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Product liability when cumulative harm is incurred by both consumers and third parties

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Abstract

Traditional law and economics analyses of product liability assume that expected harm is proportional to usage. This paper builds on Daughety and Reinganum (2013a, 2014) by assuming that harm is increasing and convex in usage. In contrast to previous contributions, we analyze liability rules when not only consumers but also third parties incur harm. We show that the social ranking of liability rules previously established for the case in which only consumers suffer harm (strict liability dominates no liability and negligence) may be reversed if third party harm is sufficiently important.
Keywords: Product liability; Cumulative harm; Environmental harm

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1 Introduction

1.1 Motivation and Main Results

Product liability makes manufacturers of defective products liable for harm caused, and has gained major importance in the USA. A lively debate about its use in general and potentially superior liability rules continues to exist in policy and academic circles (e.g., Polinsky and Shavell, 2010a; 2010b; Goldberg and Zipursky, 2010). In the traditional model, which assumes that fully informed, homogeneous consumers incur expected harm that is proportional to output, optimal product safety is independent of output and the market outcome (including equilibrium product safety) is independent of the liability rule put in place (see, e.g., the survey by Daughety and Reinganum, 2013b).

Daughety and Reinganum (2013a, 2014) highlight that many realistic circumstances do not match the proportionality assumption and show that assuming cumulative harm instead has radical consequences for the results obtained under different liability rules. In their framework, the level of product safety and the level of output are inextricably linked and different liability rules yield very different market outcomes. Strikingly, Daughety and Reinganum (2014, DR 2014 in the following) establish that a firm subject to negligence prefers to be strictly liable and that welfare is higher under strict liability than under no liability, which leads them to argue in favor of strict liability.

In addition to lacking proportionality, many realistic instances feature that a product may harm not only consumers but also third parties (i.e., parties with no contractual relationship with the firm). Third-party effects can result from the widespread usage of the product in their neighborhood, through leakages, disseminating effects etc., as well as from the accidental event itself that also induces consumers' harm. Consider, for example, the use of glyphosate by farmers for agricultural weed control. Glyphosate is currently the most widely used herbicide in the world (Dias et al., 2019). Glyphosate supposedly harms both human health (as it is classified by the International Agency for Research on Cancer as probably carcinogen) and the environment (as it kills populations of insects such as bees).

Third-party effects may stem from, for example, food consumption or exposure to spraying of fields.[1]

This paper analyzes the performance of different product liability regimes when cumulative harm is incurred by both consumers and third parties. We thereby generalize the analysis by DR 2014 as they focus on the scenario in which the product may cause harm only to consumers. We are interested in describing how different liability regimes (no liability, strict liability, and negligence) influence privately optimal care and output choices by a monopolistic firm, whose product may harm consumers as well as third-party victims.

Our results show that the previously established ranking of liability rules (with strict liability dominating the other regimes) may be reversed. First, we show that no liability can in specific circumstances produce the outcome that obtains under strict liability. To obtain this finding in our framework, second-party harm must be as important as third-party harm. Relative to strict liability, no liability implies two distortions which are exactly offsetting each other when second-party harm is as important as third-party harm. More importantly, second, we delineate circumstances in which negligence yields higher welfare than strict liability. In order to have negligence possibly dominating strict liability, third-party harm must be more important than second-party harm.

1.2 Related Literature

Our paper considers different product liability regimes when both consumers and third parties incur cumulative harm. There is a vast literature on *product liability* (see, e.g., the surveys by Daughety and Reinganum 2013b, and Geistfeld 2009). The traditional setup considers perfectly competitive firms, identical risk-neutral consumers, costless trials, and that both care costs and expected harm are proportional to output. The traditional framework delivers the key finding that strict liability, negligence, and no liability are all equally efficient when consumers are perfectly informed about care and do not misperceive risk (e.g.,

[1]Other examples for products that may cause harm to consumers as well as third parties include smoke from tobacco products, potentially exploding smart phones (Samsung Galaxy Note 7), and soft drinks in bottles (e.g., Escola v. Coca-Cola Bottling Co.).

Shavell 1980). The rationale is that the consumers' willingness to pay introduces the concern for the minimization of the expected harm when it would otherwise be missing from the firm's profit maximization. In that standard framework, when harm is incurred by third parties instead of by consumers, strict liability and negligence are equally efficient whereas no liability produces an inefficient outcome (e.g., Shavell 1987).

