Negligence, Causation, and Incentives for Care

Keith N. Hylton[*]
Haizhen Lin[**]

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Abstract: We present a new model of negligence and causation and examine the influence of the causation test on the level of care under negligence. In this model, the injurer's decision to take care reduces the likelihood of an accident only in the event that some nondeterministic intervention occurs. The effects of the causation test depend on the information available to the court, and the manner in which the test is implemented. The key effect of the causation test is to induce actors to take into account the distribution of the intervention probability as well as its expected value. In the most plausible scenario – where courts have limited information – the causation test generally leads to socially excessive care.

[*] Boston University, Law School, knhylton@bu.edu. We thank Steve Marks, Ken Simons, Ted Sims, Mike Meurer, and David Walker for helpful comments on an early draft.
[**] Indiana University, Kelley School of Business, hzlin@indiana.edu.

The negligence case law distinguishes factual and proximate causation. Factual causation is typically described as determined by a *but-for* test: would the injury not have occurred but for the defendant's negligence? The proximate causation inquiry usually focuses on the extent to which the plaintiff's injury was a foreseeable result of the defendant's negligence. In some cases, these tests are easy to distinguish, and may generate different answers; in other cases, the tests are not easily distinguished in terms of the answers that they generate.

The economic literature on causation under negligence has recently focused on the factual causation test, and has examined the effects of that test on incentives for precaution. In this paper, we will also focus on factual causation. However, the framework we adopt is equally applicable to proximate causation issues.

Previous literature on causation has focused on how the factual causation test removes a discontinuity in the incentive for precaution, and the implications of that removal. In a negligence regime that does not incorporate the factual causation inquiry, there would be a discontinuous jump in liability once a potential injurer adopts a precaution level slightly below the reasonable care level. When the factual causation test is incorporated, there is no longer such a discontinuous jump. This has implications for the effects of uncertainty on the level of precaution.

In this paper we present a new model of causation and its influence on the level of care under negligence. The new model is based on a more general description of the causation problem. In this more general description, the injurer's decision to take care reduces the probability of an accident only in the event that some nondeterministic intervention occurs. For example, the probability that the decision to equip a boat with life-preservers reduces the likelihood of a drowning depends on the probability that a rescuer will be present and able to accurately throw a life-preserver in time. Similarly, the probability that the decision to increase the height of a fence reduces the likelihood of a passerby being hit by a cricket ball depends on the trajectory of the cricket ball when hit, which is a nondeterministic intervention. Negligence is determined *after* the intervention probability has been revealed – which is the key feature distinguishing this model from previous work. A finding that lack of care did not "cause" the plaintiff's injury typically means that the intervention probability, as revealed, is so low that the benefit from additional care would have been less than its cost (Shavell, 1980, Landes and Posner, 1983).

In general, the incentive effects of the causation test depend on the information available to the court, and precisely how the causation test is implemented. The natural assumption is that the court has limited information, in the sense that it does not know the range of possible interventions, and their associated probabilities. The injurer, on the other hand, does know the distribution of the intervention probability. The key results of this paper are based on these assumptions. Under these constraints the court performs an ex post assessment of negligence.

We show that the extent to which the causation test distorts care from the socially optimal level depends on several factors: the productivity of care (in reducing the likelihood of an accident), the size of the victim's loss, and the distribution of the intervention probability. As care becomes more productive, the causation test tends to lead to socially inadequate care. The size of the victim's loss has no effect on the direction of the inefficiency but does affect the magnitude.

The key effect of the causation test, with limited-information courts, is to induce actors to take into account the distribution of the intervention probability in addition to its expected value. Hence, the more interesting results concern the distribution of the intervention probability – in a model where the effectiveness of care is an increasing function of the intervention probability. We show that when the distribution of the intervention probability is symmetric the incentive for care is excessive. The exception to this result (in the symmetric distribution case) is when the probability of an injury is zero when the both the injurer takes care and the intervention occurs, and in this case the incentive for care is optimal.

If the intervention probability does not have a symmetric distribution then the incentive to take care will not be socially optimal. As the distribution skews to the right, resulting in a high expected intervention probability, the incentive to take care tends to be socially inadequate. As the distribution skews to the left, resulting in a low expected intervention probability, the incentive to take care tends to be socially excessive.

That the causation test leads to excessive care in some of the most plausible scenarios is a bit counterintuitive. Causation doctrine generally cuts off liability for a substantial set of cases. Given this, one's first intuition is that such a truncation of liability should reduce incentives for care.

The alternative to the assumption that the court has limited information is to treat the court as having full information, in the sense of knowing just as much as does the injurer about the distribution of the intervention probability. If the court has full information in this sense, the incentive effects of the causation test depend on the type of test implemented. If the court applies an ex post negligence test in order to determine causation, socially inadequate care results. If the court applies a but-for test to determine causation then the resulting care level is optimal.

We consider the effects of uncertainty in the application of the causation test and in the application of the negligence test. Again, the results depend on the information available to courts. If courts have limited information, uncertainty in the application of the causation test leads to excessive precaution, while uncertainty in the application of the negligence test dilutes the precaution incentive. If courts have full information and apply an ex post negligence inquiry to determine causation, the effects uncertainty in the application of the negligence test are ambiguous. If, in the full information case, courts apply a but-for causation test, uncertainty leads generally to excessive care (Marks, 1994).

Modeling causation as part of an ex post negligence inquiry generates implications for other topics in tort law. The long-running debate between legal realists and formalists over whether causation is a policy or fact determined issue may be reducible to a matter of the information possessed by the court. If the court has limited information, it is likely to apply an ex post negligence test, and the decision on causation will be inseparable from the policies influencing the negligence assessment.[1] If the court has full information, it can adopt an optimal care standard and determine causation as a purely factual matter. In addition, the ex post negligence model suggests a positive theory of the custom defense in tort law; and the model is easily extended to the problem of hindsight bias in tort law.

I. Causation Literature and Law

The economic literature on causation consists of three parts. The first article to explore the economics of causation is Shavell (1980), followed by Landes and Posner (1983).[2] Since Shavell and Landes-Posner both conclude that causation analysis can be subsumed within the negligence inquiry, we will refer to this as the Shavell-Landes-Posner position. The second part of the literature consists of articles by Grady (1983), Kahan (1989), and Marks (1994). The third includes recent articles examining topics that branch off from these earlier contributions, such as the influence of causation on care and activity (Tabbach, 2008), or the influence under informational asymmetry (Feess, 2010). This paper returns to a focus on the first and second parts of the literature.

The Shavell-Landes-Posner approach implies that factual causation analysis has little to offer beyond the standard analysis of negligence associated with the Hand Formula – that is, the comparison of the cost of precaution with the incremental losses avoided by precaution. In any case in which the injurer would be exempted from liability on factual causation grounds, a close factual inspection would conclude that the injurer is not negligent. Under this analysis it would be incorrect to describe the injurer (defendant) as negligent but not liable on factual causation grounds.

For example, suppose, as in *Perkins v. Texas and New Orleans Ry. Co.*,[3] the defendant's train is traveling 15 miles greater than the speed limit, and runs over the plaintiff's car as it is stalled on the railroad tracks (due to no negligence on the part of the plaintiff). Suppose in addition that the plaintiff would not have been able to get out of the way of the train even if it had been operating at the speed limit. Traditional legal analysis would hold that the defendant's negligence (driving above the speed limit) is excused because of the absence of factual causation. However, a fact-intensive application of the negligence test would ask if the additional precaution of slowing down to the speed limit would have

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[1] On the legal realist view that causation decisions are essentially inseparable from the policies influencing negligence findings, see Malone (1956).

