

Precaution with endogenous litigation choices

Ian A. MacKenzie^{*†}

[†]School of Economics, The University of Queensland, Brisbane, 4072 Australia.

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Abstract

A central question in tort liability is how to induce a socially optimal level of precaution. In most analysis it is common to assume that litigation is either costless or the costs are exogenously fixed. Yet, in reality, litigation costs are large and litigants have the ability to choose their own level of litigation expenditure. In this paper we advance the theory of tort liability by investigating the incentive to invest in precaution when litigation efforts are endogenously chosen by parties. We outline a two-stage game where, in the first stage, the injurer invests in a level of precaution. In the second stage—if harm has been realized—the victim can sue for damages and go to trial. Parties then choose their level of litigation effort in order to win the trial. We model the court's decision over liability as a stochastic 'lottery' contest, where the probability of being successful at trial depends on relative litigation efforts and inherent legal presumptions. We allow the level of precaution to compliment the injurer's generation of evidence at trial. We show how the equilibrium litigation efforts are chosen and how this determines the equilibrium level of precaution. We compare both strict liability and negligence rules and also solve for the optimal damages to minimize social losses.

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^{*}E-mail: i.mackenzie@uq.edu.au

1 Introduction

A central theme within tort liability is how to induce an injurer to select a socially optimal level of precaution. It is well known that in a simple environment—for example, one of unilateral precaution and costless litigation (e.g., Brown, 1973)—that both strict liability and simple negligence rules provide equivalent incentives for an injurer’s efficient level of precaution (Cooter and Ulen, 2011).¹ These simple environments, however, rarely exist: litigation is costly. For example, sunk investments must be made into preparatory and legal expenditure for trial, such as the gathering and presentation of evidence, obtaining expert witnesses, to name but a few. Additional to litigation being costly, it is also apparent that the level of investment into litigation is endogenously chosen by litigants: budget permitting, litigants have the ability to choose their own level of investment into legal services. Thus, to consider the relative merits of different liability rules, one must consider how the choice of litigation efforts and the choice of precaution interact. How does the choice of litigation efforts affect the incentive to invest in precaution (and vice versa)? How do different liability rules alter the equilibrium litigation efforts? Is there a difference in equilibrium precaution between strict liability and negligence rules when litigation efforts are endogenously determined?

In this article we analyze the incentives for an injurer to invest in precaution when the choice of litigation effort is endogenously determined. We outline a two-stage model. In the first stage, the injurer invests in a level of precaution, which will generate a probability of harm occurring. In the second stage, if harm has been realized, the victim can seek damages. At trial, both victim and injurer choose their level of litigation efforts and the court determines liability. We solve the game using a subgame-perfect Nash equilibrium and therefore are able to show how the level of precaution is influenced by endogenous litigation efforts.

We treat the litigation process as an adversarial mechanism.² Thus the court’s role is one of evaluating the evidence and persuasive arguments provided by the litigants. It is likely that the court has imperfect information about the injurer’s actions; therefore, it must base their decision on the relative merits of the evidence and arguments made. Consequently litigants will invest in litigation effort in order to persuade the court and thus maximize their expected payoff. To capture this we model litigation as a ‘lottery’ contest. This means that the probability of being successful at trial is dependent on relative litigation efforts. In particular, *ceteris paribus*, the probability of success at trial is increasing in a litigant’s own legal expenditure. Thus with litigants having the ability to

¹Of course, that is not to say both rules are equivalent as many other features are distinct (see, for example, Shavell, 1980; Cooter and Ulen, 2011).

²See Parisi (2002) for an approach that combines both adversarial as well as inquisitorial systems

invest in the presentation, fabrication, suppression and manipulation of evidence (e.g., Sanchirico and Triantis, 2008), there exists the potential for legal errors to occur over the court verdict (that is, both type I and type II errors may exist).

The use of alternative liability rules—such as strict liability and negligence rules—is likely to influence the incentive to invest in litigation and consequently on the incentive to invest in precaution. For example, under strict liability evidence is required to show causation. For negligence rules, additional evidence also needs to be presented that shows an injurer's breach of care. Whether strict liability or negligence rules result in the largest litigation costs remains an open question. One argument, highlighted by Spier (2007, p. 332), suggests that the litigation costs under a negligence rule may be higher as there is a need to show causation as well as negligence. This standard argument, however, neglects any potential complementarity between the injurer's choice of precaution and litigation expenditures. At trial, an injurer could benefit from being able to draw from evidence regarding their own precaution and invest less effort on other types of evidence. For example, one would expect then that if a due-care standard has been met, litigation costs for the injurer may be relatively small: presentation of the precautionary evidence would be relatively cheap to produce. If a precaution level was relatively small then it would be relatively more costly to produce evidence that favored the injurer. We follow the literature on evidence production (e.g., Sanchirico, 2000; Sanchirico and Triantis, 2008), and assume it is relatively more costly to present evidence if it is fabricated or manipulated. In our framework presented here we assume an injurer's marginal cost of litigation is decreasing in their level of precaution. Within our framework, then, we focus on a key difference between negligence rules and strict liability in that the former may result in the ability of additional (complementary) evidence to be sourced for trial.

Given the differences in litigation incentives from alternative liability regimes, we find the injurer's equilibrium litigation efforts are unambiguously lower under strict liability compared to a negligence rule. This, however, does not always translate into reduced costs as we find the change in costs to be ambiguous. To determine which liability rule results in higher equilibrium litigation costs one must consider the extent to which marginal litigation costs differ between players and the strength of legal presumption. We find the victim has higher expected litigation payoffs under strict liability and the injurer has higher expected litigation payoffs under a negligence rule. We then provide conditions where the level of equilibrium precaution differs between strict liability and negligence rules. In particular, a negligence rule will incentivize a higher level of precaution when this precaution level provides significant cost reductions in litigation. That is, the greater the reduction in marginal losses

from litigation (due to the complementarity of precautionary effort) the more likely it is that a negligence rule will result in a higher level of precaution.

