On the optimality of negligence and causation standards in cases of uncertain causation

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Preliminary version. Comments are very welcome.

Abstract

We analyze different liability rules in a model of uncertainty over causation where harm may either be caused by a potentially liable injurer or a natural entity. The court can only imperfectly observe the injurer’s level of care, and the value of the risky activity is private information to the injurer. We aim at explaining why strict liability is only rarely applied to cases of uncertain causation, and why causation standards (threshold probabilities) and negligence standards (due care levels) are used simultaneously. Depending on the probability that the natural entity causes the accident, we show that either strict liability, ordinary or gross negligence may be second-best optimal. Furthermore, we show that adopting threshold probabilities and due care levels jointly may increase social welfare if the injurer has private information on the risk caused by the natural entity.

Keywords: liability rules, uncertainty over causation, negligence, threshold probabilities.
JEL classification: K13

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1 Introduction

1.1 Motivation and main results

In many circumstances, the design of optimal liability rules is aggravated by uncertainty over causation. Following the seminal paper by Shavell (1985), we define uncertain causation as a situation where it is unclear whether harm was caused by someone who can be held liable or by an exogenous entity. Typical examples are health problems that may be either caused by medical malpractice or by genetic disposition, and environmental damages either caused by hazardous substances or natural circumstances. Two assumptions separate the problem of uncertain causation from the one of multiparty accidents: first, it is assumed that harm has been caused by exactly one entity - one simply doesn’t know which one it was. Second, the risk caused by the natural entity is treated as being exogenously given. This seems to be reasonable for genetic dispositions, whereas it may be oversimplified in other cases.

In this paper, we aim at shedding light at the following three stylized facts which are commonly observed in tort law: First, in cases of uncertain causation, courts usually do not apply strict liability but negligence. A typical example is the German Environmental Liability Law (GELL): If causation is not uncertain, strict liability applies. With uncertain causation however, a potential injurer is held liable only if he also violates a given negligence standard. Our first contribution is to show why negligence rules may in fact be superior in the context of uncertain causation even when the injurer’s care level is only imperfectly observed by the court.¹ For instance, should the injurer be judged against what an "ideal individual would be supposed to do in his place" (see e.g. Keeton, Dobbs, Keeton, and Owen (1984, p.174)). Or, as in US medical malpractice legislation, should due care be defined as the “customary practice of practitioners in good standing” (Danzon (2000, p.1343)) or simply with respect to the “average member of the profession” (see Keeton, Dobbs, Keeton, and Owen (1984, p.187) for a discussion)? Especially, we are interested in analyzing whether the court should deliberately deviate from implementing the efficient care level in order to avoid potential underinvestment problems caused by the fact that potential injurers may be liable for damages caused by the natural entity. In the GELL already mentioned, negligence standards in cases of uncertain causation are relatively weak: to become exonerated, it suffices to simply prove that all emission standards were fulfilled. When this legislation was developed, a majority of

¹See Feess (1995).
experts believed that the adoption of such somewhat weak negligence standards would induce inefficiently low care levels, but on the other hand, would help to avoid anticipated underinvestment problems in risky activities.

Third, in many countries, liability rules with uncertain causation are based on both, causation and negligence standards. This is puzzling from a theoretical point of view, since, as we show below, any negligence standard can be transformed into an equivalent causation standard. We suggest asymmetric information as a solution to this puzzle.

To make our points, we closely follow Shavell (1985) in the sense that we adapt his formalization of uncertainty over causation, and we also assume that the value of the injurer’s activity is private information. As for the first two questions mentioned above, we extend the basic model by assuming that the court only gets a noisy signal about the actual care level chosen by the injurer. As a consequence, for any level of precautionary care he might choose ex ante, the injurer is uncertain whether or not he will meet the negligence standard ex post. In such a framework, we show that the second best optimal negligence standard depends on the accident risk posed by the natural entity. Furthermore, we characterize under which circumstance negligence rules where the due care standard is below the first best level are optimal. We refer to such negligence rules as gross negligence.

As for the third question, we further extend the model to illustrate how the joint use of both, causation and negligence standards may enhance social welfare. In particular, we also introduce private information with respect to the natural accident risk; for example, a doctor may have superior information than the court ex ante about the patient’s genetic disposition. We propose a liability rule consisting of a negligence and a causation standard which is Pareto-superior to either a causation or a negligence standard alone. The basic idea is that, by jointly applying causation and negligence standards, the court can actually define two thresholds, and that potential injurers will then self-select in an efficiency-improving way.

