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Learning-by-Doing in Torts: Liability and Information About Accident Technology

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Florian Baumann* Tim Friehe†

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Abstract

In the economic analysis of liability law, information about accident risk and how it can be influenced by precautions is commonly taken for granted. However, a profound understanding of the relationship between care and accident risk often requires learning-by-doing. In a two-period model, we examine the implications for the optimal level of care and behavior under strict liability and negligence, showing that liability law may not induce efficient incentives.

Keywords: Liability rules; care incentives; accident technology

JEL-Classification: K13, D62, D83

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1 Introduction

In the economic analysis of liability law, parties generally know about the accident risk and how it can be influenced by precautions. In these circumstances, the well-known *Hand rule* describes the efficient level of care as the one that sets the marginal costs of care equal to the reduction in expected harm (e.g., Cooter 1991). Strict liability and negligence can induce the efficient level of care in such a system.

However, the relevant parties are not always equipped with such abundant information. Shavell (1992) has scrutinized the case in which potential injurers must incur a fixed cost to know whether an accident risk exists or not. He finds that strict liability always induces efficient incentives regarding information acquisition and the precautions taken, whereas for negligence, it depends on what is understood by the *reasonable behavior* that would allow the injurer to avoid liability.

The present analysis studies the scenario in which – starting from some prior – information about the true accident technology (i.e., the level of risk and how it responds to a variation in care) can only be inferred from the history of accidents. This means that care has a role not only with respect to the minimization of social costs in a given period but also regarding the acquisition of information about the accident technology. We establish the socially optimal care levels and argue that both liability rules (strict liability and negligence) may fail to induce them.

2 The model and social optimum

We investigate a two-period unilateral care model. In each period, a potential injurer undertakes an activity that may involve a risk of harm $d > 0$ for others. The risk-neutral injurer chooses precautions $x \geq 0$ at cost x. At the outset, it is common knowledge that one of two possible accident technologies applies.[1] With probability q, technology H applies and the accident probability amounts to $h(x)$, $0 \leq h(x) \leq 1$ and $h'(x) \leq 0 \leq h''(x)$. With probability $1 - q$, accident technology L applies instead and the accident probability is $\ell(x)$, $0 \leq \ell(x) \leq h(x)$ and $\ell'(x) \leq 0 \leq \ell''(x)$. Accidents are thus at least as likely with accident technology H as

[1]Feess and Wohlschlegel (2006) analyze a setup in which some injurers possess perfect knowledge about the accident technology whereas others do not.

with technology L. However, no assumption is made about how the reductions in accident risk $-h'(x)$ and $-\ell'(x)$ compare.

In the second period, using the outcome from the first period (either *accident* (A) or *no accident* (N)) and the level of first-period care x_1, we can update the probability that accident technology H is the true one. After an accident, we obtain

$$q_A(x_1) = \frac{qh(x_1)}{qh(x_1) + (1-q)\ell(x_1)}, \tag{1}$$

and for no accident,

$$q_N(x_1) = \frac{q(1-h(x_1))}{q(1-h(x_1)) + (1-q)(1-\ell(x_1))}. \tag{2}$$

Due to $h(x) \geq \ell(x)$, the outcome *accident* (*no accident*) is a noisy signal for accident technology H (L) (i.e., $q_A(x_1) \geq q \geq q_N(x_1)$). The strength of the signal and thus the conditional probabilities are influenced by the level of first-period care, i.e.,

$$q'_A(x_1) = \frac{q(1-q)\ell(x_1)h(x_1)\left[h'(x_1)/h(x_1) - \ell'(x_1)/\ell(x_1)\right]}{\left(qh(x_1) + (1-q)\ell(x_1)\right)^2} \tag{3}$$

and

$$q'_N(x_1) = \frac{q(1-q)(1-\ell(x_1))(1-h(x_1))\left[\ell'(x_1)/(1-\ell(x_1)) - h'(x_1)/(1-h(x_1))\right]}{\left(q(1-h(x_1)) + (1-q)(1-\ell(x_1))\right)^2}. \tag{4}$$

For example, the term in (3) is positive when care is relatively more productive with respect to reducing the accident probability when technology L applies instead of H – that is, when $-\ell'(x_1)/\ell(x_1) > -h'(x_1)/h(x_1)$.

