Split-Award Tort Reform, Firm’s Level of Care, and Litigation Outcomes

by

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We investigate the effect of the split-award tort reform, where the state takes a share of the plaintiff’s punitive damage award, on the firm’s level of care, the likelihood of trial, and the social costs of accidents. A decrease in the plaintiff’s share of the punitive damage award reduces the firm’s level of care and therefore increases the probability of accidents. The effects of split awards on the likelihood of trial and social costs of accidents are ambiguous. Conditions under which a decrease in the plaintiff’s share of the punitive damage award reduces the probability of trial and the social cost of accidents are derived. (JEL: K 41, C 70, D 82)

1 Introduction

There is a common perception that excessive punitive damage awards have contributed to the escalation of liability insurance premiums and have generated excessive financial burdens on firms. This perception has motivated several tort reforms in U.S. states (SLOANE [1993]). Some reforms take the form of caps or limits on punitive damage awards, while others mandate that a portion of the award be allocated to the plaintiff with the remainder going to the state. These latter reforms, called split awards, have been implemented in Alaska, California, Georgia, Illinois, Indiana, Iowa, Missouri, Oregon, and Utah. Statutes vary with the state: the base for computation of the state’s share can be the gross punitive award or the award net of attorney’s fees; the state’s share can be 50%, 60%, or 75%; the destination of the state’s funds can be the Treasury, the Department of Human Services, or indigent victims’ funds (DODSON [2000], EPSTEIN [1994], STEVENS [1994], SLOANE [1993]).

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Split awards may affect litigation outcomes and liability. Commentators (Dodson [2000], Evans [1998], Epstein [1994], Stevens [1994], Sloane [1993]) argue that, given that split awards reduce the plaintiff’s award in case of trial, these statutes induce plaintiffs to accept lower settlement offers and therefore generate an incentive to settle out of court. As a consequence, this tort reform decreases the firm’s expected litigation loss and therefore influences its expenditures on accident prevention (firm’s level of care). In addition, the lower plaintiff’s recovery at trial under split awards reduces the plaintiff’s windfall and the incentives to file a lawsuit.

Previous formal work on the split-award tort reform, however, has focused only on its effects on litigation outcomes. Drawing on the analysis of litigation in isolation, it has been argued that split awards decrease the likelihood of trial. This direct effect of split awards operates through the plaintiff’s willingness to accept lower out-of-court settlement offers. These studies, however, overlook the indirect effect of split awards on litigation outcomes, which operates through the care taken by potential injurers. Our paper extends these previous studies by investigating the effects of this tort reform on litigation outcomes and on the firm’s level of care, and by exploring the interactions between these two effects.

We construct a strategic model of liability and litigation under a care standard for assessing gross negligence. Punitive damages are intended to punish defendants for their egregious conduct against society and to deter others from engaging in similar conduct in the future. In addition, punitive damages serve to encourage plaintiffs to bring forth minor criminal offenses that are not likely to be prosecuted, and to compensate plaintiffs for their attorneys’ fees (Dodson [2000], Evans [1998], Epstein [1994], Stevens [1994], Sloane [1993]). In real-world settings, punitive damages are awarded only in cases where the defendant is found grossly negligent (i.e., where the defendant’s actions were malicious, oppressive, gross, willful and wanton, or fraudulent). This implies that a care standard is applied.

We build upon PNG’s [1987] theoretical framework and extend his work in a number of ways. First, we incorporate the split-award statute into the framework. Second, we establish sufficient conditions for a unique litigation-stage equilibrium that survives the universal divinity refinement (Banks and Sobel [1987]). Third, we find a sufficient condition for the positive relationship between the plaintiff’s share of the punitive award and the conditional and unconditional probabilities of trial. Fourth, we study the effects of this statute on social costs of accidents and establish necessary and sufficient conditions for a reduction in social costs of accidents under the split-award regime. In addition, our framework allows for heterogeneity in firms’ costs of preventing accidents, which permits us to capture the two ways that firms’

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1 The plaintiff’s windfall refers to any amount in excess of the costs of pursuing the punitive claim. Commentators claim that this windfall promotes unnecessary litigation.

2 We refer to firms that just meet or exceed the care standard as careful firms, and to firms that fail to meet the standard as negligent firms.
choices of care may affect the outcomes of litigation: through the probability of accidents, and through the composition of firms involved in accidents, i.e., the shares of careful and negligent injurers.

Our model consists of two stages. First, there is a firm’s optimization stage, where a level of care is chosen by the firm according to its cost of preventing accidents and the expected litigation loss in case of an accident. The level of care determines the probability that an accident occurs. If an accident occurs, a litigation stage begins. The plaintiff first decides whether to file a lawsuit. In case of lawsuit, the pretrial negotiation between two Bayesian risk-neutral parties – an uninformed plaintiff and an informed defendant – starts. The defendant possesses information about its cost of preventing accidents and therefore about its level of care and the decision of the court should the case go to trial. The pretrial negotiation is modeled as a signaling–ultimatum game. Our analysis generates an equilibrium in which the more efficient firms choose to be careful and the less efficient ones choose to be negligent, and one where some lawsuits are dropped, some are settled out of court, and some go to trial.

Our model predicts that a decrease in the plaintiff’s share of the punitive damage award reduces the firm’s expected litigation loss, and therefore lowers the aggregate level of care. More importantly, this lower expected litigation loss also increases the share of negligent firms and may reduce the degree of care of some of the careful firms. Hence, this tort reform not only increases the probability of accidents, but also changes the composition of injurers. We show that, as a consequence of this change in the composition of injurers, the effects of split awards on the likelihood of trial and the social costs of accidents are in general ambiguous. For instance, in activities where most potential injurers exceed the care standard, split awards may increase the probability that an accident is caused by a careful injurer. Therefore, negligent firms will have a stronger incentive to mimic the behavior of careful firms and refuse to make a settlement offer. As a result, despite plaintiffs’ willingness to accept lower settlement offers, the likelihood of trial may be higher under split awards, a counterintuitive effect. If, in addition, the harm an accident causes to society is sufficiently high, we may expect that split awards increase the social costs of accidents. We derive conditions under which a decrease in the plaintiff’s share of the punitive damage award unambiguously reduces the probability of trial and the social cost of accidents.

Our analysis has several policy implications. First, it shows that the effects of split awards are more ambiguous than one might expect, and that this ambiguity may hinder their use as an effective policy tool. Second, this analysis points to the significance of the strategic behavior of plaintiffs and defendants for the analysis of the effects of this tort reform on the firm’s choice of level of care, and underlines the importance of the composition of injurers for the likelihood of trial. In activities

3 The level of care of these careful firms will be reduced, but those firms will still meet the care standard. Therefore, the probability that an accident is caused by a careful defendant will increase.
where most potential injurers exceed the care standard, the higher likelihood of trial under split awards, combined with the reduction in the level of care, might allow the state to collect substantial revenue. However, if the social harm an accident causes is sufficiently high, these funds will be collected at the expense of a welfare loss.

Several papers have formally addressed the issues of liability and litigation. SPIER [1997] constructs a framework that combines liability and litigation to study the divergence between the private and social motives to settle under a negligence rule. She shows that social welfare can be improved if plaintiffs commit to take a tougher stance in pretrial negotiations and therefore more cases go to trial. In her model, however, there is only one type of defendant (i.e., all defendants have the same cost of achieving a given level of care). This simplification leads to a striking result: The size of the damage award should be made infinitely large to align private and social incentives to settle and hence to maximize social welfare.

With respect to optimal deterrence, POLINSKY AND CHE [1991] propose a liability system where the award to the plaintiff differs from the payment by the defendant (i.e., awards are decoupled). This system makes the defendant’s payment as high as possible, and therefore it allows the award to the plaintiff to be lowered. The authors claim that this policy reduces the incentives to sue without affecting the firm’s incentives to take care. Note that the reduction in the plaintiff’s award resembles that under the split-award statute. However, the split-award reform does not involve an increase in the award paid by the defendant. CHOI AND SANCHIRICO [2004] show that the system proposed by POLINSKY AND CHE [1991] may still have a negative effect on deterrence. Given that the award paid by defendants is increased, they will spend more on legal advice. This will force plaintiffs to spend more on attorneys as well and discourage some plaintiffs from filing a lawsuit.

Among previous formal studies of the split-award statute is the work of KAHAN AND TUCKMAN [1995]. They construct a simultaneous-move game between a plaintiff and a defendant, where each party’s expected punitive damage award depends on the effort of both parties’ lawyers (litigation expenses) and on the parties’ beliefs about the trial outcome. They study the effects of split awards on litigation expenses and the resulting effect on the size of the contract zone, allowing for agency problems between the plaintiff and his lawyer. Their model does not allow for information asymmetry as an additional source of dispute, strategic interaction of players at the pretrial bargaining stage, or defendant’s choice of level of care. They find, in the absence of agency problems, that split awards reduce the plaintiff’s litigation expenses and consequently reduce the expected amount paid by the defendant. The effect of split awards on the size of the contract zone is ambiguous.

DAUGHETY AND REINGANUM [2003] examine the effects of the split-award reform on the likelihood of trial and settlement amounts by modeling the pretrial

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4 This common feature of SPIER [1997] and POLINSKY AND CHE [1991] – that the defendant’s payment should be as high as possible in order to maximize social welfare – is at variance with the direction of tort reform in the U.S., where several states have adopted caps on punitive damage awards in an effort to reduce the defendant’s payments.
bargaining as a strategic game of incomplete information between two Bayesian players – an informed defendant and an uninformed plaintiff – using signaling and screening game setups. The defendant knows the true probability that he will be found liable for gross negligence and made to pay punitive damages, should the case go to trial. Daughety and Reinganum find that, holding filing constant, split-award statutes simultaneously lower settlement amounts and the likelihood of trial. We extend this study by modeling the defendant’s level-of-care decision, investigating the interaction between liability and litigation outcomes under split awards, and analyzing the effects of split awards on the probability of accidents and the social costs of accidents.

