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Abstract. In this paper, a theoretically testable model of the incentives for injurers and victims to avoid accidents under both the comparative and contributory negligence rules is developed. The model takes account of the fact that in the automobile accident context, drivers do not know in advance with whom they will be involved in an accident and whether they will be the injurer or the victim, or both, when an accident occurs. It also allows for uncertainty in legal decision making. The theoretical model suggests that either liability rule could give drivers incentives to take economically efficient levels of care to avoid accidents, but only in special cases. The model is tested using a data set of rear end automobile accidents. The results suggest, first, that incentives to take care to avoid accidents are stronger under the newer comparative negligence rule than under the older contributory negligence rule and, second, that the incentives set up by both liability rules for drivers to avoid accidents are weaker than is economically efficient.

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1. Introduction

Liability rules in accident law provide a system under which those who cause accident damage under some circumstances must pay compensation to those who incur the damage. Such a system is normally interpreted by economists as putting a price on a negative externality—dangerous behavior. This has the beneficial effect of deterring accidents by encouraging potential injurers to take care to avoid harming others.[1] However, whether the actual liability rules used in accident law in the U.S.—the "contributory negligence" rule and the comparative negligence rule—provide economically efficient incentives to avoid accidents has been a subject of controversy for a number of years. The contributory negligence rule provides that the injurer is liable to the victim for the full amount of the victim's damage, but only when the injurer is found to have behaved negligently *and* the victim is found to have behaved non-negligently.[2] The comparative negligence rule provides that the victim's damage be shared between the injurer and the victim when both are found to have behaved negligently. Early writers in the "new" law and economics established that a number of liability rules, including the contributory negligence rule, gave rise to economically efficient incentives to avoid accidents, at least in theory. But theoretical predictions of the effects of the comparative negligence rule have been mixed. In the 1970's, the dominant view was that the rule led to inefficient accident avoidance incentives, but more recently a "revisionist" view has emerged that the rule may in fact be efficient.[3]

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[1] Lawyers, in contrast, sometimes view the function of liability rules in accident law as that of providing compensation to accident victims, rather than of providing a deterrence incentive to injurers. See, for example, Keeton and O'Connell (1965), which advocates the no-fault system.

[2] The name refers to the fact that the injurer has a legal defense for her own negligence when the victim is also negligent, or "contributorily negligent."

[3] This question was the first on which the "new" law and economics focused attention. Posner, in the first edition of *Economic Analysis of Law,* (1972) argued that a number of different negligence-based liability rules led to incentives for efficient accident avoidance, but that the comparative negligence rule did not. Calabresi, in *The Cost of Accidents,* (1970) also argued that the comparative negligence rule led to inefficient accident avoidance incentives. Brown (1973) produced the first formal analysis of the effects of different liability rules in tort law and concluded that all the rules he considered except the comparative negligence rule led to economically efficient incentives. However, Diamond (1974) argued that the result under the comparative negligence rule is indeterminate and depends on how the rule is specified. In more recent papers, a number of economists argue either that the comparative negligence rule leads to efficient behavioral incentives or that the result under it is indeterminate, with the efficient outcome as a special case. See Haddock and Curran (1985), Cooter and Ulen (1986), Rubinfeld (1987), Rea (1987) and Shavell (1987, section 2.2.9).

In addition to the stronger theoretical argument in favor of the efficiency of accident avoidance incentives under the contributory negligence rule, a number of other considerations also suggest that the rule of contributory negligence is preferable. The comparative negligence rule encourages litigation by increasing the proportion of cases which the plaintiff is likely to win and also increases courtroom congestion by raising the complexity level of a typical case.[4] The contributory negligence rule, in contrast, discourages litigation by reducing the proportion of cases which the plaintiff is likely to win. Also, because of the widespread use of third party insurance, the attractive property of the comparative negligence rule that it shares risk between the injurer and victim by sharing the victim's damage between them is of questionable value in providing compensation for accident damage.

However, despite these theoretically attractive characteristics, the fact of the matter is that the comparative negligence rule has become enormously popular and spread widely in recent years, virtually replacing the rule of contributory negligence. Comparative negligence was adopted in many U.S. states during the 1970's and 1980's and, at present, is the prevailing law in 44. Comparative negligence is also used in England, Japan, Russia, most of Europe, and in maritime law involving accidents at sea.[5]

The controversy over the efficiency effects of the comparative negligence rule and other liability rules has remained theoretical, because there have been no empirical tests of behavioral incentives under any liability rules. In this paper, I address the issue empirically for the first time. Using a data set of automobile accident cases litigated under both the comparative negligence and contributory negligence rules, I test a model of the efficiency of injurers' and victims' incentives to avoid accidents under both rules. The results suggest, first, that incentives for drivers to avoid accidents are stronger under the newer comparative negligence rule than under the older contributory negligence rule and, second, that the incentives set up by both liability rules for drivers to avoid accidents are weak relative to the level that would be economically efficient.

2. Incentives for accident avoidance—theoretical model

Because the data used in the empirical part of this study are for automobile accidents, the standard theoretical model of accident avoidance behavior needs to be modified to take account of a peculiarity of automobile accidents—that drivers do not know ahead of time with whom they will be involved in an accident and whether they will be the injurer or the victim or both. This differs from other types of accidents, such as medical malpractice incidents and accidents involving defective products, in which the parties do know in advance the identity of the other party and the position they will be in if an accident occurs. The model specified here modifies the existing literature by allowing for the *ex ante* indeterminacy of roles and identities in automobile accidents and by assuming that both the injurer and victim suffer damage when an accident occurs. The model also allows for the fact that legal rules in the real world operate less than perfectly.[6]

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[4] This is because the court must decide on the degree of negligence by both parties, not just if the parties were negligent or not. See White (1988) for discussion and an argument that lawyers may prefer more complex legal rules.

[5] See Cooter and Ulen (1986).

[6] Diamond (1974) provided the only model in the literature specifically oriented to automobile accidents

The social value of accident avoidance

Suppose an arbitrary driver, referred to as the "particular driver," is considering in advance what care level to use to avoid accidents. The particular driver has a probability of having an accident with another driver whose identity is unknown in advance. When an accident occurs, both the particular driver and the "other driver" suffer damage. The expected accident damage to the particular driver, denoted D^p, is the product of the probability of an accident occurring per period times the dollar amount of damage to the particular driver when an accident occurs. Similarly, the expected accident damage to the other driver, denoted D^o, is the product of the probability of an accident occurring per period times the damage to the other driver. The care level of the particular driver is denoted x_p, where $x_p \geq 0$. The care level of the other driver involved in the accident is denoted $x_o \geq 0$, where x_o varies randomly within the population. If the particular driver and the other driver are using care levels x_p and x_o, respectively, then the expected accident damage to the particular driver is $D^p(x_p, x_o)$ and the expected accident damage to the other driver is $D^o(x_p, x_o)$. Expected damage to both drivers depends negatively on the levels of care taken by each driver, or $D^p_{x_p} < 0, D^o_{x_p} < 0, D^p_{x_o} < 0$ and $D^o_{x_o} < 0$. In the automobile accident context, higher care can naturally be thought of as driving more slowly. However, it can also involve driving more carefully, driving without drinking beforehand, or driving a car in good repair.

