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Economic Efficiency of Liability Rules for Joint Torts With Uncertainty

The influence of liability rules on human behavior and hence on economic efficiency has received a great deal of attention since the early works of John P. Brown (1973), Richard Posner (1972), and others. Recently, Landes and Posner (1980) have discussed the efficiency of liability rules when two parties are involved in causing an injury to a third party. They find that several classes of liability rules promote economic efficiency. Like most previous authors writing in this area, Landes and Posner assume that courts have complete information. This paper analyzes the efficiency of various liability rules when courts have imperfect information.

In jurisprudence, questions of liability for accidents are addressed by tort law. A tort is a "wrong" that leads to an accident. The body of tort law defines those actions which are "wrong" and therefore bring liability onto the perpetrator of the "wrong," or the "tortfeasor," to pay the injured party, or victim. If the actions of more than one party cause the injury, the tort is called a "joint tort" and the parties are called "joint tortfeasors".

Many liability rules developed in tort law employ a negligence standard to determine what actions bring liability. A party is said to be "negligent" if the level of care he exercises is below some "due care standard." In a tort where only one party causes the injury, the negligent party must usually compensate the victim for the damages. If the person who "causes" the accident exercises due care, however, the victim is left uncompensated.[1] In a joint tort, if only one party acts negligently, that party is liable for full damages. If more than one party is negligent, every negligent party is potentially liable for the full amount of the damages in most states. However, under tort law, victims are usually not allowed to recover more than the damages. Thus, the sum of the amounts paid by all the negligent parties never exceeds the total damages. It often happens that the victim recovers the damages from only one of the negligent parties. Liability rules vary as to whether the sued party can then recover any of the damages from the other negligent parties. Under a "no contribution rule," the sued party is not allowed to recover any portion of the awarded damages from the other negligent parties. Under a "contribution rule," he may be allowed to recover some fraction of the awarded damages.

In Section 1, I show that, under perfect information, i.e., when there are no unobservables, all negligence rules can produce efficient results, whether they employ contribution or no contribution. However, joint tortfeasors never behave negligently. This result appears in Landes and Posner. In Section 2, I discuss joint torts under imperfect information. With imperfect information, joint tortfeasors are sometimes found to be negligent. The result that both rules with no contribution and rules with contribution can produce efficient outcomes is shown to be true only when the unobservables are unobserved by both the tortfeasors and the court. However, when the tortfeasors have better information than the courts, rules of contribution can produce more efficient results than rules of no contribution. I then discuss two cases where rules of contribution can lead to results which are just as efficient as when courts have perfect information. In Section 3, I discuss society's choice of liability rules in light of these in results and other considerations.

1. Joint Torts with Perfect Information

This section outlines a simple model for analysing the economic efficiency of various liability rules for joint torts in a world of perfect information. It is shown that there are many types of liability rules that promote economic efficiency. The model is similar to that of John P. Brown. For simplicity, I assume that there are two tortfeasors, X and Y.[2] The tortfeasors choose to exercise levels of care, x and y, respectively. The probability of an accident occuring, $P(x,y)$, depends on the levels of care chosen by X and Y. If either X or Y increases his level of care, the probability of an accident declines, i.e. $P_x<0$, and $P_y<0$. However, there are diminishing returns to care, i.e., $P_{xx}>0$ and $P_{yy}>0$. I make no assumptions about whether the levels of care of X and Y are substitutes or complements, i.e., $P_{xy}\gtreqless 0$. However, I assume that $P^2_{xy}<P_{xx}P_{yy}$, i.e., the degree of substitution or complementarity is not extreme. This assures convexity. For simplicity, I assume that the victim's actions do not affect the probability of an accident. All accidents result in A dollars of damage.

Taking care is costly. The costs of units of care for X and Y are w_x and w_y, respectively. (When the subscripts are dropped, it is assumed $w_x = w_y = w$.)

The joint tortfeasors and the victim are all assumed to be risk neutral. This assumption is crucial for many of the results in this paper. A brief discussion of liability rules with risk averse tortfeasors can be found in the conclusion. Therefore, when X and Y choose their levels of care, the expected loss to society is the sum of the costs of taking care and the expected loss from accidents, that is:

1) $L(x,y) = w_x x + w_y y + AP(x,y)$.

If income redistribution can be effected through lump sum transfers, then the efficient levels of care, x* and y*, which maximize the social welfare function, are the same as the levels which minimize the loss function. The first order conditions for minimizing the loss functions are:

2) $w_x + AP_x(x^*,y^*) = 0$, or $P_x = -w_x/A$

3) $w_y + AP_y(x^*,y^*) = 0$, or $P_y = -w_y/A$.

The second order conditions are:

4) $P_{xx} > 0$

5) $P_{yy} > 0$

6) $P^2_{xy} < P_{yy} \cdot P_{xx}$.

Therefore, if x^* and y^* satisfy equations 2) through 6), x^* and y^* are the efficient levels of care.