The paper is organized as follows. Section 2 presents the setup and solution of the model. Section 3 describes the effects of the split-award statute on the firm’s level of care, probability of accidents, litigation outcomes, and social costs of accidents. Section 4 outlines some possible extensions to our analysis. Section 5 contains concluding remarks and describes possible directions for further research.

2 The Model

Our framework combines the decision about the level of care of a potential injurer, which participates in some activity, and the outcome of a lawsuit in case of an accident, under a split-award statute. Our model allows for heterogeneity in firms’ costs of preventing accidents, which permits us to capture the two ways that firms’ choices of care may affect the outcomes of litigation: through the probability of accidents, and through the composition of firms involved in accidents, i.e., the shares of careful and negligent injurers. We model the interaction between plaintiff and defendant in case of a lawsuit using a game-theoretic approach. In addition, we incorporate information asymmetries and strategic behavior based upon them into our model.5

We base our definition of equilibrium on the concept of perfect Bayesian equilibrium and apply the universal-divinity refinement, developed by BANKS AND SOBEL [1987],6 to achieve uniqueness.

In equilibrium, those defendants with relatively high costs of preventing accidents will choose to be negligent, while those with relatively low costs will choose to be careful. In addition, some negligent defendants reveal their negligence through

5 Seminal papers assess the economic incentives underlying the process of litigation, but they do not incorporate strategic aspects of information asymmetries (see LANDES [1971], GOULD [1973], POSNER [1973], and SHAVERL [1982]). Given the relevance of asymmetric information to disputes in real-world settings (FARBER AND WHITE [1991]) and the development of dynamic game theory, more recent studies incorporate information asymmetries and strategic behavior of litigants. See REINGANUM AND WILDE [1986], HYTON [2002], SPIER [1997], [1994], and PNG [1987].

offers to settle, which are accepted by plaintiffs. Other negligent defendants try to hide their type by mimicking the behavior of careful defendants and make no offer. There is a sufficient number of those negligent and “dishonest” defendants for the information provided to the plaintiff by the action chosen by the defendant (refusal to settle) to be not transparent. Therefore, some plaintiffs respond to a refusal to settle by bringing their case to trial, while others drop their action. This equilibrium resembles the actual state of affairs of lawsuit termination. Data from the U.S. Department of Justice indicate, for a sample of the largest 75 counties (1-year period ending in 1992), that 76.5% of product liability cases were disposed through agreed settlement and voluntary dismissal and 3.3% were disposed by trial verdict. The rest of cases were disposed as follows: 4.5% by summary judgment, 0.5% by default judgment, 6% by involuntary dismissal, 2.7% by arbitration award, 6.1% by transfer, and 0.3% by other dispositions (Smith et al. [1995]).

2.1 Model Setup

Nature first decides the efficiency type $n$ of the firm from a continuum of types. We define $\phi(n)$ as the probability density function of the distribution of firms by type, and $y(n)$ as the level of product safety (level of care) for a firm of type $n$. The realization of $n$ is revealed only to the firm, but $\phi(n)$ is common knowledge. The firm’s type determines its cost $c(y(n), n)$ of achieving a given level of care $y(n)$. We define $\lambda(y(n))$ as the probability of an accident for a firm of type $n$, which depends on the level of care $y(n)$, and assume that the higher the level of care $y$, the lower the probability of an accident (i.e., the probability of accident is a decreasing function of the level of care).

After observing its type, the firm then decides its optimal level of care, i.e., the one that minimizes its total expected loss $L$. We define the defendant’s total expected loss function as $L = c(y(n), n) + \lambda(y(n))l$, where $l$ is the expected loss from legal action. We will take this loss as parametric in order to describe the properties of $L$, but ultimately $l$ will be derived as the continuation value of the litigation stage, and hence it will differ for negligent and careful defendants. The firm is careful if the level of care chosen is greater than or equal to the due standard of care for gross negligence, $\bar{y}$ (common-knowledge parameter); otherwise, the firm is negligent.

If an accident occurs, the litigation stage starts. The plaintiff first decides whether to file a lawsuit, without knowing the defendant’s level of care. This decision is based on her beliefs about the negligence of the defendant conditional on the occurrence of an accident: With probability $q$ she believes that the defendant is negligent, and with probability $1 - q$ she believes that the defendant is careful. These beliefs are taken as parametric for the analysis of the litigation subgame; however, the equilibrium values for $q$ and $1 - q$ will ultimately be determined as part of the overall equilibrium (and are provided at the end of section 2). These equilibrium values depend on the optimal levels of care chosen by all firms in the first stage of the game, according to their types and expected litigation costs (which
correspond to the equilibrium in the litigation stage). Note that the values of $q$ and $1 - q$ are common knowledge, but the firm’s type and the chosen level of care are known only by the firm. We assume that the plaintiff’s expected payoff from suing is positive. Therefore, every injured plaintiff has an incentive to file a suit. The pretrial bargaining negotiation is modeled as a signaling–ultimatum game. The defendant has the first move and makes a settlement proposal. After observing the proposal, the plaintiff, who knows only the distribution of $n$, decides whether to drop the case, to accept the defendant’s proposal (settle out of court), or to reject the proposal (bring the case to the trial stage). The plaintiff’s decision is based on her updated beliefs about the type of defendant she is confronting after observing the defendant’s proposal. If the plaintiff drops the case, both players incur no legal costs. If the plaintiff accepts the defendant’s proposal, the game ends and the defendant pays to the plaintiff the amount proposed.

If the plaintiff rejects the proposal, plaintiff and defendant incur exogenous legal costs ($K_P$ and $K_D$, respectively). If the defendant is negligent, the court awards punitive damages $A$ to the plaintiff. The court can perfectly observe the defendant’s level of care, but it does not necessarily make a perfect estimation of the social harm caused by the negligent behavior of the defendant. Under the split-award regime, the plaintiff receives only a fraction $f$ of the total punitive award,7 and the state gets the remaining share $1 - f$. If the plaintiff rejects the proposal and the defendant is careful, no punitive damages are awarded. Given that $A$ is determined by the jury and the information about the split-award statute is supposed to be kept from the jury, $A$ does not depend on $f$. This is also the reason why $\bar{y}$ is independent of $f$; otherwise, the judge could not communicate to the jury what the negligence standard represents without reference to $f$.8 Thus, we will treat $A$ and $\bar{y}$ as exogenous parameters of the model.

Note that the total harm caused by an accident includes (1) the private harm caused to the plaintiff, which we assume is fully compensated with the compensatory damage award; and (2) the social harm $H$, generated by the defendant’s wanton behavior, and which warrants punitive damages. $H$ may include additional losses directly caused to the plaintiff but not compensated with the compensatory award, such as time spent on and emotional distress caused by the compensatory-damages lawsuit; and social losses such as the undermining of society’s moral standards and institutions due to the wanton behavior of the defendant. Given that we have not assumed that the court perfectly estimates the social harm caused by the negligent behavior of the defendant, our model allows for $H$ and $A$ to be different.

Note also that, without loss of generality, for the sake of mathematical tractability and given that our primary goal is to explore the effect of the split-award statute, which applies to the punitive damage award only, we abstract from compensatory damages.

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7 We assume that the split award is computed over the gross punitive award. Our qualitative results, however, will also hold in case of computing the split award over the punitive award net of plaintiff’s litigation costs.

8 We thank Jennifer Reinganum for the suggestions on independence of $A$. 
The sequence of events in the game is shown in Figure 1.

**Figure 1**
Sequence of Events in the Game

- Nature decides D's type \( n \)
- D chooses level of care \( y \) — Accident does not occur — Game ends
- Accident occurs
- D damages P
- P files a lawsuit
- D makes an offer \( S \) — P accepts — Game ends
- P rejects \( K_P, K_D \)
- Trial — No award \( y \geq \hat{y} \) — Game ends
- Court awards \( A \)
- \( y < \hat{y} \) — Game ends

*Note:* \( D \) = defendant, \( K_D \) = defendant’s litigation costs, \( K_P \) = plaintiff’s litigation costs, \( A \) = punitive damage award, \( \hat{y} \) = standard for gross negligence.

We start by finding the solution of the litigation stage, using the concept of perfect Bayesian equilibrium. Second, we solve the defendant’s optimization problem and find the defendant’s optimal level of care. This level of care depends on the defendant’s type and the litigation-stage equilibrium.
2.2 Solution of the Litigation Stage

We focus our analysis on the equilibrium in which some negligent defendants reveal their negligence through offers to settle, which are accepted by plaintiffs. Other negligent and "dishonest" defendants try to hide their type by mimicking the behavior of careful defendants and make no offer. Some plaintiffs respond to a refusal to settle by bringing their case to trial, while others drop their action. This equilibrium resembles the actual state of affairs of lawsuit termination.

Under conditions $q f A - K_p > 0$ and $f A - K_p > K_D$, this equilibrium constitutes the unique perfect Bayesian equilibrium of the litigation stage that survives BANKS AND SOBEL's [1987] universal divinity refinement. The condition $q f A - K_p > 0$ rules out the outcome where no lawsuit is filed, and the condition $f A - K_p > K_D$ rules out the pooling outcome where careful defendants behave as negligent defendants by making a settlement offer. Under these conditions, there are, however, other partially separating equilibria and other pooling equilibria, but they do not survive the universal divinity refinement (see Appendix for details).

Proposition 1 characterizes the unique universal divine equilibrium of the litigation stage.

PROPOSITION 1 Assume that $q f A - K_p > 0$ and $f A - K_p > K_D$. The following litigation strategy profile, together with the plaintiff's beliefs, represents the equilibrium path of the unique universally divine perfect Bayesian equilibrium of the litigation stage.

**Strategy Profile.** (i) The plaintiff always files a suit. In response to an offer $S_1 = 0$, the plaintiff rejects the offer (goes to trial) with probability

$$\alpha = \frac{f A - K_p}{A + K_D}$$

and accepts the offer (drops the action) with probability

$$1 - \alpha = \frac{A + K_D}{A + K_D} - \frac{f A - K_p}{A + K_D}$$.

