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On the optimal structure of liability laws

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We consider the control of two-party accidents through the use of liability rules that assign damages according to whether or not predetermined standards for care have been met. Particular emphasis is given to how the differential in the costs of accident avoidance activities affects the optimal legal rule and optimal care standards. It is shown that when the costs are close to uniform across individuals, an approximation to the first-best can be obtained. Moreover, alternative legal rules are equally efficient in achieving this situation. When the differential widens, legal rules will differ in their ability to reach the second-best. In contrast to previous models of liability law, it is shown that the courts must play an active adjudicatory role in the optimal solution.

■ Liability law is a social policy whose aim, as we shall view it, is to administer the distribution of accident costs in an efficient manner. As an economic problem this poses a compounding of two issues which have each, separately, been the subject of much discussion. By their nature, accidents involving more than one party are an example of externalities, and the law, whose goal is a better pattern of individual behavior, is an example of an incentive scheme. Studies of these complex issues have led to fruitful economic insights; their interaction makes the problem of choosing optimal liability laws an interesting question.

1. Introduction

We shall show that the optimal form of the liability law depends on the relative dispersions of the costs of accident avoidance activity within the classes of injurers and victims, as well as on the stochastic structure through which accidents are produced. We shall also try to classify some cases in which alternative legal rules are equivalent, or equally capable of producing the best outcome, and some in which they are not.

Before proceeding we must ask why liability laws are used at all. Can we attain a superior, or even optimal, situation by other means? If each accident has a social cost of C and the probability of an accident between any pair of individuals is given as a function, π, of their levels of activity in accident avoidance, x_i and x_j, then the minimization of total social cost is

$$\min \sum_{i=1}^{N} \sum_{\substack{j=1 \\ j>i}}^{N} C\pi(x_i, x_j) + \sum_{i=1}^{N} g_i(x_i),$$

where $g_i(x_i)$ is the cost of the accident avoidance activity to individual i. It is assumed that g and π are both convex functions. Necessary conditions for this problem to have an interior solution, $(x^*_1, \ldots, x^*_N)$, are given by the first-order conditions:

$$\sum_{j \neq i} C \frac{\partial \pi(x_i, x^*_j)}{\partial x_i} + g'_i(x_i) = 0, \text{ for each } i.$$

A truly (first-best) optimal system would be one that creates these first-order conditions as the relevant ones for each individual, and thereby induces them to choose the socially optimal actions. Such policy is clearly attainable if one charges the full social cost to each of the individuals involved in any accident.

This simple rule has many advantages. It requires no knowledge of the cost functions, probability functions, or actual individual actions by the policy-maker. Unlike liability rules, as we shall see, it is likely to be relatively easy to administer; further, no knotty philosophical problems like "justice" arise.

Given that such an easy policy is available for attaining the first-best optimum, it is a little curious that we should have a liability system at all. It will soon be clear that a liability system is highly complex to analyze, more difficult to enforce, and cannot generally attain a first-best solution. A search for the reasons why it is prevalent in so many diverse aspects of human interaction would lead us far beyond the scope of this paper.

One drawback of the scheme above is that this alternative does not have the proper incentives for reporting accidents. If an agreement on distributing accident costs could be reached between the parties, it will surely be preferable to having each of them pay the full cost. Liability rules that establish an adversary relationship do create the incentive to report the accident and to adjudicate the costs, rather than to circumvent the system. Imposing the additional restriction that only the exact accident costs can be collected from the participants, we can ask whether liability rules or some other mechanisms might be the best means available for minimizing social costs. Thus, a liability system is a second-best type of policy. We must now specify the information available to the courts, and the other restrictions on the implementation of a policy which induces individuals to choose socially optimal actions.

Fault is judged and costs are allocated only after an accident has occurred, on the basis of the care taken.[1] Costs are allocated in our model of liability law to either the injured party or the victim, but are never shared. The distribution of costs depends on the care levels as monitored by the court, but the court is restricted to use cut-off levels of care (called "due-care" standards) for each type of agent that are

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[1] It might be better to monitor care before accidents happen and to allocate some costs to those uninvolved as well. By restricting attention to those systems that allocate costs to the participants in an accident on the basis of their care at the time of the accident, we implicitly assume that knowledge about care prior to the occurrence of an accident is prohibitively costly to obtain. Further, for some political or sociopolitical reason, uninvolved parties cannot be charged any accident costs at all.

independent of the action taken by the other. More general systems would allow a more complex region of care patterns in which one can shift costs to the injurer. Still more general systems would allow costs to be shared between the parties in a way that is functionally dependent on their care levels.

We abstract from many problems in our analysis, and a few of these should be mentioned at the outset. (1) Participation in the activity is taken as fixed. (2) All accidents have a very simple character—they involve two parties: an easily identifiable injurer and his victim. (3) Complex legal issues of determining fault when the "true cause" of the accident is unknown are ignored. The "proximate cause" doctrine is therefore irrelevant in the simple situations we study. (4) We also ignore all repercussions of the legal system on the basic data of the system and ensuing general equilibrium considerations. (5) Perhaps the greatest restriction of all is the assumption that the court acts costlessly and without error.

Models of this type have previously been treated by Brown (1973) and Diamond (1974a and 1974b). Diamond is primarily concerned with the selection of due-care standards within a given legal system. Brown's analysis, like ours, treats the selection of the legal system as the central issue; he finds that a variety of different liability rules are equivalent in that they all lead to first-best optimal results. The central part of this paper will be to generalize his model and to analyze which of these rules are superior under various conditions. In the process we hope to shed further light on the following two issues: first, why a policy as restrictive as we have modeled liability law to be can attain optimal results; and second, on what assumptions such optimality crucially depends.

The next section presents and discusses the framework for the analysis. The results of Brown and Diamond are studied with particular reference to the structure of the legal rules allowed. The remainder of the article is concerned with the selection of an optimal legal rule when the assumption that avoidance costs do not vary across individuals is relaxed. Sections 2 and 3 set out the model to be analyzed. The potential equilibria of the model are discussed and classified in Section 4. Section 5 compares the relative efficiency of these equilibria as it depends on the difference in costs of accident avoidance activity among the potential injurers and victims. The question of constructing liability laws to arrive at the best of these equilibria is discussed.

2. Basic model

■ The model is, in essence, identical to that used previously by Brown and Diamond, with additional complications introduced to enable us to address the problems discussed in the introduction.

The individuals are divided into potential injurers and potential victims. The economic decision of each is the level of accident-avoidance costs to incur—which we call "care"—denoted by x, for injurers, and by y, for victims. Accidents occur with a probability dependent on the level of care taken by the two parties. It is implicit in this formulation that each accident involves one member of each group. If care levels are the same for every member within a group, which is the case that we shall be treating in the next section, we write the probability of an accident's occurring between a representative member of one group and any member of the other group as

$\pi(x,y)$. This implicitly assumes that the groups are of equal size. Accident occurrences between different pairs are taken to be independent random events.