1.2 Relation to the Literature

As mentioned above, our paper builds on the model by Shavell (1985) who also assumes that the injurer’s activity is private information. However, he assumes that the court can perfectly observe the injurer’s care level, and does not consider the simultaneous use of causation and negligence standards. Furthermore, our analysis is related to the literature on threshold standards.

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2 As for US tort law, see for example Keeton, Dobbs, Keeton, and Owen (1984, p.164).
3 In the following, we use the terms "threshold probability" and "causation standard" synonymously.
probabilities and on gross negligence. Also assuming that the injurer’s care level is only imperfectly observable, Demougin and Fluet (2005) analyze under which circumstances the commonly used “more likely than not”-criterion (preponderance of the evidence) as standard of proof is indeed the optimal probability threshold. Other papers analyzing causation standards either focus on the minimization of legal errors (Miceli (1991), Rubinfeld and Sappington (1987), Sanchirico (1997)) or on the trade-off between optimal care and the incentives to invest in evidence production (Bernardo, Talley, and Welch (2000)).

Kahan (1989) considers partial liability in cases of uncertain causation under the negligence rule, but assumes that courts can perfectly observe the level of care chosen by injurers. Ex ante uncertainty whether or not a certain care level will satisfy the negligence standard ex post is considered in Diamond (1974), Craswell and Calfee (1986), Schwartz (1998), Ewert (1999) and Kolstad, Ulen, and Johnson (1990), but we are not aware of a paper combining this issue with uncertain causation. Moreover, except the last one, these papers assume do not aim at determining the second best efficient negligence standard.

Although in a different context, the idea that gross negligence rules might be helpful to reduce underinvestment incentives is also analyzed in Parisi (2003) and Schaefer (2004) for the case of purely financial losses where the private loss is often larger than the social loss. As in our case of uncertain causation, an excessively strict negligence standard may then lead to over-deterrence. Finally, to the best of our knowledge, this is the first paper to formally explore the joint use of causation and negligence standards.

2 Basic model

A firm decides whether or not to carry out a risky activity, \( I \in \{1, 0\} \). The private value of this activity coincides with the social value and is given by \( v \) which is privately known to the firm while the regulator (or court) only knows that \( v \) is distributed in the interval \([0, \bar{v}]\) according to distribution function \( F(v) \).

The activity may lead to an accident and cause harm the size of which we normalize to 1. The accident probability is denoted by \( p_e \) and depends on the firm’s care level \( e \in \{0, E\} \) where \( E > 0 \). The cost of care is \( e \), and clearly, more care reduces the accident probability, i.e. \( p_E < p_0 \). In addition, independent of whether or not the firm carries out the activity, the accident occurs for exogenous reasons with probability \( q \). Following Shavell

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4See also Schweizer (2005).
(1985), we introduce the simplifying assumption that the accident is caused by exactly one entity, and that the total accident probability is given by $p(e) + q$ satisfying $p_0 + q \leq 1$.\(^5\)

Whenever an accident occurs, the firm’s care level cannot be perfectly observed or re-constructed in court but the court only obtains a noisy signal $\tau \in \{0, E\}$. With probability $\beta$, the court errs in which case $\tau$ does not coincide with the true effort choice of the firm. We assume $\beta \leq \frac{1}{2}$ so that high (low) care makes a high (low) realization of $\tau$ more likely (first order stochastic dominance). The following table summarizes the probabilities for each of the four possible $(e, \tau)$-combinations:

<table>
<thead>
<tr>
<th>$\tau = E$</th>
<th>$\tau = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e = E$</td>
<td>$1 - \beta$</td>
</tr>
<tr>
<td>$e = 0$</td>
<td>$\beta$</td>
</tr>
</tbody>
</table>

Table 1: Signal Technology

We consider the following three liability rules: Under strict liability (rule $S$), the firm is held liable for any harm caused regardless of its care level. Under negligence-based rules, the court sets a due care level $\hat{e} \in \{0, E\}$, and the firm is only liable if the court’s signal indicates that the negligence standard has been violated, i.e. if $\tau < \hat{e}$. We analyze the two different negligence-based rules. Under ordinary negligence ($O$), an injurer is held liable if some “reasonable man” standard is violated which, in economic terms, is usually interpreted as efficient care (see e.g. Shavell (2004)). Under a gross negligence ($G$) rule, an injurer is treated more leniently in the sense that he is only held liable if the court believes that he has departed significantly from the efficient level.\(^6\) Abstracting from wealth constraints, the firm thus has to pay damages of size 1 whenever it is found liable.

