CAUSATION AND INCENTIVES TO TAKE CARE UNDER THE NEGLIGENCE RULE

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Abstract

Most law and economics models of the negligence rule have implicitly assumed that negligent injurers are liable for all accidents associated with their activity. This characterization fails to take account of the causal requirement that injurers are only liable for accidents that would not have occurred if they had not been negligent. Because of this disregard of the causation requirement, an injurer, once he exercises slightly less than due care and becomes negligent, faces a sharp increase in liability--from no liability to liability for all accidents in which he is involved. But since, in fact, injurers are only liable for accidents caused by their negligence, liability at this point will increase gradually rather than sharply--from no liability to liability for only those accidents that would have been avoided had the injurer exercised slightly more care, i.e., due care.

That there is no discontinuous increase in liability under the negligence rule has implications that differ from those drawn by the previous literature. For example, I find that if due care is set above optimal care, injurers will still exercise optimal care. And if injurers are uncertain about the level of due care, I conclude that they will exercise less than optimal care. The previous law and economics literature has generally arrived at partially or fully contradictory results. The conclusions of the previous literature would only be valid if injurers, by being negligent, avoid all the accidents that would have occurred had they exercised due care.

This paper presents an analysis of the incentives to take care that are created under the negligence rule. As a matter of legal doctrine, injurers are liable for accident damages if two conditions are satisfied. First, of course, the injurer must have acted negligently -- that is, he must have exercised less than "due care." Secondly, the injurer's negligence must have caused the accident[1] -- that is, the accident would not have occurred had there been no negligence. Injurers will have incentives to take care inasmuch as additional care reduces the risk of either being found to have acted negligently or of this negligence being found to have caused the accident[2].

In the now standard models[3] developed in the law and economics literature, the second, causal requirement for liability is not explicitly included or, at least, not fully elaborated. Rather, in most models, liability turns solely upon an injurer's negligence: if the injurer was not negligent, he is not liable; but if he was negligent, he is liable for any accident that arises -- including, by implication, those accidents that would have happened even if he had employed due care[4]. Consequently, in these models, once an injurer exercises slightly less than due care and becomes negligent, he finds that his liability increases discontinuously -- from no liability to liability for the harm done in all accidents in which he is involved.

This characterization of liability is incorrect. To see that a discontinuity in liability, as one's level of care

falls below due care, does not in fact decribe the negligence rule, consider the example of accidents in which cricket balls fly over a fence surrounding the playing field and injure bypassers[5]. Suppose the proper height of the fence is 10 feet, so that it is negligent to build a fence of less than 10 feet. Under the standard models of negligence, a cricket field owner who builds a fence of 9 feet, 11 inches, rather than 10 feet is negligent and assumed to be liable for all injuries caused by balls that fly over the fence. In particular, he is assumed to be liable whether balls fly over at a height of 9 feet, 11.5 inches; 11 feet; or even 100 feet.

But, in fact, an injurer is only liable for accidents caused by his negligence. Therefore, the owner would not be liable for injuries from balls flying over the fence at heights exceeding 10 feet. Accidents caused by balls flying over at greater heights are not caused by his negligence since they would have occurred just the same if the fence had been 10 feet high. Thus, if his fence is only 9 feet, 11 inches, rather than 10 feet high, he is liable only for accidents caused by balls flying over the fence at a height between 9 feet, 11 inches, and 10 feet. In other words, as one becomes slightly negligent, one's liability increases slightly, and continuously.

This character of liability for negligence -- i.e. that liability increases gradually and continuously rather than sharply and discontinuously when one's care falls below due care -- has a variety of important implications. In many

cases, these implications contradict the conclusions arrived at in the previous literature.

I will begin the present paper by modeling the negligence rule in a way that explicitly incorporates the doctrinal requirement of causation. Then, in Section 2, I will describe the incentives to take care under a perfectly operating negligence rule. Under perfect conditions, a negligence rule will provide incentives for injurers to take the optimal level of care. In the next Section, I will deal with instances where courts set a level of due care that exceeds the level of optimal care. According to previous models, injurers will tend to exercise the excessive level of due care in order to avoid the sudden increase in liability. I will show, however, that, since the liability cost will be less than the cost of excessive care, injurers will exercise optimal care, even though that means that they become liable for negligence. Subsequently, in Section 4, I will consider cases where injurers are judgment proof or for other reasons expect to pay less than the actual harm caused by their negligence. It will be shown here that injurers will always exercise less than optimal care. In previous models, by contrast, liablity for less than actual harm did not necessarily result in such inadequate care. In Section 5, I investigate uncertainty about the required level of due care. The standard analysis found uncertainty often to cause an excessive level of care. But, in this paper, uncertainty will be shown to result in injurers' taking less than optimal care. In Section 6, I will examine

how incentives are affected by uncertainty over and requirements of proof for causation. I will argue that, where accidents caused by negligence cannot be distinguished from other accidents, requirements of proof of causation will ordinarily lead injurers to take less than optimal care. In Section 7, I will consider cases where the injurer, by being negligent, avoids some accidents that would have occurred had the injurer exercised due care. If these avoided accidents do not in some way correspond to accidents caused by the negligence, the liability of injurers would increase discontinuously. The previous models have not explicitly analyzed the possibility of such accidents. Finally, in Section 8, I will conclude the paper with a summary of the findings and some normative implications of the analysis.

1. The Model

Apart from explicitly modeling the causation requirement, the model developed in this paper does not differ significantly from the standard models[6]. The expected cost of accidents decreases with the level of care exercised by injurers. The cost of care increases with the level of care. The optimal or efficient level of care is the level at which the sum of costs of care and costs of accidents are minimized[7].

Injurers always bear the cost of care, and they bear liability for an accident if they are found to be negligent and if their negligence has caused the accident. Injurers will

be regarded as negligent if the observed level of care is less than due care. But even negligent injurers will not be liable for accidents that would have happened even if they had exercised due care[8]. Injurers try to minimize the sum of costs of care and expected liability for accidents.

2. Perfectly Operating Negligence Rule

In this model, as in the models not containing an explicit causation requirement[9], a perfectly enforced negligence rule with due care set at the optimal level of care will result in an efficient outcome[10]. Injurers that exercise due care will have to bear the cost of care but no liability for accidents. Injurers will not exercise more than due care since that would increase their cost of care without lowering their liability. By exercising less than due care, injurers would reduce the cost of care but incur some liability for accidents. However, the additional liability for accidents that would not have occurred had injurers exercised due care will exceed the reduction in cost of care. Otherwise, a lower level of care would have been optimal. Therefore, injurers will also not exercise less than due care[11].

Suppose, for example, our cricket field owner faces the following costs of accidents and care:

Height of Fence	Cost of Fence	Cost of Accidents	Total Costs
9	90	120	210
10	100	100	200
11	110	95	205

Due care is set at the optimal level of 10 feet.

If the owner exercises due care, he incurs a cost of 100 for a 10 foot fence. Since he exercises due care, he will not be liable for any accidents. Building an 11 foot fence would only increase costs by 10. Building a 9 foot fence would save 10 in building costs; but the owner would also face some liability since he exercised less than due care. With a 9 foot fence, cricket balls will cause accident costs of 120. However, 100 of these 120 are caused by balls flying over the fence at more than 10 feet and would have occurred even if the owner had exercised due care. Thus, his liability for accidents caused by his negligence would be 20, and his total costs would be 110, 10 more than if he takes due care. Under a perfectly operating negligence rule, the cricket field owner will therefore have incentives to exercise optimal care.

