The Korean Economic Review
Volume 37, Number 1, Winter 2021, 5-35.
DOI : 10.22841/kerdoi.2021.37.1.001

Burdens of Proof and Judicial Errors in Civil Litigation*

Jeong-Yoo Kim**

This paper considers the effect of whether burden of proof is assigned to plaintiffs or defendants in tort claims on the defendant's care-taking incentive under the possibility of judicial error. We argue that it is socially better to place burden of proof on the plaintiff if the proof costs of both parties are low and the evidence is very accurate, thus reducing the wasteful incentive for defendants to commit over-precaution. If the burden of proof is placed on the defendant, it exacerbates the defendant's over-precaution due to an accident-avoidance effect whereby the defendant is incentivized to take more care to avoid an accident, thereby saving evidence costs. We also discuss the sine qua non rule in the case of noisy evidence and reconfirm the accident-avoidance effect. This is compared to the result of Gómez (2002).

JEL Classification: K13
Keywords: Burden of Proof, Due Care, Negligence, Judicial Error, Sine Qua Non Rule

I. Introduction

When popular Korean rock singer Hae-Chul Shin died in October 2012 following stomach surgery, his family filed a malpractice suit alleging that the surgeon provided negligently inadequate post-operative care. The singer's death prompted his fans to lobby Korean lawmakers to amend the "Korea Medical Act," first enacted in 2016, resulting in what is now called the "Shin Hae-Chul Act."

One of the controversial issues leading to the passage of this amendment focused on the question of who should bear the responsibility of burden of proof in medical

Received: July 16, 2020. Revised: Oct. 30, 2020. Accepted: Nov. 13, 2020.
* The author is grateful to the audiences at the monthly seminar held under the Transdisciplinary Research Program of the Korea Institute for Advanced Study (KIAS) in 2016 for helpful comments and to Nathan Berg for excellent English editing.
** Professor, Department of Economics, Kyung Hee University, 24, Kyungheedae-ro, Dongdaemun-gu, Seoul 02453, Korea (Tel) 82-2-961-0986, E-mail: jyookim@khu.ac.kr

malpractice cases.[1] Such cases typically involve profound uncertainty regarding all the relevant counterfactuals, which may have occurred under alternative courses of medical treatment. Furthermore, these cases impose unusually high information costs related to gathering information regarding human physiology, disease pathology, and highly technical details concerning the professional standard of medical care based on a patient's medical profile. Under current law (i.e., the yet to be amended Korean Medical Act), the burden of proof is the sole responsibility of the plaintiff (i.e., the patient or the patient's family in this case). Therefore, it is up to the plaintiff to prove that his/her doctor is liable for the damages claimed. Owing to the informational requirement of expert testimony, it is currently very costly to prove medical negligence against a doctor. Thus, medical malpractice cases in which the plaintiff successfully achieves a malpractice verdict against a doctor are relatively rare, because potential plaintiffs who consider financial benefits and costs are often deterred from filing malpractice claims.

In this paper, we address the issue of the incentive effects of different legal institutions regarding the burden of proof on potential defendants' efforts. Hay and Spier (1997), in their influential paper, provided extensive analysis of the effects of allocating the responsibility of burden of proof on legal parties' various behaviors, including effort applied to due care. One of their findings is the so-called "neutrality result": if the standard of care is efficient, then a potential defendant's incentive to take care is invariant to the assignment of the burden of proof. The intuition is that if the defendant fails to take due care, then he//she will lose regardless of whether the burden of proof is placed on him/her or on the plaintiff. Therefore, he or she will take due care in equilibrium, and this is expected by both parties. The result of Hay and Spier (1997), however, crucially depends on the assumption of no uncertainty regarding the judicial outcome. However, in real-world tort cases, legal parties face a great deal of uncertainty in the trial outcome when they present evidence. Therefore, our analysis introduces this crucial element of uncertainty about the trial outcome (i.e., the possibility of judicial error) into the standard model,[2] and shows that introducing the possibility of judicial error significantly changes the results from those of the standard model.

Our theoretical focus on judicial error enjoys empirical support from the literature on judicial error in real-world court decisions. Berger (1992) identified 30 out of 2000 cases that were decided in 1990 alone, which were subsequently revised

[1] In the U.S. it is always the plaintiff's burden in a medical malpractice case to prove the defendant's negligence. If the plaintiff cannot prove such negligence, the medical malpractice lawsuit would be dismissed.

[2] Judicial error may be due to inadequate education and training of judges, immorality and corruption among judges, or simply the lack of sufficient knowledge about substantive and procedural law. See Savchyn (2014) for further details.

in appeals court due to evidentiary error at trial.[3] It is also well known theoretically that many important properties regarding the efficiency of legal rules no longer hold once uncertainty is introduced into an otherwise ideal world of perfect information (Haddock and Curran, 1985; Calfee and Craswell, 1984; Craswell and Calfee, 1986; Cooter and Ulen, 1986). Introducing the possibility of judicial error leads to a number of questions. For example, which liability rule is more efficient under uncertainty (Haddock and Curran, 1985; Cooter and Ulen, 1986)? Can social efficiency be restored by altering the legal standard of due care?[4] In the current paper, we investigate a different question regarding who should bear the burden of proof: How might uncertainty due to judicial error affect the social efficiency of assigning burden of proof on defendants versus plaintiffs?

The main findings of this paper can be summarized as follows. In a standard model without uncertainty, we confirm Hay and Spier's neutrality result. In equilibrium, the defendant takes the same level of care regardless of the assignment of the burden of proof, but placing it on the plaintiff improves social efficiency, because a plaintiff who expects the defendant to take due care in equilibrium will not collect and present evidence. Thus, evidence costs are saved under this rule.