The timing of the game is as follows: At stage 0, the value of $v$ is determined by a nature’s move and revealed to the firm only. At stage 1, the court decides on the liability rule $r = S, O, G$. At stage 2, the firm decides

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\(^5\)Assuming instead the total accident probability to be $p_e + q - p_e \cdot q$ would render the analysis considerably more tedious without affecting our results qualitatively.

\(^6\)There is some controversy in the legal literature over whether or not gross negligence does require "willful, wanton or reckless misconduct". However, according to the more common view, it is simply characterized by "failure to use even slight care". Obviously, we use the latter definition in which case gross negligence differs from ordinary negligence “only in degree but not in kind”, see Keeton, Dobbs, Keeton, and Owen (1984, pp. 208).
on $I$. If $I = 0$, the game ends. If $I = 1$, then at stage 3, the firm chooses its care level $e$. If $I = 1$ and an accident occurs, then at stage 4, the liability of the firm is determined according to the liability rule in place.

Before determining the equilibrium of this game, consider the efficiency benchmark. For given $v$, the efficient care level $e^*$ maximizes expected social welfare, i.e.

\[ e^* = \arg \max_{e \in \{0, E\}} SW = v - p_e - e \]  

and high care is efficient whenever the total expected cost of doing so is sufficiently low:

\[ e^* = E \iff p_E + E < p_0. \]  

We will assume a slightly stronger version of this inequality to hold throughout:

**Assumption 1** $p_E + 2E < p_0$

Note that the efficient care level is independent of the project’s value. Moreover, it is then clear that rule $O$ corresponds to setting due care level $\hat{e} = E$, while under the more lenient rule $G$, $\hat{e} = 0$ holds.\(^7\)

As for the activity level, from a social point of view, the activity should be carried out whenever it is sufficiently valuable:

\[ I^* = \begin{cases} 
1 & \text{if } v \geq v^* \\
0 & \text{otherwise} 
\end{cases} \]  

where $v^* := p_E + E$. To avoid trivial outcomes, we assume that $v^* < \overline{v}$. We will refer to the case where the firm’s equilibrium threshold is higher (lower) than the efficient one as **under- (over)-investment**.

When designing the liability rule, the regulator is therefore concerned with both, the activity level and the care level it induces along the equilibrium path.

### 3 Analysis

It is instructive to perform the equilibrium analysis separately for each rule, then compare the equilibrium activity and care levels, and finally determine which of the rules is preferred by the court. As for this, define $l^r(\tau(e, \beta)) \in$

\(^7\)Of course, the fact that $\hat{e} = 0$ will be identical to no liability at all is an artefact of our discrete modelling framework and the normalization of low effort to zero. The intuition of our results generalizes to the case where $e$ can take on more than two values (including the case where it is continuous).
[0, 1] as the probability that the firm is held liable after the accident has occurred under rule \( r = S, O, G \) when choosing care level \( c \), and when the court errs with probability \( \beta \). Since \( q \) is the probability that the accident is caused by an exogenous entity in which case the firm might also be held liable, the firm’s preferred care level \( c^* \) solves the following maximization problem:

\[
e^r = \arg\max_{c \in \{0, E\}} v - (p_e + q) \cdot I^r(\tau(e, \beta)) - e
\]

Analogously, let \( I^r \) denote the firm’s optimal choice to carry out the project under liability rule \( r \).

### 3.1 Strict liability (rule \( S \))

Under strict liability, we have \( l^S \equiv 1 \) since the firm is liable whenever the accident occurs. In this case, its expected profit is given by \( v - p_e - q - c \) so that high care is preferred whenever

\[
v - p_e - q - E > v - p_0 - q \iff p_E + E < p_0
\]

which is exactly condition (2) and which is implied by Assumption 1 so that \( e^S = E = e^f \). This is simply the well-known result that strict liability induces efficient incentives with respect to the care level.\(^8\)

On the other hand, the firm carries out the project whenever its expected net profit from doing so is non-negative, i.e.

\[
I^S = \begin{cases} 
1 & \text{if } v \geq v^S \\
0 & \text{otherwise}
\end{cases}
\]

where \( v^S := p_E + q + E > v^* \) \( \forall q > 0 \). Thus, while inducing the efficient care level, strict liability leads to underinvestment whenever the probability is positive that the accident will not be caused by the firm but by some exogenous entity.

