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The Robust Efficiency of Comparative Negligence

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Abstract

In this essay I propose a novel comparative negligence rule that achieves efficiency in a range of situations where simpler rules fail. For example, when parties are unable to perfectly choose their levels of care, resulting in a risk that they are accidentally or inadvertently careless, traditional rules tend not to provide efficient incentives, particularly when the parties act sequentially and one party is able observe the other's level of care before acting or when parties cannot choose their care precisely. This essay shows how these inefficient incentives arise, and proposes an optimal comparative negligence rule that corrects these inefficiencies. The optimal comparative negligence rule is designed so that each party's share of liability rises with their negligence at a rate that exactly counteracts the additional liability for damages the negligence imposes on the other party. Under this rule, each party completely internalizes the external cost of their own lack of care, and will have efficient incentives to provide care, regardless of their own costs of care, and regardless of whether they can choose their own care perfectly or run the risk of inadvertent carelessness.

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Section 1. Introduction

Over the preceding several decades, an overwhelming majority of jurisdictions in the United States have followed the rest of the common law countries and adopted a comparative negligence standard for tort liability. Much of the rationale for the adoption of comparative negligence focused on equity rather than efficiency considerations, and adoption took place amid some controversy regarding both the theoretical and real world efficiency of comparative negligence rules relative to simple liability rules. Several early economic analyses of tort liability suggested that comparative negligence rules would be inefficient in conditions where more traditional liability laws would be efficient.\(^1\) Even the arguments by early supporters of comparative negligence took on the character of a defensive rear guard action when discussing efficiency. For example, in defending comparative negligence, Gary Schwartz argued that the efficiency justification for a contributory negligence rule is overstated, and suggests that people do not take into account the relationship between their actions and their potential liability in the manner suggested by economists and are often not aware of the possibility of recovering in court.\(^2\) This was not so much an argument that comparative negligence is more efficient, as an argument that it might not be less efficient.

However, it has been well known for several decades that a comparative negligence rule will lead to efficient actions in a simple model where an injurer and victim both contribute to preventing accidents, and all parties have full information about the other parties.\(^3\) By efficiency in this context, we mean that every agent is acting so as to maximize total social welfare, that is to say they are acting as if they are taking the effect of their actions on others fully into account. Because many simpler liability laws

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\(^1\) For a good discussion of how the earlier literature came to this conclusion see Robert Cooter and Thomas Ulen, “An Economic Case for Comparative Negligence” 61 N.Y.U. L. REV. 1079-1082 (1986). Some examples of works that came to this conclusion, are: John Prather Brown, "Towards an Economic Theory of Liability", 2 J. LEGAL STUD. 323 (1973), GUIDO CALABRESI, THE COSTS OF ACCIDENTS: A LEGAL AND ECONOMIC ANALYSIS (1970), and RICHARD POSNER, AN ECONOMIC ANALYSIS OF LAW (1st ed., 1973). These findings occurred primarily in the case of unilateral care, where one agent's care had no effect after the other agent has taken care. Furthermore, several of these arguments seem to have been based on either a non-standard understanding of the way comparative negligence rules are applied, or a non-standard understanding of the due care threshold.

\(^2\) Gary Schwartz “Contributory and Comparative Negligence, A reappraisal” 87 YALE L. J. 697 (1978)

also lead to efficiency in such a setting, this result alone is not enough to provide an efficiency rationale for comparative negligence. In contrast, this essay puts forward strong efficiency justifications for a kind of comparative negligence rule. Specifically, in situations where agents have private information about their costs of care, or where the agents act sequentially and cannot perfectly choose their level of care, a properly constructed comparative negligence rule can achieve first best efficiency, while any other simple negligence rule can only achieve second best.\(^4\)

The fundamental difficulty in providing incentives to act efficiently where the actions of both a victim and an injurer contribute to the likelihood of an accident is known as the `paradox of compensation'.\(^5\) In order for each party to face the proper incentives to provide precaution on the margin, each party should absorb all the costs of their lack of precaution. However for any rule where liability is assigned according to a fixed split regardless of fault, at least one party will not bear full liability, and thus at least one party will not have efficient incentives. Traditional rules solve this problem by assigning liability according to fault. When the court knows exactly what level of care each agent should provide, the court sets the due care standard at that level. One agent can be absolved from any liability if she provides at least the efficient level of care, and assigned full liability if she provides less. This agent will wish to provide the level of care that absolves her from liability. The second agent will anticipate that the first agent will meet the due care standard, so the second agent expects to bear full liability, and he has incentives to act efficiently as well.

In the real world, when the court cannot perfectly identify the efficient level of care for each agent, the traditional solution breaks down. The cost of care is likely to vary across different agents, and even a single agent placed in a similar situation would be likely to face different costs of care at different times. The efficient levels of care will generally depend on the agents’ marginal cost of care. It will be efficient for agents with low costs of care to be relatively careful, and for agents with high costs of care to be

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\(^4\) First best refers to a situation where each agent is acting efficiently. Second best refers to a situation where it is impossible to eliminate all inefficiency, but the rules are chosen to minimize expected inefficiency on average.

relatively careless. For example, it might be efficient for someone who is late for an important meeting to drive more quickly and with necessarily less care than someone who is driving to the park for a picnic. If the courts could observe the cost of care in every situation, it would be possible to individually tailor the standard of care to each unique situation and provide for the correct incentives. However, the cost of care is typically private information for the actors. Anyone could claim that it was very difficult or costly for them to exercise care for some idiosyncratic reason that would be very difficult for the courts to verify.

When the courts do not know the efficient level of care, under a traditional negligence-type rule the best the courts can do may be to set the standard of care at the level which would be most efficient on average. Under this kind of rule, agents with low costs of care, such as the picnicker, will exercise too little care, since they have no incentive to provide care above the standard of care, while agents with high costs of care, such as the person late for the meeting, will tend to exercise more care than is efficient.

Consider a situation where the injurer has a very high cost of care so it would be efficient for her to provide less care than the due care standard. This agent will still have a very strong incentive to provide enough care to meet the standard and absolve herself of all liability, so she will tend to provide too much care. Because traditional rules rely on a sharp increase in liability at the due care standard, when the standard cannot be adjusted perfectly to fit the individual circumstances, traditional rules tend to rely on a one size fits all approach which causes some agents to supply too much care while others supply too little.

Another difficulty arises when agents cannot perfectly choose their level of care. Agents may intend to provide the legally mandated standard of care but might inadvertently fail to do so. A negligence rule tends to give an agent too much incentive to avoid inadvertent negligence, because when an agent avoids inadvertent negligence, the agent avoids all liability, but not all risk of accident.

Furthermore, traditional negligence rules perform particularly poorly in sequential models where one agent acts after observing the other's (perhaps inadvertent) failure to meet the standard of care. For example, a rule with contributory negligence gives an injurer no incentive to avoid an accident when she observes a potential victim is being
negligent, because the injurer knows she will face no liability. Of course this was recognized in the 19th Century in *Davies v Mann*6, and the Last Clear Chance rule was developed in response, but the Last Clear Chance rule presents problems of its own. A Last Clear Chance rule places the burden on the injurer to make up for the negligence of the victim, and when care by the injurer is a substitute for care by the victim, it gives the victim an incentive to shift the cost of care onto the injurer.

Thus traditional rules that place liability completely on one party or the other as a function of whether they have a met fixed standard of care only achieve efficiency when the courts can always exactly identify the efficient level of care, and the agents can be sure to exercise care at exactly that level. In contrast, this essay proposes a comparative negligence rule that solves the paradox of compensation by increasing each party's share of liability with that party's carelessness. Unlike traditional rules, which attempt to identify the efficient level of care and give incentives to the agent to provide exactly that level of care, the proposed rule mandates a liability split that ensures that agents internalize the results of their actions over a range of levels of care. As a result agents will have an incentive to choose the efficient investment in care, without requiring the courts to identify exactly what the efficient level is.

Under the proposed rule, the standard of care for the injurer is set at very high level that only the injurers with the lowest cost of providing care will provide. In most cases when there is an accident, both parties will expect to share the liability. If this share was held fixed, the parties would face insufficient incentives. However, each party's share of liability increases with carelessness to compensate for the fact that the party does not bear full liability, and hence restores efficient incentives. Since the proposed rule forces agents to internalize the results of their actions, each party will be on average, indifferent over the actions of the other party. For example, if a potential victim takes a careless action that doubles the likelihood of accident, the injurer's share of liability will be reduced by half, leaving the injurer just as well off.

Section 2 of this essay provides a history of the development of the comparative negligence rule in the United States. A fuller explanation of how simple liability rules fail to efficiency is presented in Section 3, along with some intuition as to how

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6 152 Eng. Rep. 588 (1842)
comparative negligence rules may be an improvement. Sections 4 and 5 present examples which illustrates how conventional rules fail, and shows how the proposed rule can succeed when parties have private information about their own costs or cannot perfectly choose their level of care. Section 6 describes the how to construct the efficient rule, and discusses in detail under what circumstances efficiency can be achieved. For the more technically inclined reader, an appendix presents a formal model and a rigorous demonstration of how the proposed rule achieves efficiency.

Section 2. Development of Comparative Negligence in the United States

Prior to the widespread adoption of comparative negligence, the customary rule was negligence with a defense of contributory negligence. This rule was famously adopted in *Butterfield v. Forrester*[^7], and nicely put forth in *Brown v. Kendall*: "if both plaintiff and defendant at the time of the blow were using ordinary care, or if at that time the defendant was using ordinary care, and the plaintiff was not, or if at that time, both the plaintiff and defendant were not using ordinary care, then the plaintiff could not recover."[^8] Strictly applied, the rule held that negligence by the plaintiff was a complete bar to recovery. The last clear chance rule, put forward in *Davies v. Mann*,[^9] represented a step away from the contributory negligence rule, holding that a plaintiff's negligence would not bar recovery when the defendant had the last clear chance to avoid the accident. Most states also adopted doctrine holding that when the negligence of the defendant was wanton, willful or reckless, and the plaintiff's merely ordinary, the plaintiff could recover.[^10] However these rules did not allow for a sharing of damages and cannot be considered true comparative negligence rules.

The class of comparative negligence rules can be defined as rules where contributory negligence is not a complete defense, so a plaintiff can recover partial damages from a defendant even when the plaintiff's negligence contributed to the accident.

[^7]: 11 East 60 (K. B. 1809)
[^8]: 60 Mass. 292 (1850)
[^9]: Supra note 6
[^10]: For example see *Atchison, T\& S.F. RR Co. v. Baker*, 79 Kan. 183 (1908), or *Ziman v. Whitley*, 110 Conn. 108 (1929)
accident. It is possible to divide comparative negligence rules into four categories: 1) Pure comparative negligence, which allows the plaintiff to recover at least a portion of damages so long as the defendant's negligent conduct contributed to the accident, 2) Fifty percent rules, which allow a plaintiff to recover as long as his or her negligence was not greater than that of the defendant. 3) Not as great rules, where a plaintiff can recover as long as his or her negligence was not as great as that of the defendant. 4) Slight-Gross rules, where a plaintiff can recover only if his or her negligence was slight compared to the negligence of the plaintiff.

By mid-twentieth century most of the common law world, with the exception of the United States, had adopted some form of comparative negligence rule, abandoning the doctrine that contributory negligence was an absolute defense. However, the doctrine of contributory negligence was the general rule in force in most of the United States until the late 1960's. The major exceptions were maritime law which provided for equal division of damages among plaintiffs and defendants when both were negligent, and the Federal Employees Liability Act which provided for a comparative liability rule only when railroad employees sued their employers. Many states also had laws which applied some form of comparative negligence to employees of railroads or other specified hazardous industries.

Aside from these rules with particular applications, comparative negligence rules that applied generally were quite rare. A civil war era statute in Georgia, which seemed to apply pure comparative negligence to damages and injuries caused by railroads, was soon interpreted by the courts as a not as great rule applying to all accidents. Mississippi, according to Prosser, adopted a pure comparative negligence rule that applied to personal injuries in 1910 and applied it to property damage as well in 1920. Adoption by other states was slow with only 4 other states adopting comparative negligence until the mid-

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11 In a two-party accident, in theory there will only be a difference between a not greater and a not as great rule if the negligence of both parties contributed exactly the same amount to the accident. A mathematician would say that the chance of such an occurrence is vanishingly small, however in practice the rules are considered quite differently.

12 The form of apportionment used in U.S. admiralty law was not a true comparative negligence rule in that liability fell equally on all negligent parities, regardless of the comparative magnitude of their negligence. In contrast England adopted a rule allowing for apportionment according to fault in 1911.

13 According to William Prosser “Comparative Negligence” 41 CAL. L. REV. 1,12-13 (1953), at least 18 states had such rules by 1950.

sixties. But then between 1965 and 1984, 37 states adopted comparative negligence. One proposed explanation for this rapid adoption is that the widespread adoption of product liability laws led to a reduction in opposition from manufacturing concerns, freeing the way for attorneys to successfully push for adoption.

Currently only five jurisdictions in the United States have not adopted comparative negligence and retain contributory negligence as a bar to any recovery.15 These jurisdictions are Alabama, Maryland, North Carolina, Virginia and the District of Columbia. South Dakota is the only state to retain a slight/ gross rule. Thirteen states have pure comparative negligence. The remainder use either a not greater or a not as great rule. In the majority of cases the new comparative negligence rules were adopted by legislation, but in a sizeable minority of states, comparative negligence rules were adopted through judicial ruling.16

The judicial adoption of comparative negligence appeared motivated primarily by concerns over equity “Today it is almost universally regarded as unjust and inequitable to vest an entire accidental loss on one of the parties whose negligent conduct combined with the negligence of the other party to produce the loss”17. As illustrated by the California Supreme court's opinion in Li, judicial adoption, although motivated primarily by concern over equity and fairness was aided by a belief that there were no strong efficiency justifications for a rule of contributory negligence: “the doctrine is inequitable in its operation because it fails to distribute responsibility in proportion to fault. Against this have been raised several arguments in justification, but none have proved even remotely adequate to the task.”18

In contrast, when the doctrine of contributory negligence was originally adopted in the 19th century, it was directly justified by efficiency: "A party is not to cast himself upon an obstruction that has been made by the fault of another and avail himself of it."19

16 Three important cases of judicial adoption of comparative negligence were in Florida: Hoffman v Jones, 280 So. 2d 431, 78 A.L.R. 3d 321 (Fla. 1973), in California: Li v. Yellow Cab Co. of Cal., 13 Cal. 3d 804, 532, P 2d 1226, 119 Cal. RPTR.858, 78 A.L.R. 3rd 393(Cal. 1975), and in Illinois: Alvis v. Ribar 421 N.E.2d 886.
17 Hoffman, supra note 17 at 436
18 Li, supra note 17 at 1230-1231
19 Butterfield v. Forrester, 11 East 60 (K.B., 1809)
Likewise, when the last clear chance rule was adopted, concerns about efficiency were voiced in *Davies v. Mann* "...still the defendant was bound to go along the road at such a pace as would be likely to prevent mischief. Were this not so, a man might justify the driving over goods left on a public highway."²⁰

Although courts did not point to efficiency motivations for the adoption of comparative negligence, in a classic and influential law review article, William Prosser argues that comparative negligence rules have as good an intuitive claim to efficiency as contributory negligence rules. Speaking of a contributory negligence rule that bars any recovery for a negligent defendant he writes; "It has been said that the rule is intended to discourage accidents, by denying recovery to those who fail to use proper care for their own safety, but ... it is quite as reasonable to say that the rule promotes accidents by encouraging the negligent defendant."²¹ Thus, without a formal model, Prosser was able to grasp the intuition that a contributory negligence rule can lead to inefficient incentives, particularly when an injurer(defendant) is faced with a negligent victim. Nonetheless the primary justification for comparative negligence has been concern over equity and fairness, specifically the belief that a victim injured by the negligence of another should be entitled to some compensation even if the victim's negligence may have contributed to the accident.

Originally, the last clear chance rule was seen as a necessary counterweight to a strict contributory negligence rule, which would give no incentive for an injurer to avoid an accident once she observes a victim acting negligently. In contrast to strict contributory negligence, under comparative negligence an injurer will expect to pay something if she negligently injures a negligent victim. Under a comparative negligence rule, her share of responsibility will be increasing in her negligence, she will have at least some incentive to reduce her liability by exercising care. Thus, although comparative negligence is often justified by equity concerns while the last clear chance rule was justified by efficiency, the adoption of a comparative negligence standard may diminish the need for a last clear chance rule. Many states have recognized this and have abrogated the last clear chance doctrine at the same time they adopted the comparative negligence

²⁰ *Davies V. Mann*, 10 M. & W. 545 (Ex. 1842)
²¹ Prosser, *supra* note 13 at 4
doctrine. Although a standard comparative negligence rule would tend to perform better than a strict contributory negligence rule in cases where the injurer acts in response to the victim's action, this paper shows that there is still room for improvement. Specifically, I show that first best efficiency can be achieved in those conditions through a special `comparative last clear chance rule' 

One significant difficulty with applying a comparative negligence rule is that it requires juries or judges to quantify the amount by which each party was at fault. This is no easy task, and there is little sound theoretical basis for any method of making such a quantification. Without specific guidelines for allocating shares of negligence, any division is at best subjective if not arbitrary. Early commentators such as Prosser had major reservations about the ability of juries to compare the magnitudes of each party's negligence, and feared that comparative negligence would give juries an opportunity to divide liability according to their sympathy or prejudices, rather than on any firm and consistent legal basis.

