Split-Award Tort Reform, Firm's Level of Care, and Litigation Outcomes[*]

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Abstract

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. 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.

KEYWORDS: Settlement; Bargaining; Litigation; Asymmetric Information
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1 Introduction

There is a common perception that excessive punitive damage awards[1] have contributed to the escalation of liability insurance premiums[2] and have generated excessive financial burden on firms.[3] This perception, combined with the Supreme Court adjudications, 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,[4] Georgia, Illinois, Indiana, Iowa, Missouri, Oregon, and Utah.[5] In addition, New Jersey and Texas have contemplated, but not yet adopted, split-award statutes (White, 2002).

Split-awards may affect litigation outcomes and liability. Given that split-awards reduce the plaintiff's award in case of trial but do not affect the defendant's[6] payment at trial, these statutes generate an incentive for both parties to settle out of court and induce the plaintiff to accept a lower settlement offer.[7] Then, split-awards reduce the firm's expected litigation loss and therefore, influence its expenditures on accident prevention (firm's level of care) and the probability of accidents. In addition, the lower plaintiff's expected compensation under split-awards reduces the plaintiff's windfall and affect the incentives to file a lawsuit.[8] As a consequence, the firm's expected

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[1]Justice O'Connor stated that punitive damage awards had "skyrocketed" more than 30 times in the previous ten years, with an increase in the highest award from \$250,000 to \$10,000,000 (Browning-Ferris Indus., Inc. v. Kelco Disposal, Inc., 492 U.S. 257, 282, 1989).

[2]Note that liability coverage is widely spread in the United States. In 1990, the total tort liability payments were approximately \$65 billion (more than 1% of the U.S. GDP), of which 93.5% were made by liability insurers (O' Connell, 1994).

[3]Karpoff and Lott (1999) find that announcements of lawsuits seeking punitive damages caused losses in market capitalization of listed companies' shares that, on average, exceeded the eventual settlement. They attribute this effect to lawyers fees and lasting damage to corporate reputations.

[4]On August 16, 2004, Governor Arnold Schwarzenegger signed the state budget legislation SB 1102 as an "urgency" matter, i.e., becoming effective immediately instead of January the 1st of next year. The SB 1102 provided that 75 percent of all punitive damages were payable to the state, i.e., split-awards were enacted in that legislation (Metropolitan News Enterprise; August 18, 2004). Given that California has approximately 10 percent of the U.S. population, the effects of this statute may have a great impact on the U.S. tort system.

[5]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. For details, see Dodson (2000), Epstein (1994), Stevens (1994), Sloane (1993).

[6]We will use the terms firm, defendant and potential injurer interchangeably.

[7]Given that the plaintiff's payoff at trial is lower under the split-award, she is more willing to accept lower offers.

[8]The "plaintiff's windfall" refers to any amount in excess of the costs of pursuing the punitive claim. Commentators

litigation loss and its level of care will be further influenced.[9]

Previous studies of the split-award tort reform, however, have focused only on its effects on litigation outcomes. This paper extends those studies by investigating the effects of this reform on litigation outcomes and the firm's level of care under a standard for gross negligence.[10] We construct a strategic model of liability and litigation, that allows for heterogeneity in firms' costs of preventing accidents and therefore, permits to study firm's decision about the level of care.[11]

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 pre-trial negotiation between two Bayesian risk-neutral parties, an uninformed plaintiff and an informed defendant,[12] starts. It is modeled as a signaling-ultimatum game.

We build upon Png's (1987) theoretical framework, developed to study the effects of changes in the court award, negligence standard and the allocation of litigation costs (from the American to the English rule)[13] on liability and litigation.[14] We extend Png's 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

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claim that this windfall promotes unnecessary litigation (Dodson, 2000).

[9]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 the split-award statute. However, the split-award reform does not involve an increase in the award paid by the defendant.

Choi and Sanchirico (2003) 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.

[10]In real-world settings, punitive damages are awarded only in cases where the defendant is found grossly negligent. This implies that a due care standard is applied.

[11]Spier (1997) also uses a framework that combines liability and litigation to study the divergence between the private and social motive to settle under a negligence rule. 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).

[12]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.

[13]Under the American rule each party pays her own litigation costs at trial. In contrast, under the English rule the loser at trial pays the litigation costs of the winner.

[14]Png does not conduct social welfare analyses of these reforms.

(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 cost of accidents and establish necessary and sufficient conditions for a reduction in social costs of accidents under the split-award regime. Our analysis generates an equilibrium in which the more efficient firms choose to be careful and the less efficient ones choose to be negligent[15] and one where some lawsuits are dropped, some are resolved out-of-court and some go to trial.

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 party's beliefs about the trial outcome. They study the effects of split-awards on litigation expenses and the resulting impact on the size of the contract zone,[16] 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 pre-trial 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.[17] 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 pre-trial bargaining as a strategic game of incomplete information between two Bayesian players, an informed defendant[18] and an uninformed plaintiff, using signaling and screening games setups. They 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 and analyzing the effect of the split-award tort reform on the probability of accidents and the social cost of accidents.

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[15]We refer to defendants who just meet or exceed the care standard for gross negligence as careful defendants; and, to defendants who fail to meet the standard as negligent defendants.

[16]Contract zone is defined as the range of settlement values that makes both sides better off than not settling.

[17]If agency problems exist, this effect may not hold.

[18]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.

Consistent with Daughety and Reinganum (2003), we predict that, holding filing constant, and under certain conditions, a decrease in the plaintiff's share of the award decreases the probability of trial. Given that the split-award statute applies only when the case is settled in court, the parties have an incentive to settle out of court in order to cut out the state. In addition, we find that a reduction in the plaintiff's share of the award increases the probability of accidents. This effect arises because a decrease in the plaintiff's share reduces the defendant's expected litigation losses. The firm reacts to these lower expected losses by reducing its expenditures on safety. Conditions under which this reform reduces the social cost of accidents are derived.

The paper is organized as follows. Section Two presents the setup and solution of the model. Section Three 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 Four contains concluding remarks and outlines possible directions for further research.

2   The Model

Our framework combines the decision about the level of care of a potential injurer 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 and therefore, permits to study the firm's decision about the level of care. 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.[19]

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

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[19]Seminal papers on litigation analyze the factors that determine whether a dispute between two parties is litigated or settled out of court. These studies assess the economic incentives underlying the process of litigation, but they do not incorporate strategic aspects of information asymmetries. See for example, Landes (1971), Gould (1973), Posner (1977), and Shavell (1982). Given the relevance of asymmetric information to disputes in real-world settings (see for example, Farber and White, 1991, for an empirical analysis of the effect of information asymmetry on settlement in medical malpractice cases) and the development of dynamic game theory, more recent studies on litigation and litigation and deterrence incorporate information asymmetries and strategic behavior of litigants. See for example, Reinganum and Wilde (1986) for a strategic model of litigation; and, Hylton (2002), Spier (1997, 1994), and Png (1987) for strategic models of litigation and deterrence.

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 pre-trial negotiation between two Bayesian risk-neutral parties, an uninformed plaintiff and an informed defendant, starts. It is modeled as a signaling-ultimatum game. We base our definition of equilibrium on the perfect Bayesian equilibrium concept and apply the universal divinity refinement, developed by Banks and Sobel (1987),[20] 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 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.[21]

2.1   Model Setup

Nature first decides the efficiency type n of the firm from a continuum of types.[22] 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, that depends on the level of care $y(n)$, and assume that the higher the level of care y, the lower the probability

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[20]See Reinganum and Wilde (1986) and Schweizer (1989) for previous applications of the universal divinity refinement to litigation games.

[21]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 other 20.2% were disposed as follows: 4.5% by summary judgment, 0.5% by default judgment, 6% were dismissed, 2.7% by arbitration award, 6.1% by transfer, and 0.3% by other dispositions (Smith et al., 1995).

[22]In real-world settings, firms have different costs of complying with a regulatory standard. So, considering a continuum of types is appropriate.

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.[23] The due standard of care for gross negligence $\bar{y}$ is set by the court.

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.[24] We assume that the plaintiff's expected payoff from suing is positive. Therefore, every injured plaintiff has an incentive to file a suit. The pre-trial 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 (out-of-court settlement) 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.

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[23]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 due care standard is applied.

[24]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 (that 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.

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.[25] 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,[26] and the state gets a share $(1 - f)$ of the award. 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.[27] Then, 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 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

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[25]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 (Sloane, 1993). In addition, punitive damages serve to encourage plaintiffs to bring forth minor criminal offenses that are not likely to be prosecuted yet nonetheless are offensive to society (reward for their civil duty as a "private attorney general") and compensate plaintiffs for their attorneys' fees (Case Note, 1993; Dodson, 2000; Evans, 1998; Epstein, 1994; Stevens, 1994; Sloane, 1993).

[26]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.

[27]We thank Jennifer Reinganum and an anonymous referee for the suggestions on independence of A and $\bar{y}$, respectively.

damage award only, we abstract from compensatory damages.[28]

The sequence of events in the game is shown in Figure 1.