The cost of care per period is assumed to be c_p for the particular driver. Other drivers are assumed to be identical except for their cost of care. The probability distribution of the cost of care for other drivers is $h(c_o)$, where c_o is a particular draw from this distribution. Other drivers' chosen care levels x_o are assumed to depend only on c_o (plus common factors), and can therefore be described by $x_o(c_o)$. Let the derived probability distribution of x_o be denoted by $g(x_o)$.

The total social cost of accidents equals the sum of expected accident damage plus the cost of accident prevention. It is

$$c_p x_p + \int_0^\infty c_o x_o g(x_o) dx_o + \int_0^\infty [D^p(x_p, x_o) + D^o(x_p, x_o)] g(x_o) dx_o \tag{1}$$

The expected accident damage to the particular driver, $\int_0^\infty D^p(x_p, x_o) g(x_o) dx_o$, can be integrated and the resulting function, denoted $\bar{D}^p(x_p)$, depends only on x_p. Similarly, the expected level of accident damage to the other driver, $\int_0^\infty D^o(x_p, x_o) g(x_o) dx_o$, can be integrated and the result is denoted $\bar{D}^o(x_p)$. Substituting these definitions into (1) results in:

$$c_p x_p + \int_0^\infty c_o x_o g(x_o) dx_o + [\bar{D}^p(x_p) + \bar{D}^o(x_p)] \tag{2}$$

The economically efficient level of care by the particular driver is determined by minimizing total accident costs, (2), with respect to x_p. The level of care by the particular

(which he referred to as "single activity accidents"), while most writers have concentrated on accidents in which individuals' roles as victim or injurer are known in advance. My model differs from Diamond's in its emphasis on the role of errors and uncertainty in court behavior. Other models of the effect of uncertainty and of court error under different liability rules have been explored by Haddock and Curran (1985), Shavell (1987), sections 4.3 and 4A.3, and White (1988).

driver which minimizes the social cost of accidents is denoted x_p^*. It must satisfy the first order condition:

$$c_p = -\bar{D}^p_{x_p}(x_p^*) - \bar{D}^o_{x_p}(x_p^*) \tag{3}$$

In the next two subsections, the incentives of the particular driver to take care under both the comparative and contributory negligence rules are analyzed in a way which brings out empirically testable predictions of the effects of both rules.

The comparative negligence rule

All liability rules consist of criteria determining: (1) when the injurer is liable to pay damages to the victim and (2), if the injurer is liable, what is the dollar amount of the damage award. Under the comparative negligence rule, the criterion for liability is that the injurer is liable whenever the injurer is found negligent by the court, regardless of whether the victim is found negligent or not. (However, the amount of the damage award varies depending on the victim's behavior.)

The court is assumed to decide liability on the basis of whether or not the injurer's actual care level met or exceeded a threshold level which the court requires to avoid a finding of negligence. This threshold is referred to as the due care standard and is denoted x^d. It is assumed to be the same for both drivers involved in an accident. The particular driver is found negligent if $x_p < x^d$ and non-negligent if $x_p \geq x^d$ and the other driver is found negligent if $x_o < x^d$ and non-negligent if $x_o \geq x^d$. Because different judges and juries use different standards in determining negligence and drivers do not know in advance what the standard will be, the due care standard is assumed to be stochastic. It has a probability distribution $f(x^d)$. The probability of the particular driver being found negligent is therefore $\int_{x_p}^{\infty} f(x^d)dx^d$ and the probability of the other driver being found negligent is $\int_{x_o}^{\infty} f(x^d)dx^d$. Note that since the due care level is stochastic, drivers may be found negligent even if they use a very high level of care and may be found non-negligent even if they use a very low level of care. Further, since the same standard is applied to both drivers, the particular driver expects that with positive probability, the other driver involved in an accident will be found negligent by the court, and vice versa.

The due care standard set by the court could be higher than, lower than, or equal to the economically efficient level of care for the particular driver, x_p^*. Economists often interpret the negligence rule to require the economically efficient level of care to avoid being found negligent.[7] However, judges and juries can adopt any due care standard in any particular case and do not have to explain the standard they adopt. Since the attractive feature of the comparative negligence rule appears to be its provision for damage sharing, it seems likely that juries will frequently set a high due care level, in order to find the injurer negligent and invoke the damage sharing property. This suggests that courts may tend to set the due care standard higher than the economically efficient care level.

[7] The legal justification for interpreting negligence rules to require use of the economically efficient level of care comes Judge Learned Hand's opinion in United States v. Carroll Towing Co., 159 F.2d 169 (2d Cir. 1947).

The second property of the comparative negligence rule is its sharing rule for damages. If the injurer is found negligent, then the injurer and victim may share liability for the victim's damage. The injurer's share of the victim's damage is denoted s, where $0 < s \leq 1$.

Different versions of the comparative negligence rule share damages differently. The simplest sharing rule is the traditional rule in maritime law in the U.S., which requires that damage be split equally if both parties are found negligent. Thus $s = .5$.[8] An alternative sharing rule apportions liability in proportion to fault. Suppose $x^d > x_p$, so that the particular driver is found negligent. Then $x^d - x_p$ measures the additional amount of care that the particular driver would have had to use to avoid being found negligent, or in the driving context, the number of miles per hour that the particular driver would have to slow down to be found non-negligent. Assuming that the other driver is also negligent, $x^d - x_o$ is defined similarly. Then the sharing rule becomes $s = \frac{x^d - x_p}{(x^d - x_p) + (x^d - x_o)}$. This sharing rule is probably closest to what judges and legislators in most U.S. states intended when they adopted the comparative negligence rule.[9] However, it has the problem that it sometimes results in large discrete changes in injurers' share when injurers' care level changes by a small amount. For example, when both the injurer and the victim are non-negligent, the injurer's share is zero under the rule. But suppose the injurer becomes slightly negligent while the victim remains non-negligent. Then the formula calls for the injurer's share to shift from zero to one.[10] Realistically, in such a situation, a jury would probably require the slightly negligent injurer to pay some share of the victim's damage, but not the full amount of the victim's damage. Juries can do this, without any explicit finding of negligence by the victim, merely by awarding the victim an amount less than actual damage.[11]

In this paper, the intent is to estimate the sharing rule rather than to assume a particular rule in advance. I assume that when the particular driver is found liable for damage, her share depends generally on her own care level, the other driver's care level, and the due care level. The sharing rule, written in general form as $s = s(x_p, x_o, x^d)$, is assumed to be continuous. It has the properties that as long as the particular driver is found negligent, the particular driver's share falls as her care level rises, holding everything else constant, or $s_{x_p} < 0$, and the particular driver's share increases as the other driver's care level rises, holding everything else constant, or $s_{x_o} > 0$. If instead the other driver is the injurer, then the injurer's share is denoted σ and the sharing rule can be expressed as $\sigma = \sigma(x_p, x_o, x^d)$. Then as long as the other driver is found negligent, the other driver's share falls as his care level rises, or $\sigma_{x_o} < 0$, and the other driver's share increases as the particular driver's care

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8 Since 1974, maritime law cases have used a flexible sharing rule. See Epstein (1980).