The plaintiff always accepts the offer $S_2 = f A - K_p$ (settles out of court).

(ii) The negligent defendant makes no offer (offers $S_1 = 0$) with probability

$$\beta = \frac{K_p(1 - q)}{q(f A - K_p)}$$

and offers $S_2 = f A - K_p$ with probability

$$1 - \beta = \frac{q(f A - K_p) - K_p(1 - q)}{q(f A - K_p)}$$.

The careful defendant always makes no offer (offers $S_1 = 0$).

9 These other partially separating equilibria do not allow for cases to be dropped, and therefore they do not conform to the empirical regularities on termination of lawsuits.
Plaintiff’s Beliefs. The equilibrium beliefs are as follows. If an accident occurs, the plaintiff believes with probability \(1-q\) that she is confronting a careful defendant, and with probability \(q\) that she is confronting a negligent defendant. When the plaintiff receives an offer, she updates her beliefs using Bayes’s rule: when she receives an offer \(S_1 = 0\), she believes with probability \((1-q)/(q\beta + (1-q))\) that she is confronting a careful defendant, and with probability \(q\beta/(q\beta + (1-q))\) that she is confronting a negligent defendant; when the plaintiff receives an offer \(S_2 = fA - K_P\), she believes with certainty that she is confronting a negligent defendant. The off-equilibrium beliefs are as follows: When the plaintiff receives an offer \(S'\) such that \(0 < S' < fA - K_P\) or when she receives an offer \(S' > fA - K_P\), she believes that this offer was made by a negligent defendant.

**Proof** See Appendix.

The expected payoffs for the plaintiff and for a careful and a negligent defendant are \(V_p = qfA - K_P\), \(V_{Dc} = -(fA - K_P)/(A + K_D)K_D\), and \(V_{DN} = -(fA - K_P)\), respectively.

The conditional probabilities of out-of-court settlement (acceptance of an offer \(S_2 = fA - K_P\), dropping a lawsuit (acceptance of an offer \(S_1 = 0\)), and trial (rejection of an offer \(S_1 = 0\)) are as follows. The conditional probability of out-of-court settlement is

\[
q(1 - \beta) = \frac{qfA - K_P}{fA - K_P}.
\]

The conditional probability of dropping the lawsuit is

\[
(1 - \omega)[1 - q(1 - \beta)] = \frac{[A(1 - f) + K_D + K_P]}{A + K_D} \left[ \frac{fA(1 - q)}{fA - K_P} \right],
\]

and the conditional probability of trial is

\[
\omega[1 - q(1 - \beta)] = \frac{fA(1 - q)}{A + K_D}.
\]

### 2.3 Optimization Problem of the Defendant

The defendant’s optimization problem is to choose the level of care that minimizes his total expected loss \(L = c(y, n) + \lambda(y)l\). The values of \(l\) for the negligent and the careful defendant are equal to \(-V_{DN}\) and \(-V_{Dc}\) respectively. In order to guarantee the existence of an interior solution to the defendant’s optimization problem, we assume that \(\lambda'(y) < 0\) (the probability of accident is a decreasing function of the level of care); \(\lambda''(y) > 0\) (expenditures on accident prevention exhibit diminishing marginal returns); \(\lim_{y \to +\infty} \lambda(y) = 0\) (infinitely high level of care makes the probability of accident infinitely small); and \(\lambda(0) = 1\). In addition, we assume that \(c_\epsilon(y, n) < 0\) (firms with higher \(n\) are more efficient and need to spend less to achieve a given level of care) and that \(c_\delta(y, n) > 0\) (higher levels of care require larger expenditures on safety). We also assume that \(c_\delta(y, n) > 0\) (the marginal cost of care increases with the degree of care, i.e., \(c_\delta(y, n)\) is increasing in \(y\)) and that \(c_\epsilon(y, n) < 0\)
(the marginal cost of care is greater for injurers of lower skill, i.e., \( c_i(y, n) \) is decreasing in \( n \)). For both functions \( c(\cdot) \) and \( \lambda(\cdot) \), we assume that their first and second partial derivatives are continuous functions. In addition, we assume that \( \lim_{y \to 0} \lambda(y)[(f_A - K_P)K_D/(A + K_D)] + c_i(y, n) < 0 \).

It is easy to show that under these assumptions the function \( L = c(y, n) + \lambda(y)l \) is convex and U-shaped for any positive \( n \) and any \( l \geq (f_A - K_P)K_D/(A + K_D) \). Therefore, it has a single interior minimum.

The total expected loss function \( L \) is different for each defendant’s type \( n \). \( L \) (for a given \( n \)) is defined as

\[
L = \begin{cases} 
  c(y, n) + \lambda(y)(f_A - K_P) & \text{if } y < \bar{y}, \\
  c(y, n) + \frac{\lambda(y)(f_A - K_P)}{A + K_D}K_D & \text{if } y \geq \bar{y}.
\end{cases}
\]

The total expected loss \( L \) (for a given \( n \)) is then a discontinuous function of \( y \), with discontinuity at the point \( y = \bar{y} \). \( L \) follows the function \( c(y, n) + \lambda(y)(f_A - K_P) \) until the point of discontinuity; after this point, \( L \) follows the function \( c(y, n) + \lambda(y)((f_A - K_P)/(A + K_D))K_D \). Given that \( f_A - K_P > (f_A - K_P)K_D/(A + K_D) \), the function \( L \) shifts down discontinuously at the point \( y = \bar{y} \).

Lemmas 1 and 2 (in Appendix) show that the value of \( y \) that minimizes the total expected loss function for a negligent defendant of a given type is higher than the value of \( y \) that minimizes the total expected loss function for a careful defendant of the same type. Hence, we cannot have a combined loss function with two local minima, one in the negligent range of values for \( y \) and another one in the careful range.\(^{10}\) Therefore the combined loss function can have at most one interior local minimum.\(^{11}\) Intuitively, this result means that each type of defendants chooses at most one optimal level of care.

The last technical assumption is that the difference between the cost function evaluated at the standard for gross negligence \( [c(\bar{y}, n)] \) and the minimum value of the total loss function for a negligent defendant \( [c(y(n), n) + \lambda(y(n))(f_A - K_P)] \) is strictly decreasing in \( n \). Proposition 2 summarizes the relationship between the defendant’s type and the optimal level of care.

**Proposition 2** Given \( f, \bar{y}, A, K_P, K_D \), potential defendants pertain to one of the following interval types: a low-type interval, \( n < \bar{n} \), whose members choose \( \arg \min \{c(y, n) + \lambda(y)(f_A - K_P)\} < \bar{y} \); an intermediate-type interval, \( \bar{n} \leq n \leq \bar{n} \), whose members choose \( \bar{y} \); and a high-type interval, \( n > \bar{n} \), whose members choose \( \arg \min \{c(y, n) + \lambda(y)(f_A - K_P)/(A + K_D))K_D\} > \bar{y} \).

\(^{10}\) If there is a local minimum of the combined loss function in the negligent range, then it is the minimum of the function \( c(y, n) + \lambda(y)(f_A - K_P) \). Therefore, the minimum of the function \( c(y, n) + \lambda(y)((f_A - K_P)/(A + K_D))K_D \) must be attained at a lower value of \( y \), which must also belong to the negligent range. Hence, there is no local minimum of the combined loss function in the careful range.

\(^{11}\) This result rules out multiplicity of the optimal level of care chosen by each type of defendant. It thus allows us to construct an optimal-level-of-care function in \( y(n) \).
Proposition 2 states that, in equilibrium, those defendants with relatively high cost of preventing accidents (low type) will fall below the standard for gross negligence and choose an interior solution in the negligent range of $y$. Those with low costs of preventing accidents (high type) will exceed the standard and choose an interior solution in the careful range of $y$. The intermediate-type defendants choose the corner solution at $\bar{y}$, i.e., they just meet the standard for gross negligence.

For a low-type defendant, the optimal level of care is an interior minimum of $c(y,n) + \lambda(y)(fA - K_P)$ and is lower than the negligence standard. That is, $\arg \min \{c(y,n) + \lambda(y)(fA - K_P)\} \leq \bar{y}$. The optimal level of care is increasing in $n$ until the point where the defendant of that type interval is indifferent between being negligent and just meeting the standard. This critical level of skill is denoted by $\bar{n}$ and separates the low interval and the intermediate-type interval.

The critical skill $\bar{n}$ is implicitly defined by the following condition:

$$c(y, \bar{n}) + \lambda(y)(fA - K_P) = c(\bar{y}, \bar{n}) + \lambda(\bar{y})\left(\frac{fA-K_P}{A+K_D}\right) K_D.$$

This equation states that the defendant of type $\bar{n}$ is indifferent between being negligent and exactly meeting the standard. The left-hand side of the equation represents the expected loss of the defendant if he chooses to be negligent. The right-hand side represents the expected loss for the defendant if he just meets the standard. Figure 2 shows the total expected loss function for an $\bar{n}$-type defendant.

The other critical level of skill is $\bar{n}$. It separates the intermediate interval and the high-type interval. Intermediate-type defendants with $n$ such that $\bar{n} \leq n < \bar{n}$ just meet the standard ($y = \bar{y}$), while the intermediate-type defendants of type $\bar{n}$ have the interior minimum of $c(y, n) + \lambda(y)\left(\frac{fA-K_P}{A+K_D}\right) K_D$ just at $\bar{y}$.

The critical skill $\bar{n}$ is implicitly defined by the condition stated in (6):

$$c(y, \bar{n}) + \lambda(\bar{y})\left(\frac{fA-K_P}{A+K_D}\right) K_D = 0.$$

Figure 2
Total Expected Loss Function $L$ for Firm’s Type $\bar{n}$
This condition uses the fact that \( \bar{y} \) is an interior minimum of the loss function 
\[ c(y, \bar{n}) + \lambda(\bar{y})[(fA - K_P)/(A + K_D)]K_D, \]
and hence its derivative with respect to \( y \) is equal to zero. It also takes into account the fact that the injurer of the type \( \bar{n} \) chooses a level of care equal to \( \bar{y} \).