Indeed, under modern law there is little guidance for fact-finders in apportioning comparative fault. Speaking of apportioning fault, the draft third restatement notes “This involves apportioning the loss both by causation and by percentages of responsibility. Very few courts have addressed how this should be done." One notable exception is Dobson v. Louisiana Power & Light, 567 So.2d 569 (La. 1990), in which the court explicitly endorsed applying a version the Hand Formula in proportioning fault under comparative negligence.

\[ \frac{P_I \times L_I}{B_I} + \frac{P_V \times L_V}{B_V} \]

For example in Hoffman, supra note 16 at 438, the Florida Supreme Court stated “The doctrine of last clear chance would, of course, no longer have any application in these cases.” Other states such as Delaware have retained last clear chance, but only as “one of many factors to be weighed by the trier of fact in assessing and comparing the parties relative fault, instead of an inflexible `all or nothing' doctrine of liability.” Laws v. Webb, 658 A. 2d 1000 (Del. 1995)

RESTAMENT (THIRD) OF TORTS §7 cmt. e (1999)

The Hand Formula, formulated in United States v. Carroll Towing Co., 159 F.2d 169 (2d. Cir. 1947), determines whether failing to take a precaution constitutes negligence by comparing the harm prevented (in Hand's terms: $P \times L$) with the cost of the precaution (in Hand's terms $B$.)

Dobson does not explicitly state how the Hand Formula is to be applied, but refers to David Sobelsohn, “Comparing Fault” 60 INDIANA LAW J. 413,420 (1984). The formula that Sobelsohn suggests for the injurer's share is (in Hand's notation):

\[ \frac{P_I \times L_I}{B_I} \]

where the $I$ and $V$ subscripts refer to the values for the injurer and victim respectively. Interestingly, this is more or less the rule considered by the authors

\[ \frac{P_I \times L_I}{B_I} + \frac{P_V \times L_V}{B_V} \]
The Law and Economics literature has suggested a different formula for division of liability under comparative negligence. Specifically if $x$ and $y$ are the levels of care for the injurer and victim respectively and $x^*$ and $y^*$ are the respective legally mandated standard of care, the injurer's share of liability is taken to be: $\frac{x^*-x}{(x^*-x)+(y^*-y)}$. While this formula could lead to efficiency in simple models if care is quantifiable, it is often not practically useful because there may be no way to quantify levels of care that is not arbitrary. One natural possibility would be to compare how much the respective agents spent on precaution relative to the amount they would have spent under due care. But given that expenditure on precaution is often in the form of opportunity cost, and thus difficult to observe, this would cause substantial administrative costs. Even when it is possible assign a level of care a cardinal number, such as driving speed, or seconds spent looking, it is not clear that the cardinal number corresponds to the effect of that care. For example the increase in likelihood of accident from doubling driving speed may be much greater than the impact from halving the time a pedestrian spends looking for traffic before crossing.

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26 See for example, ROBERT COOTER AND THOMAS ULEN, LAW AND ECONOMICS (4th Ed.) (2003)
The efficient comparative negligence rule proposed in this essay does not rely on an arbitrary quantification of care to determine the liability split. Rather than using a quantification or description of the actions themselves, the efficient rule assigns liability according to the probability of accident induced by these actions. In other words, the proposed rule assigns the liability share according to the output (probability of accident), and does not need to directly quantify the input (care). Another way the proposed rule differs from a traditional comparative negligence rule is that it has very high due care standards. Under the efficient comparative negligence rule, the due care standard for the injurer is essentially set at the maximum level of care that it will ever be efficient for the injurer to provide. The only way for the injurer to avoid all liability is to provide this highest efficient level of care. For the victim, there isn't really a due care standard at all, the victim will not be fully compensated even if the injurer provides a low level of care and the victim provides a high level. Figure 1 illustrates the differences between the traditional comparative negligence rule, and the proposed efficient comparative
negligence rule. In both of the graphs, darker areas represent a greater liability share for
the injurer. Under the traditional comparative negligence rule on the left, all the area to
the right of \( x^* \), is pure white, implying the injurer faces no liability, and the area to the
left of \( x^* \), but above \( y^* \) is pure black, implying the victim is being fully compensated. In
contrast under the proposed rule shown on the right Figure 1, the entire area is grey, with
the exception of the right edge of the graph, where the injurer is supplying the highest
efficient level of care (\( x^* \)), so all liability falls on the victim. The smooth transitions
between shades of grey represent the smooth transitions in liability shares, leading to
efficient incentives over the whole range of efficient actions for both actors.

Section 3. The Trouble with Traditional Rules

The first generation of economic models showed that if agents can choose their
levels of care perfectly, and courts can identify the efficient action, then courts can
achieve efficiency with a negligence rule, a rule of strict liability with contributory
negligence, or a rule of negligence with a defense of contributory negligence.\(^{27}\) Later
models due to Cooter and Ulen, and Rea showed that efficiency could also be achieved
by a comparative negligence rule.\(^{28}\) Given that the traditional rules are simpler to
implement than a comparative negligence rule, the later findings alone do not provide a
strong justification for comparative negligence.

However, this paper is by no means the first to argue that there can be strong
efficiency justification for a comparative negligence rule, and that it can be more efficient
than a simple rule. The efficiency of traditional rules depends on assumption that the
courts can perfectly identify the level of care supplied by both parties. When there is
evidentiary uncertainty, injurers will not be able to ensure that they will not be able held
liable by supplying precisely the due level of care. When courts are likely to make small
or moderate errors in assessing the level of care, under simple liability rules at least one
party may provide excessive care so as to avoid being found negligent and bearing
responsibility for the accident. For example if the standard of due care is to drive at 65
mph, and courts can only measure speed with a margin of error of 5 mph, a driver will


have incentive to drive at 60 mph to avoid any chance of liability. As argued by
professors Cooter and Ulen, comparative negligence may be preferable in these
circumstances.\textsuperscript{29} A comparative negligence rule leads to a more symmetric bias and may
diminish the incentive to provide excessive care, leading to greater efficiency. However,
this justification is not entirely convincing on two levels. For one, it is not necessary to
always set the due care standard at the level of care that is efficient and in cases of
evidentiary uncertainty it is generally not desirable to do so. In the example above, if it is
efficient for drivers to proceed at 60 mph, it is possible to simply set the due care
standard at 65 mph, so that drivers who drive no faster than 60 mph need not fear being
found negligent. In general positive, but low levels of evidentiary uncertainty tend to
create a bias to exert too much care. By setting a lower standard of care, courts can
correct for this bias, and in the absence of private information, may be able achieve first
best with any of the popular liability rules under evidentiary uncertainty.

Secondly, even when the legal standard is mechanically set at the efficient level of
care, comparative negligence rules will not always be more efficient. Using simulations,
Oren Bar-Gill and Omri Ben-Shahar compare a simple negligence rule, a contributory
negligence rule and a comparative negligence rule and show that a comparative
negligence rule will not always be the most efficient when the legal standard is set at the
efficient level of care.\textsuperscript{30} Evidentiary uncertainty that leads to small errors with high
probability tends to lead parties to provide extra care so as to meet the due care standard,
but other forms of evidentiary uncertainty may have a different effect. As evidentiary
uncertainty becomes more severe, it dilutes the relationship between care and fault and
can lead to an opposite bias. For example consider the most extreme form of evidentiary
uncertainty, in which the court's estimation of care bears no relationship to care actually
provided. In this case, each party's level of care would not affect the likelihood that party
is liable, so it would be as if each party bore liability for a fixed fraction of damages, and
each party would under-invest in care. Because the direction of the bias from evidentiary
uncertainty can be ambiguous, it is not surprising the efficiency ranking of the respective
rules is also ambiguous.

\textsuperscript{29} Cooter and Ulen, supra note 3 at 1086-1097
\textsuperscript{30} Oren Bar-Gill and Omri Ben Shahar, “The Uneasy Case for Comparative Negligence” 5 AMER L. &
A more compelling argument for the use of comparative negligence is the issue of self-selection, as introduced by Daniel Rubinfeld.\textsuperscript{31} A comparative negligence rule can be more efficient than a simple rule because it smooths the discontinuity in liability. Rather than facing a discrete jump in liability, agents may face a liability schedule that increases continuously with their fault.\textsuperscript{32} As a result they will be more likely to adjust the care they provide according to the cost of care, and agents with higher costs of care will choose to provide less care while agents with lower costs of care will provide more care. Under a comparative negligence rule, agents with high costs provide less care, and agents with low costs tend to provide more care, so the agents sort themselves and adjust their care towards the efficient level as a function of their private information.

Another source of inefficiency from simple negligence rules can occur when one party is able to observe the other's level of care before they choose their own. For example, one might think that a driver should be more careful going through an intersection if they notice a pedestrian that is crossing carelessly. However, a negligence rule that did not adjust the standard of care would not give incentive for the injurer to increase care when the potential victim is careless. Worse yet, rules with contributory negligence actually remove the incentive for the injurer to take any care when she observes a negligent pedestrian.

In a perfect information model with infallible homogenous actors the situation above will never occur. The victim will have incentive to provide the appropriate level of care and will never be negligent. Unfortunately, the mere fact that a defendant's liability has ever been denied on account of contributory negligence belies the applicability of the ideal model cited above. There are several reasons why even rational victims may fail to meet the standard of care and be contributorily negligent. If we drop the assumption that agents are homogenous, we note that an agent may have a particularly high cost of care, and may be willing to assume the liability to avoid paying the cost of care. For example somebody who is deeply immersed in thought might find it very costly to pay attention

\textsuperscript{31} Daniel Rubinfeld, “The Efficiency of Comparative Negligence” 16 J. LEGAL STUD. 375 (1987)
\textsuperscript{32} Under a standard comparative negligence rule this will not be true when an injurer faces a plaintiff who is not at all negligent. For this reason Rubinfeld suggests that with a comparative negligence rule the standard of care be set artificially high.
to her surroundings, and even the imposition of full liability in the case of an accident may be insufficient to induce her to take the legally mandated level of care. Another reason that victims may be negligent is that care may be stochastic; victims might intend to provide the standard of care but fail to do so because of inattention or distraction. Unlike the traditional rules, a comparative negligence rule gives each agent incentive to provide care regardless of whether or not the other agent is negligent. Even if the other party is negligent, either party will face some incremental liability as a result of their negligence.

The fact that a contributory negligence rule may not provide proper incentives to injurers facing negligent victims has been known for centuries, and the development of the last clear chance rule was predicated on this. However, under a last clear chance rule, a careless victim imposes the cost of extra care upon the injurer, and need not take this cost into account when he chooses his action. As a result, with a last clear chance rule a victim will often have insufficient incentive to provide proper care, particularly when care by the victim is a substitute for care by the injurer. Donald Wittman notes this in a 1981 paper and proposes a solution where careless victims are required to reimburse other parties who were required to exercise extra care to avoid accidents. Wittman's mechanism is theoretically elegant, and would provide efficient incentives to potential victims. Unfortunately, it would require that reimbursement would often occur where there had been no accident; in fact it would require reimbursement when there has

33 Mark Grady describes how agents who are making efficient investments in what he terms 'advertence' will sometimes be unintentionally negligent and how the traditional economic analysis of tort law has failed to account for this. Mark Grady, “Multiple Tortfeasors and the Economy of Prevention”, 19 J. LEGAL STUD. 653 (1990)
34 Samuel Rea makes a similar argument for the desirability of comparative negligence rules, postulating the presence of 'unresponsive actors', whose actions do not respond to incentives or legal rules. Supra note 4. These unresponsive actors could be modeled as agents who either have care that is so stochastic they have no control over care at all, or agents with such idiosyncratic and pathological cost functions that it is prohibitively expensive for them to meet the standard of care. He notes that compared to contributory negligence, a comparative negligence rule imposes more appropriate incentives when a victim is likely to be negligent and unresponsive. Steven Shavell “Torts in which Victim and Injurer Act Sequentially” 26 J. L. & ECON. 589 (1983) also notes that comparative negligence gives an injurer incentive to avoid an accident when faced with negligent agent whereas contributory negligence does not.
35 For a more recent, and more rigorous treatment, see the work of Shavell, supra note 34, which examines the performance of a number of liability rules under sequential action, both in cases where care is determinate and where care may be stochastic. He shows that a last clear chance rule can give an injurer proper incentive to provide care to make up for a victim's shortcomings.
been no more than a fleeting interaction between the parties. For example, in order for this mechanism to be efficient, a careless pedestrian would be required to compensate the drivers who simply had to slow down to avoid him. It is hard to imagine a mechanism that called for frequent transfers of picayune sums would ever be implemented.\footnote{Susan Rose-Ackerman “Dikes, Dams, and Vicious Hogs: Entitlement and Efficiency in Tort Law”, 18 J. LEGAL STUD. 25, (1989) also looks at complementary situation in which it is efficient for a a victim to provide extra care in response to the a dangerous condition created by an injurer and proposes a mirror image rule on fairness and efficiency grounds.}

Recent work by Oren Bar-Gill and Omri Ben-Shahar challenges many of the traditional efficiency justifications for comparative negligence.\footnote{Bar-Gill and Ben-Shahar, supra note 30.} First they consider the argument that rather than one large distortion, a comparative negligence rule provides for two smaller symmetrical distortions and that it is better to have two intermediate distortions than one large distortion. They convincingly argue that simple negligence rules, contributory negligence rules, and comparative negligence rules are all inherently asymmetric since they all place liability on the victim when neither party is negligent. Given this it is not clear that a comparative negligence rule is more likely to provide for two intermediate distortions. Furthermore they argue against the premise that it is better to have two small distortions than one big one. Although there are reasons to believe that it is often better to have two intermediate distortions than one large one; this paper confirms their argument that a comparative negligence rule will not necessarily replace a large distortion with two smaller ones. However, I show a properly constructed comparative negligence rule can eliminate all distortions, so the efficiency ranking between the outcome with the comparative negligence rule and a simple negligence rule is unambiguous.

Additionally, Bar-Gill and Ben-Shahar show that the `one size fits all effect' of traditional rules is diminished under evidentiary uncertainty, and some self-selection will occur under certain forms of evidentiary uncertainty. Evidentiary uncertainty tends to morph traditional rules into a form of comparative negligence rules. Because it is no longer certain that an injurer can escape liability by choosing a level of care just above the standard, and an agent is more likely to be have deemed to have met the standard if she provides more care, each agent's expected share of liability becomes a smooth function of the care that she provides. Under some parameters it is possible that the noise
added from evidentiary uncertainty might lead the expected liability share curve to have just the right slope in some region, and in that region agents will efficiently self select. However, this happy result does not stem from the design of traditional rules, but rather from the difficulty in applying them as designed. As will be discussed in the extensions section of this paper, it is possible to modify the comparative negligence rule presented here to achieve efficiency in some cases of evidentiary uncertainty. Rather than relying on a fortunate coincidence of errors, this paper advocates designing an efficient rule, and modifying it maintain efficiency in the face of limitations on implementation.

In summary, traditional rules with no sharing of liability are able to induce efficient behavior in simple models where the courts can directly identify the efficient action for at least one of the participants, and where participants are able to accurately choose their level of care. However, in cases where parties vary in their cost of care, or where they are sometimes accidentally negligent, simple rules tend to lead to inefficiencies. These inefficient incentives arise because when one party is forced to accept full liability when negligent, the other party will face no liability, and will have no incentive for care. When one considers that many accidents occur due to failures of care by multiple parties, one might think that it is precisely times when one party is negligent where it is important to ensure that incentives on the other party are correct. As a result, the fact that a rule provides efficient incentives only when both parties face average costs and are not accidentally negligent may not be reassuring.

One simple mechanism that would in theory provide efficient incentives for both victims and injurers would be to hold the injurer liable for the entire loss by the victim, but to provide no compensation to the victim. There would be two practical difficulties with such a mechanism. To begin, it would provide no incentive for victims to actually bring a lawsuit. If the costs to bringing a lawsuit were sufficiently small, the incentive to bring suits could be restored by allowing victims who sue successfully just enough compensation to induce them to sue. However, this would still lead to strong incentives for the victims and the injurers to settle out of court. The government could decouple

39 Matthew Clement has recognized that allowing for decoupling can soften the paradox of compensation and make it easier to provide proper incentives to the injurer and victim. “Precautionary Incentives for Privately Informed Victims”, 23 INT’L REV. OF L. AND ECON. 237,250 (2003)
settlement as well by confiscating a large fraction of any settlement, but one might guess that this would lead to informal extralegal settlements before any charges are brought.

This paper shows that even when decoupling is not possible, a properly constructed comparative negligence rule can avoid the inefficiencies due to both the problem of unobservable cost of care, and the difficulties of sequential choice of care. If the marginal loss borne by the victim from carelessness is always equal to the marginal expected damage from carelessness, the victim will always choose the correct level of care. Because the victim's loss borne by the victim is equal to the marginal damage, the injurer is actually indifferent as to the level of care that the victim chooses. Therefore if the marginal expected damage from the injurer's carelessness is equal to the injurer's marginal liability the injurer will choose the efficient level of care as well.