### 3.2 Gross negligence (rule \( G \))

As explained above, the analysis of rule \( G \) is trivial in our framework since the due care level under gross negligence is simply \( c^* = 0 \). Therefore, regardless of the court’s signal, the firm is never liable \( (l^G \equiv 0) \) and the firm’s profits is just equal to \( v - c \). Clearly, this leads to \( e^G = 0 \) and \( I^G \equiv 1 \) \( \forall v \) so that the implied threshold for \( v \) is simply \( v^G = 0 < v^* \). Thus, gross negligence leads to an inefficiently low care level and to overinvestment.

\(^8\)See e.g. Shavell (2004, pp. 179).
3.3 Ordinary negligence (rule $O$)

Under ordinary negligence, the due care level is $\hat{e} = E$ so that the firm’s profit when choosing $e = E$ is
\begin{equation}
v - (p_E + q) \cdot \beta - E
\end{equation}

since the court receives signal $\tau = 0$ with probability $\beta$ in which case the firm is liable (see Table 1). Thus, when choosing $E$, the firm is only liable if the court’s signal is erroneous. Analogously, when choosing $e = 0$, the firm gets
\begin{equation}
v - (p_0 + q) \cdot (1 - \beta)
\end{equation}

It follows that high care is preferred whenever
\begin{equation}
(p_E + q) \cdot \beta + E < (p_0 + q) \cdot (1 - \beta)
\end{equation}

Clearly, high care is the more attractive, the lower the probability that the court’s signal is erroneous. Thus, when $\beta = 0$, the inequality is always satisfied. When $\beta$ increases, high care becomes less attractive, but Assumption (1) ensures that the inequality still holds for $\beta = \frac{1}{2}$ which implies that it does so for all $0 < \beta < \frac{1}{2}$ so that we have $e^O = E$.

As for the firm’s activity level, with $e^O = E$ we have
\begin{equation}
I^O = \begin{cases} 
1 & \text{if } v \geq v^O \\
0 & \text{otherwise}
\end{cases}
\end{equation}

where $v^O := (p_E + q) \cdot \beta + E \leq v^\ast$. We may thus either have over- or underinvestment under rule $O$ as there are two countervailing effects: on the one hand, when the accident occurs, the firm is liable only with probability $l^O = \beta \leq \frac{1}{2}$ which ceteris paribus leads to overinvestment (the $l$-effect). On the other hand, the firm might have to pay for damages for an accident it has not caused which ceteris paribus leads to underinvestment (the $q$-effect). Note that when the court’s signal is non-erroneous ($\beta = 0$), then there is always overinvestment in which case the firm will certainly be exonerated for $e = E$, so that the $q$-effect disappears. This resembles the well-known result that negligence-based rules tend to induce excessive activity levels.\textsuperscript{9}

4 The optimal liability rule

As shown in the previous section, the three rules tend to induce different activity and care levels along the equilibrium path. For convenience, the following table summarizes all relevant information:

Rule ($r$) | Care ($e'$) | Activity ($v'$) | Expected surplus ($E[SW']$)  
--- | --- | --- | ---  
$S$ | $E$ | $(p_E+q) + E$ | $\int_{v_S}^{v_O} [v - p_E - E] dF(v)$  
$G$ | 0 | 0 | $\int_{v_G}^{v_O} [v - p_0] dF(v)$  
$O$ | $E$ | $(p_E+q) \cdot \beta + E$ | $\int_{v_O}^{v_O} [v - p_E - E] dF(v)$  
Benchmark | $e^* = E$ | $v^* = p_E + E$ | $\int_{v^*}^{v_O} [v - p_E - E] dF(v)$  

Table 2: Summary Information

To determine the (second best) optimal liability rule, it is crucial whether rule $O$ leads to over- or underinvestment: Therefore, as a first step define $q^{O*} := \left( \frac{p_E (1-\beta)}{\beta} \right)$ as that value of $q$ which equates $v^O$ and $v^*$. By monotonicity, when $q > q^{O*}$, we have $v^O > v^*$ so that rule $O$ leads to under-investment. Analogously, when $q < q^{O*}$, rule $O$ leads to over-investment. The intuition is straightforward: if $q$ is high, then the firm is often held liable for damages it has not caused which induces underinvestment. Moreover, we have $\frac{d}{dq} q^{O*} = -\frac{p_E}{\beta} < 0$ because a lower probability of being (erroneously) held liable when choosing $E$ increases overinvestment incentives (the $l$-effect described above). This given, we can summarize our findings as follows:

**Proposition 1** (i) If $q > q^{O*}$ (underinvestment case), then strict liability is never optimal. Depending on the parameters, either ordinary or gross negligence is optimal. That gross negligence is preferred is the more likely the higher $q$ and the higher $\beta$.
(ii) If $q < q^{O*}$ (overinvestment case), then gross negligence is never optimal. That strict liability is preferred is the more likely the lower $q$ and the lower $\beta$.
(iii) If $q = q^{O*}$, then rule $O$ leads to the first best and is thus the optimal liability rule.

