

Vicarious Liability: Negligence or Strict Liability*

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January 15, 2005

Abstract

We study how two rules of vicarious liability, strict liability and negligence affect the incentives to take precautions so as to avoid accidents from taking place. We argue that the negligence rule could lead to a better social outcome than the strict liability rule, not just because of increased incentives to induce more effort induced by the avoidance of liabilities, but also because it provides the principal with additional signals about the agent's actions. We conclude, however, that when courts are very likely to make a mistake in their rulings, then it might be better to rely on the strict liability rule.

1 Introduction

A major function of tort law is to induce agents to be cautious whenever their activities can cause damage to third parties. This function is achieved by making injurers liable for the damage caused, or at least for part of it, and thus, by making them internalize the potential social costs of their activities. Liabilities, however, tend to be imposed not just on the injurer, but also on any party that had the means to control the injurer's actions when the damage was caused. In this latter case, the responsibility is vicarious because even though one party's actions directly caused the damage, it is another one who can be liable for it. The branch of tort law that deals with these type of cases has become to be known as *vicarious liability*.

More formally, vicarious liability can be defined as the imposition of liability upon one party for a wrong committed by another one whenever that wrong was not ordered, authorized or encouraged by the former party¹. A quick review of some legal cases shows that, at least in the United States, courts tend to impose vicarious liability only whenever the liable party had the right and means to control the process by which the tort-feasor was acting upon when the wrong was committed².

*Preliminary and Incomplete.

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¹Adapted from Sykes (1984) and Sykes (1988).

²See for example: *i*) Crinkley v. Holiday Inns, Inc. (844 F.2d 156); *ii*) Martin v. McDonald's Corporation (572 N.E.2d 1073); *iii*) Parker v. Domino's Pizza (629 So. 2d 1026); *iv*) Ross v. Mobil Oil Corporation

This suggests that for vicarious liability to be applicable, it is required that *i*) the task that caused the damage be delegated on some agent; and that, *ii*) the party who delegated the task be able to exert some sort of control over the agent's actions. This situation is commonly found, for example, in corporations where the employers can be held liable for the harm that any of the employees can cause to a third party. In this case, the employment contracts designed by the owners are the means they have to control the employees' actions, for example, through clauses granting bonuses or imposing penalties in cases of good or bad performance.

As is well known, delegation of tasks may induce agents to choose actions that are not desirable for the employer and which cannot be directly controlled by the latter. This opportunistic behavior on the part of the employee -or *moral hazard* problem- has important effects on the contractual conditions to be set by the employer in order to be able to incentivize the employee to choose some desired action. It is the main purpose of this paper to study the effects these contractual conditions have on the employee's actions whenever the employer can be held vicariously liable for the wrongs of the latter.

The purpose of the paper will be pursued by assuming that the owner of a firm or employer (she) hires an employee (him) to perform a task that entails exerting some level of effort which is costly to the latter. This is done without loss of generality as the relation employer-employee can very well be replaced by the relation franchisor-franchisee, shareholder-manager or any other application of the principal-agent model. What's important is that the agent's task is valuable to the principal and that the she can be held liable for the wrongs of the agent. Also, the conclusions of this paper presume that the victim cannot recover an amount larger than the damage caused, therefore, our analysis is restricted to the cases where the injurers are *jointly liable* or *jointly and severally liable with contribution*.

As an example of vicarious liability, take the case *Crinkley v. Holiday Inns, Inc.* (844 F.2d 156) where the plaintiffs were awarded a total compensation of \$500,000 from the franchisor Holiday Inns, Inc. for damages they suffered while staying at a franchise of the defendant for considering that inadequate security was provided in those facilities.

1.1 Strict Liability and Negligence Rules

The imposition of liabilities has been subject to the usage of different criteria -or rules- by courts, being two of the most discussed ones the *strict liability rule* and the *negligence rule*³. Under the rule of strict liability the injurers are always liable for the harm caused to third

(173 A.D.2d 361); *v*) *Stevenson v. Rochdale Investment Management, Inc.*; *vi*) *Hong v. Dunkin' Donuts Inc.* (105 F. Supp. 2d 83); *vii*) *Greil v. Travelodge International, Inc.* (541 N.E.2d 1288).

³Other possibilities are the rules of no liability, negligence with a defense of contributory negligence, strict liability with contributory negligence, or comparative negligence.

parties regardless of the precautions that were initially taken to avoid it, while under the negligence rule, liability is only imposed whenever a reasonable level of precautions were not taken by the injurers.

The strict liability rule has the advantage of being easy to apply by courts, for it only requires the damage to be caused to turn the injurers to be liable. However, strict liability might also have the effect of reducing the incentives to be cautious, for even the most responsible party will be liable in case an injury is caused. On the contrary, the negligence rule has the disadvantage of requiring an investigation to determine the level of effort that was being exerted by the employee at the time the damage was caused. The possibility of being able to avoid paying liabilities, however, can be a powerful incentive for the employer to comply with the legal threshold.

The negligence rule, in addition, may also help reduce the information asymmetry between employer and employee. This is because the court's ruling when an accident takes place constitutes a signal that is correlated with the agent's effort. Merely, if the court declares the firm to be negligent, then this -probably- implies that the agent was exerting a low level of effort. Thus, this information, which is not available to the principal under the strict liability rule, might serve her to design a more complete contract and, therefore, to exert a better control on the agent's actions.

The legal threshold under the negligence rule is usually assumed to be the level of effort that minimizes social costs (i.e., the sum of expected damages and the cost of exerting effort). Determining the threshold adds the difficulty of requiring the court to have perfect information on the agent's cost of exerting effort, the damage caused to the third party, as well as the probability that the damage be caused. In addition, the court needs to be able to determine the level of effort that was being exerted by the employee and to compare it with the threshold. As courts don't usually have perfect information, the application of the negligence rule might end up imposing liabilities on non-negligent parties as well as waiving that responsibility from negligent parties. This additional uncertainty on the possibility of paying liabilities also does have an effect on the level of effort that will ultimately be exerted, as will be shown later.

As an example of the negligence rule consider the case of *Crinkley v. Holiday Inns, Inc.* where the court considered that "... defendants were negligent in providing inadequate (sic) security, and that such negligence caused the Crinkley's injuries.". However, in *Diffenderfer v. Staner* (722 A.2d 1103) the court initially found the defendants to be strictly liable following a principle from the Restatement (Second) of Torts⁴ for considering that the harm was caused by an *abnormally dangerous activity* carried by the plaintiff.

⁴ "One who carries on an abnormally dangerous activity is subject to liability for harm to the person, land or chattels of another resulting from the activity, although he has exercised the utmost care to prevent the harm." (§519)

1.2 Literature Review

Early works comparing liability rules model the injurer as a single individual and therefore moral hazard problems and vicarious liability play no role in them. The conclusions arrived under these conditions are suitable to analyze the incentives to exert effort on individuals who are not acting under other person's commands. This is the case, for example, of independent car drivers. The main conclusions in these cases are that the first best level of effort is achieved with the strict liability rule -Shavell (1980)- or with strict liability in the long run in a market setting -Polinsky (1980)-.