The analysis is static in the sense that the care level is chosen once, for all time; the unit of time is fixed and enters into the determination of π. One can interpret $\pi(x,y)$ as the rate at which accidents are occurring, that is, the parameter of a Poisson process through which they are generated. Whenever an accident occurs there is a cost, C, which we suppose to be independent of the care levels chosen, which falls naturally (in the absence of legal determinations) on the victim. This cost is "recognized" in the sense that the court can shift it to the injurer.[2]

A *fault system of accident law* is a function that determines the distribution of the recognized costs between the parties to an accident. This function can, in general, depend on whatever information is available to the court. We shall suppose that the court can determine the care levels at the time of the accident. The restriction of a fault system is that the costs are paid by the parties themselves, rather than a wider spreading of costs as, for example, the opposite extreme of complete social insurance.[3]

In this paper we shall be concerned with the case of a fault system in which the court can monitor care without error. The most general problem of this type is to find a function $\lambda(x,y)$ which determines how the costs should be shared, $C\lambda(x,y)$ by the injurer and $C(1 - \lambda(x,y))$ by the victim, to optimize some social objective. However, courts are usually not disposed to making such fine continuous judgments about care, since in actuality it is a multidimensional and highly complex entity not really expressible in a single number. Courts seem to be much more comfortable with decisions about whether or not an individual has met some predetermined due-care *standard*. In this case, $\lambda(x,y)$ is restricted to have values of either zero or one and to be constant over the regions

$$\{(x,y) \mid x < x^*, \ y < y^*\}$$
$$\{(x,y) \mid x < x^*, \ y \geqq y^*\}$$
$$\{(x,y) \mid x \geqq x^*, \ y < y^*\}$$
$$\{(x,y) \mid x \geqq x^*, \ y \geqq y^*\},$$

where x^* and y^* are the due-care standards.

Thus, the choice of an optimal liability system can be thought of as consisting of two parts, a pair of due-care standards, determining four regions of the (x,y)-plane and a legal rule specifying liability in these regions. Naturally the optimal policy subject to these restrictions will generally give a poorer result than that obtainable with a more general apportioning of the costs. This adds yet another aspect to the second-best nature of the problem, since the use of a fault system is a prior restriction on the entire analysis.

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[2] Diamond (1974) considers the possibility of "unrecognized" or unshiftable costs, as well.

[3] This is natural in the context in which the court (or government agency) cannot determine the care levels of anyone not involved in an accident, or can do so only at very high cost, but can ascertain this whenever an accident occurs. If some incentive structure is desired in a nonfault legal system, then some monitoring of care levels for nonaccident cases is necessary. A somewhat intermediate system is spot-checking, with increments in the insurance rate if a low care level is found.

We assume that all individuals have linear von Neumann-Morgenstern utility functions. The argument of the utility function is the loss incurred in the situation that has occurred: the share of accident costs, if any, and the cost of the care taken.

Let care, which has no natural units, be measured in dollars so that care level x (or y) is the highest level of accident avoidance that can be attained by spending x (or y) dollars. (We shall later consider the case in which the same level of care has a different cost for different individuals, but costs of different levels of care are linearly related. This would be satisfied if care were "produced" and the factor prices faced by different individuals were proportional, or if individual production functions for care differed by neutral technological shifts.) This method of measuring care implicitly assumes that the best accident avoidance technique is independent of the care being taken by the other group.[4]

Thus the utility function to be maximized by the injurer is

$$-x \qquad \qquad \text{if not liable}$$
$$-x - C\pi(x,y) \quad \text{if liable}$$

and for the victim, y replaces x. The question of liability is determined by using one of the legal rules described below.

We shall say that an individual is *negligent* if his care level is less than the due-care standard, and *nonnegligent* otherwise. Let x^* and y^* denote these standards. It is convenient to consider the liability of the injurer as it depends on the care level, y, selected by the victim.

If $y < y^*$, we have the following possible rules:

(1) injurer is not liable, independent of x;
(2) injurer is liable if $x < x^*$, and not otherwise.

For $y \geqq y^*$, the possibilities are

(3) injurer is liable if $x < x^*$, and not otherwise;
(4) injurer is always liable, independent of x.

A legal rule is a choice from the four pairs (1)–(3), (2)–(3), (1)–(4), and (2)–(4).[5] Note, however, that the rule specified by (1)–(4) is equivalent to (1)–(3) when $x^* = \infty$; similarly, (2)–(3) is the special case of (2)–(4) corresponding to $y^* = \infty$. Accordingly attention will be restricted to the rules (1)–(3) and (2)–(4).

The pair (1)–(3) is called the negligence-contributory negligence rule. This is the most prevalent rule in United States accident law and is the one on which Diamond concentrates. However, in some areas of liability law other rules are used, and abandoning the fault system has been suggested in the case of automobile accidents.[6] Brown (1973) has termed rule (2)–(4) the dual contributory negligence rule.

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[4] Such a condition might be violated if, for instance, in a pedestrian-automobile situation, care could have been taken by either better brakes or brighter lights. The better accident avoider for pedestrians might depend on which of these were employed if their choice were between shoes (to run away) or fluorescent jackets (to be seen better without lights).

[5] One should observe that there are four other possibilities: (i) strict liability of injurer; (ii) no liability of injurer; (iii) injurer liable if $x \geqq x^*$ and $y < y^*$; and (iv) injurer liable if $x \geqq x^*$ or $y < y^*$. The first two of these are interesting, but there is little to study relative to this model, since the legal constraints of due care are inoperative (see Calabresi, 1970 and Diamond and Mirrlees, 1975). The last two are absurd, and we ignore them.

[6] See Calabresi (1970).

Brown (1973) has shown that (1)–(3) and (2)-(4) are equivalent in the case in which costs of care are uniform within both classes of accident participants. Further, either of these methods can attain the first-best solution. Let $\bar{x}$ and $\bar{y}$ be the levels of care associated with a first-best minimization of expected accident costs plus costs of avoidance. That is $(\bar{x},\bar{y})$ minimize $x + y + C_\pi(x,y)$. Using rule (1)–(3), we can set $x^* = \infty$ and $y^* = \bar{y}$. If $y = y^* = \bar{y}$, injurers are liable and will choose x to minimize $C_\pi(x,y) + x$, or $x = \bar{x}$.

Victims, given $x = \bar{x}$, can choose $y > y^* = \bar{y}$ and have to pay only the costs of care, which are clearly minimized at $\bar{y}$, or can choose $y < y^*$, in which case costs will be $C_\pi(x,y) + y$, which we know are minimized at $y = y^* = \bar{y}$. The decision of victims will therefore be $y = y^* = \bar{y}$, thus avoiding liability. Thus, $(\bar{x},\bar{y})$ is a noncooperative equilibrium under this rule. Similarly, setting $x^* = \bar{x}$ and $y^* = \infty$ with liability determined by rule (2)–(4), can achieve the optimum.

In all situations in which the first-best solution is attained via the imposition of zero-one liability laws, one of the individuals bears the full weight of the social cost and therefore equates the marginal cost of care with its expected marginal benefit, thereby choosing the socially optimal level of accident avoidance activity. The other individual does not bear costs at all in the equilibrium situation. He chooses the social optimum, however, to avoid those costs which the legal system would assign to him if he decreased his level of care to any extent. The due care standard for this type of individual can be raised to the socially optimal level, where he prefers matching the due care standard, avoiding all liability judgments, to bearing the full weight of accident costs and taking no care.