1.1 Related literature

Our article focuses on the analysis of liability rules when litigation choices are endogenously determined by litigants. As such, our article is related to the literature on the economics of liability (Cooter, 1991). Although this literature is large, only a small subset focuses on costly litigation. One of the first attempts to incorporate costly litigation was Ordover (1978) who assumed litigation was given by a fixed and exogenous cost to both parties. This analysis has been the foundation for further advances in this area (Ordover, 1981; Polsinky and Rubinfeld, 1988; Hylton, 1990a,b, 2002), all of which assume that litigation costs are fixed and given. As litigation costs are fixed and exogenous to the choices of the litigants, the incentive for the victim to sue depends on the size of litigation costs relative to the level of harm: a victim will sue only when the cost of litigation is relatively low. Yet—as already stated—it is clear that exogenous litigation costs are an abstraction. Reality dictates that litigants have the option to spend as little or as much on litigation, subject to budgetary constraints. Thus an alternative approach to analyzing costly litigation is to allow litigants to determine their own level of litigation efforts.

In this article we depart from the conventional fixed-cost approach and instead model litigation as a contest, where litigants have the option to choose their level of investment in litigation efforts.³ As such the requirement for the discrete decision of whether to sue or not is adapted to include the litigant's ability to choose as much or as little litigation as they deem optimal.

Our contest approach has additional benefits over-and-above that of modeling endogenously determined litigation behavior. As the outcome of litigation depends on relative investments in litigation costs, we can investigate the role of legal presumptions as well as legal error. First, the existence of legal presumption—in terms of burden of evidence production or persuasion (Dobbs, 2000, p. 365)—has the ability to alter the productivity of evidence and persuasion. Following the framework of Bernardo et al. (2000), this can be modeled by allowing the probability of litigation success to be altered by legal presumption. We can therefore directly observe the consequences of legal presumption, not only on the equilibrium of the litigation subgame but also the equilibrium level of precaution. Thus we highlight the connectivity between legal presumption and the incentive

³For litigation modeled through a contest see, for example Tullock (1975), Braeutigam et al. (1984), Plott (1987), Katz (1988), Farmer and Pecorino (1999), De Mot (2013), and Farmer and Pecorino (2013).

to invest in precaution. Second, our model has inherent legal error as part of the legal system. Indeed, the court has imperfect information about the actions of the injurer (and victim) and thus the court must decide, on the balance of evidence, the most convincing argument. Assuming litigation to be costly, Hylton (1990a) has considered legal error via an exogenous uncertainty parameter. Yet, in reality, a prominent source of legal error is the ability of litigants to provide inaccurate, misleading, and fabricated evidence to persuade a jury. Indeed the source of legal error is associated with the choice of investments in litigation efforts.

A clear goal within the literature on costly litigation is determining a socially optimal adjustment to compensatory damages (Polsinky and Rubinfeld, 1988; Shavell, 1999; Polinsky and Shavell, 2014). The conventional argument is to allow the injurer to bear the costs of harm as well as the associated litigation costs. Yet, as recently shown by Polinsky and Shavell (2014), the optimal damages can range between zero and the cost of harm plus litigation costs. This is a consequence of litigation costs consisting of both a fixed component and a variable component that increases with the level of damages: there is a trade-off between increased damages and increased litigation costs. As a result, damages should be reduced in order to reduce litigation costs. Although introducing a variable component can capture litigation costs associated with changes in damages, it cannot capture the endogenous choice of litigation by litigants. In our article we are able to determine the socially optimal level of damages with fully endogenous litigation choices. We show equilibrium litigation costs are increasing in the level of damages and thus there also exists a trade-off between increased damages and increased litigation costs as outlined by Polinsky and Shavell (2014).

Only a small number of articles have investigated the effects of precaution on the probability of being found liable. In Craswell and Calfee (1986) an injurer can reduce their chance of being found liable by investing in a level of precaution. Craswell and Calfee (1986) assume that there exists an uncertainty distribution (influenced by precaution) that results in the defendant being found liable; accordingly, they abstract from the litigation process. In contrast, we focus on the litigation process and show how litigation efforts—coupled with levels of precaution—can determine whether a defendant is held liable or not. By extending the analysis of Craswell and Calfee (1986), Beckner III and Katz (1995) compare outcomes of costly litigation for the American or English rule. Yet, they do not consider a trial with fully endogenous litigation efforts. In our approach we provide a model of litigation where efforts are endogenously determined. Recently Farmer and Pecorino (2014) have focused on how an injurer responds to a changing negligence standard. They introduce a contest framework where the litigation outcome is, in part, determined by the level of precaution. We are

similar to Farmer and Pecorino (2014) in that we use a contest approach to analyze the trial, however, our focus is on the complementarity of precaution towards evidence generation. As a result we identify alternative mechanisms by which the choice of precaution can alter litigation outcomes. We allow investments in precaution to complement evidence generation and reduce marginal costs and are able to highlight when strict liability or negligence rules result in higher equilibrium litigation efforts, costs, and precautionary levels.

Our main contribution, therefore, provides a framework of precaution in which litigation choices are endogenously determined and where precaution provides a complementarity aspect to evidence generation. We are able to show how incentives to invest in precaution are linked to the choice of litigation efforts. Further, we are able to show how equilibrium litigation efforts are determined and influenced by legal error and legal presumption. This assists us in comparing scenarios under strict liability and negligence rules. The article is structured as follows. In Section 2 the generalized model is introduced. In Section 3 comparisons are made between strict liability and negligence. Section 4 provides a policymaker's optimal choice of damages and Section 5 provides further discussion and extensions to the main model. Section 6 has some concluding remarks.

2 The model

2.1 Preliminaries

Consider a situation in which player X 's actions may cause harm to player Y . Player X , the injurer, has the ability to invest in precautionary effort, $x \geq 0$, such that the probability of harm being inflicted on player Y , the victim, is given by the function $\phi(x)$, where $\phi'(x) < 0$ and $\phi''(x) > 0$. We initially assume that the victim has imperfect information about the injurer's choice of precaution, but relax this later in the article. With a probability of $\phi(x)$, the victim suffers harm $H > 0$ from player X and has the choice to sue for damages.

We assume the court has imperfect information regarding the actions of players and has to base its decision on the evidence brought before the court. As such, in the litigation process, both players expend resources in order to direct the court's decision in their favor. We denote player Y 's probability of winning the lawsuit as $p_Y(\kappa_X, \kappa_Y)$, where κ_X and κ_Y are the sunk litigation efforts chosen by players X and Y , respectively. Note that $p_X(\kappa_X, \kappa_Y) = 1 - p_Y(\kappa_X, \kappa_Y)$ with p_Y increasing in κ_Y and non-increasing in κ_X . The choice variables κ_X and κ_Y can be interpreted as persuasive or evidence-generating activities used to influence the court's decision in the litigants' favor. As

such there is no requirement for these activities to be factually correct. Thus we view the process of litigation as adversarial rather than an inquisitorial system. Further, we allow for the litigation process to have a number of alternative legal presumptions (Bernardo et al., 2000). For example, there may be burdens of evidence production or persuasion that may act in favor or against a litigant. To incorporate this we define the strength of legal presumption as $\pi \in (0, 1)$. If $\pi \rightarrow 0$ the litigation institution is in favor of the victim whereas if $\pi \rightarrow 1$ the injurer is favored.