3. Due Care Set at Incorrect Levels

This Section will deal with cases where the level of due care exceeds or falls below the level of optimal care[12]. Several reasons might contribute to such mistakes in setting the level of due care. For example, the level of due care might be set by the legislature. Then, even after it became apparent that the legislature had set due care at a non-

optimal level, courts would have to follow the legislative determination of due care. Similarly, the level of care might be set by custom or by precedent, and courts might be slow to modify it. Courts might also make conceptual mistakes in determining the relevant costs. For example, in determining the cost of one extra foot of fence, courts might consider the cost of raising the fence by one foot instead of the (presumably lower) cost of building a higher fence to start with. Courts might also make predictable mistakes in the determination of the expected costs of accidents. Misestimated accident costs would then result in a non-optimal level of due care. Lastly, juries might exhibit predictable biases in determining the level of due care.

How will injurers react if the level of due care is set above optimal care? If injurers exercise optimal care, they are liable for those accidents that would not have occurred had they exercised due care. By increasing their level of care, they can reduce their liability. However, at optimal care, the cost of increasing care exceeds the cost of accidents avoided by increasing care. Therefore, it does not pay for injurers to increase care above optimal care[13].

This conclusion differs from the conclusion drawn by the standard models. In the standard models, injurers who go the extra step and exercise due care do not only avoid liability for the accidents avoided by the additional care. Rather, they also avoid liability for all those accidents that would have occurred even if they had exercised due care[14]; since, in the

standard models, negligent injurers are liable for these accidents as well. Therefore, in many cases, the reduction in liability will exceeed the increase in costs of care[15].

To illustrate this point, let us return to our cricket field owner. Due to price increases in fence construction, he faces the following situation:

Height of Fence	Cost of Fence	Cost of Accidents	Total Costs
9	100	120	220
10	130	100	230
11	160	95	255

The cost minimizing height of a fence is now 9 feet rather than 10 feet. His lawyer, however, informs him that, based on previous precedent, operating cricket fields with a fence of lower than 10 feet is regarded as negligent.

Building a 10 foot fence will cost 130 in fence construction, and the owner will not be liable for any accidents. If he builds a 9 foot fence, the building costs are 100 and he will be liable for the cost of accidents caused by balls flying over the fence at between 9 and 10 feet, i.e. for 20. The owner will, however, rather be liable for these accident costs of 20 caused by his failure to take due care than spend an extra 30 to build another foot of fence. Therefore, even though he will incur some liability, he will build an fence of optimal height for a total cost of 120.

By contrast, under the standard models, an injurer who becomes negligent faces a discontinuous jump in liability. Here, the owner, if he builds a 9 rather than 10 foot fence,

would be liable for all the accident costs of 120. By spending an extra 30 on the 10th foot, the owner could save himself this accident liability. Therefore, the owner would build a 10 feet fence at cost of 130 even though such a fence is inefficient.

It is interesting next to note the effects of setting the level of due care below optimal care. Under both the standard models[16] and this model[17], injurers will have no incentive to exercise more than due care. By merely exercising due care, they already avoid all liability for accidents. Therefore, they will exercise due care, i.e. less than optimal care, and only bear the cost of care[18]. To summarize the results of this Section, if due care is set above optimal care, injurers will exercise optimal care; but if due care is set below optimal care, they will only exercise due care.

4. Liability for Damages Less Than Harm Done

I will consider here how holding injurers liable for less than the full amount of harm done affects incentives to take care[19]. One reason why injurers might not have to pay the full amount of harm is that they are judgment proof, i.e. that they do not have enough assets to pay their liability. Corporations that enjoy limited liability are an especially important example of potentially judgment proof injurers. Another reason is that legal damages may be less than actual damages. For example, damages in wrongful death actions are often assessed with reference to lost earnings without taking into account

lost life enjoyment[20]. Similarly, not every person that suffered a loss might be entitled to be compensated; e.g., only certain family members might be permitted to sue for loss of consortium or companionship[21]. Lastly, expected liability might be less than actual damages because not all victims entitled to compensation bring suit.

For any of these reasons, the expected liability of injurers will be less than the amount of actual harm caused by their negligence. In those cases, even if the negligence rule operates otherwise perfectly, injurers will exercise less than optimal care[22]. At optimal care, cost savings from reducing care will be just less than the cost of additional accidents. But if expected damages are below actual harm done, the cost savings from reducing care will exceed the additional liability from negligence, i.e. it will pay for injurers to reduce their care[23].

To show this, let us return to our cricket field owner from Section 1:

Height of Fence	Cost of Fence	Expected Cost of Accidents	Total Costs
9	90	120	210
10	100	100	200
11	110	95	205

Let us further assume that all accidents cause harm of 200 and that exercising care affects only the expected number[24] of such accidents. I.e., if the fence is 10 foot high, the expected number of accidents is .5; if the fence is 9 foot high, the expected number is .6. Consequently, the expected

number of accidents caused by balls flying over the fence between 9 and 10 feet is .1. Further assume that the cricket field owner incorporates his field with a capital of 150 from which he must also build his fence.

If the owner builds a fence of 10 feet, he incurs construction costs of 100 and no liability. If he builds a 9 feet fence, he incurs construction costs of 90. In addition, he will be liable for any accident caused by balls passing between 9 and 10 feet. Any such accident, if it occurs, would eradicate the remaining corporate assets of 60. But since the corporation has no further assets, it will not have to pay more than 60. The owner's expected liability is therefore at most 6, the expected number[25] of such accidents times what the corporation will have to pay if an accident occurs. Total expected costs for a 9 foot fence are then 96 and thus less than the cost of 100 for the optimal fence.

It is not surprising that having to pay for less than actual harm done creates incentives to take less than optimal care. It should, however, be noted that the standard models regard liability for less than harm done as a much less serious concern than it is[26]. The sudden increase in liability when an injurer becomes negligent was thought to counteract the incentives to take less than optimal care[27]. In our example, if the owner builds a 9 foot fence, he would incur an expected liability of up to 36, i.e. assets of 60 times an expected number of accidents of .6. His total expected cost of building a 9 foot fence would then be 126 and thus

significantly larger than the cost of a 10 foot fence. Only if corporate assets were below 16 2/3 would the owner build a 9 foot fence. Thus, under the standard models, liability must be significantly less than harm done in order to induce injurers to take less than optimal care.

5. Uncertainty About the Level of Due Care

In this Section, I will analyze how uncertainty about the level of due care affects injurers' behavior[28]. To determine the optimal level of due care, courts need complete and accurate information on the cost of care and the expected cost of accidents for each level of care. But the data necessary to set the optimal level of care will often not be available. Moreover, once an accident has occurred, parties have an incentive to misrepresent the actual cost of care and expected cost of accidents in order to influence the determination of the level of due care. For such reasons, courts will not always succeed in setting due care at the optimal level. Even if courts, through a complex process, always succeeded in determining the optimal level of care after an accident has occurred, the injurers might not know before the accident what level of care is due. Thus, there will be uncertainty about the level of due care.