In our paper, the firm may be liable for both harm for consumers and harm for *third parties* (including the environment). In the previous literature, liability of firms for harm to third parties was usually separated from liability of firms for harm to consumers. The former has been studied in relation with various issues including liability sharing (Hansen and Thomas 1999; Watabe 1999), or extended liability and the judgment proofness problem (Boyer and Laffont 1997); more recent work has focused on the incentives to adopt green innovations (Endres and Friehe 2011a,b), or the interplay with competitive distortions (Charreire and Langlais 2018).

For our analysis and results, it is important that we consider *cumulative* harm, thereby building on Marino (1988) and Daughety and Reinganum (2013a, 2014). Our contribution to this branch of literature is the consideration of the scenario in which harm is incurred not only by consumers but also third parties. This is particularly interesting because the driving force in this context, namely that the marginal expected harm exceeds the average expected harm per unit of output, is only relevant to the extent that it affects consumers, but not third parties.

1.3 Plan of the Paper

In Section 2, we present the framework used for our analysis. In Section 3, we first derive the benchmark featuring the socially optimal levels of product safety and output, and we propose a benchmark for a second best allocation. Next, we address the relative performance of the potential arrangements of no liability, strict liability, and negligence. We conclude in Section 4.

2 Model

Our model builds on DR 2014 who use a representative consumer framework. Specifically, we consider a risk-neutral monopolist serving a market described by a linear (inverted) market demand *gross of any harm* $P(q) = a - bq$, where q denotes output and a and b are positive parameters. This (inverted) demand results from maximizing a quasi-linear utility *gross of any harm*, $U = aq - bq^2/2 + r$, subject to the budget constraint, $y = r + Pq$ where r represents a numeraire good and y exogenous income. The firm incurs a cost $C(q, x) = c(x)q$, where x denotes product safety and $c'(0) = 0 = c(0)$, $c' > 0$, and $c'' > 0$ for all $x > 0$.

Product safety influences the expected harm caused to the representative consumer and/or a third party. For simplicity, we follow the presentation in DR 2014 and assume that the total expected harm can be described by $H(q, x) = \gamma h(x)q^2$, where $h(0) > 0$ and, for any x, $h'(x) < 0 < h''(x)$. Importantly, we assume that $\gamma = \alpha + \beta$ where $\alpha \geq 0$ ($\beta \geq 0$) scales up consumer (third-party) harm such that $\mathcal{B}(q, x) = \alpha h(x)q^2$ ($\mathcal{T}(q, x) = \beta h(x)q^2$) represents the level of harm that buyers (third-parties) incur. In DR 2014, the assumption is that $\alpha = 1$ and $\beta = 0$. We follow DR 2014 in assuming that H is convex.

The timing is such that, in Stage 1, the firm determines the level of observable product safety and the level of output in view of the consumer's decision-making in Stage 2, as represented by the market demand function. In Stage 3, after any accident, the firm is made to compensate any harm when it is judged liable in (socially and privately) costless litigation.

3 Analysis

We will first derive the socially optimal levels of product safety and output, and introduce our benchmark for the second best solution. Next, we describe market outcomes when the firm faces no liability, is subject to strict liability, or optimizes under a negligence rule with a well-defined product safety standard.

3.1 Benchmarks

3.1.1 First Best: Welfare Optimum

Welfare can be defined by the sum of consumer's utility gross of harm less the total harm incurred and the firm's cost of care. Thus, we obtain

$$W(q,x) = \left(a - \frac{b}{2}q - c(x)\right) q - \gamma h(x) q^2 \tag{1}$$

as the specification of welfare for the framework laid out in Section 2.

The social planner maximizes welfare by the choice of output and product safety. The first-order conditions for an interior solution at levels $(\hat{q}^W, \hat{x}^W)$ are[2]

$$a - bq = 2\gamma h(x) q + c(x) \tag{2}$$

$$-h'(x)\gamma q = c'(x). \tag{3}$$

The marginal benefit from an additional unit of output balances the marginal costs comprising the marginal harm created for consumers and/or third parties and the cost of care. With respect to the level of product safety, we find that the marginal reduction of total expected harm per unit of output should be equal to the marginal costs of care per unit of output. In contrast to the traditional framework, the optimal level of product safety depends on the level of output.

We denote the first-best output level conditional on product safety by $q^W(x)$ and state it explicitly as

$$q^W(x) = \frac{a - c(x)}{b + 2\gamma h(x)}.$$

The first-best product safety conditional on output is denoted by $x^W(q)$, cannot be stated explicitly, and solves equation (3). Both functions are positively sloped (for $q^W(x)$ this holds at least at product safety levels that solve the condition; see the appendix).