To provide a foundation for litigation that includes persuasive and evidence-generating techniques as well as legal presumption, we use a contest structure. The probability of player Y winning the litigation game is

$$p_Y(\kappa_X, \kappa_Y) = \begin{cases} \frac{(1-\pi)\kappa_Y}{\pi\kappa_X + (1-\pi)\kappa_Y} & \text{if } \max\{\kappa_X, \kappa_Y\} > 0, \\ \frac{1}{2} & \text{otherwise.} \end{cases} \quad (1)$$

Note from (1) that player Y 's probability of winning is equal to their litigation effort relative to total outlays. Further, observe that the legal presumption parameter π alters the marginal productivity of litigation effort: if legal presumption is in favor of the victim, for example, then each unit of their litigation effort is marginally more productive and increases their probability of winning the trial. As the litigation system is adversarial, it can be seen from (1) that legal error may occur over the decision. Unlike the existing literature—that assumes legal error is caused due to an exogenous uncertainty parameter (e.g., Hylton, 1990a)—we assume that legal error is an endogenous element of the litigation game, which litigants can alter due to their choice of litigation efforts. That is, legal error may occur due to a litigant investing sufficiently large amounts of litigation effort in order to persuade the court—regardless of the factual correctness of the evidence.

Our framework has two stages. In the first stage, player X has the ability to choose a level of precaution. In the second stage, player Y has the choice to seek damages in court, and if this occurs, players invest in litigation efforts within the legal system. Our main aim in this article is to investigate the relationships between the choice of litigation resources—in order to persuade the court—the incentive for precautionary effort as well as the structure of damages. We solve the model using backward induction and thus begin with the second stage. We now outline the general form of litigation that can incorporate both strict liability and negligence.

2.2 Stage two

Assume that in stage one the harm H on player Y was realized and that the injurer chose a level of precaution $\hat{x} \geq 0$. Then the victim has the option to enter into a litigation game. In stage two each player will invest in litigation effort which will determine $p_Y(\kappa_X, \kappa_Y)$ defined in (1). We assume throughout that legal fees are in the form of the American rule, where each party pays their own legal fees irrespective of litigation outcome. We assume the costs of litigation are linear in litigation effort such that the costs to the players X and Y are given by $c_X \cdot \rho(\hat{x}) \cdot \kappa_X$ and $c_Y \cdot \kappa_Y$, respectively. The terms $c_X > 0$ and $c_Y > 0$ are constant marginal cost parameters. The term $\rho(\hat{x})$ captures the possibility, that for player X , the level of precaution reduces their marginal cost of litigation.⁴ In particular, we allow for cases where player X 's marginal cost of litigation decreases in the level of precaution from stage one such that for a $x \geq 0$, $\rho(x)$ has the following properties $\rho(0) = 1, \rho'(x) < 0, \rho''(x) > 0$. This is important for cases of negligence, where the ability of an injurer to provide evidence of precaution may help them in trial. Following the literature on evidence generation (e.g., Sanchirico, 2000; Sanchirico and Triantis, 2008) we allow preexisting levels of precaution to lower the injurer's marginal cost of litigation. Injurers—regardless of the level of precaution—must defend themselves in court. If some level of precaution has been used then this may complement the generation of evidence for trial and thus reduce the marginal cost of litigation. At the extreme, where the injurer has, in fact, chosen a level of precaution that meets a standard of care, the costs of persuasion and evidence generation may be small. Note that litigation costs may not be zero as the imperfect information experienced in court requires a trial to commence to decide on an outcome. At the other extreme where $\hat{x} = 0$, the costs of litigation are the largest: there are no additional advantages for the injurer.

As already stated, for strict liability the level of precaution is not necessarily an important element to generate proof of causation. In this respect, evidence of precaution is not complementary for the generation of evidence at trial. Strict liability can be interpreted as a special case of negligence: a case where the level of due care is independent of evidence generation for causation, where $\rho(x) = 1$ for all x . Under strict liability, litigants' objectives are to persuade the court that an unobservable activity by the injurer did or did not occur. Thus the use of persuasive activities and evidence generation (and not levels of precaution) are paramount to this understanding.

⁴As player Y experiences imperfect information over the choice of precaution it is assumed that the level of precaution does not alter their marginal cost of litigation. Later in the article, we relax this assumption and allow player Y 's marginal cost of litigation to be increasing in precaution. This is intuitive: as the level of precaution increases the ability of player Y to distort or manipulate evidence in their favor becomes harder and thus marginally more expensive.

Players' expected payoffs are therefore given by:

$$\max_{\kappa_X} -p_Y(\kappa_X, \kappa_Y)D - c_X \rho(\tilde{x})\kappa_X, \quad (2)$$

$$\max_{\kappa_Y} p_Y(\kappa_X, \kappa_Y)D - c_Y \kappa_Y. \quad (3)$$

With a probability $p_Y(\kappa_X, \kappa_Y)$ player X will lose the court case and have to pay damages of value D . We treat D as fixed and given but will return later in the article to discussing the optimal level of D . If player X wins (with probability $1 - p_Y(\kappa_X, \kappa_Y)$) then no damages are transferred. We will denote the pure strategy Nash equilibrium levels of litigation efforts as (κ_X^*, κ_Y^*) . We focus on the case where parties litigate and return later in the article to the issue of pre-trial settlement.

Under conventional negligence rule analysis (with perfect information), an injurer can avoid liability by providing due care: some threshold minimum of precaution is achieved. Yet in our framework, where a court has imperfect information on the injurer's actions (and therefore the source of legal error), there is inherent uncertainty over whether an injurer is negligent or not (and thus their liability).