Figure 3 shows the total expected loss function for an \( \bar{n} \)-type defendant.

The defendants pertaining to the high-type interval \( (n > \bar{n}) \) choose a higher level of care (greater than the negligence standard), which is the interior minimum of the function 
\[ c(y, n) + \lambda(y)[(fA - K_P)/(A + K_D)]K_D. \]
Specifically, for those defendants, 
\[ \text{arg min}\{c(y, n) + \lambda(y)[(fA - K_P)/(A + K_D)]K_D\} > \bar{y}. \]

The relationship between the defendant’s type and the optimal level of care is illustrated by the solid line in Figure 4.
For the low-type interval, the optimal level of care is increasing in \( n \) until the critical level of skill \( \bar{n} \). Then, the optimal-level-of-care function experiences a discontinuity, remaining constant between \( \bar{n} \) and \( n \). For high values of \( n \) (after the point \( n = \bar{n} \)), the optimal level of care is also increasing in \( n \). Note that, although higher levels of care imply lower expected litigation losses, they also imply higher expenditures on care. This second effect is stronger for defendants whose types pertain to the low and intermediate intervals. This is the reason why defendants pertaining to the low type choose a level of care lower than \( \bar{y} \). Those defendants pertaining to the intermediate interval (slightly more efficient types) will, however, choose a level of care equal to \( \bar{y} \), but not higher than that.

Intuitively, given that the defendant is choosing a level of care above the negligence standard, a reduction in its marginal cost of taking care leads to a higher level of care. Causing an accident is costly even for a nonnegligent firm, so avoiding accidents is beneficial. The level of care is set so the firm is trading off the marginal cost and the marginal benefit. Similarly, if the firm is below the negligence standard, the same type of trade-off applies. The reason for the discontinuity at the negligence standard is that the firm that is negligent bears an extra cost. Firms that would choose a level of care just below the negligence standard find themselves better off putting in the extra effort.

From Figure 3, it is clear why the optimal care schedule is discontinuous at \( \bar{n} \) and why this discontinuity is always present. The level of care that makes the negligent defendant indifferent between remaining negligent and just meeting the standard, \( y(\bar{n}) \), is smaller than \( \bar{y} \). Defendants with lower skill level \( (n < \bar{n}) \) will choose the care level \( y(n) < y(\bar{n}) < \bar{y} \). But defendants with slightly higher skill level \( (n > \bar{n}) \) will choose just to meet the care standard, \( y(n) = \bar{y} \). Therefore, at \( n = \bar{n} \) there is an upward discontinuous shift of the optimal care schedule by \( \bar{y} - y(\bar{n}) \).

Using the previous results, we can now derive the probability of accident and the probability of accident involving a careful defendant. Let \( \phi(n) \) be the probability density function of the distribution of potential injurers by type. Then the probability of an accident is \( \mu(0) = \int_{n=0}^{\bar{n}} \lambda(y(n))\phi(n)\,dn \), and the probability of an accident involving a careful defendant is given by \( \mu(\bar{n}) = \int_{n=\bar{n}}^{\infty} \lambda(y(n))\phi(n)\,dn \).

Now, we can obtain the unconditional probabilities of trial, out-of-court settlement, and dropping the case. The probability of trial conditional on occurrence of the accident is \( fA(1 - q)/(A + K_D) \); thus the unconditional probability of trial is given by \( [fA(1 - q)/(A + K_D)]\mu(0) \). Given that \( 1 - q \) is the probability that a defendant has been careful conditional on the occurrence of an accident, and that the probability of an accident involving a careful defendant is \( \mu(\bar{n}) \), then, by Bayes’s rule, \( 1 - q = \mu(\bar{n})/\mu(0) \). Hence, the unconditional probability of trial is equal to \( [fA/(A + K_D)]\mu(\bar{n}) \). Similarly, given that the probability of out-of-court settlement conditional on occurrence of the accident is equal to \( (qA - K_P)/(fA - K_P) \), then the unconditional probability of out-of-court settlement is equal to \( \mu(0) - [fA/(fA - K_P)]\mu(\bar{n}) \). Finally, given that the probability of dropping a case conditional on the occurrence of an accident is \( [(A(1 - f) + K_D + K_F)/(A + K_D)]\mu(0) \), the probability of an accident involving a careful defendant is given by \( \mu(\bar{n}) = \int_{n=\bar{n}}^{\infty} \lambda(y(n))\phi(n)\,dn \).
Split-Award Tort Reform  

3 Comparative Statics

This section evaluates the effects of a change in $f$ (plaintiff’s share of the punitive award) on the level of care, probabilities of an accident and trial, and social costs of accidents. We assume that a change in $f$ is small enough to preserve the conditions $q(A - K_F) > 0$ and $fA - K_P > K_D$, where $q = 1 - \left[ \int_{y(\bar{n})}^{\infty} \lambda(y) \phi(y) \, dy \right] / \left[ \int_{y(0)}^{y(\bar{n})} \lambda(y) \phi(y) \, dy \right].$

Proposition 3 shows that split awards affect the composition of firms by level of care and also the levels of care of low-type and high-type defendants.

PROPOSITION 3 A decrease in $f$ decreases the level of care (if the optimal level of care differs from the care standard $\bar{y}$) and increases both $n$ and $\bar{y}$.

PROOF See Appendix.

Specifically, for the low-type and the high-type defendants (for those with $n < \bar{n}$ and $n > \bar{n}$), a reduction in $f$ reduces their level of care. In addition, a reduction in $f$ increases both $n$ and $\bar{n}$: some firms that just met the standard for a higher $f$ become negligent for a lower $f$ (move from the intermediate-type interval to the low-type interval), and some careful firms that exceeded the standard for a higher $f$ reduce their level of care to the standard for a lower $f$ (move from the high-type interval to the intermediate-type interval). The intuition behind these results is as follows.

A reduction in $f$ decreases the expected loss from litigation for negligent and careful defendants. This will induce a general downward shift in the optimal schedule of care (except for the middle values of $n$). In particular, one consequence will be that fewer firms meet the standard. This effect is shown in Figure 4 (presented in the previous section), where the solid curve denotes the optimal schedule of care under a higher value of $f$ and the dotted curve shows the optimal schedule of care when $f$ is decreased.

The effects of a change in $f$ on the probability of an accident is summarized in Proposition 4.

PROPOSITION 4 A decrease in $f$ increases the probability of an accident.

PROOF See Appendix.

By assumption, the probability of an accident is negatively related to the level of care, for any $n$. We also know that if $f$ decreases, some firms diminish their level of care so that

\[ \frac{A(1 - f) + K_D}{(A + K_D)} \frac{[fA - (fA - K_P)]}{[fA/(fA - K_P)]} \mu(\bar{n}). \]
care and become negligent (move to the low-type interval) and some firms remain careful but reduce their level of care (move to the intermediate-type interval). Then, the probability of an accident for those firms increases. In addition, a lower \( f \) will generate lower levels of care for the low- and high-type interval firms and therefore increase the probability of an accident for those firms. We can then conclude that a decrease in \( f \) will increase the probability of an accident.

We proceed now to discuss the effects of split awards on the unconditional and conditional probabilities of trial. Drawing on analyses of litigation in isolation, previous studies argue that the split awards decrease the likelihood of trial. These analyses, however, overlook the indirect effect of split awards on litigation outcomes, which operates through the care taken by potential injurers. Heterogeneity in firms’ costs of preventing accidents allows us to capture the two effects of the firms’ choice of care on the outcome of litigation: through the probability of accident, and through the composition of firms involved in accidents, i.e., the shares of careful and negligent firms.

The unconditional probability of trial, \( \frac{fA}{A + K_0} \mu(n) \), is positively related to the probability of an accident involving a careful defendant, \( \mu(n) \). A decrease in \( f \) will lead some potential injurers to decrease their level of care and not to meet the standard (move from the intermediate-type interval to the low-type interval). This decrease in the number of careful defendants reduces the probability that a careful defendant will be involved in an accident. On the other hand, the decrease in \( f \) will lead potential injurers who previously met the standard at levels of care greater than \( \bar{y} \) to take less care and just meet the standard (move from the high-type interval to the intermediate-type interval), which increases the probability that a careful injurer will be involved in an accident. Thus, the net effect may be to decrease or to increase the unconditional probability of trial. For instance, in activities where most potential injurers exceed the care standard, the larger effect may be the decrease in care taken by those who previously exceeded the standard. Split awards will then increase the probability that an accident is caused by a careful injurer. Therefore, negligent firms will have a stronger incentive to mimic the behavior of careful firms and refuse to make a positive settlement offer. As a result, despite the plaintiff’s greater willingness to accept the zero offer, the likelihood of trial may be higher under split awards, a counterintuitive effect. However, in activities where the most careful firms just meet the care standard, this tort reform unambiguously reduces the unconditional probability of trial.

The effect of \( f \) on the conditional probability of trial, \( \frac{fA}{A + K_0} \mu(n) \frac{1}{\mu(0)} \), is also ambiguous. It can be explained by the ambiguous relationship between \( f \) and the unconditional probability of trial, \( \frac{fA}{A + K_0} \mu(n) \), and the negative relationship between \( f \) and the probability of an accident, \( \mu(0) \). Hence, in activities where the most careful firms just meet the care standard, this tort reform unambiguously reduces the conditional probability of trial.

Proposition 5 summarizes the condition under which the unconditional and conditional probabilities of trial and \( f \) are positively related.

Define \( n_m \) as the maximum possible value of \( n \).
PROPOSITION 5 A decrease in \( f \) decreases the unconditional and conditional probabilities of trial if \( \arg \min[c(y, n) + \lambda(y)\{(fA - KD)/(A + K_D)\} \leq \bar{y}] \).

PROOF See Appendix.

