

Caution, Children Crossing: Heterogeneity of Victim's Cost of Care and the Negligence Rule*

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Abstract

The paper deals with a bilateral accident situation in which victims have heterogeneous costs of care. With perfect information, efficient care by the injurer raises with the victim's cost. When the injurer cannot observe at all the victim's type, and this fact can be verified by Courts, first-best cannot be implemented with the use of a negligence rule based on the first-best levels of care. Second-best leads the injurer to intermediate care, and the two types of victims to choose the best response to it. This second-best solution can be easily implemented by a negligence rule with second-best as due care. We explore imperfect observation of the victim's type, characterizing the optimal solution and examining the different legal alternatives when Courts cannot verify the injurers' statements. Counterintuitively, we show that there is no difference at all between the use by Courts of a rule of complete trust and a rule of complete distrust towards the injurers' statements. We then relate the findings of the model to existing rules and doctrines in Common Law and Civil Law legal systems.

KEYWORDS: Imperfect Information, Negligence rule, Accidents, Heterogeneous Victims.

JEL classification numbers: K13, D82.

1 INTRODUCTION

The standard economic model of accidents and liability, in its simplest form, assumes a world of homogenous populations of potential injurers and victims. Potential injurers are typically assumed to be identical, in terms of benefits derived from the potentially harmful activity, of costs of care, and of wealth. The same happens with victims, who are also assumed to be perfectly interchangeable in all respects. Expositions of this simple standard economic model can be found in Shavell (1987), and Schäfer and Schönenberger (1998).

It is undeniable that in the real world many situations giving rise to accidents significantly depart from this restrictive set of assumptions. Both the injurer and the victim in a given accident may be drawn from heterogeneous populations of potential injurers, potential victims, and both. Some injurers derive larger, sometimes much larger, benefits than others from engaging in an activity which might result in harm to third-parties. Some injurers face larger, sometimes much larger, costs of taking care and adopting precautionary measures than others. Some injurers are wealthier, sometimes much wealthier, than others.

These departures from the most basic set of assumptions have already been, to a large extent, substantially explored in the Law and Economics literature.

The heterogeneity of injurers in terms of their ability (and cost) to take care has been analyzed in economic terms, and the benefits and costs of using general and average standards of due care instead of individualized and subjective standards have been duly examined in previous work: Landes and Posner (1987), Shavell (1987), Schwartz (1989), Miceli (1997)], Edlin (1998). Similarly, wealth differences among injurers and their impact on liability rules have also been considered in the literature (Arlen (1992), Miceli and Segerson (1995))¹.

The issues arising from victims' heterogeneity have received a good deal less of attention in the literature. The source of victims' heterogeneity most extensively considered has been that related to the level of harm suffered by the victim. Landes and Posner (1987), Miceli (1997), and specially Kaplow and Shavell (1996), have analyzed the use of average versus individualized damage awards in the presence of heterogeneous victims in terms of their levels of harm resulting from an accident.

But victims, ostensibly, do not only differ in terms of the harm they are likely to experi-

¹The use of Tort liability as a redistribution mechanism has also been extensively discussed in the literature, although with different theoretical and policy goals in mind: Kaplow and Shavell (1994,2000), Sanchirico (2000, 2001), and Avraham, Fortus and Logue (2002).

ence if an accident takes place, but also in their relative ability and cost of taking care. For some types of victim, several (or many, even all) measures that may be adopted to reduce the likelihood of an accident are more costly than for other types of victim. Let's think, for instance, of children (although other examples are possible, and even likely) compared to adults. Taking care is, for most activities in which the participant might be harmed, more costly for children than for adults. Refraining from running on the sidewalk, watching for coming autos before crossing the road, using equipment with strength and ability, or resisting the temptation of trespassing on a premise that promises some excitement, is usually easier for adults than for children. For children under a certain age, and for some of those activities, even the most obvious precautionary measures can be prohibitively costly.

These differences in the costs of taking care carry over to the determination of the optimal levels of precaution. Other things being equal, the costlier the care for a given victim, the lower the optimal level of care should be. This is universally acknowledged by legal systems: The levels of care that legal systems require of minors are consistently lower than those required of adults. Even if still "general" or "objective", because they do not descend to the individual abilities and conditions of every single child, due care standard for a child is that of reasonable care not for an adult, but for a typical child within that age range. Evidence of this attitude across legal systems (both Common Law and Civil Law systems) can be found in Von Bar (1998) and Prosser and Keeton (1984).

In a bilateral accident setting when care measures of injurers and victims are correlated (they are substitutes, for instance), the lower optimal level of care of a given group within the population of potential victims, increases the optimal level of care of the injurer. This issue of the interaction of victims' heterogeneity, on the one side, and levels of care of the injurer, on the other, in simultaneous choice of care situations, has been largely unexplored in the previous Law and Economics literature on these issues, who has, explicitly or implicitly, restricted its scope to unilateral accidents, strict liability, or both.

The goal of the paper is precisely to analyse the interaction between the levels of care of heterogeneous victims and the injurer under a negligence regime, and how different legal implementation options can bring us close or far from the optimal levels of care for victims and injurer.

The paper will be organized as follows: In section 2 we present the model and characterize the first best and the second best. In section 3 we examine some of the basic

implementation options using a negligence rule defining due care levels. Section 4 analyzes the optimal solutions and implementation options when the injurer can observe the victim type with some positive probability lower than one. Section 5 discusses the major implications of the model for the application of the negligence rule and compare them with existing rules and doctrines in different legal systems. We conclude by discussing the scope and implications of the model. All proofs are relegated to a technical appendix.

2 THE MODEL

We study the standard bilateral accident setting in which the behavior of a injurer and the behavior of the potential victim, affect the likelihood of an accident but considering that there are different types of victims. In particular, we assume that there are two different types of victims θ_1 and θ_2 . The ex-ante probability of type θ_1 is α , and the ex-ante probability of θ_2 is $1 - \alpha$. We assume that all the actors are risk neutral and that it is costly for the injurer and the victim to take precautions. Let $C(x)$ be the injurer cost of the precaution effort x . We assume $\frac{\partial C(x)}{\partial x} > 0$ and $\frac{\partial^2 C(x)}{\partial x^2} > 0$. While the harm resulting from the accident is the same for the two types of victims, D , victim cost of the precaution effort y differs across types, $C(y, \theta)$. We assume $\theta_2 > \theta_1$, and $\frac{\partial C(y, \theta)}{\partial y} > 0$, $\frac{\partial^2 C(y, \theta)}{\partial y^2} > 0$, $\frac{\partial C(y, \theta)}{\partial \theta} > 0$ and $\frac{\partial^2 C(y, \theta)}{\partial \theta \partial y} > 0$. Finally, the probability of accident depends on the victim precaution effort y and on the injurer precaution effort x , $p(x, y)$. We assume $\frac{\partial p(x, y)}{\partial y} < 0$, $\frac{\partial^2 p(x, y)}{\partial y^2} > 0$, $\frac{\partial p(x, y)}{\partial x} < 0$, $\frac{\partial^2 p(x, y)}{\partial x^2} > 0$, and we assume that the injurer and the victim precaution effort are substitutes $\frac{\partial^2 p(x, y)}{\partial x \partial y} > 0$. We also assume that the legal system regulates behavior through the use of negligence rules implemented by Courts.