9 See, for example, the discussion in Li v. Yellow Cab Company of California, 532 P.2d 1226, 1975, the case in which the rule of comparative negligence was adopted in California by judicial decision. Some U.S. states require that for damage sharing to occur, the injurer must be more negligent than the victim. See Cooter and Ulen (1986) for discussion.

10 Such knife-edge shifts in liability in response to small changes in behavior form the basis for one of the major criticisms of the contributory negligence rule—that victims shift from receiving full compensation to receiving no compensation when their behavior shifts from non-negligent to slightly negligent.

11 In most U.S. states, juries decide on both the injurer's liability and on the damage award. They do not have to explain how they calculated the damage award, nor whether they found the victim to be negligent.

level rises, or $\sigma_{x_p} > 0$.[12]

This sharing rule differs from those analyzed by other writers in that it is assumed to be continuous and it allows for damage sharing whenever the injurer is found negligent, even if no evidence is presented suggesting negligent behavior by the victim. Econometric evidence is presented in the next section supporting this interpretation of the sharing rule under comparative negligence. Other variables might also enter the sharing formula. An example investigated below is whether the injurer is a corporation or an individual.

Turn now to the particular driver's private cost of accidents. Under the comparative negligence rule, the particular driver may be both injurer and victim simultaneously in any accident, since both drivers may be found negligent. The determination of the injurer designation for the particular driver depends on whether she is found negligent and the determination of the victim designation depends on whether the other driver is found negligent. *Qua* injurer, the particular driver is liable for damage to the other driver if she is found negligent and, *qua* victim, she receives a damage award from the other driver if the other driver is found negligent.

The particular driver is liable for a share s of the other driver's expected damage if she is found negligent. Her expected liability to the other driver is $\int_0^\infty D^o(x_p, x_o)[\int_{x_p}^\infty s(x_p, x_o, x^d) f(x^d)dx^d]g(x_o)dx_o$. The particular driver is also liable for the full amount of her own damage or for a share $1 - \sigma$ of her own damage, depending on whether the other driver is found negligent or not. The particular driver's expected liability for her own damage is $\int_0^\infty D^p(x_p, x_o)[1 - \int_{x_o}^\infty \sigma(x_p, x_o, x^d)f(x^d)dx^d]g(x_o)dx_o$.

The particular driver's *ex ante* private cost of accidents under the comparative negligence rule is therefore the sum of her cost of care, her expected liability for the other driver's damage and her expected liability for her own damage, or:

$$\begin{aligned} c_p x_p &+ \int_0^\infty D^o[\int_{x_p}^\infty s(x_p, x_o, x^d)f(x^d)dx^d]g(x_o)dx_o \\ &+ \int_0^\infty D^p[1 - \int_{x_o}^\infty \sigma(x_p, x_o, x^d)f(x^d)dx^d]g(x_o)dx_o \end{aligned} \tag{4}$$

Eq. (4) can be simplified. First, substitute the definition of expected damage to the particular driver and the other driver given in the previous section, $\bar{D}^p(x_p)$ and $\bar{D}^o(x_p)$. Second, the particular driver's expected probability of being found liable is $\int_{x_p}^\infty f(x^d)dx^d$. Integrating this expression eliminates x^d, so that the result can be written $\lambda(x_p)$. Also, the other driver's expected probability of being found liable is $\int_{x_o}^\infty f(x^d)dx^d$. Integrating this expression eliminates x^d, so that the result can be written $\mu(x_o)$. Third, the expression $\frac{\int_0^\infty D^o(x_p,x_o)[\int_{x_p}^\infty s(x_p,x_o,x^d)f(x^d)dx^d]g(x_o)dx_o}{\int_0^\infty D^o(x_p,x_o)g(x_o)dx_o \int_{x_p}^\infty f(x^d)dx^d}$ can be interpreted as the expected share of the other driver's damage paid by the particular driver, contingent on the particular driver being found liable. Integrating this expression eliminates both x_o and x^d, so that it can be

12 If the sharing rule takes on the form $s = \frac{x^d - x_p}{x^d - x_p + x^d - x_o}$, then it must be the case that $s = 1 - \sigma$. But for the general sharing rule, it is not necessary that $s = 1 - \sigma$.

written $\bar{s}(x_p)$. Similarly, the expression $\frac{\int_0^\infty D^p(x_p,x_o)\int_{x_o}^\infty \sigma(x_p,x_o,x^d)f(x^d)dx^d g(x_o)dx_o}{\int_0^\infty D^p(x_p,x_o)g(x_o)dx_o \int_{x_o}^\infty f(x^d)dx^d}$ can be interpreted as the expected share of the particular driver's damage paid by the other driver, contingent on the other driver being found liable. Integrating this expression eliminates both x_o and x^d, so that it can be written $\bar{\sigma}(x_p)$.[13]

Substituting these expressions into eq. (4), the particular driver's private cost of accidents can be expressed as:

$$c_p x_p + \bar{D}^o(x_p)\lambda(x_p)\bar{s}(x_p) + \bar{D}^p(x_p)[1-\mu(x_o)\bar{\sigma}(x_p)] \tag{5}$$

The particular driver has an incentive to minimize her private cost of accidents with respect to her choice of care level x_p. The particular driver's preferred care level is denoted x_p^a and it satisfies the first order condition:

$$\begin{aligned} c_p+&\bar{D}^o_{x_p}(x_p^a)\lambda\bar{s} + \bar{D}^o\lambda_{x_p}(x_p^a)\bar{s} + \bar{D}^o\lambda\bar{s}_{x_p}(x_p^a) \\ &+\bar{D}^p_{x_p}(x_p^a)[1-\mu\bar{\sigma}] - \bar{D}^p\mu\bar{\sigma}_{x_p}(x_p^a) = 0 \end{aligned} \tag{6}$$

Suppose the particular driver's chosen level of care is less than the economically efficient level, or $x_p^a < x_p^*$. The social first order condition for x_p, eq. (3), is satisfied at the care level x_p^*. But if $x_p^a < x_p^*$, then at x_p^a, it must be the case that $c_p < -\bar{D}^o_{x_p}(x_p^a) - \bar{D}^p_{x_p}(x_p^a)$. This says that at x_p^a, the cost of using an additional unit of care is less than the reduction in expected accident damage to both drivers. Substituting this inequality into eq. (6), and assuming that the marginal effect of more care on both drivers' damage is the same $(\bar{D}^p_{x_p} = \bar{D}^o_{x_p} = \bar{D}_{x_p})$, we get:[14]

$$-\frac{\bar{D}_{x_p}}{\bar{D}^o} > \frac{-\lambda\bar{s}_{x_p} - \lambda_{x_p}\bar{s} + (\frac{\bar{D}^p}{\bar{D}^o})\mu\bar{\sigma}_{x_p}}{1-\lambda\bar{s}+\mu\bar{\sigma}} \tag{7}$$

The left hand side of (7) is positive, since $\bar{D}_{x_p} < 0$. It is the percent reduction in damage to the other driver as x_p increases. To interpret the right hand side of (7), assume that $\bar{D}^o = \bar{D}^p$. Then the denominator is the share of total damage for which the particular driver is not liable, since the particular driver is liable for the share $\lambda\bar{s}$ of her own damage and for the share $1-\mu\bar{\sigma}$ of the other driver's damage. Also if $\bar{D}^o = \bar{D}^p$, then the numerator is the derivative of the denominator with respect to x_p. Therefore the right hand side of (7) is the percent reduction in the share of total damage for which the particular driver is not liable as x_p increases. Since the terms in the numerator of the right hand side of (7) are all expected to be positive, the right hand side of (7) must be positive. Ineq. (7) characterizes the condition under which the particular driver has an incentive to use less

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[13] $\bar{s}$ and $\bar{\sigma}$ are actually weighted averages of the shares of damage paid by the particular driver and the other driver. Note that these two expressions bring out the potential correlations between the damage level and the probability of the injurer being found liable. For example, if the probability of the injurer being found liable were higher when the victim's damage level is high, then a higher weight would be put on the injurer's share in high damage cases.