The condition \( \arg \min[c(y, n) + \lambda(y)\{(fA - KD)/(A + K_D)\} \leq \bar{y} \) implies that no firm belongs to the high type, i.e., the most efficient firms choose to just meet the care standard and not to exceed it. It is important to note that this is a sufficient, but not necessary condition for the result of Proposition 5 to hold. Even if potential injurers choose a level of care greater than \( \bar{y} \) and \( \mu(y) \) rises following a decrease in \( f \), a reduction in the first term, \( fA/(A + K_D) \) can fully offset the previous effect. So, the existence of high-efficiency type defendants does not rule out the result of Proposition 5.

The effects of \( f \) on the social costs of accidents are described next. Define the social cost of accidents, \( C_s \), as follows:

\[
C_s = \int_{n \geq 0} \left\{ c(y, n) + \lambda(y(n)) \left[ H + \frac{(\lambda(y(n))\phi(K_D + K_P))}{\lambda(y(n))\phi(A + K_P)} \right] \phi(n) \, dn, \tag{11}
\]

where \( c(y, n) \) represents the expenditures on accident prevention; \( \lambda(y(n)) \) is the probability of an accident; \( H \) represents the harm (damage) an accident causes to society, conditional on the occurrence of an accident;\(^{13} \) \( fA(1 - q)/(A + K_D) \) is the conditional probability of trial; and \( K_D + K_P \) are the resources spent on litigation when a trial occurs (litigation costs).

Given that \( \mu(0) = \int_{n \geq 0} \lambda(y(n))\phi(n) \, dn \) and \( \mu(n) = (1 - q)\mu(0) \), the social welfare loss function can be rewritten as

\[
C_s = \int_{n \geq 0} \left\{ c(y, n)\phi(n) \, dn + H \int_{n \geq 0} \lambda(y(n))\phi(n) \, dn \right.
\]
\[
+ \frac{fA(K_P + K_D)}{A + K_P} (1 - q) \int_{n \geq 0} \lambda(y(n))\phi(n) \, dn \right.
\]
\[
\left. + \mu(0) + \frac{fA}{A + K_P} \mu(n)(K_P + K_D) \right] \phi(n) \, dn. \tag{12}
\]

The first term of this expression, \( \int_{n \geq 0} c(y, n)\phi(n) \, dn \), represents the aggregate expenditures on accident prevention. A decrease in \( f \) reduces the level of care of firms of the low-type and high-type intervals and does not affect the level of care of firms of the intermediate-type interval. Therefore the aggregate expenditures on accident prevention must decrease.\(^{14} \) The second term, \( H\mu(0) \), is the unconditional expected damage that accidents cause to society. We know that a decrease in \( f \) lowers the level of care and therefore increases the probability of an accident, \( \mu(0) \). So we can conclude that a decrease in \( f \) increases the unconditional expected damage that accidents cause to society. The third term, \( [fA/(A + K_D)]\mu(0)(K_P + K_D) \), denotes

\(^{13} \) Given that we abstract from the compensatory award in the litigation analysis, we also abstract here from the direct monetary damage to the plaintiff.

\(^{14} \) By assumption, \( c_y(y, n) > 0 \).
the unconditional expected litigation costs, where \( fA/(A + KD) \mu(n) \) is the unconditional probability of trial. Remember that the effect of \( f \) on the unconditional probability of trial is in general ambiguous. Therefore, the effect of a decrease in \( f \) on the unconditional expected litigation cost is ambiguous. Hence, the effect of \( f \) on the social costs of accidents is also ambiguous. For instance, in activities where most potential injurers exceed the care standard, the likelihood of trial may be higher under split awards. Therefore, a decrease in \( f \) will increase the unconditional expected litigation cost. Hence, if the reduction in the aggregate expenditures on accident prevention is sufficiently small, or the level of the harm an accident causes to society is sufficiently high (for a particular value of \( f \)), we may expect that split awards increase the social costs of accidents. Note that, even if we rule out the high-type defendants (i.e., if the condition stated in Proposition 5 holds), the effect of a decrease in \( f \) decreases the aggregate expenditures on accident prevention, decreases the unconditional expected litigation costs (by reducing the unconditional probability of trial), but increases the unconditional expected damage that accidents cause to society.

However, under the condition stated in Proposition 6, a decrease in \( f \) unambiguously decreases the social cost of accidents and therefore increases the social welfare. Define \( T(f) \), a social-harm threshold, as follows:

\[
T(f) = \int_{n \geq 0} c_\gamma(y, n) \frac{\Delta(n)}{\partial f} \phi(n) \, dn + \frac{A(K_D + K_P) \mu(n)}{A + K_D} + \frac{fA(K_D + K_P) \Delta(n)}{A + K_D} \partial \mu(n) \partial f > 0.
\]

**PROPOSITION 6** Assume that \( \arg \min \{ c(y, n_w) + \lambda(y) [(fA - K_P)/(A + K_D)] K_D \} \leq \bar{y} \). A decrease in \( f \) decreases the social costs of accidents if and only if the social harm \( H \) is lower than the threshold \( T(f) \) for a given \( f \).

**PROOF** See Appendix.

This condition can be interpreted as follows. If the efficiency of all potential injurers in achieving a certain level of care is below the threshold \( \bar{n} \) (if there are no high-type firms) and the harm an accident causes to society is sufficiently low for a particular value of \( f \), the split-award statute unambiguously reduces the social cost of accidents. This is because the negative welfare effect of this reform (the increase in the unconditional expected damage to society) is offset by the positive welfare effect of the statute (the reduction in the unconditional expected litigation costs and the reduction in the aggregate expenditures on care).

Note that the condition stated in Propositions 5 and 6, \( \arg \min \{ c(y, n_w) + \lambda(y) [(fA - K_P)/(A + K_D)] K_D \} \leq \bar{y} \), is independent of \( q \) but has some implications for \( q \). This condition precludes the existence of a high-interval type. Then, the interval of

\[\text{Note that when } H \text{ is equal to the threshold } T(f), C_S \text{ is unaffected by a marginal change in } f \text{ (i.e., } \partial C_S/\partial f = 0).\]
defendants’ types meeting the standard will be equal to \([n, m_u]\). For a given \(n\), this implies a maximum value for the conditional probability of an accident involving a careful defendant, \(1 - q = \left(\int_{n_u}^{n} \lambda(y(n))\phi(n)dn \right) / \left(\int_{0}^{n} \lambda(y(n))\phi(n)dn \right)\), and hence a minimum value for \(q\) (the complementary probability). On the other hand, the condition stated in Proposition 1, \(q_{fA} - K_P > 0\), depends on \(q\) and implies that \(K_P / fA < q\), i.e., a minimum value for \(q\). Hence, both conditions imply a minimum value for \(q\). For sufficiently large values of \(q\), both conditions are satisfied.

4 Extensions of the Analysis

This section outlines three possible extensions to our analysis.

4.1 Effects of Split Awards in a Bilateral Care Model

Consider a bilateral care framework. Specifically, suppose that the probability of an accident depends negatively on the levels of care of plaintiff and defendant, and that the plaintiff’s level of care depends negatively on his expected litigation payoff.\(^{16}\) Given that split awards reduce the plaintiff’s expected litigation payoff, we should expect a lower plaintiff’s level of care. Hence, the effects of split awards on the probability of an accident will be stronger than those observed in the unilateral care model. In the litigation stage, we should expect that defendants randomize between offering high and low proposals, while plaintiffs randomize between accepting and rejecting a low proposal. Given that split awards reduce the plaintiff’s expected payoff at trial, we still expect that plaintiffs will be willing to accept lower out-of-court settlement offers under the split-award statute. Hence, the direction of the effect of split awards on the likelihood of trial will be the same as in the unilateral care model.

4.2 Effects of Split Awards in a Model that Includes Filing

Consider now a model with a continuum of types of plaintiffs, who differ in their opportunity cost of time. This cost, independent of the defendant’s level of care, captures the effect of personal characteristics of plaintiffs that influence the decision to file a lawsuit. Assume that the decision of filing a lawsuit depends on this opportunity cost and on the expected gains at trial for the plaintiff. The lower expected gains for the plaintiff under split awards depends on this opportunity cost and on the expected gains at trial for the plaintiff. The lower level of care under the split award generates a higher likelihood that a plaintiff confronts a negligent defendant, and therefore,

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\(^{16}\) This last assumption can be justified in a scenario where taking care is costly for the plaintiff. Note also that only the defendant’s level of care is relevant for the court’s decision of awarding punitive damages (i.e., the court’s decision depends on whether the defendant was grossly negligent or not and is independent of the plaintiff’s level of care). Thus, the level of care of the plaintiff will not influence the likelihood that the plaintiff gets an award.
a higher likelihood that the plaintiff suceeds at trial. This effect increases the incentives to file a lawsuit. Hence, the effect of split awards on filing is in general ambiguous. As a consequence, the effects of split awards on the defendant’s level of care will be also ambiguous. In the litigation stage, we should expect that defendants randomize between offering high and low proposals, while plaintiffs randomize and between accepting and rejecting a low proposal. The direction of the effect of split awards on the likelihood of disputes in a model that includes the filing decision should be the same as in the original model.

4.3 Effects of Split Awards in a Model with an Endogenous Award

Consider a model with an endogenous award. The award can be endogenous in the case, for example, of prior knowledge about the statute by a member of the jury. As a consequence, the determination of the award might be influenced by $f$. We can expect that the presence of split awards will generate an increase of the award: knowing that the plaintiff receives only a part of the award, a plaintiff-sympathetic jury will increase the size of the award to “compensate” the plaintiff for the share of punitive damages that goes to the state. A second source of endogeneity of the award can arise from the interest of the state in using the split-award statute as a means of revenue collection. As a consequence, split awards might influence the size of the award. In that case, we should also expect an increase in the size of the award under split awards.