[**INSERT FIGURE 1**]

We start by finding the solution of the litigation stage, using the Perfect Bayesian equilibrium concept. 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 $qfA - K_P > 0$ and $fA - K_P > K_D$, this equilibrium constitutes the unique perfect Bayesian equilibrium of the litigation stage that survives Banks and Sobel's (1987) universal divinity refinement. Condition $qfA - K_P > 0$ rules out the outcome where no lawsuit is filed, and condition $fA - K_P > K_D$ 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[29] and other pooling equilibria, but they do not survive the

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[28]The model can be modified to incorporate compensatory damages, without altering the qualitative predictions presented here, in the following way. Assume that the court awards compensatory damages CDA (common-knowledge) whenever the accident happens (i.e., strict liability applies), but it awards punitive damages A only if the firm fails to achieve the due care standard for gross negligence. Assume also bifurcation of trial, i.e. two separate trials decide on compensatory and punitive damage awards; that the compensatory damages game has the same structure as the punitive damages game presented here; and that legal costs, K_{PCDA} and K_{DCDA} are paid by the plaintiff and defendant, respectively, only in case of trial. Then, in case of an accident, the plaintiff and the defendant do not have asymmetric information with regard to prospective compensatory damage awards, and therefore, they settle out of court. Thus, every defendant will offer $CDA - K_{PCDA}$, and every plaintiff will accept.

Thus, the total loss function is given by $L = c(y(n), n) + \lambda(y(n))(CDA - K_{PCDA} + l)$, where l is the expected loss from legal action related to punitive damages. It is easy to show that all qualitative results presented in Sections 2 and 3 will hold.

[29]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.

universal divinity refinement (see Appendix A for details).

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

Proposition 1. Assume that $qfA - K_P > 0$ and $fA - K_P > K_D$. 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

1) The plaintiff always files a suit. In response to an offer $S_1 = 0$, the plaintiff rejects the offer (goes to trial) with probability $\alpha = \frac{fA - K_P}{A + K_D}$ and accepts the offer (drops the action) with probability $(1 - \alpha) = \frac{A + K_D - fA + K_P}{A + K_D}$; the plaintiff always accepts the offer $S_2 = fA - K_P$ (settles out-of-court).

2) The negligent defendant makes no offer (offers $S_1 = 0$) with probability $\beta = \frac{K_P(1-q)}{q(fA - K_P)}$ and offers $S_2 = fA - K_P$ with probability $(1 - \beta) = \frac{q(fA - K_P) - K_P(1-q)}{q(fA - K_P)}$. The careful defendant always makes no offer (offers $S_1 = 0$).

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' rule: when she receives an offer $S_1 = 0$, she believes with probability $\frac{(1-q)}{q\beta + (1-q)}$ that she is confronting a careful defendant and with probability $\frac{q\beta}{q\beta + (1-q)}$ 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 A.

The expected payoffs for the plaintiff and careful and negligent defendant are $V_P = qfA - K_P$, $V_{D_C} = -\left[(\frac{fA - K_P}{A + K_D}) K_D \right]$ and $V_{D_N} = -(fA - K_P)$, respectively.

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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

$$q(1 - \beta) = \frac{qfA - K_P}{fA - K_P}, \tag{1}$$

the conditional probability of dropping the lawsuit

$$(1 - \alpha)[1 - q(1 - \beta)] = \left[\frac{A(1 - f) + K_D + K_P}{A + K_D} \right] \left[\frac{fA(1 - q)}{fA - K_P} \right], \tag{2}$$

and the conditional probability of trial

$$\alpha[1 - q(1 - \beta)] = \frac{fA(1 - q)}{A + K_D}. \tag{3}$$

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 $L = c(y, n) + \lambda(y)l$.[30]   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 $c_n(y, n) < 0$ (firms with higher n are more efficient and need to spend less to achieve a given level of care) and that $c_y(y, n) > 0$ (higher levels of care require larger expenditures on safety). We also assume that $c_{yy}(y, n) > 0$ (the marginal cost of care increases with the degree of care, i.e., $c_y(y, n)$ is increasing in y) and that $c_{ny}(y, n) < 0$ (the marginal cost of care is greater for injurers of lower skill, i.e., $c_y(y, n)$ is decreasing in n). For both functions $c(.)$ and $\lambda(.)$, we assume that their first and second partial derivatives are continuous functions. In addition, we assume that $\lim_{y \to +0} \lambda'(y) \frac{(fA - K_P)K_D}{A + K_D} + c_y(y, n) < 0$.

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[30]The values of l for the negligent and careful defendant are equal to $-V_{D_N}$ and $-V_{D_C}$ respectively.

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 $l \geq \frac{(fA-K_P)K_D}{A+K_D}$. Therefore, it has a single interior minimum.[31]

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

$$
\begin{cases}
c(y, n) + \lambda(y)(fA - K_P) & \text{if} \quad y \quad < \quad \bar{y} \\
\\
c(y, n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D & \text{if} \quad y \quad \geq \quad \bar{y}.
\end{cases}
\tag{4}
$$

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 $c(y, n) + \lambda(y)(fA - K_P)$ until the point of discontinuity; after this point, L follows the function $c(y, n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D$. Given that $fA - K_P > \frac{(fA-K_P)K_D}{A+K_D}$, the function L shifts down discontinuously at the point $y = \bar{y}$. Figure 2 illustrates the function L.

[**INSERT FIGURE 2**]

Lemmas 1 and 2 (in Appendix A) 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. Therefore the combined loss function can have at most one interior local minimum.[32] 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 $c(y(n), n) + \lambda(y(n))(fA - K_P)$ be 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, $n < \underline{n}$, whose members choose $\arg\min\{c(y, n) + \lambda(y)[fA - K_P]\} < \bar{y}$; an

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[31]Assumptions $\lambda''(y) > 0$ and $c_{yy}(y, n) > 0$ guarantee that the function L is convex. Furthermore, given that $\lim_{y \to +0} \lambda'(y)\frac{(fA-K_P)K_D}{A+K_D} + c_y(y, n) < 0$, then $\lim_{y \to +0} L' < 0$ for both $l = \frac{(fA-K_P)K_D}{A+K_D}$ and $l = fA - K_P$. Therefore the function L is decreasing for sufficiently small values of y. On the other hand, given that $\lim_{y \to +\infty} \lambda(y) = 0$, the term $\lambda(y)l$ vanishes in the limit, and for sufficiently large values of y, the function L is increasing in y just because $c(y, n)$ is increasing in y.

[32]If the value of y that minimizes the total expected loss for the careful defendant were larger than the value of y that minimizes the expected loss for the negligent defendant, it would be possible that the combined loss function had two interior minima, one greater than $\bar{y}$ (in the careful range) and one smaller than $\bar{y}$ (in the negligent range).

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intermediate-type interval, $\underline{n} \leq n \leq \bar{n}$, whose members choose $\bar{y}$; and, a high-type interval, $n > \bar{n}$, whose members choose arg $\min\{c(y,n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D\} > \bar{y}$.

Proof. See Appendix A.

Proposition 2 states that, in equilibrium, those defendants with relatively high costs of preventing accidents (low type) will fall below the standard for gross negligence, while those with relatively low costs of preventing accidents (intermediate and high types) will meet or exceed the standard.

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 $\min\{c(y,n) + \lambda(y)[fA - K_P]\} < \bar{y}$. 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 $\underline{n}$ and separates the low interval and the intermediate-type interval.

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

$$\{c(y,\underline{n}) + \lambda(y)[fA - K_P]\} = c(\bar{y},\underline{n}) + \lambda(\bar{y})\frac{fA - K_P}{A + K_D}K_D. \tag{5}$$

Equation (5) states that the defendant of type $\underline{n}$ 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 of the equation represents the expected loss for the defendant, if he just meets the standard. Figure 3 shows the total expected loss function for an $\underline{n}$-type defendant.

[**INSERT FIGURE 3**]

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 $\underline{n} \leq n < \bar{n}$ just meet the standard ($y = \bar{y}$), while the intermediate-type defendants of type $\bar{n}$ have the interior minimum of $c(y,n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D$ just at $\bar{y}$. The critical skill $\bar{n}$ is implicitly defined by the condition stated in equation (6).

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$$c_y(\bar{y}, \bar{n}) + \lambda'(\bar{y})\frac{fA - K_P}{A + K_D}K_D = 0. \tag{6}$$

This condition uses the fact that $\bar{y}$ is an interior minimum of the loss function $\{c(y, \bar{n}) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D\}$, 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 4 shows the total expected loss function for an $\bar{n}$-type defendant.

[**INSERT FIGURE 4**]

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 $\{c(y, n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D\}$. Specifically, for those defendants, $\arg\min\{c(y, n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D\} > \bar{y}$.

The relationship between the defendant's type and the optimal level of care is illustrated by the solid line in Figure 5.