**Proof.** Part (i). If $q > q^{O*}$, then $v^S > v^O > v^*$. Note that $p_0 > v^*$, but depending on the parameters, $p_0$ may be larger or smaller than $v^O$. Clearly, rule $O$ outperforms rule $S$:

$$E[SW^O] - E[SW^S] = \int_{v_O}^{v_S} [v - p_E - E] dF(v),$$

(5)
which is positive as \(v^O > v^\ast\). The difference in expected social welfare between rules \(O\) and \(G\) is

\[
E[SW^O] - E[SW^G] = - \int_0^{v^O} v dF(v) - (p_E + E) \cdot (1 - F(v^O)) + p_0,
\]

which may be positive or negative, and the derivatives of this difference w.r.t. \(q\) and \(\beta\) are, respectively, \(-f(v^O) \cdot \beta \cdot (v^O - v^\ast)\) and \(-f(v^O) \cdot (p_E + q) \cdot (v^O - v^\ast)\), both of which are strictly negative.

**Part (ii).** If \(q < q^O\), then \(p_0 > v^\ast > v^O\). Hence, rule \(O\) outperforms rule \(G\):

\[
E[SW^O] - E[SW^G] = \int_0^{v^O} [p_0 - v] dF(v) + \int_{v^O}^\theta [p_0 - (p_E + E)] dF(v) > 0.
\]

Recall that the difference in expected social welfare between negligence and strict liability is given by equation (5), which may be positive or negative, since \(v^S > v^\ast > v^O\). The derivatives of the expression on the right-hand side of (5) w.r.t. \(q\) and \(\beta\) are, respectively, \(-f(v^S) \cdot (v^S - v^\ast) - f(v^O) \cdot \beta \cdot (v^O - v^\ast)\) and \(-f(v^O) \cdot (p_E + q) \cdot (v^O - v^\ast)\), both of which are strictly positive.

**Part (iii).** If \(q = q^O\), then \(v^O = p_E + E = v^\ast\) and hence \(E[SW^O] = E[SW^\ast]\).

Intuitively, as for part (i), strict liability can not be optimal when underinvestment would result even under ordinary negligence: the effort choice is the same, whereas the underinvestment problem is even more pronounced under strict liability. Here, gross negligence may be optimal: as shown above, under gross negligence, the care level is inefficiently low while the activity level is excessive. But social welfare under these two inefficiencies may still be higher than under rule \(O\) where the care level is efficient but where there is underinvestment. Below, we present a numerical example where rule \(G\) is indeed optimal under plausible parameter constellations.

The economic key result of part (i) is that gross negligence should be chosen if \(q\) and \(\beta\) are high. If \(q\) is high, then it is likely that the firm must pay for damages it has not caused, which leads to underinvestment. And if \(\beta\) is high, then the underinvestment problem is only partially mitigated by an ordinary negligence rule as it is relatively likely that the court errs, so that the firm is held liable even if it has exerted due (efficient) care.

As for part (ii), because the \(l\)-effect outweighs the \(q\)-effect, overinvestment results under rule \(O\). This problem is the more severe, the lower \(q\), and the lower the probability of being held liable at all (i.e. when \(\beta\) is small). From
a social point of view, it might be better to accept the underinvestment problem induced by strict liability compared to the overinvestment problem induced by negligence. Note that the court’s decision will be based on the comparison of $v^S$ and $v^O$ only since the care level is the efficient one under both rules.

Finally, part (iii) describes the borderline case $q = q^{OF}$, in which by definition of $q^{OF}$, the $q$-effect and the $l$-effect cancel out each other, so that the first best emerges.

