CAUSATION AND INCENTIVES TO TAKE CARE UNDER THE NEGLIGENCE RULE

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This article 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—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 either of being found to have acted negligently or of this negligence being found to have caused the accident.2

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1 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). W. Page Keeton et al., Prosser and Keeton on Torts, § 41 (5th ed. 1984).

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. See also Restatement (Second) of Torts, § 454 (1964).

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In the now-standard models 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, if only by implication, those accidents that would have happened even if he had employed due care. 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 describe the negligence rule, consider the example of accidents in which cricket balls fly over a fence surrounding the playing field and injure passersby. 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

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Only the models that explicitly analyze the causation requirement note that negligent injurers are not liable for all accidents, but only for those caused by their negligence. These models, however, have not analyzed the implications of the causation requirement if due care is not set at the optimal level or the negligence rule is not perfectly enforced. See William Landes & Richard Posner, The Economic Structure of Tort Law (1987); Steven Shavell, Economic Analysis of Accident Law 105–126 (1987). A partial exception to this failure is Mark Grady, A New Positive Economic Theory of Negligence, 92 Yale L. J. 799 (1983). Grady notes, without presenting a formal proof, that, if injurers were only liable for accidents that would not have occurred had they exercised due care, uncertainty about the level of due care would induce injurers to take less than optimal care.

4 With respect to strict liability, the standard models did not find a discontinuous jump in liability. An injurer is liable for all accidents caused by his activities whether he is negligent or not. Therefore, when the level of care falls, the amount of damages increases gradually as more accidents are caused by the activity.

5 Except for Grady, supra note 3, even those authors who include a causation requirement have not explicitly pointed to this error in the standard models or even repeated the same error themselves; see, for example, Shavell, Economic Analysis, supra note 3, at 79–83 (analyzing uncertainty about the level of due care as if injurers were liable even for accidents not caused by their negligence).

6 This hypothetical was inspired by Bolton v. Stone, [1951] A.C. 850. Cause in fact was, however, not an issue in this case.
economic 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, as a matter of common law, 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.\footnote{It should be noted that at least one author disputes that, as a matter of legal doctrine, injurers are liable only for accidents that would not have occurred had they exercised due care. See Grady, supra note 3 (injurers are liable if a measure of care, the costs of which are lower than its benefits, would have prevented the accident). Furthermore, as elaborated below, enforcement problems like errors in observing the level of care and in determining the cause of an accident could result in liability for accidents that would have occurred even under due care.}

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—that is, 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 article by modeling the negligence rule in a way that explicitly incorporates the doctrinal requirement of causation. Then, in Section II, 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 Section III, 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 an excessive level of due care in order to avoid the sudden increase in liability.\footnote{See Shavell, Economic Analysis, supra note 3, at 83; Peter A. Diamond, Single Activity Accidents, 3 J. Legal Stud. 107, 123–24, 139–40 (1974); see also Richard Craswell & John Calfee, Deterrence and Uncertain Legal Standards, 2 J. L. Econ. & Org. 279 (1986) (effect of a less than optimal level of due care in presence of uncertainty).} 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 may be exposed to some liability for negligence. Next, in Section IV, 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 that in such cases injurers will always exercise less than optimal care. In previous models, by contrast, liability for less than actual harm did not necessarily result in such inadequate care. In Section V, I investigate uncertainty about the required level of due care. The standard analysis found that uncertainty often induced injurers into taking an excessive level of care. But, in this article, uncertainty will be shown to result in injurers taking less than optimal care. In Section VI, I will examine how incentives are affected by uncertainty over whether harm was caused by the injurer's negligence. I will argue that, where accidents caused by negligence cannot be distinguished from other accidents, putting the burden of proof on the injured party will ordinarily lead injurers to take less than optimal care. Finally, in Section VII, I will conclude the article with a summary of the findings. I also present some normative implications of the analysis.

