# 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 decreases the likelihood of trial but also 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 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, Georgia, Illinois, Indiana, Iowa, Missouri, Oregon, and Utah.[4] In addition, New Jersey, California and Texas have contemplated, but not yet adopted, split-award statutes (White, 2002).

Split-awards 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[5] 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.[6] As a result, 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.[7] As a consequence, the firm's

[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, Bock and Petoe, 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] 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).

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

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

[7] The "plaintiff's windfall" refers to any amount in excess of the costs of pursuing the punitive claim. Commentators claim that this windfall promotes unnecessary litigation (Dodson, 2000).

expected litigation loss and its level of care will be further reduced.[8]

However, previous studies of the split-award tort reform 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. 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.[9]

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. It is modeled as a signaling-ultimatum game, where two Bayesian risk-neutral parties, an uninformed plaintiff and an informed defendant,[10] negotiate prior to a costly trial.

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)[11] on liability and litigation.[12] 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 (Banks and Sobel, 1987). Third, we find a sufficient condition for the positive relationship between

[8]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.

[9]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). See also Hylton (2002), Polinsky and Rubinfeld (1988), and Ordover's (1978) seminal paper.

[10]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.

[11]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.

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

the plaintiff's share of the punitive award and the probability 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 a unique empirically relevant equilibrium in which the more efficient firms choose to be careful and the less efficient ones choose to be negligent and one where some lawsuits are dropped, some are resolved out-of-court and some go to trial.

A previous formal study of the split-award statute, conducted by Daughety and Reinganum (2003), addresses the effects of this reform on litigation but not on liability.[13] They 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[14] 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.

Consistent with Daughety and Reinganum (2003), we predict that, holding filing constant, a decrease in the plaintiff's share of the award decreases the conditional and unconditional probabilities 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 expected litigation costs. The firm reacts to these lower expected costs by reducing 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.

[13] Kahan and Tuckman (1995) also study the effects of the split-award statute on litigation. However, they use a simultaneous-move game with inconsistent priors (non-Bayesian players) and do not model explicitly the pre-trial bargaining stage.

[14] 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.

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

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

After observing its type, the firm then decides its optimal level of care, i.e., the one that minimizes its total expected loss $L$. We define the defendant's total expected loss function as $L = c(y(n), n) + \lambda(y(n))l$, where $l$ is the expected loss from legal action, different for careful and negligent defendants. The firm is careful if the level of care chosen is greater than or equal to the due standard of care $\bar{y}$ (exogenous and common knowledge parameter);[15] otherwise, the firm is negligent.

If an accident occurs, the litigation stage starts. The plaintiff first decides whether to file a lawsuit. 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.[16] We assume that the plaintiff's

[15]The due standard of care, $\bar{y}$, is set by the court. We assume that the cost of collecting information about each defendant is too high, so the court sets a unique due standard of care at the value that equates the marginal cost of preventing accidents (computed over all types of defendants) to the marginal benefit of avoiding social harm due to accidents, and applies this standard to all defendants. Let $H$ be the social harm due to accidents, $c(.)$ the expenditure on care, and $\lambda(.)$ the probability of accidents for a firm of type $n$. Then, $\bar{y}$ is set so that $\int_{n\geq 0} c_y(\bar{y}, n)\phi(n)dn = -\lambda'(\bar{y})H$.

Note that the mechanism for computing $\bar{y}$ suggested here resembles the Hand rule used by courts to determine negligence. According to the Hand rule, a party is negligent if an accident occurred as a result of a party's failure to take a particular precaution, and if the cost of the precaution is less than the expected harm.

[16]The values for $q$ and $(1-q)$ depend on the optimal levels of care chosen by all firms in the first stage of the game,

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.

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 $A$[17] to the plaintiff. Under the split-award regime, the plaintiff receives only a fraction $f$ of the total punitive award,[18] and the state gets a share $(1-f)$ of the award.[19] If the plaintiff rejects the proposal and the defendant is careful, no punitive damages are awarded.[20] 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.

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.

[17]Given that $A$ is determined by the jury, it is an exogenous parameter of the model.

For the sake of mathematical simplicity and given that our primary goal is to explore the effect of the split-award statute which applies to the punitive damage award only, we abstract from compensatory damage awards. Our qualitative results will also hold if we include the compensatory award in the model.

