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The Robustness Case for Proportional Liability

Abstract: In important areas like medical malpractice and environmental torts, injurers are potentially insolvent and courts may make errors in determining liability (e.g. due to hindsight bias). We show that proportional liability, which holds a negligent injurer liable for harm discounted with the probability that the harm was caused by the injurer's negligence, is less susceptible to these imperfections and therefore socially preferable to all other liability rules currently contemplated by courts. We also provide a result which might be useful to regulators when calculating minimum capital requirements or minimum mandatory insurance for different industries.

Keywords: compliance, uncertain causation, court error, judgment-proof problem, proportional liability

JEL Classification: K13

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1 Introduction

We analyze efficiency of different liability rules in the presence of two sources of imperfections. First, some injurers may be insolvent due to limited liability or because their assets are insufficient to satisfy a judgment against them (the “judgment-proof problem”). Second, courts may err in determining whether an injurer acted negligently, for example, because of hindsight bias. Although access to expert witnesses may reduce the occurrence of court errors and certain legal strategies (such as mandatory insurance, minimum capital requirements, and veil piercing) can mitigate the judgment-proof problem, both problems

continue to pervade areas such as environmental torts and medical malpractice.¹ We therefore evaluate whether certain liability rules are better suited than others to induce socially efficient behavior in the presence of these imperfections.

It has been frequently argued in the literature that negligence-based rules are more robust against the judgment-proof problem than is strict liability (Shavell 1986; Craswell and Calfee 1986; Landes and Posner 1987) but also more vulnerable to court errors in determining the standard of due care (Shavell 1987, 79ff; Cooter 1991). However, as Grady (1983) and Kahan (1989) point out, these results hinge on the notion that the scope of liability under the negligence rule is unrestricted; that is, a negligent injurer is liable for all harm done, including the harm that would have occurred even if the injurer had taken due care. They argue that this regime, known as negligence-based full liability or in short full liability, does not correspond to actual law since the scope of liability is legally restricted by the requirement that harm was actually *caused* by the injurer's *negligence*. Therefore, an injurer is not liable for harm that would still have occurred even if the injurer had taken due care. Grady (1983) and Kahan (1989) showed that a negligence rule with a restricted scope of liability, referred to as a negligence-based threshold liability or in short threshold liability, is neither robust against the judgment-proof problem nor vulnerable to systematic court error.

While, as a matter of legal doctrine, the causation requirement should be taken into account, courts often do not apply it in situations of uncertain causation (see, e.g. Shavell 2004, 253, n. 36). Instead, if harm materializes and the injurer is found negligent, courts will often award full damages if they cannot *rule out* that the harm was caused by the injurer's negligence. Consider the example where negligence increased the probability of an accident from 40% to 50%. Here, the ex-post probability of causation would be 20% $(50 - 40)/50$), that is, it is more likely than not that the harm was *not* caused by the injurer.² Hence, under a preponderance of the evidence rule, the injurer would not be liable and there would not be any incentives for the injurer to take care. However, it is not clear that courts actually make decisions in this way.

1 Kornhauser and Revesz (1990) point to the problem that the strict liability rule under the Comprehensive Environmental Response, Compensation, and Liability Act is likely to drive some injurers into bankruptcy.

2 Strictly speaking, the probability of causation can be calculated as just described if we rule out the possibility that harm is prevented *because* the injurer fell short of exercising due care. (See Schweitzer 2009, for a rigorous treatment of the application of the causation requirement under uncertainty.) Given this assumption, the causation requirement is equivalent to the rule of proportional liability as proposed by Shavell (1985) and others. This rule exactly internalizes the consequences of deviating from the due care standard.

There is evidence that courts only require proof up to a given evidence standard that the injurer's negligence caused the *probability* of harm to increase.³ If this can be established – normally a straightforward task – full damages are granted (full liability).⁴

Moreover, threshold liability, as formalized by Kahan (1989), implicitly assumes that, after harm is done, courts can verify with certainty whether or not the harm was caused by the negligence of the injurer. Therefore, even if the courts want to apply the causation requirement in cases of uncertain causation they cannot do so by just applying the threshold liability rule.⁵ However, it is possible to account for the causation requirement in a *probabilistic* way. Many scholars have proposed a negligence rule under which a negligent injurer would be liable whenever an accident occurs but the liability would be proportional to the probability of causation.⁶ This rule has become known in the literature as proportional liability and has been applied by courts in cases of “market-share liability”⁷ and in cases in which plaintiffs are “indeterminate”.⁸ Indeed, as

3 In *Evers v. Dollinger*, 95 N.J. 399 (1984), the Supreme Court held that, in the context of a claim of medical malpractice, when there is evidence that the defendant's negligence increased the risk of harm to the plaintiff and that the harm was in fact sustained, it becomes a jury question whether or not the *increased risk* constituted a *substantial factor* in producing the injury. The Court determined that a less onerous burden of establishing causation should be applied. See also *Hake v. Manchester Tp.*, 98 N.J. 302 (1985); *Scafidi v. Seiler*, 225 N.J. Super. 576 (App. Div.1988); *Battista v. Olson*, 213 N.J. Super. 137 (App.Div.1986); *Gaido v. Weiser*, 227 N.J. Super. 175 (App.Div.1988). Both *Dubak v. Burdette Tomlin Memorial Hosp.*, 233 N.J. Super. 441, 450–452 (App.Div.1989) and *Zuchowicz v. United States*, 140 F.3d 381 (U.S. Court of Appeals for the Second Circuit, 1998) contain very insightful discussions of increased risk/substantial factor theory. In *King v. Burlington Northern Santa Fe Ry. Co.* 277 Neb. 203, 762 N.W.2d 24 Neb., 2009 the Court, suggests that any positive association that could reasonably support a causal inference could be sufficient to send a case to a jury. See also Grechenig and Stremitzer (2009) for a survey of court practice across jurisdictions.

4 To the same effect, the German Federal Court (BGH) shifts the burden of proof to the injurer, if it can be established that he acted with gross negligence. He then has to prove *beyond a reasonable doubt* that his negligence did not cause the harm, which will be impossible for him. See Stoll (1976, 145, 155ff) and Wagner (2004).

5 Kahan (1989) discusses the case of uncertain causation and considers an all-or-nothing rule in combination with a preponderance of the evidence standard of proof. We will not analyze such a rule since it does not achieve socially efficient behavior even if the standard of due care is set at the socially optimal care and injurers are solvent (see Kahan 1989, 440–1; Shavell 1987, Proposition 1, 52–3).