[2] Calabresi (1975) should also be considered a part of the early literature on the economics of causation. Calabresi's discussion anticipates some of the findings of the formal economic models in the Shavell and Landes-Posner articles.

[3] 147 So.2d 646 (La. 1962).

reduced the probability of the injury. Since the answer is no in *Perkins*, the defendant was not negligent.

Generalizing from *Perkins*, the causation issue arises where the effect of taking care is dependent on some contingency or intervention.[4] Thus, negligence can be assessed in two time periods. One is ex ante, before the contingency is revealed. In this period, an observer might conclude that the defendant would be negligent if he failed to adopt a specific precaution. The second period is ex post, after the contingency has been revealed. In this period, an observer might reach a different conclusion – and hold that the defendant was not negligent given the revealed contingency. It follows that the role of the causation test, as suggested by Shavell-Landes-Posner, is to serve as an ex post negligence evaluation; i.e., an assessment of negligence based on facts bearing on the likelihood that the accident would have happened even if the injurer had taken care.

The Grady-Kahan analysis focuses on the effects of the causation rule on incentives for care. The argument is best explained by the cricket fence hypothetical explored by Kahan. In the cricket hypothetical, the ball flies over the fence at a height that would have still led to the same accident (victim hit by cricket ball) even if the fence had been set at the reasonable height. Since the accident would have happened even if the fence had been set at the reasonable height, the factual causation test would not be satisfied by the plaintiff's claim.

To see the incentive implications of the causation test, suppose causation is not taken into account and that the reasonable height is 10 feet. If the owner of the cricket grounds has his fence at 10 feet he will not be held liable for negligence. Now suppose the owner lowers the fence to 9 feet 11 inches. If causation is not taken into account by the court, the owner will become liable for all cricket balls that fly over the fence, irrespective of the height at which the ball clears. If factual causation is taken into account, the owner becomes liable only for cricket balls that pass between 10 feet and 9 feet 11 inches. Thus, when the factual causation test is incorporated, the owner's liability increases slowly and continuously, starting from zero, as he lowers the fence from the reasonable height. When factual causation is not taken into account the owner's liability jumps discontinuously the moment he lowers his fence slightly below the reasonable height.

In the Grady-Kahan model, the injurer exercises reasonable care whether the court applies the factual causation test or not, provided actors have perfect information and courts set due care at the socially optimal level.[5] However, when imperfectly accurate

[4] We will use the term intervention in the text as if it were synonymous with contingency. The causation case law, especially that on proximate cause, often refers to intervening factors, which can be due to nature or to human action.

[5] Marks (1994) refuted the Grady-Kahan "optimal care" result. Specifically, Marks shows that under a rule where there is no liability if the accident still would have occurred with a level of care socially superior to that which the injurer took, then incentives for care would not be optimal, even if judicial errors in setting the negligence standard were symmetric. The Grady-Kahan and Marks results fall out as special cases of the model in this paper.

courts and uncertainty are introduced into the analysis, the injurer's precaution decision is affected by whether the court takes factual causation into account.[6]

We focus on incentives for care in this paper, but our point of departure from the previous literature is the explicit treatment, in this model, of the difference between the ex ante and the ex post information scenarios. The court's analysis of causation depends on whether it can evaluate negligence ex ante or only by an ex post test. Moreover, this paper differs from the incentives-focused literature (Grady, Kahan, Marks) by relaxing the assumption that the class of causation problems to be analyzed consists of those in which the causation inquiry has a dichotomous response (the accident would have happened anyway or would not have happened). In our model, there is a probability of an intervention that determines whether the accident would have happened even if the defendant had taken care.[7] When that probability is dichotomous, viewed from the ex post perspective, our model becomes more similar to that discussed by Grady, Kahan, and Marks.[8]

There are many causation cases that fit the more complicated scenario we consider here. For example, in *New York Central R.R. v. Grimstad*,[9] the plaintiff's decedent, Angell Grimstad, drowned after falling off of a barge into the water. The decedent's wife sued on the theory that the barge owner was negligent in failing to equip the barge with life buoys. If the barge had been equipped with life buoys, according to the plaintiff, she (apparently the only person present at the time) would have been able to save her husband's life. However, even if the barge owner had equipped the barge with life buoys, there was no guarantee that they would have saved Grimstad's life. His wife may not have been able to find a life buoy in time, or she may have thrown it too far from him to grab it, or he may not have been able to grab hold of it before sinking under.

Grimstad is more complicated than the cricket hypothetical because it is not clear that the accident would have happened even if the defendant had taken the desired precaution. Moreover, it is unclear that the court had sufficient information to determine negligence

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[6] Specifically, in the Grady-Kahan analysis the factual causation test can modify incentives for care (in comparison to a negligence test that does not take factual causation into account), if there is uncertainty in the application of the negligence test. Suppose the court does not take factual causation into account. If the owner's fence is mistakenly found to be slightly above the reasonable height, the owner's liability is zero. If his fence is erroneously found to be slightly below the reasonable height, his liability is jumps discontinuously. If, in contrast, the court takes causation into account, then a finding that the owner's fence is slightly below the reasonable height leads to a small increase in liability above the zero level.

[7] This class of cases is discussed in Landes and Posner, 1983, 120-123, and examined as a specific application of their model. However, Landes and Posner did not consider the incentive issues studied by Grady and Kahan. In this paper, we return to a more general model of the sort analyzed by Landes and Posner. Still, our model differs from that of Landes and Posner by explicitly treating the causation problem as based on an intervention in the chain of events leading to the accident.

[8] Though still not the same. The Grady, Kahan, and Marks analyses are models where the intervention signal is dichotomous, and uncertainty, if any, occurs in the application of the negligence test. In this paper, uncertainty is inherent in the accident event because the signal can take any value between zero and one. Our basic model assumes no error in the application of the negligence test. We extend the basic model to consider error in parts II.D and II.E.

[9] 264 F. 334 (2d Cir. 1920).

on an ex ante basis; there is no discussion of the issue in the court's decision. Inherent uncertainty of this sort is characteristic of a large class of causation cases.[10] The courts have recognized the difficulty of assessing causation in the more general context by using the *substantial factor* test instead of the but-for test.[11] The model we set out below captures this general class within a simple framework.

The model below takes into account the structural features of the causation cases, specifically the distinction between an ex ante determination of negligence and an ex post determination of negligence. Within this structure, we examine the influence of the negligence-causation test on the incentive to take care.

II. Model

Taking care affects the probability of an accident, but the effect is conditional on an intervention. For example, suppose the type of care is installation of life-preservers on a boat. The life-preservers will be effective in preventing a drowning only if they are deployed rapidly and accurately, which is not guaranteed. Thus, taking care by installing life-preservers is effective in reducing the probability of an injury only if there is the "intervention" of effective deployment.

Let r = the probability of an injury given that the injurer does not take care, s = the probability of an intervention that makes care effective, w = the probability of an injury if the intervention occurs, $w < r$. Let x = the cost of taking care, and let L = the loss suffered by the accident victim.

The causation problem examined in this model is captured in the following tree diagram.