[14] This assumes that $1-\lambda\bar{s}+\mu\bar{\sigma}$ is positive.

care than is economically efficient, because the proportional gain from reduced damage to the other driver when more care is used exceeds the proportional gain to the particular driver from the reduction in her share of total damage.

Alternately, suppose the particular driver uses more care than the economically efficient level, or $x_p^a > x_p^*$. Then going through the same steps as above, we find that ineq. (7) must be reversed. Finally, suppose the particular driver uses exactly the economically efficient level of care, or $x_p^a = x_p^*$. Then (7) must be satisfied as an equality. Thus the particular driver has an incentive to use more than, less than, or exactly the economically efficient level of care depending on whether (7) is satisfied as an inequality, reversed, or satisfied as an equality. Ineq. (7) thus constitutes a testable prediction concerning whether the comparative negligence rule results in drivers having an incentive to use too much, too little, or the economically efficient level of care. In the next section, this prediction is investigated empirically.

Special cases of ineq. (7) apply when the sharing rule is fixed or when courts are assumed to administer the comparative negligence rule without error. Suppose the sharing rule is $s = \sigma = .5$. Then the particular driver then has an incentive to use too little care as long as $-\frac{\bar{D}_{x_p}}{\bar{D}^o} > \frac{-.5\lambda_{x_p}}{1-.5(\lambda-\mu)}$. Thus the comparative negligence rule with a fixed injurer's share can lead to efficient care incentives only in a special case. Alternately, suppose the due care standard is known with certainty and the comparative negligence rule operates without error. Then the particular driver knows she will always be found liable if $x_p < x^d$, so that $\lambda = 1$ in that situation and $\lambda = 0$ otherwise. The other driver will always be liable if $x_o < x^d$, so $\mu = 1$ in that situation and $\mu = 0$ otherwise. Then the particular driver has an incentive to use too little care (and be found negligent) if $-\frac{\bar{D}_{x_p}}{\bar{D}^o} > \frac{-\bar{s}_{x_p}+(\frac{\bar{D}^p}{\bar{D}^o})\bar{\sigma}_{x_p}}{1-\bar{s}+\bar{\sigma}}$ when the other driver is negligent and if $-\frac{\bar{D}_{x_p}}{\bar{D}^o} > -\frac{\bar{s}_{x_p}}{1-\bar{s}}$ when the other driver is non-negligent.[15] These conditions imply that even a non-stochastic, error-free comparative negligence rule results in incentives for inefficient behavior by drivers, except in special cases.

If the particular driver is assumed to know in advance that she will be the injurer or the victim if an accident occurs, then other special cases of (7) hold. When the particular driver will be the injurer with certainty, $\mu = 0$ and (7) becomes:

$$-\frac{\bar{D}_{x_p}}{\bar{D}^o} > \frac{-\lambda\bar{s}_{x_p} - \lambda_{x_p}\bar{s}}{1 - \lambda\bar{s}} \tag{8}$$

When the particular driver will be the victim with certainty, $\lambda = 0$. Then if only the victim suffers damage, ineq. (7) becomes $-\frac{\bar{D}_{x_p}}{\bar{D}^p} > -\frac{\bar{\sigma}_{x_p}}{\bar{\sigma}}$. While these assumptions are unrealistic in the automobile accident context, they apply to other types of accident cases, such as medical malpractice or products liability cases.

Thus in the model developed here, the comparative negligence rule does not in general give injurers and victims efficient incentives to avoid accidents. Efficient incentives are a possible result under the rule, but only in special cases. My conclusions concerning the effects of the comparative negligence rule thus differ from those of several recent writers who

[15] The latter condition implies that a fixed sharing rule, such as the 50-50 sharing rule, cannot lead to economically efficient results in an error free context, since $\bar{s}_{x_p}/(1-\bar{s}) = 0$, while $-\bar{D}_{x_p}/\bar{D}^o > 0$. This point has been made by Diamond (1974) and Rubinfeld (1987).

argue that the rule does lead to economically efficient care incentives.[16] Another line of argument, made by Haddock and Curran (1987) and Shavell (1987, section 2.2.9), is that the comparative negligence rule must lead to economically efficient accident avoidance incentives, because any cost minimizing solution other than the economically efficient outcome is dominated by the efficient outcome for both parties. However, this argument assumes that injurers and victims both escape liability with certainty by using the economically efficient level of care and that damage sharing occurs only when both parties are negligent. Here, in contrast, using the economically efficient level of care does not guarantee that the injurer will avoid being found negligent. Rather, since the due care level is stochastic, any level of care which allows injurers to be reasonably certain of avoiding liability is likely to be quite high and therefore unattractive. Similarly, victims cannot guarantee that injurers will bear the full amount of victims' damage by using the economically efficient level of care. As a result, the economically efficient level of care does not dominate other care levels.[17]

The contributory negligence rule

The liability rule used in accident cases in all U.S. states and in England before the advent of the comparative negligence rule is the rule of contributory negligence. Under this rule, the injurer is liable to the victim for the full amount of the victim's damage whenever the court finds injurer to be negligent *and* the victim to be non-negligent. Otherwise the injurer is not liable at all. This "all-or-nothing" rule has often been termed harsh, because it treats the injurer and victim unequally when both are found negligent and because it has the knife-edge property of shifting from full compensation to no compensation for victims of negligent injurers, depending on whether victims are found to be at or above versus slightly below the threshold level determining negligence. The rule has therefore been seen as less fair than that of comparative negligence, which reduces but does not eliminate the damage award when the victim is found negligent.

In the traditional theoretical model of the contributory negligence rule, both injurers and victims turn out to have incentives to behave efficiently.[18] In an error-free world of certainty, this is because injurers' liability for victims' damage falls from liability for the full amount of damage to no liability when injurers' care level just reaches the due care level, which is assumed to equal the economically efficient level of care. Injurers therefore have a large discrete incentive to increase their care to just the efficient level. Further, victims also have an incentive to take an efficient level of care. If injurers are negligent, then being non-negligent allows victims to avoid being found contributorily negligent and

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[16] In a number of recent articles in which authors conclude that the comparative negligence rule leads to economically efficient care incentives, the results of the models actually are indeterminate and the efficient outcome is a special case. In that sense, the results are similar to those derived here. The indeterminacy result appears in Haddock and Curran (1987), Cooter and Ulen (1987), Rubinfeld (1987), and Rea (1987).

[17] It is straightforward to modify the proof presented by Shavell and Haddock and Curran to reflect the model developed here. In that case their proof that the efficient outcome dominates any other outcome under the comparative negligence rule does not hold.