6 See, for example, Landes and Posner (1983), Rosenberg (1984), and Shavell (1985).

7 See, for example, *Sindell v. Abbott Laboratories*, 26 Cal.3d 588, 607 P.2d 924, 163 Cal.Rptr. 132 (1980).

8 This is the case where the harm – for example cancer – can be “caused” by a particular substance, but where it is impossible to pinpoint which particular person's cancer would have

Schweizer (2009) shows, proportional liability follows from extending the causation requirement analyzed by Grady (1983) and Kahan (1989) to situations of uncertain causation.⁹

The main result of our paper is that proportional liability is socially preferable to other existing negligence-based rules in a setting where injurers are potentially judgment proof and courts make errors in determining the standard of due care. Moreover, we demonstrate that proportional liability is socially preferable to strict liability if the standard of due care is set equal to or above the socially optimal level (which is the case that concerns most commentators). This result is a robustness result, that is, proportional liability outperforms the other regimes in the presence of court error and judgment-proof injurers, but performs *at least* as good as the other rules in the absence of these frictions.

The intuition for these results is that proportional liability combines the best of two rules: In contrast to threshold liability, proportional liability is as robust against the judgment-proof problem as full liability if the due care standard is set at or below the socially optimal level of care.¹⁰ At the same time, in contrast to full liability, proportional liability preserves the robustness of threshold liability to setting the due care standard above socially optimal care. Not only does proportional liability prevent excessive investment in care, but it also generates less underinvestment in care at low levels of injurer's wealth than under full liability. Therefore, counterintuitively, a proportional liability regime which imposes *less* liability on injurers may actually lead to higher investment in care.¹¹

Our analysis offers an interesting policy implication about the value of accuracy in adjudication (see Kaplow 1994). Rose-Ackerman (1990) has previously argued that courts should rely on statistical evidence and forbid individualized causal claims in market-share liability cases because such information

occurred naturally and which would not have occurred but for exposure to the substance (see the famous case *In Re "Agent Orange" Product Liability Litigation*, 597 F. Supp. 740 (E.D.N.Y. 1984).)

9 This is true if we rule out the pathological case that harm can be prevented precisely because the injurer was negligent, like in the case where an accident is prevented because he drove too fast.

10 This might be surprising, as one would expect that proportional liability performs better than full liability as the wealth constraint binds more often under full liability than under proportional liability. The reason this is not the case is that both rules cause injurers to pay more than is necessary to induce the efficient care level. As long as the wealth constraint just eats away the slack for deterrence purposes it does not matter. As soon as it starts to matter, it does so for both rules alike.

11 This is in the same vein as Ganuza and Gomez (2008) but a completely different effect than the one analyzed in their paper.

does not improve social welfare. Therefore, efforts to link the harm suffered by a plaintiff to the actions of a particular defendant only wastes resources. Our analysis suggests that such evidence should be barred even if information on causation were available at zero cost. The reason is that the lack of information forces courts to apply a socially preferable legal rule, namely proportional liability.

Finally, we show that the minimum wealth level for which first-best care levels can be induced has an intuitive meaning and can be calculated relatively easily. This finding could be useful to inform legislators who wish to set minimum capital requirements or mandatory insurance provisions for different industries.

To the best of our knowledge, our paper is the first to analyze the effects of wealth constraints on the performance of proportional liability (and disgorgement liability) and to focus explicitly on the interaction of the judgment-proof problem with the possibility of court error. However, the paper is related to a larger literature analyzing the effect of the judgment-proof problem on the incentives created under different liability rules. Shavell (1986) analyzes the effects of the judgment-proof problem with respect to full and strict liability. Kahan (1989) explores how wealth constraints affect threshold liability. The analyses of Kornhauser and Revesz (1990) and Landes (1990) are closest to ours; they analyze how the relative efficiency of rules for imposing liability and apportioning damages among joint tortfeasors is affected by the potential insolvency of some of the actors. Yet, the driving force in their models is the effect of different rules on the strategic interaction among joint tortfeasors, which is absent from our paper as we are only concerned with a single injurer. Moreover, those papers assume that the standard of due care is set at the socially efficient level, while the present paper allows for the standard of due care to be set at socially inefficient levels.¹²

Our paper is organized as follows: Section 2 sets up the model and derives a few useful benchmarks. Section 3 describes the different negligence-based lia-

¹² In a recent paper, Leshem and Miller (2009) compare full liability and proportional liability in a model of costly litigation. They recommend full liability on the ground that it leads to higher rates of compliance (conceding that it will also lead to higher rates of litigation and therefore to higher litigation cost). Yet, compliance is only unambiguously welfare increasing if it is assumed that courts set the standard of due care at the socially optimal level. Hence, they implicitly rule out the possibility of systematic court error. As they also assume solvent injurers, the two main ingredients of our model, court error and the judgment-proof problem, are absent from their analysis.

bility rules and derives preliminary results about their effects on the expected cost of accidents in the presence of wealth constraints. Section 4 contains our main result regarding the social desirability of proportional liability compared to full liability and strict liability. Section 5 discusses several policy implications including the value of accuracy in adjudication and minimum capital requirements. Section 6 concludes.

2 Model

We consider a unilateral accident model with two risk-neutral parties: an injurer and a victim. The injurer undertakes a dangerous activity and chooses a level of care $x \geq 0$. Subsequently, with a probability of $p(x)$, the victim suffers harm $h > 0$, where $p(\cdot)$ is a decreasing and twice differentiable strictly convex function in x . To guarantee an interior solution to the social welfare problem, we assume that $\lim_{x \rightarrow 0} p'(x) = -\infty$ and $\lim_{x \rightarrow \infty} p'(x) = 0$. We further assume that care can be monetary or non-monetary in nature,¹³ and that the injurer's wealth is $w \geq 0$. We shall now derive two useful benchmarks:

2.1 Social optimum

The social cost of engaging in the activity can be written as the sum of the cost of care and the expected harm, $x + p(x)h$. The care level, x^* , which minimizes social cost is therefore implicitly defined by the following first-order condition:¹⁴

$$1 = -p'(x^*)h. \quad [1]$$

Throughout the paper, the care level satisfying condition [1] will be referred to as the socially optimal level of care or as efficient care.

13 In the latter case, we assume the effort to take care has an opportunity cost of x . One could interpret non-monetary care as the cost of effort that can be evaluated in monetary terms but does not reduce the wealth constraint. Alternatively, one could think of non-monetary care as an investment that is made in an asset which is subsequently transferred to a limited liability company. The value of the asset would then determine the wealth constraint. The assumption that care is non-monetary is made in (Shavell 1986), the assumption that care is monetary is made in Beard (1990).