If there exists a positive probability that courts would make an error in processing and interpreting evidence submitted to the judge, then it would still be more efficient to assign burden of proof to the plaintiff insofar as the costs of proving one's case are very low for both parties, and the evidence is very accurate. When those conditions hold, regardless of the burden of proof assignment, the potential defendant takes over-precaution due to judicial uncertainty. However, the legal institution of plaintiffs being assigned the burden of proof can alleviate excessive caution or hyper-diligence among potential defendants, which would otherwise be induced by judicial uncertainty. If the defendant's cost of proving his/her negligence is very high, however, then it is socially efficient to assign burden of proof to defendants, whereas both rules are equally efficient without judicial uncertainty. Paradoxically, this rule of defendants carrying the burden of proof achieves the first-best level of care. Under this rule, the defendant will not present evidence when he/she is in fact negligent; therefore, the defendant must internalize all the social costs of accidents. Due care becomes meaningless when defendants carry the responsibility of burden of proof (because they internalize the costs of accidents anyhow). This implies that the negligence rule when the defendant's proof costs are very large is almost equivalent to the strict liability rule under which the defendant

[3] This number should be interpreted as an underestimation of the frequency of judicial error, because some cases involving evidentiary error may not have been appealed.

[4] Calfee and Craswell (1984) suggested that, in order to correct any incentive for potential defendants to over- or under-comply with the standard of due care induced by uncertainty, courts should make corresponding adjustments in legal standards of damages awarded. Edlin (1994) also followed this line of analysis.

bears all the risks associated with accidents and takes the socially optimal level of due care.

Finally, if the plaintiff's cost of submitting evidence is very large relative to the defendant's, then the defendant may be induced to take insufficient care, precaution, or diligence in response to the possibility that plaintiffs with legitimate tort claims may fail to prove negligence. In this case, it may be more efficient to place the burden of proof on the defendant, which can alleviate the problem of potential defendants taking insufficient care or diligence, although the general comparison of efficiency is ambiguous. This implies that the efficiency of the Shin Hae-Chul Act, which is intended to place burden of proof on defendants is, in general, not guaranteed, although it will clearly induce the defendants to take more care.

Gómez (2002) considers what is called the *sine qua non* rule. He criticizes the neutrality result of Hay and Spier by arguing that their result would no longer hold if the modified negligence rule incorporating the *sine qua non* causality was used instead,[5] under which the expected loss evaluated according to the level of due care should be deducted. Gomez argues that, if the burden of proof would be allocated to the defendant, it could reduce the incentive to take the optimal level of care, because the cost of presenting evidence makes it less worthwhile for potential defendants to take due care. Sanchirico (2008) also shows that allocating the burden of proof to the plaintiff generates a larger incentive for the defendant to take adequate care when the evidentiary contest concerns the care of the defendant. The intuition is similar. If the burden of proof is on the defendant's side, the defendant's total cost when he/she takes due care is increased by the proof cost, implying that he/she has less incentive to take due care. In this paper, we provide a counterargument. We argue that the assignment of the burden of proof to defendants can strengthen potential defendants' incentive to take care if evidence is noisy. This is because such a move can give them an incentive to reduce an accident thereby saving their proof costs.

Recently, Guerra *et al*. (2019) obtained a similar result indicating that the rule whereby burden of proof is placed on defendants (the presumption of negligence or *res ipsa loquitur* doctrine) increases the defendant's care incentive. Despite its similarity to our result, there is an important difference between the two results. In their model, the defendant's over-precaution does not appear under a presumption of negligence, even if he/she is likely to take more care than under a presumption of non-negligence (i.e., the rule whereby burden of proof is placed on plaintiffs). The main source of this difference lies in a discontinuity of the defendant's payoff function at the due care level in their model. In comparison, in our model, the defendant's payoff function is continuous due to the assumption that judicial errors have continuous distributions. Although our insight that an increase in a care level

[5] In much earlier works, Grady (1983) and Kahan (1989) analyzed the modified negligence rule.

has an accidence-avoidance effect is still valid in their model, a marginal benefit from increasing a care level is overwhelmed by a jump in payoffs at a discontinuous point.

Hay and Spier (1997) examined the effects of different allocations of burden of proof on the incentives to present evidence and to take care. They argued that if legal parties have access to a common body of evidence, then the party who bears the burden of proof will present the evidence if and only if the evidence supports his/her position, while the other party will refrain from presenting evidence regardless of whether it supports his/her position.

Meanwhile, Kim (2016) showed that if the evidence that each party possesses is not perfectly correlated, then each party will choose to present the evidence that supports his/her position whenever it is available, regardless of the assignment of burden of proof; if a party without the burden of proof does not present evidence, then it risks being interpreted as absence of evidence and therefore weakens his/her position. The current paper is closer to Hay and Spier's (1997) analysis in the sense that a set of information pieces isidentically available to both parties but at a cost.

Relatedly, Demougin and Fluet (2008) and Kaplow (2011) examined the issue of the optimal burden (or standard) of proof in terms of the incentive to take care.[6] Demougin and Fluet considered the standard of a preponderance of evidence and demonstrated that it is socially efficient, not because it minimizes error, but because it gives the defendant the optimal incentive ex ante to take care when used together with appropriate exclusionary rules. The intuition is similar to the unraveling result in the literature on voluntary information disclosure (e.g., Milgrom and Roberts, 1981; Grossman, 1981; Farrell, 1986; and Shavell, 1994).[7] Under the preponderance of evidence standard, one of the interested parties would find it useful to disclose the evidence, and then all relevant information is revealed unless there is no possibility of strategic manipulation of information. Kaplow (2011) revealed that the optimal burden of proof involves trading off deterrence against the chilling of desirable behavior, unlike the preponderance of evidence standard.

The rest of the paper is organized as follows. In Section 2, a benchmark model without judicial uncertainty is introduced. In Section 3, the possibility of judicial error is considered to examine its effect on the incentive to take care. Section 4 discusses the effect of the *sine qua non* rule. Section 5 contains a discussion of some modifications of our model. The concluding remarks are presented in Section 6.