**Example 1** Let $v$ be uniformly distributed on $[0, 1]$ and $\beta = \frac{1}{2}$ so that $q^{OF} = p_E$. Furthermore, assume $p_0 = \frac{14}{100}$, $p_E = \frac{5}{100}$ and $E = \frac{4}{100}$. From Table 2, we then get

$$E [SW^S] = \left( \frac{1}{2} - p - E + \frac{1}{2} (p + E)^2 - \frac{1}{2} q^2 \right) = 0.41 - 0.5q^2$$

$$E [SW^G] = \left( \frac{1}{2} - p_0 \right) = 0.36$$

$$E [SW^O] = \left( pE - p - E + \frac{1}{2} E^2 + \frac{1}{2} p (p + q) - \frac{1}{8} (p + q)^2 + \frac{1}{2} \right)$$

$$= \frac{33179}{80000} - \frac{1}{8} q^2 - \frac{1}{80} q$$

Let us start with the underinvestment case, i.e. $q \in (p_E, 1 - p_0)$ and define $\Delta^{GO}(q) := E[SW^G] - E[SW^O]$. We then have

$$\lim_{q \to \frac{5}{100}} \Delta^{GO}(q) \approx -\frac{5}{100} < 0$$

$$\lim_{q \to \frac{5}{100}} \Delta^{GO}(q) \approx \frac{3}{100} > 0$$

$$\Delta^{GO}(q^{GO}) = 0 \iff q^{GO} \approx 0.71$$

Since $\Delta^{GO}(q)$ is strictly increasing in $q$ in the relevant range, it follows that rule $O$ ($G$) is optimal for all $q < (>)q^{GO}$.

Now consider the case of overinvestment, i.e. $q \in [0, p_E)$ and define $\Delta^{SO}(q) := E[SW^S] - E[SW^O]$. This leads to

$$\Delta^{SO}(q = 0) = \frac{1}{3200} > 0$$

$$\lim_{q \to \frac{1}{100}} \Delta^{SO}(q) \approx -\frac{1}{1000} < 0$$

$$\Delta^{SO}(q^{SO}) = 0 \iff q^{SO} = \frac{1}{60}$$
Again, by monotonicity, it follows that rule $S(O)$ is superior for all $q < (>) q^{SO}$.

5 Liability rules with causation standards (threshold probabilities)

5.1 Equivalence of negligence and causation standards

In reality, liability rules in cases of uncertain causation are usually based on both, causation standards and negligence. As discussed above, in the case of medical malpractice claims for example, to establish a valid claim, and after having shown to have actually suffered an adverse event, the claimant needs to i) attribute the injury to the activity of the health care provider as opposed to nature and ii) show that the provider was negligent (see Kessler and McClellan (1996, p.356)). Thus, an injurer is only held liable if the ex post probability of having caused the accident is above a critical threshold and if the court finds that he has acted negligently.

To the best of our knowledge, the economic literature has not yet discussed the merits of the simultaneous use of the two instruments on the incentives of potential injurers. The reason is that in many economic models (including the one discussed so far), each negligence standard can easily be transformed into a causation standard and vice versa. To see this, recall that in court, the injurer is found to have violated negligence standard $\tau < \theta$. Thus, for the injurer to escape liability with respect to the negligence standard, the critical signal is

$$\tau_N = \theta.$$

As for causation, for a given $q$, each signal $\tau$ transforms into an (ex post) probability $x(\tau, q)$ with which the firm has caused the accident

$$x(\tau, q) := \frac{p(\tau)}{p(\tau) + q}$$

The firm thus violates the causation standard if $x(\tau, q)$ is above a given threshold $\hat{x}$. Since it is easily verified that $x(\tau, q)$ is monotone decreasing in $\tau$, we can solve for the critical signal $\tau_C$ for which $x(\tau_C, q) = \hat{x}$ holds:

$$\frac{p(\tau)}{p(\tau) + q} = \hat{x} \iff p(\tau) = (p(\tau) + q) \cdot \hat{x} \iff p(\tau) = \frac{\hat{x} \cdot q}{1 - \hat{x}} \iff$$

$$\tau_C(\hat{x}, q) = p^{-1}(\frac{\hat{x} \cdot q}{1 - \hat{x}})$$

(6)
To summarize, the firm violates a given causation standard \( \hat{x} \) if \( \tau < \tau_C \) and it violates a given negligence standard \( \hat{e} \) if \( \tau < \tau_N \). Then, the following result is immediate:

**Proposition 2** For any negligence standard \( \hat{e} \), there exists a causation standard

\[
\hat{x}^{eq} := \frac{p(\hat{e})}{p(\hat{e}) + q}
\]

which is equivalent in the sense that for all possible signals, the liability consequences for the firm are identical under each standard.