Hence, under these two scenarios of endogenous awards we should expect that a reduction in $f$, i.e., the introduction of the split-award statute, might increase the size of the award. Denote the endogenous award by $A_f$. If $fA_f$ is lower (under split awards) than $A$ (the award in the case of no split award), then the direction of the effects of split awards on the likelihood of disputes and level of care will be the same as in the original model, although the magnitude might be smaller: split awards will reduce the conditional probability of trial and reduce the expected losses for both the careful and the negligent defendants. This last result, in turn, implies that the expected loss from litigation will be lower for both types of defendants, and the optimal level of care will go down for most defendants (it will not change for some of the defendants who just meet the standard). Therefore, the probability of an accident will be higher under the split-award statute.

5 Conclusions

This research contributes to the economic analysis of tort reforms by constructing a model that incorporates the effect of the split-award statute on liability and litigation. Our model allows for heterogeneity in firms’ costs of preventing accidents, and therefore captures the two ways that the firms’ choice of care may affect the outcomes of litigation: through the probability of accident, and through the composition of firms involved in accidents, i.e., the shares of careful and negligent injurers.
We find that split awards reduce the firm’s expected litigation loss, and therefore lower the aggregate level of care. More importantly, this tort reform not only increases the probability of accidents but also changes the composition of injurers. As a consequence of this change in the composition of injurers, the effects of split awards on the likelihood of trial and the social costs of accidents are in general ambiguous. We derive conditions under which a decrease in the plaintiff’s share of the punitive damage award unambiguously reduces the probability of trial and the social cost of accidents.

Our analysis has several policy implications. First, it shows that the effects of split awards are more ambiguous than one might expect, and that this ambiguity may hinder their use as an effective policy tool. Second, this analysis points to the significance of the strategic behavior of plaintiffs and defendants for the analysis of the effects of this tort reform on the firm’s choice of level of care, and underlines the importance of the composition of injurers for the likelihood of trial. In activities where many potential injurers exceed the care standard, the likelihood of trial may be higher under split awards, a counterintuitive effect. This effect, combined with the reduction in the level of care, might allow the state to collect substantial revenue. However, if the social harm that an accident causes is sufficiently high, these funds will be collected at the expense of a welfare loss.

Appendix: Proofs

Proofs of Proposition 1, Lemmas 1 and 2, and Propositions 2–6 follow.

A.1 Proof of Proposition 1

A.1.1 Existence of Perfect Bayesian Equilibria of the Litigation Game

(1) We eliminate the dominated and iteratively dominated strategies for each player. Rationality suggests that since the plaintiff can get at most \( fA - KP \) at trial, he should accept any pretrial offer over \( fA - KP \), and that, given that the plaintiff can drop the case and lose nothing, he should reject any pretrial offer \( S < 0 \). Because the plaintiff accepts all offers over \( fA - KP \), any strategy in which the defendant offers more than \( fA - KP \) when she is negligent is iteratively dominated by a strategy in which she offers exactly \( fA - KP \). Rationality also tells us that the defendant will offer no more than \( KD \) if she is careful. Finally, because the plaintiff rejects all offers below zero, any strategy in which the defendant offers less than zero is iteratively dominated by a strategy in which she offers exactly zero. Thus, the minimum possible offer is \( S = 0 \) and represents the defendant’s refusal to settle. Hence, we can restrict our attention to the offer space \( [0, fA - KP] \) for the negligent defendant, and to the offer space \( [0, KD] \) for the careful defendant.

Apply iterative elimination of dominated strategies again. Because the careful defendant never offers more than \( KD \) and because the plaintiff can get \( fA - KP \) at trial, rationality suggests that the plaintiff should reject any pretrial offer greater
than $K_D$ and less than $fA - K_F$, because such an offer can be made by a negligent
defendant only, who reveals his type. Rationality also tells us that the negligent
defendant will not make any offer greater than $K_D$ and less than $fA - K_F$, because
it will always be rejected. Thus, the offer space for a negligent defendant gets
reduced to $[0, K_D] \cup \{ fA - K_F \}$.

(2) We prove that in equilibrium the negligent defendant randomizes at most between
two possible strategies. It suffices to show that there is no more than one equilibrium
offer $S_1 \in [0, K_D]$.

First, we show that there is no equilibrium offer in this interval that is proposed
by the negligent defendant only. If such an equilibrium offer $\tilde{S}$ existed, the plaintiff
would reject it with probability 1. Hence the case would be resolved at trial, and the
negligent defendant would lose $A + K_D$. He is better off offering $fA - K_F$, which
is accepted with certainty.

Second, we show that there are no two distinct equilibrium proposals proposed
by both types of defendant. We prove it by contradiction. Assume that there exist
two such offers, $S_1$ and $S_2$, such that $0 \leq S_1 < S_2 \leq K_D$. Denote by $p_1$ and $p_2$ the
respective equilibrium probabilities of acceptance of these proposals by the plaintiff.
Each type of defendant is indifferent between these proposals. Hence

\[(A1) \quad S_1 p_1 + (1 - p_1) K_D = S_2 p_2 + (1 - p_2) K_D \]

and

\[(A2) \quad S_1 p_1 + (1 - p_1)(A + K_D) = S_2 p_2 + (1 - p_2)(A + K_D) \]

Subtracting the first equation from the second one, we get

\[(A3) \quad (1 - p_1) A = (1 - p_2) A \]

Hence, $p_1 = p_2$. But in that case defendants of both types are strictly better off
offering $S_1$. Contradiction follows.

(3) We show that under the conditions $q fA - K_F > 0$ and $fA - K_F > K_D$, there
are infinitely many partially separating equilibria (one of them is the one stated in
Proposition 1) and infinitely many pooling equilibria.

(a) Existence of Partially Separating Equilibria. The description of the partially
separating equilibria is as follows. If $q fA - K_F > 0$ and $fA - K_F > K_D$, then (1)
careful defendants offer $S_1$ such that $0 \leq S_1 \leq K_D$, and negligent defendants mix
the two strategies – offer $S_1$ such that $0 \leq S_1 \leq K_D$ with probability $\tilde{\beta}$, and offer
$S_2 = fA - K_F$ with probability $(1 - \tilde{\beta})$; (2) plaintiffs always file a lawsuit; plaintiffs
always accept\(^{17}\) $S_2$ and mix rejection (with probability $\tilde{\alpha}$) and acceptance (with
probability $1 - \tilde{\alpha}$) when the offer is $S_1$. Note that because the plaintiff accepts some
of the offers of $S_1$, a negligent defendant has an incentive to mimic the behavior of
the careful defendant and offer $S_1$ as well.

\(^{17}\) A defendant offering $S_2$ reveals his type, and hence $S_2$ should be equal to
$fA - K_F$ to be always accepted.
Consider the expected payoffs for the plaintiff and the careful and negligent defendants, in terms of $\bar{\alpha}$ and $\bar{\beta}$. The expected payoff for the plaintiff, $V_P$, is
\begin{equation}
V_P = (1 - q)[\bar{\alpha}(-K_P) + (1 - \bar{\alpha})S_1] + q[\bar{\beta}(fA - K_P) + (1 - \bar{\alpha})S_1] + (1 - \bar{\beta})(fA - K_P)].
\end{equation}

The expected payoff for the careful defendant, $V_{DC}$, is
\begin{equation}
V_{DC} = \bar{\alpha}(-K_D) + (1 - \bar{\alpha})S_1,
\end{equation}
and the expected payoff for the negligent defendant, $V_{DN}$, is
\begin{equation}
V_{DN} = \bar{\beta}[\bar{\alpha}(-(A + K_D)) + (1 - \bar{\alpha})S_1] + (1 - \bar{\beta})[-(fA - K_P)].
\end{equation}

The values of $\bar{\alpha}$ and $\bar{\beta}$ are calculated from the condition that both parties (the plaintiff and the negligent defendant) have to be indifferent between their strategies to mix them. So,
\begin{equation}
fA - K_P = \bar{\alpha}(A + K_D) + (1 - \bar{\alpha})S_1
\end{equation}
and
\begin{equation}
S_1 = \frac{q\bar{\beta}}{q\bar{\beta} + (1 - q)}(fA - K_P) + \frac{1 - q\bar{\beta}}{q\bar{\beta} + (1 - q)}(-K_P).
\end{equation}

Equation (A4) says that a negligent defendant is indifferent between admitting his negligence (i.e., offering $S_1 = fA - K_P$) and stating that he is careful (i.e., offering $S_1$) with the risk of losing $A + K_D$ if the case goes to court. Equation (A5) says that a plaintiff is indifferent between dropping the case and getting a payoff of $S_1$, and going to court. Solving (A4) for $\bar{\alpha}$ and (A5) for $\bar{\beta}$, we get $\bar{\alpha} = (fA - K_P - S_1)/(A + K_D - S_1)$ and $\bar{\beta} = [(S_1 + K_P)(1 - q)]/q(fA - S_1 - K_P)].$\(^{18}\)

Then, the expected payoffs for the plaintiff and the careful and negligent defendants are $V_P = qfA - K_P$, $V_{DC} = -S_1[(1 - f)A + K_P] + (fA - K_P)K_D]/(A + K_D - S_1)$, and $V_{DN} = -(fA - K_P)$, respectively.

The equilibrium beliefs are as follows. If an accident occurs, the plaintiff believes with probability $1 - q$ that she is confronting a careful defendant, and with probability $q$ that she is confronting a negligent defendant. When the plaintiff receives an offer, she updates her beliefs using Bayes’s rule: When she receives an offer $S_1$, she believes with probability $(1 - q)/[q\bar{\beta} + (1 - q)]$ that she is confronting a careful defendant, and with probability $q\bar{\beta}/[q\bar{\beta} + (1 - q)]$ that she is confronting a negligent defendant; when the plaintiff receives an offer $S_1$, she believes with certainty that she is confronting a negligent defendant. The off-equilibrium beliefs are as follows. When the plaintiff observes an offer $S < S_1$ or an offer $S_1 < S < fA - K_P$, she believes that she faces a negligent defendant. Then, the plaintiff rejects the offer with certainty because she will obtain a higher payoff $(fA - K_P)$ if she brings the negligent defendant to trial. Given that $S$ is rejected with certainty, the careful defendant will not make the offer $S$, because he will receive a higher payoff by offering $S_1$, which is accepted with positive probability in the proposed equilibrium.