Incentives to exert effort in firms or corporations calls for the consideration of more than one individual as well as for the existence of asymmetric information between them. Also, having more than one individual that are somehow involved in the potential damage to a third party is what gives rise to the possibility of one of them being vicariously liable for the wrongs of the other. In this line of argument, Sykes (1984) and (1988) explicitly deals with vicarious liability and describes the potential effects of moral hazard.

Newman and Wright (1990) model a principal-agent relation and conclude that the strict liability rule induces a socially optimal level of effort either under the presence or absence of moral hazard. Their conclusions are contingent, however, on a different definition of a socially optimal level of effort than the one we consider here. Specifically, different socially optimal levels of effort are considered either under the presence of moral hazard or on its absence. In addition, their conclusions are also based on having a risk averse agent with unlimited assets. Newman and Wright (1992) use these same assumptions to compare the strict liability and the negligence rules. In here they use different legal thresholds for the application of the negligence rule depending on the presence, or not, of moral hazard. They conclude that the choice of liability rules may affect the level of effort exerted by the agent, being the effort exerted under strict liability larger or smaller than the one exerted under the negligence rule, depending on where the court sets the threshold. They also conclude that the principal will choose to comply with the threshold whenever it is set at the level that would be exerted under the strict liability rule.

Polinsky and Shavell (1993) consider the case of an agent with limited assets and conclude that the imposition of criminal sanctions on them might be beneficial to society, because these sanctions may serve as a way to impose a more stringent punishment on agents than just by extracting all of their assets and therefore may serve as a way to incentivize them to exert a socially optimal level of effort.

Arlen (1994) studies the application of criminal liabilities in a corporate environment. Her conclusions lean towards the application of a negligence standard as an efficient way to induce corporations to take an optimal level of effort. Chu and Qian (1995) consider the case of vicarious liability under the negligence rule whenever the principal holds the evidence for the agent's liability. Their main conclusion is that an inefficient outcome is achieved due to the incentives that the principal has to hide evidence for the agent's liability

so as to avoid being liable herself. In this regard, they conclude that it might be desirable to set the due care standard of the negligence rule below the first best level.

The work of Demougin and Fluet (1999) is more similar to ours in the sense that they consider the socially optimal level of effort to be the one that minimizes social costs, the agent is risk neutral and is also protected by a limited liability constraint. The main conclusion of this paper is that the negligence rule cannot do worse than the strict liability one either under the presence of moral hazard or adverse selection, whenever the legal threshold is set at the socially optimal level of effort and whenever the activity level is exogenously determined.

More recently, Garmon (2001) compares personal and vicarious liability under a strict liability rule whenever the agent has specialized skills. Mattiachi and Parisi (2003) analyze the incentives to exert effort and to reduce monitoring costs under different schemes like vicarious liability, secondary liability and mandatory insurance. One of their conclusions is that the presence of strict liability might lead to a risk of an excessive level of effort being exerted. Contrary to ours, this analysis, however, assumes that the agent always gets a payoff equal to his reservation utility and therefore the possibility of economic rents are not considered. Furthermore, it is assumed that the agent always complies with the level of effort the principal desires and therefore moral hazard problems are not relevant.

In the present study we seek to resemble the case of a firm where the activity level is taken as given and where the agent has insufficient assets to cover the compensatory damages to be paid to the victim in case an accident takes place. We start solving for the social optimum level of effort and then compare the level of effort exerted either under strict liability or negligence whenever the courts never make a mistake in their rulings. Later we also add this possibility to the model, so that the court does not perfectly observe actual induced levels of effort or the due care standard, which leads to the possibility of having non negligent parties being legally liable and vice versa.

2 A Model for Vicarious Liability

We consider a firm whose owner (the principal) hires a worker (the agent) to perform a duty that entails exerting some level of effort which is costly to the agent. The agent's cost of exerting level of effort $e \in [0, \bar{e}]$ is $\Psi(e)$, where Ψ is a strictly increasing and convex function ($\Psi' > 0$, $\Psi'' > 0$) such that $\Psi(0) = \Psi'(0) = 0$. The worker's duty generates fixed gross revenues R to the firm⁵ but might also cause an accident with probability $p(e) \in (0, 1)$ where p is strictly decreasing and convex in the level of effort exerted by the agent ($p' < 0$, $p'' > 0$) such that $\lim_{e \rightarrow \bar{e}} p'(e) = 0$.⁶ We also require $p(\cdot)$ and $\Psi(\cdot)$ to be continuous on $[0, \bar{e}]$

⁵We assume R is sufficiently large such that the firm's profits are always positive.

⁶For some results shown later in the paper we also require the following sufficient conditions: $\Psi''' \geq 0$ and $p''' \geq 0$.

at least up to the second derivative. In case of an accident occurring a third party will be affected and the firm might have to incur into a loss of L due to compensatory damages to be paid to the third party. We assume that the third party cannot unilaterally avoid suffering the damages of the possible accident.

We further assume a moral hazard environment in which effort is not a contractible variable, therefore, in return for his services, the owner agrees to pay the worker a salary contingent on some observable variable like, for example, the occurrence of an accident. It is also assumed that both owner and worker are risk neutral and that the latter is protected by a limited liability constraint which guarantees that he will always get a non negative salary. Finally, it is also assumed that the worker's expected utility function is concave in effort for any given salary structure and that his outside option gives him a payoff of zero.

The timing of the model is as follows, at time $t = 0$, the owner designs an incentive compatible contract which is accepted by the worker; at $t = 1$ the worker performs his duty exerting some level of effort e ; at $t = 2$ an accident occurs with probability $p(e)$ and the firm's revenues R are realized. If an accident occurs, at $t = 3$ a court of law decides whether, or not, to impose vicarious liability upon owner and worker. Finally, at $t = 4$ the contract is executed and damages L is paid to the third party in case the court imposes vicarious liability upon the parties. We assume there is no time discounting.

2.1 The First Best

Assuming that the firm's activities are desirable for the society, then the first best or social optimum solution is achieved when the social costs associated to the firm's activities are minimized. These social costs are equal to the cost of exerting effort plus the third party's expected loss; i.e., $\Psi(e) + p(e)L$. Given the assumptions on Ψ and p , a unique first best level of effort (e^{fb}) minimizes this expression and is implicitly defined by $\Psi'(e^{fb}) = -p'(e^{fb})L$.

2.2 The Strict Liability Rule

In this section we consider the case whenever an accident occurring implies that the firm's owner and worker will be liable for the damages caused to the third party regardless of the level of effort that the owner originally induced or that the worker actually exerted. Under these circumstances, an accident occurring, or not, are the only verifiable events the firm's owner can use to condition the worker's salary. We denote the salary as \underline{t} whenever an accident takes place and \bar{t} otherwise, so that for a given contract (\underline{t}, \bar{t}) the worker chooses the level of effort that gives him the maximum expected utility. That is, the worker's problem is to:

$$\max_e p(e)\underline{t} + (1 - p(e))\bar{t} - \Psi(e)$$

which yields the first order condition:

$$p'(e) (\underline{t} - \bar{t}) = \Psi'(e). \quad (1)$$

Since p' is strictly negative and Ψ' is strictly positive, this first order condition can only be satisfied as long as $\underline{t} < \bar{t}$. This result also guarantees that the second order condition $p''(e) (\underline{t} - \bar{t}) < \Psi''(e)$ is satisfied.