[18] See Posner (1972) or Shavell (1987).

therefore losing their damage award. Alternately if injurers are non-negligent, then victims bear their own damage and so the efficient level of care minimizes their total accident cost.

However, the contributory negligence rule is assumed here to operate with the same types of error and uncertainty as discussed above in the context of the comparative negligence rule. Thus the due care level used by the court is again assumed to be stochastic. Also, damage sharing is assumed to be a possibility, even though in theory, the contributory negligence rule specifies that injurers' share should always equal 1 when they are found liable, so that there should be no sharing of damage. However, in practice juries can easily accomplish damage sharing under the contributory negligence rule merely by setting the damage award at an amount less than the victim's total damage.[19]

Using the notation of the previous section, suppose the particular driver is involved in an accident with the other driver. Under the contributory negligence rule, the particular driver is found negligent if $x_p < x^d$ and the other driver is found non-negligent if $x^d \leq x_o$. Both conditions must hold for the particular driver to be found liable for damage, or $x_p < x^d \leq x_o$. The probability of the particular driver being found liable is therefore $\int_{x_p}^{x_o} f(x^d)dx^d$.[20] Similarly, suppose the particular driver suffers damage in an accident. The other driver is liable if $x_o < x^d$ and if $x^d \leq x_p$. Then the probability that the other driver will be found liable for damage to the particular driver is $\int_{x_o}^{x_p} f(x^d)dx^d$. Note that under the contributory negligence rule, only one driver can be found liable for damage in a single accident.

The sharing rule is assumed to take the same general form as in the previous section. The particular driver's share of the other driver's damage is $s'(x_p, x_o, x^d)$, where primes denote the contributory negligence rule. Similarly, the other driver's share of the particular driver's damage is $\sigma'(x_p, x_o, x^d)$.

The particular driver's *ex ante* private cost of accidents under the contributory negligence rule is therefore:

$$c_p x_p + \int_0^\infty D^o \int_{x_p}^{x_o} s' f(x^d)dx^d g(x_o)dx_o + \int_0^\infty D^p[1 - \int_{x_o}^{x_p} \sigma' f(x^d)dx^d]g(x_o)dx_o \qquad (9)$$

The particular driver's probability of being found liable, $\int_{x_p}^{x_o} f(x^d)dx^d$, can be integrated to eliminate x^d and the result is written $\lambda'(x_p, x_o)$. The other driver's probability of being found liable, $\int_{x_o}^{x_p} f(x^d)dx^d$, can also be integrated to eliminate x^d and the result is written $\mu'(x_p, x_o)$. Expected damage levels to the two drivers, $\bar{D}^o(x_p)$ and $\bar{D}^p(x_p)$, are defined in the same way as in the previous sections. The particular driver's expected share of the other driver's damage, contingent on being found liable, is denoted $\bar{s}'(x_p, x_o)$, where

19 Wittman (1986) has suggested that juries tend to follow the comparative negligence rule in deciding liability and damages even when the contributory negligence rule is in effect.

20 This formulation ignores the "last clear chance" doctrine, under which victims can recover their damage despite being contributory negligent if the injurer had the last clear chance to avoid the accident. In the empirical work discussed in the next section, this doctrine is unimportant since for the type of accident studied, the injurer's action is always last. The last clear chance doctrine is not used in states that have adopted the comparative negligence rule.

$\bar{s}'(x_p, x_o) = \frac{\int_0^{\infty} D^o(x_p, x_o)[\int_{x_p}^{x_o} s' f(x^d) dx^d] g(x_o) dx_o}{\int_0^{\infty} D^o(x_p, x_o) g(x_o) dx_o \int_{x_p}^{x_o} f(x^d) dx^d}$. The other driver's share of the particular driver's damage is denoted $\bar{\sigma}'(x_p, x_o)$. It equals $\frac{\int_0^{\infty} D^p(x_p, x_o)[\int_{x_o}^{x_p} \sigma' f(x^d) dx^d] g(x_o) dx_o}{\int_0^{\infty} D^p f(x^d) dx^d \int_{x_o}^{x_p} f(x^d) dx^d}$.

Substituting these definitions into eq. (9) results in the following expression for the particular driver's private cost:

$$c_p x_p + \bar{D}^o(x_p)\lambda'(x_p, x_o)\bar{s}'(x_p, x_o) + \bar{D}^p(x_p)[1 - \mu'(x_p, x_o)\bar{\sigma}'(x_p, x_o)] \tag{10}$$

The particular driver minimizes this expression with respect to x_p, which yields the first order condition for the preferred level of care, $x_p^{a'}$. Following the same procedure as in the previous section, the social first order condition, eq. (3), is evaluated at $x_p^{a'}$, assuming that $x_p^{a'} > x_p^*$. The resulting expression is then combined with the private first order condition for $x_p^{a'}$ to obtain an expression for the condition under which the particular driver has an incentive to use too little care. Making the same assumptions as above, the resulting condition for the particular driver to have an incentive to use too little care is:

$$-\frac{\bar{D}_{x_p}}{\bar{D}^o} > \frac{(-\lambda'\bar{s}'_{x_p} - \lambda'_{x_p}\bar{s}') + (\frac{\bar{D}^p}{\bar{D}^o})(\mu'\bar{\sigma}'_{x_p} + \mu'_{x_p}\bar{\sigma}')}{1 - \lambda'\bar{s}' + \mu'\bar{\sigma}'} \tag{11}$$

Ineq. (11) has the same general form and the same interpretation as ineq. (7) derived above for the comparative negligence rule, except that (11) contains an extra term reflecting the fact that the probability of the other driver being found liable as injurer depends on the particular driver's own care level. If ineq. (11) holds as shown, then drivers have an incentive to use too little care. If ineq. (11) is reversed or holds as an equality, then drivers have an incentive to use too much care or exactly the efficient level of care, respectively. Note that both the contributory and comparative negligence rules have the property that they can give drivers economically efficient care incentives, but only in special cases. Also, the individual terms in ineq. (11) may be different from those in ineq. (7). In the next section, these values are estimated separately for the two liability rules.

3. Empirical test of the efficiency of accident avoidance incentives

In this section, I examine empirically the economic efficiency of incentives for injurers and victims to prevent accidents under both the comparative negligence and contributory negligence rules. This is done by estimating a model which determines the parameters contained in exp. (7) for the comparative negligence rule and in exp. (11) for the contributory negligence rule.

I use a data set collected by Donald Wittman of approximately 550 rear end automobile accident cases decided by juries in California during 1974-76.[21] This data set is the only one

[21] The data come from *Jury Verdicts Weekly,* a reporting service for cases decided by juries in California. Wittman used the data to test whether juries' behavior differed when applying the two liability rules. See Wittman (1986) for further results and discussion of the data.

available that includes information concerning the care levels of injurers and victims. Since California shifted from using contributory negligence to using the comparative negligence rule in 1975, the sample includes cases litigated under both rules.[22] The data set also includes information concerning the dollar amount of pecuniary accident damage incurred by the victim, whether the plaintiff won or lost, and, if the plaintiff won, the amount of the damage award.[23]

The care levels of the injurer and victim are measured in three categories for each driver: (1) "very bad" driving means evidence was presented in court that the driver was drinking or exceeded the speed limit by a large margin; (2) "mediocre" driving means evidence was presented of a mild driving transgression and (3) "good" driving means no evidence was presented of fault. Victims who were passengers rather than drivers are classified in category (3). However, among injurers, virtually none were in category (3) and among victims, none were in category (1). Therefore care was measured as a single dummy variable for injurers and a single dummy variable for victims. The care variable for injurers, denoted x_j, equals one if the injurer's driving was mediocre and 0 if the injurer's driving was very bad. The care variable for victims, denoted x_v, equals one if the victim's driving was good and zero if the victim's driving was mediocre.