\(^{18}\) Note that $\bar{\alpha}(S_1 = 0) = \alpha$ and $\bar{\beta}(S_1 = 0) = \beta$, i.e., the equilibrium path just described corresponds to the partially separating perfect Bayesian equilibrium stated in Proposition 1.
Given that the plaintiff will reject the offer \( S' \) with certainty, the negligent defendant will not make an offer \( S \), because he will receive a higher payoff by offering \( S_2 = fA - K_p \) with probability \( 1 - \beta \) and \( S_1 \) with probability \( \beta \) (as stated in the proposed equilibrium).

Note also that \( V_p = qfA - K_p > 0 \). Therefore, plaintiffs file a suit with probability one.

(b) Existence of Pooling Equilibria. The description of the pooling equilibria is as follows. If \( qfA - K_p > 0 \) and \( fA - K_p > K_D \): (1) negligent and careful defendants offer the same amount \( S \), where \( 0 < S \leq K_D \) and \( S \geq qfA - K_p \); (2) plaintiffs always file a lawsuit; plaintiffs always accept the offer \( S \). If \( S \) fails to hold, the careful defendant will find it optimal to deviate, offer \( 0 \), and go to trial; if \( S \) fails to hold, the plaintiff will find it profitable to deviate and reject the proposal \( S \).

Note also that there is no possible pooling with \( S = 0 \) and the plaintiff accepting the offer with certainty: If every defendant offers \( S = 0 \), then the plaintiff will be better off by rejecting the offer, because \( qfA - K_p > 0 \), i.e., her ex ante expected payoff from going to trial is greater than the offer. Then, it would be optimal for the negligent defendant to deviate from offering \( S = 0 \) to \( S = fA - K_p < A + K_D \) (loss at trial).

The equilibrium beliefs are as follows. If an accident occurs, the plaintiff believes with probability \( 1 - q \) that she is confronting a careful defendant, and with probability \( q \) that she is confronting a negligent defendant. Given that defendants pool, when the plaintiff receives an offer, she cannot update her beliefs. Then, the plaintiff accepts if the offer is greater than or equal to her ex ante expected return from trial \( S \geq qfA - K_p \).\(^{19}\) The off-equilibrium beliefs compatible with this equilibrium are as follows. If the defendant offers \( \tilde{S} \neq S \), then the plaintiff believes with certainty that he faces the negligent defendant, and rejects the offer.

A.1.2 Uniqueness of the Litigation-Stage Equilibrium

It is easy to show that the other partially separating equilibria and the pooling equilibria do not survive the universal divinity refinement.\(^{20}\) Hence, the partially separating PBE stated in Proposition 1 is the unique universally divine PBE of the litigation stage.

Q.E.D.

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\(^{19}\) The plaintiff computes the ex ante return from trial by using her prior beliefs and the payoffs at trial from confronting negligent and careful defendants. So the ex ante return from trial is \( q(fA - K_p) + (1 - q)(-K_D) = qfA - K_p \).

\(^{20}\) Following BANKS AND SOBEL [1987], the implementation of the universal divinity refinement proceeds as follows. First, we find (for careful and for negligent defendants) the minimum probability of acceptance (by the plaintiff) of an offer that differs from the equilibrium offers (deviation offer), such that the defendant is willing to deviate. Second, we compare these minimum probabilities. The defendant with the lower minimum probability will be the one the plaintiff should expect (with probability one) to deviate.
LEMMA 1 For any positive value of $l$, the value of $y$ that minimizes the function $c(y, n) + \lambda(y)l$ is increasing in $l$.

Proof Given the assumptions about the functions $c(n, y)$ and $\lambda(y)$, the function $c(y, n) + \lambda(y)l$ is convex, and it has a single minimum point, which is characterized by the first-order condition

$$\frac{\partial}{\partial y} c(y, n) + \lambda(y)l = 0,$$

Totally differentiating this first-order condition yields

$$[c_{yy}(y, n) + \lambda''(y)]dy = -\lambda'(y)dl.$$

The last equation can be rewritten as

$$\frac{dy}{dl} = -\frac{\lambda'(y)}{c_{yy}(y, n) + \lambda''(y)} > 0.$$

This inequality holds because both second derivatives, $c_{yy}(y, n)$ and $\lambda''(y)$, are positive, $\lambda'(y) < 0$, and $l \geq (fA - K_F)K_D/(A + K_D) > 0$ by assumption.

LEMMA 2 For all $n$, the value of $y$ that minimizes the function $c(y, n) + \lambda(y)(fA - K_F)$ is larger than the value of $y$ that minimizes the function $c(y, n) + \lambda(y)((fA - K_F)K_D/(A + K_D))$.

Proof $(fA - K_F)K_D/(A + K_D) < fA - K_F$. Hence the lemma is a direct application of Lemma 1.

A.2 Proof of Proposition 2

(1) We prove that the value of $y$ that minimizes the function $c(y, n) + \lambda(y)l$ is increasing in $n$. Totally differentiating the first-order condition yields

$$c_{yy}(y, n) dy + c_{yn}(y, n) dn + \lambda''(y)l dy = 0.$$

The last equation can be rewritten as

$$\frac{dy}{dn} = -\frac{c_{yn}(y, n)}{c_{yy}(y, n) + \lambda''(y)l} > 0.$$

The last inequality follows from the assumption $c_{yn}(y, n) < 0$.

(2) We prove that for any $\tilde{y}, \bar{y}$ is unique. Let the “negligent” segment of the total loss function be $L_N$ and its “careful” segment be $L_C$. Define $L_N$ and $L_C$ as follows: $L_N = c(y, n) + \lambda(y)(fA - K_F)$ and $L_C = c(y, n) + \lambda(y)((fA - K_F)K_D/(A + K_D))K_D$, Let $y^*$ be the level of care at which $L_N$ is minimized.

We will proceed to compare three values of the total loss function. We define $L_N^* = c(y^*, n) + \lambda(y^*)(fA - K_F)$ as the interior minimum value for the “negligent” segment of the total loss function $L$.

\[21\] Given that $y^*$ is the value that minimizes the “negligent” segment of the total loss function $L$, $L_N^*$ is defined as the value of the “negligent” segment of the total loss function $L$ that corresponds to $y = y^*$. 
the value of the “negligent” segment of the total loss function \( L \) that corresponds to \( y = \bar{y} \). Define \( L^1_N = c(\bar{y}, n) + \lambda(\bar{y})(fA - K_P)/(A + K_D)K_D \) as the value of the “careful” segment of the total loss function \( L \) that corresponds to \( y = \bar{y} \). We will show uniqueness by comparing \( L^1_N - L^1_N \) and \( L^1_N - L^1_N \), respectively. We first show that \( L^1_N - L^1_N \) does not depend on \( n \). Second, we show that \( L^1_N - L^1_N \) is decreasing in \( n \) and eventually falls to zero. We then conclude that there exists exactly one value of \( n \), denoted by \( \bar{n} \), such that \( L^1_N - L^1_N = L^1_N - L^1_N \), and hence equation (5) is satisfied.

(a) We have
\[
L^1_N - L^1_N = c(\bar{y}, n) + \lambda(\bar{y})(fA - K_P) - c(y^*(n), n) - \lambda(y^*(n))(fA - K_P).
\]
(A14)

The last expression does not depend on \( n \).

(b) We have
\[
L^1_N - L^1_N = c(\bar{y}, n) + \lambda(\bar{y})(fA - K_P) - c(y^*(n), n) - \lambda(y^*(n))(fA - K_P).
\]
(A15)

The second term \( \lambda(y^*(n))(fA - K_P) \) does not depend on \( n \). The difference between the first and the third term, \( c(\bar{y}, n) - c(y^*(n), n) \), is decreasing in \( n \).22 However, the last term \(-\lambda(y^*(n))(fA - K_P)\) is increasing in \( n \), because \( \lambda'(y) < 0 \).

By assumption, \( c(\bar{y}, n) - c(y^*(n), n) - \lambda(y^*(n))(fA - K_P) \) is decreasing in \( n \). Then \( L^1_N - L^1_N \) will be monotonically decreasing in \( n \) and will fall to zero when \( y^* = \bar{y} \). Hence, at exactly one value of \( n \), denoted by \( \bar{n} \), we have \( L^1_N - L^1_N = L^1_N - L^1_N \). At this \( \bar{n} \), equation (5) is satisfied.

(3) We prove that, for any \( \bar{y} \), \( \bar{n} < \bar{n} \). By construction of \( \bar{n} \), the value of \( y \) that minimizes \( c(y, n) + \lambda(y)(fA - K_P) \) is less than \( \bar{y} \). Also, by the definition of \( \bar{n} \), arg \( \min(c(y, \bar{n}) + \lambda(y)(fA - K_P)K_D/(A + K_D)) \) = \( \bar{y} \). Therefore,
\[
\text{arg min} \left[ c(y, n) + \lambda(y)\frac{(fA - K_P)K_D}{A + K_D} \right] < \bar{y} = \text{arg min} \left[ c(y, \bar{n}) + \lambda(y)\frac{(fA - K_P)K_D}{A + K_D} \right].
\]
(A16)

By part (1), it follows that \( \bar{n} < \bar{n} \).