It is true that in order to construct an efficient rule in the manner I propose, the court must know the relationship between the agents' care and the probability of accident, but this information would typically be required to choose the appropriate due care standard under a traditional rule.\(^{40}\) If parties act sequentially, the court needs to know only a lower and upper bound for the efficient level of care for the first party (injurer) and merely knows the distribution of the efficient level of care for the second party (victim), whereas with a traditional rule the court must know the distributions for both agents to achieve only second best.

The efficient comparative negligence rule is found by solving two equations. First the injurer's care is fixed and an initial value is chosen for the division of liability for one level of care for the victim. There is an equation for the division of liability as a function of the victim's care that guarantees the injurer faces efficient incentives. In general, this equation will have a range of feasible initial values. It is then possible to construct another equation for these initial values as a function of the injurer's level of care that can guarantee that the injurer faces efficient incentives. The solution to this pair of equations will be feasible for a range of specifications and that it will have many of the properties of a conventional comparative negligence rule. The injurer can choose a level

\(^{40}\) To be precise, if one wishes to set the due care standard under a traditional rule at the level of care which should be supplied by the average agent, it is only necessary to know the marginal effect of care, whereas to construct the due care standard that achieves second best it would be necessary to know actual probability of accident.
of care high enough to avoid all liability, and the injurer's share will tend to be decreasing in the injurer's observed level of care and will be increasing in the victim's level of care.

Under the efficient comparative negligence rule discussed in this paper agents will generally face less than full liability for harm. Therefore if the liability split was constant both parties would have insufficient incentive to avoid harm. However, under the proposed comparative negligence rule, carelessness by an agent increases the share of liability borne by that agent. If the share of liability increases at precisely the correct rate, the marginal liability faced by each agent will be equal to the marginal social harm, and each agent will have the correct incentives. Furthermore, even when the agents choose levels of care sequentially, so for example the victim observes the injurer's level of care before choosing his own action, the injurer has no incentive to act strategically and distort the victim's level of care. This occurs because the victim's marginal liability is equal to the marginal harm from carelessness. Since the injurer expects her share of liability to decrease in proportion to the increased likelihood of accident caused by the victim's carelessness, the injurer is indifferent to the victim's level of care, and has nothing to gain by distorting the victim's action. Since the injurer is indifferent to the victim's care, choosing the efficient level of care is a dominant strategy for her.

A variant of the rule proposed in this paper could also be applied to determining liability when agents jointly cause harm to a third party. In terms of economic analysis there is little difference between a case where both the injurer and the victim's conduct leads to the possibility of accident and a case where the actions of two independent actors lead to an accident that causes harm to a third party. Thus any analysis that is applied to comparative negligence can also be applied to the division of damages among defendants who are jointly negligent. The rule that I consider in this paper could easily be the basis for an efficient joint liability rule when the actions of two agents combine to put a third agent at risk.

There are some differences between the proposed rule and the way comparative negligence is conventionally applied. Firstly, the due care standard for the injurer is set

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41 The fact that these cases are analytically identical has been noted in William Landes and Richard Posner “joint and multiple tortfeasors: an economic analysis”, 9 J. LEGAL STUD. 517 (1980). Interestingly, they come to the conclusion that contribution can lead to an inefficiency in the same manner that they had earlier concluded that comparative negligence leads to inefficiency. This conclusion was based on the same questionable interpretation of the rule.
very high. To avoid all liability, the injurer must provide the level of care that would be efficient for the type of injurer with the lowest cost of care. Unlike conventional comparative negligence, there is no level of care that will guarantee full compensation for the victim if the injurer is negligent. In order to provide efficient incentives between any two choices of care, in general the liability share must vary between those two levels of care. More precisely, if the injurer was absolved of liability for providing care that met a lower level of care, it would not be possible to give her proper incentives to choose a higher level of care.

Secondly, to achieve efficiency in cases where the injurer acts after observing the victim's action, it will be necessary to apply a slightly different rule, a `comparative last clear chance rule.' Under one form of this rule the victim can insure full compensation by choosing the highest level of care that is ever efficient, under an alternative efficient comparative last clear chance rule it is the injurer who can avoid liability by choosing the highest efficient level of care, but only when the victim chooses the lowest level. Nevertheless, these rules do share the feature that each agent's share of liability decreases with that agent's carelessness.

Section 4. Example with Private Information

To illustrate the inefficiencies caused by simple negligence rules, and the improvement possible from a correctly constructed comparative negligence rule we consider a simple example of an interaction between a potential injurer (driver) and a potential victim (pedestrian). We shall see that if there is some uncertainty about the cost of care for the driver and the pedestrian, all of the simple rules will sometimes lead to inefficient choices of care. On the other hand, a properly constructed comparative negligence rule can always lead to efficient care even if the court has no specific information about a particular driver or pedestrian.

Imagine a pedestrian crosswalk where there is a (female) driver and a (male) pedestrian. Assume that if there is an accident the pedestrian suffers a broken leg with monetary equivalent of damages equal to $2000. As the driver is approaching the

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42 We can think of this as setting the due care standard above the highest level that is ever efficient for the victim to provide.
intersection, she makes a choice between proceeding *aggressively, moderately* or *defensively*. The pedestrian chooses his own care; he can be either *careless* or *careful*. We assume it costs nothing for the pedestrian to be *careless*, but the pedestrian must incur some cost to be careful. This cost which, we denote $z$, is equally likely to be any value between 0 and 100. It is most costly for the driver to be provide the least care (drive *aggressively*), and most costly for the driver to drive *defensively*, but to construct an efficient rule in this example we will not need to make any assumptions about the driver's actual costs. The probability of an accident for any combination of driver and pedestrian's care is given below.

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<td>.03</td>
</tr>
<tr>
<td>Defensive</td>
<td>.04</td>
<td>.02</td>
</tr>
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</table>

Table 1: Probability of Accident

### 4.1 Sequential Model

We first consider a model in which the pedestrian observes the driver's action before choosing his own level of care. The first step is calculating the pedestrian's socially optimal response to the driver's action. If the driver is *aggressive*, by crossing *carefully*, the pedestrian reduces the probability of accident from .08 to .04 and reduces the expected accident damages from 160 to 80, so it is socially optimal to be *careful* if his cost is less than $80 (i.e. if $z < 80$). If the driver drives *moderately*, by being *careful* the pedestrian reduces the expected damages from $120 to $60, so it is efficient to be *careful* for pedestrians with $z < 60$. In response to a *defensive* driver, the pedestrian reduces expected damages only from $80 to $40 by being *careful*, so he should do so whenever $z < 40$. Note that in the example we are considering, there is some substitution between care provided by the driver and care by the pedestrian; it is efficient for more pedestrians to exercise care when the driver exerts less care. Although one might expect many accident situations to have this feature, one could conceive of situations where this is not the case. For example, there might be a spacecraft that would explode if any one component fails. In that case when one manufacture fails to exercise care, it is
efficient for all other manufacturers to exercise less care. Nonetheless, the proposed rule will be efficient in either case, it does not require that one agent's care is a substitute for the other's.

We will now consider the efficiency of incentives provided under various rules, beginning with simple liability rules in which liability is never shared. We will show that all of these rules will fail to provide efficient incentives in some situations. Finally we will show that if it is possible for liability to be shared between the two agents we can construct an efficient comparative negligence rule that will provide efficient incentives.

4.2 Negligence with Contributory Negligence

A rule of negligence with contributory negligence will place liability on the injurer (in this case, driver) if and only if the injurer is negligent while the victim has met the standard of care. If the standard of care for the driver is to drive defensively while the standard for the pedestrian is to be careful, the liability share placed on the driver will be as follows.

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<tbody>
<tr>
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<td>1</td>
</tr>
<tr>
<td>Moderate</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Defensive</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2: Negligence with Contributory Negligence

Under this rule, the pedestrian has excessive incentive to invest in care when the driver is driving aggressively or moderately. If the driver is driving aggressively or moderately the pedestrian can shift all liability onto the driver by being careful. Against an aggressive or moderate driver, by being careful, a pedestrian expects to reduce uncompensated accident costs by $160 or $120, respectively. Since the cost of care is less than $100 for all pedestrians, all pedestrians choose to be careful when the driver is aggressive or moderate. On the other hand, against a defensive driver, the pedestrian will

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43 This example is due to Michael Kremer "The O-Ring Theory of Economic Development", 108 QUARTERLY J. OF ECON 551 (1993)
never receive any compensation, and will thus bear all the marginal costs of carelessness and face efficient incentives. Thus only 40\% of pedestrians will be careful in response to a \textit{defensive} driver. Turning to the driver, she will face excessive incentive to drive \textit{defensively} rather than \textit{moderately}, because she can avoid all liability by driving \textit{defensively} her expected costs go down by $60. However she does not prevent all accidents by driving defensively. In fact because many pedestrians respond by lowering their level of care, the likelihood of an accident actually goes up from .03 to .032\textsuperscript{44}, although total social costs including the costs of the pedestrians care go down from $110 to $72\textsuperscript{45}. In this example, the driver faces efficient incentives in choosing between driving \textit{aggressively} and driving \textit{moderately}, because in response to either, all pedestrians will choose actions that place all liability on the driver, but one can envision circumstances in which the driver could have either excessive or insufficient incentive to choose to drive \textit{moderately} rather than \textit{aggressively}.\textsuperscript{46}

\section*{4.3 Simple Negligence}

Under simple negligence, the driver will be liable whenever she fails to meet the standard of care. In this case we somewhat arbitrarily interpret the standard of care as driving \textit{defensively}. In response to this rule all pedestrians have no incentive to provide any care against a driver who does not meet the standard of care. Note that it is precisely in cases where the driver is providing the least care when it is socially most beneficial for the driver to be careful. On the other hand when the driver does meet the standard of care by driving \textit{defensively}, pedestrians face efficient incentives, since they bear full liability. In a manner similar to the example above, drivers face excessive incentive to drive

\textsuperscript{44}0.032 = 60\% \times 0.04 + 40\% \times 0.02

\textsuperscript{45}If all pedestrians are careful the average costs of pedestrian care are $50, whereas if only the lowest cost 40\% of pedestrians are careful, the average costs of care for the careful pedestrians is $20, and since the other pedestrians do not provide care, the total expected cost of care is $8. So we compare total social costs of $0.03 \times 2000 + 50 = \$110$ with $0.032 \times 2000 + 8 = \$72$

\textsuperscript{46}If we added a type of pedestrians who would be careless regardless of the driver's action, she would not face liability when meeting these pedestrians, and would have insufficient incentives to provide care. On the other hand, if there were some pedestrians who would be careless in response to a \textit{moderate} driver, but all pedestrians would be careful in response to an \textit{aggressive} driver, the driver would have too much incentive to provide care. By driving moderately she would induce some pedestrians to be \textit{careless}, and shift the risk of accident upon themselves.
defensively rather than moderately or aggressively. In fact the incentive is even stronger in this case, because by driving moderately or aggressively the driver accepts all liability and removes any incentive for the pedestrian to take care, further increasing the likelihood of an accident. The driver's private savings in legal liability from driving defensively rather than driving moderately is $120, whereas the social savings are only 120-72 = $48.

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<td>Moderate</td>
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<td>1</td>
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<tr>
<td>Defensive</td>
<td>0</td>
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Table 3: Injurer's Share under Simple Negligence

In addition to the 2 rules considered above there are 62 other simple liability rules in which all liability falls on either one party or the other depending on the level of care. None of these rules will lead to efficiency. However, the subsection below shows that it will be possible to achieve efficiency with a special comparative negligence rule that sometimes leads to liability being shared between the pedestrian and the victim.

4.4 Optimal Comparative Negligence Rule

Here we present a rule that will always lead to efficient incentives for the pedestrian as well as leading the driver to choose the socially efficient level of care. Under this rule, unless the driver is providing the highest efficient level of care, an increase in care by one party, holding the other party's care constant, will lead to a decrease in the liability share borne by the first party. We note also that such a rule is similar to a comparative negligence rule, albeit one with a high due care standard, in that it never places any liability on a driver who chooses the highest level of care.

\[^{47}\text{To see this note that a given row, which represents the pedestrian’s liability holding the driver’s action constant, can take on 4 values: Strict liability (1,1), Perverse Liability (1,0), Contributory Negligence (0,1), or No Liability (0,0). Perverse Liability or Strict Liability both give the pedestrian insufficient incentives to provide care, and Contributory Negligence gives the pedestrian excessive incentives. Thus only a global rule of No Liability always gives the pedestrian the correct incentives. But a rule with No Liability gives no incentive to the driver to avoid accidents, and does not lead to efficiency.}\]
We will first consider the incentives that such a rule will give to the pedestrian. The following table illustrates how many dollars worth of uncompensated damage the pedestrian expects to face as a result of his level of care. Each entry is simply the probability of accident multiplied by the cost of accident times the share of the loss for which the driver is not liable that must be borne by the pedestrian.

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<tr>
<td>Defensive</td>
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<td>0</td>
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</table>

Table 4: Efficient Comparative Negligence Rule

When the driver is aggressive the pedestrian will cross carefully unless $z > 80$. Likewise if the driver drives moderately defensively, the pedestrian will be careless only if $z > 60$ or $z > 40$, respectively. Note that whether the driver drives aggressively, moderately, or carefully, the pedestrian will choose the socially efficient level of care. This is because for every level of care by the driver, the difference in expected liability for the pedestrian is equal to the expected difference in accident costs to society. Another way of seeing this is to look at the expected liability faced by the driver, shown in table 6. This is just the likelihood of accident multiplied by the damage multiplied by the share of liability borne by the driver.

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<td>30</td>
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<tr>
<td>Defensive</td>
<td>80</td>
<td>40</td>
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</table>

Table 5: Pedestrian's Expected Uncompensated Loss

Note that regardless of how she drives, the driver will be indifferent to the pedestrian's choice of care. Since there are only two participants in the model, this
implies there is no externality from the pedestrian's action, and the pedestrian must internalizes all the effects of his action.

We now look at the choice of care by the driver and see if it will be efficient. When the driver chooses care first, so the pedestrian observes this choice before crossing, the choice has two effects. In addition to the direct effect on the likelihood of accident, there is an indirect effect on the pedestrian's precaution costs. For example when the driver reduces her care and is merely moderate rather than defensive, 20% of pedestrians will change their behavior from careful to careless. These pedestrians have precaution costs \((z)\) between 40 and 60 with an average of 50. So the expected increase in precaution cost is $10. Meanwhile, the probability of accident goes from \(0.4 \times 0.02 + 0.6 \times 0.04\) to \(0.6 \times 0.03 + 0.4 \times 0.06\), or from 0.032 to 0.042, leading to an increase in direct accident costs of $20, thus the total increase in social cost is $30. Likewise when the driver decreases her level of care from moderate to aggressive, this leads to an increase in expected precaution cost for the pedestrian from $18 to $32, and leads to an increase in the probability of accident from 0.042 to 0.048 leading to a total increase in social costs of $26. Note that when the driver changes her driving from moderate to defensive, she sees a difference in liability of $30, exactly the difference in social costs. Likewise the difference in liability when she changes from careless to aware will be $26, again equal to the difference in social cost. Because the driver internalizes the effect of her level of care on society, her incentives are efficient, and she will choose the socially efficient level of care.

Another way of seeing this is to note that the average pedestrian is indifferent to the driver's level of care. Since the pedestrian is the only other participant in the model, the driver must be internalizing all of the effects of her choice.

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<tbody>
<tr>
<td>Average Pedestrian's Cost of Care</td>
<td>32</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>Average Pedestrian's Uncompensated Loss</td>
<td>40</td>
<td>54</td>
<td>64</td>
</tr>
<tr>
<td>Total Expected Cost to Pedestrian</td>
<td>72</td>
<td>72</td>
<td>72</td>
</tr>
</tbody>
</table>

Table 7: Expected Costs for Average Pedestrian
Thus the comparative negligence rule above achieves *ex-ante* first best, providing efficient incentives to both the pedestrian and the driver. It is worth noting that in this sequential model we do not need to know anything about the driver's cost of care to find an efficient rule. We do however need some information about the expected cost of care for the pedestrian. This is because the social cost of the driver's action depends on both what level of care the pedestrian chooses and how much it costs the pedestrian to respond to the driver's decision by changing his level of care.

The comparative negligence rule above is not the only efficient rule; one can construct a rule that will provide efficient incentives, but will always lead to some liability for the driver and hence be more favorable to the pedestrian. We present one such rule below, and demonstrate that it will provide efficient incentives to the pedestrian by presenting the matrix of the pedestrian's expected liability. We leave it to the reader to confirm that it will also lead to efficient incentives for the driver.

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Table 8: Alternate Efficient Comparative Negligence Rule

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<td>6</td>
</tr>
<tr>
<td>Defensive</td>
<td>56</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 9: Pedestrian's Expected Uncompensated Loss

There are a number of other rules that will be equally efficient; the rules shown are the most favorable to the driver and to the pedestrian respectively. Any other rule that is always efficient will provide for a liability split that is intermediate between the two shown for every element of the matrix.