[**INSERT FIGURE 5**]

For the low-type interval, the optimal level of care is increasing in n until the critical level of skill $\underline{n}$. From Figure 3, it is clear why the optimal care schedule is discontinuous at $\underline{n}$. The level of care that makes the negligent defendant indifferent between remaining negligent and just meeting the standard, $y(\underline{n})$, is smaller than $\bar{y}$. Hence defendants with lower skill level ($n < \underline{n}$) will choose the care level $y(n) < y(\underline{n}) < \bar{y}$. But defendants with slightly higher skill level ($n > \underline{n}$) will choose just to meet the care standard, $y(n) = \bar{y}$. For high values of n (after the point $n = \bar{n}$), the optimal level of care is also increasing in 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 $\mu(0) = \int_{n \geq 0} \lambda(y(n))\phi(n)dn$, and the probability of an accident involving a careful defendant is given by $\mu(\underline{n}) = \int_{n \geq \underline{n}} \lambda(y(n))\phi(n)dn$.

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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 $\frac{fA(1-q)}{A+K_D}$, then the unconditional probability of trial is given by $\frac{fA(1-q)}{A+K_D}\mu(0)$. 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 $\mu(\underline{n})$, then, by Bayes' rule, $(1-q) = \mu(\underline{n})/\mu(0)$. Hence, the unconditional probability of trial is equal to $\frac{fA}{A+K_D}\mu(\underline{n})$. Similarly, given that the probability of out-of-court settlement conditional on occurrence of the accident is equal to $\frac{qfA-K_P}{fA-K_P}$, then the unconditional probability of out-of-court settlement is equal to $\mu(0) - (\frac{fA}{fA-K_P})\mu(\underline{n})$. Finally, given that the probability of dropping a case conditional on the occurrence of an accident is $\left[\frac{A(1-f)+K_D+K_P}{A+K_D}\right]\left[\frac{fA(1-q)}{fA-K_P}\right]$, then the unconditional probability of dropping a case is equal to $\left[\frac{A(1-f)+K_D+K_P}{A+K_D}\right]\left[(\frac{fA}{fA-K_P})\mu(\underline{n})\right]$.

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 $qfA - K_P > 0$ and $fA - K_P > K_D$, where $q = 1 - \frac{\int_{n \geq \underline{n}} \lambda(y(n))\phi(n)dn}{\int_{n \geq 0} \lambda(y(n))\phi(n)dn}$.[33]

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 $\underline{n}$ and $\bar{n}$.

Proof. See Appendix A.

Proposition 3 shows that for low-type and the high-type defendants (for those with $n < \underline{n}$ and $n > \bar{n}$), a reduction in f reduces their level of care. In addition, a reduction in f increases both $\underline{n}$ and $\bar{n}$: some firms which 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 which

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[33]The right-hand-side of this equation is independent of q. So, this equation simply specifies the equilibrium value of q (for a given f) in terms of exogenous parameters and the distribution of firms' types.

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 5 (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 and unconditional and conditional probabilities of trial are summarized in Propositions 4 and 5.

Proposition 4: A decrease in f increases the probability of an accident.

Proof. See Appendix A.

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 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.

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 $\arg\min\{c(y, n_m) + \lambda(y)\frac{fA - K_P}{A + K_D}K_D\} \leq \bar{y}$.

Proof. See Appendix A.

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The unconditional probability of trial $\frac{fA}{(A+K_D)}\mu(\underline{n})$ is positively related to the probability of an accident involving a careful defendant $\mu(\underline{n})$. 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. Then, the net effect may be to decrease or increase the unconditional probability of trial. However, under the condition stated in Proposition 5, which 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), the unconditional probability of trial depends positively on f.

The effect of f on the conditional probability of trial $\frac{fA}{A+K_D}\mu(\underline{n})\frac{1}{\mu(0)}$ can be explained by the positive relationship between f and the unconditional probability of trial $\frac{fA}{(A+K_D)}\mu(\underline{n})$, and the negative relationship between f and the probability of an accident $\mu(0)$.[34]

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[34]For the sake of mathematical tractability and in order to get qualitative predictions under a general framework, we abstract from endogenous filing and from the influence of lawyers' effort on court outcome. Our qualitative results, however, are robust (under certain conditions) to the addition of lawyers' effort and filing in the model. Given that under split-awards the plaintiff's lawyer will reduce his effort, then the likelihood that the plaintiff wins at trial and the plaintiff's litigation costs will be lower. The lower effort at trial by the plaintiff's lawyer will induce the plaintiff to accept out-of-court settlement offers more frequently, and therefore, will reduce the likelihood of disputes. This effect operates in the same direction as the effect of split-awards on likelihood of trial that we observe in our model. But given that the plaintiff's litigation costs will be also lower, the accepted offers will be higher than the ones reported in our model. Hence, the effect of split-awards on defendant's expected losses will be in general ambiguous. Consider the scenario where the reduction in plaintiff's litigation costs due to the split-award does not offset the reduction in likelihood of plaintiff's success at trial. Then, the lower effort of the plaintiff's lawyer at trial under the split-award will reduce the expected gains for the plaintiff and will reduce the defendant's expected litigation losses. Therefore, split-awards will reduce the defendant's level of care. This effect operates in the same direction as the effect of split-awards on level of care that we observe in our model.

The effect of split-awards on filing (in a framework that also considers the effects of lawyers' effort on court outcome) will be, in general, ambiguous. Consider the scenario where the reduction in plaintiff's litigation costs due to the split-award does not offset the reduction in likelihood of plaintiff's success at trial. Then, the lower effort of the plaintiff's lawyer at trial under the split-award will reduce the expected gains for the plaintiff and therefore, will reduce the incentives to file a lawsuit. On the other hand, the lower level of care under the split-award will generate a higher likelihood that the plaintiff confronts a negligent defendant, and therefore, a higher likelihood that the plaintiff succeeds at trial. This effect will increase the incentives to file a lawsuit. Hence, the effect of split-awards on level of care, will be in general ambiguous. Filing, however, will not affect the direction of the effect of split-awards on the likelihood of disputes.

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It is important to note that the condition $\arg \min\{c(y, n_m) + \lambda(y)\frac{fA - K_P}{A + K_D}K_D\} \leq \bar{y}$ 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 $\mu(\underline{n})$ rises following a decrease in f, a reduction in the first term, $\frac{fA}{(A + K_D)}$ 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.

$$C_S = \int_{n \geq 0} \left\{ c(y, n) + \lambda(y(n)) \left[H + \frac{fA(1 - q)}{A + K_D}(K_D + K_P) \right] \right\} \phi(n)dn, \tag{7}$$

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;[35] $\frac{fA(1-q)}{A+K_D}$ 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 $\mu(\underline{n}) = (1 - q)\mu(0)$, the social welfare loss function can be rewritten as

$$C_S = \int_{n \geq 0} c(y, n)\phi(n)dn + H \int_{n \geq 0} \lambda(y(n))\phi(n)dn + \frac{fA(K_P + K_D)}{A + K_D}(1 - q)\int_{n \geq 0} \lambda(y(n))\phi(n)dn =$$

$$= \int_{n \geq 0} c(y, n)\phi(n)dn + H\mu(0) + \frac{fA}{A + K_D}\mu(\underline{n})(K_P + K_D). \tag{8}$$

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.[36] The third term $\frac{fA}{A+K_D}\mu(\underline{n})(K_P + K_D)$ denotes the unconditional expected litigation costs, where $\frac{fA}{A+K_D}\mu(\underline{n})$ is the

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[35]Given that we abstract from the compensatory award in the litigation analysis, we also abstract here from the direct monetary damage to the plaintiff.

[36]By assumption, $c_y(y, n) > 0$.

unconditional probability of trial. By Proposition 5, if no defendant belongs to the high-type interval, the unconditional probability of trial positively depends on f. Therefore, a decrease in f will reduce the unconditional expected litigation cost. 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.

Thus, the effect of a decrease in f on the social costs of accidents is, in general, ambiguous because a reduction 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 (by increasing the frequency of accidents due to a reduction in the level of care). 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

$$
T(f) \equiv \frac{\int_{n \geq 0} c_y(y,n)\frac{\partial y(n)}{\partial f}\phi(n)dn + \frac{A(K_P+K_D)}{A+K_D}\mu(\underline{n}) + \frac{fA(K_P+K_D)}{A+K_D}\frac{\partial \mu(\underline{n})}{\partial f}}{-\frac{\partial \mu(0)}{\partial f}} > 0. \tag{9}
$$

Proposition 6: Assume that $\arg\min\{c(y,n_m) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D\} \leq \bar{y}$. 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.[37]

Proof. See Appendix A.

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[37]The condition stated in Propositions 5 and 6, $\arg\min\{c(y,n_m) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D\} \leq \bar{y}$, is independent of q but has some implications for q. This condition precludes the existence of a high-interval type. Then, the interval of defendants' types meeting the standard will be equal to $[\underline{n}, n_m]$. For a given $\underline{n}$, this implies a maximum value for the conditional probability of an accident involving a careful defendant, $1 - q = \frac{\int_{\underline{n}}^{n_m} \lambda(y(n))\phi(n)dn}{\int_{n \geq 0} \lambda(y(n))\phi(n)dn}$, and hence, a minimum value for q (the complementary probability).