A liability rule is a rule that defines the proportion of the damages, A, paid by each party. Since tort law does not usually allow punitive damages, the share each party pays is non-negative, and the shares sum to one. A liability rule is said to include a negligence standard, $(\bar{x},\bar{y})$, if there is no liability for X (or Y) when his level of care, x (or y), exceeds the "due care" or "negligence" standard, $\bar{x}$ (or $\bar{y}$). Thus, it is said that X (or Y) is negligent if his level of care is below the negligence standard, $\bar{x}$ (or $\bar{y}$). When neither X nor Y is acting negligently, i.e., $x \geq \bar{x}$ and $y \geq \bar{y}$, the victim pays for the accident. When either X or Y is acting negligently, i.e., $x < \bar{x}$ or $y < \bar{y}$, the victim is fully compensated for the accident. Therefore, if only one party is negligent, that party pays for the accident. If both parties are negligent, then the liability rule has an implicit sharing rule, $s(x,y)$, which defines X's share of the liability. Y's share is $1-s(x,y)$. The sharing rule is one of "mechanical contribution" if the courts set $s(x,y) = s$, i.e., the share paid by the negligent parties is not affected by their degrees of negligence. The rule is one of "judgmental contribution" if $s(x,y)$ depends on the levels of care, x and y. The more care one party exercises when the other party's level of care is held constant, the less that party pays, i.e., $s_x < 0$ and $s_y > 0$. The sharing rule is one of "no contribution" when the share of the sued party is set at one. *Ex ante*, a rule of no contribution is similar to one of contribution if the tortfeasors are risk neutral. Under a no contribution rule, the share X expects to pay is not determined by the courts, but rather by the probability that the victim sues X rather than Y for full damages:

$$s(x,y) = \text{Prob } [x \text{ is sued}].$$

The following chart summarizes any liability rule that has a negligence standard $(\bar{x},\bar{y})$ and a sharing rule $s(x,y)$.

	X pays	Y pays	Victim pays
$x \geq \bar{x}$, $y \geq \bar{y}$	0	0	A
$x \geq \bar{x}$, $y < \bar{y}$	0	A	0
$x < \bar{x}$, $y \geq \bar{y}$	A	0	0
$x < \bar{x}$, $y < \bar{y}$	$s(x,y)A$	$[1-s(x,y)]A$	0

Faced with a liability rule, each party minimizes his expected expenses, i.e., the sum of his cost of care and his expected liability. The expected expenses for X depend on what he expects Y's level of care to be, and vice versa. Let X's expectation of y be y^e and Y's expectation of x be x^e.

Thus, X's expected expenses are:

$$l(x,y^e) = \begin{cases} w_x x & \text{if } x \geq \bar{x} \text{ and } y^e \gtreqless \bar{y} \\ w_x x + P(x,y^e)A & \text{if } x < \bar{x} \text{ and } y^e \geq \bar{y} \\ w_x x + s(x,y^e)P(x,y^e)A & \text{if } x < \bar{x} \text{ and } y^e < \bar{y} \end{cases}$$

Y's expected expenses are:

$$m(y,x^e) = \begin{cases} w_y y & \text{if } y \geq \bar{y} \text{ and } x^e \gtreqless \bar{x} \\ w_y y + P(x^e,y)A & \text{if } y < \bar{y} \text{ and } x^e \geq \bar{x} \\ w_y y + [1-s(x^e,y)]P(x^e,y)A & \text{if } y < \bar{y} \text{ and } x^e < \bar{x} \end{cases}$$

Let $x(y^e)$ be the level of care that minimizes $l(x,y^e)$ and $y(x^e)$ be the level of care that minimizes $m(y,x^e)$.

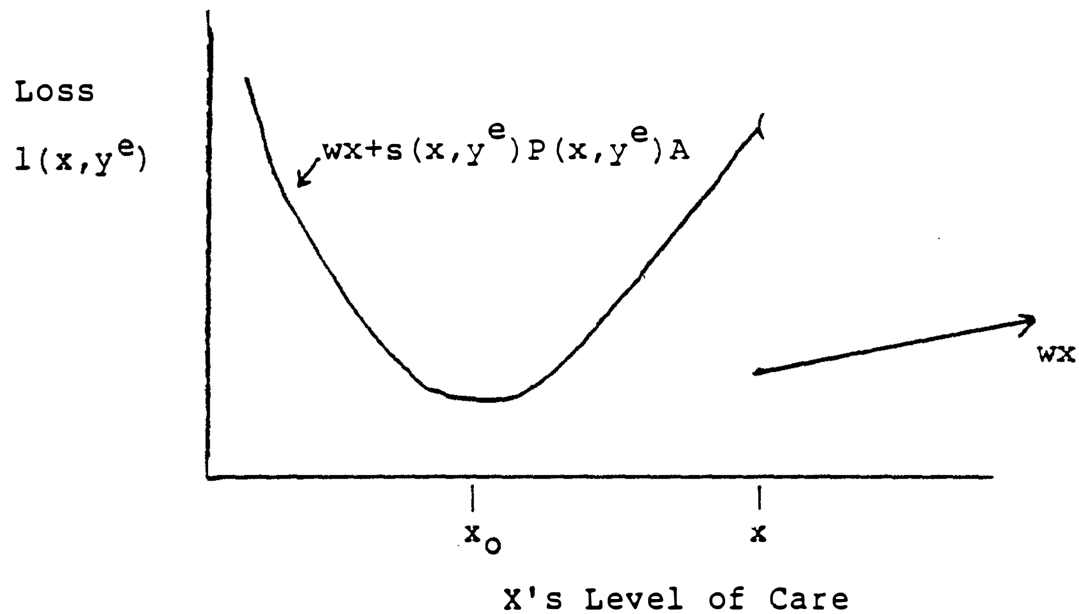
A Nash equilibrium in pure strategies is defined as (x',y') such that $x'=x^e$ and $y'=y^e$.

Equilibrium may not be unique nor exist in pure strategies because of non convexities in the loss function. The loss function, l, is shown in figure 1.