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[10] Consider the following examples within this class of cases. In Gyerman v. United States Lines, 7 Cal. 3d 488, 498 P.2d 1043, 102 Cal. Rptr. 795 (1972), the defendant charged the plaintiff with contributory negligence for failing to inform the correct supervisor of a dangerous condition in the workplace. But the evidence suggested that the accident probably would have happened even if the plaintiff had informed the correct supervisor. The court concluded that the defendant failed to show that the plaintiff's negligence was a substantial factor causing the injury. In Rouleau v. Butler, 152 Atl. 916 (N.H. 1931), involving an accident between the defendant's truck and the plaintiff, the defendant failed to signal his turn, but the plaintiff's driver was not looking for the signal over most of the time in which it might have made a difference. In City of Piqua v. Morris, 98 Ohio St. 42, 120 N.E. 300 (1918), the evidence suggested that the flood caused by an unusual rainfall was sufficient to account for the plaintiff's property loss, even if the defendant had taken the precautions urged by the plaintiff. The court in Weeks v. McNulty, 48 S.W. 809 (Tenn. 1898), found that the hotel was negligent for failing to install a fire escape, in violation of a statutory duty, but there was no evidence to suggest that the plaintiff's decedent would have attempted to use a fire escape.

[11] The substantial factor test was introduced as a tool for analyzing cases in which two actors were guilty of negligence, with each actor's conduct sufficient to cause the plaintiff's injury. But the substantial factor test has expanded since then and has become or more general approach in the torts case law. In a case where the intervention probability is not dichotomous, a court might consider whether the defendant's negligence is a substantial factor in causing the plaintiff's injury. The substantial factor language is sufficiently flexible to allow the court to assign a probability to the intervention and to consider the productivity of care on the part of the injurer in light of the assigned probability of intervention.

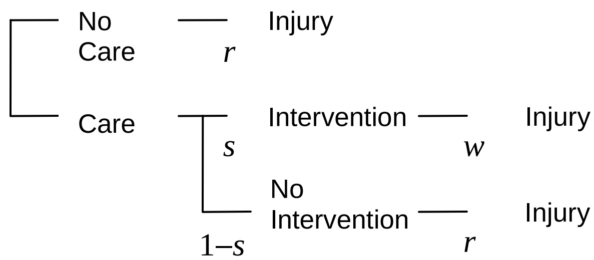

Figure 1: Causation event diagram

Before the injurer chooses how much care to take, the probability of intervention is unknown; only its distribution is known. Some time after the injurer invests in care, the intervention probability is revealed and an accident occurs.

The court can observe the intervention probability when it determines liability at the final stage, while the injurer cannot observe it ex ante. The injurer's care decision is a *durable* type of precaution that affects the probability of an accident once the intervention probability is realized later. As a result, the injurer may be negligent on an ex ante evaluation, but not on an ex post evaluation.

The converse proposition, where the injurer is not negligent ex ante but is negligent on an ex post evaluation, will not occur in this framework, though it may be possible under alternative fact models. In this model, the injurer takes care first and the care is fixed at that stage. For example, the injurer has to decide whether to equip his boats with life-preservers, or the height at which to set the fence surrounding his cricket yard. If the injurer is not negligent in taking the early durable precaution, a court will have no reason to find him negligent ex post. However, if the precaution is not of a durable type, then it is possible that the converse proposition, where the injurer is not negligent ex ante but is negligent ex post, could be observed. But in this case there would be no interesting causation issue, because the court would just examine the injurer's negligence from the ex post perspective.

The injurer knows the distribution of the intervention probability when he decides whether to take care. Let the intervention probability be governed by the distribution $G(s)$ with corresponding density $g(s)$. The court, with limited information, does not know the distribution of the intervention probability; it is in a position of Knightian uncertainty.

In practical terms, these assumptions mean that in a scenario like *Grimstad*, the barge owner knows the distribution of the intervention probability (e.g., how often the captain is likely to be alone instead of surrounded by experienced sailors), while the court does not. This seems to a plausible and quite natural set of assumptions to take as a default position. An alternative scenario that we view as equivalent is when the court is constrained from attempting an ex ante assessment of negligence – for example, because of the existence of a statute that declares certain conduct negligent.[12]

Taking care is socially desirable if the expected social cost when the injurer takes care is less than the expected social cost when the injurer does not take care. Thus, care taking is socially desirable when

$$x + \left(\int_0^1 (sw + (1-s)r)g(s)ds\right)L < rL \quad .$$

or equivalently when

$$x < (r - w)\left(\int_0^1 sg(s)ds\right)L \, , \qquad (1)$$

where $\int_0^1 sg(s)ds = E(s)$, the expected value of the intervention probability. This is equivalent to saying that care is socially desirable when its expected marginal benefit (in terms of loss avoidance) is greater than its marginal cost. If the law imposed strict liability on injurers, their caretaking incentive would be governed by (1). All injurers would exercise the socially desirable level of care.[13]

Now consider the injurer's incentive to take care under the negligence rule. When the injurer takes care, he will face no liability under the negligence rule. Thus, when the injurer takes care the only cost he bears is x. When the injurer does not take care, he will be liable for liable for the victim's loss, but only if the victim's negligence claim satisfies the factual causation test.

Note that in this problem, it cannot be said as a general matter that the accident would have happened anyway if the injurer had taken care – it may have happened anyway, or may not have happened, depending on the probability of intervention. If the probability of intervention is equal to zero, the accident would have happened anyway. However, if the probability of intervention is close to zero, the factual causation conclusion would very likely be the same.

We will treat the causation test as an ex post negligence inquiry – an assessment based on the observation of the intervention probability.[14] Under the ex post assessment of

[12] Landes and Posner (1980), at 115, note that many of the causation cases involve breaches of statutory care standards.

[13] We are ignoring positive activity level externalities which might provide an argument for relieving the injurer from liability when he takes care. The possibility that beneficial activity level externalities could justify a causation-based limitation on the scope of liability is discussed in Shavell (1980).

[14] This is consistent with the approach courts take in the causation cases. In addition, this is assumption implicitly adopted in Landes and Posner (1980), though their model does not distinguish between the ex ante and ex post scenarios and the various informational assumptions. Under the ex post approach, the causation inquiry is subsumed within the negligence evaluation. Recall that the court is either constrained

negligence, the injurer will be held liable if he fails to take care and, under the particular realization of the intervention probability, say s_0, care would have been socially beneficial

$$x < (r - (s_0 w + (1 - s_0)r))L$$

which is equivalent to $x < (r - w)s_0 L$, or

$$\frac{x}{(r-w)L} < s_0 \quad . \qquad (2)$$

So that the injurer's decision will be interesting in a causation analysis, we will assume $x < (r - w)L$, which means that the injurer is potentially negligent, in the sense that the cost of taking care is less than the benefit under the best-case scenario where the intervention probability is equal to one. If the cost of taking care is greater than the benefit under the best-case scenario, then the injurer could not be held negligent whatever the level of the intervention probability – and the causation question would become irrelevant.

The ex post negligence assessment is equivalent to a two-step process in which the court first determines that the injurer is potentially negligent and then determines whether causation excuses the injurer from liability. The court determines negligence in the first step provisionally because it does not have enough information (specifically, it does not know $g(s)$) to determine whether care is socially optimal.[15] Indeed in this model it is possible to distinguish three concepts of negligence: *potential negligence*, where $x < (r-w)L$; *ex post potential negligence*, determined by (2); and *ex ante potential negligence*, determined by (1).

Using (2), the probability that the injurer will be held liable for negligence is $1 - G(x/[(r - w)L])$. The inequality in (2) establishes a threshold level that the intervention probability must cross for the injurer to be deemed negligent.

When the injurer decides whether to take care, he does not know the specific realization of s that will hold at the time of the accident. He must choose ex ante whether to take care. He takes care under the negligence test when

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from conducting an ex ante assessment of negligence, or it does not have enough information (Knightian uncertainty) to evaluate the social benefit from care ex ante.