In terms of notation, we distinguish between first-best levels of output and product safety, $(\hat{q}^W, \hat{x}^W)$, and functions giving the socially optimal level conditional on a specified level of the other variable, $(q(x)^W, x(q)^W)$. Clearly, we have $(\hat{q}^W, \hat{x}^W) = (q(\hat{x}^W)^W, x(\hat{q}^W)^W)$.

[2]See our appendix for second-order conditions for this problem and the ones presented below.

3.1.2 Second Best: Taking Market Power as Given

When we want to compare privately optimal incentives under any liability arrangement to socially optimal incentives, we must distinguish between two reasons for a possible departure of the market outcome from the social planner's ideal outcome:

First, we are considering a monopolist whose marginal benefit from raising output is described by the marginal revenue which falls short of the social marginal benefit. Specifically, the monopolist considers $a - 2bq$ while the social planner considers $a - bq$. This aspect is *independent of the liability regime* and will be relevant to how *both* privately optimal choices compare to socially optimal choices when harm is cumulative. Below, we will refer to second-best outcomes when we mean outcomes that are socially optimal taking the monopolistic output distortion as given. To clarify, what we label second-best outcomes maximizes

$$\widetilde{W}(q, x) = (a - bq - c(x))q - \gamma h(x)q^2$$

instead of W from Section 3.1.1. The social planner is *restricted* by having a deviation in terms of the objective function imposed on her.[3]

The second-best product safety level is the first-best level for a given level of output, $x^W(q)$. The second-best output level as a function of care differs from the first-best level only due to the output distortion. Specifically, second-best output (i.e., the output level that solves (2) when the private marginal revenue $a - 2bq$ replaces the social marginal benefit $a - bq$) is given by

$$\tilde{q}^W(x) = \frac{a - c(x)}{2b + 2\gamma h(x)}.$$

Using first-best product safety $x^W(q)$ and second-best output $\tilde{q}^W(x)$ leads to second-best levels of output and product safety denoted by $(\hat{q}^W_{SB}, \hat{x}^W_{SB})$.[4]

[3] This formulation is consistent with the argument presented in DR 2014. They explain that the role of product liability is allocating the responsibility for harms due to product failures and not improving market performance in terms of output.

[4] Daughety and Reinganum (2006) similarly consider a restricted social optimum in which they take the output distortion that results in settings with market power as given. However, in their setup the social planner chooses the level of safety taking into account how safety influences equilibrium output levels (i.e., the social planner may strategically distort safety to influence output).

The second reason for a possible departure of the market outcome from the social planner's ideal outcome, in addition to the market power distortion, results from how the total harm is represented in the firm's trade-off. The firm considers harm and how product safety can lower harm either because consumers care about it or because the firm is made to compensate harm. This second potential cause of a deviation between socially optimal incentives and privately optimal incentives is *dependent on the liability regime* and thus of prime interest below.

3.2 Care and Output Under No Liability

Under no liability, total harm remains with the consumer and/or the third party. This influences the consumer's willingness to pay derived in Stage 2. Considering the marginal effects flowing from the maximization of $\tilde{U} = aq - bq^2/2 + y - Pq - \alpha h(x)q^2$, that is, expected payoffs taking account of the budget constraint and the expected harm, we can assert that

$$P(q) = a - bq - 2\alpha h(x)q$$

is the relevant (inverted) market demand for the firm to consider in the first stage.

In Stage 1, the monopolist chooses output and product safety in order to maximize

$$\Pi^{NL}(q, x) = (a - bq - 2\alpha h(x)q - c(x))q. \tag{4}$$

Under no liability, the privately optimal level of product safety conditional on output, $x^{NL}(q)$, and the privately optimal level of output conditional on product safety, $q^{NL}(x)$, satisfy:

$$\begin{aligned} a - 2bq &= 4\alpha h(x)q + c(x) && (5) \\ -h'(x)2\alpha q &= c'(x) && (6) \end{aligned}$$

As is clear from (5), under no liability, the firm perceives the marginal output costs stemming from the change in the consumer's willingness to pay to be $4\alpha h(x)q$. In contrast, marginal harm amounts to $2\gamma h(x)q$. Stating the privately optimal (conditional) level of output under no liability explicitly, we get

$$q^{NL}(x) = \frac{a - c(x)}{2b + 4\alpha h(x)}.$$

This level will generally depart from both the first-best and second-best (conditional) output levels, except for some combinations of parameters as we explain below.