14 The second-order sufficient condition is satisfied by the convexity of the $p(x)$.

2.2 Strict liability

Under a strict liability regime, the injurer will have to pay for all harm, unless he is judgment proof, in which case he will only pay his wealth. Hence, he will minimize his expected costs,

$$J_{ST} = x + p(x) \min[h, w - \alpha x],$$

where $\alpha \in \{0, 1\}$ is a parameter determining whether or not care is monetary. For $\alpha = 0$, care is non-monetary (effort), implying that it does not affect the wealth constraint. For $\alpha = 1$, care is monetary (precaution expenditures) and therefore it tightens the wealth constraint.¹⁵

If the injurer is not wealth constrained he will take socially optimal care, x^* . Otherwise, his care level, $\tilde{x}(w, \alpha)$, is implicitly defined by

$$1 - \alpha p(x) = -p'(x)(w - \alpha x), \quad [2]$$

where the left-hand side reflects marginal costs and the right-hand side reflects marginal benefits of taking care.¹⁶ We will sometimes write \tilde{x} , suppressing the arguments w and α .

The comparison of expressions [1] and [2] reveals that private marginal benefits are less than social marginal benefits since $w - \alpha x < h$. In contrast, private marginal costs are equal to social marginal costs if care is non-monetary, but are strictly less than social marginal costs if care is monetary (provided that $x \neq 0$). Therefore, a wealth-constrained injurer will take less than socially optimal care (i.e. insufficient care), if care is non-monetary, but may take either more or less than socially optimal care (i.e. excessive or insufficient) if care is monetary. In particular, for $w = h + x^*$, the injurer will always be judgment proof and take excessive care, because, at care level x^* , private marginal benefits are equal to the social marginal benefits, while private marginal costs are less than social marginal costs. On the other hand, for $w = h$, the injurer will always be judgment proof and will take less (more) than the socially optimal care level if $-\frac{p'(x^*)x^*}{p(x^*)} > (<) 1$. More importantly, there exists a threshold level of w implicitly

¹⁵ The analysis can be easily extended to the case where care is partially monetary in nature, in which case $0 < \alpha < 1$. Strictly speaking the minimization problem here and in the rest of the paper is subject to the constraint $w - \alpha x \geq 0$. However, as will become evident in Footnote 16, this constraint never binds.

¹⁶ The first-order condition is necessary and sufficient as the probability function is decreasing and convex: $p''(\tilde{x}(w))(w - \alpha \tilde{x}(w)) - 2\alpha p'(\tilde{x}(w)) > 0$.

Note that the constraint $w - x \geq 0$ is never binding as, for $x \rightarrow w$, marginal benefits from care are zero, while marginal costs are strictly positive.

defined by $1 - p(x^*) = -p'(x^*)(w - x^*)$, that is, $\tilde{w} = \frac{1-p(x^*)}{-p'(x^*)} + x^*$, such that the injurer takes less than socially optimal care for wealth levels below \tilde{w} and more than optimal care for wealth levels above this threshold level. The existence of such a threshold level follows because – regardless of whether care is monetary or non-monetary – the level of care is (weakly) increasing in wealth,

$$\text{sign} \left[\frac{d\tilde{x}(w)}{dw} \right] = \text{sign}[-p'(\tilde{x}(w))] > 0.$$

In the next part, we will introduce three possible, commonly used negligence-based rules that differ with respect to their treatment of the causation requirement.

3 Negligence-based rules and causation

3.1 Full liability

As a matter of legal doctrine, injurers under a negligence rule are liable for damages if two conditions are met. First, the injurer must have acted negligently, that is, exercised less than due care, \bar{x} . Second, the injurer's negligence must have *caused* the accident, that is, without his negligence, the accident would not have occurred.¹⁷ However, standard accident models have usually disregarded the causation requirement and implicitly assumed that the injurer, if found negligent, must compensate the victim for all the harm done whenever an accident occurs. This has become known as negligence-based full liability regime or in short the “full liability” regime. Some scholars (e.g. Shavell 2004, 253, n. 36) argue that courts often do not apply the causation requirement in situations where the cause of the accident is not known with certainty ex-post. Instead, courts will often award full liability if they cannot *rule out* that the harm (or accident) was caused by negligence. Given that uncertain causation is the rule rather than the exception, “full liability” seems to fit real-world behavior of courts in a very relevant class of cases. Under full liability, negligent injurers are liable to compensate the victim for harm h . However, if the wealth constraint binds, $w - \alpha x < h$, the injurer is judgment proof and accordingly only pays his

¹⁷ In this paper, acting negligently means exercising less than “due care” as determined by whoever sets the standard, regardless of whether it is determined efficiently.

remaining assets, $w - \alpha x > 0$. Therefore, the injurer's expected cost can be written as:

$$J_F(x) = \begin{cases} x & x \geq \bar{x} \\ x + p(x) \min[h, w - \alpha x] & x < \bar{x}. \end{cases} \quad [3]$$

Expression [3] reveals that full liability differs from strict liability only if the injurer takes at least due care. It is easy to see that the expected cost function is discontinuous at \bar{x} .¹⁸ It follows that, with full liability, there are three potential minimizers for the injurer, \bar{x} (due care), x^* (efficient care), and \tilde{x} . These minimizers are associated with expected private costs of \bar{x} , $x^* + p(x^*)h$, and $\tilde{x}(w) + p(\tilde{x}(w))(w - \alpha\tilde{x}(w))$, respectively, as illustrated in Table 1.¹⁹

3.2 Certain causation – threshold liability

While full liability practically ignores the legal requirement of causation, negligence-based threshold liability, as first discussed by Grady (1983) and elaborated and formalized by Kahan (1989), incorporates causation in situations of *certain* causation. Under threshold liability, the injurer is liable for damages if he acted negligently *and* if his negligence caused the accident. The legal doctrine of causation excludes from the scope of liability accidents that would have occurred even if the injurer had not been negligent. To illustrate, consider the owner of a cricket ground who is legally required to have a fence 10 ft tall but only builds a fence 9 ft tall. Kahan (1989) argues that the cricket ground owner is liable if a ball crosses the fence between 9 and 10 ft high and causes harm but not if the ball crosses the fence above 10 ft. This is because, in the latter case, harm is not *caused* by the owner's deviation from due care. More generally, under threshold liability, if an accident has occurred and the injurer exercised less than due care, he will only be liable with probability

$$\pi(x, \bar{x}) \equiv \frac{p(x) - p(\bar{x})}{p(x)}, \quad [4]$$

¹⁸ Unless $\bar{x} = \{x^* + p(x^*)h, \tilde{x} + p(\tilde{x})w\}$.