2.1 First best solution

We start by characterizing the first best solution, in which the injurer can observe the victim type before choosing his precautionary effort.

$$\max_{x_1, x_2, y_1, y_2} \alpha [-p(x_1, y_1)D - C(x_1) - C(y_1, \theta_1)] + (1 - \alpha)[-p(x_2, y_2)D - C(x_2) - C(y_2, \theta_2)]$$

The next Lemma shows, as expected, that the first best solution implies that the less able victim (the one with higher cost of effort) optimally exerts a lower level of care, which is fully intuitive given the higher cost of the θ_2 type of victim.

Lemma 1 $y_1^* > y_2^*$.

Given that, and as we are assuming that the injurer and the victim precautionary efforts are substitutes, the next Lemma follows as an immediate consequence of Lemma 1. It states that at the optimum the injurer exerts a higher precautionary effort when facing a high cost victim.

Lemma 2 $x_1^* < x_2^*$

2.2 Second best solution

In the second best solution the injurer can not observe the victim type, so he has to choose the same kind of precautionary effort with respect to both types of victims.

$$\max_{x, y_1, y_2} \alpha[-p(x, y_1)D - C(y_1, \theta_1)] + (1 - \alpha)[-p(x, y_2)D - C(y_2, \theta_2)] - C(x)$$

Similarly to the first best solution, and due to the cost difference between the two, the next Lemma shows that in the second best solution the less able victim exerts a lower level of precautionary effort.

Lemma 3 $y_1^{**} > y_2^{**}$.

The next Lemma states that the second-best solution leads the injurer, as might be expected, to exert an intermediate level of precautionary effort. Moreover, this precautionary effort is increasing in the ex-ante probability of facing a less able victim.

Lemma 4 $x^{**} \in [x_1^*, x_2^*]$ and decreasing on α . If $\alpha = 1$ then $x^{**} = x_1^*$, if $\alpha = 0$ then $x^{**} = x_2^*$

Finally, given that the injurer exerts an intermediate level of precautionary effort and that the injurer and the victim precaution effort are substitutes, the less able victim increases his precaution effort while the more able victim reduces his precaution effort.

Lemma 5 $y_1^{**} < y_1^*$ and $y_2^{**} > y_2^*$.

Notice that the less able victims are better off in the first best solution than in the second best solution since the injurer's effort towards them is reduced, and thus they are forced to increase care to make up for that reduction.

3 IMPLEMENTING SOLUTIONS WITH THE NEGLIGENCE RULE

3.1 Differentiated negligence rule when the victim's type is observable

We start with the simplest case in which the injurer can observe the victim's type. In this case we will show that a differentiated negligence rule based on the victim's type can implement the first best solution. A differentiated negligence rule sets two different levels of care depending on the victim's type. This differentiated negligence rule determines that the injurer has to pay damages equal to D if an accident materializes and the precautionary effort of the injurer is lower than \bar{x}_i where i is the victim's type.

Lemma 6 *If $\bar{x}_1 = x_1^*$ and $\bar{x}_2 = x_2^*$ the differentiated negligence rule implements the first best solution*

So, according to Lemma 6, if Courts are able to set due care levels at the optimal levels for each type of victim, the differentiated negligence rule can directly induce the first-best solution when the injurer can observe the victims' type prior to the adoption of care.

3.2 Uniform negligence rule when the victim's type is not observable

When the injurer is unable to observe to which type belongs the victim he is facing, a differentiated negligence rule does not seem, in principle, an appealing alternative on efficiency grounds. A uniform negligence rule can do the trick in this case. If the negligence rule sets a single required level of precaution effort \bar{x} , which coincides with the second-best level of care for the injurer, the second-best solution is attainable. Now we cannot achieve the first best solution since the injurer can not observe the victim's type, but, as the next Lemma shows, the simple uniform negligence rule just mentioned can implement the second-best optimum.

Lemma 7 *If $\bar{x} = x^{**}$ the uniform negligence rule implements the second best solution.*

4.1 *The benchmark case*

We consider that the injurer can observe the victim type with probability σ , being this probability common knowledge. We assume that the victims do not know whether or not the injurer observes their type². The efficient solution under these informational constraints is given by the following maximization problem, where x_N is the intermediate effort exerted by the injurer when he does not observe the victim's type:

$$\max_{x_1, x_2, x_N, y_1, y_2} \sigma [\alpha[-p(x_1, y_1)D - C(x_1)] + (1 - \alpha)[-p(x_2, y_2)D - C(x_2)]] + (1 - \sigma)[- \alpha p(x_N, y_1)D - (1 - \alpha)p(x_N, y_2)D - C(x_N)] - \alpha C(y_1, \theta_1) - (1 - \alpha)C(y_2, \theta_2)$$

Notice that if $\sigma = 1$ this problem coincides with the first best, while that if $\sigma = 0$ the problem coincides with the second best solution. The next Lemma characterizes the solution of this problem

Lemma 8 $x_1^* < x_1^{*N} < x_N^{*N} < x_2^{*N} < x_2^*$ and $y_1^* > y_1^{*N} > y_1^{**} > y_2^{**} > y_2^{*N} > y_2^*$.

The efficient solution under imperfect observability is characterized by victims' intermediate levels of care (labelled y_1^{*N} and y_2^{*N}) between the first best and the second best solution. Given that, when the injurer observes the victim, he takes less care when the victim is a high cost victim and higher care when the victim is a low cost victim with respect to the first best solution. Finally, when the injurer does not observe he chooses an intermediate level of care, similarly to the second best.

This solution can be easily implemented using a negligence rule when Courts can verify whether the injurer actually observed the victim's type or not. The optimal negligence rule has two cases,

- a) when the injurer has observed the victim's type the rule should be a differentiated negligence rule based on the victim's type, like the one that implements the first best solution. This differentiated negligence rule sets two different levels of care depending

²Notice, that if the victims know whether the injurer observe or not the solution coincides with the first best (in the case of informed injurer) or second best (in the case of uninformed injurer).

on the victim's type. The injurer has to pay damages equal to D if an accident materializes and the precautionary effort of the injurer is lower than \bar{x}_i , where i is the victim's type. The levels of care should be $\bar{x}_1 = x_1^{*N}$ and $\bar{x}_2 = x_2^{*N}$.