On the other hand, the condition stated in Proposition 1, $qfA - K_P > 0$, depends on q and implies that $\frac{K_P}{fA} < q$, 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.

This condition can be interpreted as follows. If the efficiency of all potential injurers in achieving 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,[38] 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 that accidents cause 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).

4   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. This framework allows for heterogeneity in firms' costs of preventing accidents and generates an equilibrium in which the more efficient firms choose to be careful and the less efficient ones choose to be negligent, and some lawsuits are dropped, some are resolved out-of-court and some go to trial. Our analysis highlights the effect of the split-award statute on the potential injurer's level of care. In particular, it shows that the split-award statute may reduce the social cost of accidents if the efficiency of potential injurers in achieving certain level of care is below some threshold and the social harm from an accident is sufficiently low.

Avenues for further research may involve the incorporation of frivolous lawsuits into the model. If the defendant cannot distinguish between truly injured and uninjured plaintiffs (frivolous cases) before the trial, an opportunistic person has an incentive to file a frivolous suit in order to extract a positive settlement offer. Following Katz (1990) and Miceli (1994), it is possible to introduce a filing cost into the model, so that in equilibrium, prospective uninjured plaintiffs randomize between filing and not filing a lawsuit. It will be interesting to investigate how this setup change affects the equilibrium of the litigation game, the level of care that the prospective defendant chooses, and the impact of the split-award statute. Another potential extension would be to assume that

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[38]Notice that when H is equal to the threshold $T(f)$, C_S is unaffected by a marginal change in f (i.e., $\frac{\partial C_S}{\partial f} = 0$).

the plaintiff hires a lawyer to file the lawsuit, and that this lawyer works on a contingency basis.[39] Miceli (1994) shows that, under certain conditions (i.e., a high threat of frivolous litigation), the contingency fee results in fewer frivolous suits and lower total litigation costs. Given the results of our model, we would expect that the lower litigation costs reduce the level of care of the defendant and increase the likelihood of an accident. Hence it would be important to analyze whether the overall welfare effect is positive or negative.

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[39]Under a contingent-fee compensation, the attorney receives a percentage of the plaintiff's out-of-court settlements or trial award as a compensation for her services.

Appendix A. Proofs

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

Proof of Proposition 1. The proof has two main parts. In the first part, we prove the existence of perfect Bayesian equilibria, one of which is the partially separating PBE stated in Proposition 1, under conditions $qfA - K_P > 0$ and $fA - K_P > K_D$, In the second part, we show that the equilibrium proposed in Proposition 1 is the only partially separating equilibrium that survives the universal divinity refinement and therefore, is the unique universal divine PBE of the litigation stage.

Part 1. Existence of Perfect Bayesian Equilibria of the Litigation Game

Part 1.1. We eliminate the dominated and iteratively dominated strategies for each player.

Rationality suggests that since the plaintiff can get at most $fA - K_P$ at trial, the plaintiff should accept any pretrial offer over $fA - K_P$. That is, any strategy that calls for the plaintiff to reject an offer greater than $fA - K_P$ is weakly dominated by a strategy in which he accepts the offer.[40] Rationality also suggests, given that the plaintiff can drop the case and lose nothing, the plaintiff should reject any pretrial offer $S < 0$. That is, any strategy that calls for the plaintiff to accept an offer lower than zero is dominated by a strategy in which he rejects the offer.

Because the plaintiff accepts all offers over $fA - K_P$ (maximum payoff at trial), any strategy in which the defendant offers more than $fA - K_P$ when she is negligent is iteratively dominated by a strategy in which she offers exactly $fA - K_P$. Rationality also tells us that the defendant will offer no more than K_D (loss for a careful defendant at trial) 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. Then, the minimum possible offer is $S = 0$ and represents the defendant's refusal to settle.

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[40]It is only weakly dominated because the second strategy does not result in a strictly higher payoff against every one of the defendant's strategies. In particular, it does not result in a strictly higher payoff if the defendant's strategy is to refuse to offer a settlement (i.e., offer $S = 0$) whether negligent or careful.

Hence, after eliminating the dominated strategies and a first round of elimination of the iteratively dominated strategies for each player, we can restrict our attention to the offer space $[0, fA - K_P]$ for the negligent defendant (i.e., a proposal cannot be negative or greater than the maximum payoff the plaintiff can get in court); and, to the offer space $[0, K_D]$, for the careful defendant (i.e., a proposal cannot be negative or greater than the maximum loss the careful defendant can get in court).

Let's apply iterative elimination of dominated strategies again. Because the careful defendant never offers more than K_D and since the plaintiff can get $fA - K_P$ at trial, rationality suggests that the plaintiff should reject any pretrial offer over K_D and lower than $fA - K_P$. That is, any strategy that calls for the plaintiff to accept such an offer is iteratively dominated by a strategy in which he rejects the offer. Rationality also tells us that the negligent defendant will not make any offer greater than K_D and lower than $fA - K_P$. Then, the offer space for a negligent defendant gets reduced to $[0, K_D]$ U $\{fA - K_P\}$.

Part 1.2. We prove that in equilibrium the negligent defendant randomizes at most between two possible strategies. In Part 1.1. we show that the offer space for the negligent defendant is given by $[0, K_D]$ U $\{fA - K_P\}$, then it suffices to show that there is no more than one equilibrium offer $S_1 \in [0, K_D]$.[41]

We consider 3 steps. First, we show that there is no equilibrium offer in this interval which is proposed by the negligent defendant only. Second, we show that there is no equilibrium offer in the interval proposed by the careful defendant only. Finally, we show that there is no two distinct equilibrium proposals proposed by both types of defendant.

Part 1.2.1.

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 $fA - K_P$ which is accepted with certainty.

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[41]No more than one equilibrium offer $S_1 \in [0, K_D]$ implies that the negligent defendant randomizes at most between 2 possible strategies, one of which is $fA - K_P$.

Part 1.2.2.

If such an equilibrium offer $\tilde{S}$ existed, then the plaintiff would accept it with probability 1. Hence the negligent defendant would be better off, switching to this offer.

Part 1.2.3.

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

$$S_1 p_1 + (1 - p_1)K_D = S_2 p_2 + (1 - p_2)K_D \qquad (A1)$$

and

$$S_1 p_1 + (1 - p_1)(A + K_D) = S_2 p_2 + (1 - p_2)(A + K_D). \qquad (A2)$$

Subtracting the first equation from the second one, we get:

$$(1 - p_1)A = (1 - p_2)A. \qquad (A3)$$

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

Part 1.3. We show that under conditions $qfA - K_P > 0$ and $fA - K_P > K_D$, there are infinitely many partially separating equilibria (one of them is the one stated in Proposition 1) and infinitely many pooling equilibria.[42]

Part 1.3.1. Existence of Partially Separating Equilibria

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[42]Condition qfA - K_P > 0 rules out the equilibrium where no lawsuit is filed; and, condition $fA - K_P > K_D$ rules out the pooling equilibrium where the careful defendant behaves as a negligent defendant by making a positive settlement offer.

A separating equilibrium is not possible in this game. Suppose that a separating equilibrium exists: careful defendants offer $S_1 \leq K_D$ and negligent defendants offer $S_2 \neq S_1$. Given that S_1 is always accepted by the plaintiff and S_2 is always rejected by the plaintiff, then the negligent defendant has an incentive to deviate to S_1 because $S_1 < A + K_D$.

The description of the partially separating equilibria is as follows. If $qfA - K_P > 0$ and $fA - K_P > K_D$: 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 $S_2 = fA - K_P$ with probability $(1 - \tilde{\beta})$; 2) plaintiffs always file a lawsuit; plaintiffs always accept S_2[43] and mix between rejection (with probability $\tilde{\alpha}$) and acceptance (with probability $(1 - \tilde{\alpha})$ when the offer is S_1 such that $0 < S_1 \leq K_D$.[44]

Consider the expected payoffs for the plaintiff, careful and negligent defendants, in terms of $\tilde{\alpha}$ and $\tilde{\beta}$. The expected payoff for the plaintiff V_P is

$$V_P = (1-q)[\tilde{\alpha}(-K_P) + (1-\tilde{\alpha})(S_1)] + q\{\tilde{\beta}[\tilde{\alpha}(fA - K_P) + (1-\tilde{\alpha})(S_1)] + (1-\tilde{\beta})(fA - K_P)\}. \quad (A4)$$

The expected payoff for the careful defendant V_{D_C} is

$$V_{D_C} = \tilde{\alpha}(-K_D) + (1-\tilde{\alpha})(S_1). \quad (A5)$$

And, the expected payoff for the negligent defendant, V_{D_N} is

$$V_{D_N} = \tilde{\beta}[\tilde{\alpha}(-(A + K_D)) + (1-\tilde{\alpha})(S_1)] + (1-\tilde{\beta})[-(fA - K_P)]. \quad (A6)$$

The values of $\tilde{\alpha}$ and $\tilde{\beta}$ 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,

$$fA - K_P = \tilde{\alpha}(A + K_D) + (1-\tilde{\alpha})S_1 \quad (A7)$$

and

$$S_1 = \frac{q\tilde{\beta}}{q\tilde{\beta} + (1-q)}(fA - K_P) + \frac{1-q}{q\tilde{\beta} + (1-q)}(-K_P). \quad (A8)$$