[18]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' litigation costs.

[19]Given that $A$ is determined by the jury and the information about the split-statute is supposed to be kept from the jury, $A$ does not depend on $f$. We thank Jennifer Reinganum for this suggestion.

Note also that, under the computation of the standard of due care based on the Hand Rule, $\bar{y}$ does not depend on $f$.

[20]We have restricted the proposal space to $[0, fA - K_P]$ (i.e., a proposal cannot be negative or greater than the maximum amount the plaintiff can get in court).

## 2.1 Solution of the Litigation Stage

We focus our analysis on the unique empirically relevant equilibrium of the litigation stage under conditions $qfA - K_P > 0$ and $fA - K_P > K_D$, that survives Sobel and Bank's universal divinity refinement:[21] a partially separating equilibrium in which some cases are dropped, some proceed to trial, while others settle before trial.[22]

Proposition 1 characterizes the 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

[21] Condition $qfA - K_P > 0$ ensures that plaintiffs always file a suit (necessary condition) and condition the $fA - K_P > K_D$ rules out pooling equilibria (sufficient condition). Under these conditions, there are other partially separating equilibria, that are non-empirically relevant (i.e., they do not allow for lawsuits to be dropped) and do not survive the universal divinity refinement.

[22] 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).

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 $0 < S^{'} < fA - K_P$, 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.

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

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

## 2.2 Optimization Problem of the Defendant

The defendant's optimization problem is to choose the level of care that minimizes his total expected loss $L = c(y,n) + \lambda(y)l$.[23] 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

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

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. The final technical assumption is that $\lim_{y \to +0} \lambda'(y) \frac{(fA - K_P)K_D}{A + K_D} + c_y(y, n) < 0$. It is easy to show that under these assumptions the function $L = c(y, n) + \lambda(y)l$ is convex and U-shaped for any positive $n$ and any $l \geq \frac{(fA - K_P)K_D}{A + K_D}$. Therefore, it has a single interior minimum.[24]

The total expected loss $L$ of a defendant 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 $y = \bar{y}$. 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.[25] Figure 2 illustrates the function $L$.

[24] 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 $y$.

[25] 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).

[**INSERT FIGURE 2**]

Note that the total expected loss function is different for each type $n$. 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 $y = \arg\min\{c(y,n)+\lambda(y)[fA-K_P]\} < \bar{y}$; 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 $y = \arg\min\{c(y,n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D\} > \bar{y}$.

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, $y = \arg\min\{c(y,n)+\lambda(y)[fA-K_P]\} < \bar{y}$. 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 two conditions

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

and

$$c_y(y,\underline{n}) + \lambda^{'}(y)[fA - K_P] = 0. \tag{6}$$

Equation (5) states that the defendant of type $\underline{n}$ is indifferent between being negligent and exactly meeting the standard. Equation (6) uses the fact that $\underline{n}$ is an interior minimum of the loss function $\{c(y,n) + \lambda(y)(fA - K_P)\}$, and therefore its derivative with respect to $y$ should be equal to zero. 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 (7). This condition uses the fact that $\bar{n}$ is an interior minimum of the loss function $\{c(y,n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D\}$, and hence its derivative 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 $\bar{y}$.

$$c_y(\bar{y},\bar{n}) + \lambda^{'}(\bar{y})\frac{fA-K_P}{A+K_D}K_D = 0. \tag{7}$$

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 defendants of type $n$ such that $n \geq \bar{n}$, $y = \arg\min\{c(y,n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D\} \geq \bar{y}$.

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 $n$.

Lemmas 3–6 (in Appendix A) verify formally that the value of $y$ that minimizes loss functions is increasing in $n$; $\bar{n} > \underline{n}$; defendants with $n < \underline{n}$ find it optimal to be negligent and defendants with $n \geq \underline{n}$ find it optimal to be careful; and, defendants with $n \leq \bar{n}$ do not exceed the standard and defendants with $n > \bar{n}$ exceed the standard.

Using the previous results, we can now derive the unconditional probabilities of trial, out-of-court settlement and dropping the case. Start with the analysis of the probability of an 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 $\mu(\underline{n}) = \int_{n\geq \underline{n}} \lambda(y(n))\phi(n)dn$.