On the other hand, the firm's owner looks forward to design a worker's-acceptable contract (\underline{t}, \bar{t}) that maximizes her expected payoff while inducing the worker to exert the level of effort desired by her. In other terms, the owner's problem is to:

$$\begin{aligned} & \max_{e, \underline{t}, \bar{t}} p(e) (R - \underline{t} - L) + (1 - p(e)) (R - \bar{t}) \\ & \text{subject to:} \\ & p(e)\underline{t} + (1 - p(e))\bar{t} - \Psi(e) \geq 0 \quad (\text{PC}) \\ & e \in \arg \max_{e'} p(e')\underline{t} + (1 - p(e'))\bar{t} - \Psi(e') \quad (\text{IC}) \\ & \underline{t} \geq 0, \bar{t} \geq 0. \quad (\text{LL}) \end{aligned}$$

In what follows we will denote the solution to this particular problem with the superscript 'sl', so that the level of effort exerted under the strict liability rule is e^{sl} . The following proposition summarizes one of the main implications of this problem.

Proposition 1 *Compared to the first best solution, the strict liability rule leads to an underprovision of effort (i.e., $e^{sl} < e^{fb}$).*

When a certain level of effort can't be enforced for being unobservable, owner's and worker's objectives can only be aligned by having the worker bear some risk. In our model, this risk arises because the worker is rewarded with a positive salary only if an accident does not take place. If it does take place, the owner would need to severely punish the worker to achieve objectives alignment, but she is limited in doing so, because the worker has no assets. Hence, the best the owner can do is to promise to apply the most stringent feasible punishment if an accident takes place (i.e., no payment at all) and to give him a high compensation if it does not take place.

It is easy to check that if there were no information asymmetry between the owner and the worker (and therefore effort were a contractible variable), then the first best level of effort would be achieved and the worker would earn an expected compensation equal to his cost of exerting that level of effort. With moral hazard and a judgment proof worker, however, an inefficient alignment of objectives is reached, because the owner has to guarantee a positive expected rent to the worker. In our model this rent is equivalent to $-(1 - p(\cdot)) \frac{\Psi'(\cdot)}{p'(\cdot)} - \Psi(\cdot)$, expression which is positive and strictly increasing for all levels of effort, thus, having the effect of reducing the principal's incentives to induce an optimal level of effort.

From a social perspective the effort exerted with moral hazard and a judgment proof agent is suboptimal because at e^{sl} the marginal benefit of effort ($-p'L$) is larger than the marginal cost of exerting it (Ψ'), so that a higher level of effort is desirable, thus, leading to a deadweight loss.

2.3 The Negligence Rule without Judicial Error

If the court in charge of the tort case between the firm and the affected party considers that the former should be liable only if some minimal level of effort was not being exerted by the agent once the accident occurred, then we are in the presence of an application of a negligence rule. The applicability of this rule depends on the court being able to determine the level of effort that the worker was exerting when performing the delegated task and on being able to compare it with some negligence threshold or due care standard level which we will consider to be the first best level of effort (e^{fb}). In this section we will assume that the court can either perfectly observe the level of effort that was exerted by the worker or that she can observe the contract celebrated by both parties, thus being able to infer the level of effort the worker was induced to exert.

Under the negligence rule there are three verifiable states of the world that the principal can use to condition the worker's salary. These states are: *i*) whenever an accident does not occur; *ii*) whenever an accident occurs but the court considers the firm should not be liable; and, *iii*) whenever the firm has to pay compensatory damages as a result of an accident taking place. We will denote the worker's salary in each of these states as \bar{t} , \hat{t} and \underline{t} , respectively.

As we mentioned in the introduction, the negligence rule allows the principal to condition the agent's salary on an event that is not available under the strict liability rule; this event being an accident occurring but not being declared negligent. This additional event might be of use for the principal to design a better contract, because it can potentially provide her with additional information about the level of effort exerted by the agent.

The application of the negligence rule gives the principal the possibility whether to design a contract that induces the agent to comply with the due care standard or not. In each of these cases the principal's maximization problem will be different, because liabilities L can only be incurred if she decides to design a contract that does not induce the agent to comply with the standard and because the worker's salaries in case of an accident occurring (\hat{t} and \underline{t}) enter the maximization problem in a different manner, as shown below:

a) If the principal induces a level of effort below the standard ($e < e^{fb}$)

$$\max_{e, \bar{t}, \hat{t}, \underline{t}} p(e)(R - \underline{t} - L) + (1 - p(e))(R - \bar{t})$$

subject to:

$$\begin{aligned} p(e)\underline{t} + (1 - p(e))\bar{t} - \Psi(e) &\geq 0 \\ p(e)\underline{t} + (1 - p(e))\bar{t} - \Psi(e) &\geq p(e')\underline{t} + (1 - p(e'))\bar{t} - \Psi(e') \quad \forall e' < e^{fb} \\ p(e)\underline{t} + (1 - p(e))\bar{t} - \Psi(e) &\geq p(e'')\hat{t} + (1 - p(e''))\bar{t} - \Psi(e'') \quad \forall e'' \geq e^{fb} \end{aligned}$$

b) If the principal induces a level of effort above the standard ($e \geq e^{fb}$)

$$\max_{e, \bar{t}, \hat{t}, \underline{t}} p(e)(R - \hat{t}) + (1 - p(e))(R - \bar{t})$$

subject to:

$$\begin{aligned} p(e)\hat{t} + (1 - p(e))\bar{t} - \Psi(e) &\geq 0 \\ p(e)\hat{t} + (1 - p(e))\bar{t} - \Psi(e) &\geq p(e')\underline{t} + (1 - p(e'))\bar{t} - \Psi(e') \quad \forall e' < e^{fb} \\ p(e)\hat{t} + (1 - p(e))\bar{t} - \Psi(e) &\geq p(e'')\hat{t} + (1 - p(e''))\bar{t} - \Psi(e'') \quad \forall e'' \geq e^{fb} \end{aligned}$$

The first constraint in each of these two problems denotes the respective agent's participation constraint while the second and third sets of constraints denote the incentive compatibility constraints. For simplicity the limited liability constraints are not shown. A difficulty with this set-up is dealing with the infinite number of incentive compatibility constraints that are specified. Lemma 1 in the Appendix however, shows, for a more general setting, that these sets of constraints can be reduced to two single conditions for each case.

If effort were observable, then the agent's participation constraint would bind, so that the principal's expected cost would be $pL + \Psi$ if she chooses not to comply and Ψ otherwise. Thus, if effort were observable, then the first best level of effort would always be exerted.