Similarly, courts will not always be able to observe perfectly the actual level of care exercised by the injurer. Measurement errors, insufficient evidence, and misrepresentation about the actual level of care will lead to

misestimates. Consequently, injurers exercising a certain level of care might not know whether they will be found negligent or not; either because they are not certain about the level of due care or because they are not certain what level of care they will be assessed to have exercised.

Except where injurers who exercise optimal care expect to be always found negligent[29], uncertainty about where due care will be set and what level of care they will be found to have exercised will cause them to take less than optimal care[30]. The reason is that injurers no longer bear the full cost of their negligence.

Where there was no uncertainty about the level of due care, injurers, when they moved from due care to less than due care, became liable for the cost of all the additional accidents they caused. However, when injurers are uncertain about the level of due care, their expected liability changes by less. At any possible level of due care, injurers already expected to be liable for some accidents, i.e. where courts set a higher level of due care. If they reduce their level of care, they will be held liable for the additional accidents they cause if they are found negligent. Since in some cases courts will set a lower level of due care, injurers will not always be found negligent. Therefore, additional liability for accidents will be less than the cost of additional accidents.

But injurers will still get the benefits of the reduced cost of care. At the level of optimal care[31], the cost savings from reduced care are just less than the additional cost of

accidents. Since, due to uncertainty, injurers will not expect to be liable for all the cost of additional accidents, they will have an incentive to exercise less than optimal care[32].

The standard models have arrived at opposite conclusions about the effects of uncertainty. They have argued that uncertainty will make injurers take more than optimal care[33]. The reason for this lies, again, in the sudden jump of liability as injurers exercise less than due care. When injurers become negligent, their liability in the standard models increases by more than the additional cost of accidents; it increases by the cost of all accidents whether or not caused by the injurer's negligence. Even injurers who will not always be found negligent would often have an expected liability of more than the additional cost of accidents. In these cases, injurers would take more than optimal care.

To illustrate these points, let us return to our example. The cost of care and accidents, slightly modified, are:

Height of Fence	Cost of Fence	Cost of Accidents	Total Costs
9	90	112	202
10	100	100	200
11	110	94	204

The cricket field owner is uncertain about the level of due care. He estimates that, with equal likelihood, either a fence of 9, 10, or 11 feet might constitute due care.

Under the standard models, the injurer would build an 11 foot fence to avoid a liability of 100 or 112 for building a

10 or 9 foot fence if due care is assessed to be at 11 foot. But, as the injurer is only liable for accidents caused by his negligence, his expected liability is:

Height of Fence	Liability if due care is 9ft 33%	10ft 33%	11ft 33%	Expected Liability
9	0	12*.33=4	18*.33=6	10
10	0	0	6*.33=2	2
11	0	0	0	0

The cricket field owner, if he builds a 10 foot fence, thus faces a total cost of 102 (100 for the fence, 2 for expected liability), a cost of 110 if he builds an 11 foot fence, but only a cost of 100 if he builds a 9 foot fence. Therefore, uncertainty results in the owner building a fence of less than optimal height.

6. Uncertainty About Causation and Burdens of Proof

In this Section, I will take a closer look at how uncertainty about causation affects incentives to take care. In general, it is not necessary that injurers expect always to be held liable for accidents caused by their negligence and never to be held liable for those not caused by their negligence. Rather, it is sufficient that their total expected liability is equal to the cost of accidents caused by their negligence. This total liability might include liability for some accidents not caused by their negligence but not include liability for some accidents caused by their negligence. As long as the total expected liability equals the accident

costs, injurers will have incentives to exercise optimal care[34].

An interesting case arises where accidents caused by negligence are indistinguishable from accidents that would have occurred even in the absence of negligence[35]. Assume, for example, that the expected number of cardiac arrests in operations depend on the level of care. The level of care is observable; but, if a cardiac arrest occurs, one cannot determine whether the cardiac arrest would have occurred at a different level of care[36]. In such cases, if the injurer is found to have been negligent, the only evidence on causation are the expected numbers of cardiac arrests occurring at that level of care due to negligence and due to other reasons.

Under ordinary circumstances, the victim bears the burden of proof that the negligence of the injurer has caused his accident[37]. If the victim can show that is was more likely than not that the injurer's negligence has caused his accident -- i.e. if, at that level of care, the expected number of cardiac arrests caused by negligence exceeds the expected number of cardiac arrests that would have occurred anyhow -- he will be compensated in full. If not, the injurer will not have to pay for any of these accidents.

Where due care is set at the optimal level, the possibility of such indistinguishable accidents in conjunction with the burden of proof will result in injurers taking less than optimal care. For slight departures from optimal care, only very few accidents will have been caused by negligence.

Therefore, for any single accident, the likelihood that it was caused by other causes will be much greater than the likelihood that it was caused by negligence. The victim will therefore not be able to meet the burden of proof, and the injurer will not be liable for any accidents[38]. Specifically, in the absence of other sources of uncertainty, the injurer will reduce care until the number of indistinguishable accidents caused by his negligence will be just below the number of accidents caused by other reasons[39]. At this point, the injurer will minimize his cost of care and still not incur any liability for accidents.

Interestingly, the liability pattern for such accidents bears some resemblance to the one in the standard models. When the injurer crosses the point where more than half of the accidents are caused by his negligence, his liability jumps discontinuously from no liability to liability for all such accidents[40]. However, this discontinuous jump will not occur at due care but at a level of care significantly below due care.

7. Avoided Accidents

So far, it has been assumed that exercising less than due care causes the same accidents as due care and, in addition, some further accidents. It is, however, also possible that exercising less than due care, while increasing the total cost of accidents, helps to avoid some accidents that would have occurred under due care. In such cases, the cost of accidents

for which negligence was the cause in fact exceeds the difference between the cost of accidents at the negligent level of care and the cost of accidents at due care. Then, if injurers are liable for all accidents for which their negligence was the cause in fact and if they are not, in some way, rewarded for avoiding accidents, their liability will increase discontinuously as they exercise slightly less than due care.

Some of these accidents that are avoided by being negligent fall into categories of accidents whose ex ante probability has not been changed by the negligence[41]. For example, such a category of accidents consists of trolleys running at excessive speeds that are crushed by a falling trees[42]. Negligent speeding will avoid instances of this type of accidents that occur in the absence of negligence (since a trolley hit a by falling tree while going at regular speed would have been at a different location had it run at a higher speed); but the ex ante probability of being crushed by a falling tree (i.e of any accidents within the category rather than for a specific instance) will not have been changed by the negligence. In such cases, injurers are not liable for even those accidents for which their negligence was a cause in fact, since it was not a proximate cause of the accident[43]. Thus accidents that, while they would not have occurred had the injurer exercised due care, fall into categories of accidents whose ex ante probability was not affected by the

negligence do not cause liability to exceed the additional harm caused by negligence.

However, some accidents might not lend themselves to such a categorization. Consider, for example, a desease for which two treatments exist. Treatment A has a side-effect of causing headaches (costs of 100); treatment B has a side-effect of causing stomach-aches (costs of 150). Suppose treatment B is regarded as negligent. All stomach-aches are caused (in fact) by the negligence, and no portion of the stomach-aches can be classified in a way that their probability was not increased by the negligence. In such a case, injurers would be liable for all the accident costs of 150, i.e. for more than the additional harm of 50 caused by their negligence. Nor would injurers be able to get restitution for the headaches that were avoided by their negligence. Thus, if such accidents occur at due care, the liability of injurers increases discontinuously by the cost of these accidents when injurers become negligent -- as posited by the standard models.