[15] This is the approach reflected in the causation cases. Courts never discuss the difficulties in estimating the ex ante negligence standard, and appear to be applying an ex post negligence evaluation. In a substantial number of the cases negligence is presumed because of the breach of a statute; in others courts implicitly assume that the best-case scenario in which the intervention occurs is the norm. One alternative to the ex post assessment described here is for the court to assume a specific distribution for the intervention probability – though this is never observed in the case law. Such an alternative could obviously lead to inefficient care incentives, depending on the relationship between the court's assumed distribution and the real distribution.

$$x < [1 - G\left(\frac{x}{(r-w)L}\right)]rL \ , \qquad (3)$$

because with probability $G(x/[(r-w)L])$ he will not be held liable due to the ex post assessment of negligence.

The care-taking condition (3) is difficult to interpret because the cost of care appears on both sides of the inequality. The care-taking condition implicitly defines a specific precaution cost level, $\bar{x}$, below which the injurer will take care and above which the injurer will not take care. In plain terms, one can describe $\bar{x}$ as the cost of care for the marginal actor – the one who is just indifferent between taking care and not taking care. The result is described by Figure 2.

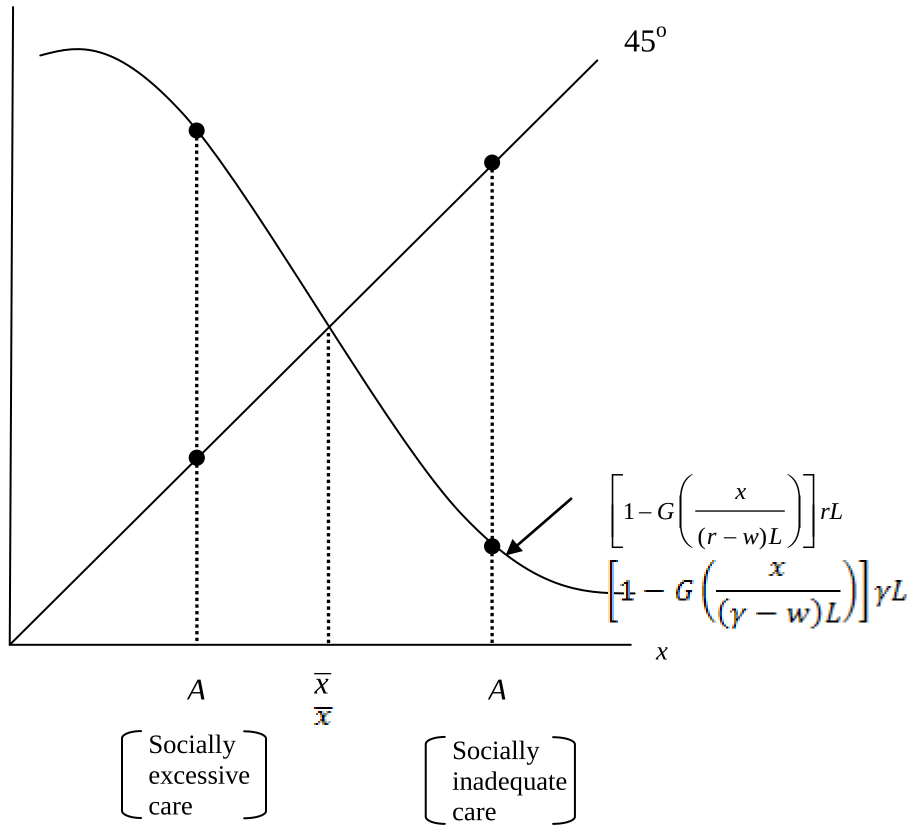

Figure 2: Conditions determining social optimality of care

Using (1) and (3) it should be clear that the incentive for care is socially optimal if $\bar{x} = (r - w)E(s)L$, socially excessive if $\bar{x} > (r - w)E(s)L$, and socially inadequate if $\bar{x} < (r - w)E(s)L$. Thus, if the expected marginal benefit from care, $(r - w)E(s)L$, is greater than the cost of care for the marginal actor, the incentive for care under the causation test will be socially inadequate. Whether this holds true is ambiguous a priori.

A few implications follow from this analysis. First, the factual causation requirement of negligence law does indeed influence the incentive to take care. In this model courts are not setting a specific due-care standard. However, we regard this as a realistic feature since courts in general examine specific untaken precautions rather than attempt to set globally optimal care levels (Grady, 1989).

Second, it should be clear that the effect of the negligence-causation test on the incentive for care is ambiguous and depends on a number of variables, such as the productivity of care, the cost of care, the size of the victim's loss, and the distribution of the intervention probability. The causation test does not systematically distort care above or below the socially optimal level. In contrast to Grady and Kahan, this model does not imply that the injurer will exercise socially optimal care under the court's negligence-causation test.

Because the causation test is subsumed within an ex post assessment of negligence in this model, we will refer to it as the "negligence-causation" test. As we will argue later, the ex post negligence model has implications that go beyond the causation issue. The following result provides a general overview.

Proposition 1: *The negligence-causation test leads to socially excessive care if* $(r - w)E(s) < r[1-G(E(s))]$. *The test leads to socially inadequate care if the inequality is reversed, and optimal care in the case of equality*.

Proof: Care is socially desirable when $x < A = (r-w)E(s)L$. Care is privately desirable when (3) holds. Let

$$f(x) = x - r[1 - G\left(\frac{x}{(r-w)L}\right)]L.$$

Since

$$f'(x) = 1 + rg\left(\frac{1}{(r-w)}\right) > 0,$$

we know that $f(x)$ is strictly increasing in x. Note that $f(x = 0) < 0$ and $f(x = (r - w)L) = (r - w)L > 0$, so that there must exist an $\bar{x}$ where $0 < \bar{x} < (r - w)L$ so that

$$\begin{cases} f(x) \geq 0 & when\ x \geq \bar{x} \\ f(x) < 0 & when\ x < \bar{x} \end{cases}$$

We know that (3), the private care condition, is equivalent to $x < \bar{x}$. Let us check whether $A = (r - w)E(s)L$ is greater than or smaller than $\bar{x}$. To do that we need to check the sign of $f(x = (r - w)E(s)L)$.

$$\begin{aligned} f(x = (r - w)E(s)L) &= (r - w)E(s)L - r[1-G(E(s))]L \\ &= L\{(r - w)E(s) - r[1-G(E(s))]\}. \end{aligned}$$

Thus, if $f(x = A) \geq 0$, $A \geq \bar{x}$, and if $f(x = A) < 0$, $A < \bar{x}$.

Proposition 1 compares the expected marginal benefit from care to the expected liability if there is a greater-than-average realization of the intervention probability. The intervention probability (or "signal") makes care effective in this framework.

The key implication of this model is that *the causation test induces agents to think about the distribution of the intervention probability in addition to its average value*. If the distribution is one that implies a high chance that the intervention probability will exceed its expected value, the causation test will lead to socially excessive care. If, on the other hand, the distribution is one that implies a low probability that the intervention probability will exceed its expected value, the causation test reduces incentives for precaution below the optimal degree.

The basic reason for this can be seen in the factors inducing agents to take care. First, note that from (1), care is socially optimal when the marginal cost of care is less than the marginal benefit multiplied by the expected value of the signal. However, from (2), the agent will be held liable under the causation test only if the marginal cost of care is less than the marginal benefit multiplied by the realized value of the signal. Putting these two observations together, the causation test induces excessive precaution when the probability that the signal will exceed its expected value is high.