When effort is unobservable we get that:

Proposition 2 *Under the negligence rule with no judicial error, either the first best (e^{fb}) or the level of effort implied by the strict liability rule (e^{sl}) is implemented; whichever leads to lower expected costs to the principal.*

An immediate implication of this proposition is that:

Corollary 1 *If there's no possibility of judicial error, then the negligence rule performs -weakly- better than the strict liability rule.*

The negligence rule, by relieving the possibility of having to pay liabilities even if an accident takes place, can serve as a powerful incentive to have the first best level of effort implemented. If the principal chooses not to comply with the legal threshold or due care standard, then her problem is equivalent to the one faced under the strict liability rule

and therefore her best response is to induce e^{sl} . Complying with the threshold requires the principal to give the agent a higher compensation, in exchange for which, she will be relieved from paying liabilities in case an accident takes place, so that the principal faces a trade off between avoiding liabilities and giving the agent a larger rent. Thus, the principal will comply with the legal standard if and only if the reduction in expected liabilities is at least as large as the expected salary increase required to induce compliance.

The negligence rule can have two potential beneficial effects. On one hand, as described above, it can help as a way to have the first best level of effort implemented by relieving the liability burden on the firm. On the other hand, by creating a new verifiable event on which the agent's compensation can be conditioned, it may also serve as a way to reduce the information asymmetry between principal and agent and therefore to reduce the inefficiency generated by the moral hazard environment with limited liability constraints. Our results, however, show that whenever there's no judicial error, then all the gains come from the liability burden relief.

To see this, suppose the principal does not use the court's ruling to condition the agent's salary and, instead designs the following contract: *i*) salary equal to \underline{t} if an accident occurs (regardless of negligence); and, *ii*) salary equal to \bar{t} if no accident occurs. The optimal transfers for this contract are $\underline{t} = 0$ and $\bar{t} = -\frac{\Psi'(\cdot)}{p'(\cdot)}$ where \bar{t} is to be evaluated at e^{sl} or e^{fb} depending on whether it is convenient for the principal to comply with the legal standard for the level of effort. These transfers yield the same payoff at optimum for both the principal and the agent as whenever the agent's salary is also conditioned on the court's ruling. Following Holmström (1979), this implies that the additional signal about the agent's effort obtained from the court's ruling is not valuable and, therefore, not informative.

This is so because if the principal decides not to induce compliance from the agent, then she already knows that negligence will be declared for sure if an accident takes place since, under this setting, the court never makes a mistake. A similar conclusion holds for the case where the principal decides to induce compliance. In other words, because the court never makes a mistake, then an accident occurring contains all the relevant information about the agent's actions.⁷

In short, the negligence rule without judicial error does not provide any new information about the agent's effort than the strict liability rule. This implies that the agent must obtain a positive ex ante rent, either if the legal standard is being complied or not. At the optimum this rent equals $-(1 - p(\cdot))\frac{\Psi'(\cdot)}{p'(\cdot)} - \Psi(\cdot)$, expression to be evaluated at e^{fb} or e^{sl} , depending on whether the principal has chosen to comply with the legal standard or not, respectively. Since, this expression is strictly increasing in effort, the agent gets a larger rent whenever the principal chooses to induce e^{fb} .

⁷Or equivalently, under this setting, an accident is a sufficient statistic for an accident plus the court's ruling.

Even though the negligence rule without judicial error might lead to a higher expected rent to the agent, from a social perspective this rule performs equally or better than strict liability, because the level of effort implemented is always going to be at least e^{sl} , implying that the deadweight loss is never larger than the one implied by the strict liability rule.

2.4 The Negligence Rule with Possible Judicial Error

The results in the previous section have been derived assuming that the court in charge of the tort case can perfectly determine the level of effort implemented in the firm and that this level of effort can be directly compared to the first best. In this section we modify the analysis by assuming that the court does not have perfect information, implying that it could very well ‘make a mistake’ when deciding the outcome of a case. In other words, in case of an accident taking place, there is a chance for the firm to be declared negligent even though the due care level of effort was being complied, or for the firm not having to pay damages even though the level of effort exerted was below the due care standard.

We add this possibility to the model by including a new variable $q(e)$ which denotes the probability of the firm being declared negligent if an accident occurs whenever level of effort e is being exerted. This variable is continuous at least up to the second derivative on $[0, \bar{e}]$ and is such that $q(e) \in (0, 1)$, $q' < 0$, $q'' > 0$ and $\lim_{e \rightarrow \bar{e}} q'(e) = 0$; that is, higher levels of effort reduce the probability of being declared negligent at a decreasing rate. In this section we also assume that the principal’s cost function is strictly concave in effort.⁸

It is worth noting that, as opposed to the perfect information case, conditional on an accident occurring, the probability of being declared negligent (q) is negatively correlated with the level of effort exerted by the agent. Therefore, in this case, the application of the negligence rule might potentially provide the principal with an additional informative signal of the agent’s actions. In other words, the negligence rule allows the principal to condition -on an ex ante stage- the agent’s salary on the court’s decision, possibility which is not available under the strict liability rule and which may lead to a more efficient alignment of objectives. Using the same notation as in the previous section for the salaries, the principal’s maximization problem becomes:

$$\max_{e, \hat{t}, \underline{t}, \bar{t}} p (q(R - \underline{t} - L) + (1 - q)(R - \hat{t})) + (1 - p)(R - \bar{t})$$

subject to:

$$pqt + p(1 - q)\hat{t} + (1 - p)\bar{t} - \Psi \geq 0 \tag{PC1}$$

$$(p'q + pq')\underline{t} + (p' - p'q - pq')\hat{t} - p'\bar{t} = \Psi' \tag{IC1}$$

$$\underline{t} \geq 0, \hat{t} \geq 0, \bar{t} \geq 0. \tag{LL1}$$

⁸The addition of this new variable serves to consider either the case when the court fails to perfectly observe the level of effort implemented in the firm or the case when the court does not exactly know the level of effort at the first best.

The incentive compatibility constraint is the first order condition of the agent's maximization problem. Also, to avoid unnecessary clutter, the argument on the p and q functions has been suppressed.

We note that in this case, even if there were no information asymmetry between the principal and the agent, the first best level of effort might not end up being attained. In fact, if effort were a contractible variable the level of effort to be implemented is implicitly defined by $-(p'q + pq')L = \Psi'$. This implies that the level of effort could fall above or below the first best, depending on how the ex ante or unconditional probability of not being declared negligent responds to changes in effort.

Specifically, if at the first best level of effort $\frac{d}{de}[p(1-q)] > 0$, then inducing more effort leads a higher chance of being relieved from paying liabilities, so that it is worth inducing a higher level of effort. Similarly, whenever at e^{fb} , $\frac{d}{de}[p(1-q)] < 0$, increasing effort leads to higher expected liabilities, so that the principal's best response is to choose a level of effort that is below the first best. The first best level of effort is only attained whenever there are no expected gains or losses from not having to pay liabilities in case an accident takes place; that is, whenever $\frac{d}{de}[p(1-q)] = 0$, implying that marginal savings from effort are equal under strict liability or under the negligence rule.