The zero-one optimality result relies crucially on the assumption that the cost of care is constant across all potential injurers and across all potential victims.

3. Nonuniform equilibria

■ If there are differences in the cost of care between individuals in the same class, we cannot be sure that they will choose the same level of care when faced with the actions of the other group and the structure of the legal system. Thus, unlike the simpler case treated above, all individuals in the group which is not bearing the accident costs in equilibrium may not be forced to choose the socially optimal level. An optimum could be attained only if the court could apply different standards to individuals with different costs of care—that is, if the court could discriminate between otherwise identical individuals by applying care standards that vary with the cost of accident avoidance activity. Since such discrimination is excluded, either as a matter of policy or because of the court's imperfect information, we are in a second-best situation.

One result of our observations in the last section is that, rather than being a restriction, the zero-one characteristic of liability law is essential to the structure of the system. It is necessary to impose the full impact of any decrease in care level upon the group that is not bearing the accident cost in an equilibrium. Rules that allow for the sharing of costs cannot, by their very nature, impose the full marginal impact on this group, and therefore are not optimal in situations in which avoidance costs are identical. Perhaps, however, in the second-best world induced by the "justice-constraint" that due-care

standards be independent of avoidance costs, sharing rules or rules that divide costs with more than one step can surpass zero-one rules in performance.[7] We now turn to the question of the selection of the second-best legal system under conditions of nonuniformity of costs.

Such an undertaking in its fullest generality would be virtually impossible to exposit, let alone to analyze. We therefore shall deal with a very simple case in which the accident probability is additively separable in the two care levels:

$$\pi(x,y) = \phi(x) + \psi(y)$$

and ϕ and ψ are convex in their respective arguments.

The assumption that π is additively separable is not so severe as it might sound. It can be interpreted as saying that the accident is actually caused by either the injurer or the victim independently of the other's actions. The designations "injurer" and "victim" in this case simply indicate the group on which costs will fall in the absence of a legal determination.[8]

In this section we shall be treating cases in which all individuals are not necessarily alike. Therefore, in equilibrium, an individual who has an accident may be liable against only some of the members of the other group. For simplicity, we shall treat the case in which each group is composed of individuals with two levels of cost of care. The injurers have unit costs of either

$$1 \quad \text{(low cost)}$$
or
$$\alpha \quad \text{(high cost)}$$

per unit of care.

Similarly, the victims have unit cost levels of

$$1 \quad \text{(low cost)}$$
or
$$\beta \quad \text{(high cost)}.$$

Further, we assume that these four categories of people are all of the same size. Our analysis will focus on how the structure of the second-best legal system depends on α, β and the comparative accident probability response to care level.[9]

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[7] Brown (1973) has studied the efficiency of sharing rules in such situations under the name of relative negligence—a system used in Britain for some types of cases. His results concerning efficiency are largely negative. Shavell has recently pointed out to me that the relative negligence rule studied by Brown has a curious kind of one-sided stability. Upward deviations from the optimum will be corrected, but downward deviations will be unstable.

[8] But it may be that the victim actually "injures" himself and that the injurer is really an "innocent party" in a particular accident. Such circumstances may arise, for example, in industrial accidents that are caused either by equipment malfunction or by failure to take appropriate safety precautions, where the employees are the potential victims and the firm is the potential injurer. However, if these precautions are designed to protect a worker in the event of an equipment breakdown, the separability assumption will not be suitable.

[9] In the process of making all of the assumptions above, we have left open problems in the wake. Some of these are undoubtedly of serious practical importance. For example, the assumptions of equal group size and equal likelihood of accident with any member of the opposite class rule out those types of accidents in which the potential injurers and victims are paired off in advance. This might occur in on-the-job accidents, where a worker has no chance of an accident with any employers other than

□ **Individual behavior.** It will be useful to introduce some terminology at the outset of our discussion. In the model of Section 2, the liability status of an individual might or might not depend on his chosen level of care. That is, he would be always liable, never liable, or liable only if negligent, according to the legal rule and the actions of the other group. In the model with different cost classes these distinctions become more complex.

In a typical situation, the liability status of an individual will depend on his actions, the actions of the other party to the accident and the legal rule being used. If individuals in the two cost classes within the other group are choosing two levels of care, uniform within each, then there are three possibilities concerning the frequency with which a given individual will be liable. He could be liable in all accidents, irrespective of the identity of his opposite number; he could be liable only if the other party was taking the higher of the two care levels; or he might never be liable. We denote these *liability statuses* by

    A—always liable
    S—sometimes liable
    N—never liable.

When choosing his care level, an individual is assumed to know both levels chosen by the other group. Depending on the legal rule, his liability status will then be solely a function of whether or not he meets the due-care standard. Since meeting the due-care standard cannot worsen the liability status, there are six possibilities.

Three of these correspond to cases in which the individual is in the same liability status independent of his own action. We call this situation one of *insensitivity* to indicate that his liability is insensitive to his care level. The other three cases are those in which the liability status improves when the due-care standard is met.

We therefore classify the sensitivity of the members of either group according to the following scheme:

        sensitive: If below due care, liable in all accidents, A.
                    If above due care, never liable, N.
   + sensitive: If below due care, liable to low-cost group only, S.
                    If above due care, never liable, N.
   − sensitive: If below due care, liable in all accidents, A.
                    If above due care, liable to low cost group only, S.
   insensitive: Liability status independent of care level—can be A, S, or N.

Because of our assumption that π is additively separable, the care level selected by any individual depends only on his chosen liability status. In particular, it is independent of the care levels chosen by the other group, given the status he selects. The actions of the other group do influence his behavior, however, through two indirect effects. They determine his sensitivity category, and they may affect his

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his own, or in product liability, where the producing firm is the only potential injurer. The difference between these types of accidents is that the employer can monitor the care taken by his employees more easily than the seller can monitor his customer's care levels. These types of accidents can be treated in the same general framework we have been using, but the specific assumptions made will have to be altered. At any rate, this potentially fruitful line of inquiry will not be pursued herein.

choice of the liability status in which to place himself, given the sensitivity category. An example follows.

Let us consider a typical injurer of cost class α under liability rule (1)–(3), and facing a situation in which the care levels, y_1 and y_β, chosen by the two cost class of victims are such that $y_\beta \leqq y^* \leqq y_1$. Using the definition of the liability rule, we see that this injurer is +sensitive. In this situation his expected loss, as a function of his care level x_α is given by

$$\begin{aligned} \alpha x_\alpha + C\pi(x_\alpha, y_1) \qquad &\text{if} \quad x_\alpha < x^* \\ \alpha x_\alpha \qquad &\text{if} \quad x_\alpha \geqq x^*. \end{aligned}$$

With the separability assumption this is

$$\begin{aligned} \alpha x_\alpha + C\phi(x_\alpha) + C\psi(y_1) \quad &\text{if} \quad x_\alpha < x^* \\ \alpha x_\alpha \qquad\qquad\qquad &\text{if} \quad x_\alpha \geqq x^*. \end{aligned}$$

This is minimized at either $x_\alpha{}^s$ or x^*, where $x_\alpha{}^s$ is the solution to

$$\phi'(x) = \frac{-\alpha}{C}$$

according to whether or not $\alpha x_\alpha{}^s + C\phi(x_\alpha{}^s) + C\psi(y_1)$ is smaller than αx^*. This comparison depends on y_1, and hence so does the ultimate choice of care level, x_α. However, once the comparison is known, and the optimal liability status is determined, the particular value of x_α chosen is independent of the actions of victims by virtue of the separability assumption. This is the essential simplifying feature of the separability assumption, and it is easy to see the morass of special cases which would exist without it.

