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Boston University School of Law Working Paper No. 11-15
(March 24, 2011)
Revision of April 30, 2013

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January 2013

Abstract: We present a new model of negligence and causation and examine the influence of the negligence test, in the presence of intervening causation, on the level of care. 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 negligence test depend on the information available to the court, and the manner in which the test is implemented. The key effect of the negligence test, in the presence of intervening causation, 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 test generally leads to socially excessive care.

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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 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 others, the tests are not easily distinguished in terms of the answers that they generate.

The economic literature on causation under negligence has 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. The framework we adopt, however, 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 (Grady, 1983). This has implications for the effects of uncertainty on the level of precaution.

In this paper we present a new model of causation – more precisely, of the negligence test in the presence of intervening causation – and its influence on the level of care. 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. Negligence is determined in this model, as it is in the courts, *after* the intervention probability has been revealed (Wright, 1985; Landes and Posner, 1983),[1] and using the revealed information.

In general, the incentive effects of the negligence test in the presence of intervening causation depend on the information available to the court, and how the causation inquiry is conducted. 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, is likely to know the distribution of the intervention probability.

[1] That negligence is assessed ex post rather than ex ante in the causation cases is stressed by Wright (1985) in his critique of the economics literature on causation. While we reject Wright's critique of law and economics, his more limited claim regarding the causation case law appears to be valid. Landes and Posner (1983) present an economic model of causation in which negligence is determined ex post using information revealed by the accident.

We assume that the court, given its informational constraints, performs an ex post assessment of negligence. This assumption is supported by observation: many of the causation cases in tort law, as Calabresi (1975) first noted, are essentially ex post assessments of negligence.

We show that the extent to which the negligence test, applied in the intervening causation setting by limited-information courts, distorts care from the socially optimal level depends on several factors: the productivity of care, the size of the victim's loss, and the distribution of the intervention probability. As care becomes more productive, the negligence test tends induce socially inadequate care.

The key effect of the negligence test, in the presence of intervening causation, is to induce actors to take into account the distribution of the intervention probability in addition to its expected value. We show that when the distribution of the intervention probability is symmetric the incentive for care is generally excessive. The exception (in the symmetric case) is when the probability of an injury is zero when both the injurer takes care and the intervention occurs, in which 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 right, resulting in a high expected intervention probability, the incentive to take care tends to be socially inadequate. As the distribution skews left, resulting in a low expected intervention probability, the incentive to take care tends to be socially excessive.

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. We examine this scenario as a special case of the model in this paper. If the court has full information the incentive effects of the negligence test, in the presence of intervening causation, depend on the type of test implemented. If the court applies a but-for test to determine causation then the resulting care level is optimal (Grady, 1983; Kahan, 1989). If the court uses the ex post negligence test, socially inadequate care results.

Finally, we consider the effects of uncertainty in the application of the negligence test, both in the limited information and in the full information settings. Since, in the limited information setting, the negligence and causation inquiries are merged under an ex post negligence assessment, we distinguish between error in the assessment of the intervention probability (causation) and error in the assessment of the burden or of the productivity of care (negligence factors). As the probability that courts will mistakenly overestimate (underestimate) the intervention probability increases, the negligence test generates socially excessive (inadequate) care. The incentive effects of errors in the assessment of negligence factors, however, are muted under the ex post assessment of negligence. In the full information setting, our analysis of error in the assessment of negligence factors reconciles and extends the results of Grady and Marks within a unified framework. Generalizing the results of Grady and Marks, we specify relationships between the error rate, the productivity of care, and the intervention probability that generate excessive or inadequate care.

Modeling the causation assessment as part of an ex post negligence inquiry generates implications for some 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. 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 provide a positive theory of hindsight bias in tort law.

I. Causation Literature and Law

The economic literature on causation, under negligence law, consists of three parts. The first article to formally 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 a court finds an injurer negligent and then exempts him from liability on factual causation grounds, a close factual inspection would conclude that the injurer simply is not negligent under the Hand Formula.

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

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[2] Calabresi (1975) is also an important part of the early literature on the economics of causation. Calabresi's discussion anticipates arguments of the formal economic models in the Shavell and Landes-Posner articles.