The main results whenever effort is unobservable is summarized in the following proposition:

Proposition 3 *When there's possible judicial error, the properties of the optimal contract induced by the negligence rule are:*

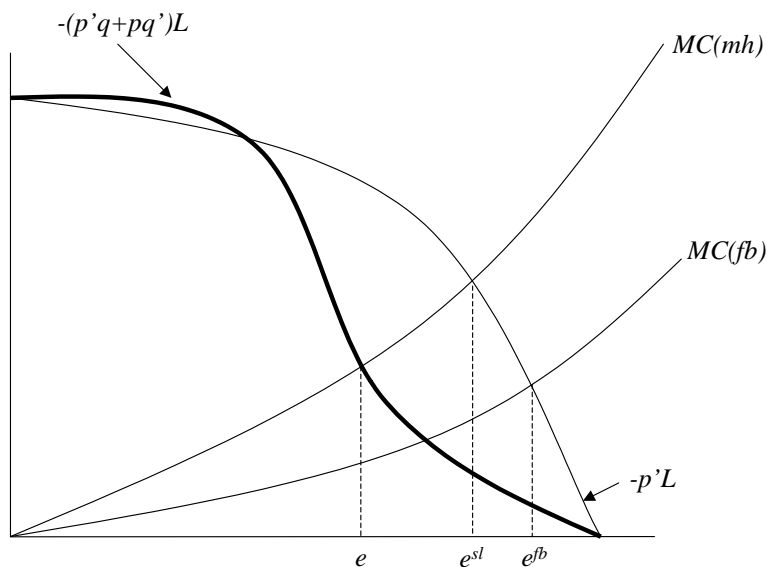
<i>If $\frac{d}{de}[p(1-q)] < 0$</i>	<i>If $0 < \frac{d}{de}[p(1-q)] < -p^2q'$</i>	<i>If $\frac{d}{de}[p(1-q)] > -p^2q'$</i>
$\bar{t} > 0$	$\bar{t} > 0$	$\hat{t} > 0$
$\underline{t} = \hat{t} = 0$	$\underline{t} = \hat{t} = 0$	$\underline{t} = \bar{t} = 0$
$e < e^{sl} < e^{fb}$	$e = e^* > e^{sl}, e^* \geq e^{fb}$	$e > e^* > e^{sl}, e \geq e^{fb}$

Above we saw that when the agent's actions were observable, the equilibrium level of effort depended on the sign of $\frac{d}{de}[p(1-q)]$. Particularly, if $\frac{d}{de}[p(1-q)] < 0$, then the level of effort fell below the first best and viceversa. With unobservable effort, the optimum also depends on the sign of $\frac{d}{de}[p(1-q)]$, but here the deviations are from the level of effort exerted under the strict liability rule (e^{sl}) rather than from the first best (e^{fb}).

Intuitively, $\frac{d}{de}[p(1-q)]$ measures how likely the court is to make a mistake in favor or detriment of the defendants. To see this, suppose e^{sl} is being exerted so that if an accident occurs then negligence should be declared with certainty. But if $\frac{d}{de}[p(1-q)]$ is negative, then lower levels of effort than e^{sl} induce a higher probability of not being declared negligent, meaning that the court is likely to declare non negligence when it should be really declaring negligence; in other words, the court is likely to make a mistake in favor of the defendants. Also, as not being declared negligent if an accident occurs is the best possible

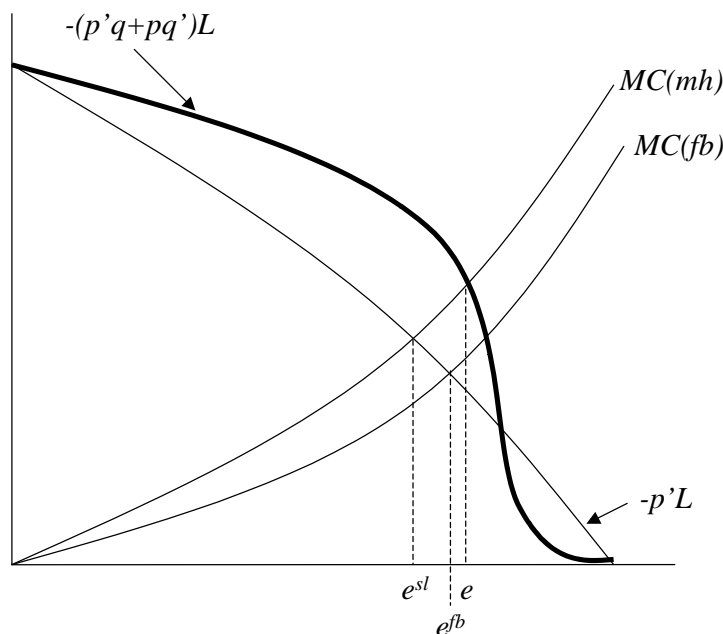
state of the world for the principal, then she will try to induce a level of effort that increases the likelihood of this event from taking place, so that if $\frac{d}{de} [p(1 - q)]$ is negative, then the equilibrium level of effort will fall below the first best.

Since the principal's savings from exerting more effort are $-pqL$, while her costs are $-(1-p)\frac{\Psi'}{p'}$, then $\frac{d}{de} [p(1 - q)] < 0$ implies that a change in effort will have a more significant effect on costs than on revenues, so that her best response is to induce a level of effort below e^{sl} . The following diagram depicts this case:



In the picture above the level of effort exerted at optimum results from the intersection of the principal's marginal revenue curve, $-(p'q + pq')L$, with the marginal cost curve under moral hazard, $MC(mh)$. We readily see that because at e^{sl} , $\frac{d}{de} [p(1 - q)] < 0$, then marginal costs would be higher than marginal savings and therefore it is optimal to induce a lower level of effort than e^{sl} .

Similarly, if $\frac{d}{de} [p(1 - q)]$ is positive then the court is more likely to make a mistake in detriment of the defendants by falsely declaring negligence. This induces larger levels of effort than e^{sl} , but if $\frac{d}{de} [p(1 - q)]$ takes on large positive values, then an inefficiently high level of effort that falls above the first best will be exerted because the court is just too likely to make a mistake. The following figure illustrates this case:



This discussion serves to justify that:

Corollary 2 *The negligence rule can lead to a poorer performance than the strict liability rule if the court is likely to make a mistake in its ruling.*

Despite this conclusion, because the probability of not being declared negligent is correlated to the level of effort, this event can reveal valuable information about the agent's performance and, thus, can serve to get a better outcome. To see why this is so, we need to analyze what each of the possible states of the world tells us about the level of effort exerted by the agent.