More generally, given all of our assumptions, the individual's selection of his liability status will be determined in two steps. The legal rule combined with the actions of members of the other group gives his sensitivity. This, combined with the location due-care standard for his group, defines the two possible liability statuses as a function of the care level he selects.

Let these optimal care levels determined by the liability statuses A, S, and N be denoted $x_1{}^A$, $x_1{}^S$, $x_1{}^N$, $x_\alpha{}^A$, $x_\alpha{}^S$, $x_\alpha{}^N$, $y_1{}^A$, $y_1{}^S$, $y_1{}^N$, $y_\beta{}^A$, $y_\beta{}^S$, and $y_\beta{}^N$, respectively, where the superscript indicates the (fixed) liability status and the subscript indicates the cost category of the individual.

We can therefore give a complete analysis of the decision making process of an individual as follows: He first ascertains his sensitivity category according to Table 1 below. Denote by x_1, x_α, y_1, and y_β the chosen levels by members of the four groups, retaining the uniformity of care assumption within each cost class.

He then locates the optimal care levels for the liability statuses he might choose. There will be one or two of these, according to whether or not the individual is insensitive. If such an action lies in the interior of the relevant interval, then it will be a potentially optimal action. However, as in Section 2 above, we must also recognize the possibility of corner solutions at the "match due care" solution. These may arise when the liability status corresponding to care levels above due care has an optimal action associated with it that is below due care. Similarly[10] it may be that the care level associated with the worse

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[10] This can only arise in the case of a −sensitive individual.

TABLE 1

SENSITIVITY CLASSIFICATION DEPENDING UPON LEGAL RULE
AND ACTIONS OF THE OTHER GROUP

		RULE 1–3	RULE 2–4
X IS:	WHEN,		
SENSITIVE		$y_1 \gtreqless y^*, \; y_\beta \gtreqless y^*$	$y_1 < y^*, \; y_\beta < y^*$
+ SENSITIVE		$y_1 \gtreqless y^*, \; y_\beta < y^*$	ϕ
– SENSITIVE		ϕ	$y_1 \gtreqless y^*, \; y_\beta < y^*$
INSENSITIVE		$y_1 < y^*, \; y_\beta < y^*$	$y_1 \gtreqless y^*, \; y_\beta \gtreqless y^*$
Y IS:	WHEN,		
SENSITIVE		$x_1 < x^*, \; x_\alpha < x^*$	$x_1 \gtreqless x^*, \; x_\alpha \gtreqless x^*$
+ SENSITIVE		ϕ	$x_1 \gtreqless x^*, \; x_\alpha < x^*$
– SENSITIVE		$x_1 \gtreqless x^*, \; x_\alpha < x^*$	ϕ
INSENSITIVE		$x_1 \gtreqless x^*, \; x_\alpha \gtreqless x^*$	$x_1 < x^*, \; x_\alpha < x^*$

liability status is above due care and that associated with the better
liability status is below due care. The reader can verify easily that the
optimal action will then be to match due care exactly.

   Having located the potentially optimal actions in this way, they
must be compared in a manner analogous to that in the example of the
+sensitive injurer above. The one with the lower expected costs is
selected.

□ **Equilibria of the model.** With these preliminaries behind us, we
proceed to analyze and classify alternative modes of equilibria for this
model.

   In any situation, each individual will be making his choice from
among the four care levels given by the A, S, and N levels and the
due-care standard, denoted by $*$. As there are four groups, it would
appear at first glance that there are 4^4, or 256, potential combinations
of equilibrium care levels. We now show that this large number of
possible care patterns can be narrowed down to 9.

   First, consider both types of injurers (or victims) together. Their
sensitivity status is the same in any situation, since it is determined
solely by the legal system and actions of the other group. The follow-
ing eight pairs of behavior modes are the only pairs that could occur
in an equilibrium; the other eight are ruled out by a variety of consid-
erations we explore below. The upper symbol indicates the care level
chosen by cost group 1 and the lower symbol characterizes cost group
α (or β):

$$\binom{*}{*} \quad \binom{A}{A} \quad \binom{S}{S} \quad \binom{N}{N} \quad \binom{*}{A} \quad \binom{*}{S} \quad \binom{S}{*} \quad \binom{S}{A}.$$

The pattern $\binom{A}{*}$ for example, which would mean that cost group 1
chooses to be always liable when the higher cost group chooses to

match the due-care standard (and be either sometimes liable or never liable, depending on whether the sensitivity class is $-$sensitive or sensitive), can be ruled out as follows. (We take the case of injurers and full sensitivity for concreteness.) If this pair of actions were simultaneously optimal, then we would have both

$$\alpha x^* < \alpha x_\alpha{}^A + C(2\phi(x_\alpha{}^A) + \psi(y_1) + \psi(y_\beta)) \qquad (1)$$

and

$$x^* > x_1{}^A + C(2\phi(x_1{}^A) + \psi(y_1) + \psi(y_\beta)). \qquad (2)$$

From the definitions of $x_1{}^A$ and $x_\alpha{}^A$ as optimal care levels when the two cost classes of injurers are in the always liable status, we have,

$$\phi'(x_1{}^A) = \frac{-1}{2C} \qquad (3)$$

$$\phi'(x_\alpha{}^A) = \frac{-\alpha}{2C}. \qquad (4)$$

The convexity of ϕ then yields

$$\phi(x_1{}^A) > \frac{-\alpha}{2C}(x_1{}^A - x_\alpha{}^A) + \phi(x_\alpha{}^A). \qquad (5)$$

From (5)

$$2C\phi(x_1{}^A) + \alpha x_1{}^A > 2C\phi(x_\alpha{}^A) + \alpha x_\alpha{}^A. \qquad (6)$$

Substituting (6) into (1) and dividing by α gives

$$x^* < x_1{}^A + \frac{C}{\alpha}(2\phi(x_1{}^A) + \psi(y_1) + \psi(y_\beta)), \qquad (7)$$

which contradicts (2) as $\alpha > 1$.

We can also rule out $\binom{A}{S}$ with a similar argument. The other six omitted patterns $\binom{A}{N}$, $\binom{S}{N}$, $\binom{*}{N}$, $\binom{N}{A}$, $\binom{N}{S}$ and $\binom{N}{*}$ do not correspond to any sensitivity class and are therefore inconsistent. This is because when one cost class can avoid liability without taking any care ($x_1{}^N = x_\alpha{}^N = 0$), it is impossible for the other cost class to have any liability status other than nonliable. We can thus reduce the possible combinations of behavior patterns for the two cost classes in each group to those listed above. This will be very helpful in classifying the potential equilibria to be studied presently.