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48 *Ex-ante* first best is the best any rule can do given the informational assumptions. This rule will not achieve *ex-post* first best, but it is not possible for any rule to achieve *ex-post* first best unless there is some way of conditioning the driver's choice of care on the pedestrian's unobservable idiosyncratic costs.
The reader may now be asking how one can find or construct an efficient comparative negligence rules. Section 5 develops a more general model where each agent chooses a level of care from a range of possible values and shows how it is possible to find an efficient comparative negligence rule. Our guiding principle when choosing these rules is to make sure that when an agent chooses a lower level of care the rule gives marginal liability to the agent that is equal to the expected marginal accident and precaution costs caused by the lower level of care. A liability rule that places a fixed share of liability on each party will give insufficient incentives to both parties, because neither party will bear the entire cost of the accident. In our example, if the driver is aggressive, additional care (being careful rather than careless) by the pedestrian is socially efficient to provide if it costs him less than $80. Suppose the pedestrian always bore 65% of the cost of the accident, he would provide the additional care only if it cost him less than $52 ($80 × .65) to do so. Thus a rule that shares liability according to a fixed rule will lead the agents to provide insufficient care. An efficient comparative negligence rule will decrease an agent's share of liability when they increase their care precisely enough so that the agent's private saving from being careful is exactly equal to the expected social savings in accident costs. As an example consider the efficient rule from section 4.4. According to this rule, the pedestrian's uncompensated share of damages drops from 65% to 30%, if he crosses carefully rather than carelessly when the driver is aggressive. Therefore in the 4% of cases where there is an accident even though the pedestrian is careful, his expected loss is decreased from $1300 to $600 because he bears a smaller share of the costs; this leads to an expected savings of $28 (.04 × $700). His total savings from being careful are now $80, consisting of the $52 he saves from avoiding accidents, and $28 from increased compensation if there is an accident. In other words the change in the share of liability must be calibrated to exactly compensate for the fact that neither party bears full responsibility. Of course if the injurer chooses an action such that the victim bears full liability (for example drives defensively under the rule in section 4.4), the victim faces the proper incentives and it is not necessary to adjust his liability share based on his actions.

Determining how the liability depends on the injurer's action follows the same principal, but must take into account the fact that the victim adjusts his care in response
to the injurer's action. In many situations, we would expect it is efficient for the victim to increase his care in response to a decrease in care by the victim. Thus the injurer must be penalized for the expected cost of the increase in care by the victim as well as for the increase in probability of accident.

4.5 Simultaneous Actions

Just as in the example with sequential action above, it is possible to construct an efficient comparative negligence rule with simultaneous actions. If the pedestrian chooses his level of care before he sees the driver's care he must now base his level of care on the action he believes the driver will take, so the beliefs of the pedestrian become important. To rationally form beliefs of how the driver will react to different legal rules, we will assume that the pedestrian knows how drivers vary in their costs of care. We assume that there are three types of driver, ½ of drivers are busy, ¼ are employed and ¼ are leisured. Further we assume that the precaution costs of driving moderately are $40, $20 and $10 for the three types of drivers respectively, and the precaution costs of driving defensively are $150, $50, and $30. We assume that there are no precaution costs associated with driving aggressively for any drivers.

We note that if ¼ of drivers drive aggressively, ½ drive moderately and ¼ drive defensively on average when the pedestrian is careful rather than careless he will reduce the accident costs by $60. Therefore, in this case, 60% of pedestrians (i.e those with $z < 60$) should be careful. When 60% of pedestrians are being careful, a driver can reduce accident cost by $28 by driving moderately rather than aggressively, or $56 by driving defensively rather than aggressively. Thus it is efficient for busy drivers to drive aggressively, for the employed drivers to drive moderately and the leisured drivers to drive defensively.
### 4.6 Negligence with Contributory Negligence

If the standard of care for the driver is to drive *moderately* while the standard for the pedestrian is to be *careful*, under negligence with contributory negligence, the liability split will be as follows.

<table>
<thead>
<tr>
<th></th>
<th>Careless</th>
<th>Careful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggressive</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Moderate</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Defensive</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 10: Negligence with Contributory Negligence

Here the pedestrian will have too much incentive to be *careful* when the driver drives *aggressively*, because he can shift all liability onto the driver by doing so. On the other hand, if the driver drives *normally* or *defensively*, the pedestrian bears full liability regardless of his actions and thus faces efficient incentive. Since the pedestrian does not know which action the driver will take on balance he will supply too much care. Turning to the driver, she has no incentive to drive *defensively* rather than *moderately*, since she faces no liability once she drives *moderately*. On the other hand the direction of her distortion regarding the choice between driving *aggressively* and driving *moderately* is ambiguous. If the driver expects that the pedestrian will be *careful*, she has excessive incentive to drive *moderately*, since she can shift all liability onto the pedestrian by doing so, and her expected liability goes down by $80, even though she only reduces expected accident costs by $20. On the other hand, if the driver expects the pedestrian to be *careless*, she will face no liability in either case, and thus has no incentive to provide care. Note that under this rule the driver's incentive to provide care is decreasing as the percentage of *careless* pedestrians increases, while the social value of the driver's care is increasing in the number of *careless* pedestrians. As long as at least 50% of pedestrians are expected to be *careful*, even *busy* drivers will find it advantageous to drive *moderately*. This equilibrium illustrates the `one size fits all' nature of negligence standards. Even though it is efficient for the three types of driver to drive differently, in equilibrium, all drivers end up driving *moderately*. 

4.7 Efficient Comparative Negligence with Simultaneous Action

It is necessary to slightly modify the comparative negligence rule to provide for efficient incentives when action is sequential. The efficient rule with simultaneous actions differs slightly from the efficient rule with sequential actions because the effects of a change in care are slightly different. Specifically, in the simultaneous model, the pedestrian has no opportunity to adjust his care in response to the driver's care. Furthermore, because the pedestrian chooses care before he sees the driver's care, the pedestrian's baseline level of care may be less appropriate for the driver's action, and this will affect the impact of a change in the driver's action.

<table>
<thead>
<tr>
<th></th>
<th>Careless</th>
<th>Careful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggressive</td>
<td>.35</td>
<td>.7</td>
</tr>
<tr>
<td>Moderate</td>
<td>.23333</td>
<td>.46666</td>
</tr>
<tr>
<td>Defensive</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 11: Efficient Comparative Negligence

Looking at the expected loss for the pedestrian, we see that under this rule the pedestrian has the efficient incentive to be careful conditional on any action by the driver, so if the pedestrian correctly anticipates the driver's actions, the pedestrian will behave efficiently.

<table>
<thead>
<tr>
<th></th>
<th>Careless</th>
<th>Careful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggressive</td>
<td>104</td>
<td>24</td>
</tr>
<tr>
<td>Moderate</td>
<td>92</td>
<td>32</td>
</tr>
<tr>
<td>Defensive</td>
<td>80</td>
<td>40</td>
</tr>
</tbody>
</table>

Table 12: Pedestrian's Expected Uncompensated Loss

Turning our attention to the driver, in the simultaneous model, the pedestrian cannot alter his care in response to a change in the driver's care, so the effect of a change in the driver's care is limited to the change in expected damage from accidents, and it is easy to confirm the driver's incentives are efficient.
### Table 13: Impact of Driver's Action

<table>
<thead>
<tr>
<th></th>
<th>Aggressive</th>
<th>Moderate</th>
<th>Defensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Pedestrian's Cost of Care</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Average Pedestrian's Uncompensated Loss</td>
<td>56 $(.4 \times 104 + .6 \times 24)$</td>
<td>56 $(.4 \times 92 + .6 \times 32)$</td>
<td>56 $.4 \times 80 + .6 \times 40$</td>
</tr>
<tr>
<td>Total Expected Cost to Pedestrian</td>
<td>74</td>
<td>74</td>
<td>74</td>
</tr>
</tbody>
</table>

4.8 Last Clear Chance Rule

Scenarios in which the victim acts first present special problems under a contributory negligence rule. In cases where the injurer's care is a substitute for the victim's, a contributory negligence rule gives an injurer no incentive to provide care at precisely the times when her care is most important. This has been recognized by the common law since *Davies v. Mann*. However, the common law response, the last clear chance rule, presents problems of its own. We now consider our example from above with the modification that the pedestrian chooses care first, and the driver then chooses how to drive.

We begin by looking at a last clear chance rule, which recognizes that the driver is able to observe when the pedestrian is not careful. We assume that the court sets its due care standard according to what is efficient for the average (in this case *employed*) driver. If the average driver observes that the pedestrian is careless she can reduce accident damage by $40 by driving defensively rather than moderately at a marginal cost of $30, so if the pedestrian is careless, the last clear chance rule will place liability on the driver unless she drives defensively. On the other hand if the pedestrian is careful, it is equally efficient for the employed driver to drive moderately or aggressively. We note that in this case, the efficiency loss when the busy drivers drive moderately is greater than the efficiency loss when the leisured drivers drive aggressively, so we suppose that the law recognizes driving aggressively is meeting the standard of care. The driver's share of liability under the last clear chance rule is shown below. Note that under this rule a decrease in the pedestrian's care leads to an increase in the driver's standard of care.

---

49 152 Eng. Rep. 588 (1842)
If the pedestrian is careless, the driver can save $120 by driving defensively rather than moderately (and $160 by driving defensively rather than aggressively). When the pedestrian is careful, the driver saves nothing by driving defensively or moderately rather than aggressively. Therefore all drivers will drive defensively when faced with a pedestrian who is careful, but all drivers will drive aggressively when faced with a careless pedestrian. Intuitively, because we are setting the standard of care according to the behavior that is socially optimal for the average driver, in some cases we are causing the drivers with high costs of care to take excess care, and in other cases drivers with low costs of care will not take enough care. The incentives given to the pedestrian with a last clear chance rule are even more problematic. Under this rule, the pedestrians have no incentive to be careful. If they are careful, all drivers will drive aggressively and they will be hit .04 of the time, and will receive no compensation. On the other hand if they are careless then drivers will drive defensively and victims will be hit with the same .04 probability. In essence, the last clear chance rule forces injurers to substitute their own care for care not provided by the victims. Recognizing this, the victims will provide less care than socially efficient.

### 4.9 Efficient Comparative Last Clear Chance Rule

If we are not restricted to placing the entire liability on only one of the agents, it is possible to construct a rule which provides for efficient incentives in a last clear chance type scenario. We can construct a liability rule in which each party's share of liability is decreasing in that party's care as in the example above.
<table>
<thead>
<tr>
<th></th>
<th>Careless</th>
<th>Careful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggressive</td>
<td>.5</td>
<td>.7</td>
</tr>
<tr>
<td>Moderate</td>
<td>.3333</td>
<td>.6</td>
</tr>
<tr>
<td>Defensive</td>
<td>0</td>
<td>.4</td>
</tr>
</tbody>
</table>

Table 15: Efficient Comparative Last Clear Chance Rule

First, looking at the driver, we can see that in response to a careless pedestrian, she can reduce her expected liability by $40 by driving moderately rather than aggressively and can save a further $40 by driving defensively rather than aggressively. When the pedestrian is careful the driver can reduce her liability by $20 for each step she increases her care. Thus the driver faces efficient incentives.

Turning to the pedestrian, when he crosses carefully and all drivers respond efficiently, busy and employed drivers are aggressive, and leisured drivers drive moderately. Given the distribution of drivers, the total expected accident costs are $75 and expected costs of care by the driver are $2.50. When the pedestrian crosses carelessly the busy driver drives moderately, while the employed and leisured drivers drive defensively. The total expected accident costs are $90, and the expected cost of driver's care is $43.5. Thus the social cost of crossing carelessly rather than carefully is $56. We note that regardless of the driver's action, the pedestrian expects $80 worth of uncompensated losses if he crosses carelessly and $24 in uncompensated losses if he is careful. The rule that is efficient when the injurer has the last clear chance is qualitatively similar to the efficient rule when the injurer acts first. The principle difference is that when the injurer acts first (or both parties act simultaneously) it is possible to write an efficient rule where the injurer is able to avoid all liability by choosing a high level of care. When the victim acts first, and does not choose a low level of care, an efficient rule will place at least some share of liability on the injurer, even when the injurer chooses the highest level of care. The reason for this has to do with how efficient rules must be constructed, and is explored in more detail in Section 5. We now turn to another rationale for a comparative negligence rule, incentives under stochastic care.
Section 5: Stochastic Care Example

The first generation of economic models of tort law suggested that many of the standard laws would lead to efficient behavior by both victims and injurers, but inherent in this result was the unfortunate prediction that if the laws were set optimally, no rational agents would ever be negligent. As asserted by Mark Grady “Economists commit negligence several times on the way to work, but once at their desks they continue to imagine that negligent behavior is exceptional.”50 As shown above, one explanation for why rational agents may sometimes be negligent is that the negligence standard may be set for an average agent with an average cost of precaution. If an agent faces a particularly high cost of precaution, she may choose to be negligent even though she exposes herself to full liability for any accident that occurs.

This section considers the implications of another explanation, namely that agents may not always be able to precisely choose their actual level of care and might sometimes be inadvertently negligent. For example, a driver may negligently fail to stop at a red light because she was momentarily distracted or lost in thought rather than because she made a calculated decision to run the light. Of course an agent could have some influence on the likelihood that she is accidentally negligent. Specifically, an agent can expend resources on attention to increase the likelihood that she exercises due care. In this example we distinguish between precaution and care by assuming that precaution is a state of mind and is not observable by the court, whereas care is the result of precaution and is observable by the courts. For example, somebody who intends to be cautious may inadvertently wander into a busy street. Because the courts cannot observe this person's intention, they must base their assessment of this agent's liability on the fact that he wandered into a busy street; they must base his liability on his actual care, rather than attempting to discern how hard he was trying to be careful.

The efficiency of the traditional negligence rules relies on an assumption that agents can accurately chose a level of care and can always avoid unintentional negligence. We use the following examples to show how traditional rules fail to provide efficient incentives in a case of stochastic care where even agents who intend to be

50 "Multiple Tortfeasors and the Economy of Prevention", 19 J. LEGAL STUD. 653
careful may be negligent. Furthermore, we show that in this scenario a properly constructed comparative negligence rule can lead to efficient investments in precaution. Again, we consider an interaction between a driver and pedestrian, but now we assume neither can choose their level of care precisely. Suppose that if the pedestrian spends $\chi$ on precaution, we assume there is a \( \frac{3\chi}{160} - \frac{5\chi^2}{64000} \) chance that he walks smoothly and a \( 1.125 - \frac{3\chi}{160} + \frac{5\chi^2}{64000} \) chance that he stumbles. Likewise assume that if the driver spends $\xi$ on precaution there is a \( \frac{1.8 \times \xi}{100} - \frac{\xi^2}{10000} \) chance she drives slow and a \( 1 - \frac{1.8 \times \xi}{100} + \frac{\xi^2}{10000} \) chance she drives fast. We assume that the court cannot observe or condition liability on how much the pedestrian (or driver) spends on precaution, the court can only observe whether he walks smoothly or stumbles (or whether she drives slow or fast).

Assume that the likelihood of accident conditional on care shown is given in the table below, and that an accident causes $2000 in damage as before.

<table>
<thead>
<tr>
<th></th>
<th>Stumble</th>
<th>Walk Smoothly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>.16</td>
<td>.08</td>
</tr>
<tr>
<td>Slow</td>
<td>.08</td>
<td>.04</td>
</tr>
</tbody>
</table>

Table 16: Probability of Accident

Examining the first order conditions for the pedestrian, we see that it is socially efficient for the pedestrian to choose expenditure on attention $\chi = 80$ when the driver is fast and $\chi = 40$ when the driver is slow. As a result if the driver is fast, under the efficient outcome the pedestrian will walk smoothly with probability 0.875 and stumble with probability 0.125. If the driver is slow, under the efficient outcome the pedestrian will walk smoothly with probability 0.5 and stumble with probability 0.5. The expected social cost of accident plus the cost of the pedestrian's precaution when the driver is fast is given by \( 80 + .125 \times 320 + .875 \times 160 = 260 \), and when the driver is slow

\[ \text{We can assume that if the pedestrian spends less than $7 on precaution, he stumbles with probability 1.} \]
the sum of the costs is $40 + .5 \times 160 + .5 \times 80 = 160$. Thus the driver reduces expected social costs from $260$ to $160$ when she drives slow. Taking first order conditions\textsuperscript{52} we see that it will be efficient for the driver to spend $\xi = 40$ on precaution, implying that she will drive slow with probability 56\%.\textsuperscript{53}

5.1 Negligence standards with stochastic care

The introduction of stochastic care inherently introduces some difficulties into the problem of establishing a reasonable level of care. Negligence is traditionally defined as failure to exercise the level of care that a reasonably prudent person would do in the same situation. In the Law and Economics literature this is taken to imply that negligence is simply a failure to provide the socially efficient level of care. However, when care is stochastic, the agents do not directly choose their level of care and the traditional rule becomes muddled. Under models of stochastic care, a person who is making a reasonable investment in precaution might sometimes exercise any level of care, including very low levels. Using the Law and Economics definition of reasonable care is also problematic, care is the outcome of a random process; how can we determine which outcomes of a random process are efficient? One somewhat ad-hoc solution would be to set the standard of care at the median level of care actually provided by an agent who makes the efficient investment in care. In the example we are currently considering, if the driver is making a first best efficient investment in precaution she will drive slow with probability 0.56, so we might set the standard of due care as driving slow. We note that even a driver who is making efficient investments in precaution will fail to meet the standard of due care over 40\% of the time.