Given that the probability of trial conditional on occurrence of the accident is $\frac{fA(1-q)}{A+K_D}$ and $(1-q)$ is the probability that a defendant has been careful conditional on the occurrence of an accident, the unconditional probability of trial is given by $\frac{fA(1-q)}{A+K_D}\mu(0)$. Given that the probability of an accident involving a careful defendant is given by $\mu(\underline{n})$, 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 $fA - K_P > K_D$

*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 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.

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 $\mu(0)$.

The effects of $f$ on the social costs of accidents are described next. Define the social cost of accidents, $C_S$, as follows.

$$C_S = \int_{n\geq 0} \left\{c(y,n) + \lambda(y(n))\left[H + \frac{fA(1-q)}{A+K_D}(K_D+K_P)\right]\right\}\phi(n)dn, \tag{8}$$

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;[26] $\frac{fA(1-q)}{A+K_D}$ 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

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

$$=\int_{n\geq 0}c(y,n)\phi(n)dn+H\mu(0)+\frac{fA}{A+K_D}\mu(\underline{n})(K_P+K_D). \tag{9}$$

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.[27] 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 unconditional probability of trial. By Proposition 3, 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

[26] We characterize the total damage that accidents cause to society as follows: 1) direct monetary damage to the plaintiff, that we assume is fully compensated with the compensatory award; 2) damage to society (including the plaintiff) in the form of reckless behavior from the injurer that can be followed by others, for which the defendant is punished with the punitive award. Given that we abstract from the compensatory award in the litigation analysis, we also abstract here from the direct monetary damage to the plaintiff.

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

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

$$T(f) \equiv \frac{\int_{n \geq 0} c_y(y,n) \frac{\partial y(n)}{\partial f} \phi(n) dn + \frac{A(K_P+K_D)}{A+K_D} \mu(\underline{n}) + \frac{fA(K_P+K_D)}{A+K_D} \frac{\partial \mu(\underline{n})}{\partial f}}{-\frac{\partial \mu(0)}{\partial f}} > 0. \tag{10}$$

*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 $f$.

*Proof.* See Appendix A.

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 $f$,[28] 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

[28]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 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 the plaintiff hires a lawyer to file the lawsuit, and that this lawyer works on a contingency basis.[29] 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.

[29] 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 1–6 and Propositions 3–6 follow.

*Proof of Proposition 1.* The proof has three parts: in the first part, we show that the equilibrium proposed in Proposition 1 is a PBE (proof of existence); in the second part, we describe the other partially separating equilibria under the conditions $qfA - K_P > 0$ and $fA - K_P > K_D$; and, in the third part, we show that the equilibrium proposed in Proposition 1 is the only separating equilibrium that survives the universal divinity refinement and therefore, is the unique PBE of the litigation stage (proof of uniqueness).[30]

First, we prove that the strategy profile, together with the players' beliefs, stated in Proposition 1 is a PBE of the litigation stage.

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

$$V_P = (1-q)[\alpha(-K_P) + (1-\alpha)(0)] + q\beta[\alpha(fA - K_P) + (1-\alpha)(0)] + (1-\beta)(fA - K_P). \quad (A1)$$

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

$$V_{D_C} = \alpha(-K_D) + (1-\alpha)(0). \quad (A2)$$

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

$$V_{D_N} = \beta[\alpha(-(A + K_D)) + (1-\alpha)(0)] + (1-\beta)[-(fA - K_P)]. \quad (A3)$$

The values of $\alpha$ and $\beta$ 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,

$$fA - K_P = \alpha(A + K_D) \quad (A4)$$

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

and

$$0 = \frac{q\beta}{q\beta + (1-q)}(fA - K_P) + \frac{1-q}{q\beta + (1-q)}(-K_P). \qquad (A5)$$

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 $S_1 = 0$) with the risk to lose $A + K_D$ if the case goes to court. Equation (A5) says that a plaintiff is indifferent between dropping the case and getting a payoff of 0 and going to court. Solving (4) for $\alpha$ and (5) for $\beta$ we get $\alpha = \frac{fA-K_P}{A+K_D}$ and $\beta = \frac{K_P(1-q)}{q(fA-K_P)}$.