■ These restrictions reduce the number of potential equilibria to 64. Table 2 shows the conditions under which any of these are possible under rule (1)–(3), the negligence-contributory negligence rule. The potential modes of equilibrium are classified into *types* as indicated by the Roman numerals. Vacant boxes mean that the indicated type of equilibrium is inconsistent with this legal rule.

Basically there are three causes of inconsistency among the 64 potential modes of equilibria:

(1) Total accident costs may not be divided exactly between all parties to an accident. They may not be covered completely or they may be overcovered, violating one of the second-best restrictions of the model.

4. Classification of types of equilibria

TABLE 2
TYPES OF EQUILIBRIA ATTAINABLE UNDER LEGAL RULE 1–3

$\binom{x_1}{x_\alpha}$ \ $\binom{y_1}{y_\beta}$	$\binom{*}{*}$	$\binom{A}{A}$	$\binom{S}{S}$	$\binom{N}{N}$	$\binom{*}{A}$	$\binom{*}{S}$	$\binom{S}{*}$	$\binom{S}{A}$
$\binom{*}{*}$		$y_1^A > y^*$ II						
$\binom{A}{A}$	$x_1^A < x^*$ I							
$\binom{S}{S}$					$x_1^S < x^*$ $y_\beta^A < y^*$ IV			
$\binom{N}{N}$		$y_1^A < y^*$ III						
$\binom{*}{A}$	$x_\alpha^A < x^*$ V		$x_\alpha^A < x^*$ $y_\beta^S < y^*$ VI				$x_\alpha^S < x^*$ $y_\beta^A < y^*$ VII	
$\binom{*}{S}$					$x_\alpha^S < x^*$ $y_1^S > y^*$ VIII			$x_\alpha^S < x^*$ $y_\beta^A < y^* < y_1^S$ IX
$\binom{S}{*}$								
$\binom{S}{A}$								

(2) A combination of behavior patterns, while possible in general, may be inconsistent with the particular legal rule under consideration.

(3) The sensitivity of one group, established by the actions of the other, may be inconsistent with their indicated choices.

Examples of the first type are $\binom{S}{S}$ for injurers and $\binom{S}{A}$ for victims, which involves more total liability than the total accident costs.

An example of the second category is $\binom{S}{S}$ for injurers and $\binom{*}{A}$ for victims. This would be possible if $x_1^S > x^* > x_\alpha^S$ and if injurers of cost class α were sometimes liable when matching the due-care standard. However, legal rule (1)–(3) makes injurers never liable if they behave in this way. Thus, this behavior pattern is inconsistent with legal rule (1)–(3)—but note that it is possible under rule (2)–(4) (see Table 3). The remaining possibility is that cost class α injurers are not liable when they match due care. Costs would be covered exactly, but this combination of liability statuses is also inconsistent, as it requires lower-cost injurers to choose lower care levels than higher cost injurers.

The third category covers $\binom{*}{A}$ for injurers and $\binom{*}{S}$ for victims, for example. Under (1)–(3), matching the due care standard makes injur-

TABLE 3

TYPES OF EQUILIBRIA ATTAINABLE UNDER LEGAL RULE 2–4

$\binom{x_1}{x_\alpha}\backslash\binom{y_1}{y_\beta}$	$\binom{*}{*}$	$\binom{A}{A}$	$\binom{S}{S}$	$\binom{N}{N}$	$\binom{*}{A}$	$\binom{*}{S}$	$\binom{S}{*}$	$\binom{S}{A}$
$\binom{*}{*}$		$y_1^A < y^*$ II′			$y_\beta^A < y^*$ V′			
$\binom{A}{A}$	$x_1^A < x^*$ I′			$x_1^A < x^*$ III′				
$\binom{S}{S}$					$x_\alpha^S > x^*$ $y_\beta^A < y^*$ VI′			
$\binom{N}{N}$								
$\binom{*}{A}$			$x_\alpha^A < x^*$ $y_1^S < y^*$ IV′			$x_\alpha^A < x^*$ $y_\beta^S < y^*$ VII′		
$\binom{*}{S}$								
$\binom{S}{*}$					$x_1^S > x^*$ $y_\beta^A < y^*$ VIII′			
$\binom{S}{A}$					$x_\alpha^A < x^* < x_1^S$ $y_\beta^S < y^*$ IX′			

ers never liable. The due-care standard behavior for victims must correspond to a sometimes liable status in order to cover accident costs between two individuals of cost class 1. Therefore, both victims have the same liability status and are −sensitive according to the liability rule. Hence $y_\beta^S > y^*$, for otherwise cost class β victims would be always liable. But since $y_1^S > y_\beta^S$ by the convexity of ψ, we have $y_1^S > y^*$. Victims of cost class 1 are choosing y^* when y_1^S would give them the same sometimes-liable status. By the optimality of y_1^S given this status, the choice of y^* is contradictory. All cases in which the boxes are left blank can be eliminated by arguments parallel to those above.

Table 3 gives the restrictions on the characterizations of equilibria under rule (2)–(4). By symmetry, it can be obtained from Table 2 by interchanging x with y and α with β.

Before proceeding to analyze the comparative efficiency of these types of equilibria, we shall find it useful to examine further Tables 2 and 3. The equilibria can be grouped into three categories, and the following section will be organized along these lines. In types I, II, and III, the two cost classes in each group have the identical liability status in equilibrium. In types IV, V, and VI, one group has a uniform liability (sometimes liable) while the other group is divided into an always liable higher cost class and a never liable lower cost

class. Finally, types VII, VIII, and IX are characterized by nonuniform liability status in both groups.

A comparison of these tables reveals further that equilibria of types I, II, IV, V, and VI are attainable under either legal rule. (Type III, which later will be shown to be an inefficient mode, is symmetric to type III'.) However, if the desired mode of equilibrium is among the last three, the two legal rules are not equivalent. This represents a difference with the results of Brown and Diamond. In their models, the two legal rules were always identical in their potential to attain any equilibrium. Moreover, the court never played an active adjudicatory role. In equilibrium it would either assign liability always to injurers or always to victims, independent of the accident in which they were involved. In equilibria of types IV–IX and IV'– IX' the court does adjudicate accidents differently, according to the care levels taken by the parties to the accident, which in equilibrium reflects the cost classes to which they belong.

5. Variations of due care standards and legal rules to attain superior types of equilibria

■ The previous sections have provided a classificatory scheme under which we can study alternative possible equilibria as they respond to changes in due care standards and alternative legal rules. The strategy will be as follows: we shall study for each of the types of equilibria I–IX and I'–IX', the best levels for due-care standards consistent with attaining an equilibrium of that type. This is done most easily by dividing the eighteen types into three groups of six, within which the characteristics of the equilibria are very closely related. Then, these "best" equilibria are compared to ascertain which is the overall optimum.