The social planner minimizes the level of social costs (defined by the sum of precaution costs and expected losses) by her choice of first-period care x_1 and second-period care $x_2(q_j(x_1))$ conditional on the probability $q_j(x_1)$, $j = A, N$. In the second and final period, social cost minimization mandates that

$$x_2^*(q_j(x_1)) = \arg\min_{x_2}\{x_2 + [q_j(x_1)h(x_2) + (1-q_j(x_1))\ell(x_2)]\, d\}, \tag{5}$$

where

$$\frac{\partial x_2^*(q_j(x_1))}{\partial q_j(x_1)} = \frac{\ell'(x_2^*) - h'(x_2^*)}{q_j(x_1)h''(x_2^*) + (1-q_j(x_1))\ell''(x_2^*)}. \tag{6}$$

Intuitively, an increase in the conditional probability that accident technology H applies induces a higher (lower) optimal level of care in the second period when the marginal reduction in the accident probability is relatively higher (lower) for technology H in comparison to technology L.

In the *accident* (*no accident*) state, second-period care will be tailored more towards technology H (L) due to $q_A(x_1) \geq q \geq q_N(x_1)$. However, this inference may be inadequate; indeed, there are two kinds of possible error. The error we label α occurs when $x_2^*(q_N(x_1))$ is chosen because there was no accident in period 1 but technology H actually applies, implying that $x_2^*(q_A(x_1))$ would have been the better choice. Similarly, the error we label β occurs when $x_2^*(q_A(x_1))$ is chosen because there was an accident in period 1 but technology L actually applies, implying that $x_2^*(q_N(x_1))$ would have been the more appropriate choice. The probability of an error of type α is $q(1-h(x_1))$ and *increases* with first-period care. In contrast, the probability of an error of type β amounts to $(1-q)\ell(x_1)$ and *decreases* with first-period care. Error costs amount to

$$\begin{aligned}\Delta_\alpha =& x_2^*(q_N(x_1)) + h(x_2^*(q_N(x_1)))d - [x_2^*(q_A(x_1)) + h(x_2^*(q_A(x_1)))d] > 0\\ \Delta_\beta =& x_2^*(q_A(x_1)) + \ell(x_2^*(q_A(x_1)))d - [x_2^*(q_N(x_1)) + \ell(x_2^*(q_N(x_1)))d] > 0\end{aligned}$$

for errors of type α and β.

Neglecting discounting, total social costs amount to

$$\begin{aligned}SC =& x_1 + q\left\{h(x_1)\left[d + x_2^*(q_A(x_1)) + h(x_2^*(q_A(x_1)))d\right] + (1-h(x_1))\left[x_2^*(q_N(x_1)) + h(x_2^*(q_N(x_1)))d\right]\right\}\\ &+ (1-q)\left\{\ell(x_1)\left[d + x_2^*(q_A(x_1)) + \ell(x_2^*(q_A(x_1)))d\right] + (1-\ell(x_1))\left[x_2^*(q_N(x_1)) + \ell(x_2^*(q_N(x_1)))d\right]\right\},\end{aligned} \tag{7}$$

which leads to the first-order condition for socially optimal care in the first period, x_1^*,

$$\begin{aligned}\frac{dSC}{dx_1} =& 1 + \left[qh'(x_1^*) + (1-q)\ell'(x_1^*)\right] d\\ &- qh'(x_1^*)\underbrace{\left[x_2^*(q_N(x_1)) + h(x_2^*(q_N(x_1)))d - [x_2^*(q_A(x_1)) + h(x_2^*(q_A(x_1)))d]\right]}_{=\Delta_\alpha}\\ &+ (1-q)\ell'(x_1^*)\underbrace{\left[x_2^*(q_A(x_1)) + \ell(x_2^*(q_A(x_1)))d - [x_2^*(q_N(x_1)) + \ell(x_2^*(q_N(x_1)))d]\right]}_{=\Delta_\beta} = 0.\end{aligned} \tag{8}$$

In contrast, the level of care that minimizes social costs in the first period – that is, the myopic benchmark level of care denoted $x_1(q)$ – sets the first line of (8) equal to zero.

The socially optimal level of first-period care incorporates the fact that the outcomes *accident* and *no accident* yield signals about the accident technology. The additional marginal incentives that result from this in (8) can be described as follows: A higher level of care in the first period makes the *no accident* outcome more likely. This makes the choice of $x_2^*(q_A(x_1))$ in the second period less likely. The second line in (8) explicates that this is socially undesirable when technology H applies, whereas it lowers social costs when technology L is applicable (see the third line). The second (third) line represents the increase (decrease) in social costs due to the higher (lower) probability of an error of type α (β). We use three examples to illustrate different scenarios for the informational value of first-period care and the corresponding adjustment in optimal care away from $x_1(q)$.