[6] Strictly speaking, two terms, "burden of proof" and "standard of proof," should be distinguished although they are often used interchangeably. The former determines who has to prove, while the latter determines proving *what* and to *what extent*.

[7] See Shin (1998) regarding limitations of the unraveling result in legal contexts.

II. Baseline Model with No Judicial Errors

An accident can occur by an unlawful act of a potential injurer (defendant, or D) against a potential victim (plaintiff, or P). The size of losses inflicted to P is common knowledge.

We assume that both the injurer and the victim are risk-neutral. We also assume that the accident is unilateral; in other words, the probability of an accident depends on the injurer's care level but not on the victim's care level. For example, imagine a situation in which a surgeon operates on a patient under anesthesia so that the latter can do nothing during the operation. For a liability rule, we consider the negligence rule, because the burden of proof is meaningless under the strict liability rule, which does not require proving negligence.

The following notation will be used throughout the paper:

x = the care level of a defendant ($x \geq 0$);
$\overline{x}$ = the legal standard for the care level of a defendant;
$p(x)$ = the probability of an accident ($p' < 0$, $p'' > 0$);
L = losses from the accident;
c_p = the plaintiff's cost of presenting evidence; and
c_d = the defendant's cost of presenting evidence.

The decisions are made sequentially. First, the defendant chooses a care level x. If an accident occurs, they (the defendant and the plaintiff) go to trial, and the party who bears the burden of proof (either the plaintiff or the defendant) decides whether to present evidence. We assume that if the party who bears the burden of proof presents evidence, he/she wins the case with certainty, and if that party fails to present evidence, he/she will lose the case with certainty. In other words, there is no uncertainty in the judicial decision. For simplicity, we assume that the parties do not enter into settlement negotiation prior to trial. We also assume that all trial costs (e.g., the cost of hiring an attorney) other than the cost of presenting evidence are negligible or the same for P and D.

We will consider two alternative rules; one wherein the burden of proof is placed on P and the other wherein the burden of proof is placed on D. On the one hand, under the former rule (i.e., the P-Rule), P must gather and present evidence of D' negligence ($x < \overline{x}$); otherwise, P will lose. This rule corresponds to the presumption of non-negligence. On the other hand, under the latter rule (i.e., the D-Rule), D needs evidence that he himself was not negligent ($x \geq \overline{x}$); otherwise, D would lose. This rule corresponds to the presumption of negligence.

It is usually expected that $c_p > c_d$, as P needs evidence for negligence of the other (D), while D needs evidence for his own non-negligence; however, for the sake of generality, we will not exclude the possibility that $c_p < c_d$. For now, we assume that $c_p < L$ and $c_d < L$, although this assumption will be relaxed later. We also assume that the party who bears the burden of proof can gather evidence perfectly, that is, if $x < \overline{x}$, P obtains perfect evidence for it, but D can never obtain even imperfect evidence for $x \geq \overline{x}$ from the implicit assumption that no such evidence exists.

Suppose the burden of proof is placed on P. Given that D has no need to gather evidence to prove that he was not negligent and P will gather and present evidence against D if and only if $x < \overline{x}$ and $c_p < L$, the defendant's cost can be expressed as

$$C_0(x;P) = \begin{cases} x + p(x)L & \text{if } x < \overline{x} \\ x & \text{if } x \geq \overline{x}. \end{cases} \tag{1}$$

That is, $C_0(x;P)$ is the cost of D under the P-Rule when there is no judicial error. The subscript 0 in C_0 stands for no judicial error. Under this rule, D has no extra burden even if we consider the cost of proof, because it is on the side of P to bear the burden of proof. Thus, the decision of D to take care is $x^P = \overline{x}$ if due care is set to the socially optimal level, i.e., $\overline{x} = x^S$ where x^S minimizes the social cost $SC(x) = x + p(x)L$.

Now, suppose the burden of proof is placed on D. Given that he must present evidence to win the case when $x \geq \overline{x}$, his cost can be expressed as

$$C_0(x;D) = \begin{cases} x + p(x)L & \text{if } x < \overline{x} \\ x + p(x)c_d & \text{if } x \geq \overline{x}. \end{cases} \tag{2}$$

The graph of $C_0(x;D)$ drawn in a bold curve in Figure 1 shows a discontinuity at $x = \overline{x}$.

As the defendant's cost of proof is low relative to the losses from the accident ($c_d < L$), D's optimal care level is $x^D = \overline{x}$.[8] That is, the incentive to take care is neutral regardless of the assignment of the burden of proof. In this case, D takes the socially optimal level of care in both cases. However, in terms of social costs, it is socially more efficient to place the burden of proof on P, because the society must bear the extra cost of proof if the burden of proof is placed on D. Even if the defendant's cost of proof is so high that $c_d > L$, the result is the same. In this case, D chooses not to prove his non-negligence, so $C(x;D) = x + p(x)L$ for any x.

[8] If we consider trial costs other than c_p and c_d, say $k(>0)$, then the defendant's cost functions $(C_0(x;P)$ and $C_0(x;D))$ under the two rules simply shift upward by $p(x)k$. D's optimal care level would still be achieved at the discontinuity point $x = \overline{x}$ (i.e., D's choice of x remains unaffected as long as k is small).