5.2 Simple Negligence

Under simple negligence, the driver will be liable whenever she fails to meet the standard of care, interpreted as driving slow in this case.

\[ \frac{180}{100} \times \frac{25}{10000} - 1 = 0 \]

\[ \frac{72}{100} \times \frac{1600}{10000} = 0.56 \]
Table 17: Driver's Liability under Simple Negligence

<table>
<thead>
<tr>
<th></th>
<th>Stumble</th>
<th>Walk Smoothly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Slow</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

With this liability rule, when the pedestrian sees that the driver is fast, he knows that the driver will have to compensate him for any accident that occurs and he has no incentive to invest in precaution. On the other hand when the driver is slow, the pedestrian has efficient incentives to invest, because he will not be compensated for any harm that befalls him.

The driver has socially excessive incentive to invest in precaution. The private benefit to the driver of driving slow is greater than the social benefit, because when she drives fast she has full liability for accidents, but when she drives slow she is able to avoid all liability for accidents. This is exacerbated by the fact that the driver knows the pedestrian will have no incentive to provide care if she drives fast. In this example the pedestrian will invest $\chi = 0$ and stumble for sure when faced with a fast driver and invest $\chi = 40$ and cross smoothly with probability .5 when faced with a slow driver. As a result the driver expects liability of $320$ if she drives fast and $120$ if she drives slow. As a result she will invest $\xi = 65$ in precaution and reduce her probability of driving fast to 25.25%.

5.3 Negligence with Contributory Negligence

A rule of negligence with contributory negligence places all liability on the pedestrian unless the driver was negligent and the pedestrian met the standard of care. Here we are assuming that the pedestrian meets the standard of care only if he walks smoothly and that driving slow is the standard for the driver. The liability share faced by the driver is given in table 18.

Table 18: Driver's Liability under Negligence with Contributory Negligence

<table>
<thead>
<tr>
<th></th>
<th>Stumble</th>
<th>Walk Smoothly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Slow</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
In this case when the driver goes *fast* the pedestrian has excessive incentive to invest in precaution, since the pedestrian can shift all accident costs onto the driver by *walking smoothly*. However when the driver is *slow*, the pedestrian knows he will bear all accident costs regardless of his level of care or investment in precaution, thus he has efficient incentive to invest. The direction of the distortion of the driver's effort becomes ambiguous. To the degree she expects the pedestrian to *stumble* when she drives *fast*, she has an incentive to under-invest, since she will bear no liability, but to the degree she expects the pedestrian to *walk smoothly*, she has an incentive to over invest, so as to shift liability onto the pedestrian. With the parameters presented in this model, when she drives *slow*, she bears no liability, when she drives *fast*, the pedestrian will invest $\xi = 100$ in care and will *walk smoothly* with probability .9675. We can see that the driver expects to save $155$ by driving *slow*, whereas the social savings from driving *slow* are only $105$, so in our example the driver has excessive incentive to invest in precaution.

### 5.4 An Efficient Comparative Negligence Rule

Without exhaustively considering all of the possible rules, we see that simple liability rules introduce similar inefficiencies regardless of whether we are considering a model with privately observed precaution costs or a model of stochastic care. As in the case with privately observed precaution costs, a properly constructed comparative negligence can induce efficient behavior in the stochastic care example. Because the parameters in this example are slightly different, the rule will be slightly different. Nevertheless, as shown later in the paper, the method of constructing the rule is similar and it is possible to construct a general rule that will be efficient with both stochastic care and privately observed precaution costs.

---

54 The driver faces no liability if she drives *slow*, and liability of $160 \times .9675 = 155$ if she drives *fast*. When she drives *fast* this increases the expenditure on precaution by the pedestrian by 60, it also increases accident costs from $.5 \times 80 + .5 \times 160$ to $0.0325 \times 320 + .9675 \times 160$, an increase of 45, so the total marginal social cost is $105$.
Table 19: Efficient Comparative Negligence Rule with Stochastic Actions

<table>
<thead>
<tr>
<th></th>
<th>Stumble</th>
<th>Walk Smoothly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>.3125</td>
<td>.65</td>
</tr>
<tr>
<td>Slow</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 20 below illustrates how much liability the driver and pedestrian expect to face as a result of their level of care. The first number in each cell represents the pedestrian's liability and the second represents the driver's. As before, each entry is simply the probability of accident multiplied by the cost of accident times the driver's share of liability. Note that regardless of whether the driver is fast or slow, the marginal liability the pedestrian faces when he stumbles is equal to the increase in expected accident damages. Thus the driver is indifferent as to what level of care is provided by the pedestrian.

<table>
<thead>
<tr>
<th></th>
<th>Stumble</th>
<th>Walk Smoothly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>220, 100</td>
<td>60, 100</td>
</tr>
<tr>
<td>Slow</td>
<td>160, 0</td>
<td>80, 0</td>
</tr>
</tbody>
</table>

Table 20: Pedestrian and Driver's Expected Liability under Efficient Comparative Negligence

<table>
<thead>
<tr>
<th>Pedestrian's Precaution Costs</th>
<th>Pedestrian's Uncompensated Loss</th>
<th>Pedestrian's Total</th>
<th>Driver's Liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>80</td>
<td>160</td>
<td>100</td>
</tr>
<tr>
<td>Slow</td>
<td>40</td>
<td>160</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 21: Impact of Driver's Action with Stochastic Care

We now look at the driver's investment in precaution and see if it will be efficient. Our first clue that it will be efficient is that we see that the pedestrian will face the same expected costs whether the driver is fast or slow. When the driver is fast the pedestrian increases his investment in precaution from 40 to 80 but he recovers much more when there is an accident, and ends up just as well off. Note that since the driver is indifferent about the pedestrian's realized level of care, she is also indifferent as to the pedestrian's
investment in precaution, since this investment affects only the pedestrian's level of care. Since there are only two agents in the model, if the pedestrian is indifferent to the driver's care, this implies the driver faces efficient incentives. We confirm this by noting that regardless of the pedestrian's action the driver will face an increase in uncompensated accident losses of $100 when her driving is fast rather than slow. This difference is exactly equal to the increase in social costs. Since her savings from increased care are equal to society's savings, she has efficient incentives to invest in precaution.

Regardless of whether there is a stochastic element to care, or agents have private information about their costs, or both, if we can write a liability sharing rule such that each agent is on average indifferent to the other agent's choice of care or precaution, we can give both agents efficient incentives and achieve first best. In the following section we show precisely how we can derive these rules. At this point it should be noted that it will not always be possible to construct a first best efficient rule if we require the injurer's share of liability to be between 0 and 1. In other words, if we refuse to allow punitive damages or payments from the victim to the injurer we may not always be able to achieve efficiency. Specifically, if the injurer is able to be very careful so accidents are unlikely, and the defendant is able to be very careless, there can be situations where an optimal rule would require that either the injurer would sometimes face negative liability or would face a liability share above one. A more precise consideration of when the liability share must be greater than one or less than zero is given in the appendix.

Section 6: Constructing the Efficient Comparative Negligence Rule

As shown above, rules which never require the two parties to share liability for an accident will generally not be efficient when parties have private information, or when they cannot choose care perfectly. Comparative negligence rules can however give the parties efficient incentives in those circumstances. This section provides an explanation of how to construct an efficient comparative negligence rule as well as an intuitive argument for why such a rule will be efficient. The following section will more rigorously define a model, and give a formal proof that the rule provides efficient incentives.
Unlike the standard model, where agents have private information or can't choose care perfectly, even when agents are acting efficiently they will end up providing different levels of care. The key to constructing an efficient comparative negligence rule is to construct a rule where each agent completely internalizes the impact of the level of care that they provide. When the agents act simultaneously, or the injurer acts first, and then the victim acts subsequently an efficient rule can be constructed as follows. For any arbitrary level of care by the injurer, we begin by choosing a baseline level of care by the victim, for convenience we can call this level of care \( \bar{y} \), and set it at the highest level of care that it ever makes sense for the victim to provide. If we hold the injurer's care fixed it is easy to determine how the injurer's share of liability must vary with the victim's level of care. If the victim is internalizing all of the effects of his care or carelessness, the injurer should be indifferent to the victim's level of care. The expected liability of the injurer is simply the likelihood of accident multiplied by the damage from an accident, multiplied by the injurer's share of liability.

The way to make the injurer indifferent is to ensure that the injurer's share of liability varies with the victim's care in inverse proportion to the likelihood of accident. That is to say if the victim acts carelessly and doubles the likelihood of accident relative to the baseline, the injurer's share of liability must be reduced by half relative to the starting value for the injurer's level of care. This way the injurer is compensated for the increased likelihood of accident by the lower liability should there be an accident, and her expected liability will not depend on the victim's level of care. We refer to the principle that the injurer's liability share varies with victim's care in inverse proportion to the likelihood of accident as the victim's rule.

The effect of the `victim's rule' is illustrated in Figure 2, the injurer's share of liability (dotted line) increases with the victim's care, while the expected damage (short dashes) decreases. Thus the injurer's expected liability (long dashes) is held constant. Note that the victim's expected uncompensated damage decreases in parallel with total damage, implying that the on the margin the victim internalizes the consequences of his action.

\[ L(x,y') = \frac{f(x,y)}{f(x,y')} \frac{L(x,y)}{L(x,y')}. \]

\[ ^{55} \text{Formally if } f(x,y) \text{ is the likelihood of accident when the injurer supplies care } x \text{ and the victim supplies care } y, \text{ and the liability share is given by } L(x,y), \text{ the victim's rule can be stated as the equality:} \]

44
Determining how the liability share must vary with the injurer's actions is somewhat more difficult. A change in the injurer's level of care will affect different types of victims differently. For example, potential victims with low costs of care may be already be supplying a high level of care, so the likelihood of an accident may not increase substantially for them when the injurer is careless. On the other hand victims with a high cost of care may be relying upon the injurer to supply care, and for them a lack of care by the injurer might lead to a greatly increased likelihood of accident. Furthermore, in cases where the victim acts after the injurer, victims may differ in their ability to supply care to make up for the injurer's carelessness.

The first step in constructing the efficient comparative rule for the injurer is determining the average impact of a given degree of carelessness by the injurer. In cases where the victim acts before he knows the action of the injurer, this is just the expected increase in the probability of accident multiplied by the damage if there is an accident,
that is to say the expected increase in probability of accident for the average victim. In cases where the victim sees the injurer's action and has a chance to react, the efficient rule must take into account the cost of any change in care supplied by the victim. Suppose that care by the victim and injurer are substitutes, the victim might react to a lack of care by injurer by supplying more care himself. In this case, the most important social cost of the injurer's lack of care might be the fact that the victim had to supply more care, rather than in increased likelihood of accident. Thus a computation of the social cost of the injurer's lack of care must also take into account the cost of increased care supplied by the victim.\textsuperscript{56}

Once the social cost of the lack of care by the injurer is determined, the next step is determining how the injurer's share of liability must vary so that the injurer expects to bear this cost. This might appear difficult, but it is made much simpler by the fact that under the victim's rule the liability share varies with the victim's care in a way that keeps the injurer indifferent as to the victim's action. Thus, for the purpose of figuring out how much liability the injurer expects to face, it does not matter what level of care we assume the victim takes, so we can arbitrarily assume that the victim takes the baseline level of care.\textsuperscript{57} It is now simply a matter of determining what share of liability leads to the correct expected total liability for the injurer. For example, suppose that when the injurer chooses level of care $\hat{x}$ she faces no liability, and that when she chooses a lower level of care called $x'$, this leads to an increase in expected social costs of $50. Furthermore suppose that when the injurer chooses $x'$ and the victim choose $-y$, the likelihood of an accident that causes $2000$ worth of damage is $5\%$. In order to make the injurer internalize the cost of her carelessness, she must bear liability for half of the damage if she chooses $x'$ and the victim chooses $\hat{y}$. Note that if this is the case, and instead of choosing $\hat{y}$, the victim actually chose $y'$, which led to a $10\%$ likelihood of accident, according to the victim's

\textsuperscript{56} Formally let us use $k$ to refer to the type of the victim, so that $c_{V}(y,k)$ is the cost to a victim of type $k$ of supplying care $y$, and let $y^{*}(x,k)$ be the efficient level of care for a victim of type $k$ in response to care $x$ by the injurer. We could define a function \( C(x) = E_{k} f(x,y^{*}(x,k)) \times D + E_{k} c_{V}(y^{*}(x,k)) \). Here \( C(x) \) would be the total expected external cost and would consist of the expected damage from accidents \( E_{k} f(x,y^{*}(x,k)) \times D \) plus the expected cost of victim's care \( E_{k} c_{V}(y^{*}(x,k)) \).

\textsuperscript{57} Note that for the purposes of determining the social cost of the victim's carelessness, the victim's level of care is important, and to achieve efficiency, the rulemaker must be able to know on average, what level of care victims are likely to take.
rule, the injurer's share would be reduced by half, so the injurer would bear liability only for one quarter of the cost of accident, and her expected liability would still be $50.\textsuperscript{58}

Figure 3 shows how the injurer's liability share and expected liability varies with care. In this example the care of the injurer and the victim are substitutes, as care by the injurer increases, the victim decreases his care in response. As result, the savings to society are greater than the decrease in expected damage from accidents, and the injurer's expected liability decreases faster than the expected damage from accident. Note that the sum of the victim's expected liability and the expected cost of care supplied by the victim remains constant.

The last step is to choose a specific liability share and set of care levels as a starting point. The rule proposed in this paper sets the injurer's starting share of liability

\textsuperscript{58} More generally, the condition is \( L(x',y) \times f(x',y) - L(x,y) \times f(x,y) = C(x') - C(x) \). Solving we have

\[ L(x',y) = L(x,y) \frac{f(x,y)}{f(x',y)} + \frac{C(x') - C(x)}{f(x',y) \times D} \]
at zero when the victim chooses the lowest level of care and she chooses the highest level of care that is ever efficient, that is to say the level of care that should be supplied by the lowest cost injurer. Essentially we are setting the due care standard for the injurer at this highest level of care. Note that when the injurer chooses this level of care, the victim bears full liability, and the injurer's share of liability need not vary with the victim's level of care to provide the victim efficient incentives. This in this case the choice of the victim's starting level of care was not important.\textsuperscript{59} It would also possible to construct an efficient rule with a different starting liability split. For example, rather than starting by assigning no liability to the injurer when she uses the highest efficient level of care it would be possible to start by assigning full liability to the injurer when she uses to the lowest efficient level of care and the victim uses the highest efficient level of care. The use of a different starting point would not affect the agents' efficient incentives to choose the level of care, but it would have distributional consequences, and would affect the agents' incentives to efficiently choose activity levels.

Although the injurer will never care what level of care the victim uses, some victims will be affected by the injurer's level of care. In particular, when care by the victim is a substitute for care by the injurer, victims with high costs of care will prefer the injurer to present higher care, while victims with low cost of care will prefer injurers to supply less care. Because the injurer's expected liability does not depend on the victim's action or type, the injurer expects to pay the average expected social cost of his action regardless of the type or action of the victim. However, when the injurer's care is a substitute, the social cost of the injurer's lack of care will be lower when the victim supplies more care. Low cost victims will tend to supply more care, and likewise be able to more cheaply adjust their care to make up for a lack of care by the injurer. As a result the actual expected social cost of a lack of care by the injurer will be lower when the victim can supply care at low cost. Since the increase in the injurer's expected payment is equal to the average expected social cost, it will be greater than the actual expected social cost. If the injurer's expected payment is increased by more than the social cost of her action, in expectation the victim gets to keep the difference and will be better off. Of

\textsuperscript{59} This is consistent with the victim's rule, which simply determines the injurers' share which multiplies the injurer's baseline share, namely zero, by an adjustment for the victim's action.
course if the victim has a very high cost of providing care, the impact of the injurer's carelessness will be greater than average, and the injurer will not fully compensate the victim in expectation, so the victim will be worse off. Figures 4 and 5 illustrate the differential effect of injurer's care on victim's of different type. Figure 4 shows the cost of victim's care along with the expected accident damage, injurer's liability and victim's liability as a function of the injurer's care when the victim can provide care cheaply. Here the injurer's liability decreases more quickly than the sum of expected accident damage and cost of victim's care, so the victim is made worse off. In contrast in Figure 5, the expected accident damage decreases more when the injurer supplies more care, and the high cost victim is better off when the injurer supplies more care.