Since injurers are induced to think about the distribution of the signal, one very natural case to consider is that of a symmetric distribution, such as the uniform or the normal.

Proposition 2: *Assume the probability of intervention is symmetrically distributed. If the probability of injury is positive when the injurer takes care and the intervention (which makes care effective) occurs, the negligence-causation test leads to socially excessive care. If the probability of injury is equal to zero when the injurer takes care and the intervention occurs, then the negligence-causation test leads to socially optimal care.*

Proof: Recall from the proof of Proposition 1 that $f(x = (r - w)E(s)L) = L\{(r - w)E(s) - r[1 - G(E(s))]\}$. Now, suppose s has a symmetric distribution, so that $E(s) = ½$ and $G(½) = ½$. Then $f(x = A) = L[(1/2)(r - w) - (1/2)r] = - wL < 0$, which implies $A < \bar{x}$.

In general, the causation test leads to excessive care in the presumptive default setting where the intervention probability has a symmetric distribution. This includes the normal and uniform as special cases. The special case where the causation test leads to optimal care is observed when the intervention probability distribution is symmetric *and* the probability of an injury is zero when care is taken and the intervention occurs.[16]

[16] This special case appears to incorporate the Grady, Kahan, and Marks analyses, though this model assumes a limited-information court, unlike Grady, Kahan, and Marks, who assume a full information court. We examine full information courts later in the text, and in that discussion derive the results of Grady, Kahan, and Marks.

Proposition 3: *If the distribution of the intervention probability is (sufficiently) skewed toward one, the negligence-causation test generates socially inadequate care. If the distribution of the intervention probability is (sufficiently) skewed toward zero, the negligence-causation test generates socially excessive care*.

Proof: If *s* has a distribution with a mean that approaches one, then, using the argument of the first proposition, $f \to r - w > 0$, which implies $A \geq \bar{x}$. If *s* has a distribution with a mean that approaches zero, then $f \to -r < 0$, which implies $A < \bar{x}$.

Our first proposition implies that one way of analyzing causation is to think of the size and welfare impact of the incentive distortion created by the causation test. If the individual cost of taking care is governed by the density $h(x)$, the social cost of the incentive distortion created by the causation test is given by

$$Welfare\ Loss = \int_{(r-w)E(s)L}^{\bar{x}} [x - (r-w)E(s)L]h(x)dx$$

where $\bar{x} = [1 - G\left(\frac{\bar{x}}{(r-w)L}\right)]rL$.

One short-hand approach to measuring the incentive distortion is to consider how far apart are the marginal private benefit of care and the marginal social benefit of care when the agent's cost of care is equal to the marginal social benefit of care. That measure is equal to: $L\{(r - w)E(s) - r[1 - G(E(s))]\}$, which is negative in the case of a distortion toward excessive care and positive in the case of a distortion toward inadequate care. Letting *D* represent the distortion,

$$D = \left(\frac{r-w}{r}\right) - \frac{(1-G(E(s)))}{E(s)}, \qquad (4)$$

where the first term captures the productivity of care. This distortion measure indicates that one need only have information on the productivity of care and the distribution of the intervention probability in order to assess the relative degree of the incentive distortion.

Since the difference between the private and social marginal benefit of care is equal to *DL*, a change in the amount of the victim's loss has no effect on the direction of inefficiency, just the size. In addition, an increase in the productivity of care makes it more likely that care will be socially inadequate under the causation test.

It should be clear that, in contrast to Shavell (1986), a *proportionate damages remedy* will be insufficient to guarantee optimal care incentives. If the damage award is set equal to $(r-w)L/r$, the first term in the distortion measure becomes one. But the distortion measure remains unequal to zero. The one special case in which optimal care is guaranteed under the proportionate damages remedy is when the distribution of the intervention probability is symmetric.

A. Application to a Complicated Case

Consider *Grimstad* in light of this model. The first question is whether the distribution of the intervention probability – i.e., the probability that a person on the barge would grab a life buoy and throw it in time, with accuracy, after the barge captain falls from the barge into the water – is symmetrical or skewed. Suppose it is symmetrical, so that the expected likelihood that someone would get to the life buoy in time is 50 percent. Thus, when contemplating whether to install life-preservers, the barge owner, who knows the distribution, would anticipate a 50 percent likelihood of successful intervention.

In *Grimstad*, the court had information on the intervention probability after the accident. The person who would have attempted the rescue, if the barge had been equipped with life buoys, was the barge captain's wife. There was no reason to believe that she would have been informed about the location of the life buoys, or that she would have been able to throw one or more over the side of the barge with accuracy. Given this information, the court rejected on causation grounds the claim that the owner was negligent in failing to equip the barge with life buoys.

The incentive effect of the causation test can be identified in this case. On the assumption that the intervention probability has a symmetrical distribution, the only additional question implied by this model is whether the probability of a drowning is zero if life-preservers are installed and someone actually finds one and throws it in time. The probability of a drowning is still positive in the best-case scenario, since there is no guarantee that the barge captain would swim to the life-preserver in time, even if it were thrown quickly and with reasonable accuracy. Given this, the model implies, counterintuitively, that the negligence-causation test generates an incentive for socially excessive precaution in *Grimstad*.

One way of thinking about the complicated causation cases is that there are several accident types that might occur after the injurer takes care. For example, in *Grimstad*, the rescuer may have been a seasoned barge sailor, or someone inexperienced, like the captain's wife. The expected signal, ex ante, averages over both types. After the accident occurs, the court sees the precise rescuer type and can form an estimate of the signal for that accident type.

B. Application to Simple Causation Cases: the Cricket Hypothetical and Similar Cases

We have distinguished the complicated case just considered above from simple causation cases where the probability of intervention is either one or zero. The cricket hypothetical and *Perkins* are both examples of simple causation cases.

And there are other examples. In *Stacy v. Knickerbocker Ice Co.*,[17] the defendant negligently failed to erect a fence to prevent people from walking on the portion of ice covering a lake that had been thinned by the defendant's operation (removing and storing

[17] 84 Wis. 614, 54 N.W. 1091 (1893).

ice for sale). The plaintiff sued for the loss of his horses, which had fallen through the ice and drowned, after bolting in fright across the frozen lake. The court found that the weak fence required by statute would not have prevented the horses from running over the thin portion of the ice. In *Peterson v. Nielsen*[18] the plaintiff negligently exceeded the speed limit, but the accident would have happened even if the plaintiff had been driving at the speed limit.

In the cricket hypothetical the intervention occurs if the cricket ball is hit at a height that does not exceed the reasonable fence height. If the ball's trajectory does not permit it to fly over the (reasonable-height) fence, then $s = 1$. But that conclusion is reached only from an ex post perspective. Ex ante, the cricket ground owner does not know what the trajectory of the ball will be. Given this, the social desirability of precaution (i.e., raising the fence) is governed by (1) in the cricket hypothetical.

Now consider the incentives of the cricket grounds owner under negligence. Negligence will be determined after the ball's trajectory is revealed. There are two possibilities: the ball's trajectory carries it over the reasonable fence height, or below it. If the trajectory is high ($s = 0$), additional care would not have been productive, and the owner cannot be negligent. If the trajectory is low ($s = 1$), care would be socially beneficial (because $x < (r - w)L$ is assumed to hold) and the owner would be negligent for failing to raise the fence.

Given this, if the owner takes care his total cost will be x, since he cannot be found negligent. If the owner does not to take care, then if the ball's trajectory is high, he will not be liable, and if the ball's trajectory is low his expected liability is rL. The expected liability of the owner if he does not take care is therefore $Prob(s = 1)\times rL$, or $E(s)rL$. Using (1), the owner's incentive to take precaution is socially excessive if $(r - w)E(s)L < E(s)rL$. The result is a special case of Proposition 2.