In the interval $[0,\bar{x}]$, $l(x,y^e)$ is convex in x, i.e., $l_{xx}<0$, because s and P are convex and $s_x P_x>0$. However, there is a discontinuity in the loss function at $\bar{x}$, since liability is completely avoided by nonnegligent behavior $(x \geq \bar{x})$. This discontinuity gives rise to a nonconvexity, and either multiple or nonexistent pure strategy equilibria are

Figure 1

X's Loss Function



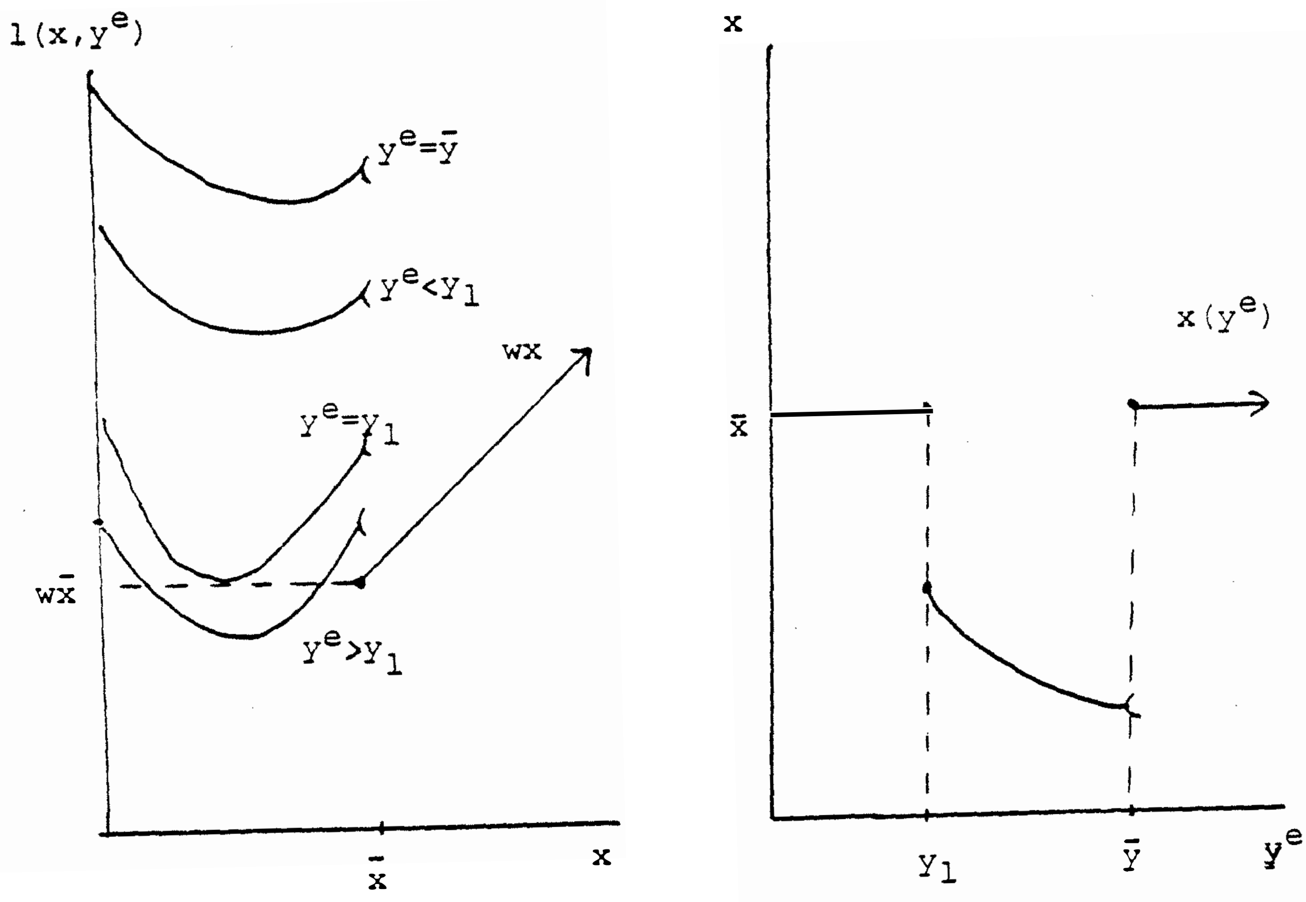
possible. (Also, because the payoff function, which is the negative of l, is not quasi-concave a mixed strategy equilibrium need not even exist.[3])

The loss function is minimized either at x_0, where the derivative of the loss function is zero, or at $x=\bar{x}$. Thus, $x(y^e)$ and $y(x^e)$ are reaction curves. The reaction curve has another possible discontinuity where $y^e=\bar{y}$, because at this point, liability jumps from a fraction of the cost of the accident to the entire cost if $x<\bar{x}$ and if the limit of $s(x,y)$ as y goes to $\bar{y}$ is not 1. Thus, a possible reaction curve is shown in Figure 2.

For $y<y_1$, the probability of an accident may be so great that X wants to avoid all liability. At $y=y_1$, X is indifferent between $x=\bar{x}$ with no liability or a lesser level of care with partial liability. As Y increases care above y_1, X may find care less worthwhile because Y's care further prevents an accident, (the slope, however, is not determinant; see below). At $y=\bar{y}$, however, X now pays the full share and then will most likely want to change the level of care, perhaps to $x=\bar{x}$ and thus avoid liability.

Figure 2

Derivation of X's Reaction Curve



The slope of $x(y^e)$ between y_1 and $\bar{y}$ is determined by the total differentiation of l_x.

$$6) \qquad l_x = w + [s_xP + sP_x]A = 0$$

$$7) \qquad D[l_x] = [s_{xx}P + 2s_xP_x + sP_{xx}]dx + [Ps_{xy} + s_x + s_yP_x + sP_{xy}]dy^e = 0$$

$$8) \qquad dx/dy^e = \frac{-[Ps_{xy} + s_x + s_xP_x + sP_{xy}]}{[s_{xx}P + 2s_xP_x + sP_{xx}]}$$

Since the numerator in 8) can be either positive or negative and the denominator must be positive, the reaction curves can slope either up or down. When there is a rule of mechanical contribution, i.e. $s_x=s_y=0$ then $dx/dy^e=-P_{xy}/P_{xx}$. As $P_{xx}>0$, $\mathrm{sgn}[dx/dy^e] = -\mathrm{sgn}[P_{xy}]$. This result would be expected. $P_{xy}<0$ corresponds to the marginal product of X's care, $(-P_x)$, increasing with increases in y. Thus, as Y's care increases, X finds it more valuable to increase care, and hence $\mathrm{sgn}[dx/dy^e]$ is positive.