Unlike with the traditional simple rules, this general method of constructing an efficient comparative negligence rule works regardless of whether or not the parties can choose their levels of care perfectly. Traditional negligence rules typically have a discontinuity, and provide strong incentives for the agent to end up on one side of that discontinuity. Furthermore, under the traditional rule, typically one agent faces efficient incentives primarily because they think the other agent will take a particular action. For example, under negligence with a defense of contributory negligence, an injurer has incentive to provide due care because she believes she will be liable for any accident if she does not, this belief depends on the belief that the victim will also provide due care. However if she believes the victim is unlikely to provide due care, she has less incentive to ensure that she meets the standard.\(^60\)

\(^60\) For a general discussion about how incentives under liability rules are sensitive to assumptions about the other party's actions, see Chapter 2 of DOUGLAS BAIRD, ROBERT GERTNER, & RANDAL PICKER, GAME THEORY AND THE LAW (1994). Rather than simply examining how agents act under various rules in a Nash Equilibrium, Baird, Gertner, and Picker focus on which rules can achieve efficiency as a dominant strategy. (A dominant strategy is a strategy that an agent prefers to all other strategies regardless of her beliefs about how the other agent is likely to act. A Nash Equilibrium merely requires that each agent's strategy is a best response to the other agent's actual strategy) They find that when comparative negligence rules are very 'skewed' so that one party tends to bear the bulk of liability unless both parties are equally negligent, exercising due care may not be a dominant strategy. If the first party expects the second to be negligent, the first party may expect to escape virtually all liability by being only a little less negligent, and may not choose to meet the due care standard. Furthermore, under traditional rules as well, providing due care will not be a dominant strategy for both parties. However if liability is apportioned in a traditional comparative negligence rule according to the difference in cost between the level of care provided and the cost of providing due care, and there is no risk that agents will provide too much care, then providing due care is a dominant strategy.
Figure 4

Figure 5
When an agent internalizes the consequences of her actions, she has efficient incentives whether or not she can perfectly choose her action or can only influence the likelihood of various actions. For the victim, the efficient rule provides efficient incentives regardless of what level of care the injurer provides, so the fact that the injurer is not able to perfectly choose her care does not affect the efficiency of the victim's incentives. The expected liability of the injurer does not depend on the victim's action, so for a given rule the fact that the victim cannot choose his action perfectly will not affect the incentives of the injurer.

Because the expected cost to each agent of providing less care is the same as the expected social cost of providing less care, each agent will make any efficient investment in providing care, regardless of whether it will ensure that she provides a certain amount of care, or just probabilistically increases the amount of care she provides. Likewise, the proposed comparative negligence rule can provide efficient incentives regardless of whether or not the agents act simultaneously or whether the injurer acts first, and the victim acts subsequently. Of course the social cost of injurer's action might differ if the victim has a chance to react to the injurer's action so the efficient rule will be somewhat different. Likewise, we could imagine that the victim cannot perfectly observe the action of the injurer, but only gets an imperfect signal of the injurer's action. In this case, the liability rule can still provide efficient incentives, the only change is that the computation of the cost of the injurer's action must be modified slightly to account that the victim can react only imperfectly to the injurer's action. A formal proof of this result is included in the appendix.

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61 Under the efficient rule comparative negligence rule, it is a dominant strategy for the injurer to provide the efficient level of care, because the injurer's payoff does not depend on the victim's action. Although the victim always has efficient incentives under the efficient rule, he has incentive to respond efficiently to the action he thinks the injurer will take, so if he miscalculates the injurer's actions, his action will not be efficient. Of course in the case where the victim acts after he sees the injurer's action, this is not a factor, and efficiency will be reached as a dominant strategy equilibrium.

62 Note that the liability rule may depend on the way the victim chooses care. The social impact of the injurer's action will depend on how the victim is expected to act, if a change in the way the victim chooses care changes the distribution of levels of care he actually chooses, this will need to be reflected in the liability rule.
However, when the victim acts first, and the injurer reacts to the victim's action a different rule must be used.\textsuperscript{63} The construction of this comparative 'last clear chance rule' is the mirror image of the construction of the efficient comparative negligence rule. For any fixed level of care by the victim, the injurer's liability share must vary with the injurer's care so as to leave the victim indifferent. The liability share must vary with the victim's action so that the victim internalizes the average impact of his action.\textsuperscript{64} Because the victim's share of liability is adjusted to reflect both the increased likelihood of accident from his lack of care, and cost of extra care provided by the injurer to make up for his lack of care, unlike with a traditional last clear chance rule the victim does not have an incentive to inefficiently shift the burden of providing care onto the injurer.

One might be given pause that the choice of liability rule must depend on the timing of the model, and worry that trials might begin to focus on the timing of the agent's actions and information rather than more substantive issues of responsibility. However under the traditional rules the timing of the actions is an issue whenever the victim makes a claim of last clear chance. In fact under the proposed rules, the stakes from determining the timing of the model are reduced. Under traditional rules and a finding of negligence by both parties, the timing determines which agent bears liability for the entire loss, whereas with the comparative rule the court's ruling tends to have a less stark impact.\textsuperscript{65}

\textsuperscript{63} The original proposed comparative negligence rule only ensures that the injurer internalizes the consequences of her rules on average. Suppose that care offered by the victim is a substitute for the injurer's care, and suppose that the injurer has observed that the victim has supplied a low level of care. In this case, the social cost of providing less care would be especially high, but the injurer only expects to pay the average cost of supplying less care. Similarly, if the injurer has observed the victim provide a high level of care she will have incentives to provide more care than is privately efficient. Essentially the original proposed comparative negligence rule does not give the injurer an incentive to adjust her care in response to the victim's care.

\textsuperscript{64} A comparative last clear chance rule can also be efficient when the victim and the injurer act simultaneously, or when the victim acts without any knowledge of the injurer's action. When agents act without the knowledge of the other agent's action, either the comparative last clear chance rule, or the proposed efficient comparative negligence rule can be efficient. This paper proposes using the efficient comparative negligence rule partially because it bears more resemblance to the laws that are currently in force.

\textsuperscript{65} For example comparing the efficient comparative rules given in Table 4 and Table 15, we see that when the driver is \textit{aggressive} and the pedestrian \textit{careless} ruling on timing would have an impact of only $300, rather than an impact of $2000 when comparing the traditional rules given in Table 2 and Table 14. On the other hand, when the driver is \textit{defensive} and the pedestrian \textit{careful}, the liability does not vary with timing under the traditional rules, but there is a $800 difference under efficient comparative rules. Note that under
If the courts are bound to use liability splits between zero and one, it may not always be possible to construct an efficient rule. If the starting value is chosen so that the injurer bears zero liability if she uses the highest level of care, in cases where she uses very low level of care and the victim uses high levels of care, the efficient liability rule may call for the injurer to bear more than full liability, that is to say the injurer may be required to pay punitive damages. It is possible to show that this will never occur when care by the victim and care by the injurer is additive, that is to say when the victim-- In general it is more likely to occur when care is a substitute, when the likelihood of accident is sensitive to both the victim and the injurer's level of care and a wide range of actions may be efficient. The appendix discusses the precise conditions under which we can rule out the need for punitive damages.

6.1 Evidentiary Uncertainty

The efficiency of traditional liability rules are sensitive to the possibility that courts may not be able to assess the care provide by the parties with complete accuracy. Under traditional rules with discontinuities in liability, agents may provide care above the due care standard to ensure that the even if the court underestimates the care they provided, it will judge them to have met the standard. Thus the general consensus has been that agents will tend to provide too much care under most forms of evidentiary uncertainty. Under the proposed comparative negligence rule, the introduction of evidentiary uncertainty will tend to have the opposite effect and lead to diminished incentives if the rule is not adjusted. The introduction of evidentiary uncertainty will tend to dilute the relationship between care and liability share. Because the highest levels of care may be seen by the courts as low or medium care, agents who supply high care will tend to bear too much liability, and for similar reason agents who supply low care will tend to bear too little liability.

Fortunately, as long as the court's observation of care is sufficiently informative, it is possible to adjust the proposed liability rule to restore efficient incentives. By

the efficient rules, the disparities are biggest when both parties are the most careful and accidents are least likely to occur.
making liability shares vary more sharply with the observed signal care, efficient incentives can be restored. As an example, consider the scenario presented in section 4.7, but with the modification that for each agent there is only a 90% chance that the courts correctly observes that agent's action, (So there is a 10% chance the court observes the pedestrian as careless when careful and vice versa). Likewise when the driver is aggressive there is a 5% chance the court observes her as moderate and a 5% chance she is seen as defensive. The liability shares that would provide for efficient incentives are shown in table 22. Note that the liability shares are slightly more sensitive to observed care then they are in the case where actions are perfectly observed shown in table 15.

<table>
<thead>
<tr>
<th></th>
<th>Careless</th>
<th>Careful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggressive</td>
<td>.334</td>
<td>.951</td>
</tr>
<tr>
<td>Moderate</td>
<td>.216</td>
<td>.717</td>
</tr>
<tr>
<td>Defensive</td>
<td>.008</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 22: Efficient Rule under Evidentiary Uncertainty

In the appendix it is shown formally that in cases where agents choose from a finite number of actions, and the court's signal is sufficiently informative, it is possible to construct an efficient rule. By increasing the number of actions the agents choose between, it is possible to approximate continuous action space, and thus we should be able to come arbitrarily close to efficiency for any well behaved specifications. Unfortunately, because liability must vary more sharply with observed care under evidentiary uncertainty, it will be more likely that the efficient rule will necessitate a liability share over 1 or below 0, particularly when the court's observation of care is particularly noisy. That is to say punitive damages are more likely to be necessary under evidentiary uncertainty.

6.2 Private Information about Effectiveness of Care

In addition to differing in the costs of providing care, people who are approaching a potential accident with seemingly identical behavior may have different likelihoods of

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66 Formally we require that the signal matrix is full rank. Informally this implies that each action, or randomization over actions, by an agent leads to a distinct probability distribution over signals.
accident. For example, some people might have lightning quick reflexes and exceptional peripheral vision, whereas others might be below average in those respects. Furthermore, we might expect that individuals are aware of their special skills or defects, and will take them into account when choosing behavior. In general, the rule proposed in this paper will no longer provide for first best incentives in this case, however the magnitude of distortion may not be so great, because in most cases the distortions operate in opposite directions which tend to mitigate the total distortion.

Recall that the efficient rule makes up for the fact that each agent bears only a share of the liability for an accident by adjusting each agent's share of liability. Now consider the distortion on the incentives of an agent who is (unobservably) accident prone. Because a decrease in care by this agent will lead to a greater increase in the likelihood of accident, if the liability share was fixed, there would be a greater difference between the private and social returns to care for the accident prone. However, because it is more likely that she will be involved in an accident, a change in the liability share has more impact on the accident prone agent and this mitigates the first distortion. In fact if an agent's accident proneness increases the marginal effect of carelessness in proportion to the increase in probability of accident and the agents act simultaneously there will be no distortion at all. This occurs because when agents act simultaneously, the magnitude of loss from an accident does not enter directly into the liability rule. Furthermore under the assumption that agents are risk neutral, a model where the probability of accident is multiplicative in type is equivalent to a model in which the probability of accident does not vary with type but the magnitude of loss depends on type. Since the efficient rule does not depend on the magnitude of loss, the efficient rule need not depend on accident proneness, and efficiency can be achieved even when accident proneness is not observable.

Formally, we might assume that the likelihood of accident is no longer simply a function of observed care \(x\) and \(y\), but is now also a function of type and is given by \(f(x,y,m,n)\) where \(m\) and \(n\) refer to the ‘care effectiveness types’ of the injurer and victim respectively.

The rule does need to be modified slightly to take into account the fact that the victim's action depends on his accident proneness. If agents act simultaneously and care effectiveness enters multiplicatively, the likelihood of accident can be written \(a(m)b(n)f(x,y)\) where \(a(m)\) and \(b(n)\) are functions representing the accident proneness of the injurer and victim respectively, and \(f\) is a baseline function for the probability of accident. We will have to modify the injurer's equation to take into account the fact that the victim is likely

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In cases where accident proneness affects the probability of accident proportionally more than it affects the marginal effect of carelessness, the accident prone will tend to have excessive incentive to provide care (particularly in regions where they bear a small share of liability). If the opposite is true, they will have insufficient incentive. In either case as long as agents an agent's type affects probability of accident in the same direction that it influences marginal effect of carelessness (That is as long is it is efficient for the accident prone to provide more care), the two distortions will tend to be in opposite directions. Traditional rules tend to perform poorly under uncertainty about the effectiveness of care. At least one agent is likely to have a fixed care threshold, and is unlikely to have much incentive at all to adjust her level of care because she is particularly skillful or accident prone.\(^{69}\)

### 6.3 Activity Levels

In general, the proposed rule will not provide the parties with efficient incentives to curtail their activity levels in response to the likelihood of accidents. Under the proposed rule, both parties will tend to expect to bear only a portion of expected accident costs and will tend to engage in too much activity. In contrast, with most of the traditional rules, we would expect that liability would often be concentrated on one party. That party would be likely to choose a nearly efficient level of activity, whereas the other party

\[
L(x', y') = \frac{\int \int f(x', y* (n,k))D \theta(n)g(k)\frac{\hat{\beta}(n)}{\hat{\beta}} dk dn}{\int \int f(x, y* (n,k))D \theta(n)g(k)\frac{\hat{\beta}(n)}{\hat{\beta}} dk dn} + \frac{\int \int f(x, y* (n,k))D \theta(n)g(k)\frac{\hat{\beta}(n)}{\hat{\beta}} dk dn}{\int \int f(x', y')D \theta(n)g(k)\frac{\hat{\beta}(n)}{\hat{\beta}} dk dn}
\]

Where \(\theta(n)\) is the density of care effectiveness type \(n\) and \(\hat{\beta}\) is the average care effectiveness type (\(\hat{\beta} = \frac{\int \theta(n) \theta(n) \, dn}{N}\))

\(^{69}\) In cases where agents do not vary in the marginal effectiveness of care, but do vary in the likelihood of an accident, traditional rules might actually perform better. Under the proposed rule agents will vary their level of care in response to a change in the level of the likelihood of an accident, but if the marginal effectiveness of care is constant it would be inefficient for agents to do so.
would have very little incentive to moderate activity.\textsuperscript{70} If both parties are similarly elastic, we would expect that two small distortions would cause less welfare loss than one big distortion, and expect the comparative rule to lead to more efficient activity levels. On the other hand if only one party has a meaningful choice of activity levels, it would be preferable to concentrate liability on that agent. Under many parameter levels there will be a continuum of efficient comparative negligence rules, so there would be some freedom to choose a rule which placed more or less liability on one party. Furthermore the proposed rule can be easily expanded to provide for efficient activity levels. With an efficient comparative negligence rule the expected externality of one party to the another party does not depend on the level of care the first party chooses (and hence does not depend on the type of that party). Thus a fixed activity tax, set at the expected externality, could lead to efficient activity levels.

\section*{Section 7: Conclusion}

A properly constructed comparative negligence rule can give efficient incentives to both a potential victim and a potential injurer in a bilateral precaution setting. Unlike with a traditional liability rule, it is possible to achieve first best efficiency in situations where parties have private information about their costs, and in situations where negligence may be inadvertent and where parties act either sequentially or simultaneously. Furthermore, it is possible to modify the rule to provide for efficiency in cases of evidentiary uncertainty, and in some cases of private information regarding effectiveness of care. The process of deriving an efficient rule is intuitive; it is a matter of choosing an initial liability split for an arbitrary level of care, and then choosing a liability rule that makes each party indifferent (on average), over the other party's choice of level of care. The flexibility inherent in a comparative negligence rule allows it to achieve first best efficiency in many conditions where no simpler rule can be efficient.

The information required by the courts to properly administer the proposed rule are not necessarily more stringent than the information needed to achieve second best under a traditional rule, and in fact in the case of sequential action, the information

\textsuperscript{70} For a discussion of the impact of splitting liability on the incentives to engage in activity see Francesco Parisi “Comparative Causation” 6 AM. L. & ECON. REV. 345-368 (2004)
requirements are lower. Nevertheless, one might have doubts about the likelihood of fully implementing a rule that appears so complex. Even if one is skeptical the rule could be implemented as proposed, showing how to construct an ideal rule, and how this ideal rule should be modified for factors such as evidentiary uncertainty or differences in effectiveness of care helps us understand how to modify our current application of comparative negligence. We are able to draw some practical lessons by understanding how the ideal rule makes up for the fact that individual agents tend not to bear the entire cost of an accident. For example, we have the result that an agent's share of liability should be more sensitive to cost in regions where that agent bears a smaller share of liability. Additionally, our results support the argument of Rubinfeld\(^71\) that due care standards under traditional comparative negligence should be set very high.

Finally, the rule of thumb that an agent's liability should vary with care in a way that keeps the other agent on average indifferent does not require great sophistication to apply and could provide common sense guidance to judges and juries when deciding liability splits.

**Appendix (Model)**

In this section we define a model where the actors choose a level of care from a continuous set of possibilities, and show that the proposed rule achieves efficiency. We assume that there are two actors, an injurer and a victim. Initially we assume that the injurer chooses her level of care first, and the victim observes the injurer's action and chooses his care in response. In the following subsections we show that modifications to the rule can achieve efficiency provide for efficient incentives when the parties act simultaneously or when the victim acts first.