Proposition 4: In the simple causation setting (e.g., the cricket hypothetical), the injurer's incentive to take care is socially excessive as long as the probability of injury is greater than zero when the injurer takes care and the intervention which makes care effective occurs. If the probability of injury is equal to zero when the injurer takes care and the intervention which makes care effective occurs, then the incentive to take care is socially optimal.

Applying this to the simple causation cases discussed earlier (the cricket hypothetical and *Perkins*), we can draw different conclusions in those cases. In the cricket hypothetical, the probability of injury is zero when the owner sets the fence at a reasonable height and the ball's trajectory is below the reasonable fence height. Thus, precaution incentives are socially optimal (Kahan, 1989). However, in *Perkins* it is not clear that the probability of injury would be zero if the victim had been able to get off the railroad tracks faster. Similarly, in *Peterson*, the probability of injury would not be zero if the car were driven at the speed limit. When trains and cars are operated at the speed limit, some residual

[18] 9 Utah 2d 302, 343 P.2d 731 (1959).

risk of injury remains. The causation test may induce excessive precaution in these scenarios.

C. Full Information Courts

The analysis in the preceding parts assumed that the court has less information about the distribution of the intervention probability than does the defendant. In this part, we assume the court has just as much information as the defendant has on the distribution of the intervention probability. This assumption is implicit in the analyses of Grady, Kahan, and Marks.

If the court knows the distribution of the intervention probability, then it will be able to determine whether care is socially desirable. Thus, the court will require (1) as a necessary condition to find the injurer negligent. In other words, the court will set the due care standard at the socially optimal level.

There are two ways in which the court could conduct a causation test, after determining whether the injurer was negligent. One is to conduct an ex post assessment of negligence, as in the preceding analysis which assumed a limited-information court. The second way to conduct the causation test is to determine whether the accident would have happened even if the injurer had taken care; that is, to conduct a *but-for* test of causation. We will examine the outcome under both methods of conducting the causation test. Under the ex post negligence method, socially inadequate care results. Under the but-for method, optimal care results.

1. Causation as Ex Post Negligence Test: Full Information Court

If the court, with full information, uses (1) to determine negligence, no injurers will exercise socially excessive care. The reason is that whenever $x > (r - w)E(s)L$, the injurer will not be held liable, so he will not take care. Consider, then, the case where $x < (r - w)E(s)L$, so that injurer is negligent on an ex ante basis. Under the ex post negligence inquiry, the injurer will take care when (3) holds.

Proposition 5: *If the court has full information and determines causation by using an ex post negligence test, care will be socially inadequate*.

Proof: This follows from the first proposition. If $x < (r - w)E(s)L$, and the injurer takes care, which implies $x < [1 - G(x/(r - w)L)]rL$, then $[1 - G(x/(r - w)L]rL > (1 - G(E(s))rL$. For any x within this interval $(r - w)E(s)L > (1 - G(E(s))rL$, which implies socially inadequate care.

This is the case in which the causation test works only to reduce the injurer's expected liability. Injurers who are negligent under the full information ex ante test escape liability because the court applies a second ex post negligence test based on information observable after the accident. This case replicates that considered in Shavell (1980, at

489) where a reduction in the scope of liability, associated with the causation test, reduces the incentive to take care.

2. Causation as But-For Test: Full Information Court

Now suppose the court has full information and uses (1) to determine negligence. In the second step of liability determination, the court applies a but-for test of causation.

Under a but-for test, the court would seek to determine if the probability of a successful intervention, given the facts before it, essentially zero. Of course, the court makes this assessment from the ex post perspective. Thus, the court observes the accident, and from that observation attempts to determine, ex post, if the probability of a successful intervention given the facts is zero, or very close to zero.

In terms of this model, *the but-for test implies causation only if* $s_0 > \varepsilon > 0$.

The injurer will take care, under the but-for test, only when $x < (r - w)E(s)L$ and $x < [1 - G(\varepsilon)]rL$, which approaches rL as ε gets smaller. The following claim is an immediate implication.

Proposition 6: *If the court has full information and determines causation by using the but-for test, care will be socially optimal*.

This is the scenario first examined by Grady and formalized in the later treatments by Kahan and Marks; and the result here replicates their conclusions. The negligence test leads to optimal care, and the application of a but-for causation test does not distort optimal care incentives.

D. Extension to Imperfect Assessments of Causation and Negligence: Limited Information Courts

The preceding parts have assumed courts operate without error. In this part we relax this assumption, first by allowing for error in the assessment of causation, and second by allowing for error in the assessment of negligence.

1. Error in the Causation Assessment

Suppose the court misapplies the negligence-causation rule and holds the injurer liable with some probability even when he is not negligent on the basis of an accurate ex post assessment. If this happens with probability θ, then the negligence-causation test leads to care if

$$x < r[1 - G\left(\frac{x}{(r-w)L}\right) + \theta G\left(\frac{x}{(r-w)L}\right)]L\ ,$$

or

$$x < r[1-(1-\theta)G\left(\frac{x}{(r-w)L}\right)]L. \tag{5}$$

As this condition indicates, it is more likely that injurers will exercise socially excessive precaution in this scenario, but it is not certain. Note that (5) is equivalent to the incentive condition that would be observed if the court applied the negligence-causation analysis with probability $1-\theta$, and strict liability with probability θ.

In terms of Figure 1, the effect of judicial error in the application of the causation test – specifically, failing to apply it when it should be applied – is to shift the downward sloping curve up and to flatten its slope. In the limit, as θ approaches one, the downward sloping curve of Figure 1 coincides with a horizontal line at level *rL*. Since $rL > (r - w)E(s)L$ (=*A* in Figure 1), care will be unambiguously excessive from the social perspective.

Put in more intuitive terms, as θ goes to one we get a discontinuous jump in liability. Although this is similar to the discontinuity first identified in Grady (1983), it is observed in a different setting, since Grady assumed full-information courts and we assume limited-information courts here. In this case the negligence rule definitely causes the injurer to exercise socially excessive care.

The effect of uncertainty in the application of the causation test differs from the general effect of uncertainty as analyzed in Calfee and Craswell (1986). Calfee and Craswell show that uncertainty in the application of a care standard can lead to socially excessive or socially inadequate precaution, depending on the degree of uncertainty.[19] We find a tendency toward excessive precaution because the type of uncertainty examined here is a failure to apply the causation rule, which would definitely increase the expected liability of the injurer. A failure to apply the causation test would be equivalent to imposing liability with certainty on injurers who fail to take care when precaution is potentially beneficial.

2. Error in the Negligence Assessment

The type of error considered in the previous part involves the application of the causation test. To this point we have assumed that the negligence test, though based on a provisional assessment that does not incorporate any information on the distribution of the intervention probability, is still based on accurate assessments of the cost of care and other relevant variables. In this part we will consider the implications of error in the provisional assessment of negligence.

Our model assumes that the precaution that can be exercised by the injurer is durable, in the sense that it remains in effect for the period of time in which the intervention may

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[19] Specifically, Calfee and Craswell show that excessive precaution is likely when the uncertainty is relatively small (low variance). Inadequate precaution is more likely where the uncertainty is relatively large (high variance).

occur. For example, in the *Grimstad* scenario the boat owner has the option to install life-preservers, the effectiveness of which depends on later intervention by a rescuer. The installation of life-preservers is a relatively durable precaution. Similarly, the decision to increase the height of a fence is a durable type of precaution. Durable and conspicuous precaution is a common feature of the causation cases.