I. THE MODEL

Apart from explicitly modeling the causation requirement, the model developed in this article does not differ significantly from the standard models. 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 is minimized.

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

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9 See Summers, supra note 3; Steven Shavell, The Judgment Proof Problem, 6 Int'l. Rev. L. & Econ. 45 (1986); Robert Cooter, Economic Analysis of Punitive Damages, 56 S. Cal. L. Rev. 79 (1982).

10 See Calfee & Craswell, supra note 3; Craswell & Calfee, supra note 8; Diamond, supra note 3 (errors in measurement of care). But see Grady, supra note 3, arriving at conclusions similar to this article.

11 See, for example, Brown, supra note 3, at 324–27. In modeling causation, I follow the mainstream treatment of causation in the previous literature. See Landes & Posner, Economic Structure, supra note 3, at 230–33; Shavell, Economic Analysis, supra note 3, at 119–23. For an alternative view on causation, see Grady, supra note 3 (injurers are liable for all accidents that could be prevented by a measure of care, the costs of which are less than its benefits in reduced accident costs).

12 This definition of optimal care will result in both a Pareto-optimal and a Kaldor-Hicks-efficient level of care. For an explanation and critical evaluation of these concepts, see Jules L. Coleman, 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.
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. Injurers try to minimize the sum of costs of care and expected liability for accidents.

II. PERFECTLY OPERATING NEGLIGENCE RULE

In this model, as in the models not containing an explicit causation requirement, a negligence rule where due care is set at the optimal level of care and which is perfectly enforced will result in an efficient outcome. Injurers who 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.

Suppose, for example, our cricket field owner faces the costs of accidents and care stated in Table 1. Further assume that due care is set at the optimal level, that is at 10 feet. Under these circumstances, 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 the owner's costs by $10. Building a 9-foot fence would save $10 in building costs, but the owner now 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 a height of more than 10 feet; thus, these costs of $100 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

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13 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 William Landes & Richard Posner, Causation in Tort Law: An Economic Approach, 12 J. Legal Stud. 109, 119–20 (1983); Steven Shavell, An Analysis of Causation and the Scope of Liability in the Law of Torts, 9 J. Legal Stud. 463 (1980); see also Section VII below.

14 See, for example, Brown, supra note 3, at 340–43.

15 This result has been noted previously in models incorporating causation. See Shavell, Economic Analysis, supra note 3, at 105–115, 118–23.

16 A formal proof for this result is contained below in the Appendix, proposition 1.
TABLE I
PERFECTLY OPERATING NEGLIGENCE RULE

<table>
<thead>
<tr>
<th>Height of Fence (feet)</th>
<th>Cost of Fence ($)</th>
<th>Cost of Accidents ($)</th>
<th>Total Costs ($)</th>
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<td>9</td>
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takes due care. Under a perfectly operating negligence rule, the cricket field owner will, therefore, have incentives to exercise optimal care.

III. DUE CARE SET AT INCORRECT LEVELS

This section will deal with cases where the level of due care imposed by law exceeds or falls below the level of optimal, that is, cost-minimizing care. 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 conclusively set due care at a nonoptimal level, the 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 an existing 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 determining the expected costs of accidents. Misestimated accident costs would then result in a nonoptimal 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 the higher level of due care. By increasing their level of care, they can reduce their liability. At optimal care, however, 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.

For a formal proof, see Appendix, proposition 2, below.

The incentives created by a negligence rule with a level of due care higher than optimal care are similar to those created by strict liability, which is like a negligence rule with an infinite level of due care. Under either rule, injurers will not exercise more than optimal care even though they could thereby reduce their liability.
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, under the standard model, they also avoid liability for all those accidents that would have occurred even if they had exercised due care.\(^9\) Therefore, in many cases, the reduction in liability will exceed the increase in costs of care.\(^{20}\)

To illustrate this point, let us return to our cricket field owner. Due to price increases in fence construction, he faces the situation described in Table 2. The cost-minimizing height of a fence is now 9 feet rather than 10 feet. However, based on 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 any height between 9 and 10 feet, that is, for $20. The owner will, however, prefer to be liable for these accident costs of $20 caused by his failure to take due care than to spend an extra $30 to build another foot of fence. Therefore, even though he will incur some liability, he will build a 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-foot rather than a 10-foot fence, would be liable for all the accident costs of $120. By spending an extra $30 on the tenth foot, the owner could save himself this accident liability. Therefore, the owner would build a 10-foot fence at cost of $130 even though such a fence is inefficient.