2.3 Stage one

In stage one, the injurer has the ability to choose a level of precaution, noting that if harm realizes then a litigation game may ensue in stage two. The injurer's stage one expected payoffs are

$$\min_x x + \phi(x) \cdot [p_Y(\kappa_X^*, \kappa_Y^*)D + c_X \rho(x)\kappa_X^*]. \quad (4)$$

The injurer aims to minimize the (linear) cost of precaution and the expected loss from any potential trial, where, in the case of a trial, equilibrium litigation efforts would be (κ_X^*, κ_Y^*) . For player Y , the victim, they will experience harm denoted by H with a probability $\phi(x)$. If harm is experienced they can invest in litigation efforts to obtain damages denoted by D . Thus player Y 's expected payoff is given by

$$-\phi(x) \cdot [H - p_Y(\kappa_X^*, \kappa_Y^*)D + c_Y \kappa_Y^*]. \quad (5)$$

We now focus on two common examples of liability rules: strict liability and the negligence rule.

3 Liability rules

3.1 Strict liability

3.1.1 Stage two

Suppose the legal system consists of strict liability for the injurer over any harm that is inflicted. The injurer will want to select a level of precaution that minimizes their cost of precaution as well as any potential loss from litigation. As the court's objective is to determine whether the activity occurred and hence if the injurer is held strictly liable, it is intuitive to model strict liability as the case where $\rho(x) = 1 \forall x$. Solving (2) and (3), where $\rho(x) = 1 \forall x$ the pure strategy subgame Nash equilibrium for litigation efforts is given by:

$$\kappa_X^{*,S} = \frac{\pi(1-\pi)}{c_Y(\gamma(1-\pi) + \pi)^2} D, \quad (6)$$

$$\kappa_Y^{*,S} = \frac{\gamma\pi(1-\pi)}{c_Y(\gamma(1-\pi) + \pi)^2} D, \quad (7)$$

where $\gamma = \frac{c_X}{c_Y}$ is the relative marginal cost difference for litigation between players X and Y and superscript S denotes the strict liability case.⁵ The equilibrium probability of player Y being successful in court is given by:

$$p_Y(\kappa_X^{*,S}, \kappa_Y^{*,S}) = \frac{\gamma(1-\pi)}{\gamma(1-\pi) + \pi}. \quad (8)$$

The equilibrium costs of litigation are:

$$c_X \kappa_X^{*,S} = \frac{\gamma\pi(1-\pi)}{(\gamma(1-\pi) + \pi)^2} D = c_Y \kappa_Y^{*,S}. \quad (9)$$

The literature on costly tort law litigation (e.g., Ordoover, 1978; Menell, 1983; Polsinky and Rubinfeld, 1988; Hylton, 1990a,b) usually assumes that costs are fixed. The victim has a clear decision of whether to go to court or not: filing a lawsuit will only occur when the harm associated with the tortuous act is larger than the (fixed) cost of litigation. From (6) and (7), however, it is clear that when litigation efforts are endogenous, an incentive always exists to file a lawsuit if harm is generated. Thus the equilibrium choice of litigation efforts are dependent on the size of damages, the level of legal presumption as well as the marginal litigation cost differential between players. Substituting (6), (7), and (9) into (1), (2), and (3), yields the equilibrium expected payoffs of participating in

⁵It is straightforward to show that the second-order conditions provide an interior Nash equilibrium in litigation efforts.

litigation for players X and Y , respectively.

$$U_X^S = -\frac{\gamma^2(1-\pi)^2 + 2(1-\pi)\pi\gamma}{(\gamma(1-\pi) + \pi)^2}D, \quad (10)$$

$$U_Y^S = \frac{\gamma^2((1-\pi))^2}{(\gamma(1-\pi) + \pi)^2}D. \quad (11)$$

It is convenient to denote

$$\Delta_S \equiv \frac{\gamma^2(1-\pi)^2 + 2(1-\pi)\pi\gamma}{(\gamma(1-\pi) + \pi)^2} = 1 - \frac{\pi^2}{(\gamma(1-\pi) + \pi)^2} \in [0, 1], \quad (12)$$

$$\tilde{\Delta}_S \equiv \frac{\gamma^2(1-\pi)^2}{(\gamma(1-\pi) + \pi)^2} \in [0, 1], \quad (13)$$

and expected equilibrium payoffs from litigation are simplified to

$$U_X^S = -\Delta_S D, \quad (14)$$

$$U_Y^S = \tilde{\Delta}_S D. \quad (15)$$

From the expected equilibrium payoffs from litigation, it is immediate that

$$\frac{U_X^S}{\partial \pi} = \frac{2\pi\gamma}{(\gamma(1-\pi) + \pi)^3}D > 0, \quad (16)$$

$$\frac{U_Y^S}{\partial \pi} = -\frac{2(1-\pi)\gamma^2}{(\gamma(1-\pi) + \pi)^3}D < 0, \quad (17)$$

where legal presumption in favor of a party will increase their expected equilibrium payoff, and

$$\frac{U_X^S}{\partial \gamma} = -\frac{2(1-\pi)\pi^2}{(\gamma(1-\pi) + \pi)^3}D < 0, \quad (18)$$

$$\frac{U_Y^S}{\partial \gamma} = \frac{2(\pi-1)^2\pi\gamma}{(\gamma(1-\pi) + \pi)^3}D > 0, \quad (19)$$

where a greater disparity in litigants' marginal costs of litigation—player X having an increased marginal cost of litigation—will decrease the injurer's expected payoff and increase it for the victim. With litigation efforts now endogenous, we now turn to analyze the effect on equilibrium precaution.

3.1.2 Stage one

Now we turn to the choice of player X 's equilibrium level of precaution. Substituting (10) into (4), the injurer takes D as given and selects a level of precaution to minimize the loss from precaution

expenditure and litigation, which is now endogenously formed. Differentiating, player X selects x_S^* such that:⁶

$$1 = -\phi'(x_S)\Delta_S D. \quad (20)$$

From (20) it is possible to observe how the endogeneity of litigation affects the level of equilibrium precaution. Note that in a standard model of precaution with perfect compensatory damages, litigation is costless (e.g., Cooter and Ulen, 2011) and thus equilibrium precaution will be chosen so that $1 = -\phi'(x_S)H$. Comparing (20) with the ‘no-litigation’ case, we have the following proposition.

