
1, & x \leq x_L \\
\frac{x_H - x}{x_H - x_L}, & x_L < x < x_H \\
0, & x \geq x_H.
\end{cases}
\]

The derivative in (7) demonstrates, that, if the level of precaution \( x \) increases not only the probability of a damage occurring, \( p(x) \), increases, but also the probability of being held liable *ex post*. For the following analysis, let us assume that the efficient level of precaution is in the range \( x_L < x^* = \sqrt{D} - 1 < x_H \).\(^{16}\) In order to point out the effect of a vague standard, let us assume that there is no probability weighting of \( p(x) \), but only of \( F(x) \).

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\(^{15}\) See Crasswell and Calfee (1986), Ewert (1999) and Schäfer (2004) for an analysis of vague standards of due care, however, partly related to other subjects.

\(^{16}\) This assumption seems to be plausible if courts generally try to find the efficient level of due care, however, due to a lack of information they might assign a lower or higher level *ex post*. 
Now let us consider the probability weighting function \( \omega(F) \) defined like \( \omega(p) \) in (4). The total (perceived) expected injurer’s costs amount then to:\(^\text{17}\)

\[
C(x) = \begin{cases} 
  x + \frac{1}{1+x} D, & 0 \leq x \leq x_L \\
  x + \left[ \frac{\beta}{1+x} + \alpha \right] \frac{1}{1+x} D, & x_L < x < x_H \\
  x \left( \beta \frac{x_H - x}{x_H - x_L} + \alpha \right), & x \geq x_H.
\end{cases}
\]

Note that with \( \beta = 1 \) and \( \alpha = 0 \), there is no probability weighting like under Expected Utility Theory.

**Result 2:**

(1) Under Expected Utility Theory, vague standards might lead to excessive levels of care (overdeterrence).\(^\text{18}\) (2) Probability weighting according to Prospect Theory reduces the marginal benefits from higher care levels and thus, tends to reduce overdeterrence and (3) might even induce an efficient level of precaution.

**Proof:** See appendix.

With a vague standard, in principle, an injurer has stronger incentives to take care, since a higher level of precaution reduces both the probability of a damage occurring and, in addition, the probability that the injurer will be held liable by the court ex post. Thus, the standard literature (Shavell, 1987) concludes that vague standards may induce overdeterrence in general. With the probability weighting function, this result may not hold: overdeterrence is still possible (though at lower extent), but too little care and even efficient outcomes are also possible. The reason is: with the probability weighting function the *perceived* marginal benefits from additional care – the lower probability of being held liable – are undervalued. This induces lower care levels than under Expected Utility Theory.

\(^\text{17}\) If there would be probability weighting with both \( p(x) \) and \( F(x) \), total perceives costs would be (general formula and with \( p(x) \) specified as in (1):

\[
C(x) = \begin{cases} 
  \frac{D}{x + \left[ \frac{\beta p(x) + \alpha}{1+x} \right]} D, & x = 0 \\
  \left( \frac{x}{x_L} \right)^{\beta} + \frac{\alpha}{1+x} D, & 0 < x \leq x_L \\
  x \left( \beta \frac{x_H - x}{x_H - x_L} + \alpha \right), & x \geq x_H.
\end{cases}
\]

\(^\text{18}\) It is important to note that overdeterrence occurs if \( F(x) \) is linear or concave (thus, decreasing at increasing rates). With \( F(x) \) being (partly) convex, underdeterrence might be possible as well, see Craswell / Calfee (1986), the probability weighting function might even aggravate the problem of underdeterrence then. In the model we only consider the case of \( F(x) \) being linear.
Even though perceived marginal benefits are lower with the probability weighting, still, it is possible that injurers might choose a higher effort level than under Expected Utility Theory. This case is likely to occur when the local optimum $\hat{x}$ is sufficiently close to $x_H$, such that $F(x = \hat{x})$ is quite small and such that this small probabilities is overestimated: $\omega(F(x = \hat{x})) > F(x = \hat{x})$. Certainty is not overestimated: $\omega(F(x = x_H)) = F(x = x_H) = 0$. In this case, perceived total costs with the local optimum $\hat{x}$ are likely to be larger with the probability weighting function than without (considering the local optimum $\hat{x}^{EU}$ which is optimal for the injurer under Expected Utility Theory). Since total costs with the corner optimum $x_H$ are the same in either case, there is a stronger incentive to go for $x_H$ implying overdeterrence. It is obvious when we look at the extreme case, where $\hat{x} \leq \hat{x}^{EU}$ holds, but where both are very close to $x_H$.

$$\lim_{\hat{x} \to x_H} C(x = \hat{x}) = \hat{x} + \alpha \frac{1}{1 + \hat{x}} D; \quad \lim_{\hat{x}^{EU} \to x_H} C(x = \hat{x}^{EU}) = \hat{x}^{EU}. \tag{9}$$

The term $\alpha D/(1 + \hat{x})$ denotes the perceived “fixed costs” of uncertainty since very small probabilities are overestimated. There are no such costs with $x_H$, where there is certainty, thus, there is an incentive to go for $x_H$. There are no such costs with Expected Utility Theory either.

Note that a similar argument also holds for the case where the standard of due care is precise. Because the probability of a damage occurring is very small for care levels close to $x^*$, they are overestimated $\omega(p(x)) > p(x)$ and thus, there is an even stronger incentive to go for the efficient level $x^*$.

Note that a similar argument also holds for the case where the standard of due care is precise. Because the probability of a damage occurring is very small for care levels close to $x^*$, they are overestimated $\omega(p(x)) > p(x)$ and thus, there is an even stronger incentive to go for the efficient level $x^*$. With strict liability there is no such “certainty effect”.