[3] 147 So.2d 646 (La. 1962). The court held that the defendant railroad was negligent but excused from liability on the basis of causation.

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 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.[4] However, when imperfectly accurate courts are introduced into the analysis, the injurer's precaution decision is affected by whether the court takes factual causation into account.[5]

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. In addition, 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. In our model there is a probability of an intervention that determines whether the accident would have happened even if the

[4] Marks (1994) refuted the Grady-Kahan optimal care finding. 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.

[5] 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.

defendant had taken care.[6] When that probability is dichotomous, our model becomes close to that of Grady-Kahan-Marks, though still not the same, because of our assumption that the court does not know the distribution of the intervention probability. If the court does know the distribution of the intervention probability, then our model is equivalent to Grady-Kahan-Marks.

There are many causation cases that fit the more complicated intervention scenario we consider here. For example, in *New York Central R.R. v. Grimstad*,[7] 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 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.[8] 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.[9] The model we set out below captures this general class within a simple framework.

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[6] 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 do not consider the incentive problems studied by Grady and Kahan.

[7] 264 F. 334 (2d Cir. 1920).

[8] 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.

[9] The substantial factor test was introduced as a tool for analyzing cases in which two actors are 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 a more general approach in the torts case law. 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.

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.

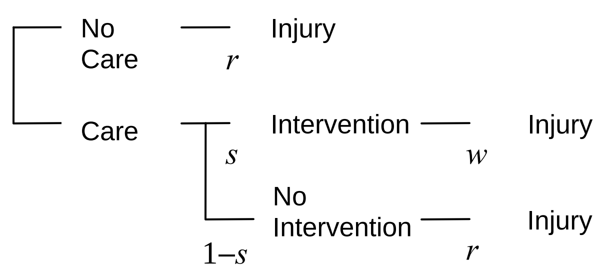

Figure 1: Causation event diagram

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

The court can observe the actual 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 injury once the intervention probability is realized later.[10]

[10] 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 model of facts. Specifically, 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.

Let the intervention probability be governed by the distribution $G(s)$ with corresponding density $g(s)$. The injurer knows the distribution of the intervention probability when he decides whether to take care. The court, with limited information, does not know the distribution of the intervention probability. However, the court observes a particular realization of s, say s_0, after the accident occurs.

In practical terms, these assumptions mean that in a scenario like *Grimstad*, the barge owner knows how often the captain is likely to be alone instead of surrounded by experienced sailors, while the court does not. After the accident, the court observes whether the captain was accompanied by an experienced sailor. This seems to a plausible and quite natural set of assumptions to take as a default position.[11]

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 is greater than its marginal cost. If the law imposed strict liability on injurers, their caretaking incentive would be governed by (1), and injurers would exercise the socially desirable level of care.[12]

Now consider the injurer's incentive to take care under negligence. 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

[11] An alternative scenario that is 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. Landes and Posner (1983), at 115, note that many of the causation cases involve breaches of statutory care standards.

[12] We ignore 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).

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 likely be the same.

We will treat the causation examination as embedded within an ex post negligence assessment – based on the observation of the intervention probability.[13] Under the ex post assessment of negligence, the injurer will be held liable if he fails to take care and, under the particular realization of the intervention probability, 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 assume $x < (r - w)L$, which means that the injurer is potentially negligent because the cost of taking care is less than the benefit under the best-case scenario where the intervention probability is one.[14] 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 intervention probability – and the causation issue would become irrelevant.[15] Indeed in this model one can 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.

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[13] This is what courts appear to do (Calabresi, 1975; Wright, 1985), as well as being the approach adopted in Landes and Posner (1980), though their model makes no distinction between ex ante and ex post scenarios.

[14] 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).

[15] We note that 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. This two-step approach is reflected in the causation cases; in most of them 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.

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

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

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, where A represents two potential values for $(r - w)E(s)L$.