**Proof.** Just note that \( \hat{x}^{eq} \) induces \( \tau_C = \tau_N \) since

\[
\tau_C(\hat{x}^{eq} \cdot q) = p^{-1} \left( \frac{q \frac{p(\hat{e})}{p(\hat{e}) + q}}{p(\hat{e}) + q} \right) = p^{-1}(p(\hat{e})) = \hat{e} = \tau_N
\]

Given this result, the simultaneous use of both instruments is puzzling, because for each causation standard, one can easily find an equivalent negligence standard and vice versa, so there is no need to use both instruments. Moreover, for each liability rule which uses both, some causation standard \( \hat{x} \neq \hat{x}^{eq} \) and some negligence standard \( \hat{e} \), and according to which the firm is only liable if both standards are violated (as is the case in reality), it is clear that the firm cares only about the weaker standard, as this suffices to become exonerated, i.e. only \( \min(\tau_C, \tau_N) \) is relevant. Again, there is no need to use both instruments.

### 5.2 Extension: Explaining the joint use of both instruments

In this section, we aim at giving a rationale based on asymmetric information for the use of both instruments as part of the optimal liability rule. Thereby, we extend our basic model as follows: Ex ante, the probability \( q \) that an accident is caused by an exogenous entity is only known to the injurer, but not to the court when deciding upon the liability rule. Ex post however, after the accident has occurred, the court can figure out the true value of \( q \). For example, consider again medical malpractice where \( q \) can be interpreted as genetic disposition of a patient. First, it is clear that once determined, each causation standard applies to very different situations. Assuming that the legislator does not know \( q \) in advance is just a simple way of modeling this fact. Second, doctors often observe \( q \) or a signal thereof before deciding
on their treatment or care level. And finally, in the course of litigation, it is plausible that at least some update about the true value of \( q \) becomes available (through expert testimony, say). We assume here that this update is perfect, but our main argument would remain unchanged when the court only receives some informative, but imperfect signal.

Clearly, since the true value of \( q \) will become common knowledge in the courtroom, the court could simply announce ex ante that it will wait until \( q \) is known and will then condition the due care level \( \hat{e} \) on \( q \) which, of course, is in stark contrast to reality. In this section, we will therefore argue that the joint use of causation and negligence standards can be interpreted as a device to mitigate the inefficiencies caused by the fact that standards can often not be tailored to the prevailing state of the world ex post.

We continue to use a discrete framework and assume that \( q \) can take on two values, \( q_h \) and \( q_l \) where \( q_h > q_l > 0 \). To make things interesting, and in the spirit of part i) Proposition 1, we assume that gross negligence (rule \( G \)) is (second best) optimal for \( q = q_h \) while ordinary negligence (rule \( O \)) is optimal for \( q = q_l \). That is, for \( q = q_l \) it is optimal do induce a high care level \( E \) by choice of due care level \( \hat{c} = E \) which, however comes at the expense of inducing some underinvestment. On the other hand, when \( q = q_h \), then the underinvestment problem is potentially more severe and to mitigate it, it then becomes optimal to lower the due care level to \( \hat{c} = 0 \).

We now show that when using both, a negligence and a causation standard, then there is no additional welfare loss even though \( q \) is private information to the firm at the time when the court decides on the liability rule:

**Proposition 3** When \( q \) is private information ex ante, and becomes commonly known only ex post, then a liability rule consisting of a negligence standard \( \hat{e} = E \) and a causation standard \( \hat{x} = \frac{p_0}{p_0 + q_h} \) implements the same (i.e. second best) allocation as the one emerging in the basic model where \( q \) is commonly known ex ante and no causation standard is used.

**Proof.** Suppose \( q = q_l \). When \( \tau = E \), then the firm passes the negligence standard and is exonerated. On the other hand, when \( \tau = 0 \), the negligence standard is clearly violated. The same is true for the causation standard since \( x(0, q_l) = \frac{p_0}{p_0 + q_l} > \hat{x} \) because \( q_l < q_h \). It follows that the firm is liable for \( \tau = 0 \) while it is exonerated for \( \tau = E \). The firm’s decision problem is thus exactly the same as in the basic model (see Eqn. 4) and it chooses \( c = E \) which, by assumption, is also the (second best) optimal choice for \( q = q_l \).