(4) We prove that, for firms with \( n < \bar{n} \), the optimal level of care \( y < \bar{y} \), and for firms with \( n \geq \bar{n} \), the optimal level of care \( y \geq \bar{y} \). Consider the following auxiliary function:
\[
\Phi(n) = [L_N(n, \bar{y}) - \min[L_N(n, y)]] - [L_N(n, \bar{y}) - L_C(n, \bar{y})].
\]
(A17)

22 This can be shown as follows: Let \( F(n) = c(\bar{y}, n) - c(y^*(n), n) \). Then, \( F'(n) = c_y(\bar{y}, n) - c_y(y^*(n), n) - c_y(y^*(n), n)dy^*/dn = c_{yn}(\bar{y}, n)(\bar{y} - y^*) - c_y(y^*(n), n)dy^*/dn < 0 \), where \( \bar{y} \in (y^*, \bar{y}) \). The expression is negative, because \( c_{yn} < 0 \) by assumption, \( \bar{y} > y^* \), \( c_y > 0 \) by assumption, and \( dy^*/dn > 0 \) by Lemma 1.
(2006)  

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It is more costly for the firm to satisfy the negligence standard than to be negligent at the minimum point $y^*$ of the function $L_N(n, y)$ if and only if the function $\Phi(n)$ attains a positive value. Notice that the second part of the function $\Phi$,

$$[L_N(n, \bar{y}) - L_C(n, \bar{y})] = [c(\bar{y}, n) + \lambda(\bar{y})(fA - KP)] - [c(\bar{y}, n) + \lambda(\bar{y})\frac{(fA - KP)}{A + KD}]$$

(A18)

is independent of $n$. The first part,

$$\frac{\partial y}{\partial f} = -A\lambda'(\bar{y})$$

(A19)

$$\{L_N(n, \bar{y}) - \min[L_N(n, y)]\} = L_N(n, \bar{y}) - L_N(n, y^*(n))$$

depends negatively on $n$, because the difference between $y^*$ and $\bar{y}$ shrinks as $n$ rises (see Lemma 3), and the function $L_N(n, y)$ is flatter for larger values of $n$. The last claim follows from the assumption $c_{ny} < 0$.

By definition of $n$, the firm of the type $n$ is indifferent between just meeting the standard and being negligent at $y^*$. Therefore, the point $n$ is the root of the function $\Phi(n)$. Hence for $n < n$, we have $\Phi(n) > 0$, and the firms find it optimal to be negligent. For $n \geq n$, we have $\Phi(n) \leq 0$, and the firms find it optimal to be careful.

(5) We prove that for firms with $n \leq n$ the optimal level of care $y \leq \bar{y}$, and for firms

with $n > n$ the optimal level of care $y > \bar{y}$. The proof follows from the definition of $n$, $\bar{y}$ is the interior minimum of the function $L_C(n, y)$. By part (1), for $n > n$, the function $L_C(n, y)$ attains its minimum to the right of $\bar{y}$, i.e., $y^* > \bar{y}$. Then, this interior minimum is the optimal level of care for the firm of that type ($L_C(n, y) < L_N(n, y)$ for any $y$, and hence it cannot be optimal for the firm to be negligent). On the other hand, for $n < n$, the function $L_C(n, y)$ attains its minimum to the left of $\bar{y}$. $L_C(n, y)$ is an increasing function of $y$ for $y \geq \bar{y}$ and $n \leq n$. Thus, the firms of these types will at most just meet the negligence standard.

Hence, potential defendants pertain to one of the following interval types: a low-type interval, $n < n$, whose members choose $\arg\min[c(y, n) + \lambda(y)(fA - KP)] < \bar{y}$; an intermediate-type interval, $n \leq n < n$, whose members choose $\bar{y}$; and a high-type interval, $n > n$, whose members choose $\arg\min[c(y, n) + \lambda(y)](fA - KP)/(A + KD)[K_D] > \bar{y}$.

Q.E.D.

A.3 Proof of Proposition 3

(1) We prove that $f$ and the optimal level of care are negatively related if the optimal level of care differs from $\bar{y}$. Consider the case when the firm is negligent. Evaluating (A9) at $l = fA - KP$ and totally differentiating it yields

$$c_{yy}(y, n) dy + \lambda''(y)[fA - KP] \frac{dy}{df} + \lambda'(y)A df = 0.$$  

(A20)

Rearranging terms,

$$\frac{\partial y}{\partial f} = -\frac{A\lambda'(y)}{c_{yy}(y, n) + \lambda''(y)fA - KP} > 0.$$  

(A21)
The case when the firm is careful can be proven in exactly the same way.

(2) We show that the plaintiff’s share of the punitive award \( f \) and \( n \) are negatively related. Let \( \bar{y} \) be the optimal level of care that the firm with \( n = \bar{n} \) chooses if it prefers to be negligent (the firm is indifferent between choosing \( y \) and \( \bar{y} \)). Consider the following equations:

\[
(A22) \quad c_n(\bar{y}, \bar{n}) + \lambda'(\bar{y})[A f - K_P] = 0
\]

and

\[
(A23) \quad c_n(\bar{y}, \bar{n}) + \lambda(\bar{y})[A f - K_P] = \bar{c}(\bar{y}, \bar{n}) + \lambda(\bar{y})\frac{A f - K_P}{A + K_D} K_D,
\]

which implicitly define \( \bar{n} \) and \( \bar{y} \). Totally differentiating equation (A23), one gets

\[
(A24) \quad c_n(\bar{y}, \bar{n}) \frac{\partial y}{\partial f} + c_n(\bar{y}, \bar{n}) \frac{df}{df} A d f + \lambda(\bar{y}) A d f + \lambda'(\bar{y})[A f - K_P] \frac{df}{df} = c_n(\bar{y}, \bar{n}) \frac{df}{df} A K_D \frac{K_D}{A + K_D} df.
\]

By (A22), the first and the last terms of the left-hand side of (A24) add up to zero. Hence,

\[
(A25) \quad \left[\lambda(\bar{y}) - \lambda(\bar{y})\frac{K_D}{A + K_D}\right] A d f = (c_n(\bar{y}, \bar{n}) - c_n(\bar{y}, \bar{n})) \frac{df}{df} = c_n(\bar{y}, \bar{n})(\bar{y} - y) \frac{df}{df}.
\]

The last transformation is a straightforward application of the mean-value theorem, and \( \bar{y} \) is a point of the interval \( (y, \bar{y}) \). Now \( [\lambda(\bar{y}) - \lambda(\bar{y})\frac{K_D}{A + K_D}] A \) is positive, because the function \( \lambda(y) \) is monotonically decreasing in \( y \) and \( K_D/(A + K_D) < 1 \); and \( c_n(\bar{y}, \bar{n})(\bar{y} - y) \) is negative, because \( c_n < 0 \) by assumption, and \( y < \bar{y} \). Therefore \( \frac{df}{df} < 0 \).

(3) We prove that the plaintiff’s share of the punitive award \( f \) and \( \bar{n} \) are negatively related. Totally differentiating the equation \( c_n(\bar{y}, \bar{n}) + \lambda'(\bar{y})[(fA - K_P)/(A + K_D)] K_D = 0 \), we obtain

\[
(A26) \quad c_m(\bar{y}, \bar{n}) \frac{df}{df} = -\frac{c_m(\bar{y}, \bar{n})}{\lambda'(\bar{y}) A K_D} A \frac{df}{df} = 0.
\]

Therefore,

\[
(A27) \quad \frac{df}{df} = -\frac{c_m(\bar{y}, \bar{n})}{\lambda'(\bar{y}) A K_D} < 0,
\]

because \( c_m < 0 \) and \( \lambda'(\bar{y}) < 0 \). \( Q.E.D. \)

A.4 Proof of Proposition 4

Given that the probability of an accident is \( \mu(0) = \int_{y=0}^{\infty} \lambda[y(n)] \phi(n) \, dn \), we have

\[
(A28) \quad \frac{\partial \mu(0)}{\partial f} = \int_{y=0}^{\infty} \lambda[y(n)] \frac{\partial \phi(n)}{\partial f} \, dn < 0,
\]

because \( \frac{\partial \phi(n)}{\partial f} \geq 0 \) for any \( n \) and \( \lambda'[y(n)] < 0 \) for any \( n \). \( Q.E.D. \)
A.5 Proof of Proposition 5

The unconditional probability of trial is equal to \( \{fA/(A + KD)\} \mu(n) \). The first term, \( fA/(A + KD) \), depends positively on \( f \). The second term is equal to

\[
(A29) \quad \mu(n) = \int_n^{\infty} \lambda(y(n))\Phi(n) \, dn = \lambda(\bar{y}) \int_n^{\infty} \phi(n) \, dn = \lambda(\bar{y})(1 - \Phi(n)),
\]

where \( \Phi(n) \) is the cumulative density function of the distribution of \( n \). By Proposition 3, \( \partial q/\partial f < 0 \). Therefore, \( \partial \Phi(n)/\partial f < 0 \). Hence a decrease in \( f \) decreases \( \mu(n) \).

The conditional probability of trial on accident occurrence is equal to \( fA(1 - q)/(A + KD) = [fA/(A + KD)]\mu(n)[1/\mu(0)] \), i.e., the unconditional probability of trial divided by the probability of an accident. A reduction in \( f \) decreases the unconditional probability of trial and increases the probability of accident, \( \mu(0) \).

Q.E.D.

A.6 Proof of Proposition 6

Differentiating \( C_S \) (from (9)) with respect to \( f \), we obtain

\[
(A30) \quad \frac{\partial C_S}{\partial f} = \int_{A > 0} c_S(y, n) \frac{\partial \mu(n)}{\partial f} \phi(n) \, dn + H \frac{\partial \mu(0)}{\partial f} + \frac{\lambda(KP + KA)}{A + KD} \mu(n) + \frac{\lambda(KP + KA)}{A + KD} \frac{\partial \mu(n)}{\partial f},
\]

where \( \partial \mu(n)/\partial f > 0 \), \( \partial \mu(0)/\partial f < 0 \) and \( \partial \mu(0)/\partial f > 0 \). We have \( \partial C_S/\partial f > 0 \) if and only if

\[
H < T(f) \equiv \int_{A > 0} c_S(y, n) \frac{\partial \mu(n)}{\partial f} \phi(n) \, dn + \frac{\lambda(KP + KA)}{A + KD} \mu(n) + \frac{\lambda(KP + KA)}{A + KD} \frac{\partial \mu(n)}{\partial f} \frac{\partial \mu(0)}{\partial f} > 0,
\]

Q.E.D.

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