- b) when the injurer has not observed the victim's type the rule should be a uniform negligence rule fixing a single required level of precaution effort $\bar{x} = x_N^{*N}$, below which the injurer would pay damages equal to D to the plaintiff (the victim).

4.2 Injurer Opportunism

More realistically, in this subsection we will analyze the previous imperfect information set up incorporating unverifiability by Courts of the injurer's observation of the victim's type. In particular, the game that we want to analyze is the following:

1. Courts set levels of due care.
2. Nature decides the types of the victims and if injurers observe or not victims' types.
3. Injurers and victims choose the level of care.
4. The accident takes place or not according with the probabilities generated by the levels of care.
5. In the case of an accident, the injurer submits a statement concerning observation of the victim's type, and Courts decide liability based on the statement (according to the policies of trust and distrust described below), the victim's type and the negligence rule.

We solve this game by backwards induction. We look first at the liability decision by Courts, then we analyze the choice of care, and finally we study the optimal levels of due care set by the Courts.

We assume that Courts could use a complex negligence regime comprising three levels of due care. A higher level of due care for injurers who observe a high cost victim x_2 , a low level of due care for injurers who observe a low cost victim x_1 , and an intermediate level of care for non-observing injurers x_N . Therefore, in this scenario there is ample room for injurer's opportunistic behavior, given that he can observe a high cost victim and later

pretend (something that Courts cannot tell if it is true or false) that he has not observed the victim's type, in order to exert a lower level of effort and save precautionary costs. What seems to be crucial in this setting is the policy that Courts follow concerning the credibility of the injurers' statements. We consider that Courts may follow two extreme policies:

1. A policy of complete trust towards the statements made by injurers and
2. A policy of complete distrust, whereby Courts never give credit to the statements by the injurer in those situations in which opportunism may play a role. Therefore, if the injurer claims that he did not observe the victim's type and the victim is actually a high cost victim, Courts would require compliance with the level of care corresponding to the high cost victim. In other words, under the policy of distrust, Courts will require for high cost victims the level of care designed for them, independently of the observability of the victim's type.

4.2.1 Policy of trust Provided that Courts believe the injurer's statement claiming that he did not observe the victim's type, and the victim is a high cost victim, the injurer is not going to exert the effort required for the high cost victim when he in fact observes that the victim is high cost. Consequently, the injurer will never exert more than the intermediate non-observability required level x_N . Thus, the injurers observing the victims' type, either low or high cost, have a dominant strategy: those observing low cost victims always choose x_1 and those observing high cost victims always choose x_N .

Contrary to the conventional asymmetric information settings, the incentive problem of the injurer not observing is more complicated than that of the informed injurers. Given our previous assumption that Courts set (x_1, x_N, x_2) and depending on parameters of the populations, they can opt for three different strategies exerting x_1 , x_N or an intermediate level between both of them, $x'(y)$, where $x'(y) \in \arg \max\{-(1 - \alpha)p(x, y)D - C(x)\}$. We characterize the conditions under which the uninformed injurer chooses among them.

1. The uninformed injurer exerts x_1 if the vector (x_1, x_N, y_2) satisfies the following condition:

(a) $x_1 \geq x'(y_2)$ and $-(1 - \alpha)p(x_1, y_2)D - C(x_1) > -C(x_N)$

In words, the second part of the condition tells us that the injurer prefers to exert the low level of effort, x_1 , and taking the risk of paying damages if he faces a high cost victim than to exert the intermediate level of effort x_N (set by the Courts, and in practice the highest level of effort required given the trust policy) and thus, avoid paying any damages. The first part of the condition excludes the adoption of an intermediate level of care between x_1 , and x_N . We denote by H_1 the set of vectors (x_1, x_N, y_2) satisfying this condition.

2. The uninformed injurer exerts $x'(y)$ if the vector (x_1, x_N, y_2) satisfies the following condition:

$$(a) \quad x_1 < x'(y_2) \text{ and } -(1 - \alpha)p(x'(y_2), y_2)D - C(x'(y_2)) > -C(x_N).$$

In words, the second part of the condition tells us that the injurer prefers to exert the intermediate level of effort, $x'(y_2)$, and taking the risk of paying damages if he faces a high cost victim than to exert the intermediate level of effort x_N . The first part of the condition shows that given the injurer is liable towards high cost victims, he prefers to increase the level of care above x_1 to reduce the probability of accident. We denote by H_2 the set of vectors (x_1, x_N, y_2) satisfying this condition.

3. The uninformed injurer exerts x_N if the vector (x_1, x_N, y_2) satisfies one of the two conditions:

$$(a) \quad x_1 \geq x'(y_2) \text{ and } -(1 - \alpha)p(x_1, y_2)D - C(x_1) < -C(x_N), \text{ or}$$

$$(b) \quad x_1 < x'(y_2) \text{ and } -(1 - \alpha)p(x'(y), y_2)D - C(x'(y)) < -C(x_N).$$

In words, the injurer prefers to exert the intermediate level of effort x_N set by the Courts, and thus, avoid paying any damages, than to exert a lower x_1 or some intermediate level between x_1 and x_N and paying damages in case of accident with a high cost victim. We denote by H_3 the set of vectors satisfying one or the other of the above conditions.

These three strategies give rise to three different equilibria.

The first equilibrium is a partial pooling equilibrium in which injurers who do not observe the victim type pool with those observing the low cost victims. Then, the efficient

levels of care under this equilibrium, will be the solution to the following problem³.

$$\begin{aligned} & \max_{x_1, x_N, y_1, y_2} \sigma [\alpha[-p(x_1, y_1)D - C(x_1)] + (1 - \alpha)[-p(x_N, y_2)D - C(x_2)]] + \\ & (1 - \sigma)[- \alpha p(x_1, y_1)D - (1 - \alpha)p(x_1, y_2)D - C(x_1)] - \alpha C(y_1, \theta_1) - (1 - \alpha)C(y_2, \theta_2) \\ \text{s.t.} \quad & (x_1, x_N, y_2) \in H_1 \end{aligned}$$

Beside the incentive compatibility constrain this problem mirrors the problem in the benchmark non-observability case, with the additional constraint $x_N = x_1$. Thus, it is clear that the welfare now has to be lower than in the benchmark case.

The next Lemma characterizes the solution of this problem

Lemma 9 $x_1^{*N} < x_1^{*NE} < x_N^{*N}$, $y_2^{*N} < y_2^{*NE}$, $y_1^{*N} > y_1^{*NE}$ and $x_2^{*NE} < x_2^{*N}$

The efficient solution under this equilibrium (labelled in this case as NE) is characterized by a level of care for the injurer in the case of unobservability or in the case of facing a low cost firm, intermediate (x_1^{*NE}) between the optimal one in the benchmark case for unobservable victims (x_N^{*N}) and the optimal one for the low cost victim (x_1^{*N}). Given this intermediate level of the injurer, the optimal level of care for the low cost victim is lower than in the benchmark case ($y_1^{*N} > y_1^{*NE}$). For the high cost victim, in turn, this implies a higher level of care than in the benchmark case ($y_2^{*N} < y_2^{*NE}$), which in turn leads to a lower level of care under the trust policy towards the high cost victims ($x_2^{*NE} < x_2^{*N}$).