Proposition 1 (Comparison of equilibrium precaution with and without litigation). *If $D > (<) \frac{H}{\Delta_S}$ then equilibrium precaution will be higher (lower) when litigation is endogenized.*

As $\Delta_S \in [0, 1]$ it follows that precautionary effort is larger than the ‘no-litigation’ case only if damages are in the form of sufficiently large and positive adjustments to compensatory damages. Alternatively, if damages are perfectly compensatory (or with a relatively small positive adjustment), precautionary effort is lower than what is experienced in the conventional tort law model. To see this let $\gamma = 1$ and $\pi = 1/2$ so that litigants have identical marginal litigation costs and legal presumption is ‘balanced.’ In such a case, precaution will only be larger in the litigation case when $D > \frac{4H}{3}$.

From (16) and (18) it is clear that the level of precautionary effort is decreasing in π and increasing in γ . The injurer will decrease precaution as their equilibrium probability of success in litigation increases due to legal presumption being more favorable to them, and increase precaution when their marginal costs of litigation increase (and therefore, ceteris paribus, decreasing their equilibrium probability of being successful in litigation). For the latter it is clear that increased marginal costs of litigation have a positive effect on equilibrium precaution, which confirms the findings of frameworks that include fixed costs of litigation (e.g., Hylton, 2002).

In Proposition 1, parallels can be established with the ‘multiplier principle’ (Becker, 1968; Polinsky and Shavell, 1998; Hylton and Miceli, 2005), whereby, in order to achieve optimal precaution, damages should be multiplied by the reciprocal of the probability of liability. From Proposition 1, equivalence between precaution with and without litigation (and perfect compensation) occurs when damages are set so that the harm associated with the victim is multiplied by the reciprocal of the injurer’s share of benefits from litigation, i.e., by how much, in expectation, the injurer will reduce damages by participating in litigation. Note, however, that we have not yet considered the optimal

⁶The second-order conditions clearly hold for an interior solution.

level of damages in order to provide efficient precaution. We return to this in Section 4.

It is ambiguous whether the injurer's expected payoff will be higher or lower when we endogenise litigation. Take, for example, the case where $D > \frac{H}{\Delta_S}$. A trade-off exists. On the one hand, the injurer has the potential to transfer a large level of damages to the victim resulting in a loss (as well as having a higher level of precaution). On the other hand, from Proposition 1, the injurer's increase in precaution will result in a lower probability of harm being realized. It follows that what is important with respect to expected relative payoffs is the slope of $\phi(x_S)$; namely, productivity of precaution (e.g., Palsinky and Rubinfeld, 1988). A relatively flat slope will result in only minor changes in the probability of harm: the injurer will thus experience a net loss from litigation. In contrast a sufficiently steep curve may well reduce the expected damages and thus improve their expected payoff.

Note that if damages result in a non-negative payoff for the victim then it must hold that $D > \frac{H}{\tilde{\Delta}_S}$, where $\tilde{\Delta}_S$ is defined in (13). We know from observation that $\tilde{\Delta}_S < \Delta_S$, thus any time the victim has positive expected payoffs the injurer has to have high levels of precaution over that of the 'no-litigation' case, where damages are higher than compensatory damages. It is clear that the victim has perfect compensation when their payoff from litigation exactly equals the harm caused ($\tilde{\Delta}_S D = H$). The level of damages that must be set for this to occur means that harm has to be multiplied by the victims 'share' of damages that they are expected to win: as described above, this is similar to the 'multiplier principle'. It follows that for a victim to receive perfect compensation for harm, there must be an element of adjustment to compensatory damages.

With implicit differentiation of (20), it follows that:

$$\frac{dx_S^*(D)}{dD} = -\frac{\phi'(x_S^*)}{\phi''(x_S^*) \cdot D} > 0. \quad (21)$$

Equilibrium precaution is increasing in D and the size of the change depends on the slope of the productivity of precaution $\phi(\cdot)$.

3.2 Negligence laws

We now turn to the case of negligence. As such, a court's decision process may differ from strict liability. In terms of the evidence required, the negligence rule requires not only to show causation but also negligent actions.⁷

⁷Throughout this analysis note that we do not explicitly define a standard of due care for negligence to be proved. As the court has imperfect information over the level of precaution, the court must rely on what is presented as evidence,

3.2.1 Stage two

The probability of the victim's success in court is given by (1), which is the same as for the strict liability case: the difference now is in the generation (complementarity) of evidence and the associated changes to the marginal cost of litigation such that $\rho(\hat{x}) \leq 1$.⁸ Solving (2) and (3) yields the following Subgame Nash equilibrium in litigation efforts:⁹

$$\kappa_X^{*,N} = \frac{\pi(1-\pi)}{c_Y(\gamma\rho(\hat{x})(1-\pi) + \pi)^2} D, \quad (22)$$

$$\kappa_Y^{*,N} = \frac{\gamma\rho(\hat{x})\pi(1-\pi)}{c_Y(\gamma\rho(\hat{x})(1-\pi) + \pi)^2} D, \quad (23)$$

where superscript N denotes cases under the negligence rule. From (22) and (23) litigation efforts are increasing in the level of precaution. Equilibrium litigation costs are therefore:

$$c_X \cdot \rho(x) \cdot \kappa_X^{*,N} = \frac{\rho(\hat{x})\gamma\pi(1-\pi)}{(\gamma\rho(\hat{x})(1-\pi) + \pi)^2} D = c_Y \cdot \kappa_Y^{*,N} \quad (24)$$

and player Y 's probability of success in court is now given by:

$$p_Y(\kappa_X^{*,N}, \kappa_Y^{*,N}) = \frac{\gamma\rho(\hat{x})(1-\pi)}{(\gamma\rho(\hat{x})(1-\pi) + \pi)}. \quad (25)$$

Expected equilibrium payoffs from litigation are

$$U_X^N = -\Delta_N(\hat{x}) \cdot D, \quad (26)$$

$$U_Y^N = \tilde{\Delta}_N(\hat{x}) \cdot D, \quad (27)$$

which may be factually incorrect. The contest—by which a verdict is determined—may implicitly have some form of threshold that is required to be proven in order to achieve a certain outcome. As shown by Skaperdas and Vaidya (2012) our contest approach can incorporate such thresholds. See also Farmer and Pecorino (2014) for negligence standards incorporated into a contest approach of litigation.