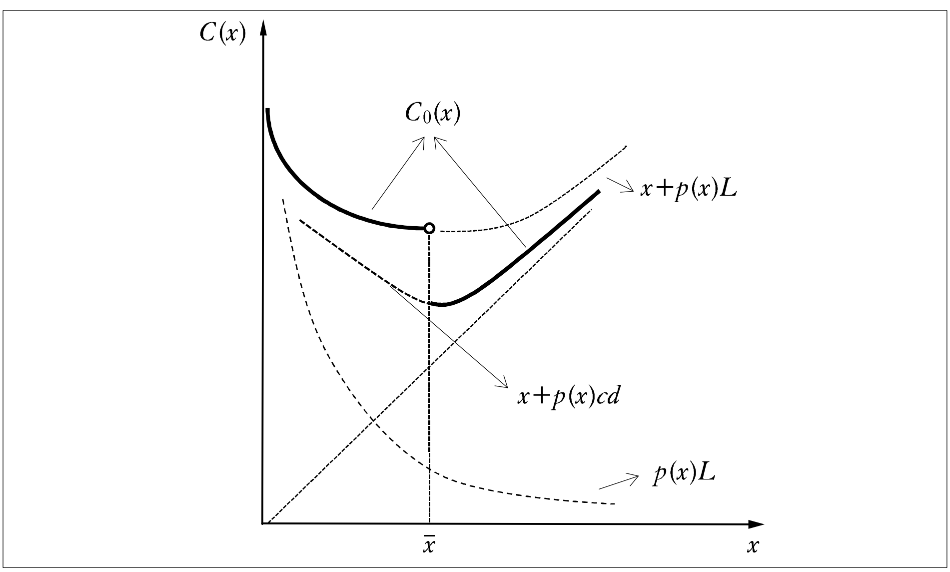
Therefore, he will choose a care level of x^S. However, given that no proof occurs in equilibrium, the neutrality result still holds in terms of the incentive to care; furthermore, they are neutral even in terms of social costs. In this case, D chooses $\bar{x}$ not because it is due care, but because it minimizes his cost associated with the accident. Thus, in this case, the negligence rule is equivalent to the strict liability rule. To summarize, we have the following proposition.

Proposition 1 *If $c_p < L$ and $c_d < L$, then it is socially efficient for P to bear the burden of proof. (i) The equilibrium care level of the defendant is the same regardless of whether burden of proof is on P or D: $x^P = x^D = \bar{x}$; but (ii) the social cost is smaller under the P-Rule: $SC^P < SC^D$.*

Proof. (i) is trivial from Figure 1. (ii) $SC^P(\bar{x}) = \bar{x} + p(\bar{x})L < \bar{x} + p(\bar{x})(L + c_d) = SC^D(\bar{x})$.

Proposition 1 implies that it is socially better to place the burden of proof on P rather than on D whenever there is no uncertainty about judicial error. Under the P-Rule, D does not have to worry about the extra cost of proving non-negligence, thereby inducing D to choose the undistorted socially optimal care level. Under the P-Rule, P is aware that D will take due care and, therefore, does not incur any costs to prove that D is negligent. In equilibrium, D takes the same level of care under the two rules; but under the D-Rule, there are extra costs incurred (if D's cost of proof is low).

[Figure 1] Standard case under the D-Rule



Let us now consider now the implications from the real-world asymmetry by which c_p is likely to be much greater than c_d, thereby corresponding to the situation described in the introduction. In the model above, it is noteworthy that the inequalities, $c_d < c_p < L$, have no effect on the neutrality result reported above so long as the key inequality, $c_p < L$, holds. What matters for the results from Proposition 1 is the size of c_d (regardless of c_p and its size relative to c_d). However, if there is a possibility that c_p becomes so large that no plaintiff would choose to prove D's negligence, then the results of the proposition could be affected, because D's cost under the P-Rule could be reduced due to the possibility of P's failure to present evidence. This possibility will be investigated in Section 5.

III. Model with Judicial Errors

Courts often commit judicial errors. In this section, we take into account the possibility that such an event can occur.[9] Here, we assume that the judge only observes a noisy signal $z = x + \varepsilon$, where ε is distributed over $(-\infty, \infty)$ according to the distribution function $F(\varepsilon)$ and the corresponding density function $f(\varepsilon)$, which is symmetric around zero. Now, incorporating the possibility of judicial error, we once again consider both the P-Rule and the D-Rule.

3.1. P-Rule

Suppose that the burden of proof is placed on P, implying that D is not liable for the losses unless P proves D's negligence (the presumption of non-negligence). Then, a defendant who did not take due care $(x < \overline{x})$ may not be liable if $z \geq \overline{x}$, i.e., $\varepsilon \geq \overline{x} - x$ when P submits evidence, and even a defendant who chose $x \geq \overline{x}$ may be liable if P submits evidence[10] and $z = x + \varepsilon < \overline{x}$, i.e., $\varepsilon < \overline{x} - x$. Taking this into account, the defendant's cost function under the P-Rule in the presence of judicial uncertainty, which is denoted by $C(x;P)$, is modified as follows:

$$\begin{aligned} C(x;P) &= x + p(x)\text{Prob}(z < \overline{x} \mid x)L \\ &= x + p(x)\text{Prob}(\varepsilon < \overline{x} - x \mid x)L \\ &= x + p(x)F(\overline{x} - x)L, \end{aligned} \tag{3}$$

[9] One unrealistic consequence from the assumption of no judicial error is that D always takes due care if both c_p and c_d are low.

[10] To beguile the judge, P may submit noisy information to the court, especially when x is close to $\overline{x}$.

if P submits evidence of x, and $C(x;P)=x$ if P does not submit evidence. Here, $F(\overline{x}-x)$ is the probability that D loses at court.

The first-order condition of minimizing the cost function given by (3) requires

$$\frac{\partial C(x;P)}{\partial x}=1-[p(x^{PE})f(\overline{x}-x^{PE})-p'(x^{PE})F(\overline{x}-x^{PE})]L=0\,. \tag{4}$$

Thus,

$$\psi^{P}(x^{PE})\equiv[f(\overline{x}+x^{PE})p(x^{PE})+F(\overline{x}+x^{PE})p'(x^{PE})]L=1\,. \tag{5}$$

The usual interpretation applies. The left hand side of Equation (5) is the benefit from an additional care level. As D bears the costs from an accident when it actually happens and the court judges that the defendant is liable, the benefit from additional care comes through falls in those probabilities. That is, the benefit is the sum of the benefits from falls in the accident probability and in the probability of losing at court. The first term of the left hand side is the gain from a fall in the losing probability and the second term is the gain from a fall in the accident probability. Equation (5) implies that this marginal benefit must be equal to the marginal cost of taking additional care.