Under no liability, the firm is concerned only about harm incurred by the consumer and not about harm incurred by the third party. The information about the marginal benefit from product safety is transmitted to the firm via the change in the consumer's willingness to pay which only mirrors repercussions for the consumer. This suggests that, from a social standpoint, the firm will invest too little in product safety. Similarly, when it comes to the output level, the firm takes into account negative effects absorbed by the consumer but not those absorbed by the third party which suggests that output will be excessive. However, we find that no liability can induce the second-best (conditional) output and the first-best (conditional) product safety when $\alpha = \beta$ as in that case $4\alpha = 2\gamma$ in condition (5) and $2\alpha = \gamma$ in condition (6).

The intuition for this result runs as follows. The fact that harm is cumulative and borne by the consumer means that the consumer deducts marginal expected harm from her willingness to pay. Marginal expected harm exceeds average harm in the case of cumulative harm and thus leads to the firm's *over-weighting* of consumer harm. With $\alpha = \beta$, we are describing circumstances in which this over-weighting exactly offsets the missing incorporation of third-party harm.

We summarize in:

Proposition 1 *(i) Assume that $\alpha = \beta$. Then, no liability induces the second-best outcome, that is, we obtain $q^{NL}(x) = \tilde{q}^W(x)$ and $x^{NL}(q) = x^W(q)$ in terms of conditional output and care levels. In terms of equilibrium levels, we obtain $\hat{x}^{NL} = \hat{x}^W_{SB}$ and $\hat{q}^{NL} = \hat{q}^W_{SB}$. (ii) Assume that $\alpha > \beta$. Then, in terms of conditional output and care levels, $q^{NL}(x) < \tilde{q}^W(x)$ and $x^{NL}(q) > x^W(q)$. In terms of equilibrium levels, we obtain $\hat{x}^{NL} > \hat{x}^W_{SB}$ and $\hat{q}^{NL} < \hat{q}^W_{SB}$. (iii) Assume that $\alpha < \beta$. Then, in terms of conditional output and care levels, $q^{NL}(x) > \tilde{q}^W(x)$ and $x^{NL}(q) < x^W(q)$. In terms of equilibrium levels, we obtain $\hat{x}^{NL} < \hat{x}^W_{SB}$ and $\hat{q}^{NL} > \hat{q}^W_{SB}$.*

Proof. Claim (i) is obvious. The first part of Claims (ii) and (iii) follow directly from the statements of conditional output levels and the first-order conditions for product safety. The second part of Claims (ii) and (iii) uses the comparative statics results from the appendix. Starting from a benchmark with $\alpha = \beta$ and then increasing (decreasing) the level of β (which leaves the solution under no liability unaffected as it depends only on α but changes the second-best outcome) means that – in the second-best outcome – output will decrease (increase) whereas product safety will increase (decrease). As a result, when the level of β increases (decreases), the unchanged output under no liability will exceed (fall short of) the second-best level and the product safety level will fall short of (exceed) it. ■

Undoubtedly, we are describing a knife-edge result because $\alpha = \beta$ will presumably not hold in the majority of cases. However, the result is important because it points out that the performance of no liability in the cumulative harm framework is much better than previously considered. In Case (ii) of Proposition 1, the third-party harm that we introduce is not important enough to overthrow the pattern described in DR 2014. Case (iii) reported in Proposition 1 makes it possible to have either $q^{NL}(x) < q^W(x)$ or $q^{NL}(x) > q^W(x)$, that is, the (conditional) output under no liability may be less than or greater than *first-best* (conditional) output. The (conditional) privately optimal level of output under no liability being greater than the (conditional) first-best level of output requires $b < 2(\beta - \alpha)h(x)$.

Furthermore, using conditions (3) and (6), we can state that

$$x^{NL}(q) = x^W\left(\frac{2\alpha}{\gamma}q\right), \tag{7}$$

which means that the product safety level that results under no liability is equal to the first-best product safety level, $\hat{x}^{NL} = \hat{x}^W$, when the output levels relate in a specific way to each other (namely $\hat{q}^{NL} = \frac{\gamma}{2\alpha}\hat{q}^W$). Using conditions (2) and (5), we can write

$$q^{NL}(x) = \frac{b + 2\gamma h(x)}{2(b + 2\alpha h(x))}q^W(x),$$

and deduce that the no liability regime can induce the firm to choose the socially optimal safety level only in the case considered by DR 2014, that is, $\gamma = \alpha = 1 > \beta = 0$, as in this case the no liability output is equal to one half of the socially optimal output.