⁸It is also possible to allow for the probability of litigation success is increasing in both their litigation effort (persuasion) and precaution. In particular, it can be assumed that the net litigation effect, defined as $\hat{\kappa}_X$, is a linear function of persuasion and precaution, such that $\hat{\kappa}_X = \kappa_X + x_N$. Thus this provides for cases where if the injurer selects a zero level of precaution they continue to have a non-zero probability of winning the litigation. Alternatively, the injurer could decide not to use persuasive litigation techniques and instead use only precaution. Note in this case even though the injurer may in fact may not be negligent (due to a high level of precaution) there is still a probability that the victim is able to persuade the court otherwise. Thus simply selecting a level of precaution to be non-negligent may not suffice in winning the litigation game. Using such an approach reduces the equilibrium litigation costs of the injurer and improves the expected payoffs from litigation.

⁹Second-order conditions are satisfied.

where

$$\Delta_N(\hat{x}) = 1 - \frac{\pi^2}{(\gamma\rho(\hat{x})(1-\pi) + \pi)^2}, \quad (28)$$

$$\tilde{\Delta}_N(\hat{x}) = \frac{(\gamma\rho(\hat{x}))^2(1-\pi)^2}{(\gamma\rho(\hat{x})(1-\pi) + \pi)^2}. \quad (29)$$

From (28), it can easily be shown that $\Delta'_N(\cdot) < 0$ as well as $\Delta_S \geq \Delta_N(\cdot)$ and $\tilde{\Delta}_S \geq \tilde{\Delta}_N(\cdot)$. For sake of tractability we assume $\Delta''_N(\cdot) > 0$, i.e., this requires the proportional gains from litigation to be convex in precaution.¹⁰

Direct comparison of (14) and (15) with (26) and (27) reveals the consequences of implementing strict liability and negligence rules. The victim has a higher level of expected payoff from litigation when there exists a strict liability rule. In contrast, the injurer has a higher level of expected payoff from litigation when there exists a negligence rule. It is ambiguous as to which liability regime results in larger equilibrium litigation costs. The relative strengths of γ and $\rho(\hat{x})$ and π determine which liability regime is more costly. Comparison of (9) with (24) yields the following proposition.

Proposition 2. *The negligence rule has a higher (lower) level of equilibrium litigation costs compared to the strict liability rule when:*

$$\rho(\hat{x}) > (<) \frac{\pi^2}{\gamma^2(1-\pi)^2}. \quad (30)$$

From Proposition 2 it is interesting to note that even though negligence rules may result in reduced marginal costs for the injurer, it is still feasible that equilibrium litigation costs increase. What is clear from Proposition 2 is that for precaution to generate lower levels of equilibrium costs under a negligence rule there must exist relatively large complementarities (compared to π and γ). Under a very simple situation where $\gamma = 1$ and $\pi = 1/2$ it can be shown that this is indeed the case as litigation costs are lower under a negligence rule if $\rho(\hat{x}) < 1$. When evidence of precaution can be used to complement other evidence at trial, as observed in the negligence rule, one finds that—due to the injurer's lower marginal cost—there is an incentive to increase litigation effort. However, the victim's change in effort between strict liability and negligence is ambiguous. Note that in equilibrium $p_Y(\kappa_X^{*,N}, \kappa_Y^{*,N}) < p_Y(\kappa_X^{*,S}, \kappa_Y^{*,S})$ so that the inclusion of complementary precautionary evidence results in the victim reducing their probability of winning in court.

¹⁰This assumption can be operationalized by assuming, for example, that $\gamma < \frac{\rho''(x_N)}{(3\rho'(x_N)^2 - \rho(x_N)\rho''(x_N))} \frac{\pi}{(1-\pi)}$.

3.2.2 Stage one

Let us now consider the equilibrium level of precaution under the negligence rule. Player X 's expected stage-one payoff is given by:

$$\min_{x_N} x_N + \phi(x_N) \cdot D \Delta_N(x_N). \quad (31)$$

Differentiating with respect to x_N , the equilibrium level of precaution x_N^* is found by solving the first-order condition:¹¹

$$1 = -D \cdot \left(\Delta_N(x_N) \phi'(x_N) + \phi(x_N) \Delta'_N(x_N) \right). \quad (32)$$

From (32) both a direct and indirect effect now exist for the incentive to invest in precaution. As standard, the direct effect is channeled through the decreasing marginal probability of an accident $\phi'(x_N)$. Under a negligence rule this direct effect results in a lower level of precaution compared to the same effect under strict liability. For the indirect channel, an increase in precaution reduces the proportional losses the injurer would experience under litigation. Direct comparisons can now be made between precaution under strict liability versus negligence laws. Comparing (20) and (32), it follows that

Proposition 3. *Equilibrium precaution under a negligence rule is larger (smaller) than strict liability when*

$$-D\phi(x_N^*) \Delta'_N(x_N^*) > (<) 1 - \frac{\Delta_N(x_N^*)}{\Delta_S}.$$

Proposition 3 shows that whether the negligence rule or strict liability provide the largest level of precaution depends on the size of the indirect effect under negligence $-D\phi(x_N^*) \Delta'_N(x_N^*)$ and the injurer's relative loss under litigation: $1 - \frac{\Delta_N(x_N^*)}{\Delta_S} > 0$. Thus if there exists a large indirect effect in litigation from an increase in precaution, a negligence rule will result in a higher level of precaution. It is clear that $\Delta'_N(x_N^*) = \frac{2\rho'(x_N^*)\pi^2\gamma(1-\pi)}{(\pi+\gamma(1-\pi)\rho(x_N^*))^3} < 0$, so that the structure of $\rho'(x_N^*)$ is important in determining the size of the indirect effect. What is also clear—due to the indirect channel of influence—is that for sufficiently large damages, negligence rules may provide larger equilibrium precaution levels. For sufficiently high damages, a negligence rule generates the highest level of precaution.

Similar to the strict liability case, implicit differentiation of (32) shows that equilibrium precaution

¹¹Second-order condition holds for interior solution.

is increasing the level of damages:

$$\frac{dx_N^*}{dD} = -\frac{(\phi(x_N^*) \Delta_N'(x_N^*) + \Delta_N(x_N^*) \phi'(x_N^*))}{2D \Delta_N'(x_N^*) \phi'(x_N^*) + D \phi(x_N^*) \Delta_N''(x_N^*) + D \Delta_N(x_N^*) \phi''(x_N^*)} > 0. \quad (33)$$

4 Optimal damages

In the previous section we investigated the consequences for precaution and litigation efforts when parties are faced with two liability regimes: strict liability and negligence laws. Given these effects, a lawmaker may have an incentive to reduce the social costs of such activities. One way the lawmaker can achieve this is by selecting the level of damages that can be allocated to the victim. We now continue our discussion on strict liability versus negligence and relate this to optimal compensatory damages.