Note that P submits evidence if his expected payoff from it exceeds the submission cost, i.e., $F(\overline{x}-x)L\geq c_p$, or equivalently, $x\leq\hat{x}^P\equiv\overline{x}-F^{-1}(\frac{c_P}{L})$. In addition, note that $\hat{x}^P$ is monotonically decreasing in c_p and $\lim_{c_p\to 0}\hat{x}^P=\infty$.[11] If x is high enough, P will not submit evidence, as it is costly and the winning probability is small. Given that $F^{-1}(\frac{c_P}{L})$ can be either positive or negative, depending on c_p and L, P may submit either too much evidence (when $x>\overline{x}$) or too little evidence (when $x<\overline{x}$). If L is large, $F^{1}(\frac{c_P}{L})<0$, so $\hat{x}^P>\overline{x}$, implying that P may submit evidence even if $x>\overline{x}$. As c_p becomes higher, P becomes more reluctant to submit evidence. We assume that c_p is so low that the problem of minimizing the cost has the interior solution satisfying the first-order condition (5).[12]

We also assume that z is very informative in the sense that the noise ε is highly concentrated around zero. That is, $f(0)\geq M$ for some large M, so that

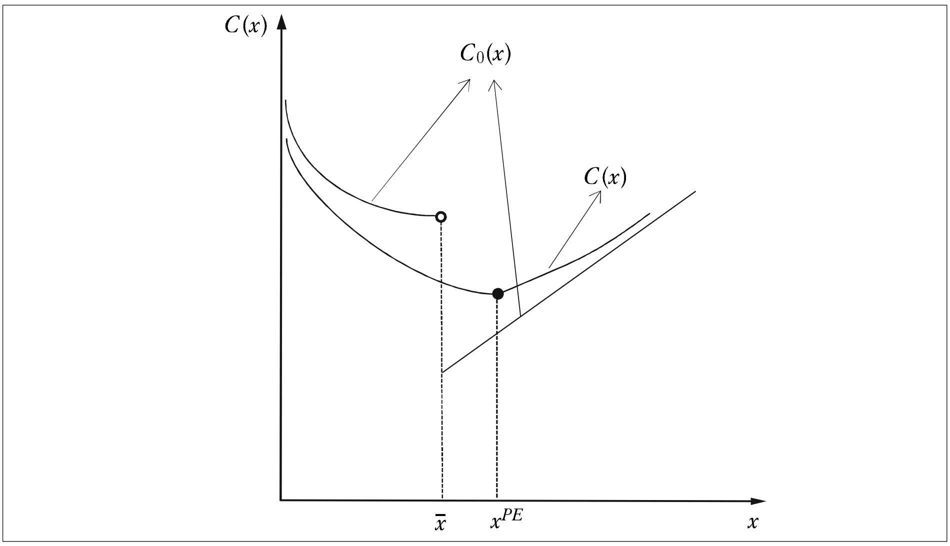
$$\left[\frac{\partial C(x;P)}{\partial x}\right]_{x=\overline{x}}=1-\left[f(0)p(\overline{x})-\frac{1}{2}p'(\overline{x})\right]L<0\,. \tag{6}$$

[11] Monotonicity follows directly from $F(\overline{x}-x)L=c_p$. Total differentiation yields that $\frac{d\hat{x}^P}{dc_p}=-\frac{1}{f}<0$.

[12] If c_p is very high, the cost minimization problem of the defendant may have a boundary solution, $x^{PE}=\hat{x}^P$.

This implies that, in equilibrium, D will take over-precaution, i.e., $x^{PE} > \overline{x}$. Judicial uncertainty induces D to take too much care because of the possibility that he is wrongfully liable for the losses of P. However, this is the case only if c_p is very low and evidence is sufficiently informative. Otherwise, D may take under-precaution, either due to the high probability that P fails to submit evidence or due to the uninformativeness of evidence. Figure 2 illustrates this point. The graph $C(x)$ shows that it has a negative slope at $x = \overline{x}$ so that $x^{PE} > \overline{x}$.

[Figure 2] Over-precaution under the P-Rule



3.2. D-Rule

Now, suppose that the burden of proof is placed on D, implying that D is liable unless he can prove his non-negligence (the presumption of negligence).[13] The cost function in this case can be similarly derived as follows:

$$C(x;D) = \min\{C_S(x), C_{NS}(x)\}, \tag{7}$$

where

$$C_S(x) = x + F(\overline{x} - x)p(x)L + p(x)c_d, \tag{8}$$
$$C_{NS}(x) = x + p(x)L, \tag{9}$$

[13] The presumption of negligence is also known as the *res ipsa loquitur* doctrine.

where $C_S(x)$ is D's cost when he submits evidence, and $C_{NS}(x)$ is his cost when he does not submit evidence. If D chooses to spend the cost c_d to prove x, the judicial outcome could be either $z < \overline{x}$ or $z \geq \overline{x}$ due to judicial error. In the former case, D must pay the loss L and c_d, and the probability that this case would occur is $\Pr\text{ob}(z < \overline{x} \mid x) = \Pr\text{ob}(\varepsilon < \overline{x} - x \mid x) = F(\overline{x} + x)$. In the latter case, D does not pay L, and the probability that this occurs is $1 - F(\overline{x} - x)$. If he does not submit evidence, he would lose at court with certainty, as he has the burden of proof. He will choose to submit evidence if $C_{NS}(x) \geq C_S(x)$, i.e., $[1 + F(\overline{x} - x)]L \geq c_d$, or $x \geq \hat{x}^D \equiv \overline{x} - F^{-1}(1 - \frac{c_d}{L})$. Given that $1 - F(\overline{x} - x)$ is increasing in x, D who took more care will prefer presenting evidence at the cost of c_d. Moreover, as c_d approaches 0, $\hat{x}^D(c_d, L)$ goes to $-\infty$, which means that D would have to submit evidence for almost all x, because it is better to submit evidence that is even unfavorable to him than to lose with certainty by failing to submit it, as far as the chance that the court interprets the evidence favorably is still positive.