The data set gives the total value of pecuniary accident damage to the victim, including present and future medical expenses, lost wages, and repairs or losses to the plaintiff's car. Pecuniary accident damage to the victim is denoted M^P. Non-pecuniary accident damage to the victim, or "pain and suffering," is not given in the data set. It is denoted M^N. Total accident damage to the victim is therefore $M = M^P + M^N$.[24]

An issue of concern is that of selection bias. Since litigation is expensive, most automobile accident cases are either filed and then settled out of court, or not filed at all, with the victim instead perhaps accepting a payment from the injurer's insurance company. Selection into the set of litigated cases becomes more likely as the expected damage award gets higher, as the plaintiff becomes more optimistic relative to the defendant concerning his chance of winning, as the plaintiff's estimate of his probability of winning increases in variance relative to the defendant's, as either side's bargaining strategy becomes tougher, or for a number of other reasons.[25] Thus the criterion determining whether the case was in the sample, which is the litigation versus settlement condition, is complicated and depends on unobservables such as litigation costs, the variance of the plaintiff's versus the

[22] The comparative negligence rule was adopted in California by judicial decision in the case of Nga Li v. Yellow Cab Company of California, 532 P.2d 1226, 1975. The version of the comparative negligence rule adopted by California does not restrict damage sharing to cases in which the injurer is more negligent than the victim. California does not use the "no-fault" system.

[23] As noted in the theoretical section, under the comparative negligence rule, it is possible for both drivers to be both injurer and victim. This theoretically could mean that each driver sues the other. However, since most legal cases are settled out of court, the probability of two litigated cases arising from one accident is small and does not occur in the data set.

[24] Most states do not allow victims to name a figure for pain and suffering, since victims have an incentive to exaggerate and this is thought to encourage juries to make large damage awards.

[25] See Shavell (1982) and Wittman (1988) for discussions of the choice between settlement and litigation in certainty and uncertainty contexts. See Danzon and Lillard (1985) for an application involving medical malpractice cases.

defendant's prediction of the outcome, and the parties' bargaining strategies. No information is available concerning the characteristics of automobile accident cases that were settled rather than litigated. Therefore, I proceed without correction for potential sample selection bias.[26] The results therefore may not accurately reflect the effect of, say, injurer's care on behavior in the overall population of cases that are both litigated and settled.

The first set of equations explains whether the verdict was for the injurer or the victim, estimated separately for the subsamples of cases litigated under the contributory and comparative negligence rules using logit. The dependent variable equals one if the injurer was found liable for damage and zero otherwise. The independent variables are the care variables, x_j and x_v, and a dummy variable which equals one if the defendant is a corporation, denoted $CORP$. The coefficient of injurer's care is predicted to be negative for cases litigated under both rules. The coefficient of victim's care is predicted to be zero for cases litigated under the comparative negligence rule (since victim's care does not affect the determination of injurer's liability) and positive for cases litigated under the contributory negligence rule (since injurers are not liable if victims are contributorily negligent). The $CORP$ variable is included since prior work by Wittman (1985) suggests that juries tend to be more favorably inclined toward plaintiffs when defendants are corporations rather than individuals. This is probably because juries view corporations as having "deeper pockets," *i.e.*, they can better afford to compensate victims, because they have more insurance or can pass the cost on to customers by raising prices.

The results are shown in columns 1 and 2 of Table 1. Injurer's care has the predicted negative sign and is significant in both equations. When the coefficient of injurers' care in each of the two equations is evaluated at the mean value of the dependent variable, we find that increasing injurers' care level in driving from very bad to mediocre causes the probability of a verdict for the plaintiff to fall by .39 under the comparative negligence rule and by .61 under the contributory negligence rule. (See Table 2.) Victim's care is insignificant in the sample of comparative negligence cases, which is as predicted by the theory. In the sample of contributory negligence cases, victim's care has the predicted positive sign, but is statistically insignificant. When the coefficients of victims' care are evaluated at the mean values of the dependent variable, we find that victims' care has little effect on the verdict—increasing victims' care level in driving from mediocre to good causes the probability of a verdict for the plaintiff to rise by .015 under the comparative negligence rule and by .0085 under the contributory negligence rule. $CORP$ has the predicted positive sign and is statistically significant in the sample of comparative negligence cases, but not in the sample of contributory negligence cases. When the defendant is a corporation, the probability of being found liable rises by .30 if the case is tried under the comparative negligence rule and by .10 if the case is tried under the contributory negligence rule.

The next step is to estimate the sharing formula for damages. However, this must be done indirectly since no data are available concerning victims' non-pecuniary damage. When an injurer is found liable by the court, the damage award equals the injurer's share of damage times the total damage to the victim. Suppose the damage award is denoted

[26] See Heckman (1979) or Hausman and Wise (1975) for procedures for correcting for sample selection bias, which require information concerning the independent variables for cases subject to truncation or the truncation criterion for each observation within the sample.

Table 1

REGRESSION RESULTS EXPLAINING THE VERDICT AND DAMAGE AWARD

	(1) Verdict	(2) Verdict	(3) Award	(4)
	Comp. Neg. Cases	Contrib. Neg. Cases	All Cases	
			Share-- Comp. Neg.	Share- Contrib. Neg.
Constant	3.42 (.74)	4.18 (.71)	.32 (.089)	.79 (.23)
Injurer's care (x_j)	-2.89 (.69)	-4.26 (.66)	-.30 (.068)	-.19 (.10)
Victim's care (x_v)	.11 (.46)	.059 (.41)	.012 (.062)	-.34 (.23)
CORP	2.25 (1.05)	.70 (.73)	.045 (.055)	.17 (.07)
			Non-tangible Damage	
Constant			15,000 (15,000)	
Injurer's care (x_j)			-8,600 (14,300)	
Victim's care (x_v)			4,500 (14,900)	
N	223	331	465	

Table 2

PARAMETER ESTIMATES AND MEAN VALUES

	Comparative Negligence Cases	Contributory Negligence Cases
Mean Values:		
Proportion of injurers using mediocre care $(x_j = 1)$ (all cases)	.46 (.50)	.31 (.46)
Proportion of victims using good care $(x_v = 1)$ (all cases)	.70 (.46)	.81 (.39)
Proportion of defendants that are corporations (all cases)	.14 (.35)	.13 (.34)
Proportion of injurers liable $(\lambda, \mu, \lambda'$ or $\mu')$ (all cases)	.84 (.37)	.83 (.38)
Injurer's share of victim's total damage (if plaintiff won)	.22 (.15)	.48 (.10)
Victims' pecuniary damage	$13,800	
Victims' non-pecuniary damage	$16,400	
Victims' total damage	$30,200	
Damage award (if plaintiff won)	$9,800 (17,600)	$10,900 (22,600)
Parameter estimates:		
λ_{x_j} or λ'_{x_j}	-.39	-.61
μ_{x_v} or μ'_{x_v}	.015	.0085
$\bar{s}_{x_j}$ or $\bar{s}'_{x_j}$	-.30	-.19
$\bar{\sigma}_{x_v}$ or $\bar{\sigma}'_{x_v}$	.01	-.34