The importance of the latter type of accidents is, however, questionable. In many cases, practically none of the accidents occurring at due care will fall into this class. Where, for example. the negligence consists of not having enough lifeboats, of not guarding holes in platforms, of not carryong a radio on a tugboat, or of not insulating electric lines, it is hard to imagine what accidents were avoided by the negligence. Even in those cases were the negligence helped to avoid some accidents, it is unlikely that all accidents

that would have occurred at due care were avoided by the negligence. In those cases, the standard models, by assuming that injurers become liable for all accidents, at least overstate the degree of discontinuity.

8. Concluding Remarks

Before summarizing the conclusions of this paper, it is appropriate to briefly reconsider the main assumption that underlies this analysis, i.e. that injurers are only liable for accidents if they acted negligently and if their negligence was the cause for the accident. While these assumptions restate the doctrine on causation, a plausible argument can be made that, in some circumstances, the doctrine is actually applied in a different way.

Factfinders can be thought of as having difficulty in determining the exact level of due care and in engaging in the counterfactual inquiry of whether at that level the accident would have occurred anyway. Some factfinders might find themselves unable to answer these questions with any confidence and might therefore act on considerations other than the actual likelihood of causation. For example, if they prefer to arrive at a consistent verdict (in the sense of favoring the same party on all issues) and if they want to punish the wrongdoer, they might semi-automatically find that the negligent injurers had also caused the accident at hand. In such cases, the standard models would inadvertently capture the essence of the law as it is applied. A finding of

negligence would in the mind of the factfinder create a presumption of causation. Once an injurer becomes negligent, he would become de facto liable for a greater number of accidents.

But it is also plausible to assume that some factfinders resolve these difficult questions in the favor of injurers. Rather than striving for consistency, factfinders might be inclined to compromise and find for the injurer on the question of causation after finding for the victim on the question of negligence. Or, as mentioned above, where causation is hard to establish, the requirement that causation be proven with the preponderance of the evidence might lead factfinders to deny any recovery.

In analyzing negligence law from the perspective of deterrence, however, the actions of individual factfinders is not of ultimate interest. What is important is how injurers expect the law to be applied, and this will depend on what factfinders in general are expected to do. And, in most cases, factfinders in general can be expected to try to act in accordance with the legal doctrine. I will therefore proceed to summarize how incentives to take care are affected in a regime where injurers must be shown both to have acted negligently and to have caused the accident.

First, setting due care at non-optimal levels has asymmetric effects. If the level of due care is too low, injurers will exercise less than optimal care. But if the level is too high, injurers will exercise optimal care. Under

the standard models, injurers would often exercise due care even if due care exceeded optimal care.

In both models, expectations to be held liable for less than the cost of accidents caused by negligence lessen incentives to take care. However, in the standard models, these lower incentives are not regarded as a serious problem since the jump in liability provides a strong incentive not to take less than due care. In this model, injurers are only liable for the accidents caused by their negligence. Therefore, any reduction in incentives to take care constitutes a serious problem.

Thirdly, the models come to opposite conclusions about the effects of uncertainty on the level of care. In the standard models, uncertainty causes injurers to exercise more than optimal care. In our model, uncertainty causes injurers to exercise less than optimal care.

If injurers are only liable for accidents caused by their negligence, the existence of indistinguishable accidents in conjunction with the usual burden of proof will create incentives to take less than due care. Unless injurers are grossly negligent, victims will have a hard time meeting the burden of proof on causation. Thus injurers will not be found liable for any of these indistinguishable accident even though their negligence has caused some them.

Lastly, to the degree to which accidents occurring at due care are avoided by exercising a lower level of care and the avoided accidents cannot be classified into categories of

accidents whose probability has not been affected by lowering care, injurers face a jump in liability as they become slightly negligent. The significance of such accidents is, however, generally not great.

The normative implication of most of these conclusions is to hold injurers to a higher level of care. Too high due care by itself will not make injurers exercise too much care, but too low due care will make them exercise too little care. A higher expected level of due care will counteract uncertainty about the level of due care and thus reduce incentives to exercise less than optimal care. And, lastly, a higher level of due care will reduce problems created by victims' inability to meet the burden of proof on causation.

The view of negligence taken in this paper also has some implications for the debate over the comparative merits of negligence and strict liability. One of the problems associated with negligence is the difficulty of determining the level of optimal care. It was previously thought that, whenever due care differs from optimal care, injurers would exercise due care and not optimal care. Therefore, the desirability of the negligence rule strongly depended on the ability to determine optimal care accurately.

This paper shows that even if due care exceeds optimal care, injurers will exercise optimal care. This makes the negligence rule significantly less sensitive to errors in the determination of optimal care. Whenever there is doubt about the level of optimal care, courts, juries, or legislatures

should just adopt the higher estimate of optimal care as due care.

Appendix

The Model

The cost of accidents A and the cost of care C are continuous functions of the level of care x. The cost of care increases with the level of care at increasing rates; the cost of accidents decreases with the level of care at decreasing (i.e., in absolute terms, increasing) rates:

$A'(x) < 0$ $\qquad$ $C'(x) > 0$

$A''(x) > 0$ $\qquad$ $C''(x) > 0$

Total costs to society S are the sum of cost of care and cost of accidents:

$$S(x) = C(x) + A(x)$$

The cost to injurers J is the sum of the cost of care and the cost of liablity L. The cost of liability L is a function of the cost of negligence N. Where the exercised level of care is greater then or equal to the level of due care $\bar{x}$, the cost of negligence is 0. At any lower level of care, the cost of negligence equals the excess of the cost of accidents at that level over the cost of accidents at the level of due care.

$$N = \begin{cases} 0 & \text{if } x \geq \bar{x} \\ A(x) - A(\bar{x}) & \text{if } x < \bar{x} \end{cases}$$

Since the limit of $A(x) - A(\bar{x})$ for x approacing $\bar{x}$ is 0, the function N is continuous. As $A(\bar{x})$ will be constant given the level of due care, N will be a monotonously decreasing function of x whose second derivative is non-negative.

The optimal level of care x^* is the level at which costs to society are minimized. Therefore, at the optimal level, it must hold that:

(1) $S'(x^*) = C'(x^*) + A'(x^*) = 0$

(2) $S''(x^*) = C''(x^*) + A''(x^*) > 0$

As $C''(x)$ and $A''(x)$ are always greater than 0, (2) is satisfied at all levels of x. This also means that $S'(x)$ is strictly monotonously increasing. Therefore, there will only be one level of x that meets (1); and it will further hold that:

(3) $C'(x) + A'(x) < 0 \quad \text{if } x < x^*$

(4) $C'(x) + A'(x) > 0 \quad \text{if } x > x^*$

Injurers will exercise care at the level that minimizes cost to injurers. Therefore, at the level of care exercised,

(5) $J'(x) = C'(x) + L'(x) = 0$

(6) $J''(x) = C''(x) + L''(x) > 0$

If, at any point at which J is continuous, the derivatives are not defined, a change in sign from negative to positive signals a minimum, a change from positive to negative signals a maximum, and no change signals the absence of extreme values.