Then, 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.

The off-equilibrium beliefs that support the PBE are as follows. When the plaintiff receives an offer $S^{'}$ such that $0 < S^{'} < fA - K_P$, the plaintiff believes that this offer was made by 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 $S_1 = 0$, 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 $(1-\beta)$ and $S_1 = 0$ with probability $\beta$ (as stated in the proposed equilibrium).

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

Second, we demonstrate that under the conditions $qfA - K_P > 0$ and $fA - K_P > K_D$, there are other partially separating equilibria of the litigation stage, that are not empirically relevant (i.e., they do not allow for lawsuits to be dropped).

The description of these other 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 $0 < S_1 \leq K_D$, and negligent defendants mix the two strategies, offer $S_1$ such that $0 < S_1 \leq K_D$ 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 $S_2$[31] and mix between rejection (with probability $\tilde{\alpha}$) and acceptance (with probability $(1-\tilde{\alpha})$ when the offer is $S_1$ such that $0 < S_1 \leq K_D$.[32]

To mix the two strategies, $S_1$ and $S_2$, the negligent defendant has to be indifferent between them. Also, to mix acceptance and rejection of $S_1$, the plaintiff has to be indifferent between them. Specifically, plaintiffs reject $S_1$ with probability $\tilde{\alpha} = \frac{fA-K_P-S_1}{A+K_D-S_1}$ and accept it with the complementary probability $(1-\tilde{\alpha})$. In equilibrium, the negligent defendant offers $S_1$ with probability $\tilde{\beta} = \frac{(S_1+K_P)(1-q)}{q(fA-S_1-K_P)}$ and $S_2$ with the complementary probability $(1-\tilde{\beta})$.[33]

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 and rejects the offer with certainty.

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

Third, we will prove that the PBE stated in Proposition 1 is the only partially separating PBE that survives the universal divinity refinement, and therefore, it is the unique equilibrium of the litigation stage.

The implementation of the universal divinity refinement proceeds as follows. First, 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

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

[32] 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.

[33] Note that $\tilde{\alpha}(S_1 = 0) = \alpha$ and $\tilde{\beta}(S_1 = 0) = \beta$.

deviate. Second, compare these minimum probabilities. The defendant with the lower minimum probability will be the one the plaintiff should expect (with probability one) to deviate.

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 $S^{'} > S_1$; 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

$$p_N(S_1 - \epsilon) + (1 - p_N)(A + K_D) \leq (fA - K_P), \qquad (A6)$$

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.[34] Solving for $p_N$ we get

$$p_N \geq \frac{(1-f)A + K_P + K_D}{A + K_D - S_1 + \epsilon}. \qquad (A7)$$

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

$$\underline{p_N} = \frac{(1-f)A + K_P + K_D}{A + K_D - S_1 + \epsilon}. \qquad (A8)$$

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

$$p_C(S_1 - \epsilon) + (1 - p_C)K_D \leq \left[ S_1(1 - \frac{fA - K_P - S_1}{A + K_D - S_1}) + K_D \frac{fA - K_P - S_1}{A + K_D - S_1} \right], \qquad (A9)$$

[34]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 $fA - K_P$.

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.[35] Solving for $p_C$ we get

$$p_C \geq \frac{[(1-f)A + K_D + K_P](K_D - S_1)}{(A + K_D - S_1)(K_D - S_1 + \epsilon)}. \tag{A10}$$

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

$$\underline{p_C} = \frac{(1-f)A + K_D + K - P(K_D - S_1)}{(A + K_D - S_1)(K_D - S_1 + \epsilon)}. \tag{A11}$$

Compare the threshold probabilities for the negligent and careful defendant.

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

$$= \frac{-A\epsilon[(1-f)A + K_D + K_P]}{(A + K_D - S_1)(K_D - S_1 + \epsilon)(A + K_D - S_1 + \epsilon)}, \tag{A12}$$

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 universally divinity refinement, if $0 \leq S' < K_D$ 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 $0 < S_1 \leq K_D$). 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

[35]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 $S_1$.

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 $0 < S_1 \leq K_D$) do not pass the test of universal divinity for $0 \leq S^{'} < K_D$.

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 $0 \leq S^{'} < K_D$.