Therefore, this optimal solution clearly yields winners and losers compared to the benchmark case. Low cost victims and injurers facing high cost victims and observing them, both gain from the policy, whereas high cost victims and the injurers facing low cost victims and observing them loose. It is ambiguous the effect on the injurers who do not observe the victim's type.

The second equilibrium is a separating equilibrium in which injurers who do not observe the victim type choose an intermediate level of care between, x_1 chosen by injurers observing low cost victims, and x_N chosen by injurers observing high cost victims. Then, the efficient levels of care under this equilibrium, will be the solution to the following problem:

$$\max_{x_1, x_N, y_1, y_2} \sigma [\alpha[-p(x_1, y_1)D - C(x_1)] + (1 - \alpha)[-p(x_N, y_2)D - C(x_N)]] +$$

³Note that x_2 is absent from the maximization problem, given that injurers' opportunism replaces it with x_N . The same applies to the following two maximization problems.

$$(1 - \sigma)[- \alpha p(x'(y_2), y_1)D - (1 - \alpha)p(x'(y_2), y_2)D - C(x_1)] - \alpha C(y_1, \theta_1) - (1 - \alpha)C(y_2, \theta_2)$$

s.t. $(x_1, x_N, y_2) \in H_2$

It would be tempting to think that with this separating equilibrium one could mimic the benchmark case, simply by choosing $x_1 = x_1^{*N}$ and $x_N = x_2^{*N}$. However, this outcome is not achievable since the uninformed injurers choose their privately optimal level of care, $x'(y_2)$, taking into account just the high cost victims, the only ones for whom they are liable, and not all victims as in the benchmark case. Besides $x'(y_2)$, the characterization of the optimal levels of this equilibrium closely resemble the previous case.

Finally, the third equilibrium is also a partial pooling equilibrium in which uninformed injurers pool with those observing the high cost victims. Then, the efficient levels of care under this equilibrium, will be the solution to the following problem:

$$\max_{x_1, x_N, y_1, y_2} \sigma [\alpha[-p(x_1, y_1)D - C(x_1)] + (1 - \alpha)[-p(x_N, y_2)D - C(x_N)]] +$$

$$(1 - \sigma)[- \alpha p(x_N, y_1)D - (1 - \alpha)p(x_N, y_2)D - C(x_N)] - \alpha C(y_1, \theta_1) - (1 - \alpha)C(y_2, \theta_2)$$

s.t. $(x_1, x_N, y_2) \in H_3$

Since this problem mirrors the problem in the benchmark non-observability case, with the constraint $x_2 = x_N$, it is clear that the welfare now has to be lower than in the benchmark case. The next Lemma characterizes the solution of this problem

Lemma 10 $x_N^{*N} < x_N^{*NT} < x_2^{*N}$, $y_2^{*N} < y_2^{*NT}$, $y_1^{*N} > y_1^{*NT}$ and $x_1^{*NT} > x_1^{*N}$

The efficient solution under the policy of trust (labelled in this case as NT) is characterized by a level of care for the injurer under (real or pretended) conditions of unobservability intermediate (x_N^{*NT}) between the optimal one in the benchmark case for unobservable victims (x_N^{*N}) and the optimal one for the high cost victim (x_2^{*N}). Given this intermediate level of the injurer, the optimal level of care for the high cost victim is higher than in the benchmark case ($y_2^{*N} < y_2^{*NT}$). For the low cost victim, in turn, the increase in the optimal intermediate level of care for the injurer implies a lower level of care than in the benchmark case ($y_1^{*N} > y_1^{*NT}$), which in turn leads to a higher level of care under the trust policy towards the low cost victims ($x_1^{*NT} > x_1^{*N}$).

Therefore, the optimal solution under this equilibrium yields clear winners and losers compared to the benchmark case. Low cost victims and injurers facing high cost victims

and observing them, both gain from the policy, whereas high cost victims and the rest of injurers (those encountering low cost victims and those not observing their high cost counterpart) loose.

One can also quite simply characterize the probability of opportunism conditioned on Courts receiving an unobservability statement by the injurer when the victim is high cost. By the Bayes' rule this probability is equal to σ .

It is unclear which of those equilibria provides a higher social surplus. It depends on the parameters of the population and on the probability of observation the victim's type. On the one hand, it seems that if σ is large, then the probability of opportunistic behavior of the injurer is high and thus, the first or second equilibrium are likely to provide a higher surplus. On the other hand, when the proportion of high cost victims is large, the third equilibrium is likely to provide more surplus since it avoids the inefficiency arising from the uninformed injurer choosing the low level of care.⁴

4.2.2 Policy of distrust If Courts do not believe the injurer's statement claiming that he did not observe the victim's type and the victim is a high cost victim. There is no room, thus, for the informed injurer to behave opportunistically. As in the previous case, the informed injurer has a dominant strategy: choose x_1 when observing a low cost victim, and choose x_2 when observing a high cost victim. The uninformed injurer can also opt for three different strategies exerting x_1 , x_2 or an intermediate level between both of them, $x'(y)$. The intermediate level, x_N , will not play as such any role in this case. Therefore, the difference between the trust and distrust policies is simply a question of labeling the higher level of care imposed by Courts, as x_2 or x_N . Contrary to intuition, and given that the labeling of choice variable is of no substance, the same outcome can be achieved using the trust policy or the distrust policy. Both policies generate the same equilibria and payoffs, thus making irrelevant the choice by Courts of rules concerning the credibility of the injurers' statements.⁵

⁴A complete characterization of the optimal solution would require assuming specific functional forms.

⁵We conjecture that this result can be extended to mixed strategies as well.

It is a general feature of most, if not all, legal systems, that some easily identifiable categories of persons are subject to less stringent standards of due care than the average person. Probably the clearest example of this differentiated treatment is given by the standards of care to which children are subject. Given their lower psychological disposition and ability to take care, in order to comply with the requirements of the negligence rule, children don't need to adopt the precautions that the average citizen would take, but just those of ordinary kids of their age and experience. As the English case *Gough v. Thorne*⁶ expressed:

The standard is that of “*any ordinary child of 13 $\frac{1}{2}$, by which I do not mean a paragon of prudence, nor do I mean a scatter-brained child, but the ordinary girl of 13 $\frac{1}{2}$* ”

This attitude towards the definition of due care concerning minors is prevalent in Continental European legal systems (Von Bar (1998), p. 98) and also in the English and Nordic legal systems (Von Bar (1998), p. 343). In the US legal system, the Restatement of the Law Third, Torts: General Principles, provides as a general rule for children in § 8:

“When the actor is a child, the actor's conduct is negligent if it does not conform to that of a reasonably careful person of the same age, intelligence and experience...”