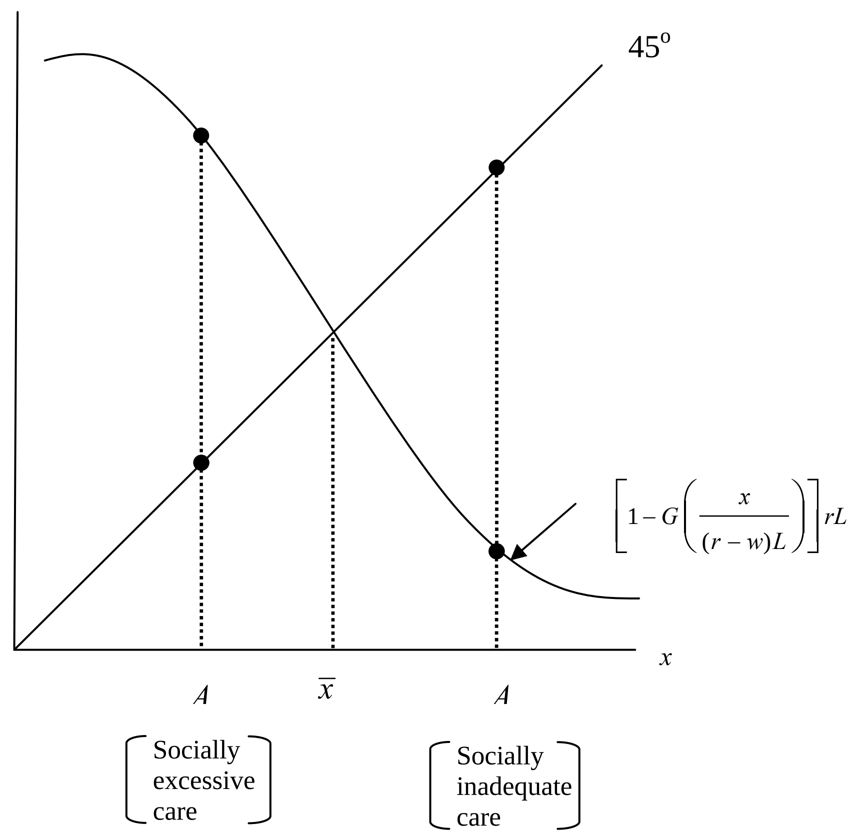

Figure 2: Conditions determining social optimality of care

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.

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 inquiry 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 test, in the intervening causation scenario, 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.[16]

The key implication of this model is that *the negligence test, in the presence of intervening causation, 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 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 negligence-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 negligence-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 negligence-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 test (with intervening causation) 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 negligence-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 negligence-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.[17]

[16] The notion of the intervention probability serving as a signal that courts observe is broadly consistent with the models of Shavell (1986) and Schweizer (2006), both of which model the accident-causation problem as consisting of signals that courts observe ex post.

[17] This special case generalizes the results of the Grady-Kahan-Marks model. The model here assumes a limited-information court, unlike Grady, Kahan, and Marks, who assume a full information court. In the symmetric distribution scenario, and under the special case identified, the different informational

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 associated with the negligence-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 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 negligence-causation test.

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assumptions have no impact on the results. We examine full information courts later in the text, and in that discussion verify the results of Grady-Kahan-Marks.

It should be clear that, in contrast to Shavell (1986), a *proportionate damages remedy* will be insufficient to guarantee optimal care incentives.[18] 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.

III. Model with 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 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. Another way is to conduct an ex post assessment of negligence, as in the preceding analysis which assumed a limited-information court. We will examine the outcome under both methods of conducting the causation test.

The but-for method is the approach described by courts, and is the natural approach to consider here. The second method we consider only because it replicates the concern noted in the early exploration by Shavell (1980, at 489) that the causation test could weaken incentives for care.

A. Causation under the But-For Test: Full Information Court

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, is essentially zero. Of course, the court makes this assessment from the ex post perspective.

In terms of this model, *the but-for test implies causation only if* $s_0 > \varepsilon > 0$. It follows that the probability that the actor will be held liable under the but-for test, given that $x < (r – w)E(s)L$, is $1– G(\varepsilon)$.

[18] Schweizer (2006) also examines causation and proportionate damages measures.

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 4: *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.