The injurer chooses her level of care \( x \) from an interval \([x_{\text{MIN}}, x_{\text{MAX}}]\). The cost of this care is given by the function \( c^I(x,z) \), where \( z \in Z \) is the injurer's type. The victim chooses a level of care \( y \) from the interval \([y_{\text{MIN}}, y_{\text{MAX}}]\) and his cost of care is given by the function \( c^V(y,k) \) where \( k \in K \) is the victim's type. Importantly, we assume that both the victim's and the injurer's type are private information; that is to say agents know their own type, but that an agent's type is not directly observed by the other agent or by the courts. We use \( G \) as the cumulative distribution function for \( k \), the type of the victim, and \( g \) as the density over \( k \). Likewise we use \( \Gamma \) and \( \gamma \) as the cumulative distribution function and density function for \( z \), the injurer's type. The likelihood of an accident, which causes damage \( D \), is a function of the victim's care and the injurer's care and is given by \( f(x,y) \).

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\(^{71}\) Supra, note 31
We assume that increasing care always decreases the likelihood of accident so \( f_1(x, y) < 0 \) and \( f_2(x, y) < 0 \).

A legal rule \( L \) is a function that maps from levels of care to the injurer's liability share, so \( L(x, y) \) represents the injurer's portion of liability when the injurer's and victim's levels of care are \( x \) and \( y \) respectively. Initially we assume that both the victim and the injurer have complete control over their levels of care, and that the courts are able to perfectly observe the level of care of both the injurer and victim. In the extensions section we explore the implications of relaxing these assumptions.

The victim's share of liability is \( 1 - L(x, y) \). We will refer to a rule as permissible if \( L(x, y) \) is always between 0 and 1. Thus we would say that a rule which imposes punitive damages on the injurer, or reverse damages onto the victim is not permissible. We assume that both the injurer and victim are risk neutral. The most important effect of an introduction of risk aversion into the model would be to introduce a tradeoff between insurance and incentives that has been examined at length in many strands of the economics literature and is not the focus here.

Each agent's choice of level of care is efficient if it minimizes the total expected cost of accident including precaution costs. This expected cost of accidents is given by:

\[
C = c^V(x, z) + c^V(y, k) + f(x, y)D
\]

Conditional on the injurer's action, a victim's level of care \( y \) is efficient if and only if for any \( y \in [y_{\text{min}}, y_{\text{max}}] \):

\[
c^V(x, z) + c^V(y, k) + f(x, y)D \leq c^V(x, z) + c^V(y', k) + f(x, y')D
\]

The victim chooses a level of care after observing the injurer's level of care. The victim is interested in minimizing his own total costs, which are comprised of his precaution costs and his expected uncompensated losses from accidents. These costs are given by: \( c^V(y, z) + (1 - L(x, y))f(x, y)D \). A rule will lead the victim to take the efficient level of care if for any \( x, y \) and \( y' \),

\[
c^V(x, z) + c^V(y, k) + f(x, y)D \leq c^V(x, z) + c^V(y', k) + f(x, y')D \Rightarrow
\]

\[
c^V(y, k) + (1 - L(x, y))f(x, y)D \leq c^V(y', k) + (1 - L(x, y'))f(x, y')D
\]

In other words, under an efficient rule, whenever society prefers a level of care for the victim, the victim also prefers that level of care for himself. If there is a rule such that:

\[
f(x, y)D - f(x, y')D = (1 - L(x, y))f(x, y)D - (1 - L(x, y'))f(x, y')D \forall y, y'
\]

then this will satisfy (3) and lead to efficient behavior by the victim conditional on the injurer's care. Therefore, if the rule calls for a liability split of \( L(x, y) \) when the care levels are \( x \) and \( y \), we can solve (4) for \( L(x, y') \) to obtain the liability split for levels of care \( x \) and \( y' \) that gives the victim efficient incentives to chose between \( y' \) and \( y \). We obtain:

\[
L(x, y') = \frac{f(x, y)L(x, y)}{f(x, y')}
\]
Because the liability rule is set so that the victim internalizes all of the marginal cost of his own care, the injurer does not care about the victim's action or type.\(^{74}\) Thus under any rule that satisfies (5) the injurer will choose a level of care \(x\) only if for all \(x' \in [x_{\min}, x_{\max}]\):

\[L(x, y^*(x,k))= L(x, y^*(x,k)) = \frac{L(x,y) f(x,y) f(x,y')}{f(x,y') f(x,y')} \text{ for any } y^*(x,k)\]

Therefore if we fix the liability split at \(L(x,y)\) for some pair of actions \(x\) and \(y\), we can use the above equation to determine the liability for any level of care by the victim \(y'\) when the injurer's level of care remains \(x\). Note that if \(L(x,y) = 0\) then \(L(x,y', k) = 0\) as well. If the victim always bears full liability then his incentives will be efficient and there is no need to vary his share of liability. Note also that if \(y' < y\), so \(f(x, y') > f(x,y)\), then \(L(x, y') < L(x,y)\), so the injurer faces a lower liability share and the victim bears a greater share of the loss when the victim is less careful. Furthermore \(L(x, y') - L(x,y)\) will be greater when \(L(x,y)\) is greater. This is because when \(L(x,y)\) is greater, the victim's share of loss is smaller, giving the victim less inherent incentive to avoid accidents. Thus his share must be increased more when he is less careful to give him the proper incentive.

We now turn to the incentives for the injurer. We note that neither the injurer nor the court necessarily knows the victim's cost of care. For social optimality the best that the injurer can do is to minimize the sum of the expected cost of care and the expected cost of accidents, given the distribution of types of the victim.\(^{73}\) Note that the efficient response of the victim will depend on his type \(k\). Let us use \(y^*(x,k)\) to refer to the socially efficient choice for a victim of type \(k\) when he sees the injurer taking care equal to \(x\).

Recall that if the liability rule satisfies (5) then we know the victim will choose the efficient level of care conditional on the injurer's care. Thus when the injurer chooses care level \(x\), the expected social costs of accidents and precaution is given by:

\[c'(x,z) + \int_k (c'(y^*(x,k),k) + f(x,y^*(x,k))D)g(k) dk\]  

\[(6)\]

A level of care \(x\) by an injurer of type \(z\) is socially efficient iff for all \(x' \in [x_{\min} - x_{\max}]\):

\[c'(x,z) + \int_k (c'(y^*(x,k),k) + f(x,y^*(x,k))D)g(k) dk \leq c'(x',z) + \int_k (c'(y^*(x',k),k) + f(x',y^*(x,k))D)g(k) dk\]  

\[(7)\]

Of course the injurer is interested in minimizing her own costs, which are given by:

\[c'(x,z) + \int_k L(x,y^*(x,k))f(x,y^*(x,k))D g(k) dk\]  

\[(8)\]

Recall from (5) that \(L(x,y^*(x,k))= L(x,y^*(x,k)) = \frac{L(x,y) f(x,y)}{f(x,y') f(x,y')} \text{ for any } y^*(x,k)\)

and \(y\). We substitute this into (8) and note that for any arbitrary \(y\):

\[\int_k \frac{L(x,y) f(x,y)}{f(x,y') f(x,y')} f(x,y^*(x,k))D)g(k) dk = L(x,y) f(x,y) D\]

\[(9)\]

This confirms that the injurer's cost does not depend on how the victim reacts. Thus the injurer's costs are given by:

\[c'(x,z) + L(x,y) f(x,y) D\]

\[(10)\]

Because the liability rule is set so that the victim internalizes all of the marginal cost of his own care, the injurer does not care about the victim's action or type.\(^{74}\) Thus under any rule that satisfies (5) the injurer will choose a level of care \(x\) only if for all \(x' \in [x_{\min} - x_{\max}]\):

\[\text{This is sometimes referred to as information constrained first best.}\]

\[\text{Interestingly this implies that the injurer need not correctly anticipate the distribution of types of the victim to achieve efficiency, although she must know the liability rule.}\]
\[ c'(x, z) + L(x, y)f(x, y)D \leq c'(x', z) + L(x', y)f(x', y)D \] (11)

A liability rule will give efficient incentives to the injurer if for any \( x \) and \( x' \in [x_{\min}, x_{\max}] \), condition (7) implies (11). It is easy to see that (7) is equivalent to (11) if:

\[
f(x, y)L(x, y)D - f(x', y)L(x', y)D = \int_k (c^v(y^*(x, k), k) + f(x, y^*(x, k))D)g(k) \, dk
- \int_k (c^v(y^*(x', k), k) + f(x', y^*(x', k))D)g(k) \, dk
\] (12)

Solving for \( L(x', y) \) as a function of \( L(x, y) \) we obtain:

\[
L(x', y) = L(x, y) \frac{f(x, y)}{f(x', y)} + \int_k \frac{\left( c^v(y^*(x', k), k) \right)}{D} + f(x', y^*(x', k))g(k) \, dk - \int_k \frac{\left( c^v(y^*(x, k), k) \right)}{D} + f(x, y^*(x, k))g(k) \, dk
\]

\[
\frac{f(x', y)}{f(x', y')}
\] (13)

We now have the two equations that will guarantee an efficient liability rule if they are satisfied. Our next order of business is to show that it is possible to satisfy them both simultaneously. Specifically once we set \( c'(x, z) \) and \( L(x, y) \) so that the victim's care is \( x \) and the injurer's liability share multiplied by the effectiveness of injurer's care when the victim chooses an optimal level of care. Intuitively the left side will be greater only when \( f(x, y) \) is high and \( f(x', y) \) is low. These conditions are likely to be simultaneously satisfied only when care by the injurer is a complement to care by the victim, and when the victim's care is high while the injurer's care is low. If care by the victim is a substitute, then \( f(x, y) > \int_k f_1(x, y^*(x, k))g(k) \, dk \) only for low values of \( y \). We also note that if \( f(x, y) \) is multiplicative so that \( f(x, y) = f^I(x)f^V(y) \), then

\[
\frac{f_1(x, y)}{f_1(x, y')} = \frac{f(x, y)}{f(x, y')} = \frac{L(x, y')}{L(x, y)}.
\]

\[75\] We note that if the likelihood of accident is additive so \( f(x, y) = f^I(x) + f^V(y) \) then

\[
f_1(x, y) = \int_k f_1(x, y^*(x, k)) \, g(k) \, dk f_1(x, y) \text{ so } L(x, y) \text{ is always decreasing in } x.
\]

We also note that if \( f(x, y) \) is multiplicative so that \( f(x, y) = f^I(x)f^V(y) \), then

\[
\frac{f_1(x, y)}{f_1(x, y')} = \frac{f(x, y)}{f(x, y')} = \frac{L(x, y')}{L(x, y)}.
\]

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injurer's liability share would be increasing in her care would be when care by both parties is complementary, and where the injurer is exercising low care while the victim is exercising high care.

In general by choosing a lower starting value for $L$ we choose a rule that tends to give less liability to the injurer and forces the victim to bear more of the burden. However, if the starting value is poorly chosen, there can be some values of $x$ and $y$ such that $L(x,y)$ is outside of the permissible range, either greater than 1 or less than 0. Note that the lowest liability share for the injurer will be $L(x_{\text{max}},y_{\text{min}})$ which occurs when she chooses the highest level of care and the victim chooses the lowest level of care. The highest liability share will tend to occur at $L(x_{\text{min}},y_{\text{max}})$. In fact let us use $\tilde{x}$ and $\tilde{y}$ to refer to the highest level of care that it is ever efficient to choose for the injurer and victim respectively. Similarly we use $\check{x}$ and $\check{y}$ for the lowest levels of care that are ever efficient. Thus, we can maximize our probability of generating a feasible rule by setting $L(\tilde{x},y) = 0$.

Now let us define $\check{x} = \arg\max_{x \in [\check{x},\bar{x}]} L(x,y)$, so that $L(\check{x},\tilde{y})$ is the highest share the victim will face if both parties take efficient actions. If we compute

$$L(\check{x},\tilde{y}) > 1,$$

there will be no rule that will be permissible and always efficient, but if

$$L(\check{x},\tilde{y}) = \max (0,\min(L,1))$$

so that if $(x,y) \in [0,1]$ then $\Lambda(x,y) = L(x,y)$ but whenever the efficient rule would choose $L > 1$ then $\Lambda = 1$ and whenever $L < 0$, then $\Lambda = 0$. We note that if (15) is satisfied and $L(\check{x},\tilde{y}) \leq 1$ then $L$ will be outside of the interval $[0,1]$ only when $x \in [\check{x},\bar{x}]$ or $y \in [\check{y},\bar{y}]$ and we confirm that if we use the function $\Lambda$ to define liability neither agent will choose a level of care outside of the efficient range. (15)

How do we interpret this condition? Note that the first integral in the numerator is the probability of accident if the injurer chooses the lowest level of care, plus the expected cost of the victim's care divided by the damage from an accident. We can interpret this as the likelihood of an accident modified by the 'accident equivalents' of

so $L(x,y)f(x,y) = L(x,y')f(x,y')$. Since there must be some $y$ such that

$$f(x,y) \leq \int_k f(x,y')(x,k)g(k)dk$$

if $L(x,y) < 1$ then $L(x,y)$ must be decreasing in $x$. (16)

Trivially since $L(\check{x},y) = 0$ for any $y$, the injurer has no incentive to choose care above $\check{x}$. Consider choosing a level of care $x'$ below $\check{x}$ such that $L(x',y) = 1$ for some $y$. If the injurer chooses care $x'$, the victim has no incentive to choose $y' > y$, because for any $y' \geq y$, $\Lambda(x',y') = 1$, and the victim bears none of the loss. Since we have shown that the victim chooses care such that $\Lambda = L$, the injurer will be indifferent as to the care chosen by the victim, and will bear liability as if the rule is given by $L$. Thus the injurer has efficient incentives and will not choose an inefficiently low level of care $x' < \check{x}$.

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care that the injurer induces the victim to take. Similarly the second integral is the modified likelihood of an accident when the injurer chooses the highest efficient level of care.

Suppose that the victim's optimal choice of action does not depend on the choice of care by the injurer. Then the numerator would refer to the difference in probability of an accident between when the injurer chooses the highest level of care and when she chooses the lowest. If, as might be expected, care by the victim is a substitute for care by the injurer, the numerator will be greater than the actual difference in probability of an accident. Thus, we can think of the numerator as the difference in probability of accident caused by the injurer adjusted by the change in precaution spending by the victim. Condition (15) implies that if this is less than the probability of an accident between when the injurer chooses the highest level of care and when she chooses the lowest level of care, then there will be a feasible rule. This implies that are two classes of models where there will always be an efficient rule: 1) When the numerator is small because the injurer's care has little impact on the likelihood of accident, and 2) Where the denominator is fairly large, because the victim is unable to unilaterally prevent accidents.

As an example, suppose that the probability of accident $f(x,y)$ had a special additive form $f^I(x)+V(y)$. In this case, care by the victim is neither a complement nor a substitute for the injurer's care, so the injurer's care has no effect on the efficient level of the victim's care. Furthermore, we know from above that the injurer's liability is decreasing in her care, so condition (15) becomes $f^I(\hat{x})-f^I(\tilde{x})<f^I(\hat{x})+V(\tilde{y})$, and it is easy to see it will always be satisfied. So when the probability of accident is additive there will always be a permissible efficient rule. Another special case is where we have multiplicative probability of accident so that $f(x,y) = f^I(x)f^V(y)$. We could interpret this as implying that an accident occurs only as a result of simultaneous independent failures on the parts of both the injurer and victim. In this case condition (15) becomes:

$$\int \frac{f^V(y^*(\bar{x},k))f^I(\bar{x}) + c^V(y^*(\bar{x},k),k)}{f^V(\bar{x})f^I(\bar{x})} \frac{g(k) dk}{D} < 1$$ (16)

Note that by the definition of $y^*$ social cost will be higher if the injurer chooses any level of care other than $y^*(\bar{x},k)$ in response to $\bar{x}$, so the following is a stronger condition than (16):

$$\int \frac{c^V(y^*(\bar{x},k),k)}{D} g(k) dk - \int f^V(y^*(\bar{x},k))f^I(\bar{x}) + \frac{c^V(y^*(\bar{x},k),k)}{D} g(k) dk < 1$$

Moving the $f^I(\bar{x})$ term from the denominator to the numerator we have:

$$\int \frac{f^V(y^*(\bar{x},k)) + \frac{c^V(y^*(\bar{x},k),k)}{f^I(\bar{x})D} g(k) dk - \int \frac{f^V(y^*(\bar{x},k)) + \frac{c^V(y^*(\bar{x},k),k)}{f^I(\bar{x})D} g(k) dk}{f^V(\bar{x})} < 1$$

This is equivalent to:
\[ 1 - \frac{f^I(\bar{x})}{f^I(\bar{x})} < \frac{f^V(y)}{\int_K f^V(y^*(x,k)) g(k) \, dk} \quad (17) \]

The left side of the inequality is the proportionate reduction in probability of accident if the injurer chooses the highest level of care relative to the lowest level, obviously this is bounded above by one. The numerator on the right side is the victim's likelihood of failure when he chooses the highest level of care, and the denominator is the expected likelihood of failure by the victim in response to the highest level of care by the injurer. It is clear that the condition above is most likely to be satisfied if

\[ \int_K f^V(y^*(\bar{x},k)) g(k) \, dk \text{ is close to } f^V(\bar{y}). \]

That is to say when it is optimal for the victim to provide care close to the maximum level, or when the victim's chance of failure does not vary significantly, it will be very easy to have a permissible rule. As before if \( f^I(\bar{x}) - f^I(\bar{y}) \) is small relative to \( f^I(\bar{x}) \), implying that the injurer's care is unimportant, it will be easy to formulate a permissible efficient rule.