¹⁹ It is important to note that under a negligence-based full liability regime (or indeed under all negligence regimes) the potential minimizers \bar{x} , x^* , or \tilde{x} need not be unique. For example, if \bar{x} is set above efficient care level, then there exists such a level for which $\bar{x} = x^* + p(x^*)h$. In such a case, both \bar{x} and x^* are minimizers of the cost function. We will adopt the convention that in such cases, the injurer chooses the care level that is more efficient from a social perspective. This qualification applies to the other negligence-based liability rules.

which reflects the probability of causation.²⁰ Note that $\pi(x, \bar{x})$ is a function of the due care standard. The amount of damages under threshold liability, however, is the same as the amount of damages under full or strict liability. This means that the injurer pays h unless he is judgment proof and then only pays $w - \alpha x$. His expected cost function can be written as:

$$J_T(x) = \begin{cases} x & \text{if } x \geq \bar{x} \\ x + (p(x) - p(\bar{x})) \min[h, w - \alpha x] & \text{if } x < \bar{x}. \end{cases} \quad [5]$$

Expression [5] reveals that threshold liability differs from full liability only by the term $p(\bar{x}) \min[h, w - \alpha x]$ if the injurer is found negligent. It follows that there are three potential minimizers of expected cost, \bar{x} (due care), x^* (efficient care),²¹ or $\hat{x}(w, \alpha)$ satisfying the following first-order condition:²²

$$1 - \alpha(p(x) - p(\bar{x})) = -p'(x)(w - \alpha x). \quad [6]$$

A comparison of expressions [2] and [6], which by virtue of the analysis in Section 3.1 is also relevant for full liability, reveals that, with non-monetary care, potential minimizers are the same under full liability and threshold liability, $\hat{x}(w, 0) = \bar{x}(w, 0)$. If care is monetary, the level of care exercised by a wealth-constrained negligent injurer is strictly lower under threshold liability than under strict liability or full liability, $\hat{x}(w, 1) < \bar{x}(w, 1)$. This is because marginal costs under threshold liability are higher than under strict liability or full liability, while marginal benefits are the same under all three rules. Finally, the private expected costs associated with these potential minimizers are \bar{x} , $x^* + p(x^*)\pi(x^*, \bar{x})h$ and $\bar{x}(w) + p(\bar{x}(w))\pi(\bar{x}(w), \bar{x})(w - \alpha\bar{x}(w))$, respectively (Table 1).

3.3 Uncertain causation – proportional liability

Following Kahan (1989), we have so far implicitly assumed that the court can verify with *certainty* at which height a cricket ball crossed the fence. Most of the time, however, the court will only observe that a cricket ball crossed the fence and know from experience that this happens less often if the fence is higher. If

²⁰ See, for example, Ben-Shahar (1999, 651); Tabbach (2008). The probability of causation can be calculated as in expression [4] if we rule out the possibility that harm is prevented *because* the injurer fell short of exercising due care (see Footnote 2).

²¹ This is because if the injurer is not wealth-constrained expected costs under threshold liability differ from expected costs under strict liability only by a constant.

²² Again the first-order condition is sufficient because of the convexity of the expected cost function.

the data are really good the court will know at which probability balls cross the fence depending on its height. Yet, in these cases, it is no longer possible to tell with certainty what would have happened if the injurer had exercised due care. It follows that threshold liability can no longer be applied.²³

As argued above, in situations of uncertain causation courts often award full damages putting the burden of the uncertainty on the negligent injurer. Alternatively, courts may find the injurer liable if it is more likely than not that his negligence caused the harm.²⁴ Yet, there is a third alternative, commonly referred to as “proportional liability”, which is occasionally applied by courts in situations of uncertain causation.

Under proportional liability, a negligent injurer is always liable if an accident occurs, but damages equal harm discounted by the probability

$$\pi(x, \bar{x}) \equiv \frac{p(x) - p(\bar{x})}{p(x)} \quad [7]$$

that the harm was caused by the injurer’s negligence.²⁵ A negligent injurer will therefore be liable for less than the full amount of harm, $\pi(x, \bar{x})h < h$. Since damages will be paid in full only if the injurer has sufficient wealth, $w - \alpha x \geq \pi(x, \bar{x})h$, his expected cost function is

$$J_P(x) = \begin{cases} x & \text{if } x \geq \bar{x} \\ x + p(x) \min[\pi(x, \bar{x})h, w - \alpha x] & \text{if } x < \bar{x} \end{cases} \quad [8]$$

A comparison of expressions [5] and [8] reveals that if the injurer’s wealth constraint is not binding under both proportional liability and threshold liability, the injurer’s expected costs under both rules coincide. However, since $\pi(x, \bar{x})h < h$, there will be levels of wealth for which the injurer will be judgment proof under threshold liability but not under proportional liability, in which case the optimization problems induced by the different rules become different. The difference stems from the fact that, under threshold liability, the level of

23 Threshold liability as formulated in this paper can be applied to situations of uncertain causation in the following way. Suppose that in the face of uncertainty over causation the courts or juries would toss an appropriate coin reflecting the probability of causation $\pi(x) \equiv \frac{p(x) - p(\bar{x})}{p(x)}$ and the probability of non-causation $1 - \pi(x)$ and would find the injurer liable in the relevant case. We would like to thank Jacob Nussim for offering us this interpretation of threshold liability.

24 Rules in which the probability threshold required to impose liability is $x \in [0, 1]$ were analyzed, for example, by Shavell (1985) and shown to induce socially non-optimal care even in the absence of wealth constraints. We therefore do not analyze these rules in the present paper.

25 See Footnote 2.

damages is *binary*, either 0 or h , depending on whether the accident was caused by negligence. In contrast, under proportional liability, the injurer is always liable for damages, but damages are continuous and equal to $\pi(x, \bar{x})h \in (0, h)$.

A comparison of expressions [3] and [8] reveals that the only difference between proportional liability and full liability arises if the injurer is negligent and not wealth constrained. Then, the injurer’s liability only differs by a constant, $p(\bar{x})h$. Moreover, since $\pi(x, \bar{x})h < h$, the injurer is more likely to be wealth constrained under proportional liability than under full liability.

It follows that, under proportional liability, there are three potential minimizers for the injurer, \bar{x} (due care), x^* (efficient care), and \tilde{x} . Those care levels lead to expected cost of \bar{x} , $x^* + p(x^*)\pi(x^*)h$ and $\tilde{x}(w) + p(\tilde{x}(w))(w - \alpha\tilde{x}(w))$, respectively. Table 1 summarizes our preliminary analysis.

Table 1: Potential Minimizers Under Different Liability Rules

Liability rule	Candidate 1 [#]	Candidate 2 [#]	Candidate 3 [#]
Full	(\bar{x}, \bar{x})	$(x^*, x^* + p(x^*)h)$	$(\tilde{x}, \tilde{x} + p(\tilde{x})(w - \alpha\tilde{x}))$
Proportional	(\bar{x}, \bar{x})	$(x^*, x^* + p(x^*)\pi(x^*, \bar{x})h)$	$(\tilde{x}, \tilde{x} + p(\tilde{x})(w - \alpha\tilde{x}))$
Threshold	(\bar{x}, \bar{x})	$(x^*, x^* + p(x^*)\pi(x^*, \bar{x})h)$	$(\tilde{x}, \tilde{x} + p(\tilde{x})\pi(\tilde{x}, \bar{x})(w - \alpha\tilde{x}))$
Strict		$(x^*, x^* + p(x^*)h)$	$(\tilde{x}, \tilde{x} + p(\tilde{x})(w - \alpha\tilde{x}))$

Notes: [#]The first argument reflects the potential minimizer and the second argument reflects the associated expected private cost for the injurer; We assume that when a minimizer is not unique, the injurers choose the more efficient care level.