*Case II:* $S^{'} = K_D$

The minimum probability of acceptance of a deviation offer made by the negligent defendant is still given by equation (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 $S^{'} = K_D$.

*Case III:* $K_D < S^{'} < fA - K_P$

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 greater than $K_D$ and his expected equilibrium loss is in the interval $(\frac{fA-K_P}{A+K_D}, K_D]$ (for $0 < S_1 \leq K_D$) 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 $\mathrm{K}_D < S^{'} < fA - K_P$.

By universal divinity, the plaintiff should expect that any deviation offer $S^{'}$ ($K_D <\ S^{'} <$

$fA - K_P$) comes from a negligent defendant. Thus, all partially separating PBE pass the test of universal divinity for $K_D < S^{'} < fA - K_P$.

Given that the empirically relevant PBE is the only partially separating equilibrium that survives the universal divinity refinement in all three cases, we conclude that this 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,

$$c_y(y, n) + \lambda'(y)l = 0. \tag{A13}$$

Totally differentiating this first-order condition yields

$$[c_{yy}(y, n) + \lambda''(y)l]dy = -\lambda'(y)dl. \tag{A14}$$

The last equation can be rewritten as

$$\frac{\partial y}{\partial l} = \frac{-\lambda'(y)}{c_{yy}(y, n) + \lambda''(y)l} > 0. \tag{A15}$$

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.

*Lemma 3.* The value of y that minimizes the function $c(y, n) + \lambda(y)l$ is increasing in $n$.

*Proof.* Totally differentiating the first-order condition (A13) yields

$$c_{yy}(y, n)dy + c_{yn}(y, n)dn + \lambda''(y)ldy = 0. \tag{A16}$$

The last equation can be rewritten as

$$\frac{\partial y}{\partial n} = -\frac{c_{yn}(y,n)}{c_{yy}(y,n) + \lambda''(y)l} > 0. \tag{A17}$$

The last inequality follows from the assumption $c_{yn}(y,n) > 0$. Q.E.D.

*Lemma 4.* For any $\bar{y}$, $\underline{n} < \bar{n}$.

*Proof.* By the definition of $\underline{n}$, arg min $\left\{c(y,\underline{n}) + \lambda(y)\frac{(fA-K_P)K_D}{A+K_D}\right\}$ is increasing in $y$ at $\bar{y}$. Hence the value of $y$ that minimizes this function 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,

$$\text{arg min}\left\{c(y,\underline{n}) + \lambda(y)\frac{(fA-K_P)K_D}{A+K_D}\right\} < \bar{y} = \text{arg min}\left\{c(y,\bar{n}) + \lambda(y)\frac{(fA-K_P)K_D}{A+K_D}\right\}. \tag{A18}$$

By Lemma 3, it follows that $\underline{n} < \bar{n}$. Q.E.D.

*Lemma 5.* For firms with $n < \underline{n}$ the optimal level of care $y < \bar{y}$. For firms with $n \geq \underline{n}$, the optimal level of care $y \geq \bar{y}$.

*Proof.* Define $L_N$ and $L_C$ as follows: $L_N = c(y,n) + \lambda(y)(fA - K_P)$ and $L_C = c(y,n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D$.

Consider the following auxiliary function

$$\Phi(n) = \{L_N(n,\bar{y}) - \min\{L_N(n,y)\}\} - [L_N(n,\bar{y}) - L_C(n,\bar{y})]. \tag{A19}$$

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

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

$$= \lambda(\bar{y})\frac{(fA-K_P)A}{A+K_D} \tag{A20}$$

is independent of $n$. The first part,

$$\{L_N(n,\bar{y}) - \min\{L_N(n,y)\}\} = L_N(n,\bar{y}) - L_N(n,y^*(n)) \tag{A21}$$

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. Q.E.D.

*Lemma 6.* For firms with $n \leq \bar{n}$ the optimal level of care $y \leq \bar{y}$. For firms with $n > \bar{n}$, the optimal level of care $y > \bar{y}$.