It is interesting next to note the effects of the law setting the level of due care below optimal care. Under both the standard models\(^{21}\) and this model,\(^{22}\) 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—that is, less than optimal care.

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\(^{20}\) 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 to or above the cost of accidents at optimal care. See Shavell, Economic Analysis, supra note 3, at 97–98; Diamond, supra note 8, at 128–34.

\(^{21}\) See Shavell, Economic Analysis, supra note 3, at 83, 97–99; Diamond, supra note 8, at 123–28, 139–40.

\(^{22}\) See the Appendix, proposition 3, below.
TABLE 2
Due Care Set above Optimal Care

<table>
<thead>
<tr>
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care—and bear only the cost of care. 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 exercise only due care.

IV. 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 their incentives to take care. One reason why injurers might not have to pay the full amount of harm is that they are judgment proof; that is, 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. Similarly, not every person that suffered a loss might be entitled to be compensated; for example, only certain family members might be permitted to sue for loss of consortium or companionship. Lastly, expected liability might be less than actual damages because not all victims entitled to compensation bring suit.

23 To illustrate what happens if due care is set below optimal care, consider the example of Section II with a 9-foot fence constituting due care:

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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.


25 Id., at §§ 8.8, 8.9.
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. 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; that is, it will no longer pay for injurers to exercise optimal care.

To show this, let us return to our cricket field owner confronted with the care and accident costs described in Table 3. Let us further assume that all accidents cause harm of $200 and that exercising care affects only the expected number of such accidents. If the fence is 10 feet high, the expected number of accidents is .5; if the fence is 9 feet 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 transfers his field to a corporation with a capital of $150, an amount 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-foot fence, he incurs construction costs of $90. In addition, he will be liable for any accident caused by balls flying over the fence at any height 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 of such accidents (0.1) times what the corporation will

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26 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 the Appendix, proposition 5, below. However, if due care is set at a supraoptimal 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.

27 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 the Appendix, proposition 4, below.

28 The previous literature often regarded the level of care as influencing the probability rather than the expected number of accidents. See, for example, Landes & Posner, supra note 13. 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 passersby times 1, the probability of two balls passing the fence and each injuring passersby times 2, and so on. To calculate the expected cost of accidents, one has to use the expected number of accidents rather than the probability of an accident occurring.

29 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
have to pay if an accident occurs ($60). 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. The sudden increase in liability when an injurer becomes negligent was thought to counteract the incentives to take less than optimal care. In our example, if the owner builds a 9-foot fence, he would incur an expected liability of up to $36, that is, 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 $16\frac{2}{3}$ would the owner build a 9-foot fence. Thus,

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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.

30 See Summers, supra note 3, at 157–59; Shavell, supra note 9, at 47–49.

31 Cooter, supra note 9, 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 to exercise either due care or substantially less than due care. Injuries who are marginally negligent are then taken as having tried to exercise due care but having failed to do so because they made a mistake about the required level of due care. Once they have realized their error, however, they will exercise due care. Injuries who are grossly negligent 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 article suggests that this qualitative distinction between injurers who try to exercise either 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 who do not expect to be liable for the full harm caused will 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, and so on. Punitive damages of various sizes are therefore needed to induce compliance with due care.
under the standard models, liability must be significantly less than harm done in order to induce injurers to take less than optimal care.