Equation (A4) says that a negligent defendant is indifferent between admitting his negligence (i.e., offering $S_2 = fA - K_P$) and stating that he is careful (i.e., offering S_1) with the risk to lose $A + K_D$ if the case goes to court. Equation (A5) says that a plaintiff is indifferent between dropping

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[43] A defendant offering S_2 reveals his type, and hence S_2 should be equal to $fA - K_P$ to be always accepted.
[44] As 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.

the case and getting a payoff of S_1 and going to court. Solving (A4) for $\tilde{\alpha}$ and (A5) for $\tilde{\beta}$ we get $\tilde{\alpha} = \frac{fA - K_P - S_1}{A + K_D - S_1}$ and $\tilde{\beta} = \frac{(S_1 + K_P)(1-q)}{q(fA - S_1 - K_P)}$.[45]

Then, the expected payoffs for the plaintiff and careful and negligent defendant are $V_P = qfA - K_P$, $V_{D_C} = -\left\{ \frac{S_1[(1-f)A + K_P] + (fA - K_P)K_D}{A + K_D - S_1} \right\}$ and $V_{D_N} = -(fA - K_P)$, 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' rule: when she receives an offer S_1, she believes with probability $\frac{(1-q)}{q\tilde{\beta} + (1-q)}$ that she is confronting a careful defendant and with probability $\frac{q\tilde{\beta}}{q\tilde{\beta} + (1-q)}$ that she is confronting a negligent defendant; when the plaintiff receives an offer S_2, 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. 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 $(1 - \tilde{\beta})$ and S_1 with probability $\tilde{\beta}$ (as stated in the proposed equilibrium).

Note also that $V_P = qfA - K_P > 0$. Therefore, plaintiffs file a suit with probability one.

Part 1.3.2. 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.[46]

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[45]Note that $\tilde{\alpha}(S_1 = 0) = \alpha$ and $\tilde{\beta}(S_1 = 0) = \beta$, i.e., the equilibrium path just described corresponds to the partially separating perfect Bayesian equilibrium stated in Proposition 1.

[46]if $S \leq K_D$ fails to hold, the careful defendant will find it optimal to deviate, to offer 0, and go to trial; if

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 $(S \geq qfA - K_P)$.[47] 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.

Part 2. Uniqueness of the Litigation Stage Equilibrium

We prove that the PBE stated in Proposition 1 is the only PBE that survives the universal divinity refinement is the partially separating PBE, and therefore, this is the unique equilibrium of the litigation stage. We proceed first to apply the universal divinity refinement to the partially separating equilibria, and second, to the pooling equilibria. The implementation of the universal divinity refinement proceeds as follows. First, we find (for careful and 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.

Part 2.1. Elimination of the Other Partially Separating Equilibria

Consider the deviation S' from an equilibrium offer S_1 or S_2. We will cover the analysis of three cases: $0 \leq S' < K_D$, $S' = K_D$ and $K_D < S' < fA - KP$.

Case I: $0 \leq S' < K_D$

For mathematical convenience, define $S' = S_1 - \epsilon$. If $\epsilon < 0$, then the deviation offer $S' > S_1$;

$S \geq qfA - K_P$ 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 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).

  [47] 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 $q(fA - K_P) + (1-q)(-K_P) = qfA - K_P$.

and, if $\epsilon > 0$, then the deviation offer $S' < S_1$.

Proceed first to analyze the case of the negligent defendant. The negligent defendant will be willing to deviate if

$$p_N(S_1 - \epsilon) + (1 - p_N)(A + K_D) \leq (fA - K_P), \qquad (A9)$$

where the left-hand side of the inequality represents the expected loss for the negligent defendant from deviating and the right-hand side represents his expected loss in equilibrium.[48] Solving for p_N we get

$$p_N \geq \frac{(1 - f)A + K_P + K_D}{A + K_D - S_1 + \epsilon}. \qquad (A10)$$

Then, the minimum probability of acceptance of the deviation offer made by the negligent defendant is

$$\underline{p_N} = \frac{(1 - f)A + K_P + K_D}{A + K_D - S_1 + \epsilon}. \qquad (A11)$$

Now find the minimum probability of acceptance of the deviation by the plaintiff, such that the careful defendant is still willing to propose it.

$$p_C(S_1 - \epsilon) + (1 - p_C)K_D \leq \left[S_1(1 - \frac{fA - K_P - S_1}{A + K_D - S_1}) + K_D \frac{fA - K_P - S_1}{A + K_D - S_1} \right], \qquad (A12)$$

where the left-hand side of the inequality represents the expected loss for the careful defendant from deviating and the right-hand side represents his expected loss in equilibrium.[49] Solving for p_C we get

$$p_C \geq \frac{[(1 - f)A + K_D + K_P](K_D - S_1)}{(A + K_D - S_1)(K_D - S_1 + \epsilon)}. \qquad (A13)$$

Then, the minimum probability of acceptance of the deviation offer made by the careful defendant is

$$\underline{p_C} = \frac{[(1 - f)A + K_D + K_P](K_D - S_1)}{(A + K_D - S_1)(K_D - S_1 + \epsilon)}. \qquad (A14)$$

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[48] Note that in every partially separating PBE of the litigation game (under the conditions $qfA - K_P > 0$ and $fA - K_P > K_D$) the expected payoff for the negligent defendant is $fA - K_P$.

[49] Remember that $\tilde{\alpha}(S_1 = 0) = \alpha$. Given that we need to apply the results of this proof to check all partially separating PBE of the litigation game, we will use $\tilde{\alpha}$ in the computation of the expected payoff for the careful defendant. Note that in every partially separating PBE of the litigation game (under the conditions $qfA - K_P > 0$ and $fA - K_P > K_D$) the expected payoff for the careful defendant does depend on S_1.

Compare the threshold probabilities for the negligent and careful defendant.

$$\underline{p_C} - \underline{p_N} = [(1-f)A + K_D + K_P] \left[\frac{(K_D - S_1)(A + K_D - S_1 + \epsilon) - (A + K_D - S_1)(K_D - S_1 + \epsilon)}{(A + K_D - S_1)(K_D - S_1 + \epsilon)(A + K_D - S_1 + \epsilon)} \right] =$$

$$= \frac{-A\epsilon[(1-f)A + K_D + K_P]}{(A + K_D - S_1)(K_D - S_1 + \epsilon)(A + K_D - S_1 + \epsilon)}, \tag{A15}$$

where the expressions in bracket and parentheses are positive. Then, if $\epsilon < 0$, $\underline{p_N} < \underline{p_C}$; and, if $\epsilon > 0$, $\underline{p_N} > \underline{p_C}$.

Following the universal divinity refinement, if $0 \le S' < K_D$ and $\epsilon < 0$ ($S' > S_1$), the plaintiff should believe that the deviation S' comes from a negligent defendant with probability one. On the other hand, if $\epsilon > 0$ ($S' < S_1$), the plaintiff should believe with probability one that the deviation S' comes from a careful defendant.

Apply the universal divinity refinement to the other partially separating equilibria (where $0 < S_1 \le K_D$). The off-equilibrium beliefs imply that the plaintiff should infer that any deviation S' comes from a negligent defendant. In case of $\epsilon > 0$ ($S' < S_1$), these off-equilibrium beliefs do not survive the refinement. The plaintiff should believe that the deviation comes from a careful defendant and accept the offer. This response from the plaintiff will generate an incentive for the negligent defendant to deviate and offer $S_1 - \epsilon$. Hence, the other partially separating equilibria (where $0 < S_1 \le K_D$) do not pass the test of universal divinity for $0 \le S' < K_D$.

We will apply now the universal divinity refinement to the empirically relevant equilibrium (where $S_1 = 0$). The off-equilibrium beliefs imply that the plaintiff should infer that any deviation comes from a negligent defendant. Note also that given that $S_1 = 0$ is the lowest possible offer, only deviations above S_1 (i.e., $S' > S_1$) are possible. Therefore, the off-equilibrium beliefs survive the universal divinity refinement. Hence, the empirically relevant equilibrium passes the test of universal divinity for $0 \le S' < K_D$.

Case II: $S' = K_D$

The minimum probability of acceptance of a deviation offer made by the negligent defendant is still given by equation (A8).

For the case of the careful defendant, note that his expected deviation loss is K_D and his expected equilibrium loss is in the interval $(\frac{fA-K_P}{A+K_D}, K_D)$ (for $0 < S_1 < K_D$) and is equal to $\frac{fA-K_P}{A+K_D} < K_D$ (for $S_1 = 0$). Then, for any probability of acceptance, the careful defendant will not be willing to deviate when $S' = K_D$.

By universal divinity, the plaintiff should expect that any deviation offer $S' = K_D$ comes from a negligent defendant. Thus, all partially separating PBE pass the test of universal divinity for $S' = K_D$.