*Proof.* Define $L_N$ and $L_C$ as follows: $L_N = c(y,n) + \lambda(y)(fA - K_P)$ and $L_C = c(y,n) + \lambda(y)\frac{fA-K_P}{A+K_D}K_D$. The proof follows from the definition of $\bar{n}$. $\bar{y}$ is the interior minimum of the function $L_C(\bar{n},y)$. By Lemma 3, 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. Q.E.D.

*Proof of Proposition 3.* We will prove first the claim that a decrease in $f$ decreases the level of care, if the optimal level of care differs from the care standard $\bar{y}$.

Consider the case when the firm is negligent. Evaluating (A13) at $l = fA - K_P$ and totally differentiating it yields

$$c_{yy}(y,n)dy + \lambda''(y)[fA - K_P]dy + \lambda'(y)Adf = 0. \tag{A22}$$

Rearranging terms,

$$\frac{\partial y}{\partial f} = -\frac{A\lambda'(y)}{c_{yy}(y,n) + \lambda''(y)[fA - K_P]} > 0. \tag{A23}$$

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

Next 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

$$c_y(\underline{y}, \underline{n}) + \lambda'(\underline{y})[Af - K_P] = 0 \tag{A24}$$

and

$$c(\underline{y}, \underline{n}) + \lambda(\underline{y})[Af - K_P] = c(\bar{y}, \underline{n}) + \lambda(\bar{y})\frac{fA - K_P}{A + K_D}K_D, \tag{A25}$$

which implicitly define $\underline{n}$ and $\underline{y}$. Totally differentiating equation (A25), one gets

$$c_y(\underline{y}, \underline{n})d\underline{y} + c_n(\underline{y}, \underline{n})d\underline{n} + \lambda(\underline{y})Adf + \lambda'(\underline{y})(Af - K_P)d\underline{y} = c_n(\bar{y}, \underline{n})d\underline{n} + \lambda(\bar{y})A\frac{K_D}{A + K_D}df. \tag{A26}$$

By equation (A24), the first and the last terms of the left-hand side of equation (A26) add up to zero. Hence,

$$\left[\lambda(\underline{y}) - \lambda(\bar{y})\frac{K_D}{K_D + A}\right]Adf = (c_n(\bar{y}, \underline{n}) - c_n(\underline{y}, \underline{n}))d\underline{n} = c_{ny}(\tilde{y}, \underline{n})(\bar{y} - \underline{y})d\underline{n}. \tag{A27}$$

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 $\frac{\partial \underline{n}}{\partial f} < 0$.

Second, we will prove the claim 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

$$c_{yn}(\bar{y}, \bar{n})d\bar{n} + \lambda'(\bar{y})\frac{AK_D}{A + K_D}df = 0. \tag{A28}$$

Therefore,

$$\frac{\partial \bar{n}}{\partial f} = -\frac{c_{yn}(A+K_D)}{\lambda'(\bar{y})AK_D} < 0 \tag{A29}$$

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

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

$$\frac{\partial \mu(0)}{\partial f} = \int_{n\geq 0} \lambda'[y(n)]\frac{\partial y(n)}{\partial f}\phi(n)dn < 0 \tag{A30}$$

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

$$\mu(\underline{n}) = \int_{\underline{n}}^{n_m} \lambda(y(n))\phi(n)dn = \lambda(\bar{y})\int_{\underline{n}}^{n_m}\phi(n)dn = \lambda(\bar{y})(1-\Phi(\underline{n})), \tag{A31}$$

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 10) with respect to $f$, we obtain

$$\frac{\partial C_S}{\partial f} = \int_{n\geq 0} c_y(y,n)\frac{\partial y(n)}{\partial f}\phi(n)dn + H\frac{\partial \mu(0)}{\partial f} + \frac{A(K_P+K_D)}{A+K_D}\mu(\underline{n}) + \frac{fA(K_P+K_D)}{A+K_D}\frac{\partial \mu(\underline{n})}{\partial f}, \tag{A32}$$

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

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

Q.E.D.