V. Uncertainty over the Level of Due Care

In this section, I will analyze how uncertainty over the level of due care affects injurers’ behavior. 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 individual 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 had occurred, the injurers might not know before the accident what level of care is due. Thus, there is a second source of 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 mistakes. 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 found to have exercised.

Except where injurers who exercise optimal care expect to be always found negligent, 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. The reason for this 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. But when injurers are uncertain about the level of due care, their expected liability changes by

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32 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 the Appendix, proposition 6, below.

33 See the Appendix, proposition 6, below. That uncertainty over the level of due care will result in less than optimal care if injurers are liable only for accidents caused by their negligence, has been noted before by Grady, supra note 3; and Craswell & Calfee, supra note 8, at 295. Grady, however, does not present a formal proof for this claim, and neither Grady nor Craswell and Calfee believe that the liability rule they analyze reflects tort doctrine.
less. At any possible level of care, injurers already expect to be liable for some accidents, that is, where courts set a higher level of due care. If they reduce their level of care, then 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.

Nonetheless, injurers will still get, dollar for dollar, the benefits of the reduced cost of care. At the level of optimal care, injurers will still exercise less than 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 suboptimal 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 the Appendix, proposition 6, below.

The standard models, however, have arrived at a different conclusion about the effects of uncertainty. They have argued that uncertainty can result in injurers taking either more or less than optimal care. 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 stan-

34 If the expected level of due care is below optimal care, injurers will still exercise less than 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 suboptimal 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 the Appendix, proposition 6, below.

35 That uncertainty will always result in suboptimal care might seem counterintuitive. For example, if there is a 90 percent probability that due care is above optimal care and only a 10 percent 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 relevant 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 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.

36 See Calfee & Craswell, supra note 3, at 974–84; Craswell & Calfee, supra note 8, at 285–87.
NEGLIGENCE RULE

TABLE 4
UNCERTAINTY OVER THE LEVEL OF DUE CARE

<table>
<thead>
<tr>
<th>Height of Fence (feet)</th>
<th>Cost of Fence ($)</th>
<th>Cost of Accidents ($)</th>
<th>Total Costs ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>90</td>
<td>112</td>
<td>202</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>11</td>
<td>110</td>
<td>94</td>
<td>204</td>
</tr>
</tbody>
</table>

dard models increases by more than the additional cost of accidents; it increases by the cost of all accidents whether or not those accidents were caused by the injurer's negligence. Therefore, some injurers, even if they would not always be found negligent, would 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 cricket field example. The costs of care and accidents, slightly modified, are shown in Table 4. 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, respectively, if due care is assessed to be at 11 feet. But, as the injurer is only liable for accidents caused by his negligence, his expected liability is that shown in Table 5.

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.

TABLE 5
EXPECTED LIABILITY UNDER UNCERTAINTY OVER THE LEVEL OF DUE CARE

<table>
<thead>
<tr>
<th>Height of Fence (feet)</th>
<th>Liability if Due Care Is</th>
<th>Expected Liability ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9 Feet (33%)</td>
<td>10 Feet (33%)</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>12(%) = 4</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
VI. 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 for injurers to expect that they are always held liable for accidents caused by their negligence and never for accidents not caused by their negligence. Rather, it is sufficient if 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 it might 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.37

An interesting case arises where accidents caused by negligence are indistinguishable from accidents that would have occurred even in the absence of negligence. Assume, for example, that the expected number of cardiac arrests in surgery depends 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.38 In such cases, if the injurer is found to have been negligent, the only evidence on causation is the expected number of cardiac arrests occurring at that level of care due to negligence and the expected number of cardiac arrests occurring at that level of care due to other reasons. With that information, one can calculate the probability that the cardiac arrest was caused by negligence.

Under ordinary circumstances, the victim bears the burden of proof that the negligence of the injurer has caused his accident.39 If the victim can show that it was more likely than not that the injurer's negligence caused his accident—that is, 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 anyhow40—he will be compen-
sated 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. 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. 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. This discontinuous jump will, however, not occur at due care but at a level of care significantly below due care.