Given that the durability and conspicuousness of precaution, error in the assessment of negligence will typically not involve a failure to determine accurately whether the injurer took care. A court will be able to tell whether life-preservers were on board, or whether the fence height had been increased. We will therefore assume that the court accurately determines whether the injurer took care.

Under the circumstances examined here error is likely to enter the negligence assessment, if at all, in the determination of whether the cost of care is greater or less than the maximum incremental harm resulting from a failure to take care. Recall that the ex post negligence assessment is equivalent to a two-step process involving a provisional assessment of negligence followed by an ex post analysis. In the provisional assessment, a court may erroneously conclude that injurer is potentially negligent when in fact he is not.

Assume the actor is potentially negligent ($x < (r - w)L$). Suppose with probably ¼, the court fails to correctly identify an injurer who is potentially negligent in the provisional assessment. Based on the model of the previous section, the injurer will take care only if $x < (1 - ¼)[1 - G(x/(r - w)L)]rL$, which implies that error of this sort dilutes the incentive to take care for the actors who are potentially negligent.

The effects of error in determining negligence are unlikely to be important in the case of the actor who is not potentially negligent. The court may incorrectly estimate the cost of care and hold him liable as a result. But this is most likely to occur when x is only slightly bigger than $(r - w)L$. Application of the causation test implies a vanishingly small likelihood of liability, so the actor will not have an incentive to take care.

The upshot is that when limited-information courts err in the assessment of negligence test, application of the causation test dilutes care incentives. However, as a general matter introducing error in the evaluation of negligence leads to ambiguous welfare implications. For example, in the symmetric signal distribution case (Proposition 2), error in the evaluation of negligence offsets the excessive care incentive created by the causation test.

E. Imperfect Assessments of Negligence: Full Information Courts

It may seem odd at first glance to consider error in the assessment of negligence in a model that assumes that the court has full information. But full information in this setting means that the court has just as much information on the signal distribution as does the defendant, not that the court is omniscient. The court may not know the precise cost of care. Given this, it is not inconsistent to consider error in the assessment of negligence in the full information setting.

First, suppose the causation test is implemented as an ex post negligence test. The results in this case are somewhat similar to that in which the courts have limited information and make mistakes in the determination of negligence. Actors who are potentially negligent on an ex ante basis ($x < (r - w)E(s)L$) will have even weaker incentives to take care, given the restriction on the scope of liability and the possibility of erroneous exemption. Actors who are not ex ante potentially negligent may have incentives to take care, given the nontrivial risk of liability when the court mistakenly classifies them as negligent actors.

Now consider the case where the causation test is implemented as a but-for test. Recall that this was the case of efficiency. If courts mistakenly classify actors who are not ex ante potentially negligent as negligent, there will be an excessive incentive to take care, in spite of the causation test. This is the result of Marks (1994), and it falls out of this model for this case. The incentive to take care is optimal under the causation test only if the probability of an injury when care is taken is equal to zero.

III. Causation-Dependent Negligence

We have focused on the scenarios in which the effectiveness of care is dependent on an intervention. An alternative set of causation scenarios to consider is where the impact of failing to take care is dependent on an intervention. The causation tree that accompanies this alternative class of cases is as follows.

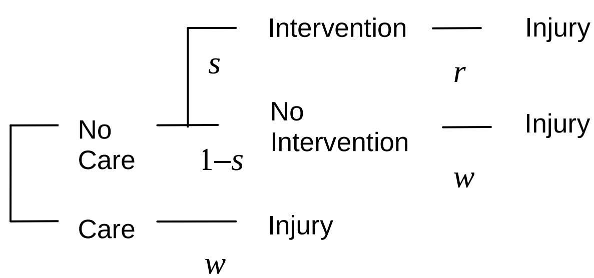

Figure 3: Causation event diagram (causation-dependent injury case)

A story that goes along with this diagram is something like the following. Suppose a teacher takes a group of school children out to a park for a picnic. She brings along a big cake and a big knife to cut it. When they arrive, she takes the knife out of her carrying bag and leaves it on a picnic table in the park. This is a rather careless act, given the risk that a child could accidentally hurt himself or a classmate with the knife. Instead, a deranged man walking by grabs the knife and attacks several people in the park.

This hypothetical is different from *Grimstad* and the other cases considered earlier because the intervention affects the impact of failing to take care in this hypothetical, while intervention affects the impact of care in the previously examined cases.

Although the causation story sounds different now, the analysis in terms of this model is the same. To see this, note that in the causation-dependent negligence case, taking care is socially desirable if

$$x + wL < \left(\int_0^1 (sr + (1-s)w)g(s)ds\right)L \quad .$$

Rearranging terms, this condition is the same as (1), the social desirability condition in the causation-dependent care scenario. This makes sense because in both scenarios an increase in the probability of intervention increases the productivity of care. The rest of the analysis of this case also mirrors the previous analysis. The results carry over without modification.[20]

Interestingly, the hypothetical considered in this part raises the issue of *proximate causation* rather than factual causation. Courts typically examine whether the intervention was foreseeable. If the court rejects liability, it will defend its decision by saying that the intervention was not foreseeable.

There are many cases similar to the cake hypothetical. Consider, for example, leaving your keys in the car. In *Ross v. Hartman*,[21] the defendant left his keys in his truck. A thief stole the truck and injured the victim. The defendant was negligent, but the impact of his negligence depended on the intervention of another actor. The court held that the defendant's negligence was a proximate cause of the victim's injury in spite of the thief's intervention.

Another case within this version of the model is *Berry v. Sugar Notch Borough*.[22] This case involved a claim of contributory negligence against the motorman of a trolley. He had been operated the trolley at an excessive speed – which was deemed negligent by the court. He was injured when a tree, defectively maintained by the borough, crashed on top of his trolley. Although his excessive speed was a cause in the but-for sense, the court rejected the contributory negligence theory on proximate causation grounds. *Berry* is a case where the intervention probability revealed, the probability that a tree falls on the trolley, was extremely low. The court's failure to discuss the ex ante evaluation of negligence – the court takes it as given that the plaintiff's conduct was negligent since it exceeded the speed limit set in a local ordinance – suggests that it was applying the ex post approach modeled in the first section of this paper.

[20] It should be clear that the causation-dependent care and causation-dependent negligence models can be combined to examine the effects of the negligence test in the dual scenario special case. The results are generally consistent with the analysis of Part II.
[21] 139 F.2d 14 (D.C. Cir. 1943).
[22] 191 Pa. 345, 43 Atl. 240 (1899).

Courts traditionally have said that intervention breaks the chain of causation between the defendant's negligence and the plaintiff's injury. If applied strictly, the intervention rule would eliminate the incentive to take care, since it would hold the injurer liable only when the probability of intervention is zero. But that view has given way over time, and indeed has always coexisted with, an approach based on foreseeability.[23] The foreseeability approach can be treated as equivalent to the ex post, or particularized, negligence inquiry examined in the previous part of this paper.

Cases of causation-dependent negligence are no different in economic terms from those of causation-dependent care. This analysis shows that causation-dependent care and causation-dependent negligence cases are essentially equivalent in terms of the economics. The causation case law includes a richer set of cases than these two categories (Landes and Posner, 1983). But these categories represent some of the most important applications, respectively, of factual causation doctrine and proximate causation doctrine.