In the Spanish legal system, also, the Supreme Court has consistently (or almost) denied that naughty, irreflexive, careless actions by children constitute negligent behavior that might be considered under contributory or comparative negligence rules. It is true, though, that some cases of reckless disregard of danger, let alone criminal conduct, by minors, have led to reductions or outright denial of liability due to contributory or comparative negligence: Ferrer and Ruisánchez (1999).

When, as it is usually the case, children (or other types of victim with higher cost of care) are the victims in the accident, how this affects the required levels of care of injurers involved?

⁶[1966] 3 All ER 398[1966] 1 WLR.

5.1 *Simultaneous accidents where victim's type is observable*

In section 3 we showed that when the type of victim is observable by the injurer, the first-best is implementable through a rule that imposes upon the injurer differentiated levels of due care depending on the type of victim: a higher level of care when encountering victims with higher costs of care, and a lower one when facing a victim belonging to the group having lower costs of care.

This kind of implementation mechanism is precisely what one observes in real-world legal systems through the use of the negligence rule. The negligence rule discriminates standards of care on the injurer's side on the basis of the type of victim, when the former is in the position to know the type of victim when deciding about the level of care.

Thus, for injurers dealing ordinarily with less able types of victims (children, physically or mentally handicapped persons) the standard of care is substantially higher than the one applied to injurers engaging in the same kind of activity, but ordinarily not interacting with those groups of victims. Just to give an example: the Spanish Civil Code and the Spanish Supreme Court apply very different standards of care to educators dealing with minors (in primary or secondary institutions) than to University professors, who usually encounter young adults, but not children, in the course of their educational activities [Ferrer and Ruisánchez (1999), Durany (1999)].

Even when the interaction with the type of victim having higher costs of care is uncommon, or merely casual, most legal systems still provide for enhanced duties of care correlated to the type of victim encountered, when the injurer observed, or could have observed, the victim's type. The injurer has to take additional precautions to counteract the lower level of care expected from that particular type of victim, and failure to do so would involve negligence and the corresponding liability for the harm caused to the less able victim [Seidelson (1981), Prosser and Keeton (1984), Von Bar (1998)]. When children, for instance, are in the vicinity, their sometimes impulsive and thoughtless behavior has to be anticipated by the potential injurer, and thus, enhanced vigilance and caution is required to escape liability, enhanced care that would not be imposed upon injurers in the presence of an adult as victim.

This attitude is again consistent with the attainment of first-best efficiency in a world of observable victim's type. The fact that the injurer does not commonly encounter that

particular type of victim, and that she is used to deal with other types of victim does not make the adoption by the negligence rule of a special and increased standard of care in these circumstances less attractive on efficiency grounds.

5.2 *Simultaneous accidents where victim's type is not observable*

Things are more complicated, also in legal terms, when the victim's type is not readily observable by the injurer.

It is undisputable that the presence in the population of potential victims of some people having higher costs of care drives up the optimal level of care with respect to the level of care that would have been optimal in face of a homogeneous pool of victims. Most legal systems seem sensitive to changes in the likely composition of the pool of potential victims, and, at least partially, along the lines that the model presented in section 2 shows to be consistent with the pursuit of second-best efficiency. For instance, the increased probability of the presence or proximity of children seems to push up the standard of care necessary to avoid being held negligent. Drivers are usually informed by adequate warnings that they approach a school area and thus, that the pool of pedestrians who might suffer an accident contains a higher fraction of children than the average neighbourhoods of the city. All legal systems require extra care from drivers entering an area covered by such a warning. In our model, it is efficient to increase the required level of precautions when $1 - \alpha$ (the fraction of high-cost victims in the population of potential victims) increases.

Similarly, when $1 - \alpha$ goes down in a certain setting, so does the optimal level of care on the part of the potential injurer, and so should the due care standard. For instance, when the pool of potential victims is less likely to contain children or other groups of high-cost victims, the desirable level of care of those carrying on the eventually harmful activity decreases. This finding seems to give theoretical support to the adult-activity doctrine in Tort Law⁷. This doctrine operates as an exception to the general rule that children are subject to a different and less stringent standard of care than adults. If children engage in so-called adult activities, they are held to the adult standard of behavior. In those activities in which typically one does not encounter children (say, driving, or motor-boat

⁷For a discussion of this doctrine and the boundaries of the adult-activity notion, see Prosser and Keeton (1984), and Dobbs (2000).

ricing), potential injurers expect $1 - \alpha$ to be zero, and therefore, that all potential victims are low-cost ones. An increase in the injurer's required level of precaution makes no sense here.

It is clear, moreover, that activities in which the participation of the high-cost victims is legally prohibited (like driving for small children or blind persons) due to the overall dangerousness of its consequences when executed with little care, are obvious candidates for the application of this doctrine⁸.

Even without specific signals, it seems that the likely increased presence of potential victims with higher costs of care suffices to justify the adoption of more stringent standards of due care for potential injurers [Prosser and Keeton (1984), p.200]. Some commentators defend the decision to impose this extra burden of precaution on potential injurers on fairness grounds: those who face higher costs of care have the right to engage in activities that allow them to lead independent and enjoyable lives. Children, some argue, have the right to explore the world and develop as human beings through recurrent interaction with fellow children, adults, and the rest of the outside world in a substantially unrestrained and spontaneous manner. At least for certain activities, this right to self-sufficiency, or to self-development, would arguably justify the extra cost of care that they impose on potential injurers through increased levels of care under the negligence rule: Keating (2002), Ferrer and Ruisánchez (1999).

It is less clear, though, that the use of more stringent levels of care before populations of victims with a higher fraction of less able people is totally consistent with our characterization of second-best efficiency. The implementation of second-best in our model would, in its simplest form, require a rule mandating in every case a standard of care that is intermediate between the first-best optimal towards victims with low costs of care and the first-best optimal towards high-care victims. It is doubtful that this is really what Courts do in most cases, given that there is little evidence that the likely presence of children effectively elevates the standard of care in the cases in which the actual victim was a low-cost victim (an adult), and not a high-cost one. Moreover, the direct implementation of the second-best would imply that high-cost victims would be induced to adopt a higher level of care than their first-best optimal, given that the injurer is complying with the intermediate and

⁸Some commentators argue for a broader use of the adult standard for children, restricting the more lenient one for those carefree activities necessary for children socialization and development [Forell (1985)].

required level of care as injurer. Nothing of this kind appears mentioned in the literature, nor the cases, when dealing with contributory and comparative negligence, contemplate any increase in the levels of care of less able victims in a bilateral accident with unobservable victim's type⁹.