$AWARD$ and the injurer's share is denoted $SHARE$. Since total damage equals the sum of pecuniary and non-pecuniary damage, we have $AWARD = SHARE * (M^P + M^N)$. $SHARE$ is assumed to be linearly related to the care variables and whether the defendant is a corporation, but is allowed to differ for the two liability rules. The dummy variable for corporate defendants is included because the "deep pocket" view would predict that juries would set the injurer's share higher when the defendant is a corporation, holding care levels constant. Thus the sharing rule under comparative negligence is $SHARE = \alpha_0 + \alpha_1 x_j + \alpha_2 x_v + \alpha_3 CORP$ and the sharing rule under contributory negligence is $SHARE = \beta_0 + \beta_1 x_j + \beta_2 x_v + \beta_3 CORP$. Pecuniary damage to the victim, M^P, is observed, while non-pecuniary damage to the victim, M^N, is not observed. It is assumed to be linearly related to the care variables, or $M^N = \gamma_0 + \gamma_1 x_j + \gamma_2 x_v$. The non-pecuniary damage function is assumed to be the same for cases litigated under both liability rules. Define the indicator variable, L, which equals one if the case was litigated under the comparative negligence rule and zero if the case was litigated under the contributory negligence rule. Also, assume that the error structure on the award equation is additive. The resulting equation to be estimated is:

$$AWARD = [L(\alpha_0 + \alpha_1 x_j + \alpha_2 x_v + \alpha_3 CORP) + (1 - L)(\beta_0 + \beta_1 x_j + \beta_2 x_v + \beta_3 CORP)] \\ * [M^N + \gamma_0 + \gamma_1 x_j + \gamma_2 x_v] + \epsilon \tag{12}$$

Eq. (12) is estimated over all cases in which the plaintiff won.

The results are shown in Table 1, cols. (3) and (4). The two columns of results at the top of the table are the share formulae under the two liability rules (the α_i and β_i terms in (12)). Injurers' care level has the predicted negative effect on the share of damage paid by injurers and is statistically significant for both liability rules. Increasing injurers' care level in driving from very bad to mediocre causes injurers' share of total damage to fall by .30 under the comparative negligence rule and by .19 under the contributory negligence rule. Victims' care level has the predicted positive sign for the comparative negligence rule and is just short of statistical significance at the 95% level. But the effect of victims' care is very small—an increase in victims' care level in driving from mediocre to good increases injurers' share by only .012. For the contributory negligence rule, victims' care level has the wrong sign and a large value, but is not statistically significant. Since victims' care probably plays an relatively unimportant role in rear end accidents, these weak results for victims' care are probably not surprising. Defendants who are corporations paid a 5% higher share under the comparative negligence rule and a 17% higher share under the contributory negligence rule, but the corporate dummy variable is statistically significant only for the sample of contributory negligence cases.

The results for the non-pecuniary damage function (the γ_i terms in (12)) are shown at the bottom of Table 1. Neither care variable is statistically significant. The results suggest that increasing injurers' care from very bad to mediocre reduces victims' non-pecuniary damage by $8,600; however the effect of increasing victims' care level from mediocre to good is to increase rather than decrease victims' damage. These weak results suggest that for rear end accidents, higher care levels by drivers probably have a much stronger effect on the probability of accidents occurring than on the damage level when an accident does occur.

Table 2 shows mean values and standard deviations (in parentheses) of several variables. Note that the proportion of injurers found liable for damage is nearly the same for both liability rules: .84 under the comparative negligence rule versus .83 under the contributory negligence rule. In those cases where the injurer was found liable, victims' pecuniary damage averages $13,800, while victims' non-pecuniary damage was found to have a mean value of $16,400. The estimated average share of victims' total damage paid by injurers was .22 under the comparative negligence rule and .48 under the contributory negligence rule. These results support the assumption made in the theoretical model that damages are shared (*i.e.*, injurers pay less than the full amount of victims' damage), even when injurers are found negligent and victims appear to be non-negligent. This effect is more pronounced under the comparative negligence rule. The lower average share paid by injurers under the comparative negligence rule is in line with the theoretical model, since under the contributory negligence rule, injurers' share in theory should always be one. In actuality, damage sharing appears to be common under both rules.

The average damage award under comparative negligence, $9,800, is lower than the average award under contributory negligence, $10,900. Multiplying the average damage award by the probability of being found liable under each rule, we find that injurers' expected liability under the comparative negligence rule, (.84)($9,800) = $8,200, is lower than injurers' expected liability under the contributory negligence rule, (.83)($10,900) = $9,050. Thus the results suggest that the shift to comparative negligence reduced rather than increased injurers' average liability for victims' damage. These results do not support the argument that the change in liability rule was responsible for large increases in liability awards or for increases in premiums for drivers' liability insurance.

Turn now to an evaluation of incentives under the two liability rules. There are two separate questions to be addressed. First, comparing the two liability rules, we wish to ask which gives stronger incentives for drivers to take care to avoid accidents. This involves a comparison between the right hand sides of expressions (7) and (11). Second, we wish to ask whether the care incentives set up by the two liability rules are economically efficient. This involves a comparison between the right and left hand sides of expressions (7) and (11), where the left hand side of both expressions is the rate of reduction in victims' expected accident damage as drivers' care level increases.

To address the first question, several assumptions are needed which relate the *ex ante* situation in which drivers make their care decisions but do not know whether they will be injurers or victims if an accident occurs to the *ex post* situation in which injurers and victims' identities are known. First, the *ex ante* probability of the particular driver being found liable for damage under the comparative negligence rule, λ, is assumed to equal the *ex ante* probability of other drivers being found liable for damage under the same rule, μ, or $\lambda = \mu$. The same assumption is made for the contributory negligence rule, so that $\lambda' = \mu'$.[27] Second, the share of damage paid by the particular driver *qua* injurer contingent

[27] This is in effect an assumption that the particular driver's unobserved characteristics other than care are the same as those of the average other driver. Such an assumption would not be true for all drivers. For example, an individual driver who drives a sports car might be more likely to be found liable for damage when an accident occurs, holding care levels constant, than would the average other driver in an accident. Therefore λ would be expected to exceed μ for the particular driver. However, the assumption that $\lambda = \mu$ for the average driver seems reasonable.

on being found liable, $\bar{s}$, is assumed to equal the share of damage paid by the other driver *qua* injurer contingent on being found liable, $\bar{\sigma}$. Thus $\bar{s} = \bar{\sigma}$. The same assumption is made for the contributory negligence rule, so that $\bar{s}' = \bar{\sigma}'$. Third, eqs. (7) and (11) involve terms capturing the *ex ante* effect of care by the particular driver *qua* injurer and *qua* victim on the probability of the injurer being found liable. These terms are evaluated using the actual *ex poste* values for injurers and victims. Thus, λ_{x_p} is the *ex ante* effect of the particular driver's care on the particular driver's probability of being found liable *qua* injurer for the other driver's damage. After the accident, injurers' identity is known, so that this term becomes λ_{x_j}. Similarly, the *ex ante* effect of the particular driver's care *qua* victim on the other driver's probability of being found liable is μ_{x_p}. After the accident, victims' identity is known, so that this term becomes μ_{x_v}. The same assumptions are made for the contributory negligence rule. Fourth, similar assumptions are made concerning the effects of injurers' or victims' care on injurers' share, so that $\bar{s}_{x_p} = \bar{s}_{x_j}, \bar{\sigma}_{x_p} = \bar{\sigma}_{x_v}, \bar{s}'_{x_p} = \bar{s}'_{x_j}$, and $\bar{\sigma}'_{x_p} = \bar{\sigma}'_{x_v}$. Finally, average expected accident damage to the particular driver is assumed to equal average expected accident damage to the other driver, or $\bar{D}^o = \bar{D}^p$.