3.3 Care and Output Under Strict Liability

Under strict liability, total harm is shifted from the consumer and the third party to the firm. The consumer's willingness to pay derived in Stage 2 thus can be stated as

$$P(q) = a - bq.$$

In Stage 1, the monopolist chooses output and product safety in order to maximize

$$\Pi^{SL}(q, x) = \big(a - bq - c(x)\big)q - \gamma h(x)q^2. \tag{8}$$

The firm bears the average of the *total* expected harm per unit of output. This contrasts with the case of no liability in two ways. First, the consumer's expected harm enters the firm's maximization problem as the average consumer harm per unit of output (avoiding the double marginalization). Second, under strict liability, the firm thinks not only about consumer harm but also about third-party harm.

The first-order conditions give equilibrium levels $\hat{q}^{SL}$ and $\hat{x}^{SL}$ when the firm is strictly liable as solving the system:

$$\begin{aligned} a - 2bq &= 2\gamma h(x)q + c(x) && (9) \\ -h'(x)\gamma q &= c'(x) && (10) \end{aligned}$$

From this description, it follows that strict liability ensures the attainment of the second-best outcome. The single distortion relative to the first-best outcome is the artificial output scarcity introduced by the monopolist. We have $x^{SL}(q) = x^W(q)$ and

$$q^{SL}(x) = \frac{a - c(x)}{2b + 2\gamma h(x)} = \tilde{q}^W(x).$$

Proposition 2 *Strict liability ensures the attainment of the second-best outcome, that is, we obtain $q^{SL}(x) = \tilde{q}^W(x)$ and $x^{SL}(q) = x^W(q)$ for any (α, β) in terms of conditional output and care levels. In terms of equilibrium levels, we obtain $\hat{x}^{SL} = \hat{x}^W_{SB}$ and $\hat{q}^{SL} = \hat{q}^W_{SB}$.*

Table 1: Ranking of Equilibrium Output and Care under No Liability and Strict Liability

Scenario	Output	Care
$\alpha > \beta$	$\hat{q}^{NL} < \hat{q}^{W}_{SB} = \hat{q}^{SL}$	$\hat{x}^{NL} > \hat{x}^{W}_{SB} = \hat{x}^{SL}$
$\alpha = \beta$	$\hat{q}^{NL} = \hat{q}^{W}_{SB} = \hat{q}^{SL}$	$\hat{x}^{NL} = \hat{x}^{W}_{SB} = \hat{x}^{SL}$
$\alpha < \beta$	$\hat{q}^{NL} > \hat{q}^{W}_{SB} = \hat{q}^{SL}$	$\hat{x}^{NL} < \hat{x}^{W}_{SB} = \hat{x}^{SL}$

3.4 Comparing Solutions Under No Liability and Strict Liability

In contrast to the analysis laid out by DR 2014, strict liability performs as well as no liability when $\alpha = \beta$. However, when $\alpha > \beta$, it is clear that strict liability produces better outcomes than no liability (as explained by DR 2014). When, in turn, $\alpha < \beta$, it may happen that (conditional) output under no liability is closer to the first-best (conditional) output level than the (conditional) output under strict liability. Higher output is clearly beneficial if $q^{NL}(x) \leq q^{W}(x)$, which is the case when $b > 2(\beta - \alpha)h(x)$. On the other hand, this benefit comes at the cost of lower product safety, $x^{NL}(q) < x^{W}(q)$. We summarize these rankings in Table 1.

We may consider the level of profits and the level of welfare as a function of τ, a variable that allows us to simulate the change from a regime of no liability (where $\tau = 0$) to a regime of strict liability (where $\tau = 1$). The value functions are

$$\Pi(\tau) = (a - bq - c(x))q - (1-\tau)2\alpha h(x)q^2 - \tau\gamma h(x)q^2 \tag{11}$$

$$W(\tau) = (a - b/2q - c(x))q - \gamma h(x)q^2 \tag{12}$$

where q and x take privately optimal values at a given τ. Accordingly, an increase in τ will – by application of the envelope theorem – be relevant to firm profits according to the direct effect only. As a result, we have that the firm prefers no (strict) liability when $\beta > (<)\,\alpha$ and is indifferent otherwise. With respect to welfare, only indirect effects are relevant when τ is changed marginally. When $\alpha > \beta$, an increase in τ induces an improvement of both choice variables, as the restricted output grows and the excessive product safety level falls. When $\alpha < \beta$, there is a conflict as increasing τ improves the firm's choice from a social standpoint only with respect to safety. From this argumentation, we get:

Proposition 3 *From a welfare point of view, we find that: (i) Strict liability outperforms no liability when* $\alpha > \beta$. *(ii) The two regimes produce the same outcome when* $\alpha = \beta$. *(iii) No liability may outperform strict liability (at least in selected circumstances) when* $\beta > \alpha$. *From the firm's point of view, strict liability dominates (is dominated by) no liability when* $\alpha > (<) \beta$.

3.5 Care and Output under Negligence

Any negligence standard allows the firm to choose between the two previously discussed regimes: the firm is strictly liable when it chooses product safety below the due level, and the firm has payoffs as under no liability provided that product safety is weakly in excess of the product safety standard.

From our previous analysis, we deduce that $\Pi^{SL}(q,x) > \Pi^{NL}(q,x)$ for any (q,x) if and only if $\alpha > \beta$. Thus, if $\alpha > \beta$, the firm will certainly not comply with any product safety standard that is excessive from her point of view. From a social perspective, under no liability and $\alpha > \beta$, product safety is excessive and the output level too low. Hence, the firm and the social planner are better off under strict liability, or (equivalently) with a product safety standard allowing the firm to operate in an effectively unconstrained manner under strict liability.

In contrast, if $\alpha < \beta$, we obtain the following ranking of firm profits

$$\Pi^{SL}(\hat{q}^{SL}, \hat{x}^{SL}) < \Pi^{NL}(\hat{q}^{SL}, \hat{x}^{SL}) < \Pi^{NL}(\hat{q}^{NL}, \hat{x}^{NL}), \tag{13}$$

such that the firm is willing to increase the level of care beyond the privately optimal level, if that implies escaping liability. When $\beta > \alpha$, it holds that $x^{NL}(q) < x^{W}(q)$ where $x^{W}(q) = x^{SL}(q)$ (see Propositions 1 and 2). Thus, the social planner can induce the firm to comply with $\hat{x}^{SL}$, that is, the first-best level of product safety when the level of output is second-best (i.e., $\hat{q}^{W}_{SB}$). Proposition 1 (iii) implies that, under no liability, the firm will provide output higher than the second-best level of output $\hat{q}^{W}_{SB}$ if the product safety standard is set at $\hat{x}^{SL}$. This increase in output is principally socially desired because the second-best output obtained under strict liability is too low from a social perspective. However, it holds true that the standard $\hat{x}^{SL}$ is no longer the ideal match for the output higher than $\hat{q}^{W}_{SB}$.

We deduce that there is scope for improving upon the strict liability outcome using the negligence rule by appropriately choosing the standard of care (possibly as a function of output) in the case $\alpha < \beta$. We will focus on these parameter constellations in the following.

3.5.1 Product Safety Standard Independent of Output

Confronted with a standard $\bar{x} \geq \hat{x}^{NL}$, a compliant firm will choose product safety equal to the standard, and an output level according to:

$$q^{NL}(\bar{x}) = \frac{a - c(\bar{x})}{2b + 4\alpha h(\bar{x})}.$$

This (conditional) output is below the socially optimal (conditional) output,

$$q^{W}(\bar{x}) = \frac{a - c(\bar{x})}{b + 2\gamma h(\bar{x})},$$

if and only if $b > 2(\beta - \alpha)h(\bar{x})$. A threshold function $\beta(\bar{x}, \alpha)$, $\beta(\bar{x}, \alpha) > \alpha \; \forall \bar{x}$, exists such that a compliant firm chooses (conditional) output below the first-best (conditional) output when $\beta < \beta(\bar{x}, \alpha)$. We show that, in such a situation, shifting from strict liability to negligence is welfare improving.