4 The social desirability of proportional liability

Having characterized the payoff profiles associated with different liability rules, we are ready to derive our main argument, namely, that proportional liability is socially preferable to other existing liability rules. In this section, we shall demonstrate this claim with respect to full liability and strict liability. In the next section, while discussing further policy issues, we will prove this claim with respect to threshold liability and another negligence-based rule known as disgorgement liability.²⁶ In comparing different liability rules we will assume throughout that the standard of due care is set at the same (possibly inefficient) level.²⁷

²⁶ In a previous working paper version of this paper we offer a full fledged analysis regarding the effects of insolvency and biased standards under the different negligence-based liability rules. The interested reader can find this analysis in Stremitzer and Tabbach (2009).

²⁷ In so doing, we rule out the possibility that sophisticated courts would fine-tune the standard of due care depending on the liability rule they apply. Allowing for such fine-tuning

4.1 Proportional liability v. full liability

Proposition 1 *If injurers may be judgment proof and courts may set the due care standard above or below the socially optimal level, proportional liability is socially preferable to full liability. This holds true both for the case of monetary and non-monetary care.*

Proof. We consider two cases, the case where due care is set at or below the socially optimal care level and the case where due care is set above the socially optimal level of care. Our proof relies on the summary in Table 1.

Due care is set at or below the socially optimal care level

If $\bar{x} \leq x^*$ then injurers under both rules will never choose x^* unless $x^* = \bar{x}$ since $\bar{x} \leq x^* < x^* + p(x^*)h$. Therefore, injurers' choice is either \bar{x} or \tilde{x} provided that the latter is feasible, namely, that the wealth constraint is binding: $w - \alpha\tilde{x} < h$ (full liability) or $w - \alpha\tilde{x} < \pi(x^*, \tilde{x})h$ (proportional liability). For both rules these choices are identical. This is so since the condition which makes a potential injurer prefer \tilde{x} over \bar{x} , $\tilde{x} + p(\tilde{x})(w - \alpha\tilde{x}) < \bar{x}$, also implies that the injurer is wealth constrained under both rules. This can be verified by the following series of inequalities:

$$\begin{aligned} \tilde{x} + p(\tilde{x})(w - \alpha\tilde{x}) < \bar{x} \leq x^* \leq x^* + p(x^*)\pi(x^*, \bar{x})h < \tilde{x} + p(\tilde{x})\pi(x^*, \bar{x})h \\ \Rightarrow (w - \alpha\tilde{x}) < \pi(x^*, \bar{x})h < h. \end{aligned} \quad [9]$$

where the fourth inequality follows from the fact that x^* is the minimizer of $x + p(x)\pi(x, \bar{x})h$. Therefore for $\bar{x} \leq x^*$, proportional liability is no worse than full liability for all wealth levels. Indeed, both rules induce exactly the same behavior.

Due care is set above the socially optimal care level

If $\bar{x} > x^*$, then under proportional liability the injurer will never choose \bar{x} . This is because, by definition, x^* dominates \bar{x} if the injurer's wealth constraint is not binding when choosing x^* . If the injurer's wealth constraint is binding when choosing x^* , $(w - \alpha x^*) < \pi(x^*, \bar{x})h$, then \tilde{x} dominates \bar{x} . To see this observe that

would increase the range of implementable outcomes under different rules and would probably weaken the case for proportional liability. It is, for instance, a well-known result that full liability converges to strict liability if the standard of due care is set to a very high level, so that no potential injurer would ever adhere to it (see, for example, Landes and Posner 1987). In line with the literature, we rule out the possibility that sophisticated courts would "game" a particular liability rule in this way. We assume that courts aim for setting the due care standard to the level of socially optimal care, but sometimes fail to do so because of systematic biases.

$$\begin{aligned} \tilde{x} + p(\tilde{x})(w - \alpha\tilde{x}) < x^* + p(x^*)(w - \alpha x^*) < x^* + p(x^*)\pi(x^*, \bar{x})h < \bar{x} \\ + p(\bar{x})\pi(\bar{x}, \bar{x})h = \bar{x} \end{aligned} \quad [10]$$

where the first inequality follows from the definition of \tilde{x} , the second inequality follows from the wealth constraint condition, and the third inequality follows from the definition of x^* . Hence, the injurer's choice is between x^* and \tilde{x} provided that the choice that minimizes expected cost is also feasible. We will now show two things: (i) Given feasibility, whenever the injurer prefers \tilde{x} over x^* under proportional liability he also prefers \tilde{x} over x^* and \bar{x} under full liability. (ii) Whenever \tilde{x} is feasible under proportional liability it is also feasible under full liability. The first claim can be verified by the following series of inequalities:

$$\tilde{x} + p(\tilde{x})(w - \alpha\tilde{x}) < x^* + p(x^*)\pi(x^*, \bar{x})h < \min[x^* + p(x^*)h, \bar{x}].$$

The second claim follows from $w - \alpha\tilde{x} < \pi(\tilde{x}, \bar{x})h < h$. Therefore, the injurer chooses \tilde{x} under full liability whenever he makes this choice under proportional liability. As we know that proportional liability leads to x^* in all other cases, proportional liability cannot be worse than full liability. However, it is easy to see that there are cases where proportional liability induces optimal care x^* and full liability induces less than optimal care \tilde{x} (when $\tilde{x} + p(\tilde{x})(w - \alpha\tilde{x}) < \min[x^* + p(x^*)h, \bar{x}]$) and more than socially optimal care \bar{x} (when $\bar{x} < \min[x^* + p(x^*)h, \tilde{x} + p(\tilde{x})(w - \alpha\tilde{x})]$). In those cases proportional liability strictly dominates full liability, while in all other cases it performs at least as good as full liability. ■

We compared proportional liability and full liability in the presence of two possible sources of inefficiency: (1) Injurer judgment proofness and (2) court biases in setting the standard of due care. We show that if the standard of care is set below or at the socially optimal levels proportional liability and full liability induce exactly the same care levels, although under proportional liability the injurer is less likely to be judgment proof. On the other hand, if the standard of due care is set above the socially optimal care level, proportional liability is socially preferable to full liability for two reasons: First, there will not be any distortion for injurers who are not wealth constrained under proportional liability. Second, fewer low-wealth injurers will take too little care.