Some commentators, moreover, appear to criticize the amalgamation of adults and children to determine a kind of average level of care (even if, as here is the case, to indirectly fix the level of care of a potential injurer facing both types of victim): Landes and Posner (1987).

In some areas of the Law, one could advance the explanation that the attainment of the second-best is far from being the motivation behind the rules implemented by the Courts. Even when observation of the victim's type seems hardly possible, Courts could still be using differentiated negligence rules based on the victim's type. So, when the person harmed by the defendant in a given case is a high-cost victim, the level of care required from the injurer under the negligence rule is the high level that was optimal for that type of victim (but not for the pool of high- and low-cost victims), whereas when the plaintiff is a low-cost victim, the standard of care that the negligence rule would impose on the injurer is the low level that was optimal for that type of victim, but not for the pool¹⁰.

This attitude is particularly noticeable in the field of tort liability of owners or occupiers

⁹In the simple world of our model, liability rules were implicitly assumed to operate perfectly, and thus, the negligence rule, unaccompanied by contributory or comparative negligence, was able, on its own, to do the trick of inducing the efficient levels of care both for the injurer and the victim. Since the direct implementation of the second-best in this setting does not require paying attention to the levels of care of the victim. The reality that in the actual cases, though, there are no traces of the increased level of care of the high-cost victims, may be interpreted as indirect evidence of the fact that Courts are not trying to use a negligence rule that mimicks the direct implementation of the second-best.

¹⁰Consider the limit case $\sigma = 0$ of the imperfect observation model developed in section 4. Assume that Courts use a differentiated negligence rule setting two required levels of precautionary effort \bar{x}_1 and \bar{x}_2 depending on the victims' type (there is no need for Courts to set a third intermediate level in this case). Under this rule, the injurer would pay damages to the victim if the former is of type θ_1 and $x < \bar{x}_1$ or if the victim is of type θ_2 and $x < \bar{x}_2$. The injurer, however, can only choose a single level of effort since he can not observe the victim's type. Then similarly to the regular case, $\sigma \neq 0$, there are only three equilibria: a) The injurer exerts \bar{x}_1 and takes the risk of paying damages in case the actual victim is high cost, b) the injurer exerts \bar{x}_2 and avoids paying any damages in all cases and c) the injurer chooses an intermediate level between \bar{x}_1 and \bar{x}_2 , paying damages in case the actual victim is high cost. Specifically, these results hold when Courts use the first best levels of care, $\bar{x}_1 = x_1^*$ and $\bar{x}_2 = x_2^*$.

of land. The traditional Common Law rule is that landowners owe no duty of reasonable care to trespassers, and thus, if a trespasser suffers harm as a result of the trespass, the owner or possessor will not be liable. The level of care of the landowner towards the so-to-speak "low-cost trespasser" is low (in fact, at least in principle, zero). The legal situation differs widely when the trespasser is a child. In this case, when the landowner knew or had reason to know that child trespassers were likely, the landowner owes a duty of care to the child trespasser. That is, when the potential injurer knew or could have known about the non-insignificant presence of high-cost victims among the population of potential trespassers, the standard of care towards them is high (positive, instead of zero¹¹). Curiously enough, under Spanish Law, the rule, although less clearly stated, is very similar. The Spanish Supreme Court, in several rulings, has determined that the owners of abandoned dangerous premises (usually, mines or industrial sites) are required to adopt adequate measures that would avoid harm to inexperienced or irreflexive persons (read: children), and would be liable in tort if failing to do so [Ferrer and Ruisánchez (1999)]. Comparable cases involving adult intruders in the premises would receive a substantially different solution.

Notice that in these cases, in order to impose upon the injurer the increased duty of care in front of the less able victims, Courts do not require observability of the victim's type (in most cases the landowner is unaware of the trespass), simply that the potential injurer knows, or has reasons to know, that there are high-cost victims. In other words, Courts diversify the level of due care on the basis of the victim's type despite its apparent unobservability.

It is clear from our results in the preceding sections that this rule is less desirable on efficiency grounds than a rule that simply and directly implements the second-best with a uniform level of due care for the injurer equal to the second-best optimal precautionary effort. But a case can be made for other factors alien to efficiency justifying the use of the differentiated standard of care even for apparent non-observability of the victim's type. If the goal of the legal system is to satisfy some kind of Rawlsian preference in favor of the welfare of the less well-off (here, by hypothesis, the group of victims with high costs of care), a differentiated standard for the injurer based on the type of victim actually encountered might, under the conditions referred to in note above, constitute an attractive policy alter-

¹¹A complete account of the American cases can be found in Prosser and Keeton (1984), p. 393, and Dobbs (2000), p. 592.

native. On fairness grounds, the use by Courts of a uniform negligence rule irrespective of the type of the actual victim encountered by the plaintiff in the tort suit might be considered by many as unfair. One could argue that the uniform rule provides both injurers and victims with lower costs of care, with the opportunity of free-riding on the higher costs of care of other groups of potential victims. The presence of the latter groups allows the more able ones to save costs of care because they can anticipate that the potential injurer would adopt hundred percent of the times (remember, type is unobservable for the injurer) more precautions under the uniform rule, precisely due to the fact that there are less able victims in the pool. Injurers, on their part, incur costs of care with respect to all types of victims lower than the first-best optimal ones with respect to the group of victims with higher costs of care. Moreover, the uniform negligence rule forces the latter group of potential victims to increase their levels of precaution, in anticipation of the lower care that potential injurers will adopt in front of the whole population of victims.

Specially if one considers the typical groups with recognizably higher costs of care (children, mentally or physically impaired persons), to many people, including many Courts, these effects might strike them as unfair. And some might even advocate that the welfare of these groups that specially deserve protection by society and by the legal system is well worth the price of some inefficiency in the functioning of Tort Law.

It can be shown that in general, the use of a differentiated negligence rule based on the victim's type, although less than optimal in terms of the attainment of second-best efficiency, appears to improve in all cases the lot of the high-cost victims compared with the uniform rule immediately implementing the second-best optimum.¹²

¹²As we mention in footnote 10, the use of a differentiated negligence rule when the injurer can not observe the victim type can generate three equilibria. In one equilibrium, the injurers choose the level of care that is required towards the high-cost victims. As this level of care should be higher than the second best solution, the level of welfare of the less able victims under the differentiated negligence rule is higher than under the uniform rule directly implementing the second-best. In the other two equilibria, the injurer neglects totally or partially the presence of the high-cost victims, and opts for the level of precaution that make him always liable towards high-cost victims alone. As injurers are always found negligent when the victim is high-cost, and the latter will always be compensated, high cost victims will be induced to incur no costs of care. If (a big if, though) damages paid by the injurer always cover the harm suffered by the victim, the welfare of high-cost victims (though not social welfare) is maximized with the use of the differentiated negligence rule: they have zero costs of care and they are indifferent, because of the damage payment, between the occurrence and not occurrence of an accident. Moreover, if the second-best level of care of potential victims

A different kind of explanation, though, could be offered for the observed pattern of legal rules actually favored by Courts. This pattern is consistent with efficiency if courts believe (and this not an unreasonable belief) that zero observability is impossible to discern from imperfect observability. Coupled with the fact that actual observation by the injurer in a given case cannot be verified by Courts, we are fully in the world of section 4 of the paper. In this setting, we have shown that efficiency calls for differentiated negligence rules, and that equilibrium behavior by injurers under this efficiency-oriented differentiated regime would be undistinguishable from the one induced by the fairness-inspired negligence regime (though victims would take zero case in the latter but not in the former).