**Result 3:**

The probability weighting function of Prospect Theory implies that very small probabilities are overweighted and also expected damages. Due to this “certainty effect” tortfeasors might be more willing than under Expected Utility Theory to choose $x_H$ under a negligence rule, implying overdeterrence. With strict liability, there is no certainty effect.

**Ambiguity aversion.** Empirical evidence indicates that people dislike ambiguity which is very close to the concept of vagueness (Camerer and Weber, 1992). Ambiguity is an intermediate state of ignorance, in which no distributions can be ruled out, and risk, in

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19 However, if the precise due level of precaution is lower or higher than the efficient level of precaution, the “certainty effect” will even worsen the resulting problems of underdeterrence and overdeterrence, respectively. We should rather expect the case of overdeterrence because the Law and Economics literature suggests to install a quite high level of due care if the lawfeasor does not know the efficient level of precaution (Shavell, 1987).
which all but one distribution is ruled out (Eide, 2005). Ellsberg (1961) was the first to show that individuals dislike ambiguity in general. There is especially aversion to ambiguity for events where a high loss may occur with low probability (Einhorn and Hogarth, 1989). The injurer’s decision with a vague standard fits the concept of ambiguity since damage payments do not only depend on the probability of damage but also on a second order probability function $F(x)$ (Camerer and Weber, 1992). Taking ambiguity aversion into account, there is an additional incentive to go for decisions which yield a certain outcome, that is, to go for $x_H$. In contrast to the issue of the probability function this holds not only for local optima $\hat{x}$ that are sufficiently close to $x_H$, but for all $\hat{x}$ in the range $\hat{x} \in (x_L, x_H)$, since then we have a second-order probability distribution. Again, note that such considerations are not important for strict liability since there is no certainty not to pay damages.

4. Conclusion

The paper investigates the impact of Prospect Theory’s probability weighting function on tortfeasor’s choice of care levels with different tort liability regimes. We obtain the following results.

Precise standard of due care: (1) The wrong estimation of probabilities decreases the marginal benefits of taking care, thus, the tortfeasor may choose too little care whereas without probability weighting the tortfeasor chooses efficient care. (2) Whereas a negligence rule not always causes underdeterrence with probability weighting, strict liability does. A negligence rule is preferable.

Vague standard of due care: (3) Vague standards may induce excessive care under Expected Utility Theory (overdeterrence). Probability weighting according to Prospect Theory tends to reduce overdeterrence and might even induce efficient care. (4) Still, due to the certainty effect, a corner solution with even more excessive care is possible, if the benefits from moving from a local optimum with “almost certainly no damages” to a local optimum with “certainly no damages” are perceived to be sufficiently big.

To sum up, with a precise standard of due care a negligence rule is preferable to a strict liability regime because distortions are less likely to occur. With a vague standard of due care results are more mixed.

Future research may extend the model and may analyse the simultaneous impact of all elements of Prospect Theory. Future research may also address the case of bilateral liability. Further, there is a need to investigate the consequences of Prospect Theory for optimal risk-sharing. A more advanced model might also be able to incorporate
ambiguity aversion. Most importantly, we need empirical research maybe based on experiments.

Appendix

Proof of Result 2:

Ad statement (1): The first derivative with respect to \( x \) yields:

\[
C'(x) = \begin{cases} 
1 - \frac{D}{(1+x)^2}, & 0 \leq x \leq x_L \\
1 - \left[ \beta \frac{D(1+x_H)}{(x_H - x_L)(1+x)^2} + \alpha \frac{D}{(1+x)^2} \right], & x_L < x < x_H \\
1, & x \geq x_H.
\end{cases}
\]

Which level of precaution does induce minimum costs? Since the efficient level of precaution (\( x^* \)) exceeds \( x_L \), the individual optimum lies in the range \( x_L < x \). The optimum is \( x = \hat{x} = \sqrt{\frac{\beta D}{(x_H - x_L)^2} (1+x_H)} + \alpha D - 1 \), if \( \hat{x} < x_H \), else it is \( x_H \). Under Expected Utility (EU), \( \beta = 1 \) and \( \alpha = 0 \), thus \( \hat{x}^{EU} = \sqrt{\frac{D}{(x_H - x_L)^2} (1+x_H)} - 1 \), where \( \hat{x}^{EU} \) exceeds the efficient level \( x^* = \sqrt{D} - 1 \), because of \( x_H > 0 \), \( x_L > 0 \) and \( (1+x_H) > (x_H - x_L) \). Thus, there is overdeterrence with a vague standard under Expected Utility Theory (see Shavell (2004): 224-227).

Ad statement (2): Due to lower marginal perceived benefits from taking care, the local optimum in the range \( x_L < x < x_H \) is smaller: \( \hat{x} < \hat{x}^{EU} \), since \( \beta D \frac{(1+x_H)}{(x_H - x_L)} + \alpha D < D \frac{(1+x_H)}{(x_H - x_L)} \) implies \( \alpha < (1-\beta) \frac{(1+x_H)}{x_H - x_L} \) which is valid due to the assumption \( \alpha < (1-\beta) \) and because of \( (1+x_H) > (x_H - x_L) \).

Ad statement (3): An efficient solution under a vague standard is possible if holds (assuming \( \hat{x} < x_H \)): \( \hat{x} = \sqrt{\beta D \frac{(1+x_H)}{(x_H - x_L)^2} + \alpha D} = x^* = \sqrt{D} - 1 \iff \alpha = (1-\beta) \frac{(1+x_H)}{x_H - x_L} \), which might be fulfilled due to \( \alpha < (1-\beta) \) and \( (1+x_H) > (x_H - x_L) \). Underdeterrence is possible, too, though.
References