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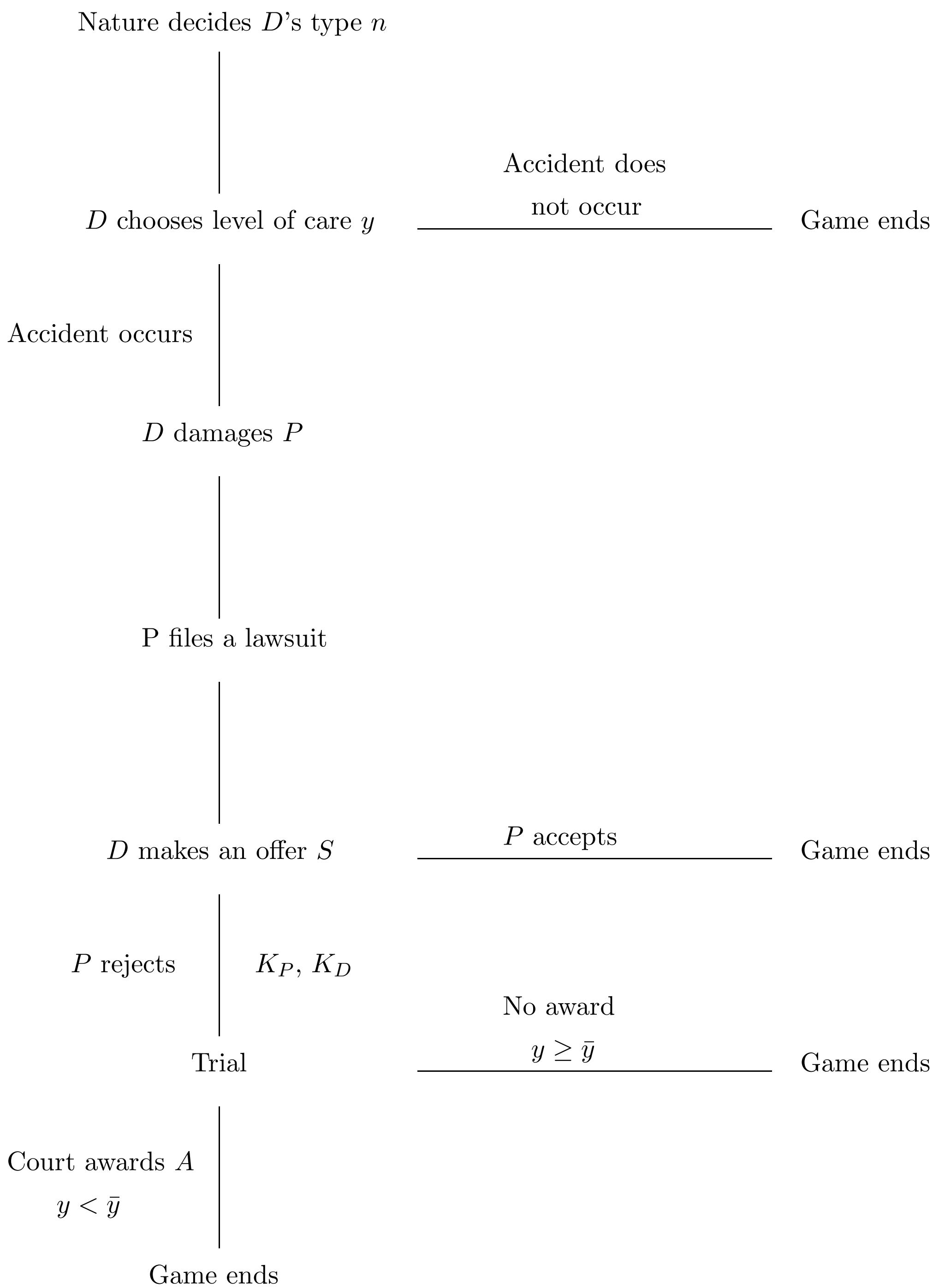
FIGURE 1
SEQUENCE OF EVENTS IN THE GAME




Note: $D$ = defendant, $P$ = plaintiff, $K_D$ = defendant's litigation costs, $K_P$ = plaintiff's litigation costs, $A$ = punitive damage award, $\bar{y}$ = negligence standard.