The goal will be to choose care standards and the legal rule in such a way as to minimize the total social costs. These are given by

$$x_1 + \alpha x_\alpha + y_1 + \beta y_\beta + 2(C\phi(x_1) + C\phi(x_\alpha) + C\psi(y_1) + C\psi(y_\beta)),$$

since for each cost class, its expected accident costs are the sum of its expected costs of an accident with each of the two cost classes of the other group. This accounts for the coefficient "2" in front of the bracketed expression above. The first-best situation occurs when all care levels are set in the always liable mode. This can be seen because the first-order conditions for the minimization of the above expression with respect to $(x_1, x_\alpha, y_1, y_\beta)$ coincide with the first-order conditions that define x_1^A, x_α^A, y_1^A, and y_β^A, respectively. The first-best will serve as a useful benchmark from which to measure the short fall from optimality associated with various equilibria.

□ **Equilibria of types I, II, III, I', II', and III'.** We investigate the conditions on x^* and y^* under which there would be equilibria of these types. Then, we seek the best attainable equilibrium consistent with these restrictions.

Type I equilibria are those in which all injurers are below due care, choosing their optimal "always liable" levels, and are liable against both cost classes of victims, who are exactly matching due care in order to avoid liability. In type I equilibria (and type II' which is symmetric), both injurers and victims are sensitive given the other group's actions. Therefore, in order that the indicated care levels be noncooperative equilibria, we require that the indicated choices be

less costly for each of the four cost classes than the choice of the alternative liability status available to them. The conditions for injurers who reject due care and no liability in favor of the optimal always liable care level are

$$x_1^A + C(2\phi(x_1^A) + 2\psi(y^*)) \leqq x^* \tag{8}$$

$$x_\alpha^A + \frac{C}{\alpha}(2\phi(x_\alpha^A) + 2\psi(y^*)) \leqq x^* \tag{9}$$

and for victims, who make the opposite choice

$$y^* < y_1^A + C(\phi(x_1^A) + \phi(x_\alpha^A) + 2\psi(y_1^A)) \tag{10}$$

$$y^* < y_\beta^A + \frac{C}{\beta}(\phi(x_1^A) + \phi(x_\alpha^A) + 2\psi(y_\beta^A)). \tag{11}$$

Thus for x^* sufficiently high and y^* sufficiently low, a type I equilibrium exists. Since there are no welfare losses attributable to nonoptimal actions by injurers, the only problem is to set y^* optimally within the range compatible with the existence of equilibrium of this type. The loss due to the victim's actions is

$$(1 + \beta)y^* + 4C\psi(y^*),$$

which is minimized when y^* satisfies

$$\psi'(y^*) = -\frac{1 + \beta}{4C}. \tag{12}$$

This value of y^* is, of course, between y_1^A and y_β^A. If the right-hand side of (10) is less than the right-hand side of (11), then satisfying (11) with equality gives rise to the optimal type I equilibrium. (Since $y^* < y_1^A$, the constraint (10) is never binding.) If (11) is not satisfied at the y^* defined by (12), then (11) should be satisfied with equality to attain the best type I equilibrium. Let us denote the y^* associated with the best type I equilibrium by y^{*I}.

In type II′ equilibria, both groups are sensitive. The behavior of victims requires the same restrictions on y^* as in (10) and (11). Therefore, these two types of equilibria can attain the same equilibrium care levels.

With type II equilibria injurers are sensitive and victims are insensitive (liable). The due-care behavior of injurers requires that

$$x^* \leqq x_1^A + C(2\phi(x_1^A) + \psi(y_1^A) + \psi(y_\beta^A)) \tag{13}$$

$$x^* \leqq x_\alpha^A + \frac{C}{\alpha} 2(\phi(x_1^A) + \psi(y_1^A) + \psi(y_\beta^A)). \tag{14}$$

Cost minimizing behavior requires that

$$\phi'(x^*) = -\frac{(1 + \alpha)}{4C}, \tag{15}$$

which is analogous to the type I case. This is either feasible subject to (13) and (14) or else the optimal x^* is given by the equality in (14). We denote the optimal value of due care for injurers with this type of equilibrium by x^{*II}.

Type I′ can be shown to be equivalent to type II, as above. Equilibria of types III and III′ involve one group in the always liable mode and the other taking no care at all. Since x^{*II} and y^{*I} are both positive, type III and type III′ produce equilibria inferior to types I

and II, and we can therefore neglect them in our second-best analysis.

In comparing the best type I equilibrium to the best type II, the relevant welfare loss compared to the first-best situation for type I is

$$(1 + \beta)y^{*I} + 4C\psi(y^{*I}) - y_1^A - \beta y_\beta^A - 2C\psi(y_1^A) - 2C\psi(y_\beta^A)$$

and for type II it is

$$(1 + \alpha)x^{*II} + 4C\phi(x^{*II}) - x_1^A - \alpha x_\alpha^A - 2C\phi(x_1^A) - 2C\phi(x_\alpha^A).$$

As α gets closer to 1, for fixed $\beta > 1$, we know that x_α^A gets close to x_1^A, and the efficiency loss in the type II equilibrium approaches zero because x^{*II} is between x_α^A and x_1^A when α is small, as (14) is not binding in such cases. A symmetric remark applies for type I equilibria when β becomes small and $\alpha > 1$. Summarizing our analysis of this section, we can state the following general principles:

(1) Types I, II, I′, and II′ always dominate types III and III′.
(2) Cost-of-avoidance patterns attainable as equilibria of types I and II are identical with those of types II′ and I′, respectively. Therefore, the two legal rules are equivalent as far as these types of equilibria are concerned.
(3) The best type I equilibrium will be superior to the best type II equilibrium when β is small relative to α. To attain the optimum, x^* is set very high and y^* is set at a level between y_1^A and y_β^A. This is reversed when α is small relative to β.
(4) When $\alpha(\beta)$ approaches 1, the best type II (I) equilibrium converges on the first-best solution. In particular, if costs of care are constant within either group, the first-best optimum can be obtained by choosing the optimal care level as the due-care standard for that group and by making it sensitive under the legal rule. If the other group is facing a very high due-care standard, it will choose its optimal always liable level below it. This will make the due-care standard the optimal response by the group with constant costs of care.

☐ **Equilibria of types IV, V, VI, IV′, V′, and VI′.** In these types of equilibria, one of the groups is acting in its sometimes liable mode, while in the other group the lower cost class is never liable and the higher cost class is always liable. In type IV equilibrium injurers are +sensitive and choose to take the sometimes liable level of care instead of the due-care standard. They are liable in accidents involving victims of cost class 1. Their behavior is optimal when the due-care standards satisfy

$$x^* \geqq x_1^S + C(\phi(x_1^S) + \psi(y^*)) \tag{16}$$

$$x^* \geqq x_\alpha^S + \frac{C}{\alpha}(\phi(x_1^S) + \psi(y^*)). \tag{17}$$

Victims are sensitive and therefore their care choices $y_1 = y^*$, $y_\beta = y_\beta^A$ are optimal if and only if

$$y^* \leqq y_1^A + C(\phi(x_1^S) + \phi(x_\alpha^S) + 2\psi(y_1^A)) \tag{18}$$

$$y^* \geqq y_\beta^A + \frac{C}{\beta}(\phi(x_1^S) + \phi(x_\alpha^S) + 2\psi(y_\beta^A)). \tag{19}$$

In choosing among type IV equilibria, the only variable is y^*, which will be the care level chosen by cost class 1 victims. The due-care standard for injurers should be set high, so that they will choose x_1^S and x_α^S, respectively. Because of the separability assumption, the optimal value at which to set y^* would be y_1^A. Therefore (18) is not a restriction for the attainment of second-best optimality. With regard to (19), if the right-hand side is above y_1^A, then the second-best policy is to set y^* equal to that expression; if it is below y_1^A, then $y^* = y_1^A$ is optimal, and if it is above the right-hand side of (18), then no type IV equilibrium exists. To ascertain the behavior of the optimal value of y^* it is therefore necessary to investigate the behavior of the right-hand side of (19) as β varies.