Proposition 4 *Assume that the product safety standard is $\hat{x}^{SL}$ and that $\beta < \beta(\bar{x}, \alpha)$. Then, the negligence rule produces higher welfare than strict liability.*

Proof. We have explained that the firm prefers to comply with the standard $\hat{x}^{SL}$ when discussing the ranking in (13). For $\beta < \beta(\hat{x}^{SL}, \alpha)$, the switch from strict liability to negligence induces a higher (conditional) output that is still less than the first-best (conditional) output. Because we hold the product safety constant, as the firm has no interest in increasing it above the requirement under negligence, we can say that the higher output raises welfare. ■

As $\Pi^{SL}(\hat{q}^{SL}, \hat{x}^{SL}) < \Pi^{NL}(\hat{q}^{SL}, \hat{x}^{SL}) < \Pi^{NL}(q^{NL}(\hat{x}^{SL}), \hat{x}^{SL})$, there is room for demanding an even higher standard of care. In fact, the social planner can choose her favorite combination $(q^{NL}(\bar{x}), \bar{x})$ subject to the compliance constraint:

$$
\begin{aligned}
&(a - bq^{NL}(\bar{x}) - 2\alpha h(\bar{x}) - c(\bar{x}))q^{NL}(\bar{x}) > \\
&(a - bq^{W}_{SB}(\hat{x}^{W}_{SB}) - \gamma h(\hat{x}^{W}_{SB}) - c(\hat{x}^{W}_{SB}))q^{W}_{SB},
\end{aligned} \tag{14}
$$

where the second line represents firm profits under strict liability (which induces the second-best levels). The social optimum can be reached only in the special case in which $b = 2(\beta - \alpha)h(\hat{x}^W)$ and the compliance constraint (14) holds for $\bar{x} = \hat{x}^W$.

3.5.2 Product Safety Standard as a Function of Output

If we allow the standard of care to be a function of output, the social planner can deter a range of output choices by associating excessive product safety standards with them. In this case, she can induce her favorite combination of (q^*, x^*) out of those that satisfy the compliance constraint (14) by linking the product safety standard to the output in such a way that (q^*, x^*) maximizes the first line of (14).

4 Conclusion

The traditional product liability framework specifies expected consumer harm as being proportional to output. Daughety and Reinganum (2014) highlight the important implications from assuming cumulative harm instead. The distinction between marginal expected harm and average expected harm is at the heart of the discussion. Out of three liability arrangements (namely no liability, strict liability, and negligence), they provide convincing arguments for favoring strict liability.

Our paper introduces third-party harm into the framework presented by Daughety and Reinganum (2014) to delineate how this aspect qualifies previous results. In fact, we establish circumstances in which no liability and negligence can outperform strict liability. This possibility emerges only when third-party harm is relatively more important as a harm category than consumer harm.

Our analysis is kept very simple. For example, we assume linear demand, a quadratic harm function where consumer harm and third-party harm have the same functional form and simply add up, and a monopolistic firm. Nevertheless, the basic insight that third-party harm is an important factor for the decision which liability rule is socially preferred in a context with cumulative harm is likely to prevail in more complex settings.

References

Boyer, M., and J.J. Laffont, 1997. Environmental risks and bank liability. European Economic Review 41, 1427-1459.

Daughety, A.F., and J.F. Reinganum, 2006. Markets, torts, and social inefficiency. Rand Journal of Economics 37, 300-323.

Daughety, A.F., and J.F. Reinganum, 2013a. Cumulative harm, products liability, and bilateral care. American Law and Economics Review 15, 409-442.

Daughety, A., and J. Reinganum, 2013b. Economic Analysis of Products Liability: Theory. In: Arlen, J.H., Research Handbook on the Economics of Torts, Edward Elgar.

Daughety, A.F., and J.F. Reinganum, 2014. Cumulative harm and resilient liability rules for product markets. Journal of Law, Economics & Organization 30, 371-400.

Dias, M., R. Rocha and R.R. Soares, 2019. Glyphosate use in agriculture and birth outcomes of surrounding populations. IZA Discussion Paper No. 12164. Geistfeld, M., 2009. Products Liability. In: Faure, M., Tort Law and Economics, Edward Elgar.

Goldberg, J.C.P., and B.C. Zipursky, 2010. The Easy Case for Products Liability Law: A Response to Professors Polinsky and Shavell. Harvard Law Review 123, 1919-1948.

Hansen, R.G., and R.S. Thomas. The efficiency of sharing liability for hazardous waste: effects of uncertainty over damages. International Review of Law and Economics 19, 135-157.

Marino A., 1988. Monopoly, Liability and Regulation. Southern Economic Journal 54, 913-927.

Polinsky, A.M., and S. Shavell, 2010a. The Uneasy Case for Product Liability. Harvard Law Review 123, 1437-1492.

Polinsky, A.M., and S. Shavell, 2010b. A Skeptical Attitude About Product Liability Is Justified: A Reply to Professors Goldberg and Zipursky. Harvard Law Review 123, 1949-1968.