IV. Discussion

A. Choice of Causation Model

As Landes and Posner note,[24] quoting Prosser, there is a great deal of confusion surrounding the causation case law. It is difficult to determine the implicit informational assumptions courts have adopted. We think that the limited information model developed here best captures what courts are actually doing in the causation cases, and the incentive effects created by the decision process employed by courts.

We have provided several models of the negligence-causation process based on the quality of information possessed by the court and the manner in which causation is determined – by an ex post negligence evaluation or by a but-for test. The ex post negligence approach is consistent with the analyses of Calabresi, Shavell, Landes and Posner. These papers have emphasized that courts are applying the causation test in a manner that essentially mimics the Learned Hand formula. This is especially noticeable in the proximate causation cases. Among the factual causation cases, the ex post negligence model provides the most general description of the incentives created by causation doctrine. Although the courts often use the language of the but-for test, there are many decisions that are not easily reconciled with it because the but-for test generates an uncertain answer.[25] These cases are much easier to reconcile with an ex post application of the negligence test. In terms of the language used in the judicial opinions,

[23] Even when courts have repeated the doctrine that intervention breaks the causation chain, they have made exceptions for the cases in which the intervention was deemed foreseeable. See, e.g., Brower v. New York Central & H.R.R., 103 A. 166 (N.J. 1918).
[24] Landes and Posner, at 109.
[25] *Grimstad* is one example; additional examples are discussed in note 9.

the substantial factor language is more general and appears to be consistent with an ex post application of the negligence test.[26]

The full information model examined in Part II.C is consistent with the approaches of Grady, Kahan, and Marks. The full information model coupled with a but-for test of causation replicates the results of those papers. Specifically, it finds that the causation test leads to efficient precaution. However, in the case of uncertainty in the application of the negligence test, the result is socially excessive precaution, except in the case in which the probability of an injury is zero when the injurer takes care. The reason for the excessive care result, which is established in the Marks article, is that there is an unavoidable discontinuity in the negligence test. Courts do not subtract from loss-based damages an estimate of the damages that would have resulted if the injurer took care. Because of that, there is always some degree of discontinuity in the negligence framework, which generates excessive precaution when there is uncertainty over the due care standard. The causation test mitigates the severity of the discontinuity but does not eliminate it.[27]

Perhaps the strongest argument for preferring the limited information model developed here to the full information model is that the limited information model describes the position that courts are actually in, at least with respect to most of the cases. They do not have enough information to determine the optimal care level, given the range of possible intervening factors. In most causation cases the courts are forced to make an ex post evaluation of negligence based on information revealed by the accident. This is consistent with the court opinions too; none of them discusses the difficulties of determining whether care is optimal given the range of contingencies. Many of the cases are based on statutory breaches, and those that are not based on statutory breaches involve presumptive or provisional findings of negligence.

B. Optimal Care Standards and Information

The ex post assessment of negligence formalized here has implications that go beyond the causation issue. A court with limited information may choose to adopt the ex post negligence approach, and resulting care incentives may be excessive, optimal, or inadequate (Proposition 1). If a court has full information and employs the but-for causation test, care incentives will be optimal (assuming no error). Substantive and evidentiary rules that enable courts to adopt or to approximate full-information standards can, unsurprisingly, enhance welfare.

One substantive rule of this sort is the custom defense in tort law. Knowledge of the distribution of the signal may be held privately by members of an industry, while unavailable to the court. If the customary care standard is optimal, in the sense of

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[26] One case that is consistent with ex post negligence analysis, and that uses the substantial factor test, is *Gyerman*, supra note 9. It is not clear, in *Gyerman*, that the accident definitely would have happened even if the plaintiff (contributory negligence) had taken reasonable care.
[27] This assumes damages are set equal to the victim's loss. The discontinuity is completely smoothed out in this model if the court adopts the proportionate damage remedy $(r-w)L/r$.

reflecting information on the actual signal distribution, then the custom defense would effectively supplant an ex post negligence assessment with a full-information standard.[28]

C. Hindsight Bias and Behavior of Courts

This model can be modified easily to apply to the problem of hindsight bias in tort law. In the hindsight bias setting, the harm to the victim typically depends on some intervention. The court does not know the probability of the intervention. After the accident occurs, the court observes the intervention and assigns a probability to it. In the causation model discussed in part II, the court assigns an accurate ex post value to the intervention probability. In the hindsight bias case, the court assigns a probability that is higher than the true value to the intervention. Because of this bias, the court is more likely to find the injurer guilty of negligence.

A model of hindsight bias begins with the court's ex post assessment of negligence. The true value of the realized intervention is s_0. The court applies a hindsight-biasing transformation to reach its subjective probability measure $\hat{s}(s_0) > s_0$, for $0 < s_0 < 1$. The injurer will be held liable if, under the particular realization of the intervention probability, care would have been deemed socially beneficial given the court's perception: $x < (r - w)\hat{s}(s_0)L$. The probability that the injurer will be held liable for negligence is then $1 - G(\hat{s}^{-1}(x/[(r - w)L]))$, where $\hat{s}^{-1}$ is the inverse of the hindsight transformation. Care incentives can be analyzed in the same manner as in the causation model.

The interesting questions in the hindsight bias case revolve around the reasons for the bias. The bias could be irrational or arbitrary; it could be based on a distaste for the defendant, or a desire to redistribute wealth. Hindsight bias could also have a rational basis. In order to determine whether the defendant was negligent on an ex ante basis, an uninformed court would have to obtain information from the litigants on the distribution of the intervention probability. The court may distrust the injurer's representations on the distribution of the intervention probability. Given a choice of two reports on the signal distribution, one from an informed defendant and another from a less-informed plaintiff, the court might rationally choose the plaintiff's report in order to weaken the defendant's incentive to report falsely.

The behavioral bases for hindsight bias may be the same, ultimately, as those for the ex post negligence approach modeled in this paper. The court, in a position of Knightian uncertainty, may be averse to attempting to estimate the distribution of the intervention probability, an aversion that has been demonstrated in experimental findings such as the Ellsberg paradox. The behavioral bases for the ex post negligence test are potentially

[28] The obvious application here is a case where physicians decide on the basis of professional knowledge (about the distribution of the intervention probability) that a particular medical test is not necessary for patients of a certain age group. A particular case might involve evidence suggesting a high intervention probability, leading a court to find negligence on the basis of an ex post assessment. See Helling v. Carey, 519 P.2d 981 (Wash. 1974), involving the application of a glaucoma test to relatively young patients.

many; including bounded rationality and strategic behavior. We view these questions as potential areas of future research.

V. Conclusion

What distinguishes causation cases is that there is typically an intervention that occurs after the injurer commits to a durable care level. The cricket ball is hit at a low trajectory or a high trajectory; the barge captain's wife can either grab the life buoy in time or not; a thief steals the car with the keys left in the ignition or does not. This intervention probability can be treated as a signal that is revealed only after the accident occurs. Courts are able to look at the signal, without knowing its distribution, while injurers choose a care level with knowledge only of the signal's distribution. We have formalized this structure in a simple model.

We find that in the most plausible scenarios the causation test generally leads to excessive care. Under certain conditions the causation test generates optimal care, and the specific conditions we derive in this model are consistent with earlier articles that find that the causation test generates optimal care. Our model also provides a more formal treatment of the problem of uncertainty in the application of the causation test. Finally, we show that the causation-dependent care and causation-dependent negligence scenarios are indistinguishable in an economic sense. The causation-dependent care scenario is associated with "factual causation" disputes and the causation-dependent negligence scenario is associated with "proximate causation" disputes. Thus, the incentive effects of proximate causation and factual causation doctrines can be analyzed within a consistent framework.

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