We don't have enough evidence about the motivations of Courts to use the differentiated rule in various accident settings, allowing us to conclude which is the most convincing explanation behind the use of differentiated rules by Courts in accidents in which observation of the victim's type seems hardly feasible. May be both of them are not mutually exclusive, and there is a combination of fairness and efficiency forces leading to the observed choice of Courts in different legal systems.

6 EXTENSIONS AND CONCLUSIONS

That potential accident victims are heterogeneous in terms of their costs of care is a fact of life. Some victims face higher costs of taking care than others. In the paper we have explored the implications of this heterogeneity for the functioning of the negligence rule.

In our approach we have opted for a model of two types of victim, differing in their costs of care. The extension of the model to a larger number of types would be trivial. We have decided not to extend the model with continuous types of victims, mainly for two reasons. First, it would essentially replicate the findings and implications of the discrete two-types model. Second, from a Law and Economics perspective, a continuous type setting would not adequately capture the actual perspective of the legal system, in which no consideration is given to each individual standard of care, but instead, broad (extremely broad, one could say, or even just one) categories are built in order to define standards of due care.

was anyway close to zero (which seems plausible for certain accidents settings given the cost functions of at least some groups of less able victims), the inefficiency arising from the differentiated rule is relatively small, and might, at least by some, be considered an affordable price to pay in order to maximize the welfare of children or other disadvantaged groups of potential victims.

In the Law, standards of care are always general and average, and not made-to-measure. Information costs would be otherwise intractable [Landes and Posner (1987)].

Our model is also built upon the assumption that there is substitutability between care by victims and injurers. This is the standard assumption in the Law and Economics literature on bilateral accidents. It could be possible to extend our model to the case of complementarity between the corresponding care efforts of injurers and victims. The basic results of our model would then be reversed, because it would be optimal for injurers to exercise more care with respect to low-cost than with respect to high-cost victims. We believe, though, that the complementary case is of little relevance for the operation of liability rules.

To summarize the main results of our paper: we characterize first-best efficient levels of care for the injurer and both types of victims. We also characterize the second-best levels of care, which cannot be improved when injurers cannot observe the victim's type when deciding about the level of precaution they will adopt. Turning to the effects of the negligence rule on the adoption of care, we consider a uniform and a differentiated (based on the actual victim's cost of care) negligence rules, both of which seem to be in use in different legal systems. When the injurer can observe the victim's type, first-best results can be achieved using a differentiated rule. When this is not the case, a uniform negligence rule with due care set at the second-best optimal care for the injurer implements the second-best. The differentiated rule cannot do the trick, and is thus less efficient than the uniform rule in an unobservable victim's type situation. We also analyze imperfect (as distinct from perfect or none at all) observation of the victim's type. We characterize the optimal solution in this setting, and examine the different legal alternatives when Courts cannot verify the injurers' statements concerning whether they had or not observed the victim before taking care. Counterintuitively, we show that there is no difference at all between the use by Courts of a rule of complete trust and a rule of complete distrust towards the injurers' statements. We finally discuss the actual use of several rules and doctrines in various legal systems, employing the results of the model as our theoretical framework. Specifically, we discuss how the departure from efficiency through the use of the differentiated rule in situations of practically unobservable type might respond to a preference for the welfare of high-cost victims at the expense of second-best efficiency, or might be consistent with efficiency tied to our results in the imperfect observability setting.

Proof of Lemma 1

$(x_i^*, y_i^*) \in \arg \max\{-p(x_i, y_i)D - C(x_i) - C(y_i, \theta_i)\}$. Then

$$-p(x_1^*, y_1^*)D - C(x_1^*) - C(y_1^*, \theta_1) > -p(x_2^*, y_2^*)D - C(x_2^*) - C(y_2^*, \theta_1)$$

$$-p(x_2^*, y_2^*)D - C(x_2^*) - C(y_2^*, \theta_2) > -p(x_1^*, y_1^*)D - C(x_1^*) - C(y_1^*, \theta_2)$$

Adding up the two equations and simplifying, we obtain:

$$-C(y_1^*, \theta_1) - C(y_2^*, \theta_2) > -C(y_2^*, \theta_1) - C(y_1^*, \theta_2)$$

Then

$$C(y_1^*, \theta_2) - C(y_1^*, \theta_1) > C(y_2^*, \theta_2) - C(y_2^*, \theta_1)$$

$\frac{\partial^2 C(y, \theta)}{\partial \theta \partial y} > 0$ this implies $y_1^* > y_2^*$. ■

Proof of Lemma 2

$(x_i^*, y_i^*) \in \arg \max\{-p(x_i, y_i)D - C(x_i) - C(y_i, \theta_i)\}$

The first order condition of x_i^* is

$$-\frac{\partial p(x_i^*, y_i^*)}{\partial x} D - C'(x_i^*) = 0$$

Applying the implicit function theorem, we obtain

$$\frac{\partial x_i^*}{\partial y_i^*} = -\frac{-\frac{\partial^2 p(x, y)}{\partial x \partial y}}{-\frac{\partial^2 p(x_i^*, y_i^*)}{\partial x^2} D - C''(x_i^*)} < 0$$

From the previous Lemma we know that $y_1^* > y_2^*$, then $x_1^* < x_2^*$. ■

Proof of Lemma 3

For the same argument used in the proof of Lemma 1.

■

Proof of Lemma 4

The first order condition of x^{**} is

$$-\alpha \frac{\partial p(x^{**}, y_1^{**})}{\partial x} D - (1 - \alpha) \frac{\partial p(x^{**}, y_2^{**})}{\partial x} D - C'(x^{**}) = 0$$

Applying the implicit function theorem, we obtain

$$\frac{\partial x^{**}}{\partial \alpha} = -\frac{-\frac{\partial p(x^{**}, y_1^{**})}{\partial x} D + \frac{\partial p(x^{**}, y_2^{**})}{\partial x} D}{-\alpha \frac{\partial^2 p(x^{**}, y_1^{**})}{\partial x^2} D - (1 - \alpha) \frac{\partial^2 p(x^{**}, y_2^{**})}{\partial x^2} D - C''(x^{**})} < 0$$

This is because, $\frac{\partial^2 p(x,y)}{\partial x \partial y} > 0$ and $y_1^{**} > y_2^{**}$ implies that $\frac{\partial p(x^{**}, y_1^{**})}{\partial x} < \frac{\partial p(x^{**}, y_2^{**})}{\partial x}$.