It is important to understand that Proposition 1 is a robustness result. Proportional liability strictly outperforms full liability in certain cases, while in *all* other cases proportional liability performs at least as good as full liability. We therefore argue that proportional liability is not only a conceptually consistent way of accounting for the causation requirement in situations of uncertain

causation, but also an attractive option, relative to other alternatives, from a social welfare perspective.²⁸

4.2 Proportional liability v. strict liability

Proposition 2 *If injurers may be judgment proof and courts may set the due care standard at or above the socially optimal level, proportional liability is socially preferable to strict liability. If courts set the due care standard below the socially optimal level, the social preferability of either of the two rules is ambiguous.*

Proof. *Due care standard set at or above socially optimal care*

Under strict liability, the injurer chooses either \tilde{x} or x^* (Table 1). If $\bar{x} \geq x^*$, we know from the proof of Proposition 1 that the injurer also chooses between \tilde{x} and x^* under proportional liability. Under both rules the injurer chooses \tilde{x} if two conditions are met: (i) \tilde{x} is feasible (the injurer is wealth constrained when choosing \tilde{x}), and (ii) the expected costs are lower when choosing \tilde{x} than when choosing x^* . It follows from $\pi(\tilde{x}, \bar{x})h < h$ that, \tilde{x} is feasible in a larger set of cases for strict liability than for proportional liability. Moreover, it follows from

$$x^* + p(x^*)\pi(x^*, \bar{x})h < x^* + p(x^*)h$$

that choosing \tilde{x} minimizes the expected costs under strict liability in a larger set of cases than under proportional liability. As, under both rules, the injurer's choice is either \tilde{x} or x^* , it follows that proportional liability induces socially efficient care x^* for a greater set of cases than strict liability. Proportional liability therefore dominates strict liability for $\bar{x} \geq x^*$.

Due care is set below socially optimal care

If $\bar{x} < x^*$ then the comparison between proportional liability and strict liability becomes ambiguous. On the one hand, it is clear that without wealth constraint strict liability is socially preferable to proportional liability (or indeed any other

²⁸ Guido Calabresi and Jeffrey O. Cooper in their 1995 Monsanto Lecture, published in the Valparaiso University Law Review, Vol. 30. No. 3, described the advent of splitting rules, replacing the dominance of all-or-nothing recovery rules, as one of the most important shifts in tort law over the past decades comparable only to the coming of insurance 80 years ago. Calabresi and Cooper deplored that while “splitting rules give us more options, we do not necessarily know whether they create a better package of incentives than existed before” (p. 883). They concluded that a much additional analysis is needed to answer this question. By showing that proportional liability as a prominent example of such a splitting rule has desirable welfare properties, our article contributes to the vast research program outlined in their article.

negligence-based rule) since it induces efficient care, while negligence-based rules cannot induce more than due care, which is by assumption set at an insufficient level. The same is true for sufficiently low standards of due care, $\bar{x} < \tilde{x}$. On the other hand, consider an injurer whose wealth satisfies $\tilde{x} + p(\tilde{x})(w - \alpha\tilde{x}) < \bar{x}$. He will not abide by due care and will instead choose \tilde{x} . Yet, if $\tilde{x} < x^*$, and due care is set at $\bar{x} \in (\tilde{x}, \tilde{x} + p(\tilde{x})(w - \alpha\tilde{x})]$, proportional liability induces $\bar{x} > \tilde{x}$ which is closer to the socially optimal choice.²⁹ ■

It seems that commentators have been more concerned with the scenario of courts or regulators setting the standard of due care too high rather than too low. This is because there are strong incentives for regulators to err on the side of safety. For ex-post decisions by courts the hindsight bias seems to have the same effect. If courts tend to conclude that the injurer must have been negligent from the mere fact that an accident occurred this can be expressed in our model as setting the standard of due care too high. Our result therefore suggests that proportional liability is socially preferable to strict liability in cases which are most practically relevant. However, if the due care standard is set below optimal levels, the social desirability of proportional liability and strict liability becomes ambiguous.

5 Other policy implications

We have argued that proportional liability is socially preferable to full liability and strict liability. In this section, we shall discuss two other interesting policy implications concerning proportional liability: One is concerned with the question of the value of accuracy in adjudication, that is, whether it is socially desirable to spend resources in order to determine with certainty whether harm was caused by negligence. The other is concerned with the policy question of setting minimum capital requirements in different industries. As will become apparent, these two issues are related to the social preferability of proportional

²⁹ This last point is similar to Ganuza and Gomez (2008) who have argued that, in the presence of wealth constraints, setting due care below socially optimal care is desirable as a second best. Dari-Mattiacci (2004), however, argued, that this effect does not occur if the causation requirement is taken into account and the precaution technology is such that only the probability of the harm occurring can be affected. Our analysis suggests that the effect of Ganuza and Gomez (2008) also holds in a setting where care reduces the probability of harm if causation is uncertain and proportional liability is applied. The criticism by Dari-Mattiacci (2004) is only valid under threshold liability.

liability over two other negligence-based liability rules: threshold liability and a rule known as disgorgement liability.

5.1 Value of accuracy in adjudication: proportional liability v. threshold liability

As explained above, threshold liability and proportional liability account for causation in two different settings. Threshold liability applies to situations of certainty about causation, whereas proportional liability applies to situations of uncertainty about causation. Yet, in many cases, the degree of uncertainty may be endogenous as it is possible to invest in more accurate information regarding causation. For example, in Kahan's example of the cricket ground, the owner could install a camera to monitor the fence. Such an investment will increase the number of cases where certainty is indeed achieved. With a camera it would be possible to know at which height the ball crossed the fence (if the crossing took place at a section of the fence within the camera's purview). An interesting question therefore arises about the desirability to spend resources in order to increase the percentage of cases in which causation can be determined with certainty and therefore threshold liability could be applied. In order to answer this question we will now compare the relative efficiency of proportional liability and threshold liability.