Since the contract is designed before the occurrence of an accident is realized, the principal only takes into account the unconditional probability of being declared negligent -or not negligent- by the court of law. The unconditional probability of being declared negligent, pq , and the conditional one, q , are both decreasing in effort. In this sense, if the agent is exerting a high level of effort, then the likelihood of being declared negligent should be small, so that the event of the court declaring negligence is more likely to occur whenever the agent is exerting a low level of effort. Thus, being declared negligent constitutes a reliable signal that the agent was exerting a low level of effort and, therefore, this event is always useful for the principal to condition the agent's salary. Similarly, an accident not occurring is always a good indicator of high levels of effort.

This is not necessarily the case with the probability of being declared non negligent, however. Indeed, even though, conditional on an accident occurring, the probability of

being declared non negligent, $1 - q$, is increasing in effort, this effect can be reversed viewed from an ex ante stage, because this event will only be observed if an accident takes place. That is, being declared non negligent is an indicator of a high level of effort, but non negligence can only be declared after an accident takes place, which is in itself an indicator of a low level of effort. This conflict limits the reliability of the event being declared non negligent, because it can very well indicate that a high or low level of effort was being exerted when the accident occurred.

Specifically, when $\frac{d}{de} [p(1 - q)] < 0$, an accident occurring is indicative of a low level of effort regardless of the court's ruling, so that the principal gets no compensation even if non negligence is declared. Also, even though when $0 < \frac{d}{de} [p(1 - q)] < -p^2q'$, not being declared negligent indicates a high level of effort, however, this event is not as informative as no accident taking place because the likelihood ratio of this last event is larger than the former, so that the agent gets no compensation in the former case; this last statement is reversed whenever $\frac{d}{de} [p(1 - q)] > -p^2q'$.

Given that the main results of this section depend on how the unconditional probability of not being declared negligent changes with effort, it is worthwhile mentioning the factors that may affect these changes. In general, the sign and magnitude of $\frac{d}{de} [p(1 - q)]$ depends on whether the likelihood of an accident occurring is more or less sensitive to the likelihood of being declared non negligent. For example, if by increasing the level of effort, the probability of being declared non negligent significantly increases while the probability of an accident occurring has a slight response to it, then $\frac{d}{de} [p(1 - q)]$ will be positive.

Since $\frac{d}{de} [p(1 - q)] \equiv p'(1 - q) - pq'$, then sufficient conditions for it to be positive is that p' be small and q' be large (both in absolute value). Intuitively, p' being small serves to guarantee that an increase in effort will not severely preclude the possibility of an accident occurring -event which constitutes a necessary condition for being declared non negligent-, while q' being large guarantees that the court will find the evidence convincing enough to declare non negligence.

From a social point of view, our results show that the decision to implement the negligence rule should be made taking into account the sign of $\frac{d}{de} [p(1 - q)]$. For instance, a necessary condition to get a better outcome than under the strict liability rule is that $\frac{d}{de} [p(1 - q)]$ be positive, so that the possibility of not having to pay liabilities in case an accident takes place incentivizes the principal to induce a level of effort that is higher than under strict liability. However, if $\frac{d}{de} [p(1 - q)]$ takes on a large value, then the savings from potential liabilities will exceed expected salaries to be paid, so that the principal will tend to induce a level of effort that falls above the first best, thus leading to a suboptimal outcome.

3 Concluding Remarks

We have analyzed how the strict liability rule and the negligence rule induce incentives to exert effort on economic agents so as to avoid accidents from taking place. The analysis has

been made not just by taking into account the monetary incentives implied by each rule, but also by considering the information revealed by each rule about the agent's actions. Specifically, we have seen that the negligence rule by providing an event that is not available under the strict liability rule (*i.e.*, an accident taking place but not having to pay damages), might provide the principal with an informative signal about the agent's actions which can be used to design a more efficient contract, thus possibly leading to an outcome that is closer to the social optimum.

Previous analyses about these liability rules either explicitly or implicitly suppose that the court in charge of determining negligence never makes a mistake in assigning damages for a given level of effort exerted and for a given first best of it. Whenever this assumption is relaxed, the general conclusion that the negligence rule weakly dominates the strict liability rule no longer holds. In fact, we find that strict liability dominates negligence whenever the court is likely to make a mistake in benefit or detriment of the defendants. For example, when the court is very likely to make a mistake in detriment of the defendants, the inefficiency arises as the result of a highly undesirable level of effort exerted in equilibrium. Thus, whenever courts are highly inefficient determining liabilities, then society would be better off by relying on a rule that does not depend on the court's abilities, but only on the state of the world that realized, merely by relying on a strict liability rule.

4 Appendix

Lemma 1 *For an induced level of effort e such that $e < e^{fb}$, the set of incentive compatibility constraints:*

$$\begin{aligned} p(e)\underline{t} + (1 - p(e))(\bar{t} + w) - \Psi(e) &\geq p(e')\underline{t} + (1 - p(e'))(\bar{t} + w) - \Psi(e') & \forall e' < e^{fb} \\ p(e)\underline{t} + (1 - p(e))(\bar{t} + w) - \Psi(e) &\geq p(e'')(\widehat{t} + w) + (1 - p(e''))(\bar{t} + w) - \Psi(e'') & \forall e'' \geq e^{fb} \end{aligned}$$

leads to the same solution as the following conditions:

$$\begin{aligned} p'(e)(\underline{t} - \bar{t} - w) &= \Psi'(e) \\ \widehat{t} &\leq \bar{t} + \frac{1}{p(e^{fb})} \left[p(e) \frac{\Psi'(e)}{p'(e)} - \Psi(e) + \Psi(e^{fb}) \right]; \end{aligned} \quad (2)$$

while for a level of effort e such that $e \geq e^{fb}$, the set of incentive compatibility constraints:

$$\begin{aligned} p(e)(\widehat{t} + w) + (1 - p(e))(\bar{t} + w) - \Psi(e) &\geq p(e')\underline{t} + (1 - p(e'))(\bar{t} + w) - \Psi(e') & \forall e' < e^{fb} \\ p(e)(\widehat{t} + w) + (1 - p(e))(\bar{t} + w) - \Psi(e) &\geq p(e'')(\widehat{t} + w) + (1 - p(e''))(\bar{t} + w) - \Psi(e'') & \forall e'' \geq e^{fb} \end{aligned}$$

leads to the same solution as the following conditions:

$$\begin{aligned} p'(e)(\widehat{t} - \bar{t}) &= \Psi'(e) \\ \underline{t} &\leq \bar{t} + w + \frac{1}{p(e^{fb})} \left[p(e) \frac{\Psi'(e)}{p'(e)} - \Psi(e) + \Psi(e^{fb}) \right]. \end{aligned} \quad (3)$$