That $x(y^e)$ is discontinuous at $y^e=\bar{y}$ can be shown by looking at the first order condition $l_x=0$ around $y^e=\bar{y}$.

At $y^e=\bar{y}-e$ $l_x=0$ yields $w +[s_xP + sP_x]A = 0$,

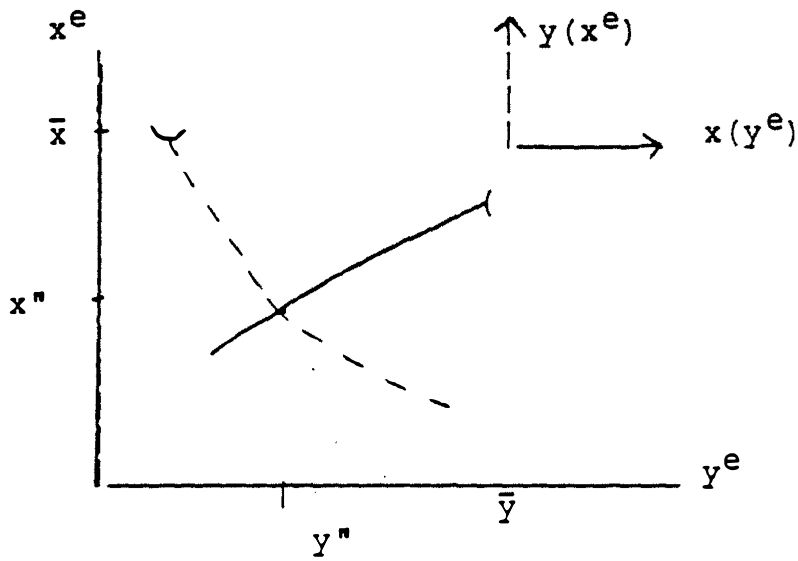
at $y^e=\bar{y}$ $l_x=0$ yields $w + P_xA = 0$.

Thus, there is continuity only if $[s_xP + sP_x] = P_x$ at $y=y^c$. That equilibrium need not be unique nor exist in pure strategies can easily be seen by looking at the interaction of possible reaction curves shown in Figures 3 and 4.

Figure 3

Nonunique Equilibria

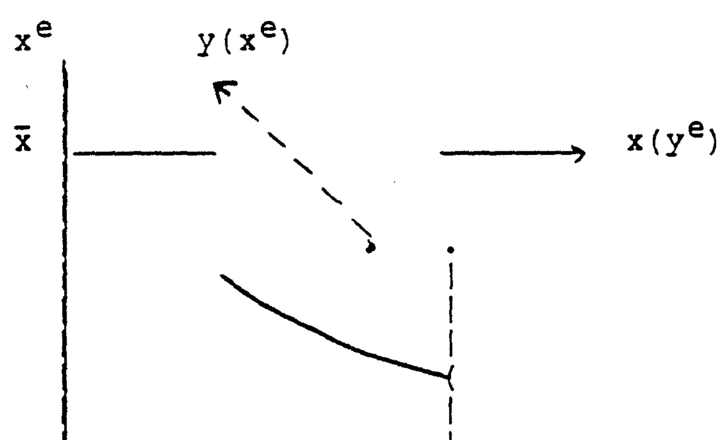
If X Is Nonnegligent, Y Is Nonnegligent, and If X Is Negligent, Y Is Negligent



Two Equilibria $(x''y'')$ and $(\bar{x},\bar{y})$

Figure 4

Non-existence of a Pure Strategy Equilibrium



Proposition 1

A liability rule with the negligence standard, (x^*, y^*), i.e., due levels of care the same as the efficient levels of care, has the unique pure strategy equilibrium $x'=x^*$, $y'=y^*$, for any sharing rule, whether it is one of no contribution, mechanical contribution or judgmental contribution. A form of this proposition appears in Landes and Posner and is discussed in Brown.

I show below that if the negligence standard, $(\bar{x},\bar{y})$, is at the efficient levels of care, (x^*,y^*), then if X takes due care, Y will also take due care, and vice versa. Therefore (x^*, y^*) is an equilibrium. I also show that no pure strategy equilibrium exists in which both parties are negligent. The proof is a proof by contradiction. I assume that an equilibrium exists where both parties are negligent, and show that, for all sharing rules, at least one party has the incentive to deviate from the "equilibrium" and exercise the due level of care.

Proof:

Part A: With a negligence standard, $\bar{x}=x^*$ and $\bar{y}=y^*$, $x(y^*) = x^*$ and $y(x^*)= y^*$.

When $y^e=y^*$, X can choose either to be nonnegligent or to be negligent. If X is nonnegligent, $x=\bar{x}=x^*$, and his loss is wx^*. If he is negligent, then he chooses the level of care, x_0, which minimizes the loss function, $[wx+P(x,y^*)A]$, and his loss is $[wx_o+P(x_o,y^*)A]$. Thus, x_o must satisfy the first order condition:

$$w + P_x(x_o,y^*)A = 0.$$

However, this is also the first order condition which defines the socially optimal level of care x^* (see equation 2), and consequently $x_o = x^*$.

Therefore, X minimizes his expected loss by acting nonnegligently, i.e., $x(y^*)=x^*$. It can be shown similarly that Y chooses $y=y^*$ when $x^e=x^*$. Thus, x^*, y^* is a pure strategy equilibrium.