Given that the partially separating PBE stated in Proposition 1 is the only partially separating equilibrium that survives the universal divinity refinement in both cases, then the equilibrium proposed in Proposition 1 is the only universal divine partially separating PBE.

Part 2.2. Elimination of the Pooling Equilibria

Consider the deviation S' from an equilibrium offer S. We will cover the analysis of two cases: $0 \leq S' < K_D$ and $S' = K_D$.

Case I: $0 \leq S' < K_D$

For mathematical convenience, define $S' = S - \epsilon$. If $\epsilon < 0$, then the deviation offer $S' > S$; and, if $\epsilon > 0$, then the deviation offer $S' < S$.

Proceed first to analyze the case of the negligent defendant. The negligent defendant will be willing to deviate if

$$p_N(S - \epsilon) + (1 - p_N)(A + K_D) \leq S, \tag{A16}$$

where the left-hand side of the inequality represents the expected loss for the negligent defendant from deviating and the right-hand side represents his expected loss in equilibrium.[50] Solving for p_N we get

$$p_N \geq \frac{A + K_D - S}{A + K_D - S + \epsilon}. \tag{A17}$$

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[50]Note that in every pooling PBE of the litigation game (under the conditions $qfA - K_P > 0$ and $fA - K_P > K_D$) the expected payoff for the negligent defendant is S.

Then, the minimum probability of acceptance of the deviation offer made by the negligent defendant

is

$$\underline{p_N} = \frac{A + K_D - S}{A + K_D - S + \epsilon}. \tag{A18}$$

Now find the minimum probability of acceptance of the deviation by the plaintiff, such that the careful defendant is still willing to propose it.

$$p_C(S - \epsilon) + (1 - p_C)K_D \leq S, \tag{A19}$$

where the left-hand side of the inequality represents the expected loss for the careful defendant from deviating and the right-hand side represents his expected loss in equilibrium. Solving for p_C we get

$$p_C \geq \frac{K_D - S}{K_D - S + \epsilon}. \tag{A20}$$

Then, the minimum probability of acceptance of the deviation offer made by the careful defendant

is

$$\underline{p_C} = \frac{K_D - S}{K_D - S + \epsilon}. \tag{A21}$$

Note that inspection of equations (A21) and (A18) show that if $\epsilon < 0$, the left-hand side of the inequalities will be greater than 1. Given that the right-hand side of the inequalities correspond to probabilities (which cannot be greater than 1), the inspection of these equations permits us to conclude that the universal divinity refinement is not applicable for cases where $\epsilon < 0$. Then, we will proceed to the application of the universal divinity refinement only in cases where $\epsilon > 0$.

Compare the threshold probabilities for the negligent and careful defendant.

$$\underline{p_C} - \underline{p_N} = \frac{-A\epsilon}{(K_D - S + \epsilon)(A + K_D - S + \epsilon)}, \tag{A22}$$

where A and the expressions in parentheses are positive. Then, if $\epsilon > 0$, $\underline{p_N} > \underline{p_C}$.

Following the universally divinity refinement, if $0 \leq S' < K_D$ and $\epsilon > 0$ ($S' < S$), the plaintiff should believe with probability one that the deviation S' comes from a careful defendant.

Apply the universal divinity refinement to the pooling equilibria (where $0 < S \leq K_D$). The off-equilibrium beliefs imply that the plaintiff should infer that any deviation S' comes from a negligent defendant. These off-equilibrium beliefs do not survive the refinement. The plaintiff should believe that the deviation comes from a careful defendant and accept the offer. This response from the plaintiff will generate an incentive for the negligent defendant to deviate and offer $S - \epsilon$. Hence, the pooling equilibria (where $0 < S \leq K_D$) do not pass the test of universal divinity for $0 \leq S' < K_D$.

Case II: $S' = K_D$

The minimum probability of acceptance of a deviation offer made by the negligent defendant is still given by equation (A11).

For the case of the careful defendant, note that his expected deviation loss is K_D and his expected equilibrium loss is in the interval $(\frac{fA - K_P}{A + K_D}, K_D)$ (for $0 < S < K_D$) and is equal to $\frac{fA - K_P}{A + K_D} < K_D$ (for $S = 0$). Then, for any probability of acceptance, the careful defendant will not be willing to deviate when $S' = K_D$.

By universal divinity, the plaintiff should expect that any deviation offer $S' = K_D$ comes from a negligent defendant. Thus, all pooling PBE pass the test of universal divinity for $S' = K_D$.

Given that no pooling PBE survive the universal divinity refinement in both cases, there is no universal divine pooling PBE.

Hence, the partially separating PBE stated in Proposition 1 is the unique universally divine PBE of the litigation stage. Q.E.D.

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,

$$c_y(y,n) + \lambda'(y)l = 0. \qquad (A23)$$

Totally differentiating this first-order condition yields

$$[c_{yy}(y,n) + \lambda''(y)l]dy = -\lambda'(y)dl. \qquad (A24)$$

The last equation can be rewritten as

$$\frac{\partial y}{\partial l} = \frac{-\lambda'(y)}{c_{yy}(y,n) + \lambda''(y)l} > 0. \qquad (A25)$$

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

Lemma 2. For all n, the value of y that minimizes the function $c(y,n) + \lambda(y)(fA - K_P)$ is larger than the value of y that minimizes the function $c(y,n) + \lambda(y)\frac{(fA-K_P)K_D}{A+K_D}$.

Proof. $\frac{(fA-K_P)K_D}{A+K_D} < fA - K_P$. Hence the lemma is a direct application of Lemma 1. Q.E.D.

Proof of Proposition 2. The proof has five parts. First, we verify that the value of y that minimizes loss functions is increasing in n. Second, we show that for given $\bar{y}$, $\underline{n}$ is unique. Third, we prove that $\bar{n} > \underline{n}$. Fourth, we show that defendants with $n < \underline{n}$ find it optimal to be negligent and defendants with $n \geq \underline{n}$ find it optimal to be careful. Finally, we prove that defendants with $n \leq \bar{n}$ do not exceed the standard and defendants with $n > \bar{n}$ exceed the standard.

Part 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 (A23) yields

$$c_{yy}(y,n)dy + c_{yn}(y,n)dn + \lambda''(y)ldy = 0. \tag{A26}$$

The last equation can be rewritten as

$$\frac{\partial y}{\partial n} = -\frac{c_{yn}(y,n)}{c_{yy}(y,n) + \lambda''(y)l} > 0. \tag{A27}$$

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

Part 2. We prove that for any $\bar{y}$, $\underline{n}$ is unique.

Let the "negligent" segment of the total loss function be L_N and the "careful" segment of the total loss function be L_C. Define L_N and L_C as follows: $L_N = c(y,n) + \lambda(y)(fA - K_P)$ and $L_C = c(y,n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D$. 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 $L_N^1 = c(y^*,n) + \lambda(y^*)(fA - K_P)$ as the interior minimum value for the "negligent" segment of the total loss function L.[51] Define $L_N^2 = c(\bar{y},n) + \lambda(\bar{y})(fA - K_P)$ as the value of the "negligent" segment of the total loss function L that corresponds to $y = \bar{y}$. Define $L_C^1 = c(\bar{y},n) + \lambda(\bar{y})\frac{fA-K_P}{A+K_D}K_D$ 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 $L_N^2 - L_N^1$, and $L_N^2 - L_C^1$, respectively. We first show that $L_N^2 - L_C^1$ does not depend on n. Second, we show that $L_N^2 - L_N^1$ is decreasing in n and eventually falls to zero. We then

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[51] Given that y^* is the value that minimizes the "negligent" segment of the total loss function L, L_N^1 is defined as the value of the "negligent" segment of the total loss function L that corresponds to $y = y^*$.

conclude that there exists exactly one value of n, denoted by $\underline{n}$, such that $L_N^2 - L_N^1 = L_N^2 - L_C^1$, and hence, equation (5) is satisfied.

Part 2.1.

$$L_N^2 - L_C^1 = c(\bar{y}, n) + \lambda(\bar{y})(fA - K_P) - c(\bar{y}, n) - \lambda(\bar{y})\frac{fA - K_P}{A + K_D}K_D = \lambda(\bar{y})\frac{fA - K_P}{A + K_D}A. \quad (A28)$$

The last expression does not depend on n.

Part 2.2.

$$L_N^2 - L_N^1 = c(\bar{y}, n) + \lambda(\bar{y})(fA - K_P) - c(y^*(n), n) - \lambda(y^*(n))(fA - K_P). \quad (A29)$$

The second term $\lambda(\bar{y})(fA - K_P)$ 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.[52] 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 strictly decreasing in n. Then, $L_N^2 - L_N^1$ will be monotonically decreasing in n and will fall to zero when $y^* = \bar{y}$. Hence, at exactly one value of n, denoted by $\underline{n}$, $L_N^2 - L_N^1 = L_N^2 - L_C^1$. At this $\underline{n}$, equation (5) is satisfied.

Part 3. We prove that, for any $\bar{y}$, $\underline{n} < \bar{n}$.