B. 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 if he fails to take care. Under the ex post negligence approach, the injurer will take care only when (3) holds.

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

Proof: 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 (Shavell, 1980, at 489). Injurers who are negligent under the full information test escape liability because the court applies a second ex post negligence test based on information observable after the accident.

IV. Extensions: Imperfect Assessments of Causation and Negligence

The preceding parts have assumed courts operate without error. In this part we relax this assumption by allowing for error in the assessment of the intervention probability, and by allowing for error in the assessment of the core components of the negligence test. We will examine first the limited-information scenario in which the court does not know the distribution of the intervention probability.

A. Limited Information Courts

1. Error in Causation Assessment

Suppose the court errs by holding the injurer liable even when the intervention probability is below the threshold necessary under the ex post negligence assessment. If the court errs in this manner with probability θ, then the negligence test, in the presence of intervening causation, 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

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

As this condition indicates, it is more likely that injurers will exercise socially excessive precaution in this scenario. In terms of Figure 1, the effect of judicial error of this sort – specifically, failing to apply the liability cut-off implied by the causation inquiry – is to shift the downward sloping curve up and to flatten its slope. In the limit as θ approaches one, the downward sloping curve coincides with a horizontal line at level rL. Since $rL > (r - w)E(s)L$, care will be excessive from the social perspective.

In other words, as the probability that the court erroneously overestimates the intervention probability (for example, erroneously thinks that the captain's wife could have thrown the life-preserver in time when in fact she could not) goes to one we get a jump in liability, similar to the discontinuity identified in Grady (1983), that causes the injurer to exercise socially excessive care.[19] If the court errs in the opposite direction, exempting the injurer from liability even when the intervention probability is above the threshold required for liability, the injurer will tend toward socially inadequate care.

2. Error in Assessing the Cost or the Productivity of Taking Care

The type of error considered in the previous part is a failure to accurately assess the intervention probability. Now we consider the implications of error in determining the cost or the productivity of care.

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 occur.[20] Given durable precaution, error in the assessment of negligence will typically not involve a failure to determine accurately whether the injurer took care – a court will

[19] The effect of type of uncertainty in the application of the negligence-causation test examined here 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. Specifically, Calfee and Craswell show that excessive precaution is likely when the uncertainty is relatively small (low variance), and inadequate precaution more likely where the uncertainty is relatively large (high variance). We find a tendency toward excessive precaution because the type of uncertainty examined, a failure to apply the liability cut-off associated with the causation analysis, increases liability.

[20] 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 durable precaution. Similarly, the decision to increase the height of a fence is a durable type of precaution.

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.

Given the durable precaution assumed in this model (and observed in the cases), error is likely to enter the negligence assessment in the determination of whether the cost of care is less than the maximum incremental harm resulting from a failure to take care ($x < (r - w)L$). We noted earlier that the negligence assessment in the presence of intervening causation (and limited information courts) is equivalent to a two-step process involving a provisional assessment of the actor's potential negligence ($x < (r - w)L$) followed by an ex post assessment of negligence using information on the realized probability of intervention. In the provisional assessment, a court may erroneously conclude that injurer is potentially negligent when in fact he is not, or vice versa.

If the actor is potentially negligent ($x < (r - w)L$), and the court mistakenly finds that he is not, he will avoid liability. Errors of this sort will tend to dilute incentives to take care. If the actor is not potentially negligent, and the court mistakenly finds that he is, he will face a risk of liability due solely to error, which generates excessive care.

Both types of error, however, are most likely to be observed when x is close to $(r - w)L$. Given this, and given that the actor will not be held liable with probability $G(x/[(r - w)L])$, the ex post negligence assessment will mute the impact of such errors on the incentive to take care. This replicates the smoothing proposition of Grady (1983), though here in the scenario of limited information courts.

In any event, introducing error in the assessment of negligence yields ambiguous welfare implications in this model. For example, in the symmetric signal distribution case (Proposition 2), error in the evaluation of the cost of care can offset the excessive care incentive created by the negligence test.