VII. CONCLUDING REMARKS

Before summarizing the conclusions of this article, it is appropriate to briefly reconsider the main assumption that underlies this analysis, that is, that injurers are liable for accidents only if they acted negligently and if their negligence was the cause of the accident. While these assumptions

\[\text{41}\] 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 has been caused by his activity or by causes unrelated to his activity is thus unclear, even if the injurer's negligence has caused only a small fraction of the accidents. See Shavell, note 3 supra.

\[\text{42}\] 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 has caused the accident, the injurer will face optimal incentives. However, for low probabilities of causation, that is, where the injurer is barely negligent, the burden of proof requirement will presumably result in underdeterrence; and for high probabilities of causation, that is, where the injurer is grossly negligent, it will result in overdeterrence.

\[\text{43}\] 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 over Causation, supra note 3.
restate the doctrine on causation, a plausible argument can be made that, in some circumstances, the doctrine is actually applied in a different way.

Fact finders 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 fact finders 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 semiautomatically 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 fact finder, 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 fact finders resolve these difficult questions in the favor of injurers. Rather than strive for consistency, fact finders 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 caution is hard to establish, the requirement that causation be proven with the preponderance of the evidence might lead fact finders to deny any recovery.

In analyzing negligence law from the perspective of deterrence, however, the actions of individual fact finders are not of ultimate interest. What is important is how injurers expect the law to be applied, and this will depend on what fact finders, in general, are expected to do. And, in most cases, fact finders, 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, for injurers to be held liable, it must be shown both that they have acted negligently and that their negligence has caused the accident.

First, setting due care at nonoptimal 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.

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

Third, the models come to opposite conclusions about the effects of uncertainty on the level of care. In the standard models, uncertainty often causes injurers to exercise more than optimal care. In our model, uncertainty always 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 accidents even though their negligence has caused some of them.

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, finally, 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 article 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 article shows that even if due care exceeds optimal care, injurers will exercise optimal care once restrictions based on causation are taken into account. 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.

\[44\] Holding injurers to a higher standard of care is preferable to increasing damages payable by injurers if they are held liable. Under any negligence rule, uncertainty over the level of due care is bound to exist. If damages payable by injurers exceed the level required to make injurers exercise optimal care, injurers will, because of uncertainty over the level of due care, exercise more than due care. However, if the level of due care exceeds the level required to make injurers exercise optimal care, injurers will exercise optimal care even if they are uncertain about the level of due care. See the Appendix, proposition 6, below.
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 (that is, in absolute terms, increasing) rates:

\[ A'(x) < 0, \quad C'(x) > 0, \]
\[ A''(x) > 0, \quad C''(x) > 0. \]

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 liability $L$. The cost of liability $L$ is a function of the cost of negligence $N$. Where the exercised level of care is greater than or equal to the level of due care $X$ (optimal care is denoted by $x^*$), 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:

\[ N(x) = \begin{cases} 0 & \text{if } x \geq X, \\ A(x) - A(X) & \text{if } x < X. \end{cases} \]

Since the limit of $A(x) - A(X)$ for $x$ approaching $X$ is 0, the function $N$ is continuous. As $A(X)$ will be constant given the level of due care, $N$ will be a monotonously decreasing function of $x$ whose second derivative is nonnegative.

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

\[ S'(x^*) = C'(x^*) + A'(x^*) = 0, \quad (A1) \]
\[ S''(x^*) = C''(x^*) + A''(x^*) > 0. \quad (A2) \]

As $C''(x)$ and $A''(x)$ are always greater than 0, (A2) 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

\[ C'(x) + A'(x) < 0 \quad \text{if } x < x^*, \quad (A3) \]
\[ C'(x) + A'(x) > 0 \quad \text{if } x > x^*. \quad (A4) \]

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

\[ J'(x) = C'(x) + L'(x) = 0, \quad (A5) \]
\[ J''(x) = C''(x) + L''(x) > 0. \quad (A6) \]

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.