<u>Proposition 1: If due care is set at optimal care (and injurers are liable for the cost of negligence), injurers will exercise due care.</u>

If $\bar{x} = x^*$ and $L(x) = N(x)$, the cost to injurers will be

$$J(x) = \begin{cases} C(x) & \text{if } x \geq x^* \\ C(x) + A(x) - A(x^*) & \text{if } x < x^* \end{cases}$$

As $A(x^*)$ is a constant, the derivative of J is

$$J'(x) = \begin{cases} C'(x) & \text{if } x > x^* \\ C'(x) + A'(x) & \text{if } x < x^* \end{cases}$$

The derivative of J at $x = x^*$ is not defined. However, J is a continuous function; J' is positive for $x > x^*$ since $C'(x) > 0$; and, J' is negative for $x > x^*$ (see (3)). Therefore, J will have the only minimum at x^*; i.e. injurers will exercise optimal care.

Proposition 2: If due care is more than optimal care (and injurers are liable for the cost of negligence), injurers will exercise due care.

If $x^- > x^*$ and $L(x) = N(x)$, the cost to injurers is a continuous function given by

$$J(x) = \begin{cases} C(x) & \text{if } x \geq x^- > x^* \\ C(x) + A(x) - A(x^-) & \text{if } x < x^- \end{cases}$$

with a first derivative

$$J'(x) = \begin{cases} C'(x) & \text{if } x > x^- > x^* \\ C'(x) + A'(x) & \text{if } x < x^- \end{cases}$$

The cost to injurers will have a minimum at x^* (see (1)). Since J is continuous and since $J' > 0$ for all $x > x^*$ (except x^- where it is not defined), there is no change in sign at x^-. Therefore, the minimum at x^* is the only miminum; i.e. injurers will exercise optimal care.

Under the standard models, J is not continuous at $\bar{x}$. Therefore, even though J will have a local minimum at x^*, the discontinuous drop in liability as $\bar{x}$ is approached from the left can result in a lower minimum at $\bar{x}$.

Proposition 3: If due care is less than optimal care (and injurers are liable for the cost of negligence), injurers will exercise due care.

If $\bar{x} < x^*$ and $L(x) = N(x)$, the cost to injurers is again given by

$$J(x) = \begin{cases} C(x) & \text{if } x \geq \bar{x} \\ C(x) + A(x) - A(\bar{x}) & \text{if } x < \bar{x} < x^* \end{cases}$$

with the first derivative

$$J'(x) = \begin{cases} C'(x) & \text{if } x > \bar{x} \\ C'(x) + A'(x) & \text{if } x < \bar{x} < x^* \end{cases}$$

For $x > \bar{x}$, J' is positive. For $x < \bar{x} < x^*$, J' is negative (see (3)). Since J is continuous, it has the only minimum at $\bar{x}$. Thus, injurers will exercise due care, i.e. less than optimal care.

Proposition 4: If injurers are liable for only a fraction $q < 1$ of the cost of negligence (and if due care is set at optimal care), they will exercise less than optimal care.

Assume that the liability of injurers L is a constant fraction $q < 1$ of the accidents caused by negligence, i.e.

$$L(x, \bar{x}) = q*N(x, \bar{x}) \quad \text{with } 0 < q < 1$$

Then

$$L' = q^*N'.$$

With $\bar{x} = x^*$, the cost to injurers is

$$J(x) = \begin{cases} C(x) & \text{if } x \geq x^* \\ C(x) + q^*[A(x) - A(x^*)] & \text{if } x < \bar{x} \end{cases}$$

and the first derivative

$$J'(x) = \begin{cases} C'(x) & \text{if } x > x^* \\ C'(x) + q^*A'(x) & \text{if } x < x^* \end{cases}$$

As $A'(x) < 0$, it will hold that $q^*A'(x) > A'(x)$ and thus $C'(x) + q^*A'(x) > C'(x) + A'(x)$. Therefore, $J'(x)$ must have a minimum at $x < x^*$ (see (1) and (3)). Since J is continuous and $J' > 0$ around x^*, this minimum will be the only minimum; i.e., injurers will exercise less than optimal care.

Under the standard models, J is not continuous at $x^* = \bar{x}$. Therefore, even though J will have a local minimum at less than x^*, the discontinuous increase in liability as $\bar{x}$ is approached from the right can result in a lower minimum at $\bar{x} = x^*$.

<u>Proposition 5: If injurers are liable for a multiple $m > 1$ of the cost of negligence (and due care is set at optimal care), they will exercise optimal care.</u>

Assume that the expected liability of injurers is a constant multiple $m > 1$ of the accidents caused by negligence, i.e.

$$L(x, \bar{x}) = m^*N(x, \bar{x}) \quad \text{with } m > 1$$

Then

$L' = m*N'$

With $\bar{x} = x^*$, the cost to injurers is

$$J(x) = \begin{cases} C(x) & \text{if } x \geq x^* \\ C(x) + m*[A(x) - A(x^*)] & \text{if } x < x^* \end{cases}$$

and the first derivative

$$J'(x) = \begin{cases} C'(x) & \text{if } x > x^* \\ C'(x) + m*A'(x) & \text{if } x < x^* \end{cases}$$

As $A'(x) < 0$, it will hold that $m*A'(x) < A'(x)$ and thus $C'(x) + m*A'(x) < C'(x) + A'(x)$. Therefore, for $x > x^*$, $J'(x)$ will be positive and for $x < x^*$, $J'(x)$ will be negative. Since J is continuous, it will have the only minimum at x^*; i.e., injurers will exercise optimal care.

Proposition 6: If the level of due care is uncertain and there is a positive probability that less than optimal care constitutes due care (and injurers bear the full cost of negligence), injurers will take less than optimal care. If the expected level of due care is less than optimal care, it is unclear whether injurers will exercise more or less than the expected level of due care.

Assume there is a continuous probability distribution P that assigns to each level of care a probability that it will turn out to be due care. As $L(x) = N(x)$, injurers' cost of liability is the sum, for all levels of care z greater than care taken x, of the probability that such care z is due care $\bar{x}$ times the difference between the cost of accidents at the

level of care taken A(x) and the cost of accidents at the level of such due care A(z).

$$L(x) = \sum_{z>x} P(z=x^{-}) * [A(x) - A(z)]$$

Liability can thus be regarded as a product of a probability portion and a liability portion. As the level of care changes decreases from x to x°, the liability portion will change in the following way. Where $z >= x$, the liability portion changes by $A(x) - A(x^{\circ})$, i.e. by the change in accident costs; and where $x < z < x^{\circ}$, the liability portion changes by $A(z) - A(x^{\circ})$, i.e. by less than the change in accident costs. Thus, the liability portion changes at most by the change in accident costs. However, as long as there is a possibility that due care is less than the level of care exercised, the probability portion will have a value of less than 1. Therefore, liability will change by less than the change in the liability portion. Assume L'(x) is defined at all point. Then $L'(x) <= 0$ and (in absolute terms) $L'(x) > A'(x)$. Therefore, at optimal care, $J'(x^{*}) > 0$ (see (1); similarly, at $x > x^{*}$, $J'(x) > 0$ (see (4)). Since costs are reduced by lowering care whenever $x >= x^{*}$, J must have a minimum below x^{*}; i.e. injurers will take less than optimal care.