B. Full Information Courts

It may seem odd to consider error in the assessment of negligence in a model that assumes that the court has full information. But "full information court" in this model means only that the court has just as much information on the signal distribution as does the defendant. The court may not know the injurer's cost of care.

If the causation test is implemented as a but-for test, we noted earlier that the care level is efficient when courts have full information and accurately assess negligence, confirming the conclusions of Grady-Kahan-Marks model. However, efficiency may not hold if courts err in the assessment of negligence factors (i.e., the cost or the productivity of care). Specifically, if the court mistakenly classifies actors who are not negligent as negligent, there generally may be an excessive incentive to take care, in spite of the smoothing due to the causation test.

Let γ represent the rate of error in the assessment of negligence (both type-one and type-two errors). As in the previous part, we will assume that the error rate increases as the negligence assessment becomes more difficult. The negligence assessment becomes more difficult as x gets closer to $(r - w)E(s)L$.

The following propositions summarize and extend the results of Grady-Kahan-Marks.

Proposition 6: If the court errs with probability γ in the assessment of negligence (*cost or productivity of care*)*, the but-for causation test results in socially excessive care if and only if* $(r - w)E(s) < \gamma(1 - G(\varepsilon))r$.

To the extent that socially excessive care results, it is attributable to three sources: the error rate, γ, the productivity of care, $r - w$, or the relationship between the expected signal value and the probability that the signal is significantly positive, $E(s) < 1 - G(\varepsilon)$.

The first source of overdeterrrence, the high likelihood of error when negligence is a close call, was identified by Grady (1983) – though Grady ultimately concluded that the but-for test substantially reduces the likelihood of overdeterrence by precluding a discontinuous jump in liability. The second source, $w > 0$, was identified in Marks (1994). It results because courts do not subtract off counterfactual harm from the damage award.

The third source of overdeterrence, $E(s) < 1 - G(\varepsilon)$, results because the social benefit of taking care depends on the average value of the signal, while liability under the but-for test depends on whether the signal is likely to be significantly positive. It has so far been only partially recognized in the literature. The discount factor, $1 - G(\varepsilon)$, is the reason Grady found that the but-for test reduces the likelihood of overdeterrence. The model here shows that the smoothing property of the but-for test, in the presence of error, depends on the relationship between the expected signal value, the discount factor, and the error rate.

Grady's conclusion is clearly correct when the expected signal value is relatively small. When the expected signal value is close to zero, the discount factor is likely to be zero too.[21] However, when the expected signal value is relatively large, the third source of overdeterrence can be significant if the rate of error is substantial.[22] Grady's analysis implicitly assumes that the error rate diminishes to offset the effect of increasing the expected signal value.[23]

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[21] Consider, for example, the cricket hypothetical examined by Kahan. Let the signal represent an initial trajectory for the cricket ball when it is hit by a player – which is the only causation evidence observed by the court. If the owner's fence is only two inches below the reasonable height, then the expected signal value, $E(s)$, is the expected probability that a batted ball will pass through the two-inch gap, which is close to zero. The probability that the signal is significantly positive is also close to zero.

[22] Return to the example of the previous footnote. If the owner's fence is eight feet below the reasonable height, then the expected signal value – the expected probability that the batted ball will pass through the six-foot gap – is significant. The probability of a trajectory that passes through the gap is at least as great, and presumably close to one. Still, the error rate is likely to be low in this example, offsetting the distortion.

[23] This is a plausible assumption, but not necessarily valid. Again, in the cricket hypothetical considered in the previous footnote, if the fence is eight feet below the reasonable height, one would think that the negligence question would be easy to determine, and the corresponding error rate low. But this is not

It follows that if the primary reason the actor is not negligent (i.e., $x > (r - w)E(s)L$) is because the expected intervention probability is low ($E(s)$ close to zero), the causation test operates to prevent the appearance of a discontinuous jump in liability, as Grady concluded, reducing the likelihood of overdeterrence. If, however, the primary reason the actor is not negligent is because the productivity of care is low (i.e., $r - w$ is close to zero), the risk of a discontinuous jump in liability remains, as Marks concluded.