Proof. First suppose the principal wants to induce a level of effort e such that $e < e^{fb}$. In this case, to have a stable level of effort e in $[0, e^{fb})$, the principal has to structure \underline{t} and \bar{t} such that the agent's utility function $p\underline{t} + (1-p)(\bar{t} + w) - \Psi$ is decreasing at e^{fb} . This implies that e satisfies the first order condition $p'(e)(\underline{t} - \bar{t} - w) = \Psi'(e)$ and thus $\underline{t} = \frac{\Psi'}{p'} \Big|_e + \bar{t} + w$. Therefore, if the agent complies with the principal's desire for e , his utility at optimum is $U_a^C = p \frac{\Psi'}{p'} + \bar{t} + w - \Psi \Big|_e$. If the agent does not comply with the principal's desire and exerts $e_a \geq e^{fb}$, then for a given salary structure (\hat{t}, \bar{t}) , $e_a = \arg \max_{e \geq e^{fb}} [p(\hat{t} + w) + (1-p)(\bar{t} + w) - \Psi]$. If $e_a \geq e^{fb}$ and $p'(e_a)(\hat{t} - \bar{t}) = \Psi'(e_a)$ then the agent's utility from not complying is $U_a^{NC} = p \frac{\Psi'}{p'} + \bar{t} + w - \Psi \Big|_{e_a}$, so that in this case $U_a^{NC} < U_a^C$ implying that the agent is incentivized to comply. On the other hand, if $e_a = e^{fb}$ and $p'(e^{fb})(\hat{t} - \bar{t}) < \Psi'(e^{fb})$, then $\hat{t} = \frac{\Psi'}{p'} \Big|_{e^{fb}} + \bar{t} + \Delta \hat{t}$, where $\Delta \hat{t} > 0$. In this latter case, the agent is incentivized to comply with $e < e^{fb}$ only if $\hat{t} \leq \bar{t} + \frac{1}{p(e^{fb})} [p(e) \frac{\Psi'(e)}{p'(e)} - \Psi(e) + \Psi(e^{fb})]$.

Now suppose the principal induces level of effort e such that $e \geq e^{fb}$. Using similar reasoning as when $e < e^{fb}$ it can be shown that if \underline{t} and \bar{t} are structured such that $p\underline{t} + (1-p)(\bar{t} + w) - \Psi$ is decreasing at e^{fb} , then the agent can only be incentivized to comply if $e = e^{fb}$ and $\hat{t} \geq \bar{t} + \frac{1}{p(e^{fb})} [p(e_a) \frac{\Psi'(e_a)}{p'(e_a)} - \Psi(e_a) + \Psi(e^{fb})]$, where e_a satisfies $p'(e_a)(\underline{t} - \bar{t} - w) = \Psi'(e_a)$. On the other hand, if \underline{t} and \bar{t} are such that $p\underline{t} + (1-p)(\bar{t} + w) - \Psi$ is increasing at e^{fb} , then similar reasoning shows that the most efficient way to incentivize compliance (from the principal's point of view) results from $p'(e)(\hat{t} - \bar{t}) = \Psi'(e)$ and $\underline{t} \leq \bar{t} + w + \frac{1}{p(e^{fb})} [p(e) \frac{\Psi'(e)}{p'(e)} - \Psi(e) + \Psi(e^{fb})]$. Since these latter conditions lead to lower expected compensation than whenever $p\underline{t} + (1-p)(\bar{t} + w) - \Psi$ is decreasing at e^{fb} , then the principal chooses this last scheme. ■

Proof of Proposition 1. We will first show that the agent's participation constraint (PC) is implied by the incentive compatibility (IC) and limited liability constraints (LL). By solving for \underline{t} from the (IC) and plugging the result into the (PC) we get that this last constraint is satisfied as long as $\bar{t} \geq \Psi(e) - p(e) \frac{\Psi'(e)}{p'(e)}$. Noting that $\underline{t} \geq 0$ implies $\bar{t} \geq -\frac{\Psi'(e)}{p'(e)}$, it suffices to show that $-\frac{\Psi'(e)}{p'(e)} \geq \Psi(e) - p(e) \frac{\Psi'(e)}{p'(e)}$ or equivalently that $-(1-p(e)) \frac{\Psi'(e)}{p'(e)} \geq \Psi(e)$. Since for $e = 0$ the left and right hand sides of this inequality equal zero, then this relation is also satisfied for $e > 0$, because $-(1-p(\cdot)) \frac{\Psi'(\cdot)}{p'(\cdot)}$ is increasing in effort at a higher rate than $\Psi(\cdot)$. Therefore, for positive levels of effort the agent's participation constraint never binds.

Now we will proceed to show that only the limited liability constraint corresponding to \underline{t} binds. First note that $\bar{t} \geq 0$ can never be binding for that would imply that $\underline{t} < 0$ (this follows from the previously obtained conclusion that $\underline{t} < \bar{t}$), therefore $\bar{t} > 0$. Now if we suppose that \underline{t} is also positive, then from the first order conditions obtained from

Lagrangian associated to this problem we get that the (IC) multiplier equals $\frac{p}{p'}$ and also $-\frac{1-p}{p'}$. This is a contradiction because these expressions have opposite signs. Therefore, at the optimum $0 = \underline{t} < \bar{t}$. Given these results it is straightforward to solve for \bar{t} from the (IC).

To get the level of effort, we plug the optimal expressions for \underline{t} and \bar{t} into the principal's objective function to get $R - p(e)L + (1 - p(e)) \left(\frac{\Psi'(e)}{p'(e)} \right)$. The first order condition with respect to e yields the following equation that implicitly determines e^{sl} :

$$\Psi'(e) + p'(e)L = (1 - p(e)) \left(\frac{\Psi''(e)p'(e) - \Psi'(e)p''(e)}{(p'(e))^2} \right).$$

Note that the right hand side of this condition is strictly negative for all e and that the left side equals zero at the first best. Since the left hand side is strictly increasing in e , we conclude that $e^{sl} < e^{fb}$. Also, the assumptions that $\Psi'''(\cdot)$ and $p'''(\cdot)$ are non negative are sufficient to guarantee the strict concavity of the objective function and, therefore, that e^{sl} is unique. ■

Proof of Proposition 2. First we will find the optimal functional form for the salaries for any level of effort. For the case where $e < e^{fb}$, from $p'(e)(\underline{t} - \bar{t}) = \Psi'(e)$ and using the same reasoning as in the proof of Proposition 1 we get that $\underline{t} = 0$, $\bar{t} = -\frac{\Psi'(e)}{p'(e)}$ while \hat{t} can take on any value that satisfies the first inequality in (2) for $w = 0$ as well as the limited liability constraint $\hat{t} \geq 0$. Similarly, for $e \geq e^{fb}$ we get $\hat{t} = 0$, $\bar{t} = -\frac{\Psi'(e)}{p'(e)}$ and \underline{t} satisfies the second inequality in (3).