If the expected value of due care is below optimal care, it is unclear whether injurers will exercise more or less than the expected value of due care. At such levels of due care $C'(x^{-}) + A'(x^{-}) < 0$. Even though $C'(x^{-}) + L'(x^{-}) > C'(x^{-}) +$

$A'(\bar{x})$, it is unclear whether $C'(\bar{x}) + L'(\bar{x}) > 0$. If it is, injurers will increase the level of care above $\bar{x}$; if not, they will decrease it below $\bar{x}$.

Under the standard models, the liability portion, where $x < z < x^{\circ}$, changes by $A(z)$ and not by $A(z) - A(x^{\circ})$. Thus the liability portion changes by more than the change in accident costs and, even though the probability portion will have a value of less than 1, liability can change by more than the change in accident costs. Then the cost to injurers would be reduced by increasing care.

Proposition 7: When some accidents caused by negligence are indistinguishable from accidents that would have occurred anyway and causation must be proven with a probability of at least 50% (and due care is set at optimal care), injurers will take less than optimal care.

At the level of care x less than due care, negligence will have caused accident costs of $A(x) - A(\bar{x})$. Assume that a fraction g of these accidents are indistinguishable from a fraction h of accidents that would have occurred in the absence of negligence. The probability that any given accident of these accidents was caused by negligence is then

$$\frac{g*(A(x)-A(\bar{x}))}{g*(A(x)-A(\bar{x})) + h*A(\bar{x})}$$

To hold an injurer liable, it must be shown that this probability exceeds 50%. Since, as x moves towards $\bar{x}$, $A(x)-A(\bar{x})$ moves towards 0, there will always be an $x < \bar{x}$ for

which the probability will not exceed 50% (or, for that matter, any threshold probability). In these cases, injurers will only bear a fraction (1-g) of the cost of negligence. As shown in Proposition 4, injurers will then exercise less than optimal care.

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1 See e.g. Restatement (Second) of Torts, sec. 432(a) (1964) (negligent conduct is not the legal cause for harm if harm would have been sustained if actor had not been negligent); id. sec. 454, comment a (if some harm would have happened in absence of negligence, actor is liable only for additional harm); Harper, James & Grey, The Law of Torts (2nd ed., 1986) sec. 20.2 (defendant's negligence is a cause in fact of an injury if the injury would not have occurred but for defendant's negligent conduct). In the words of Prosser, "A failure to fence a hole in the ice plays no part in causing the death of runaway horses which could not have been halted if the fence had been there, though of course making the hole did play a part. A failure to have a lifeboat ready is not a cause of the death of a person who sinks without trace immediately upon falling into the ocean, though taking the person out to sea was a cause. The failure to install a proper fire escape on a hotel is no cause of the death of a man suffocated in bed by smoke. The omission of crossing signals by an approaching train is of no significance when an automobile driver runs into the sixty-eighth car. The presence of a railroad embankment may be no cause of the inundation of the plaintiff's land by a cloudburst which would have flooded it in any case." (footnotes omitted) Prosser and Keeton On Torts (5th ed. 1984) sec. 41.

2 Injurers will also have incentives to take care inasmuch as additional care reduces the amount of damages for which they are liable. For simplicity this analysis will assume that care affects only the likelihood of but not the magnitude of damages in accidents. Thus negligence will have caused either all or none of the damages in a particular accident. The results of this analysis depend, however, in no way on this assumption. Cf. Restatement (Second) of Torts, sec. 454 (1964).

3 See e.g. Brown, Toward an Economic Theory of Liability, 2 J. Legal Stud. 323 (1973) (analyzing various perfectly operating liability rules); Calfee & Craswell, Some Effects of Uncertainty on Compliance with Legal Standards, 70 Va. L. Rev.

965 (1984) [hereinafter cited as Calfee & Craswell, Some Effects of Uncertainty]; Cooter, Economic Analysis of Punitive Damages, 56 S. Cal. L. Rev. 79 (1982); Craswell & Calfee, Deterrence and Uncertain Legal Standards, 2 J. L. Econ. & Organization 279 (1986) [hereinafter cited as Craswell & Calfee, Deterrence]; Diamond, Accident Law and Resource Allocation, 5 Bell J. Econ. 366 (1974) (analyzing equilibria under various liability rules) [hereinafter cited as Diamond, Accident Law]; Diamond, Single Activity Accidents, 3 J. Legal Stud. 107 (1974) [hereinafter cited as Diamond, Single Activity Accidents]; Landes & Posner, Joint and Multiple Torts: An Economic Analysis, 9 J. Legal Stud. 517 (1980) (analyzing incentives to take precautions were accidents are caused by more than one injurer); Landes & Posner, The Positive Economic Theory of Tort Law, 15 Ga. L. Rev. 851 (1981), (analyzing various liability rules); Polinsky, Strict Liability vs. Negligence in a Market Setting, 70 Am. Econ. Rev. 363 (1980) (analyzing long-run effects of negligence rule on output, price and entry); Shavell, Uncertainty Over Causation and the Determination of Civil Liability, 28 J. L. & Econ. 587 (1985) (analyzing the impact of threshold probability requirements in proving causation on incentives to take care) [hereinafter cited as Shavell, Uncertainty]; Shavell, The Judgment Proof Problem, 6 Int'l. Rev. L. & Econ. 45 (1986) (hereinafter cited as Shavell, Judgement Proof]; Summers, The Case of the Disappearing Defendant: An Economic Analysis, 132 U. Pa. L. Rev. 145 (1983) (likelihood of insolvency and incentives to take care).

To say that the standard models have not incorporated the causation requirement does not mean that causation has been ignored in the law and economics literature. To the contrary, in less systematic analyses of negligence law, it has generally been recognized that injurers are not liable for accidents that would have occurred even if they had not been negligent. See e.g. Calabresi, Concerning Cause and the Law of Torts, 43 U. Chi. L. Rev. 69 (1975) (explains but for causation as creating incentives for injurers to decide whether safety costs exceed injury costs); Richard Posner, Economic Analysis of Law (1986) (concluding that imposing liability for accidents that would not be prevented by non-negligence is like imposing punitive damages).

Several more systematic analyses of negligence law also model causation but either fail to integrate the causation requirement into the general analysis or do not analyze the implications. See Shavell, An Analysis of Causation and the Scope of Liability in the Law of Torts, 9 J. Legal Stud. 463 (1980) (relating causation to the scope of liability); Steven Shavell, Economic Analysis of Accident Law 105-126 (1987), (analyzes causation separately, but does not integrate cuasation requirement into the analysis of other issues) [hereinafter cited as Shavell, Economic Analysis]; Landes & Posner, Causation in Tort Law: An Economic Approach, 12 J.

Legal Stud. 109 (1983) (comprehensive analysis of causation, but causation requirement is only integrated into a perfectly operating negligence model); see also Grady, Proximate Cause and the Law of Negligence, 69 Iowa L. Rev. 363 (1984) (notes that standard models have incorrectly assumed the negligent injurers bear liability for all accidents; and argues without proving that uncertainty would typically induce suboptimal care).