Proposition 3 *Proportional liability is socially preferable to threshold liability if injurers may be wealth constrained and courts set the due care standard at or below socially efficient levels. If courts set the due care standard above socially efficient levels, proportional liability remains socially preferable to threshold liability for non-monetary care, but the relative desirability of the two rules becomes ambiguous for monetary care.*

Proof. *Due care is set at or below the socially optimal care level, $\bar{x} \leq x^*$.*

Recall from Table 1 that if the due care standard is set below the socially optimal level, the minimizer under proportional liability is \hat{x} or \bar{x} and the minimizer under threshold liability is \hat{x} or \bar{x} . Observe that

$$\hat{x} + p(\hat{x})\pi(\hat{x}, \bar{x})(w - \alpha\hat{x}) \leq \bar{x} + p(\bar{x})\pi(\bar{x}, \bar{x})(w - \alpha\bar{x}) < \bar{x} + p(\bar{x})(w - \alpha\bar{x}),$$

where the first weak inequality follows from the fact that \hat{x} is the minimizer of $x + p(x)\pi(x, \bar{x})(w - \alpha x)$ and the last inequality follows from the fact that $\pi(\bar{x}, \bar{x}) < 1$. There are three possibilities to consider: (i) if $\bar{x} + p(\bar{x})(w - \alpha\bar{x}) < \bar{x}$,

injurers will choose \tilde{x} under proportional liability and \hat{x} under threshold liability. As demonstrated in expression [9] $\tilde{x} + p(\tilde{x})(w - \alpha\tilde{x}) < \bar{x}$ implies $w - \alpha\tilde{x} < h$, which means that the wealth constraint is binding under threshold liability. As $\hat{x} \leq \tilde{x}$, where the equality applies to non-monetary care, it follows from $\tilde{x} < \bar{x} < x^*$ that proportional liability performs at least as good as threshold liability (and strictly better for monetary care). (ii) if $\hat{x} + p(\hat{x})\pi(\hat{x}, \bar{x})(w - \alpha\hat{x}) < \bar{x} < \tilde{x} + p(\tilde{x})(w - \alpha\tilde{x})$, then proportional liability is strictly superior to threshold liability, since it induces care level \bar{x} which is socially preferable to \hat{x} (note that $\hat{x} + p(\hat{x})\pi(\hat{x}, \bar{x})(w - \alpha\hat{x}) < \bar{x}$ implies that the wealth constraint is binding for threshold liability). (iii) Lastly if $\bar{x} < \hat{x} + p(\hat{x})\pi(\hat{x}, \bar{x})(w - \alpha\hat{x})$ then both rules induce exactly the same care level, namely, \bar{x} . Hence, if $\bar{x} \leq x^*$ proportional liability is superior to threshold liability.

Due care is set above the socially optimal care level, $\bar{x} > x^$*

If $\bar{x} > x^*$, the comparison between proportional liability and threshold liability is ambiguous. Like proportional liability, threshold liability never induces \bar{x} , since the choice of \bar{x} is dominated by x^* or by \hat{x} if the injurer is wealth constrained at x^* . Therefore, the choice is between x^* and \hat{x} . If, under threshold liability, an injurer chooses x^* (since $x^* + p(x^*)\pi(x^*, \bar{x})h < \hat{x} + p(\hat{x})\pi(\hat{x}, \bar{x})(w - \alpha\hat{x})$) he will also choose x^* under proportional liability. If an injurer chooses \hat{x} under threshold liability, he may choose either x^* or \tilde{x} under proportional liability, depending on whether $x^* + p(x^*)\pi(x^*, \bar{x})h < > \tilde{x} + p(\tilde{x})(w - \alpha\tilde{x})$.³⁰ The first choice renders proportional liability superior to threshold liability, and so is the second choice provided that $\hat{x} \leq \tilde{x} < x^*$. The latter is always true if care is non-monetary. However, if care is monetary then it is possible that $x^* < \hat{x} < \tilde{x}$. In this case threshold liability is socially preferable to proportional liability.³¹ ■

The fact that proportional liability dominates threshold liability for non-monetary care and, in most cases, for monetary care as well presents an interesting policy implication regarding the value of accuracy in adjudication. Our analysis suggests that it is socially detrimental to invest in proving causation even when that proof is costless because such investment increases the probability that threshold liability will be applied instead of the more efficient

30 Note that the wealth constraint is less binding under proportional liability than under strict liability.

31 To illustrate, suppose that \bar{x} is set sufficiently high that no injurer abides by it. Then the superiority of proportional liability to threshold liability depends on whether excessive or insufficient care is induced by these rules. For non-monetary care, $\hat{x} = \tilde{x} < x^*$, implying that proportional liability is superior to threshold liability. For monetary care and certain wealth levels such as $w = h + x^*$, $x^* < \hat{x} < \tilde{x}$. In this case, threshold liability is preferable to proportional liability.

proportional liability rule.³² Hence, it is socially optimal to discourage such investment, for example, by barring the introduction of evidence regarding causation in lawsuits and instead relying on statistical evidence. In the case of monetary care there are, however, isolated cases where investment into accuracy might be beneficial.

5.2 Minimal capital requirements: proportional liability v. disgorgement liability

The analysis in the proof of Proposition 1 above demonstrates that proportional liability induces the same care level as full liability over the entire range of wealth constraints as long as due care is set at or below the socially optimal level. This is puzzling as one might expect that proportional liability outperforms full liability since the wealth constraint binds more often under the latter than under the former rule. The reason why this intuition is wrong is that damages under both full and proportional liability are higher than necessary to induce socially optimal care. Therefore, as long as the wealth constraint just affects the portion of damages not needed for deterrence purposes, it does not impair the efficiency of these rules. Judgment proofness starts to matter when it reaches the minimum of what is necessary to induce socially optimal behavior. But then it matters for both rules alike. This explanation suggests a method to calculate the cut-off value of wealth \bar{w} , which is implicitly defined by $\bar{x}(w) + p(\bar{x})(w - \alpha\bar{x}(w)) = x^*$. As it turns out, this method is closely connected to another negligence-based liability rule, known in the literature as disgorgement liability.

To see this, consider a negligence-based liability rule which is designed to stipulate damages that are just high enough to make the injurer abide by socially optimal care (or, more generally, by the standard of due care). In other words, consider a rule under which, an injurer will act negligently whenever he is judgment proof. Under such a rule, damages $D(x)$ should satisfy the condition $x + p(x)D(x) = x^*$ for all $x < x^*$, or equivalently³³:

³² This differs from the argument by Rose-Ackerman (1990) that individualized causal claims should be discouraged in market-share liability cases because they are worthless and therefore only waste resources. See also Kaplow (1994) for the general argument that the benefits of accuracy be weighed against the cost of achieving it.

³³ Strictly speaking, to induce the socially optimal care, damages should be a little bit higher than $\frac{x^* - x}{p(x)}$, since otherwise the injurer is indifferent among all $x \in [0, x^*]$. We shall assume that damages are set in order to induce injurers to take due care.

$$D(x) = \frac{x^* - x}{p(x)}. \quad [11]$$

This rule is referred to in the literature as “disgorgement liability” (see, e.g. Polinsky and Shavell 1992; Arlen 1992, 419). Under disgorgement liability, a negligent injurer is liable if an accident occurs, but the damages he has to pay are equal to the gains he obtains from having deviated from the due care standard, $x^* - x$, multiplied by the inverse of the accident probability, $p(x)$. In other words, the rule disgorges the injurer’s expected gain from deviating from the due care standard. Hence, if an accident occurs, a negligent injurer will have to pay $D(x)$ unless his wealth constraint binds, $w - \alpha x < D(x)$, in which case he pays $w - \alpha x$. As $w - \alpha x < D(x)$ can be rearranged to $x + p(x)(w - \alpha x) < x^*$, the injurer’s expected payoff can be written as:

$$J_D(x) = \begin{cases} x & \text{if } x \geq x^* \\ \min[x^*, x + p(x)(w - \alpha x)] & \text{if } x < x^*. \end{cases} \quad [12]$$

It is easy to see that if due care is set at the socially optimal care level, disgorgement liability induces the same care as full liability and proportional liability for all wealth levels.