Part B: $x(y^*)=x^*$ and $y(x^*)=y^*$ is the only pure strategy equilibrium.

Assume there exists another equilibrium (x_n,y_n) where both parties are negligent.

Thus,

9) $$wx_n + P(x_n,y_n)s(x_n,y_n)A < wx^*$$

10) $$wy_n + P(x_n,y_n)[1-s(x_n,y_n)]A < wy^*,$$

or else X or Y would switch from x_n or y_n to x^* or y^*.

Adding the two inequalities yields:

11) $$wx_n + wy_n + P(x_n,y_n)A < wx^* + wy^*.$$

Since x^* and y^* minimize social loss, then, for all other x and y:

12) $$wx^* + wy^* + P(x^*,y^*)A < wx + wy + P(x,y)A,$$

Thus (11) contradicts (12) as $P(x^*,y^*)A>0$.

Therefore, (x_n,y_n) cannot be an equilibrium. This result is independent of the sharing rule.

Thus, as long as the court negligence standard is (x^*,y^*), efficient levels of care are achieved for any sharing rule. Landes and Posner use this proposition to defend rules of no contribution which had been earlier criticized as inefficient.

2. Joint Tortfeasors with Imperfect Information

Landes and Posner (1980, p. 529) state "We could have complicated the model to generate a positive amount of negligence and hence of litigation without affecting the basic analytical point, which is that a rule of no contribution deters negligence as effectively as one of contribution." This section shows that their statement is true only when the information possessed by the different parties (X, Y and the courts) is equivalent, but that the statement does not generally hold when the joint tortfeasors have better information than the courts. In this latter case, allowing the courts the extra degrees of freedom to optimize over a sharing rule improves efficiency.

2.1. Courts and Tortfeasors Have the Same Information

In Section 1, all parties have perfect information, and therefore they all have the same information. In this case, for any sharing rule, whether it be a rule of contribution or no contribution, the same negligence standard, $(\bar{x},\bar{y})=(x^*,y^*)$, produces efficient levels of care. Under this negligence standard, X and Y are never observed acting negligently. On the other hand, if all parties have imperfect, but equivalent information, for any sharing rule there exists a negligence standard, $(\bar{x},\bar{y})$, which produces efficient levels of care, but this negligence standard is not necessarily the same for different sharing rules. Furthermore, even though X and Y act <u>efficiently</u> under the negligence standard, they may be found to be acting <u>negligently</u> because of the "randomness" due to the imperfect information. Whether they are actually negligent depends on the nature of the imperfect information.

There are two simple extensions of the model which will produce the above results. First, suppose that the court imperfectly observes actual levels of care, x and y. The court's measurement error is unknown to X and Y when they choose their levels of care, and is unknown to the courts when it decides whether or not X and Y have acted negligently. Thus, since all parties have the same imperfect information when they act, the information possessed by the different parties, although not identical, is equivalent for operational purposes. In this case, X and Y will be found negligent even though they will never actually be negligent. Second, suppose that actual care is a stochastic function of inputs that are known by X and Y, but unobserved by the courts. When X and Y choose their care inputs they do not know how these will translate into actual care levels. When the court decides whether or not X and Y have acted negligently, it does not observe care inputs, only actual care. Thus, when they act, none of the parties know the error term of the stochastic function which translates care inputs into actual levels of care. All parties have basically the same information. In this case, X and Y will actually be negligent when the court judges them negligent. The two extensions just described are mathematically equivalent and therefore only the first extension is discussed.

<u>Proposition 2</u>

In a world of uncertainty where all parties have the same information, there usually exists, with the qualification noted below, an efficient negligence standard, $(\bar{x},\bar{y})$, for any sharing rule. Alternatively, rules of contribution and rules of no contribution can both produce efficient levels of care. This proposition is true as long as the court's observation error is not too large.

The intuition behind the proof is as follows. Assume that the level of care observed by the court is equal to the actual level of care plus a random term. Thus, X and Y are basically choosing the means of the distributions of observed care. For any negligence standard, $(\bar{x},\bar{y})$, and sharing rule, $s(x,y)$, the joint tortfeasors choose levels of care (x,y).

Given a sharing rule and a negligence standard, the tortfeasors trade off their expected liability against their costs of care. They set the marginal costs of care, (w_x,w_y), equal to the marginal reductions in expected liability. Since the expected liability and hence the marginal change in expected liability depend on the probability that the observed care levels are less than the negligence standards, changing the negligence standards affects the marginal reduction in expected liability. I will show that for most sharing rules, the standard can be altered so as to have the tortfeasors choose the optimal levels of care (x^*,y^*). If the social loss function depends only on the actual levels of care and not on how often cases are litigated, or on who pays, the social loss is independent of the sharing rule.

The care observed by the courts, (x_c,y_c), equals the sum of actual care, (x_a,y_a), and a disturbance term, (e_1,e_2):

$$x_c = x_a + e_1$$

$$y_c = y_a + e_2$$

where e_1 and e_2 are identically and independently distributed (iid) from the distribution f with mean zero. Also, assume that the limit of f(z) as z goes to either infinity or negative infinity is zero. Thus, the joint tortfeasors set the actual level of care, but the court imposes liability based on observed levels of care.