**Proposition 1.** If due care is set at optimal care (and injurers are liable for the cost of negligence), injurers will exercise due care.
NEGLIGENCE RULE

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

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

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 [A3]). Therefore, $J$ will have the only minimum at $x^*$; that is, 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 optimal care.

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

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

with a first derivative

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

The cost to injurers will have a minimum at $x^*$ (see [A1]). Since $J$ is continuous and since $J' > 0$ for all $x > x^*$ (except $\bar{x}$, where it is not defined), there is no change in sign at $\bar{x}$. Therefore, the minimum at $x^*$ is the only minimum; that is, 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 [A3]). Since $J$ is continuous, it has the only minimum at $\bar{x}$. Thus, injurers will exercise due care, that is, 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, that is,

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

\[ L' = q \cdot N'. \]

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

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

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 \( q \cdot A'(x) > A'(x) \) and thus \( C'(x) + q \cdot A'(x) > C'(x) + A'(x) \). Therefore, \( J'(x) \) must have a minimum at \( x < x^* \) (see [A1] and [A3]). Since \( J \) is continuous and \( J' > 0 \) around \( x^* \), this minimum will be the only minimum; that is, 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 \( \bar{x} = x^* \).

**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.

Assume that the expected liability of injurers is a constant multiple \( m > 1 \) of the accidents caused by negligence, that is,

\[ L(x, \bar{x}) = m \cdot N(x, \bar{x}) \quad \text{with } m > 1. \]

Then

\[ L' = m \cdot N'. \]

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

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

and the first derivative

\[
J'(x) = \begin{cases} 
C'(x) & \text{if } x > x^*, \\
C'(x) + m \cdot A'(x) & \text{if } x < x^*.
\end{cases}
\]

As \( A'(x) < 0 \), it will hold that \( m \cdot A'(x) > A'(x) \) and thus \( C'(x) + m \cdot A'(x) > C'(x) + A'(x) \). 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 \( x^* \); that is, 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 \( A(z) \).
\[ L(x) = \sum_{z>x} P(z = \bar{x}) \cdot [A(x) - A(z)]. \]

Liability can thus be regarded as a product of a probability portion and a liability portion. As the level of care changes from \( x \) to \( \bar{x} \), the liability portion will change in the following way. Where \( z \geq x \), the liability portion changes by \( A(x) - A(\bar{x}) \), that is, by the change in accident costs; and where \( x < z < \bar{x} \), the liability portion changes by \( A(z) - A(\bar{x}) \), that is, 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 one. Therefore, liability will change by less than the change in the liability portion. Assume \( L'(x) \) is defined at all points. Then \( L'(x) \leq 0 \) and (in absolute terms) \( L'(x) > A'(x) \). Therefore, at optimal care, \( J'(x^*) > 0 \) (see [A1]); similarly, at \( x > x^* \), \( J'(x) > 0 \) (see [A4]). Since costs are reduced by lowering care whenever \( x \geq x^* \), \( J \) must have a minimum below \( x^* \); that is, 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, \( C'(\bar{x}) + A'(\bar{x}) < 0 \). Even though \( C'(\bar{x}) + L'(\bar{x}) > C'(\bar{x}) + A'(\bar{x}) \), 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 \( x < z < \bar{x} \), changes by \( A(z) \) and not by \( A(z) - A(\bar{x}) \). 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 one, 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 percent (and due care is set at optimal care), injurers will take less than optimal care.

At any 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

\[ \frac{g \cdot [A(x) - A(\bar{x})]}{g \cdot [A(x) - A(\bar{x})] + h \cdot A(\bar{x})}. \]

To hold an injurer liable, it must be shown that this probability exceeds 50 percent. Since, as \( x \) moves toward \( \bar{x} \), \( A(x) - A(\bar{x}) \) moves toward 0, there will always be an \( x < \bar{x} \) for which the probability will not exceed 50 percent (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.