If we assume that c_d is very small, then the objective function given by (7) is reduced to

$$\begin{aligned} C(x;D) &= C_S(x) = x + F(\overline{x} - x)p(x)L + p(x)c_d \\ &= x + p(x)(F(\overline{x} - x)L + c_d) . \end{aligned} \tag{10}$$

The first-order condition of minimizing (10) requires

$$\frac{\partial C(x;D)}{\partial x} = 1 - [p(x)f(\overline{x} - x) - p'(x)(F(\overline{x} - x)L + c_d)]L - p'(x)c_d = 0 . \tag{11}$$

Given that $[\frac{\partial C(x)}{\partial x}]_{x=\overline{x}} = 1 - p'(\overline{x})(\frac{L}{2} + c_d) - p(\overline{x})f(0)L < 0$ if $f(0) \geq M$ for some large M, it implies that D is likely to take over-precaution again when he has the burden of proof, i.e., $x^{DE} > \overline{x}$.

In addition, the first-order condition (11) can be rearranged into

$$\psi^D(x^{DE}) \equiv \psi^P(x^{DE}) + p'(x^{DE})c_d = 1 . \tag{12}$$

Given that $p'(x) < 0$, we have $(\overline{x} <)x^{PE} < x^{DE}$ from the second-order condition. Figure 3 illustrates this. Meanwhile, our main result follows.

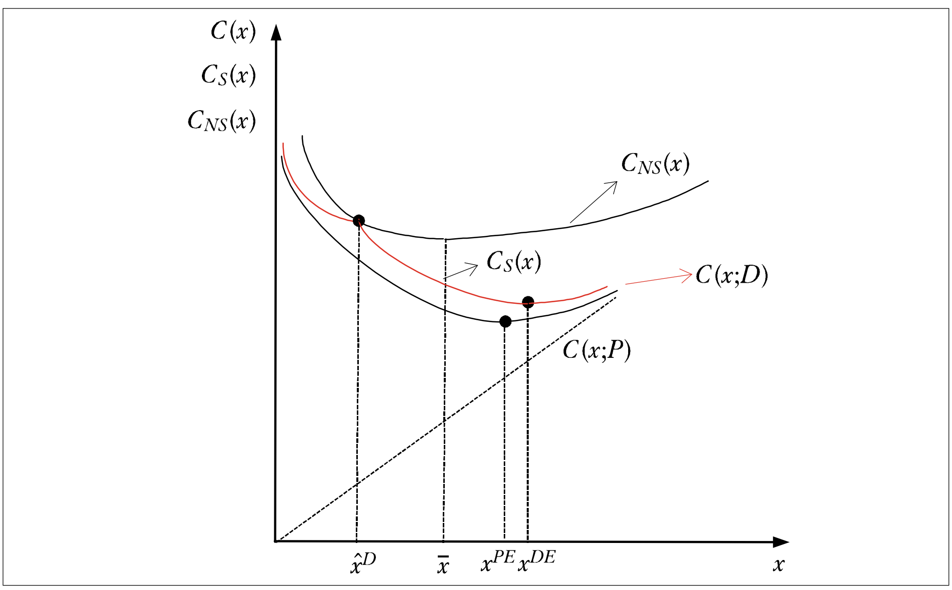
Proposition 2 *In the presence of judicial error, there is a large* $\overline{M}(>0)$ *and a small* $\overline{c}(>0)$, *such that for all* $M \geq \overline{M}$ *and for all* $c_p, c_d \leq \overline{c}$ *(i) the defendant takes over-precaution if the burden of proof is assigned to the plaintiff, and (ii) assigning the burden of proof to* D *aggravates the defendant's over-precaution, i.e.,* $x^S < x^{PE} < x^{DE}$.

The intuition for the first result is clear, because a slightly higher level of care will significantly reduce the uncertainty of being liable when the evidence submitted by P is accurate. The intuition for the second result is that if the defendant bears the burden of proof, he is likely to take more care to avoid an accident because he would be expected to bear the extra burden if an accident occurred.

The result that the P-Rule is superior to the D-Rule appears to be a limiting case of Proposition 1, but the reason is quite different. In the presence of judicial error, the P-Rule is socially better than the D-Rule, because it can alleviate the over-precaution of the defendant who would care about his burden of proof.

Proposition 2 suggests the possibility that D may take under-precaution if the evidential signal is too noisy. Intuitively, if it is believed that evidence is so inaccurate that it does not affect the trial decision very much whether the defendant takes due care or not, he will prefer taking less than due care. In this case, D is also likely to take more precaution when he bears the burden of proof than when P bears the burden of proof for the same reason described above. Thus, assigning the burden of proof to the defendant may be more efficient in the sense that it alleviates his incentive to take under-precaution.