\subsection{evidentiary uncertainty}

Assume that the injurer chooses from \( M \) levels of care, labeled \( x_1 \ldots x_M \). Similarly assume the victim chooses from \( N \) levels of care (\( y_1 \) through \( y_N \)). Let \( L \) be a matrix of liability shares that corresponds to the efficient rule if actions were perfectly observed, so that if \( l_{mn} \) is an element of \( L \), \( l_{mn} \) corresponds to the liability share when the injurer chooses action \( x_m \) and the victim chooses \( y_n \).

We assume that the court observes a signal \( \hat{x} \) of the injurer's care where \( \hat{x} \in \{ \hat{x}_1 \ldots \hat{x}_M \} \). Likewise the court observes a signal \( \hat{y} \) of the victim's care where \( \hat{y} \in \{ \hat{y}_1 \ldots \hat{y}_M \} \).

Let \( A \) be the signal matrix for the injurer's action so that element \( a_{mh} \) corresponds to the likelihood that the court observes signal \( \hat{x}_h \) when the injurer chooses care \( x_m \). Likewise \( B \) is the signal matrix for the victim's care so that element \( b_{nh} \) is the likelihood the court observes \( \hat{y}_h \) when the victim's care is \( y_n \).

If the \( M \times N \) matrix \( \Omega \) is the liability rule, so that element \( \omega_{mh} \) is the liability share the court assigns to the plaintiff when it observes signals \( \hat{x}_h \) and \( \hat{y}_h \), then the \( M \times N \) matrix \( \Lambda = A\Omega B^\prime \) is the matrix that maps levels of care into expected liability shares.

Thus if \( \lambda_{mn} \) is an element of \( \Lambda \), when the injurer chooses action \( x_m \) and the victim chooses \( y_n \), the injurer expects to be held liable for a share \( \lambda_{mn} \) of the accident losses. Clearly if \( \Lambda = L \), the agents will face efficient incentives.

Suppose the signals of the agents' actions are linearly independent so that \( A \) and \( B \) are full rank, then there will exist matrices \( A^{-1} \) and \( B^{-1} \) such that \( AA^{-1} = I_M \) and \( B^{-1}B^\prime = I_N \) where \( I_M \) and \( I_N \) are the \( M \times M \) and \( N \times N \) identity matrices. Now if we set \( \Omega = A^{-1}L B^{-1} \), then \( A\Omega B^\prime = AA^{-1}LB^{-1}B^\prime = L \). Thus if \( A \) and \( B \) are full rank, by setting \( \Omega = A^{-1}L B^{-1} \) we can achieve efficiency under evidentiary uncertainty.

\section*{8.1 Imperfect observation by victim}
We have been assuming that before acting the victim is able to perfectly observe the injurer’s level of care. However, a victim must often choose his action with limited information about the injurer’s action. An extreme, but very important case of this is when the victim and injurer act simultaneously. In this subsection, we suppose that rather than observing the injurer’s actual level of care, the victim gets only a signal of the injurer’s level of care. We assume that the victim’s prior beliefs are a distribution over levels of care by the injurer, and that the signal induces a posterior distribution over the injurer’s actual level of care that is correct in the Bayesian sense. In this case, we show that a rule similar to the one described above will induce behavior by the victim and the injurer that is efficient given the informational constraints. In fact we will use rule (5) to determine the relationship between liability share and victim’s care just as before, but we must modify (13) by generalizing it to take into account the fact that the victim’s care will now depend on the observed signal of the injurer’s care, rather than the injurer’s actual care. Note that in order for a rule to be efficient, the court and victim must both now have the correct prior beliefs about the probability distribution of the injurer’s type.

Formally, we will assume that the victim sees a signal \( \hat{x} \) of the injurer’s care. We let \( S(x) \) be the signal technology so \( S(\hat{x}, x) \) is the probability that \( \hat{x} \leq \hat{x} \) when the injurer’s level of care is actually \( x \), and likewise \( s(\hat{x}, x) \) is the probability density of the signal technology, so \( s(\hat{x}, x) \psi \) is the probability density of the signal \( \hat{x} \) when the injurer’s actual care is \( x \). Let \( H \) and \( h \) be the cumulative probability and probability density of the distribution of the injurer’s level of care in equilibrium. Note that \( H \) and \( S \) induce a posterior probability distribution \( \psi \), so that

\[
\psi(x, \hat{x}) = \frac{h(x)s(\hat{x}, x)}{\int_{\hat{x}}^x h(\xi)s(\hat{x}, \xi) d\xi}
\]

represents the probability density that the actual care is \( x \), conditional on observing signal \( \hat{x} \).

The requirement for efficiency constrained by the victim's information is that:

\[
\int_{\frac{x}{2}}^{x} f(x, y)D \psi(x, \hat{x}) dx + c^v(y, k) \leq \int_{\frac{x}{2}}^{x} f(x, y')D \psi(x, \hat{x}) dx + c^v(y', k) \forall y'
\]  

The victim will choose a level of care such that

\[
\int_{\frac{x}{2}}^{x} f(x, y)(1 - L(x, y))D \psi(x, \hat{x}) dx + c^v(y, k)
\]

\[
\leq \int_{\frac{x}{2}}^{x} f(x, y')(1 - L(x, y'))D \psi(x, \hat{x}) dx + c^v(y', k) \forall y'
\]  

Note that from (5) the liability rule is chosen to satisfy:

\[
f(x, y)D - f(x, y')D = (1 - L(x, y))f(x, y)D - (1 - L(x, y'))f(x, y')D \forall y, y'
\]  

If we use (5) clearly (18) implies (19) so the victim will not choose an inefficient level of care.

We define \( y^S \) as the map from observed signal and victim’s type into efficient care for the victim so \( y^S(\hat{x}, k) \) is the information constrained efficient level of care for a victim.

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\(^{77}\) The cumulative distribution is given by

\[
\Psi(x, \hat{x}) = \frac{\int_{\hat{x}}^{x} h(\xi)s(\hat{x}, \xi) d\xi}{\int_{\frac{x}{2}}^{x} h(\xi)s(\hat{x}, \xi) d\xi}
\]
of type $k$ who observes signal $\hat{s}$. As shown above, this is the level of care he will actually choose under our proposed comparative liability rule. We now focus on the injurer's choice of care. The efficient choice of care by the injurer minimizes
\[ \int_k \int_\tau (f(x,y^s(\hat{x},k)x)D + c^y(y(\hat{x},k),k)) s(\hat{x},x) d\hat{x} g(k) dk + c^l(x,z) \] (21)
The injurer wishes to minimize her total costs, given by
\[ \int_k \int_\tau L(x,y^s(\hat{x},k))f(x,y^s(\hat{x},k)D s(\hat{x},x) d\hat{x} g(k) dk + c^l(x,z) \] (22)
Again, by applying (5) we see that $L(x,y)f(x,y)$ does not vary with $y$, so (22) is equivalent to:
\[ L(x,y)^f(x,y)D + c^l(x,z) \] (23)
for a given $y$. For efficiency, it is sufficient to insure that for any $y$,
\[ L(x,y)f(x,y)D + c^l(x,z) - (L(x,y)f(x,y')D + c^l(x',z)) = \]
\[ \int_k \int_\tau f(x,y^s(\hat{x},k))D s(\hat{x},x) d\hat{x} g(k) dk + c^l(x,z) \] (24)
\[ \int_k \int_\tau f(x',y^s(\hat{x},k))D s(\hat{x},x') d\hat{x} g(k) dk + c^l(x',z) \]
Simplifying, we require:
\[ L(x,y)f(x,y) - L(x',y')f(x',y') = \]
\[ \int_k \int_\tau f(x,y^s(\hat{x},k))D s(\hat{x},x) d\hat{x} g(k) dk \] (25)
\[ \int_k \int_\tau f(x',y^s(\hat{x},k))D s(\hat{x},x') d\hat{x} g(k) dk \]
Solving, we obtain
\[ L(x',y) = L(x,y) \frac{f(x,y)}{f(x',y)} + \int_k \int_\tau \frac{f(x',y^s(\hat{x},k))D s(\hat{x},x') d\hat{x} g(k) dk}{f(x',y)} - \]
\[ \int_k \int_\tau \frac{f(x,y^s(\hat{x},k))D s(\hat{x},x) d\hat{x} g(k) dk}{f(x',y)} \] (26)
The interpretation of the above rule is the same as the interpretation of the original injurer's rule. Specifically, the difference in the numerator of the last term is the difference in probability of accident, adjusted for difference in the victim's expected expenditure on care. The only difference is that the victim's level of care is no longer a direct function of the injurer's care, but is now a function of the signal he receives, which is a stochastic function of the injurer's care. We note also that the original rule is a special case of the above rule. Specifically as the signal $\hat{s}$ becomes perfectly accurate, the expected social welfare loss due to inaccuracy approaches zero and
\[ \int_\tau (f(x,y^s(\hat{x},k))D s(\hat{x},x) d\hat{x} \rightarrow f(x,y^s(x,k))D \] so (26) becomes (13).
Note that the rule in (26) will be efficient even if the signal is completely uninformative (i.e. even if $\widehat{s}(\hat{x},x) = \widehat{s}(\hat{x},x')$ for all $\hat{x}, x, x'$). Since assuming that the injurer and the victim choose their levels of care simultaneously is identical to assuming that the victim gets a completely uninformative signal of the injurer's care, this implies that the rule will be efficient in a simultaneous model. We actually will need a bit less information if both parties choose their level of care simultaneously or the victim's signal is completely uninformative. We no longer need any information about the costs of care for the victim. We can see this by noting that if the signal is uninformative the optimal response of the injurer should not depend on the signal and we can replace

$$
\int_{\hat{x}}^x (f(x, y^*(\hat{x}, k)) + \frac{c^V(y^*(\hat{x}, k), k)}{D}) s(\hat{x}, x) d\hat{x} \text{ with } f(x, y^*(k)) + \frac{c^V(y^*(k), k)}{D}.
$$

The rule now becomes:

$$
L(x', y) = L(x, y) \frac{f(x, y)}{f(x', y)} + \int_k (f(x', y^*(k)) + \frac{c^V(y^*(k), k)}{D}) - (f(x, y^*(k)) + \frac{c^V(y^*(k), k)}{D}) g(k) dk
$$

(27)

Now note that the $c^V(y^*(k))$ term no longer depends on $x$. So we have:

$$
L(x', y) = L(x, y) \frac{f(x, y)}{f(x', y)} + \int_k (f(x', y^*(k)) - (f(x, y^*(k))) g(k) dk
$$

(28)

and the rule no longer depends on the victim's costs. Because the victim can no longer adjust his care in response to the injurer's behavior, the only effect of the injurer's behavior is on the likelihood of accident, and we do not have to take the victim's response into consideration.

8.2 Stochastic Care

As discussed in section 5, early law and economics analyses of accident law found that agents would have efficient incentives under traditional rules in models in which they were able to choose their level of care with perfect precision. In this subsection, we show how to construct a comparative negligence rule that provides for efficient incentives when agents' care is stochastic, and they are only able to influence the distribution of care by investing in precaution. For simplicity we will consider the implications of stochastic care in a model where there is no private information about the agents' costs of care. Specifically, we consider a model with only one type of injurer and one type of victim. It would be relatively straightforward to combine our results for multiple types with our results for stochastic care.78

Formally, let $\chi^I$ be the actual amount that the injurer invests in precaution. To capture our assumption that care is stochastic, we can model actual care as a function of the investment in precaution and an unobserved random number $\zeta^I$. Without loss of

78 The major difficulty would be fitting the relevant equations on the page!
generality, we can assume that $\zeta^I$ is uniform between 0 and 1. So $x = \pi(\chi^I, \zeta^I)^\wedge [1]$.

Likewise we can assume that the victim's actual care level is given by $y = \phi(\chi^V, \zeta^V)$, where $\chi^V$ and $\zeta^V$ are the victim's analogs of $\chi^I$ and $\zeta^I$. For a given observed level of care($x$) by the injurer the efficient level of care for the victim minimizes

$$\int_0^1 f(x, \phi(\chi^V, \zeta^V)) D \, d\zeta^V + \chi^V$$

(29)

The victim will be minimizing the sum of the expected liability and the cost of care. So the victim's optimal investment in care will minimize:

$$\int_0^1 f(x, \phi(\chi^V, \zeta^V))(1 - L(x, \phi(\chi^V, \zeta^V))) D \, d\zeta^V + \chi^V$$

(30)

As before, the liability rule is chosen to satisfy (5). By plugging in we can see that under this rule whenever (30) is minimized (29) will be as well, so the privately optimal investment in precaution for the victim will be socially efficient. To consider the incentives of the injurer we define $\chi^*(x)$ as the optimal expenditure on precaution by the victim who observes care level $x$. An efficient expenditure on precaution by the injurer minimizes:

$$\int_0^1 \int_0^1 f(\pi(\chi^I, \zeta^I), \phi(\chi^*(\pi(\chi^I, \zeta^I)), \zeta^V)) D \, d\zeta^V + \chi^*(\pi(\chi^I, \zeta^I)) d\zeta^I + \chi^I$$

(31)

The injurer wishes to minimize her own expected costs. For the sake of compactness we must suppress the arguments of $\chi^*$, so the injurer's expected costs are given by:

$$\int_0^1 \int_0^1 f(\pi(\chi^I, \zeta^I), \phi(\chi^*, \zeta^V)) L(\pi(\chi^I, \zeta^I), \phi(\chi^*, \zeta^V)) D \, d\zeta^V d\zeta^I + \chi^I$$

(32)

If we set the injurer's rule so that

$$L(x', y) = L(x, y) \frac{f(x, y)}{f(x', y)} +$$

$$\int_0^1 f(x', \phi(\chi^*(x'), \zeta^V)) d\zeta^V + \frac{\chi^*(x')}D - (\int_0^1 f(x, \phi(\chi^*(x'), \zeta^V)) d\zeta^V + \frac{\chi^*(x)}D)$$

(33)

$$f(x', y)$$

then whenever $\chi^I$ is more efficient than $\chi^V$, the injurer will prefer $\chi^I$ and the injurer faces efficient incentives. To see this we simply confirm that:

---

79 One might imagine that there could be a random element to the expenditure on care as well as the level of care provided. However as long as the actors are risk neutral they will only care about the expected expenditure on care. Therefore we can think of agents as choosing an expected expenditure on precaution and care and seeing a realization of care.
to be decreasing in that agent’s level of care. However, the efficient `comparative last chance rule’ will share some features with the original rule, namely each agent’s share of liability will both tend to have any practical application.

It is technically possible to get arbitrarily close to efficiency with a non-monotonic “simple” liability rule that really just approximates a comparative negligence rule by assigning liability more or less randomly according to a probability given by the comparative negligence rule. We could divide $\mathbb{R}^2$ into sufficiently small rectangles such as \{($x, x + \varepsilon), (y, y + \delta)$\} so that the agents have essentially no ability to affect the relative likelihood of any level of care within the rectangle. By giving full liability to the injurer for a portion $SL(x,y)S$ of the rectangle, and no liability to the injurer in the remainder of the rectangle, we have approximately duplicated a comparative negligence rule. However this sort of rule would be unlikely to have any practical application.
clear chance rule' can best be thought of as a mirror of the efficient comparative negligence rule detailed above. In contrast with the efficient comparative negligence rule, under an efficient 'comparative last chance' rule, it will generally not be possible for an injurer to completely avoid liability by choosing the highest available level of care. Instead, it is the victim who can insure that he will be fully compensated for any accident if he chooses the highest level of care.

The efficient last clear chance rule is constructed using the same methods, but in the reverse order as the efficient comparative negligence rule. First we solve for a liability split which ensures that the injurer has an efficient incentive to provide care conditional on her observation of the victim's care and obtain the analog to rule (5):

\[ 1 - L(x', y) = (1 - L(x, y)) \frac{f(x, y)}{f(x', y)} \] (35)

Next we solve for the analog to (13) so as to insure that the victim has efficient incentives. We obtain:

\[
L(x, y') = 1 - (1 - L(x, y)) \frac{f(x, y)}{f(x', y')} + \\
\int_z f(x^* (y, z), y) + \frac{c' (x^* (y, z), z)}{D} \, dz - \int_z f(x^* (y', z), y') + \frac{c' (x^* (y', z), z)}{D} \, dz
\] (36)

Combining the two as before we have:

\[
L(x', y') = 1 - (1 - L(x, y)) \frac{f(x, y)}{f(x', y')} + \\
\int_z f(x^* (y, z), y) + \frac{c' (x^* (y, z), z)}{D} \, dz - \int_z f(x^* (y', z), y') + \frac{c' (x^* (y', z), z)}{D} \, dz
\] (37)

Not surprisingly (37) bears striking similarity to (14) with the roles of the victim and injurer reversed. The rule is modified to take into account that it is now the injurer who takes the victim's care into account, and the injurer's share of liability (\(L(x, y)\)) has been replaced with share of accident losses for which the victim is not compensated (\(1 - L(x, y)\)). The similarity of the two rules is a result of the fact that when modeling the incentives the agents face what is important is not which party would bear the loss absent legal intervention, but rather how much loss each party bears after legal intervention.