X's loss, $l(x_a, y_a^e)$ is:

$$
\begin{array}{ll}
wx_a & \text{if } x_c \geq \bar{x} \text{ and } y_c \gtrless \bar{y} \\
wx_a + P(x_a, y_a^e)A & \text{if } x_c < \bar{x} \text{ and } y_c \geq \bar{y} \\
wx_a + s(x_c, y_c)P(x_a, y_a^e)A & \text{if } x_c < \bar{x} \text{ and } y_c < \bar{y}
\end{array}
$$

and the expected loss, E[l] is:

$$
\begin{aligned}
wx_a + {} & \Pr[\bar{x}-x_c>0]\Pr[\bar{y}-y_c<0]P(x_a, y_a^e)A \\
& + s^*\Pr[\bar{x}-x_c>0]\Pr[\bar{y}-y_c>0]P(x_a, y_a^e)A
\end{aligned}
$$

where s* is the average expected share of liability for X, given that both parties are judged negligent, i.e.,

$$
s^* = \int_{-\infty}^{\bar{x}-x_a} \int_{-\infty}^{\bar{y}-y_a} \frac{s(x_a+e_1, y_a+e_2) f(e_1) f(e_2)}{\Pr[\bar{x}-x_c>0]\Pr[\bar{y}-y_c>0]} \, de_1 de_2
$$

Y's loss, m, and expected loss, E(m), are determined similarly.

The efficient levels of care (x^*, y^*) are the same as in Section 1. The court has the opportunity to set the negligence standard, $(\bar{x}, \bar{y})$. It wishes to set $(\bar{x}, \bar{y})$ so that X and Y choose actual levels of care at $x_a = x^*$ and $y_a = y^*$. Thus, the court chooses $(\bar{x}, \bar{y})$ such that $E[l(x, y^*)]$ is minimized at x^* and $E[m(y, x^*)]$ is minimized at y^*.

The derivative of E[1] with respect to x_a is:

$$13)\quad w + Pr[\bar{x}-x_c>0]Pr[\bar{y}-y_c<0]P_xA$$
$$- f(\bar{x}-x_a)Pr[\bar{y}-y_c<0]PA$$
$$+ P_xA \int_{-\infty}^{\bar{x}-x_a}\int_{-\infty}^{\bar{y}-y_a} s(x_a+e_1,y_a+e_2)f(e_1)f(e_2)de_1de_2$$
$$- PA \int_{-\infty}^{\bar{y}-y_a} s(\bar{x}-x_a,y_a+e_2)f(\bar{x}-x_a)f(e_2)de_2$$
$$+ PA \int_{-\infty}^{\bar{x}-x_a}\int_{-\infty}^{\bar{y}-y_a} s_x(x_a+e_1,y_a+e_2)f(e_1)f(e_2)de_1de_2.$$

For the derivative to be zero at $x_a=x^*$, the expression 13) must equal AP_x, because x^* was chosen such that:

$$w + P_xA = 0.$$

Under this condition, the private and social first order conditions coincide at (x^*,y^*).

If s and f are continuous, then expression 13) is continuous. Thus, if P_xA is less than expression 13) for some standard, $\bar{x}$, and greater than P_xA for another standard, $\bar{x}'$, then there exists a standard, $\bar{x}_e$, where equality holds. For $x<<0$, 13) approaches zero, because $f(-\infty)=0$ and $F(-\infty)=0$. (F is the cumulative distribution function for f.) Thus, for $x<<0$, 13) $> P_xA$, since P_x is less than zero and 13) nears zero.

For $x'=x_a$ and $s_x=0$, 13) is:

$$AP_x(1/2)\Pr[\bar{y}-y_c<0] - APf(0)\Pr[\bar{y}-y_c<0] +$$

$$AP_x s(1/2)\Pr[\bar{y}-y_c>0] - APsf(0)\Pr[\bar{y}-y_c>0].$$

(If $s_x<0$, then 13) is even more negative. Thus, if 13)$<AP_x$ for $s_x=0$, then 13)$<AP_x$ for $s_x<0$.)

Thus 13)$<AP_x$ if:

14) $$P_x[1-(1/2)H] > -Pf(0)H, \quad \text{or}$$

$$P_x/P\ [(1/H) -(1/2)] < f(0),$$

where $H = \Pr[y-y_c<0] + s\Pr[y-y_c>0]$ and thus $0<H<1$.

If 14) is satisfied, by continuity there exists a standard, $\bar{x}_e$, that promotes economic efficiency, i.e., $x_a=x^*$. Whether this condition is met depends upon the distribution of the error term. The more peaked the distribution, i.e., the larger f(0), the more likely the condition is to be met.

The intuition is as follows. There are two externalities that distort incentives away from the optimal levels of care. The first distortion arises because X only pays a fraction of the accident when Y is also judged negligent. This distortion would cause X to lower care, *ceteris paribus*. The other distortion arises because X controls the mean of the observed care distribution and thus can avoid liability by shifting the distribution. This distortion would cause X to raise his care, *ceteris paribus*. This second distortion must be large enough to balance off against the first in order for the negligence standard to promote efficient levels of care. The size of the second distortion in incentives depends on:

15) $d \Pr[\bar{x}-x_c>0]/dx_a = f(\bar{x}-x_a)$,

which is at a maximum at f(0) if f is a symmetric unimodal distribution. Thus, if f(0) is large enough, the two distortions can be balanced and economic efficiency can be achieved regardless of the sharing rule, s.

2.2. Case of Asymmetric Information: The Tortfeasors Know More Than the Courts

In general, the joint tortfeasors will have more information than the courts, particularly about the actual technology of accidents. For example, when a manufacturer designs a car, he must trade off fuel efficiency and safety. The manufacturer is in a better position than the courts to know how much fuel efficiency must be given up in order to improve safety. Furthermore, the cost of the tradeoff is not likely to be the same across models. The courts, when judging whether the manufacturer was negligent in designing his car, will not be able to know the actual cost of improving safety. Nor will the courts know whether, for a particular model, it was more or less expensive than average to design a safer car.