[Figure 3] Over-precaution under the D-Rule



3.3. Related Results

Proposition 2, which is our main result, is sharply contrasted with the result of Gómez (2002), who argued that placing the burden of proof on the defendant reduces his incentive to take due care, because it is costly to present proof of his due care.[14] Under the D-Rule, however, the defendant presents evidence only if an accident occurs. Thus, he has an incentive to take additional care to reduce the probability of an accident, thereby forgoing the costly activity of presenting evidence in this model with continuum choices of care rather than in his model of binary choices of care level.[15]

Guerra *et al*. (2019) also obtained a result that is similar to Proposition 2. If D bears the burden of proof and he is presumed to be negligent unless he proves his non-negligence, then the rule (i.e., the D-Rule) can be interpreted as the *res ipsa loquitur* rule. Their Proposition 4.1 states that the *res ipsa loquitur* doctrine increases the robustness of the defendant's incentive to take due care. Moreover, they added that, "in the presence of high evidentiary problems, a presumption of negligence is always more desirable than a presumption of non-negligence." However, in our model with judicial error, if the judicial error is small enough, the defendant does not take due care, but rather takes too much care under a presumption of non-negligence. This implies that the presumption of negligence is less desirable, because it aggravates D's incentive to take over-precaution. This difference in results is a consequence of differences in assumptions regarding judicial errors. They assume that the court can make two kinds of errors, the type I error that occurs when D fails to prove his own non-negligence despite being diligent, and the type II error that occurs when P fails to prove D's negligence despite his actual negligence. This implies that type I error cannot be caused by P, who tries to persuade the judge into believing that D is negligent. That is, if $x \geq \overline{x}$, P cannot present evidence, whereas P may present evidence from his expectation that $z < \overline{x}$ in our model. Similarly, in their model, type II error cannot be caused by D; thus, if $x < \overline{x}$, it is not feasible for D to present evidence in order to increase the probability that $z \geq \overline{x}$. What constitutes evidence is not just a piece of information but a collection of many pieces of information that can be interpreted in various ways. In other words, z is not hard evidence for D's negligence or non-negligence; in reality, P may present evidence in support of his position even if D is, in fact, not negligent, leaving it to the judge or the jurors to determine whether or not the submitted evidence is convincing. Another crucial difference is that the probability that legal parties (P or D) fail to prove negligence (or non-negligence *resp*.), denoted by α (or β *resp*.), is assumed to be identical for any

[14] He also assumed the modified negligence rule incorporating *sine qua non* causality. However, even if we replace the negligence rule with the modified rule, the result remains qualitatively unaffected. Our main insight is still valid. For more details, see Section 4.

[15] Another difference between the two models is that evidence is assumed to be conclusive in his model, whereas evidence is assumed to be noisy in the current model. Therefore, D may present evidence even if he takes less care in the hope that he is mistakenly found to not be liable. This might be quite plausible, especially if $x < \overline{x}$, but x is very close to $\overline{x}$, although it cannot happen in his model. In fact, his argument relies heavily on the assumption that the defendant who takes less than due care does not present evidence.

x such that $x < \overline{x}$ (or $x \geq \overline{x}$ *resp*.). In comparison, the probabilities of judicial errors, $F(\overline{x} - x)$ when $x \geq \overline{x}$ (type I error) and $1 - F(\overline{x} - x)$ when $x < \overline{x}$ (type II error), vary with x in our model. In addition, α and β are independently given in their model, while both type I and type II errors become smaller as the expertise of the judge becomes higher (i.e., the variance of ε is smaller). Owing to the differences in assumptions on judicial errors and the resulting discontinuity in the defendant's payoff function, our main result of over-precaution under the presumption of negligence degenerates in their model.

3.4. Social Welfare

Proposition 2 does not necessarily imply that placing the burden of proof on P is socially better if evidence is accurate enough, because it may require a higher cost of proof if $c_p > c_d$, although it alleviates the defendant's incentive to take over-precaution. Next, we compare the total social costs under the two alternative rules.

First, consider the case that c_p and c_d are both so small that they are not binding in the proof decision of P and D. Under the P-Rule, P will provide evidence whenever $x \leq \hat{x}^P$, where $\hat{x}^P$ is so large that $\overline{x} < \hat{x}^P$, and thus D is expected to take care $x^{PE} < \hat{x}^P$. Therefore, D takes more than due care, and P bears the evidence cost c_p. In contrast, under the D-Rule, D takes even more care and provides evidence by incurring c_d, thereby increasing his cost by c_d. Note that the evidence cost is incurred under either rule, because $\hat{x}^D < x^{PE} < x^{DE} < \hat{x}^P$.[16] Therefore, if $c_p = c_d$, the P-Rule is socially better, as it induces less over-precaution, while incurring the same cost of presenting evidence.

Next, consider the case in which c_d is very high, while c_p is small. On the one hand, under the P-Rule, P submits evidence for most values of $x(x \leq \hat{x}^P(c_p))$, as c_p is small; thus, D is likely to take over-precaution as we argued. On the other hand, under the D-Rule, D does not submit evidence for most values of $x(x < \hat{x}^D)$. This means that he will be liable whenever an accident occurs, implying that the liability rule is almost similar to the strict liability rule.[17] Then, D will take the first-best level of care, because he must bear all the externality he incurs regardless of his actual care level. Therefore, paradoxically, it is socially better to place the burden of proof of D if c_d is very high, because it can induce him to take the first-best care and there is be no proof cost incurred.