FIGURE 2
GENERIC TOTAL EXPECTED LOSS FUNCTION $L$

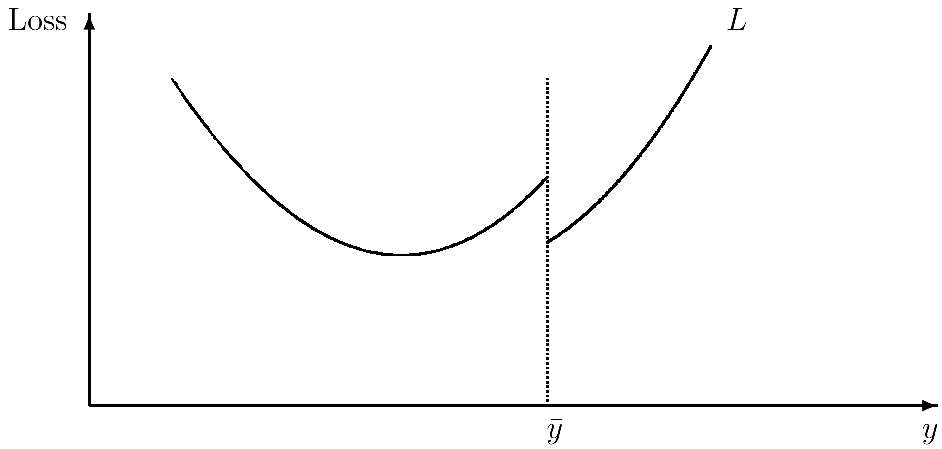


FIGURE 3
TOTAL EXPECTED LOSS FUNCTION $L$ FOR FIRM'S TYPE $\underline{n}$

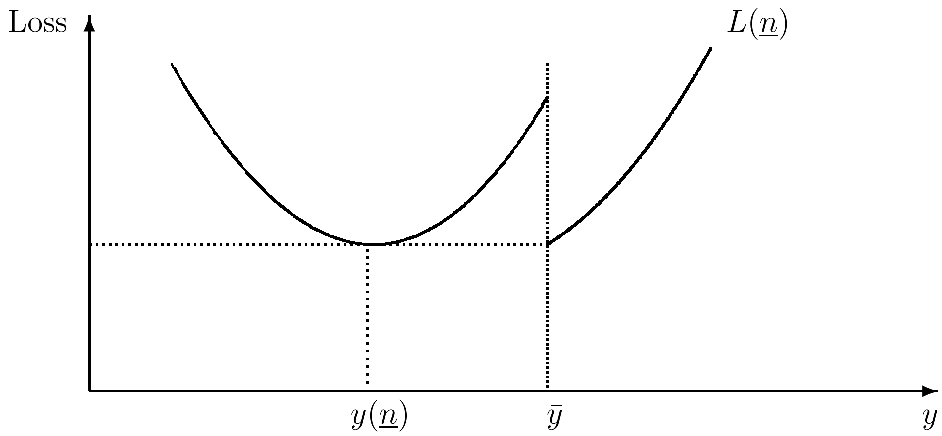


FIGURE 4
TOTAL EXPECTED LOSS FUNCTION $L$ FOR FIRM'S TYPE $\bar{n}$

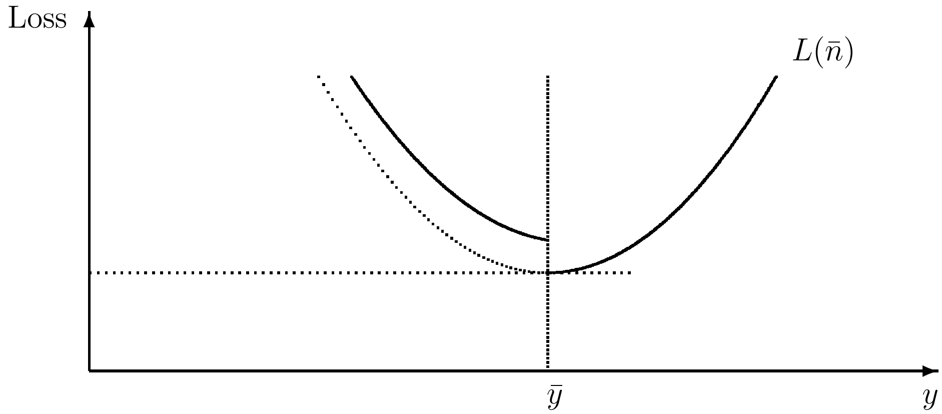


FIGURE 5
OPTIMAL LEVEL OF CARE AND EFFECT OF $f$