[4] See Brown, supra, at 328. According to equations (9), (10), (11), describing various negligence rules, negligence and contributory negligence result in complete shifts of the liability for accidents - L(X,Y) - from injurers to victims, and vice versa. Calfee & Craswell, Some Effects of Uncertainty, supra, at 975. As depicted in figure 2, defendants who are negligent - i.e. whose level of care is to the right of x^* - are liable for all accidents including those that would have occurred anyway at x^*, thus causing a discontinuous jump in liability. Cooter, supra, at 99. Negligent injurers bear an expected liability of [1-p(x)]qd reflecting the expected cost of all accidents discounted by the probability that the victim will not press his claim. Craswell & Calfee, Deterrence, supra, at 280-281. In the basic model, negligent injurers are liable for all expected losses L(x) to others. Craswell and Calfee later introduce an incremental damages rule according to which injurers are not liable for accidents that would have occurred in the absence of negligence. Id. at 295-297. Apparently, however, Craswell and Calfee regard the damage rule in their basic model and not the incremental rule as the "normal damage rule()." Id. at 299. Diamond, Accident Law, supra, at 373. According to equation (13), if the injurer is negligent and the victim not contributory negligent, the whole expected costs of accidents C(x,y) get shifted to the injurer. Diamond, Single Activity Accidents,, supra, at 117. Equations (10) and (11) assume that the negligence of other parties shifts the costs of one's own accidents completely to the other party. Landes & Posner, Joint and Multiple Torts: An Economic Analysis, 9 J. Legal Stud. 517, 522 (1980). As evident from Table 1, the expected cost of accidents - p(x,y,z)D - is born in full either by injurers or the victim, i.e. accidents are not separated into those caused by negligence and those not. Landes & Posner, The Positive Economic Theory of Tort Law, 15 Ga. L. Rev. 851 (1981). According to equation (8), negligent injurers are liable for all the expected damages - p(0, yo)D. Polinsky, supra, at 364. According to equation (8), negligent injurers are liable for all the external damages D(z)). Shavell, Uncertainty, supra, at 597-599. In determining the probability of an accident having been caused by negligence, accidents that are caused by the injurer's activity but that would have occurred even if the injurer had exercised due care, are regarded as accidents caused by negligence. Shavell, Judgment Proof, supra, at 48. According to equation (5), the expected utility of negligent injurers is the same as the expected

utility of injurers under strict liability; i.e. injurers are liable for all accidents including those that would have occurred had they exercised due care. Summers, supra, at nn. 20, 24. As evident from the example, the negligent injurer is liable for all the expected damages. See also Shavell, Economic Analysis, supra. Except in the chapter dealing with causation, negligent injurers are modeled to be liable for all accidents. See id. equation (2.1) at 34, equation (4.8) at 94, figure 4.3 at 98, or figure 7.1 at 181.

[5] This hypothetical was inspired by Bolton v. Stone, [1951] A.C. 850. Cause in fact was, however, not an issue in this case.

[6] See, e.g. Brown, supra, at 324-327; Craswell & Calfee, Deterrence, supra, at 280-283; Shavell, Economic Analysis, supra 33-40. The parts of the model dealing with causation do also not differ significantly with the treatment of causation in the previous literature. Landes & Posner, Causation in Tort Law: An Economic Approach, 12 J. Legal Stud. 109 (1983); Shavell, Economic Analysis, supra, 119-123.

[7] This definition of optimal care will result in both a Pareto optimal and Kaldor-Hicks efficient level of care. For an explanation and critical evaluation of these concepts, see Colemann, Efficiency, Utility and Wealth Maximization, 8 Hofstra L. Rev. 509 (1980). In any case, the positive results of this analysis can be easily adapted to any other definition of an optimal level of due care. The analysis only explores incentives to depart from the cost minimizing level of care. Depending on whether a differently defined optimal level of care is higher or lower than the cost minimizing level, one would hold differing normative views on these incentives.

[8] Injurers will also not be liable for accidents whose ex ante probability of occurrence was not increased by the exercise of less than due care. See Landes & Posner, Causation and Tort Law: An Economic Approach, 12 J. Legal Stud. 109, 119-120 (1983); cf. Shavell, An Analysis of Causation and the Scope of Liability in the Law of Torts, 9 J. Legal Stud. 463 (1980); see also infra Section 7.

[9] See e.g. Brown, supra, at 340-343.

[10] This result has been noted previously in models incorporating causation. See Shavell, Economic Analysis, supra, 105-115, 118-123.

[11] A formal proof for this result is contained, infra, in the Appendix, Proposition 1.

[12] The problem of due care set at other than the optimal level has been addressed by the previous literature in Shavell, Economic Analysis, supra, 83; Diamond, Single Activity

Accidents, supra, at 123-134, 139-140; see also Craswell & Calfee, Deterrence, supra, (effect of a less than optimal level of due care in presence of uncertainty).

[13] For a formal proof, see infra, Appendix, Proposition 2.

[14] See Shavell, Economic Analysis, supra, 83, 97-99; Diamond, Single Activity Accidents, supra, at 128-134, 139-140.

[15] Perversely, if due care is set at a level high enough above optimal care, injurers will take optimal care rather than due care. At that level, the cost difference between exercising due and optimal care is equal or above the cost of accidents at optimal care. See Shavell, Economic Analysis, supra, 97-98; Diamond, Single Activity Accidents, supra, at 128-134.

[16] See Shavell, Economic Analysis, supra, 83, 97-99; Diamond, Single Activity Accidents, supra, at 123-128, 139-140.

[17] See infra, Appendix, Proposition 3.

[18] To illustrate what happens if due care is set below optimal care, consider the example of Section 2 with a 9 foot fence constituting due care:

Height of Fence	Cost of Fence	Cost of Accidents	Total Cost
9	90	120	210
10	100	100	200
11	110	95	205

Building a 9 foot fence would cost the owner just 90 for building cost; he would not bear any liability for accidents. Building a higher fence would just increase costs of care without creating an offsetting benefit in reduced accident liability.

[19] For previous commentators analyzing the problems caused by liability for less than full harm, see Shavell, Economic Analysis, supra, 167- 170, 179-182; Summers, supra; Shavell, Judgment Proof, supra; Cooter, supra; see also Shavell, Economic Analysis, supra, 146-151, 159-163; Cooter, supra, for liability in excess of losses.

[20] Harper, James & Grey, The Law of Torts (2nd ed., 1986) sec. 24.2.

[21] Id. secs. 8.8, 8.9.

[22] It should be noted that, under an otherwise perfectly operating rule, holding negligent injurers liable for more

than actual damages will not result in the exercise of more than optimal care. At optimal care, injurers will never be found negligent and therefore are not influenced by an expectation to pay more than actual damages if they were to be found negligent. See infra Appendix, Proposition 5. However, if due care is set at a supra-optimal level or if injurers are uncertain about the level of due care, an expectation to pay more than actual damages can lead to excessive care.

[23] If costs of care and costs of accidents are continuous, injurers will exercise less than optimal care independent of the degree to which expected damages are below harm done since, at the margin, changes in cost of care equal changes in cost of accidents. See infra Appendix, Proposition 4.

[24] The previous literature often regarded the level of care as influencing the probability rather than the expected number of accidents. See e.g. Landes & Posner, Causation in Tort Law: An Economic Approach, 12 J. Legal Stud. 109 (1983). Expected number and probability are related concepts. The expected number is calculated by summing, for example, the probability of one ball passing the fence and injuring bypassers times 1, the probability of two balls passing the fence and each injuring bypassers times 2, etc. To calculate the expected cost of accidents, one has to use the expected number of accidents rather than the probability of an accident occurring.