Shavell, S., 1980. Strict Liability Versus Negligence. Journal of Legal Studies 19, 1-25.

Shavell, S., 1987. Economic Analysis of Accident Law. Harvard University Press.

Watabe, A., 1999. The effect of liability-sharing rules in delegating hazardous activities. International Review of Law and Economics 19, 349-368.

A Second order conditions and comparative statics

Welfare maximization. We follow DR 2014 to establish that any interior solution to the first-order conditions will be a local welfare maximum.

From the maximization of

$$W = aq - \frac{b}{2}q^2 - c(x)q - \gamma h(x)q^2 \tag{15}$$

follows:

$$W_q = a - bq - c(x) - 2\gamma h(x)q = 0 \tag{16}$$

$$W_x = -c'(x)q - \gamma h'(x)q^2 = 0 \tag{17}$$

$$W_{qq} = -b - 2\gamma h(x) < 0 \tag{18}$$

$$W_{xx} = -c''(x)q - \gamma h''(x)q^2 < 0 \tag{19}$$

$$W_{qx} = -c'(x) - 2\gamma h'(x)q, \tag{20}$$

where W_x denotes the partial derivative of W with respect to x. Using $c'(x) = \gamma h'(x)q$, we restate $W_{qx} = -\gamma h'(x)q > 0$. Next, it can be established that $W_{xx}W_{qq} - (W_{qx})^2 > 0$ since

$$(b + 2\gamma h)(c''q + \gamma h''q^2) - (-\gamma h'q)^2 > \gamma^2 q^2 \left(2hh'' - (h')^2\right) > 0, \tag{21}$$

where the second inequality sign stems from the convexity of H, which implies that $h(x)h''(x) - 2\left(h'(x)\right)^2 \geq 0$ for all x.

Condition (16) defines $q^W(x)$, where

$$\frac{dq^W}{dx} = -\frac{W_{qx}}{W_{qq}} > 0, \tag{22}$$

using the restatement $W_{qx} = -h'(x)q > 0$. Similarly, condition (17) defines $x^W(q)$, where

$$\frac{dx^W}{dq} = -\frac{W_{qx}}{W_{xx}} > 0. \tag{23}$$

Second-best outcome Consider the case in which the monopolistic quantity distortion is taken as given. We obtain:

$$\widetilde{W}_q = a - 2bq - c(x) - 2\gamma h(x)q = 0 \tag{24}$$

$$\widetilde{W}_x = -c'(x)q - \gamma h'(x)q^2 = 0 \tag{25}$$

$$\widetilde{W}_{qq} = -2b - 2\gamma h(x) < 0 \tag{26}$$

$$\widetilde{W}_{xx} = -c''(x)q - \gamma h''(x)q^2 < 0 \tag{27}$$

$$\widetilde{W}_{qx} = -c'(x) - 2\gamma h'(x)q \tag{28}$$

We are interested in the influence of a change in γ on the second-best outcome $(\hat{q}^W_{SB}, \hat{x}^W_{SB})$ and find that

$$\frac{d\hat{q}^W_{SB}}{d\gamma} = \frac{1}{H}\left(\widetilde{W}_{qx}\widetilde{W}_{x\gamma} - \widetilde{W}_{xx}\widetilde{W}_{q\gamma}\right) \tag{29}$$

and

$$\frac{d\hat{x}^W_{SB}}{d\gamma} = \frac{1}{H}\left(\widetilde{W}_{qx}\widetilde{W}_{q\gamma} - \widetilde{W}_{qq}\widetilde{W}_{x\gamma}\right), \tag{30}$$

with

$$\widetilde{W}_{q\gamma} = -2h(x)q < 0 \tag{31}$$

$$\widetilde{W}_{x\gamma} = -h'(x)q^2 > 0. \tag{32}$$

More specifically, we derive that

$$\frac{d\hat{q}^W_{SB}}{d\gamma} = \frac{1}{H}\left(\gamma(h')^2q^3 - (c''q + \gamma h''q^2)2hq\right) < \frac{\gamma q^3}{H}\left((h')^2 - 2hh''\right) < 0, \tag{33}$$

where the inequality sign stems from the convexity of h, and

$$\frac{d\hat{x}^W_{SB}}{d\gamma} = \frac{1}{H}\left(2\gamma hh'q^2 - (2b + 2\gamma h)h'q^2\right) = \frac{1}{H}(-2bh'q^2) > 0. \tag{34}$$