More interestingly, disgorgement liability offers a relatively easy way to calculate the minimum wealth necessary to induce injurers to abide by the socially optimal care level. This level is equal to:

$$\bar{w} = \max_x \frac{x^* - (1 - \alpha p(x))x}{p(x)}, \quad [13]$$

which, for non-monetary care, is simply the highest possible damage payment under disgorgement liability. This is true as damages under disgorgement liability are designed to disgorge the expected gain from deviating from the due care standard. If there existed a care level $\hat{x} < x^*$ resulting in damages which the injurer could not pay in full due to the judgment-proof problem, $D(\hat{x}) > w - \alpha \hat{x}$, damages would disgorge less than the expected gain from choosing \hat{x} rather than x^* and the injurer would minimize his expected cost by choosing \hat{x} :

$$\hat{x} + p(\hat{x})(w - \alpha \hat{x}) < \hat{x} + p(\hat{x})D(\hat{x}) = x^*.$$

Therefore, to induce x^* it is necessary that the wealth constraint does not bind for any $x < x^*$. This, in turn, implies that wealth must be at least as high as the highest possible damages payment under disgorgement liability. Hence, expression [13] provides an intuitive and easy way to calculate the level of wealth for which injurers under full and proportional liability no longer abide by the socially optimal level of care. This result offers a conceptual framework to

inform legislators about how to calculate minimum capital requirements or minimum mandatory insurance provisions using information about the available accident prevention technologies in different industries.

Concerning the efficiency of the disgorgement liability rule compared to proportional liability, it can be easily shown that while disgorgement liability induces the same behavior as proportional liability when due care is set at or below the socially optimal care level, it is socially inferior to proportional liability when the due care standard is set above the socially optimal level. This is because, under disgorgement liability, damages are set to induce injurers to abide by the due care standard. If the due care standard is set above the socially optimal level and the wealth constraint is not binding, disgorgement liability therefore induces excessive precaution, while proportional liability induces efficient care. If the wealth constraint is binding, the two rules induce the same amount of care, but the wealth constraint is binding more often for disgorgement liability than for proportional liability.³⁴

6 Conclusions

In this paper, we argue that proportional liability is socially preferable to other negligence-based liability rules and strict liability. This is true in the presence of two possible sources of inefficiency: (1) insolvency and (2) biases in setting the standard of due care.

In particular, we demonstrate that if the due care standard is set at or below the socially optimal care level, proportional liability is no worse than full liability, while if the due care standard is set above the socially optimal care level, proportional liability outperforms full liability for essentially two reasons: First, there will not be any distortion for high-wealth (non-wealth-constrained) injurers under proportional liability. Second, fewer low-wealth injurers will take too little care. Hence, counterintuitively, the rule which imposes less liability on the injurer induces less underinvestment in care and is socially preferable. We therefore argue that proportional liability is not only a conceptually consistent way of accounting for the causation requirement in situations of uncertain causation, but also socially more desirable than any other alternative rule currently contemplated by courts.

³⁴ For details see Stremitzer and Tabbach (2009).

We also show that if the due care standard is set at or above the optimal level of care, proportional liability is socially preferable to strict liability in the presence of insolvent injurers. However, if the due care standard is set below the optimal level of care, the relative performance of proportional liability and strict liability becomes ambiguous. Of course, this is not surprising since proportional liability, as other negligence-based rules, cannot implement more than due care. Still, under plausible assumptions, proportional liability will be preferable to strict liability if the deviation from the socially optimal care level is not too large and if injurers are moderately wealth constrained.

Our analysis also presents an interesting policy implication about the value of accuracy in adjudication. We find that, at least for non-monetary care and most often also for monetary care, it is socially detrimental to invest in proving causation even when that proof is without cost because such investment increases the likelihood that threshold liability will be applied instead of the more efficient proportional liability rule. Therefore, it is socially optimal to discourage such investment, for example, by barring the introduction of evidence regarding causation in lawsuits and instead relying on statistical evidence.

Finally, we provide an intuitive and relatively easy method to calculate the minimum wealth necessary to implement the socially optimal care level under a wide range of negligence-based rules including proportional liability. For non-monetary care, the minimum wealth equals the maximum damage payment under disgorgement liability.³⁵ This result can inform regulators about how to calculate minimum capital requirements or mandatory insurance provisions in different industries.

We now comment briefly on the simplifying assumptions chosen in this model. First, this paper assumes that injurers as well as victims are risk neutral. This is a common assumption in the law and economics literature on torts, which can be justified either if (1) insurance markets are available and the price of insurance is actuarially fair or (2) liability or losses are relatively small when compared to injurers' and victims' assets, respectively. However, in certain situations injurers or victims should not be treated as risk neutral but rather as risk averse. Although we do not offer a formal model of this possibility, proportional liability appears to outperform full liability and threshold liability on this account as well. The reason is simple. Compared to all-or-nothing rules (such as full liability and threshold liability), proportional liability has a lower

³⁵ With a minor correction for the monetary nature of care, a similar result holds for monetary care.

variance of outcomes. Therefore, proportional liability reduces the risk borne by injurers and victims relative to the other negligence regimes.

Second, our model does not account explicitly for administrative costs. However, the question of which negligence rule is associated with fewer administrative costs is not an easy one. On the one hand, full liability is simpler to administer than proportional liability because under the latter rule the victim needs to prove causation while under the former he does not. On the other hand, the amount of damages under full liability (and also threshold liability) is larger than under proportional liability, giving injurers and victims greater incentives to spend resources in litigation over the determination of negligence. In any event, proportional liability does not seem to be disadvantaged in comparison to threshold liability. Under both rules the determination of the probability of causation is similar and proportional liability even has the advantage of not requiring causal links to be established on a case-by-case basis.

Finally, our model assumes that courts have the relevant information regarding the probabilities of harm associated with different levels of care, so that courts can calculate the probability of causation. This assumption is probably not a restrictive assumption in areas such as medical malpractice where epidemiological data are often available, or in “market-share” liability cases, where proportional liability is an often applied liability rule. However, we believe that the lack of objective probabilities need not vitiate the application of proportional liability, and the lack of perfect data does not imply that we have no knowledge at all. There will often be upper and lower bounds to probabilities and courts may apply decision rules under uncertainty like the principle of insufficient reason to derive the probability of causation. We leave the boundaries of the applicability of proportional liability for future research.

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