Example 1: Suppose $h'(x) < \ell'(x) = \ell(x) = 0 < h(x)$. In this case, when an accident occurs in the first period, we obtain $q_A(x_1) = 1$. In addition, we have $q_N'(x_1) > 0$ (i.e., a higher level of care makes it more difficult to distinguish between technologies after *no accident*). Because care is effective only with technology H, it holds that $x_2^*(q_A(x_1)) > x_2^*(q_N(x_1))$. From (8) we obtain

$$\frac{dSC}{dx_1} = 1 + qh'(x_1^*)d - qh'(x_1^*)\Delta_\alpha = 0,$$

which implies $x_1^* < x_1(q)$. A lower level of care in the first period makes it easier to distinguish the two technologies and reduces the probability of an error of type α in the second period.

Example 2: Suppose $h(0) = \ell(0)$ and $h'(x) = 0 > \ell'(x)$. In this scenario, a higher level of care makes the signal less noisy, such that $q_A'(x_1) > 0 > q_N'(x_1)$. From (8), we obtain

$$\frac{dSC}{dx_1} = 1 + (1-q)\ell'(x_1^*)d + (1-q)\ell'(x_1^*)\Delta_\beta = 0,$$

which implies $x_1^* > x_1(q)$; this follows intuitively, as higher first-period care enables the policymaker to more easily distinguish between the precaution technologies and reduces the probability of error β.

Example 3: Suppose $h(x) > \ell(x)$ and $h'(x) = \ell'(x)$. In this scenario, the optimal level of care is independent of the technology that applies. As a result, influencing the precision of the signal about the true technology is of no social value, and $x_1^* = x_1(q)$.

These findings are summarized in:

Proposition 1 *With a possibility to learn about the accident technology, the socially optimal first-period care level exceeds (falls short of) the care level that minimizes social costs in period 1 when the expected benefit from avoiding an error of type β exceeds (falls short of) the expected costs of increasing the likelihood of making an error of type α.*

Proof. Follows from (8). ■

3 Negligence

Generally, negligence stipulates a standard of care x_c for each circumstance, such that taking $x \geq x_c$ ($x < x_c$) implies no (full) liability. It is common to assume that the relevant due-care level is set at the socially optimal level of care. In the second period, the standard of due care will be either $x_2^*(q_A(x_1))$ or $x_2^*(q_N(x_1))$ and will thus depend on the first-period outcome and the actual care taken in period 1. In the first period, the standard of due care would be set at the level of x_1^*, thereby effectively deviating from the one prescribed by the *Hand rule*.

In our analysis of liability rules, we assume that the first-period injurer anticipates being active in period 2 with probability $r \in [0, 1]$. For example, we may imagine that the injurer in period 1 has obtained permission to undertake an activity (e.g., to organize a specific important sporting event) but anticipates that a different individual will obtain this permission with probability $1 - r$ in the second period.

Starting our analysis in period 2, it is clear that the current injurer takes due care, as follows from standard reasoning (e.g., Shavell 2007).[2] In period 1, the injurer will be concerned about minimizing his total expected costs

$$IC_N = \begin{cases} x_1 + r\Omega(x_1) & \text{if } x \geq x_1^* \\ x_1 + (qh(x_1) + (1-q)\ell(x_1))\, d + r\Omega(x_1) & \text{otherwise,} \end{cases} \tag{9}$$

with

$$\begin{aligned} \Omega(x_1) =& q\left\{h(x_1)x_2^*(q_A(x_1)) + (1-h(x_1))x_2^*(q_N(x_1))\right\} \\ &+ (1-q)\left\{\ell(x_1)x_2^*(q_A(x_1)) + (1-\ell(x_1))x_2^*(q_N(x_1))\right\}. \end{aligned}$$

This incorporates the fact that the injurer will obey the standard $x_2^*(q_j(x_1))$ in period 2.