Finally if $\alpha = 1$ the victim is type θ_1 with probability 1, and the second best solution coincides with the first best solution since there is perfect information over victim type, $x^{**} = x_1^*$. For the same token, if $\alpha = 0$ then $x^{**} = x_2^*$. ■

Proof of Lemma 5

The first order condition of y_i^* coincides with the first order condition of y_i^{**} , and it is

$$-\frac{\partial p(x, y_i)}{\partial y} D - C'(y_i, \theta_i) = 0$$

Applying the implicit function theorem, we obtain

$$\frac{\partial y}{\partial x} = -\frac{-\frac{\partial^2 p(x, y)}{\partial x \partial y}}{-\frac{\partial^2 p(x, y)}{\partial y^2} D - C''(y_i, \theta_i)} > 0$$

Then, using that $x^{**} \in [x_1^*, x_2^*]$, we can conclude that $y_1^{**} < y_1^*$ and $y_2^{**} > y_2^*$. ■

Proof of Lemma 6

We denote by x_i^{DL} the precaution effort of the injurer when he is facing a victim of type i . There are two cases

1. First, we consider that $x_i^{DL} \geq x_i^*$. In this case, the injurer is not liable and consequently he has not to compensate the victim for any harm. Therefore, the injurer will never choose a precaution effort larger than x_i^* when he observes that the type of the victim is i . If the injurer exerts a precaution effort of x_i^* , the optimal response of the victim will be $y_i^{DL} \in \arg \max\{-p(x_i^*, y_i)D - C(y_i, \theta_i)\}$. The solution of this problem coincides with the first best solution, $y_1^{DL} = y_1^*$ and $y_2^{DL} = y_2^*$.
2. Assume now that, the injurer chooses $x_i^{DL} < x_i^*$. In this case, the victim optimal response is $y_i^{DL} = 0$ since in case of accident he will be compensated by the injurer. Then in case of $x_i^{DL} < x_i^*$, the optimal response of the injurer is $x_i^{DL} = x'$, where $x' \in \arg \max\{-p(x, 0)D - C(x)\}$.

Now we show that the injurer prefer the case 1 to the case 2. This is because, the first best solution maximizes the total surplus, and with the first best the victim is worse off (he has an expected cost of $-p(x_i^*, y_i^*)D - C(y_i^*, \theta_i)$) than in the case in which $x_i^{DL} < x_i^*$ (the victim has not to bear any cost). Therefore, if the total surplus is larger in the first

best solution and the surplus of the victim is lower necessarily the injurer has larger surplus with the first best solution. ■

Proof of Lemma 7

We denote by x^L the precaution effort of the injurer. There two cases

1. First, we consider that $x^L \geq x^{**}$. In this case, the injurer is not liable and consequently he has not to compensate the victim for any harm. Therefore, the injurer will never choose an precaution effort larger than x^{**} . If the injurer exerts an precaution effort of x^{**} , the optimal response of the victim will be $y_i^L \in \arg \max\{-p(x^{**}, y_i)D - C(y_i, \theta_i)\}$. The solution of this problem coincides with the second best solution, $y_1^L = y_1^{**}$ and $y_2^L = y_2^{**}$.
2. Assume now that, the injurer chooses $x^L < x^{**}$. In this case, the victim optimal response is $y_i^L = 0$ since in case of accident he will be compensated by the injurer. Then in case of $x^L < x^{**}$, the optimal response of the injurer us $x^L = x'$, where $x' \in \arg \max\{-p(x, 0)D - C(x)\}$.

Now we show that the injurer prefer the case 1 to the case 2. This is because, the second best solution maximizes the total surplus, and with the second best the victim is worse off (he has an expected cost of $-p(x^{**}, y_i^{**})D - C(y_i^{**}, \theta_i)$) than in the case in which $x^L < x^{**}$ (the victim has not to bear any cost). Therefore, if the total surplus is larger in the second best solution and the surplus of the victim is lower necessarily the injurer has larger surplus with the second best solution. ■

Proof of Lemma 8

For the same argument used in the proof of Lemma 1, $y_1^{*N} > y_2^{*N}$. Provided that $y_1^{*N} > y_2^{*N}$ and using the same argument used in the proof of Lemma 2 we obtain that $x_1^{*N} < x_N^{*N} < x_2^{*N}$. The first order condition of y_1^{*N} is

$$-\sigma \frac{\partial p(x_1^{*N}, y_1^{*N})}{\partial y} D - (1 - \sigma) \frac{\partial p(x_N^{*N}, y_1^{*N})}{\partial y} D - C'(y_1^{*N}, \theta_1) = 0$$

Applying the implicit function theorem

$$\frac{\partial y_1^{*N}}{\partial \sigma} = - \frac{-\frac{\partial p(x_1^{*N}, y_1^{*N})}{\partial y} D + \frac{\partial p(x_N^{*N}, y_1^{*N})}{\partial y} D}{-\sigma \frac{\partial^2 p(x^{**}, y_1^{**})}{\partial y^2} D - (1 - \sigma) \frac{\partial^2 p(x^{**}, y_2^{**})}{\partial y^2} D - C''(y_1^{*N}, \theta_1)} > 0$$

This is because, $\frac{\partial^2 p(x, y)}{\partial x \partial y} > 0$ and $x_1^{*N} < x_N^{*N}$ implies that $\frac{\partial p(x_1^{*N}, y_1^{*N})}{\partial y} < \frac{\partial p(x_N^{*N}, y_1^{*N})}{\partial y}$.

If $\sigma = 1$ the injurer observes the victim with probability 1, and y_1^{*N} must coincide with the first best solution y_1^* . Then, if σ is lower than 1, $y_1^{*N} < y_1^*$. For the same token, $\frac{\partial y_2^{*N}}{\partial \sigma} < 0$ and if σ is lower than 1, $y_2^{*N} > y_2^*$. Finally, for the same argument used in the proof of Lemma 2, $y_1^{*N} < y_1^*$ leads to $x_1^{*N} > x_1^*$, and $y_2^{*N} > y_2^*$ leads to $x_2^{*N} < x_2^*$. ■

Proof of Lemma 9

For similar arguments to the ones used in the proof of Lemma 8.

■

Proof of Lemma 10

For similar arguments to the ones used in the proof of Lemma 8.

■

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