One can show[11] that the right-hand side of (19) decreases as β increases assuming values ranging from above y_1^A, when β is near 1, to 0 when β is large. Thus there will be a unique value of β at which the right-hand side of (19) is equal to y_1^A, above which type IV equilibria involve both cost classes of victims at their always liable levels. Moreover, the fact that the right-hand side of (19) decreases with β indicates that type IV equilibria always exist for y^* chosen in the interval indicated by the relations (18) and (19).

A similar analysis for type VI equilibria yields the results that for small values of α, $x_1 = x^*$ will be above x_1^A, and for α sufficiently large, equilibria involve both injurers at their always liable levels of care and both victims at the sometime liable levels. As in the previous section, types VI' and IV' are directly analogous to types IV and VI, respectively, and, therefore, the two legal rules are equivalent here as well.

One central difference should be pointed out between the equilibria of the previous section and the present one. In equilibria of types I and II, the court's role was merely to act as a threat against some agent's not following his due-care standard, in which case he would become liable and the court's decision would be reversed. However, if everyone follows his equilibrium care level, the court decides all cases the same way. In types IV and VI, however, some cases are decided in favor of injurers and some in favor of victims—namely, the court plays an active adjudicatory role.

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[11]

$$\frac{d}{d\beta}\left(y_\beta^A + \frac{C}{\beta}[\phi(x_1^S) + \phi(x_\alpha^S) + 2\psi(y_\beta^A)]\right)$$

$$= \frac{dy_\beta^A}{d\beta} + \frac{C\left(2\beta\psi' \dfrac{dy_\beta^A}{d\beta} - [\phi(x_1^S) + \phi(x_\alpha^S) + 2\psi(y_\beta^A)]\right)}{\beta^2}.$$

Differentiating the first-order condition defining y_β^A,

$$\psi'(y_\beta^A) = \frac{-\beta}{2C},$$

we have

$$\frac{dy_\beta^A}{d\beta} = \frac{-1}{2C\psi''}.$$

Therefore, the expression for the derivative above becomes

$$\frac{-C(\phi(x_1^S) + \phi(x_\alpha^S) + 2\psi(y_\beta^A))}{\beta^2} < 0.$$

Finally, we turn to type V. We shall show that type V equilibria are always dominated by the best of the type I equilibria, and hence that this type may be neglected in our search for the second-best optimum. The behavior modes in these equilibria differ only in that injurers of cost class 1 are choosing the due-care standard instead of the always liable level. Of course, this makes victims who take the due-care standard liable sometimes instead of never. We shall demonstrate that the range of choice available for y^* is more restricted here than in type I. Hence, type I equilibria are superior as they involve a zero efficiency loss resulting from injurers' behavior and a smaller efficiency loss from due-care behavior by victims. To see this we note that victims are $-$sensitive in type V equilibria, hence

$$y^* \leqq y_1^A + C(\phi(x_\alpha^A) + \psi(y_1^A)) \tag{20}$$

and

$$y^* \leqq y_\beta^A + \frac{C}{\beta}(\phi(x_\alpha^A) + \psi(y_\beta^A)). \tag{21}$$

The right-hand side of (21) is always less than the right-hand side of (11), which is the relevant constraint in type I equilibria. A symmetric argument for type V′ equilibria also eliminates them from consideration as potential second-best configurations.

The following remarks summarize the result obtained in this section:

(1) Type IV (VI) equilibria involve injurers (victims) who choose the sometimes liable care level and victims (injurers) who are of different liability status, the higher cost class being always liable and the lower cost class being never liable because they are matching the due-care standard. The lower cost class can be forced to take the always-liable level of care, which is socially optimal, when $\beta(\alpha)$ is large; if $\beta(\alpha)$ is below some critical level, only values of due-care standards for victims (injurers) above the optimum can sustain these types of equilibria. Thus, the best equilibria of this type involve some welfare loss, relative to the first-best, because of the sometimes liable behavior of injurers (victims) and, if $\beta(\alpha)$ is small, a further loss due to excessive care taken by the low cost-class victims (injurers).
(2) Type V equilibria can always be dominated by type I equilibria.
(3) As α and β increase, it will eventually be impossible to sustain equilibria of types IV and VI. Thus, the short fall from the optimum in these types decreases with the cost differentials and they reach their most efficient situation when the constraints (18) and (19) are tight.

□ **Equilibria of types VII, VIII, IX, VII′, VIII′, and IX′.** These types of equilibria are characterized by different liability statuses within both of the groups. Further, the legal rules are not equivalent under these regimes.

In type VII equilibria, injurers are $+$sensitive and victims $-$sensitive. The conditions on x^* and y^* are therefore that

$$x^* \leqq x_1^S + C(\phi(x_1^S) + \psi(y^*)) \tag{22}$$

$$x^* \geqq x_\alpha^S + \frac{C}{\alpha}(\phi(x_\alpha^S) + \psi(y^*)) \tag{23}$$

and

$$y^* \leqq y_1{}^A + C(\phi(x_\alpha{}^S) + \psi(y_1{}^A)) \tag{24}$$

$$y^* \geqq y_\beta{}^A + \frac{C}{\beta}\,(\phi(x_\alpha{}^S) + \psi(y_\beta{}^A)). \tag{25}$$

The right-hand side of (23) can be shown to be monotone in α by use of the definition of $x_\alpha{}^S$. The right-hand side of (25) is not necessarily monotone in β; therefore this type of equilibrium might not exist for any y^* if this expression is above (24). When type VII equilibria do exist, however, the feasible range of values of y^* does not depend on x^*; but the range of feasible x^* values is dependent on y^*. Values of x^* and y^* that lead to potential type VII equilibria are shown in Figure 1, for fixed α and β.