By construction of $\underline{n}$, the value of y that minimizes $\{c(y, \underline{n}) + \lambda(y)(fA - K_P)\}$ is less than $\bar{y}$. Also, by the definition of $\bar{n}$, arg min $\left\{c(y, \bar{n}) + \lambda(y)\frac{(fA - K_P)K_D}{A + K_D}\right\} = \bar{y}$. Therefore,

$$\text{arg min} \left\{c(y, \underline{n}) + \lambda(y)\frac{(fA - K_P)K_D}{A + K_D}\right\} < \bar{y} = \text{arg min} \left\{c(y, \bar{n}) + \lambda(y)\frac{(fA - K_P)K_D}{A + K_D}\right\}. \quad (A30)$$

By Part 1, it follows that $\underline{n} < \bar{n}$.

Part 4. We prove that, for firms with $n < \underline{n}$ the optimal level of care $y < \bar{y}$; and, for firms with $n \geq \underline{n}$, the optimal level of care $y \geq \bar{y}$.

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[52]This can be shown as follows. Let $F(n) \equiv c(\bar{y}, n) - c(y^*(n), n)$. Then, $F'(n) = c_n(\bar{y}, n) - c_n(y^*(n), n) - c_y(y^*(n), n)\frac{\partial y^*}{\partial n} = c_{yn}(\tilde{y}, n)(\bar{y} - y^*) - c_y(y^*(n), n)\frac{\partial y^*}{\partial n} < 0$, where $\tilde{y} \in (y^*, \bar{y})$. The expression is negative, because $c_{yn} < 0$ by assumption, $\bar{y} > y^*$, $c_y > 0$ by assumption, and $\frac{\partial y^*}{\partial n} > 0$ by Lemma 1.

Consider the following auxiliary function

$$\Phi(n) = \{L_N(n, \bar{y}) - \min\{L_N(n, y)\}\} - [L_N(n, \bar{y}) - L_C(n, \bar{y})]. \qquad (A31)$$

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 Φ,

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

$$= \lambda(\bar{y})\frac{(fA - K_P)A}{A + K_D} \qquad (A32)$$

is independent of n. The first part,

$$\{L_N(n, \bar{y}) - \min\{L_N(n, y)\}\} = L_N(n, \bar{y}) - L_N(n, y^*(n)) \qquad (A33)$$

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

Part 5. We prove that, for firms with $n \leq \bar{n}$ the optimal level of care $y \leq \bar{y}$; and, for firms with $n > \bar{n}$, the optimal level of care $y > \bar{y}$.

The proof follows from the definition of $\bar{n}$. $\bar{y}$ is the interior minimum of the function $L_C(\bar{n}, y)$. By Part 1, for $n > \bar{n}$, the function $L_C(n, y)$ attains its minimum to the right of $\bar{y}$, i.e., $y^* > \bar{y}$. Hence, 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 $n < \bar{n}$, 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 $n \leq \bar{n}$. Hence 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, $n < \underline{n}$, whose members choose $\arg \min\{c(y,n) + \lambda(y)[fA - K_P]\} < \bar{y}$; an intermediate-type interval, $\underline{n} \leq n \leq \bar{n}$, whose members choose $\bar{y}$; and, a high-type interval, $n > \bar{n}$, whose members choose $\arg \min\{c(y,n) + \lambda(y)\frac{fA - K_P}{A + K_D}K_D\} > \bar{y}$. Q.E.D.

Proof of Proposition 3. The proof has three parts. We first prove the claim that a decrease in f decreases the level of care, if the optimal level of care differs from the care standard $\bar{y}$; second, we show that $\underline{n}$ is negatively related to f; third we prove that $\bar{n}$ is negatively related to f.

Part 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 (A23) at $l = fA - K_P$ and totally differentiating it yields

$$c_{yy}(y,n)dy + \lambda''(y)[fA - K_P]dy + \lambda'(y)Adf = 0. \tag{A34}$$

Rearranging terms,

$$\frac{\partial y}{\partial f} = -\frac{A\lambda'(y)}{c_{yy}(y,n) + \lambda''(y)[fA - K_P]} > 0. \tag{A35}$$

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

Part 2. We show that the plaintiff's share of the punitive award f and $\underline{n}$ are negatively related.

Let $\underline{y}$ be the optimal level of care that the firm with $n = \underline{n}$ chooses if it prefers to be negligent (the firm is indifferent between choosing $\underline{y}$ and $\bar{y}$). Consider the following equations

$$c_y(\underline{y}, \underline{n}) + \lambda'(\underline{y})[Af - K_P] = 0 \tag{A36}$$

and

$$c(\underline{y}, \underline{n}) + \lambda(\underline{y})[Af - K_P] = c(\bar{y}, \underline{n}) + \lambda(\bar{y})\frac{fA - K_P}{A + K_D}K_D, \tag{A37}$$

which implicitly define $\underline{n}$ and $\underline{y}$. Totally differentiating equation (A37), one gets

$$c_y(\underline{y}, \underline{n})d\underline{y} + c_n(\underline{y}, \underline{n})d\underline{n} + \lambda(\underline{y})Adf + \lambda'(\underline{y})(Af - K_P)d\underline{y} = c_n(\bar{y}, \underline{n})d\underline{n} + \lambda(\bar{y})A\frac{K_D}{A + K_D}df. \tag{A38}$$

By equation (A36), the first and the last terms of the left-hand side of equation (A38) add up to zero. Hence,

$$\left[\lambda(\underline{y}) - \lambda(\bar{y})\frac{K_D}{K_D + A}\right]Adf = (c_n(\bar{y}, \underline{n}) - c_n(\underline{y}, \underline{n}))d\underline{n} = c_{ny}(\tilde{y}, \underline{n})(\bar{y} - \underline{y})d\underline{n}. \tag{A39}$$

The last transformation is a straightforward application of the mean-value theorem, and $\tilde{y}$ is a point of the interval $(\underline{y}, \bar{y})$. $(\lambda(\underline{y}) - \lambda(\bar{y})\frac{K_D}{K_D + A})A$ is positive, because the function $\lambda(y)$ is monotonically decreasing in y and $\frac{K_D}{A + K_D} < 1$. $c_{ny}(\tilde{y}, \underline{n})(\bar{y} - \underline{y})$ is negative, because $c_{ny} < 0$ by assumption, and $\underline{y} < \bar{y}$. Therefore $\frac{\partial \underline{n}}{\partial f} < 0$.

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

$$c_{yn}(\bar{y}, \bar{n})d\bar{n} +$$

$\lambda'(\bar{y})\frac{AK_D}{A + K_D}df = 0. (A40)$

Therefore,

$$\frac{\partial \bar{n}}{\partial f} = -\frac{c_{yn}(A + K_D)}{\lambda'(\bar{y})AK_D} < 0 \tag{A41}$$

because $c_{yn} < 0$, and $\lambda'(\bar{y}) < 0$. Q.E.D.

Proof of Proposition 4. Given that the probability of an accident is $\mu(0) = \int_{n\geq0} \lambda[y(n)]\phi(n)dn$, we have

$$\frac{\partial \mu(0)}{\partial f} = \int_{n\geq0} \lambda'[y(n)]\frac{\partial y(n)}{\partial f}\phi(n)dn < 0 \qquad (A42)$$

because $\frac{\partial y(n)}{\partial f} \geq 0$ for any n and $\lambda'[y(n)] < 0$ for any n. Q.E.D.

Proof of Proposition 5. The unconditional probability of trial is equal to $\frac{fA}{A+K_D}\mu(\underline{n})$. The first term, $\frac{fA}{A+K_D}$ depends positively on f. The second term is equal to

$$\mu(\underline{n}) = \int_{\underline{n}}^{n_m} \lambda(y(n))\phi(n)dn = \lambda(\bar{y})\int_{\underline{n}}^{n_m} \phi(n)dn = \lambda(\bar{y})(1 - \Phi(\underline{n})), \qquad (A43)$$

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

The conditional probability of trial on accident occurrence is equal to $\frac{fA(1-q)}{A+K_D} = \frac{fA}{A+K_D}\mu(\underline{n})\frac{1}{\mu(0)}$, 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.