The courts would like to tie the negligence standard to the actual cost of taking care. The more expensive the cost of care, the less care a tortfeasor would be expected to exercise. Evidence will most likely be presented in a trial as to the cost of improving safety. The plaintiffs will try to convince the jury that it would have been inexpensive and the defendants will try to convince the jury that improving safety would have been expensive. However, the actual cost of taking care will never be established. Rather, the jury will have to base its decision of guilt or innocence on incomplete information. It will not be able to determine whether the cost of taking care is low or high.

If the court sets a low standard for due care, then, when the cost of taking care is low, tortfeasors will just meet the standard. Too little care will be taken as compared to the efficient level of care, because tortfeasors never have the incentive to exceed the standard of due care. If the court sets a high standard of due care, then, when the cost of care is high, tortfeasors must choose between meeting the standard or acting negligently. If the tortfeasor meets the standard, he is exercising more than the efficient level of care. If he acts negligently, he may be closer to the efficient level of care. Thus, it is important for the liability rule to encourage these tortfeasors to act as efficiently as possible. In this context, the sharing rule becomes an important instrument.

When the tortfeasors have better information than the courts, it can be demonstrated that a negligence rule with judgmental contribution can in general do better than a rule with no contribution. In some special cases, rules with judgmental contribution can produce as efficient results as when the courts have the same information as the joint tortfeasors.

Proposition 3

Rules that allow judgmental contribution can achieve more efficient results than rules of mechanical contribution.

Proof:

Assume that the technology of accidents is as above. However, the cost of taking care is no longer deterministic. Rather w_x and w_y are jointly distributed from a probability distribution $h[w_x, w_y]$. X knows w_x and Y knows w_y. Hence, each tortfeasor knows his own cost of taking care, but not necessarily the cost of taking care of the other. However, I assume that both tortfeasors know the joint distribution, h, and therefore can compute the conditional distributions. That is, X computes $h[w_y|w_x]$ and Y computes $h[w_x|w_y]$. It is possible that the conditional distributions are degenerate, i.e. X and Y know each others cost of taking care.

The first best, full information, levels of care would be $x^*(w_x, w_y)$ and $y^*(w_x, w_y)$ which minimize society's loss function for all w_x, w_y. That is, x^*, y^* minimize:

$$w_x x + w_y y + AP(x,y),$$

for all w_x and w_y. However, in general this will not be obtainable as X does not observe w_y and Y does not observe

w_x. The second best levels of care would be $x^*(w_x)$ and $y^*(w_y)$ which minimize the loss function constrained by X and Y acting on the information they have available. Because the torteasors only observe their own cost of taking care, the second best levels of care can only depend on the cost of taking care for that tortfeasor. Since first best results are not feasible, a sharing rule should try to obtain the second best, limited information, result.

The negligence standard and the sharing rule can be chosen so as to maximize social welfare over liability rules. Therefore, there is an optimal $\bar{x}$, $\bar{y}$ and similarly an optimal s. The constrained optimal, where s[x,y] is constrained to equal a constant, will in general produce levels of care that differ from the optimal. In any case the unconstrained optimal can never be worse than the constrained optimal.

The sharing rule can induce the joint tortfeasors to use the information they have when deciding upon their level of care. The inducement is in the form of a decrease in their share of the liability i.e. $s_x<0$. Thus, the courts should choose a sharing rule and levels of care that maximize social welfare. (See the appendix the construction of a rule that maximizes social welfare.)

It is difficult to show for the general case how much better rules of judgmental contribution can do than rules of mechanical contribution. However, below I show two special cases where rules of judgmental contribution can achieve first best results. That is, rules of judgmental contribution can lead to the same results as if the courts had full information.

Case A

Assume that there are two states of the world unobserved by the courts, one where care is expensive and one where care is less expensive. That is, in one state of the world

$$w_x = w_y = w^h,$$

and in the other state of the world

$$w_x = w_y = w^l,$$

where $w^h > w^l$.

Proposition 4

For every technology of accidents, P, there exists a negligence standard, $(\bar{x},\bar{y})$, and sharing rule, $s(x,y)$, such that efficient levels of care are exercised by both X and Y in each state of the world.

Proof by Construction:

Set the negligence standard at the efficient levels of care for when care is inexpensive. That is $(\bar{x},\bar{y})$ minimizes:

$$w^l x + w^l y + P(x,y)A.$$

When X and Y observe w^l, the unique equilibrium is at $(\bar{x},\bar{y})$ regardless of the sharing rule by Proposition 1.

Next, construct a sharing rule so that the first order conditions for the efficient levels of care and the first order conditions for the minimization of expected liability by each party are identical at the efficient levels of care, (x^*,y^*).

The first order conditions for efficient levels of care are:

$$w^h + P_x A = 0$$

$$w^h + P_y A = 0.$$

The first order conditions for minimization of expected liability are:

$$w^h + P_x(x,y^e)s(x,y^e)A + P(x,y^e)s_x(x,y^e)A = 0$$

$$w^h + P_y(x^e,y)[1-s(x^e,y)]A - P(x^e,y)s_y(x^e,y)]A = 0.$$

For the first order conditions to coincide at (x^*,y^*) the following equalities must hold:

$$P_x s + P s_x = P_x \quad \text{or} \quad (1-s)p_x = s_x P$$

and

$$(1-s)P_y - s_y P = P_y \quad \text{or} \quad sP_y = -s_y P.$$

Let $s = 1/2 + a(x^{*.5} - x^{.5}) + b(y^{.5} - y^{*.5})$

where:

$$a = -x^{*.5}P_x(x^*,y^*)/P(x^*,y^*)$$

and

$$b = -y^{*.5}P_y(x^*,y^*)/P(x^*,y^*).$$

At (x^*,y^*), $s=1/2$, $s_x=(-1/2)ax^{*.5}=P_x/2P$, and $s_y=(1/2)by^{*.5}=-P_y/2P$.

Thus,the first order conditions coincide at (x^*,y^*).