Now suppose \( q = q_h \). When \( \tau = E \), then the firm obviously passes the negligence standard and does not violate the causation standard either as
\[ x(E, q_h) = \frac{p_E}{p_E + q_h} < \hat{x} \]  because \( p_E < p_0 \). However, the firm escapes liability even for \( \tau = 0 \): while violating the negligence standard, it does not violate the causation standard since \( x(0, q_h) = \hat{x} \). The firm optimally chooses \( e = 0 \), which for \( q = q_h \) is again the second best optimal choice.

Clearly, since the effort levels are the same as in the basic model for the different values of \( q \), the same is true for the activity levels.

The intuition for Proposition 3 relies on the fact that whether the negligence or the causation standard is pivotal depends on \( q \). When \( q \) is low, then the ex post probability that the injurer has caused harm is high. Hence, the threshold probability will be violated, so that the negligence standard is pivotal. By choosing the "tough" due care level \( \hat{e} = E \), the court induces the firm to choose high care as otherwise both the threshold probability and the negligence standard will be violated. And this is exactly what the court wants as the high care level is second best optimal if \( q \) is low.

On the other hand, when \( q \) is large, then absent any causation standard, the tough due care level \( \hat{e} = E \) would induce the firm to continue to choose high care which is not optimal for \( q = q_h \). In this case, by setting \( \hat{x} \) such that the firm is exonerated for all signals at least as large as the optimal care level (when \( q = q_h \), the causation standard becomes pivotal, and the court induces the firm to choose low care, which is again the optimal choice for \( q = q_h \).

At a more general level, our result thus suggests that by setting both standards relatively strict, the court is able to circumvent potential problems due to its inflexibility to tailor liability rules to situations with different levels of \( q \).

6 Conclusion

We have considered a model of uncertain causation in the spirit of Shavell (1985). Assuming that the regulator can not perfectly observe the care level actually chosen, we have shown that the second best optimal liability rule depends on the probability \( q \) that the natural entity causes harm. If this probability is high, then underinvestment problems are severe, and gross negligence may be superior even though this induces an inefficiently low care level.\(^{10}\) For intermediate values of \( q \), ordinary negligence is second best

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\(^{10}\) Another possibility of reducing underinvestment incentives would be the introduction of damage caps which limit damage payments in malpractice cases (see Hellinger and Encinosa (2003)). As a consequence of the malpractice insurance crisis in the 1970s and 1980s, roughly half of the states in the US have introduced such caps. Clearly, the aim was to slow down the growth of the medical malpractice liability premiums and thus help
optimal, while strict liability is superior if $q$ is small.

With respect to the injurer’s effort choice and the court’s signal, we have adopted a simple discrete framework, but the intuition behind our results is robust. We have also considered a version of the model where both, the firm’s effort choice and the signal are continuous. In such a setting, one can show that the optimal due care level set by the court is weakly decreasing in $q$. In equilibrium, both over- or underinvestment incentives may arise.

Even though our results have been derived in a model on uncertain causation, there are also other situations where similar trade-offs between the optimal care and activity levels, respectively, seem to be virulent. For instance, assume that the activity causes some kind of positive externalities as in cases of development risks where the innovating firm produces information externalities for potential successors. Even more simple, firms may not be able to extract all of the consumers’s surplus, such that the privately optimal level of investment under strict liability would be below the socially optimal one. Then, (gross) negligence rules may be superior even with unilateral accidents, and even if the care level cannot be perfectly observed. Hence, our model is supposed to shed some light on the question as to why negligence rules dominate even for unilateral accidents where the textbook literature usually recommends strict liability.

Our extended model in section 5 should be interpreted as a first attempt to investigate why negligence and causation standards are jointly adopted in cases of uncertain causation. We do believe that asymmetric information together with courts’ inflexibility ex post play an important role, but clearly, more research is needed for a more comprehensive answer to this question.

Finally, one obvious issue is why we did not consider proportionate liability rules as proposed by Shavell (1985). However, proportionate rules seem to be only very rarely applied in reality.\(^{11}\) One potential reason might be transaction costs which tend to be high for at least two reasons: first, simple proportionate rules are only efficient if a potential injurer pays also part of the damage if the probability that he caused the accident is very low. This leads to a higher number of litigations. Second, the court needs to adjust $p/(p + q)$ exactly under a proportionate rule, which is much more difficult than to simply assess whether $p/(p + q)$ is above some critical threshold.

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\(^{11}\) Porat and Stein (2003) discuss a recent decision where the Court of Appeals applied a proportionate liability rule instead of threshold probabilities, but also emphasize that causality standards still dominate all over the world.

\(^{12}\) See also Shavell (2004), p. 256.
References