4.1 Strict liability

The lawmaker's objective function is to minimize the social loss:

$$\min_D x_S^*(D) + \phi(x_S^*(D)) \cdot H + \phi(x_S^*(D)) [D \cdot (\Delta_S - \tilde{\Delta}_S)]. \quad (34)$$

where $D \cdot (\Delta_S - \tilde{\Delta}_S) > 0$ are the aggregate net losses from the litigation process, which were determined in (12) and (13). The lawmaker wants to minimize social costs, which include the cost of precaution, the expected harm as well as the aggregate litigation payoffs. We thus have the socially efficient level of precaution given by:¹²

$$\frac{dx^*}{dD} (1 + \phi'(x_S^*(D)) \cdot (H + D (\Delta_S - \tilde{\Delta}_S))) + (\Delta_S - \tilde{\Delta}_S) \phi(x_S^*(D)) = 0. \quad (35)$$

The majority of the existing literature (Polsinky and Rubinfeld, 1988; Hylton, 1990b, 2002) stresses the need to set damages equal to harm plus the victim's litigation costs. Our result—although not in a closed-form solution—is similar to Polinsky and Shavell (2014) in that the optimal damage level may not be set exactly at aggregate loss plus litigation costs: equilibrium litigation costs are increasing in damages and thus put downward pressure on the setting of damages. As expected, the productivity

¹²The second-order condition requires that $D (\Delta_S - \tilde{\Delta}_S) \phi''(x^*(D)) (3\phi(x^*(D))\phi''(x^*(D)) - 2(\phi'(x^*(D)))^2) - \phi'(x^*(D)) (\phi''(x^*(D)) + D (\Delta_S - \tilde{\Delta}_S) \phi'''(x^*(D))) > 0$. That is, the second-order condition is satisfied when $\phi'''(x^*(D)) < 0$ is relatively small and $(3\phi(x^*(D))\phi''(x^*(D)) - 2(\phi'(x^*(D)))^2) > 0$. Given our assumptions on $\phi(x^*(D))$, this holds. For example, it is clear that for $\phi(x^*(D)) = e^{-\alpha x}$ for $\alpha \leq 1$ the second-order condition is satisfied.

of precaution (and the associated distortions from the perfect information case $(-\phi'(x_S^*(D)))$) plays a significant role in determining the level of damages. Further, due the endogeneity of litigation, we can directly observe how legal presumption as a well as litigation costs alter optimal damages. Implicit differentiation of (35) with respect to $\tilde{\Delta}_S \equiv (\Delta_S - \tilde{\Delta}_S)$ we have:

$$\frac{dD^*}{d\tilde{\Delta}_S} = -\frac{\frac{dx_S^*}{dD^*}\phi'(x_S^*(D^*))D^* + \phi(x_S^*(D^*))}{\Omega_S} \quad (36)$$

where $\Omega_S > 0$ is the second-order condition. Note that using (21) and (36) the following proposition can be established:

Proposition 4.

$$\frac{dD^*}{d\tilde{\Delta}_S} > (<)0 \Leftrightarrow \phi(x_S^*(D^*)) < (>)\frac{(\phi'(x_S^*(D^*)))^2}{\phi''(x_S^*(D^*))}. \quad (37)$$

From Proposition 4 it is ambiguous whether damages should be increasing or decreasing in the presence of increased aggregate losses from litigation. From Proposition 4 it is clear that the structure of $\phi(\cdot)$ is crucial. If the structure of the productivity of precaution has components that are independent of precaution—and thus $\phi(\cdot)$ may be relatively large—then damages may be decreasing in aggregate losses from litigation.

Example 1. If $\phi(x_S^*) = e^{-\alpha x_S^*}$ for $\alpha \leq 1$, then $\frac{dD^*}{d\tilde{\Delta}_S} = 0$.

In the above example $\phi(x)$ is solely dependent on the level of precaution. Consequently optimal damages are independent of aggregate litigation losses. Next consider an example where the probability of an accident has components not dependent on precaution.

Example 2. If $\phi(x_S^*) = 0.01 + 0.09e^{-\alpha x_S^*}$ for $\alpha \leq 1$, then $\frac{dD^*}{d\tilde{\Delta}_S} < 0$.

In this example, components independent of precaution result in optimal damages decreasing in aggregated loss from litigation.

4.2 Negligence

A similar analysis can be achieved for a negligence rule. The policymaker's objective function is:

$$\min_D x_N^*(D) + \phi(x_N^*(D)) \cdot H + \phi(x_N^*(D)) \left[D \cdot (\Delta_N(x_N^*(D)) - \tilde{\Delta}_N(x_N^*(D))) \right], \quad (38)$$

and the first-order condition is:¹³

$$\begin{aligned} & \frac{dx_N^*}{dD} \left(1 + \phi'(x_N^*(D)) \cdot (H + D (\Delta_N(x_N^*(D)) - \tilde{\Delta}_N(x_N^*(D)))) \right) + \\ & \left(\Delta_N(x_N^*(D)) - \tilde{\Delta}_N(x_N^*(D)) \right) \phi(x_N^*(D)) + \frac{dx_N^*}{dD} \left(D \cdot \phi(x_N^*(D)) \frac{\partial(\Delta_N(x_N^*(D)) - \tilde{\Delta}_N(x_N^*(D)))}{\partial D} \right) = 0. \end{aligned} \quad (39)$$

In comparison to the strict liability case an additional term exists that is associated with marginal changes to the aggregate loss from litigation (the last term). Consequently, implicit differentiation reveals

$$\frac{dD^*}{d\tilde{\Delta}_N} = - \frac{\frac{dx_N^*}{dD^*} \phi'(x_N^*(D^*)) D^* + \phi(x_N^*(D^*)) + \frac{dx_N^*}{dD^*} \frac{\partial^2 \tilde{\Delta}_N}{\partial D^2}}{\Omega_N}, \quad (40)$$

where $\tilde{\Delta}_N = \Delta'_N(x_N^*(D)) - \tilde{\Delta}'_N(x_N^*(D))$ and $\Omega_N > 0$ is the second-order condition under the negligence rule. It is clear that optimal damages change in a similar (but modified) fashion to that of strict liability.