It remains to discuss the problem of socially inadequate care due to error. The following result suggests that socially inadequate care is less likely to be observed than socially excessive care. Socially inadequate deterrence appears to depend largely on the existence of a high rate of error in the assessment of negligence.

Proposition 7: If the court errs with probability γ in the assessment of negligence (*cost or productivity of care*)*, the but-for causation test results in socially inadequate care if and only if* $(r - w)E(s) > (1-\gamma)(1 - G(\varepsilon))r$.

V. Applications

In this part we examine applications of the model to familiar cases discussed in the literature on causation.

A. *Grimstad*

In order to clarify the model, consider the following numerical example, based on *Grimstad*. The barge owner must decide ex ante whether to install life-preserves on the barge, given that the preservers will be useful only if a rescuer intervenes to deploy them effectively.

The probability of intervention can be viewed as the probability that a certain type of rescuer will be available. The expected probability of intervention (the signal) averages over the types. After the accident occurs, the court sees the precise rescuer type and can form an estimate of the signal for that accident type.

Suppose there are two probabilities of intervention: $s_o = ¼$ and $s_1 = ¾$. The low intervention probability corresponds to the instances in which the captain is alone on the boat, or there with only his wife. The high intervention probability corresponds to instances in which the captain is on the boat with other experienced sailors. Associated with these intervention scenarios are frequencies. The frequency with which the low intervention probability scenario occurs is $p_o = ¼$ and the frequency with which the high intervention probability scenario occurs is $p_1 = ¾$.

necessarily true. Negligence depends on the cost and the productivity of care – not on the distance between the care level and the optimal care level.

In the limited information scenario described in the basic model of this paper, the frequencies of the high-intervention and low-intervention probability scenarios are known to the captain and the barge owner, but not to the court.

Given these assumptions, the expected probability of intervention given that the defendant (barge owner) takes care (installs life-preservers) is equal to (¼)(¼) + (¾)(¾) = 5/8. Assume r = ¾, w = ¼, the cost of taking care is $40, and the injury is $160. The benefit of taking care is therefore:

$$\left(\frac{3}{4}-\left[\left(\frac{5}{8}\right)\left(\frac{1}{4}\right)+\left(\frac{3}{8}\right)\left(\frac{3}{4}\right)\right]\right)\$160=\$50$$

Thus, taking care is socially desirable because the expected benefit, $50, exceeds the cost, $40.

Suppose, however, that the accident occurs in a low-intervention probability state – for example, when the captain on the barge with only his wife. The court observes that the intervention probability is only ¼ in the case that comes before it. When the court analyzes the defendant's negligence, it compares the burden of taking care to its estimate of losses avoided, given the observed intervention probability. The court's estimate of losses avoided is therefore:

$$\left(\frac{3}{4}-\left[\left(\frac{1}{4}\right)\left(\frac{1}{4}\right)+\left(\frac{3}{4}\right)\left(\frac{3}{4}\right)\right]\right)\$160=\$20,$$

and since this is less than the cost of taking care, $40, the court concludes that the defendant is not negligent.

Incentive effects of the negligence-causation test can be identified. In this example, we assumed a left skew for the distribution of the intervention probability, which implies socially excessive care under Proposition 3. If we assumed instead that the distribution for the intervention probabilities is symmetric (p_o = ½, p_1 = ½), Proposition 2 implies socially excessive care, given that the likelihood of a drowning even when the actor takes care is still positive in this scenario.

B. Application to Cricket Hypothetical

In Part I, reviewing the literature, we distinguished complicated cases such as *Grimstad* from simple causation cases where the probability of intervention is either one or zero. The cricket hypothetical, explored in Kahan (1989), and *Perkins* are both examples of simple causation cases.[24]

[24] There are more examples. In Stacy v. Knickerbocker Ice Co., 84 Wis. 614, 54 N.W. 1091 (1893), 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 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

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).

Now consider the incentives of the cricket grounds owner under the negligence-causation test with limited information courts. 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 will not be found negligent. If the trajectory is low ($s = 1$), care would be socially beneficial ($x < (r - w)L$ is assumed) and the owner would be found negligent for failing to raise the fence.