However, w^h and w^l must be sufficiently different that X and Y prefer acting negligently to meeting the due care standard, $(\bar{x},\bar{y})$. Thus, the following must hold:

$$w^h x^* + (1/2)P(x^*,y^*)A < w^h\bar{x}$$

$$w^h y^* + (1/2)P(x^*,y^*)A < w^h\bar{y}.$$

If these conditions are satisfied, then, even though there will be a positive amount of negligent behavior, efficient levels of care will be exercised in both states of the world. A rule of mechanical contribution or no contribution cannot achieve these efficient results, because it cannot get X and Y to act efficiently in both states of the world. Thus, a rule of judgmental contribution is more efficient.

Case B

Proposition 5

If the technology of accidents is:

$$P(x,y) = D(x) + E(y),$$

then for any distribution, $h(w_x,w_y)$, the sharing rule:

$$s(x,y) = D(x)/[D(x)+E(y)]$$

will yield first best results.

Proof:

The technology of accidents in this case is the sum of two independent Poisson processes. The probability of an accident is the probability that X contributes to the accident plus the probability that Y contributes to the accident. If either D or E were large, i.e. not near zero, then the probability of an accident would not be additive. This technology of accidents is similar to the case where two hunters each fired a shot and a bystander was injured.

That this sharing rule leads to efficient results can be seen by checking the first order conditions for minimizing liability. They are:

$$w_x + D_x(x)A = 0$$

$$w_y + E_y(y)A = 0,$$

since

$$sP = D(x) \text{ and } (1-s)P = E(y).$$

These conditions are the same as the first order conditions for maximizing social welfare. Thus, this sharing rule, which is one of judgmental contribution, is more efficient than any rule of mechanical or no contribution. Under this rule, if one hunter fired two shots, and the other hunter fired only one shot, the first hunter would pay for two thirds of the cost of the accident. The other hunter would pay one third.

3. Conclusions

I have shown that in general, when there is asymmetric information, rules of judgmental contribution lead to more efficient levels of care. Rules of judgmental contribution cause joint tortfeasors to game against one another. Neither tortfeasor wants to be judged much more negligent than the other. Hence, even though in equilibrium each tortfeasor only pays a fraction of the cost of the accident, each is exercising levels of care that come closer to the levels of care that maximize social welfare. However, several other factors should also influence the choice of liability rules.

First, the results of this paper are that the best rule with judgmental contribution can do better than the best rule without contribution or with mechanical contribution. However, if the rule of judgmental contribution is inappropriately chosen, the outcome may be worse than a rule of no contribution, or a rule of mechanical contribution.

Second, rules of no contribution probably have some of the properties of rules with judgmental contribution. The victim has the choice of parties to sue under rules of no contribution. The victim is more likely to sue the party whom he has the best chance of winning against. Hence, if the plaintiff can observe x and y, the more care one party takes, the less likely that party is to be sued, and the lower his expected share of liability. Therefore, even with rules of no contribution, the expected sharing function depends on the levels of care and thus approximates a rule with judgmental contribution.

Third, the choice of a liabililty rule should be influenced by the amount of litigation the rule induces. Landes and Posner state that there is likely to be less litigation under rules of no contribution since the tortfeasor who pays cannot recover from the other tortfeasor. However, the number of litigated cases also depends on the number of cases settled out of court. It is possible that rules of judgmental contribution will have more cases settled out of court than rules of no contribution because the parties know beforehand their approximate share of liability. (Rules of mechanical contribution may have even more cases settled out of court if the number of tortfeasors is easily agreed upon.)

Fourth, if the parties are not risk neutral, rules of contribution insure tortfeasors against having to pay the full cost of the accident.

Fifth, equity concerns may enter into the decision on the choice of the rule. Landes and Posner think that states that have adopted rules of contribution are more concerned with equity. However, rules of no contribution may tend in practice to better distribute income. When the victim chooses whom to sue, he is more likely to sue the wealthier of two joint tortfeasors, because juries may tend to award larger amounts against wealthier defendants.

Sixth, the rules should be known to potential tortfeasors. Rules of judgmental contribution are more complicated and thus are not as easy to communicate.

Many considerations must enter into the decision of what liability rule to employ. However, the potential for rules of judgmental contribution to increase efficiency should not be overlooked.

Appendix

The minimization for the optimal negligence rule with asymmetric information would be:

$$\min_{\substack{\bar{x},\bar{y} \\ s(x,y)}} E_{w_x,w_y}[w_x x + w_y y + AP(x,y)],$$

subject to X minimizing over x given w_x,

$$\min[w_x\bar{x}, \min E_{w_y|w_x}[w_x x + s(x,y(w_y))P(x,y(w_y))A]],$$

and to Y minimizing over y given w_y,

$$\min[w_y\bar{y}, \min E_{w_x|w_y}[w_y y + (1-s(x(w_x),y))P(x(w_x,y)A]].$$

Thus, this problem is an optimal control problem, where w_x, w_y are the "time" variables, x and y are the state variables, and $\bar{x}$, $\bar{y}$, and s are the control variables. The objective function is the social loss function. Only when a corner solution yields s being a constant will rules of mechanical contribution be optimal. In general, little can be said about $\bar{x}$, $\bar{y}$, and s(x,y).

Notes -

1 For analayses of rules of strict liability under which the the victim is always compensated see Green (1976), Polinsky (1980), and Shavell (1980).

2 This paper discusses joint torts where the victim is not a tortfeasor, that is, where his actions do not contribute to the accident. The results of this paper hold with slight modifications when the victim is one of the tortfeasors. Thus, my results also have implications for rules of comparative negligence.

3 For a statement of why quasi-concavitiy is usually a necessary condition for existence of a mixed strategy equilibrium, see Friedman (1977).

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