5 Discussion and extensions

5.1 Settlement and the incentive to litigate choice

Our focus in this article is how litigation efforts are chosen and the implications for the incentive to invest in precaution. Thus we have abstracted from issues relating to settlement. As the victim has, in expectation, the benefit of $\tilde{\Delta}_S D$ and $\tilde{\Delta}_N(x_N^*) D$ for strict liability and negligence, respectively, there exists feasible gains from settlement prior to trial as $\tilde{\Delta}_S < \Delta_S$ and $\tilde{\Delta}_N(x_N^*) < \Delta_N(x_N^*)$. Note, however, that allowing for settlement does not eliminate the effect on precaution from endogenous litigation efforts. As settlement will occur after realization of harm but prior to the trial, the incentive to invest in precaution is similar to what is illustrated in this article. If players anticipate a bargaining solution then the incentive to invest in precaution will be influenced by the potential gains from exchange, between the values: $\Delta_S - \tilde{\Delta}_S$ and $\Delta_N(x_N^*) - \tilde{\Delta}_N(x_N^*)$. Depending on the bargaining framework assumed, the injurer's potential transfer will be within this range. Notice that it is the litigation game that generates the outside offers on any settlement and thus litigation continues to influence the incentive to invest in precaution.¹⁴

¹³The second-order condition is:

$$\begin{aligned} & (H + D (\Delta_N - \tilde{\Delta}_N)) \left(\phi'(x_N^*(D)) x''^*(D) + (x'^*(D))^2 \phi''(x_N^*(D)) + x''^*(D) + \right. \\ & \left. \phi'(x_N^*(D)) (2x'^*(D) ((\Delta_N - \tilde{\Delta}_N) + D x'^*(D) (\Delta'_N - \tilde{\Delta}'_N)) \right) + \phi(x_N^*(D)) \left((\Delta'_N - \tilde{\Delta}'_N) (2x'^*(D) + D x''^*(D)) + D (x'^*(D))^2 (\Delta''_N - \tilde{\Delta}''_N) \right). \end{aligned}$$

This holds for sufficiently large H .

¹⁴See also Farmer and Pecorino (2014) for settlement prior to trial.

Our contest approach to litigation is distinct from the conventional literature on costly litigation. Under fixed-cost approaches, the victim's choice to go to court depends on the fixed cost at trial. In our approach—where litigation efforts are endogenously chosen—there always exists a net benefit of the victim entering litigation, as litigants can simply reduce their litigation efforts. It is simple to consider our framework with the addition of a fixed cost prior to litigation. In such a case, the victim must determine whether the cost of entering the trial is higher or lower than the net expected benefits of the trial (which has been determined above). Using such a hybrid approach may be beneficial as it captures the choices of when to litigate and by how much. In such a model the net benefit to the victim and the incentive for the injurer to invest in precaution would reduce.

5.2 Bilateral precaution

To showcase the litigation effect we assumed that there was unilateral precaution. As the endogenous litigation choices affect the net benefits/losses of the game, it is relatively straightforward to include bilateral precaution, where the probability of an accident is now given by $\phi(x, y)$, where y is the level of precaution from player Y . In such a case, the litigation game remains the same but the optimization over precaution now differs. For player X , we have

$$\min_x \quad x + \phi(x, y) \cdot \left[p_Y(\kappa_X^*, \kappa_Y^*) \cdot D + c_X \cdot \rho(x) \cdot \kappa_X^* \right], \quad (41)$$

and for player Y , we have

$$\min_y \quad y + \phi(x, y) \cdot \left[H - p_Y(\kappa_X^*, \kappa_Y^*) \cdot D + c_Y \cdot \kappa_Y^* \right]. \quad (42)$$

From (41) and (42), it is clear that this optimization problem is similar to standard bilateral models where damages are not perfectly compensatory. Of course, what is new is that litigation efforts are now endogenously chosen.

5.3 The victim's changing marginal cost of litigation

When considering the negligence rule it was assumed that only the injurer's marginal cost of litigation was altered due to the level of precaution. This is intuitive as precaution could complement other evidence brought before the court in favor of the injurer at trial. Further, given the victim has imperfect information about the level of precaution, it would be unlikely that the level of precaution alters the capacity of the victim to generate evidence. As an alternative, we can assume that the level

of precaution x is common knowledge to both victim and injurer (but remains imperfect information to the court). In such a case, the marginal cost to the injurer would continue to be $c_X \rho(\hat{x}) \kappa_X$. For the victim, litigation costs are given by $\check{c}_Y \kappa_Y$, where $\check{c}_Y = \frac{c_Y}{\rho(\hat{x})}$. Thus as the injurer's level of precaution increases it become marginally more costly for the victim to use such information to generate evidence. In our approach simple substitution of $\check{c}_Y \kappa_Y$ for $c_Y \kappa_Y$ in the above framework will therefore show the consequences of precaution altering both litigants' marginal litigation costs. In particular the equilibrium costs of litigation are given by:

$$c_X \cdot \rho(x) \cdot \kappa_X^{*,N} = \frac{\gamma \pi (1 - \pi)}{(\gamma \rho(\hat{x})(1 - \pi) + \frac{\pi}{\rho(\hat{x})})^2} D = c_Y \cdot \kappa_Y^{*,N}. \quad (43)$$

6 Concluding remarks

The purpose of this article is investigate the incentive to invest in precaution when litigation efforts are endogenously chosen and the use of precaution has the ability to provide complementarities in evidence generation. We provide a model that can investigate the incentives under strict liability and negligence rules. We focus on alternative liability rules and their potential for complementarities in evidence generation. In particular, we provide a framework where, under a negligence rule, an injurer's choice of precaution can complement the generation of evidence at trial. In contrast, with strict liability the level of precaution is less important for evidence generation and does not alter the marginal cost of litigation.

We show an injurer's litigation efforts are unambiguously higher under a negligence rule. For the equilibrium costs of litigation, however, we find costs are ambiguous and depend on the relative difference in marginal litigation costs reduction as well as legal presumptions. Which liability rule results in higher equilibrium litigation costs depends on the relative difference in marginal costs between both players as well as the ability of precaution to provide cost-reducing evidence complementarity. We provide conditions where the equilibrium level of precaution differs between strict liability and negligence rules. In particular, a negligence rule will incentivize a higher level of precaution when this precaution level provides significant cost reductions in litigation.

We provide extensions to the main framework, which includes settlement and the incentive to litigate, bilateral precaution as well as additional complementarities of precaution. This framework thus provides a coherent system with which to compare how litigation efforts endogenously form and the implications on the incentive to invest in precaution.

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