There are several reasons why the injurer may prefer not to choose due care in the first period. [1] The level of care in the first period influences the due-care levels applied in the second period, $x_2^*(q_A(x_1))$ and $x_2^*(q_N(x_1))$, via its effect on $q_j(x_1)$ (as described by equations (3) and (6)). [2] Taking due-care standards in the second period as fixed, the injurer acknowledges that first-period care impacts whether the standard $x_2^*(q_A)$ or the standard $x_2^*(q_N)$ will apply in the second period (via the accident probability) and may thus have an incentive to increase (when $x_2^*(q_A) > x_2^*(q_N)$) or lower (when $x_2^*(q_A) < x_2^*(q_N)$) his own level of care in comparison to

[2]Previous research has examined imperfect information about the level of due care as a reason for possible inefficiency (e.g., Craswell and Calfee 1986).

x_1^*. To illustrate this, suppose that $x_2^*(q_A) > x_2^*(q_N)$. In this scenario, an increase in first-period care starting from $x = x_1^*$ reduces the injurer's expected costs in period 2. If this benefit more than offsets the additional care costs in period 1, $x > x_1^*$ will indeed be chosen. In summary, the effects [1] and [2] may make a higher or a lower care level than x_1^* preferable for the injurer.[3] [3] When $x_1^* > x_1(q)$ holds, the standard is excessive from a myopic point of view. This makes first-period care less than x_1^* more likely when r is relatively small and $x_1^* - x_1(q)$ relatively high.

We briefly summarize in:

Proposition 2 *With a possibility to learn about the accident technology, injurers subject to negligence with a standard of care set at x_1^* may exert due care or select either substandard or suprastandard care in period 1. In the second period, injurers choose due care.*

4 Strict liability

Under strict liability, the injurer will be held liable independent of his care choice. In the second period, an informed injurer will choose $x_2^*(q_j(x_1))$. If there is a probability $(1 - r)$ that the first-period injurer will be replaced by some other injurer in period 2, then the injurer's total expected costs are given by

$$\begin{aligned} IC_{SL} =& x_1 + (qh(x_1) + (1-q)\ell(x_1))\, d \\ &+ rq\left\{h(x_1)\left[x_2^*(q_A(x_1)) + h(x_2^*(q_A(x_1)))d\right] + (1-h(x_1))\left[x_2^*(q_N(x_1)) + h(x_2^*(q_N(x_1)))d\right]\right\} \\ &+ r(1-q)\left\{\ell(x_1)\left[x_2^*(q_A(x_1)) + \ell(x_2^*(q_A(x_1)))d\right] + (1-\ell(x_1))\left[x_2^*(q_N(x_1)) + \ell(x_2^*(q_N(x_1)))d\right]\right\}. \end{aligned} \tag{10}$$

The first-order condition defining privately optimal care in the first period, x_1^{SL}, results as

$$\frac{dIC_{SL}}{dx_1} = 1 + \left[qh'(x_1^{SL}) + (1-q)\ell'(x_1^{SL})\right] d - rqh'(x_1^{SL})\Delta_\alpha + r(1-q)\ell'(x_1^{SL})\Delta_\beta = 0. \tag{11}$$

The incentives induced by strict liability are summarized in:

Proposition 3 *With a possibility to learn about the accident technology, injurers subject to strict liability (i) choose socially optimal first-period care x_1^* when $r = 1$, and (ii) choose a level*

[3] The effects [1] and [2] do not appear in the social optimization problem because (8) also includes the effects on the expected harm in the second period, which are neglected by the injurer.

of first-period care x_1^{SL} strictly between x_1^* and $x_1(q)$ when $r < 1$. In the second period, injurers choose $x_2^*(q_j(x_1))$.

Proof. The fact that the last two terms in (11) are weighted by r (instead of one in (8)) implies that the deviation of first-period care from $x_1(q)$ is in the same direction but less pronounced when $r < 1$. ■

5 Discussion

When the accident history provides information about the accident technology, efficient care incorporates the marginal benefits and costs following from this informational aspect. In other words, socially optimal behavior may conflict with the cost-minimizing precautions set according to the *Hand rule*.

A recent court decision illustrates the empirical relevance of our setup or, more specifically, of a due-care standard that varies with the accident history (District court Düsseldorf, Germany, reference 50 C 9301/14). In this case, the court ruled that a shop owner was liable for the harm suffered by an elderly lady who collided with the shop's glass door even though such accidents generally do not trigger liability. The divergence from the common treatment of such cases was justified by reference to witnesses' reports about an earlier similar incident involving the same door, conveying the known dangerousness of the specific circumstances.

For the court in that case (and more generally in our framework), it was important that the accident history had become public information. This may be prevented when parties settle out of court, implying the possibility that settlement need not always be socially desirable.[4]

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[4]For a related argument, see Daughety and Reinganum (2005), for instance.

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