Proof of Proposition 6. Differentiating C_S (equation 9) with respect to f, we obtain

$$\frac{\partial C_S}{\partial f} = \int_{n\geq0} c_y(y,n)\frac{\partial y(n)}{\partial f}\phi(n)dn + H\frac{\partial \mu(0)}{\partial f} + \frac{A(K_P+K_D)}{A+K_D}\mu(\underline{n}) + \frac{fA(K_P+K_D)}{A+K_D}\frac{\partial \mu(\underline{n})}{\partial f}, \quad (A44)$$

where $\frac{\partial y(n)}{\partial f} > 0$, $\frac{\partial \mu(0)}{\partial f} < 0$ and $\frac{\partial \mu(\underline{n})}{\partial f} > 0$. $\frac{\partial C_S}{\partial f} > 0$ if and only if

$$H < T(f) \equiv \frac{\int_{n\geq0} c_y(y,n)\frac{\partial y(n)}{\partial f}\phi(n)dn + \frac{A(K_P+K_D)}{A+K_D}\mu(\underline{n}) + \frac{fA(K_P+K_D)}{A+K_D}\frac{\partial \mu(\underline{n})}{\partial f}}{-\frac{\partial \mu(0)}{\partial f}} > 0.$$
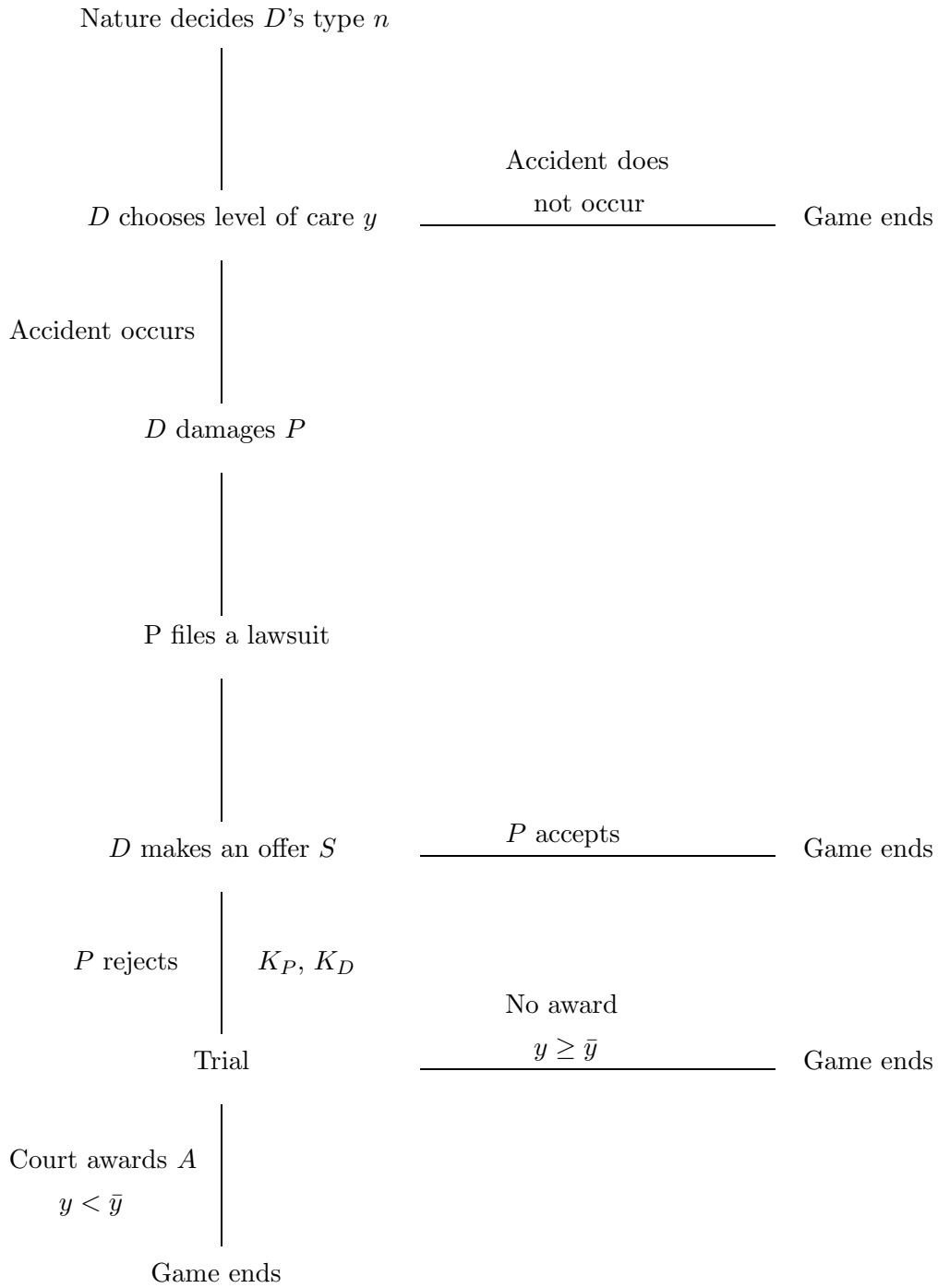
Q.E.D.

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FIGURE 1
SEQUENCE OF EVENTS IN THE GAME

Nature decides D's type n

Accident does
not occur

D chooses level of care y —————— Game ends

Accident occurs

D damages P

P files a lawsuit

P accepts

D makes an offer S —————— Game ends

P rejects K_P, K_D

No award

$y \geq \bar{y}$

Trial —————— Game ends

Court awards A
$y < \bar{y}$

Game ends

Note: D = defendant, P = plaintiff, K_D = defendant's litigation costs, K_P = plaintiff's litigation costs, A = punitive damage award, $\bar{y}$ = standard for gross negligence.
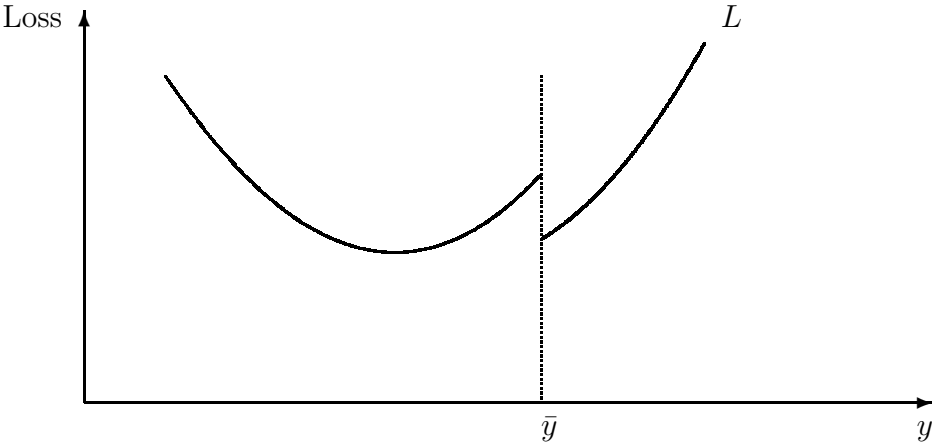
FIGURE 2
GENERIC TOTAL EXPECTED LOSS FUNCTION L

FIGURE 3
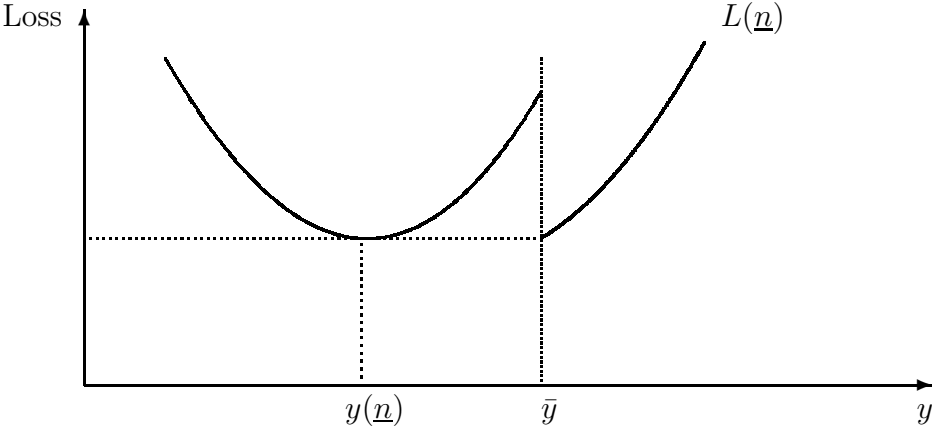TOTAL EXPECTED LOSS FUNCTION L FOR FIRM'S TYPE $\underline{n}$
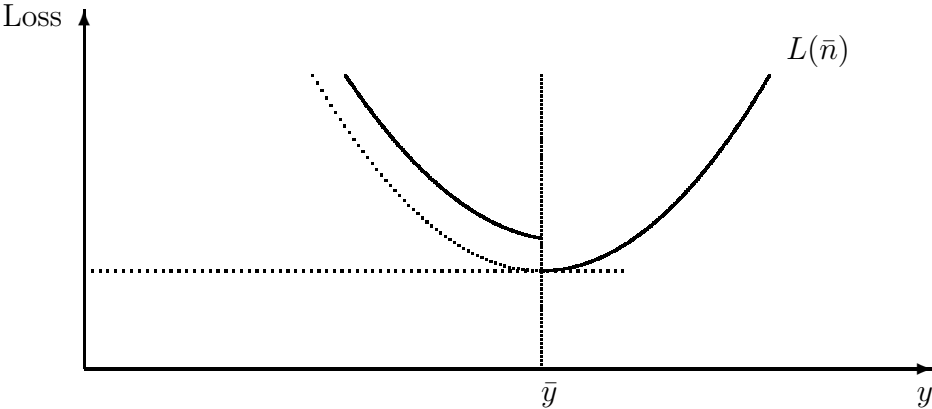
FIGURE 4
TOTAL EXPECTED LOSS FUNCTION L FOR FIRM'S TYPE $\bar{n}$

FIGURE 5
OPTIMAL LEVEL OF CARE AND EFFECT OF f