Given these optimal expressions for the salaries, the principal's expected cost as a function of the level of effort is:

$$C(e) = \begin{cases} p(e)L - (1 - p(e)) \frac{\Psi'(e)}{p'(e)} & \text{for } e < e^{fb} \\ -(1 - p(e)) \frac{\Psi'(e)}{p'(e)} & \text{for } e \geq e^{fb} \end{cases}.$$

The optimal level of effort results from the minimization of these expected costs. The first segment of this function -where $e < e^{fb}$ - are just the expected costs under the strict liability rule and therefore is minimized at e^{sl} . The second segment is minimized at e^{fb} because it is strictly increasing in effort. Therefore, the principal will choose to implement effort level e^{fb} if and only if $p(e^{sl})L - (1 - p(e^{sl})) \frac{\Psi'(e^{sl})}{p'(e^{sl})} \geq -(1 - p(e^{fb})) \frac{\Psi'(e^{fb})}{p'(e^{fb})}$, otherwise she will implement e^{sl} . ■

Proof of Proposition 3. For a non-binding participation constraint, the first order conditions of the principal's problem are:

$$\begin{aligned} \underline{t} & : -pq + \mu(p'q + pq') + \alpha = 0 \\ \hat{t} & : -p(1 - q) + \mu(p' - p'q - pq') + \beta = 0 \\ \bar{t} & : -(1 - p) - \mu p' + \gamma = 0 \end{aligned}$$

where μ stands for the Lagrange multiplier of the incentive compatibility constraint while α , β and γ stand for the multipliers of the limited liability constraints associated to \underline{t} , \widehat{t} and \bar{t} , respectively. Solving for μ in each of these equations we get:

$$\mu = \frac{pq - \alpha}{p'q + pq'} = \frac{p(1-q) - \beta}{p'(1-q) - pq'} = -\frac{1-p-\gamma}{p'}. \quad (4)$$

We will first proceed to show that at the optimum $\underline{t} = 0$. Given that $\mu = \frac{pq - \alpha}{p'q + pq'}$ and the non-negativity condition of the multipliers, we have that $pq - \alpha \leq 0$ because $p'q + pq' < 0$. Therefore, $\alpha \geq pq > 0$ and we conclude that $\underline{t} = 0$.

Now consider $\mu = \frac{p(1-q) - \beta}{p'(1-q) - pq'}$. If $p'(1-q) - pq' < 0$ then $p(1-q) - \beta < 0$ so that $\beta > 0$ and therefore $\widehat{t} = 0$. Given this result, from (IC1) we get that $\bar{t} = -\frac{\Psi'}{p'}$.

Whenever $0 < p'(1-q) - pq' < -p^2q'$, then we either have: i) $\widehat{t} > 0$ and $\bar{t} > 0$; ii) $\widehat{t} > 0$ and $\bar{t} = 0$; or, iii) $\widehat{t} = 0$ and $\bar{t} > 0$. First, suppose $\widehat{t} > 0$ and $\bar{t} > 0$, therefore $\beta = \gamma = 0$ implying that $\frac{p(1-q)}{p'(1-q) - pq'} = -\frac{1-p}{p'}$. This last expression reduces to $p'(1-q) - pq' = -p^2q'$ which contradicts the assumption that $0 < p'(1-q) - pq' < -p^2q'$. Second, suppose that $\widehat{t} > 0$ and $\bar{t} = 0$ ($\beta = 0, \gamma \geq 0$), then $\frac{p(1-q)}{p'(1-q) - pq'} = -\frac{1-p-\gamma}{p'}$, so that $\gamma = \frac{p'(1-q) - pq' + p^2q'}{p'(1-q) - pq'}$. The non-negativity condition of the multiplier implies that $p'(1-q) - pq' \geq -p^2q'$ contradicting the initial condition. Similarly, whenever $\widehat{t} = 0$ and $\bar{t} > 0$ ($\beta \geq 0, \gamma = 0$) the non-negativity of β implies that $p'(1-q) - pq' \leq -p^2q'$. Therefore, whenever $0 < p'(1-q) - pq' \leq -p^2q'$ the optimal contract is given by $\underline{t} = \widehat{t} = 0$ and $\bar{t} = -\frac{\Psi'}{p'}$.

Whenever $p'(1-q) - pq' > -p^2q'$ we also have that i) $\widehat{t} > 0$ and $\bar{t} > 0$; ii) $\widehat{t} > 0$ and $\bar{t} = 0$; or, iii) $\widehat{t} = 0$ and $\bar{t} > 0$. First, as shown in the last paragraph, both transfers are positive only whenever $p'(1-q) - pq' = -p^2q'$ which is also a contradiction in the present case. Second, \bar{t} being the only positive transfer implies that $\beta > 0$ which conduces to $p'(1-q) - pq' > -p^2q'$ contradicting the initial condition. Therefore, whenever $p'(1-q) - pq' > -p^2q'$, $\underline{t} = \widehat{t} = 0$ and from (IC1) we get that $\bar{t} = \frac{\Psi'}{p' - p'q - pq'}$.

We are left to verify that the participation constraint is indeed not binding as was initially supposed. First, whenever $\bar{t} = -\frac{\Psi'}{p'}$ and $\underline{t} = \widehat{t} = 0$, the participation constraint becomes $-(1-p)\frac{\Psi'}{p'} > \Psi$, expression that is satisfied for positive levels of effort as was shown in the proof of Proposition 1. Whenever $\bar{t} = \frac{\Psi'}{p'(1-q) - pq'}$ and $\underline{t} = \widehat{t} = 0$, the participation constraint is $p(1-q)\frac{\Psi'}{p'(1-q) - pq'} \geq \Psi$. Here we note that this relation becomes an equality for $e = 0$, and that the second order condition of the agent's problem guarantees that the left side of it is increasing in e at a higher rate than its right hand side; therefore, for $e > 0$ the participation constraint is strictly satisfied.

Given these results we can now solve for the optimal level of effort. First, if in equilibrium $\frac{d}{de} [p(1-q)] < 0$, then the level of effort is implicitly defined by the first order condition

$\frac{d}{de} \left[-(1-p) \frac{\Psi'}{p'} \right] = -(p'q + pq')L$; let e^* be this level of effort. Since in this case at e^* , $-p'L > -(p'q + pq')L$ and since $\frac{d}{de} \left[-(1-p) \frac{\Psi'}{p'} \right]$ is increasing $\forall e$ while $-p'L$ and $-(p'q + pq')L$ are decreasing $\forall e$, then $e^* < e^{sl}$ ($< e^{fb}$). Next, if in equilibrium $0 < \frac{d}{de} [p(1-q)] < -p^2q'$, then effort e^* is determined by the same condition as in the previous case but now we have that $-p'L < -(p'q + pq')L$, implying that $e^* > e^{sl}$. Finally, if in equilibrium $\frac{d}{de} [p(1-q)] > -p^2q'$, then effort e^{**} is implicitly defined by $\frac{d}{de} \left[p(1-q) \frac{\Psi'}{p'(1-q) - pq'} \right] = -(p'q + pq')L$. Since for a given level effort, $\frac{d}{de} \left[-(1-p) \frac{\Psi'}{p'} \right] > \frac{d}{de} \left[p(1-q) \frac{\Psi'}{p'(1-q) - pq'} \right]$, it follows that $e^{**} > e^*$ ($> e^{sl}$).

Therefore, if $\frac{d}{de} [p(1-q)]$ is negative or sufficiently positive, then the deadweight loss implied by the negligence rule with the possibility of judicial error is larger than the one implied by the strict liability rule. ■

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