[25] Using the expected number can actually lead to an overstatement of the expected liability of the injurer. If more than one accident occurs, only the first victim will be compensated by the remaining assets; the subsequent victims will not be compensated at all. To calculate the expected liability in such situations, the assets of the injurer must be multiplied with the probability of at least one accident occurring. This figure will usually be lower than the product of the assets and the expected number of accidents.

[26] See Shavell, Economic Analysis, supra 167- 169, 179-181; Summers, supra, at 157-159 (1983); Shavell, Judgment Proof, supra, at 47-49.

[27] Cooter, supra, at 89-91, uses this property in an ingenious way to explain punitive damages. In his analysis, depending on the degree to which legal damages are below actual damages, injurers with perfect foresight would find it optimal either to exercise due care or substantially less than due care. Injurers than are marginally negligent are then taken as having tried to exercise due care but failed to do so because they made a mistake about the required level of due care. Once they realize their error, they would, however, exercise due care. Injurers who are grossly negligent, however, are taken as having intentionally failed to exercise due care. Even after they find themselves liable for regular damages, they

will continue to exercise less than due care. Therefore, large punitive damages are needed to provide incentives for them to exercise due care.

The analysis in this paper suggests that this qualitative distinction between injurers that either try to exercise due care or substantially less than due care does not exist. Rather than trying to exercise either due care or substantially less than due care, injurers that do not expect to be liable for the full harm caused would exercise inadequate care over the full spectrum -- if their liability is slightly less than harm done, they will exercise slightly less than due care; if their liability is significantly less than harm done, they will exercise significantly less than due care, etc. Punitive damages of various sizes are therefore needed to induce compliance with due care.

[28] The effects of uncertainty have been analyzed by the previous literature in Shavell, Economic Analysis, supra, 79-83, 93-99; Calfee & Craswell, Some Effects of Uncertainty, supra; Craswell & Calfee, Deterrence, supra; see also Diamond, Single Activity Accidents, supra, at 123-140 (stochastic control and measurement of care); Diamond, Accident Law, supra, at 400-404, 139-140 (errors in measurement of care). But see Grady, supra, at 399-409 arriving at conclusions similar to this paper.

[29] If, at optimal care, injurers are certain to be found negligent, they will exercise optimal care since, if they reduce care, they will bear liability for all additional accidents. See infra Appendix, Proposition 6.

[30] See infra Appendix, Proposition 6.

[31] If the expected level of due care is below optimal care, injurers will still exercise less tha optimal care but possibly more than the expected level of due care. Injurers who vary their level of care from the expected level of due care only reduce their liability by a fraction of the decreased accident costs. But this fraction might still exceed the changes in cost of care since, at the sub-optimal level of expected due care, changes in accident costs exceed changes in cost of care. Thus, uncertainty might induce injurers to exercise more care than they would have otherwise. See infra Appendix, Proposition 6.

[32] That uncertainty will always result in sub-optimal care might seem counterintuitive. For example, if there is a 90% probability that due care is above optimal care and only a 10% probability that due care is below optimal care, injurers should expect to be liable for more accidents than if due care were certain to be at optimal care. And if injurers are liable for more accidents, one is at first inclined to believe that they would exercise more care. But holding injurers liable for

more accidents will only lead them to take more care if they thereby avoid liability. In other words, the marginal change in liability and not the total liability determines how much care injurers will exercise. Uncertainty will, however, result in a decrease in marginal liability in the relevent parts.

For optimal deterrence, two conditions must be met. First, injurers who exercise less than optimal care must bear no less than the full marginal cost of accidents; otherwise it would pay to exercise less care. Secondly, injurers who exercise more than optimal care may not bear more than the marginal cost of accidents; otherwise it would pay to exercise more care.

Under a perfectly operating negligence rule, injurers who exercise less than optimal care bear the marginal cost; injurers who exercise more than optimal care bear no cost. Thus both conditions are met. Under uncertainty, injurers who exercise less than optimal care bear less cost than before since they are sometimes not found negligent. Therefore, the first condition will no longer be met, and injurers will exercise less than optimal care. Injurers who exercise more than optimal care bear more cost than before (but not enough to induce more than optimal care) since they are sometimes found negligent. Therefore, total liability might have increased even though marginal liability for injurers who exercise less than optimal care has decreased.

[33] See Shavell, Economic Analysis, supra, 79-83, 93-99; Calfee & Craswell, Some Effects of Uncertainty, supra, at 974-984; Craswell & Calfee, Deterrence, supra, at 285-287; see also Diamond, Single Activity Accidents, supra, at 134-140.

[34] If total liability is expected to be below accident costs, the results are equivalent to holding injurers liable for less than the full amount of harm done. See also supra Section 4. For total liability in excess of the full amount of harm done, see supra footnote 22.

[35] Uncertainty over causation in indistinguishabe accidents has been analyzed before by Shavell, Uncertainty, supra; see also Shavell, Economic Analysis, supra, 115-118, 123-126.

[36] This hypothetical was inspired by Quintal v. Laurel Grove Hospital, 62 Cal.2d 154, 397 P.2d 161, 41 Cal.ptr. 577 (1964).

[37] Restatement (Second) of Torts, sec. 328A (c), 433B (1). The burden of proof shifts, however, to the injurer if several injurers acted negligently and it is uncertain whose negligence has caused the accident. Id. sec. 433B (3); see also Summers v. Tice, 33 Cal.2d 80, 199 P.2d 1 (1948). In some cases of multiple tortfeasors, damages are apportioned in proportion to the likelihood of causation. See Sindell v.

Abbott Laboratories, 26 Cal.3d 588, 607 P.2d 924, 163 Cal.Retr. 132 (1980).

[38] In these cases, as well, the standard models arrive at different conclusions. Once an injurer becomes negligent, he is liable for all accidents caused by his activity. Whether it is more likely that any single accident is caused by his activity or by causes unrelated to his activity is a thus unclear even if the injurer's negligence has caused only few of the accidents. Therefore, depending on the circumstances, an injurer might either be liable for no accidents or for all accidents, whether caused by his negligence, his activity, or other causes. See Shavell, Uncertainty, supra.

[39] In the presence of uncertainty, this result will be slightly modified. Injurers' incentives will depend on the probability that it will be found that it was more likely than not that negligence has caused the accidents. Ideally, if this probability equals the probability that his negligence had caused the accident, the injurer will face optimal incentives. However, for low probabilities of causation, i.e. where the injurer is barely negligent, the burden of proof requirement will presumably result is underdeterrence; and for high probabilities of causation, i.e. where the injurer is grossly negligent, it will result in overdeterrence.

[40] In fact, two discontinuous jumps in liability are implicit in the standard models. Once, at due care, where the injurer becomes liable for all not indistinguishable accidents caused by his activity. And a second time, when the victim meets his burden of proof, where the injurer becomes liable for all indistinguishable accidents. See Shavell, Uncertainty, supra.

[41] See Landes & Posner, Causation in Tort Law: An Economic Approach, 12 J. Legal Stud. 109, 119-121 (1983); Shavell, An Analysis of Causation and the Scope of Liability in the Law of Torts, 9 J. Legal Stud. 463, 466-470 (1980); Shavell, Economic Analysis, supra, 110-115.

[42] See Berry v. Sugar Notch Borough, 191 Pa. 345, 43 Atl. 240 (1899).

[43] Id.