Using these assumptions, the right hand side of ineq. (7) can be evaluated for the comparative negligence rule. I use the values given in Table 2 even when they are not statistically significant, since these values are the best point estimates. Since $\lambda\bar{s} = \mu\bar{\sigma}$ by assumption, the denominator of (7) equals one. Evaluating the numerator of (7), we get: $-\lambda\bar{s}_{x_j} - \lambda_{x_j}\bar{s} + \mu\bar{\sigma}_{x_v}$ = -(.84)(-.30) - (-.39)(.22) + (.84)(.01) =.35.

Similarly, the right hand side of ineq. (10) can be evaluated using the values in Table 2 for the contributory negligence rule. Again, since $\lambda'\bar{s}' = \mu'\bar{\sigma}'$ by assumption, the denominator of (11) equals one. Evaluating the numerator of (11), we get: $-\lambda'\bar{s}'_{x_j} - \lambda'_{x_j}\bar{s}' + \mu'\bar{\sigma}'_{x_v} + \mu'_{x_v}\bar{\sigma}'$ = -(.83)(-.19) - (-.61)(.48) + (.83)(-.34) + (.0085)(.48) = .17. (Note that this calculation is sensitive to the large negative value found for $\bar{\sigma}'_{x_v}$.)

Comparing the results for the two rules, we find that in practice the comparative negligence rule gives drivers stronger incentives to drive carefully than the contributory negligence rule. Thus the empirical results reverse the traditional theoretical presumption that the contributory negligence rule gives drivers stronger care incentives than the comparative negligence rule.

Finally, in order to evaluate the economic efficiency of drivers' incentives to take care under the two rules, information is needed concerning the effect of care on expected accident damage. Expected accident damage to the other driver, who is the victim when the particular driver is the injurer, is $\bar{D}^o$. It equals the probability of an accident occurring per unit of driving by the particular driver, denoted ρ, times the damage to the victim when an accident occurs, M. Since both ρ and M are expected to depend on the particular driver's level of care, we have $\frac{\bar{D}^o_{x_p}}{\bar{D}^o} = \frac{\rho_{x_p}}{\rho} + \frac{M_{x_p}}{M}$, or the rate of reduction in expected accident damage as the particular driver's care increases equals the sum of the rate of reduction in the probability of an accident plus the rate of reduction in accident damage. Further, since $M_{x_p} = M^P_{x_p} + M^N_{x_p}$, the effect of care on M can be decomposed into its effects on pecuniary and non-pecuniary damage. The effect of injurers' and victims' care on victims' non-pecuniary damage has already been estimated and the results are given in table 1. Neither care variable is statistically significant. A separate estimation of the effect of injurers' and victims' care on victims' pecuniary damage also led to the result that care levels were not significantly related to non-pecuniary damage and that the signs of the care variables were positive rather than negative. This suggests that for rear end accidents, higher care by injurers and victims has little effect on damage once an accident occurs. However higher care levels are still likely to reduce the probability of accidents occurring, although this effect cannot be studied using data for litigated accident cases.

To determine at least ballpark estimates of $\frac{\rho_{xj}}{\rho}$ and $\frac{M_{xj}}{M}$ for accidents generally, I obtained outside data concerning the effect of drivers' drinking on the probability of accidents and on accident damage. Since the care variable for injurers in the data set measures, in part, whether the injurer had been drinking, this seemed to be a logical care variable to focus on. First, the probability of accidents occurring doubles when drivers have been drinking, from .038 to .087 per driver per year.[28] Further, when drinking drivers are involved in accidents, the accidents are more likely to involve fatalities. The probability of all drivers being involved in fatal accidents is .00038, while the probability of drivers who have been drinking being involved in fatal accidents is .0028—seven times as high.[29] Further, in a survey of truck drivers who were involved in accidents, those accidents in which drivers had been drinking had a 36% higher probability of involving injuries, and an average property damage figure which was twice as high.[30] These figures suggest that $\frac{\rho_{xp}}{\rho}$ and $\frac{M_{xp}}{M}$ are each likely to be at least .5. Summing, the figures suggest that the reduction in expected accident damage when drivers take care by not drinking is at least one.

Finally, comparing figures for accident probability and accident damage to the results of evaluating the left hand sides of expressions (7) and (11) for the two liability rules, we find that $-\frac{\bar{D}_{xp}}{\bar{D}^o}$ is at least unity, while the right hand sides of expressions (7) and (11), calculated above, are well below unity. Thus the results suggest that both liability rules give drivers inefficiently low incentives to take care to avoid accidents.

To summarize the results, we have found, first, that the comparative negligence rule in practice sets up stronger incentives than the contributory negligence rule for drivers to use care in driving and, second, that both rules result in incentives to use care which are weaker than would be economically efficient. Thus while drivers have inefficiently low incentives to avoid accidents, the recent spread of the comparative negligence rule has probably improved rather than worsened the situation. These results should be interpreted with caution since they are based on data for rear end accidents only and because some of

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[28] The probability of an accident occurring (number of accidents divided by number of licensed drivers) is .038 per year, where number of accidents comes from Table II-8 of Department of Transportation (1985) and number of drivers comes from Bureau of the Census (1988), Table 1001. For all accidents, the probability of alcohol being involved is 10.5%, according to data given in Table II-8 of Department of Transportation (1985). The proportion of drivers drinking is 6% for car and light truck drivers and 1% for heavy truck drivers, according to data in Table II-10 of Department of Transportation (1985). Weighting by relative miles travelled (.72 for cars and .28 for trucks, given in Table 1002 of Bureau of the Census (1988)), the weighted average probability of drivers drinking is 4.6%. These figures are used to calculate the probability of accidents conditional on drinking, using Bayes' Theorem.

[29] The first figure is derived from information given in Bureau of the Census, (1988, Table 1001). The second figure is derived from information in the same table concerning the probability of drivers who have been drinking being involved in fatal accidents and the figure derived above that the probability of drivers drinking is .046.

[30] Figures calculated from data given in Department of Transportation (1984, p. 47).

the estimated parameter values are not statistically significant. Hopefully further research along these lines will improve our understanding of how liability rules actually work in practice, rather than just on the theorist's drawing board.

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