FIGURE 1

PAIRS OF DUE CARE STANDARDS LEADING TO TYPE VII EQUILIBRIA
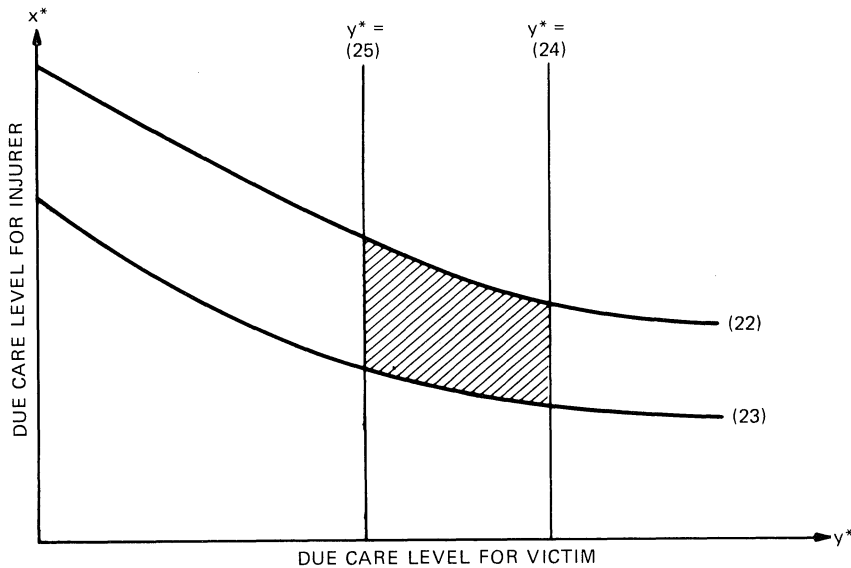
The optimal type VII equilibrium cannot be determined *a priori*. Depending on the shapes of ϕ and ψ, $y_1{}^A$ will be located within the feasible y range or to the left. The value of $x_1{}^A$ could be either above (22), in between the constraints, or below (23).

Type VII equilibria will be better relative to the equilibria of other types when α when β are both large. In that case $y_1{}^A$ is above (25), and feasible as a choice of y^*, and (23) is below $x_1{}^A$. Therefore, depending on the relationship of $x_1{}^A$ and (22), and the marginal social cost of deviating upwards from $y^* = y_1{}^A$, the optimum is attained either when both low-cost groups are at their always liable level or when low-cost victims are below that level and low-cost injurers are above it. At best, type VII equilibria can attain a position at which the optimal level of care is being taken by every group except injurers of cost class α. This is an important point, for when α and β are large, types I–IV involve large welfare losses due to nonoptimal behavior by more than one cost class.

The analyses of types VIII, VII′, and VIII′ are similar. Each potentially involves many special cases, but the limiting results as α

and β are large are the same in each case. In type VIII it is cost class 1 victims who choose their sometimes liable instead of always liable mode. Types VII′ and VIII′ give rise to this behavior by cost class β victims and cost class 1 injurers, respectively.

The best among the type IX (or IX′) equilibria when they exist can be shown to be inferior to the best type VII or (VII′) equilibria. This allows us to ignore these types in our subsequent comparisons of optimal equilibria. Let x^* and y^* be due-care standards associated with an optimal type IX equilibrium. As in all type IX equilibria, we must have $y^* \leq y_1^S$ or otherwise no cost class 1 victim would choose y_1^S when y^* would give rise to the same liability status. By the convexity of ψ, $y_1^A > y_1^S$. This means that for any other due-care standard, $\tilde{y}^*$, between y_1^S and y^*, the same type IX equilibrium exists. Victims of cost class 1 will continue to find y_1^S superior to $\tilde{y}^*$ by definition of y_1^S, and victims of cost class β will observe that becoming sometimes liable is even more costly than in the original situation. Their actions are unchanged, and therefore the injurers' equilibrium actions are still optimal. Thus, any optimal type IX equilibrium can also be sustained as a type VII equilibrium by due-care standards that are the same for injurers and y_1^S for victims. In such a situation, the two types of equilibria coincide.

Moreover, we now show that type VII equilibria can always attain a superior situation to type IX. Let x^* and y^* be set so as to attain the best type IX equilibrium. We then have the injurers' behavior defined by inequalities (22) and (23). The victims' behavior is defined by $y_1^S \geq y^* \geq y_\beta^A$.

To see that a type VII equilibrium can be found to dominate this, suppose first that (22) is slack at the type IX optimum. Then y^* can be increased to a level just slightly above y_1^S, this inequality will remain satisfied, and low-cost victims will still match the due-care standard. Since $y_1^A > y_1^S$, social costs will be decreased by the improved care level of these victims. As no other care levels will be altered, a more efficient outcome is reached.

When (22) is tight, this shift in y^* above y_1^S will force a decrease in x^* to continue to satisfy this relation and maintain a type VII equilibrium. Nevertheless, social costs will still decrease.

The change in social costs for such an incremental change y^* when (22) is tight is

$$(1 + 2C\psi'(y^*) + C\psi'(y^*)[1 + 2C\phi'(x^*)])dy^*.$$

Using $y^* = y_1^S$ and $\psi'(y_1^S) = \dfrac{-1}{C}$, this becomes

$$-2(1 + C\phi'(x^*))dy^*.$$

Since $x^* > x_1^S$ when (22) holds with equality, this is negative and social costs can thus be lowered in this case as well via a shift from the best type IX equilibrium to this type VII equilibrium.

The results of this section indicate that the optimum equilibrium is one of the types I, II, IV, VI, VIII, VII′, or VIII′, the others being either inferior or redundant due to the symmetries in the liability rules. If either α or β is close to 1, the first-best situation can be approximated by type I or II equilibria. When α and β become larger, the optimal equilibria can be of any of the other types. Generally speaking, types VII, VIII, VII′, and VIII′ are superior to types IV

and VI when they coexist, for the former tend to involve nonoptimal actions by one cost class instead of two. However, they typically exist only for larger α and β values. General results along these lines are not obtainable because of the complexities of finding the optimal equilibria within each type.[12]

■ The preceding analysis demonstrates that choosing optimal liability laws is a complex task, even under a very restrictive set of assumptions. We have tried to show that the structure of the legal rules can be important to finding an optimum, but that, over a substantial range of the parameters, the alternative rules are equivalent. It was also shown that a first-best situation cannot be expected to arise in general, due to an informational constraint on the court's behavior— namely that it does not know, or must disregard, differences in the costs of care among otherwise identical individuals.

Broadly speaking, our results can be summarized as follows. When these cost differences are small on either side of the potential injurers or potential victims, liability should be placed on the group with the relatively smaller cost spread and the other group should be exempt from liability by matching a due-care standard set between their respective socially optimal care levels. In this way, the first-best is approximated, and a welfare loss arises to the extent of this approximation.

As the cost spreads within both groups widen, this approximation to the first-best may become very bad. It might then be superior to construct liability laws in a way such that the two cost classes, in either one or both of the groups, have different liability statuses in equilibrium. Depending upon the parameters of the problem, a variety of configurations might arise. We have characterized these and tried to analyze their relative efficiency properties.

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[12] Although analytic results are not attainable, one can show by example that there may be situations in which other types of equilibria out-perform the approximation to the first-best attainable through types I and II.

The interested reader might verify this by considering the model in which

$$\phi(x) = e^{-x}$$
$$\psi(y) = e^{-y}$$

and where α and β are equal, with C greater than their common value.

In this situation, type I equilibria are superior for $\alpha(\beta)$ less than the critical value given by the solution to

$$\log \frac{2}{1+\alpha} + \alpha \log \frac{2\alpha}{1+\alpha} = \alpha\,(1 - \log 2).$$

The right-hand side is the social loss, in excess of the first-best situation, attainable in a type VII equilibrium and the left-hand side is that associated with the optimal type 1 equilibrium. The unique nonnegative solution to this equation defines the point above which type VII equilibria attain the second-best.

Further details of this example are available from the author upon request.

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