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 $E(s)rL$. The owner's incentive to take precaution is socially excessive if $(r - w)E(s)L < E(s)rL$.

Proposition 8: In the simple causation scenario (e.g., 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, so the causation test may induce excessive precaution in that scenario.

C. Application to 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

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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, 9 Utah 2d 302, 343 P.2d 731 (1959), the plaintiff negligently exceeded the speed limit, but the accident would have happened even if the plaintiff had been driving at the speed limit.

failing to take care is dependent on an intervention. The causation tree that accompanies this alternative class of cases is as follows.

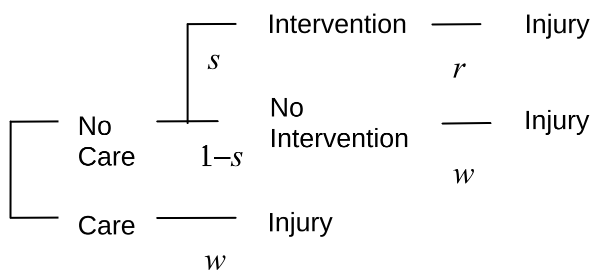

Figure 3: Causation event diagram (causation-dependent injury)

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 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.[25]

Interestingly, the hypothetical considered in this part raises the issue of *proximate causation* rather than factual causation. Courts typically examine whether the

[25] 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 a two-sided causation scenario.

intervention was foreseeable. If the court rejects liability, it will defend its decision by saying that the intervention was not foreseeable.[26]

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

VI. Some Additional Implications

The ex post assessment of negligence formalized here has implications that go beyond the intervening causation problem. The realist versus formalist debate about the nature of the causation inquiry appears to be reducible, in this model, to a matter of the information possessed by the court. Realists have held that the causation decisions reflect policies adopted by courts, while formalists have held that causation is purely a matter of fact. If the court applies an ex post negligence assessment because it has limited information, its decision on causation will be inseparable from the policies influencing the negligence assessment.[27] If the court has full information, it can adopt an optimal care standard and determine causation as a purely factual matter.

A second implication of this model is that courts with limited information can enhance welfare by adopting substantive and evidentiary rules that enable the court to approximate a full-information care standard. Under the ex post negligence approach, the resulting care incentives may be excessive, optimal, or inadequate depending on the distribution of the intervention probability. Under the full-information care standard, the court can apply the but-for causation test, and care incentives will be optimal (assuming no error).

One substantive rule that enables a court to approximate full information is the custom defense in tort law. Knowledge of the distribution of the intervention probability is likely to be held privately by members of an industry, and unavailable to the court. If the customary care standard is optimal, in the sense of reflecting information on the actual intervention probability distribution, then the custom defense would effectively enable the court to apply a full-information standard.[28]

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[26] There are many cases within the set considered here. Consider, for example, leaving your keys in the car. In Ross v. Hartman, 139 F.2d 14 (D.C. Cir. 1943), 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.

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

[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.

The third implication of this model is that the problem of hindsight bias can be understood as a strategic reaction by the court to limited information. The model in this paper can be modified easily to apply to hindsight bias in negligence 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 model discussed previously in this paper, the court assigns an accurate value to the realized intervention probability. In the hindsight bias case, the court assigns a probability that is higher than the true value of 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 $\hat{s}(s_0) > s_0$. 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 higher than it would have been without the bias.[29] Care incentives can be analyzed in the same manner as in the model examined previously.

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

VII. Conclusion

What distinguishes causation cases in negligence law is that there is typically an intervention that occurs after the injurer commits to a durable care level. The cricket ball

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[29] Specifically, the probability of liability is $1 - G(\hat{s}^{-1}(x/[(r - w)L]))$, where $\hat{s}^{-1}$ is the inverse of the hindsight transformation.

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 when the accident occurs.

The most plausible assumption is that courts are able to observe 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. However, the model is sufficiently general to include as a special case the scenario in which the court knows the distribution of the signal.

We find that in the most plausible scenarios the negligence test in the presence of intervening causation generally leads to excessive 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. Thus, the incentive effects of proximate causation and factual causation doctrines can be analyzed within a consistent framework.

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