Proposition 3 *In the presence of judicial error, there exists a large cost threshold,* $\underline{c}$*, such that for all* $c_d \geq \underline{c}$*, placing the burden of proof on* D *achieves the first-best outcome.*

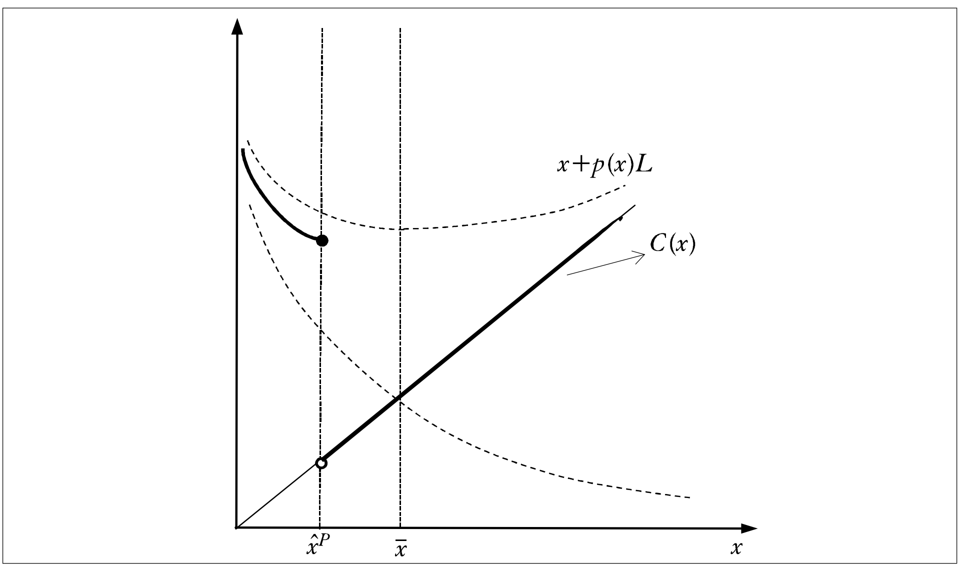
[16] This is due to the fact that $\lim_{c_d \to 0} \hat{x}^D = -\infty$ and $\lim_{c_p \to 0} \hat{x}^P = \infty$.

[17] Demougin and Fluet (2005), Salvador-Coderch *et al.* (2009), and Guerra *et al.* also noted that the negligence rule under a presumption of negligence degenerates into the strict liability rule.

This proposition implies that it may be socially efficient to make the standard of proof very strict and to place the burden of proof on D in the sense that it can induce D to take the first-best level of care. This is not surprising, although paradoxical, because the strict liability rule achieves the first-best when there is judicial error while the negligence rule does not. We note that this result in Proposition 3 resembles the result we obtained in the absence of judicial error. This is also clear, because if D does not submit evidence due to the high cost, it no longer matters whether the evidence is noisy or not.

Finally, if c_p is so high that $\hat{x}^P < \overline{x}$, D will not take due care, i.e., he will take the level of care $\hat{x}^P + \varepsilon (< \overline{x})$ under the P-Rule. Figure 4 illustrates this. D has no need to take more than $\hat{x}^P(+\varepsilon)$, as P does not provide evidence for it due to the high proof cost; thus, D avoids any liability anyhow. In comparison, under the D-Rule, a high c_p does not matter at all, because D has the burden of proof. Then, as shown above, D takes over-precaution as far as the evidence signal is accurate and incurs his cost of proof c_d. Given that $SC^P = \hat{x}^P + p(\hat{x}^P)L$ and $SC^D = x^D + p(x^D)(L + c_d)$, where $\hat{x}^P < \overline{x} < x^D$, it is ambiguous to compare social welfare under the two rules.

[Figure 4] Care-taking incentive under the P-Rule when c_p is high



IV. The effect of the *sine qua non* rule

Some scholars, including Grady (1983), Kahan (1989), and Gómez (2002), argue that the standard negligence rule fails to violate the causation requirement that a defendant is liable only for accidents that would not have occurred had he not been negligent. They thus propose a modified negligence rule under which a defendant is liable only for accidents caused by his negligence.

This modification has some advantages over the standard negligence rule. In particular, it maintains the continuity of the defendant's cost function. Under the standard negligence rule, the defendant's cost function decreases gradually up to the due care and at this due care level, the cost jumps down discontinuously. However, under the modified *sine qua non* rule, his cost decreases smoothly up to the due care level and then begins to increase beyond this care level continuously, although the slope of the cost function changes discontinuously at this sharp turning point of the due care level. Moreover, it seems to be more consistent with the observation in the real world. Under this rule, a potential defendant's care level is continuous (constant), as the government keeps increasing the due care level, whereas he keeps increasing the care level and then reduces it discontinuously at some point, with a continuous change in the due care level under the standard negligence rule.

To model the *sine qua non* rule, we assume that D is liable only for the (expected) amount exceeding the expected damage amount that would have been incurred if he had taken due care.[18] Thus, the court-awarded judgement amount w can be determined by the equation $p(x)w=(p(x)-p(\overline{x}))L$, i.e., $w=\frac{p(x)-p(\overline{x})}{p(x)}L\equiv[1-\delta(x)]L$, where $\delta(x)=\frac{p(\overline{x})}{p(x)}$ is a discount rate.[19] Under this rule, if D takes due care, the court judgement is fully discounted $(\delta(\overline{x})=1)$; if $x<\overline{x}$, it is partially discounted $(\delta(x)=\frac{p(\overline{x})}{p(x)}<1)$. Note that implementing this rule requires the assumption that the court can observe x perfectly along with $p(x)$ as well.

Now, suppose that the court cannot observe x; thus, eliciting some information of x requires either party to submit evidence. If the burden of proof is placed on P and there is no evidential error, P submits evidence if and only if $x<\overline{x}$. Thus, the defendant's cost function under the modified negligence rule can be calculated as follows:

---

[18] In a more general case wherein the loss due to an accident itself depends on the defendant's care level, i.e., $L=L(x)$, where $L'(x)<0$ and $L''(x)>0$, one can use an alternative interpretation for the judgement under the *sine qua non* rule as $\tilde{w}=L(x)-L(\overline{x})$. Then, it is easy to see that the defendant does not take due care but takes under-precaution under this rule. Under this rule, D does not bear all the social costs but gets a discounted possible damage amount when due care is taken. This implies that a fall in the accident probability reduces the discount, thereby weakening the incentive to take care to reduce an accident. This under-precaution result does not appear when the damage amount is fixed, because the amount to be discounted under this rule, $p(\overline{x})L$, is independent of x.

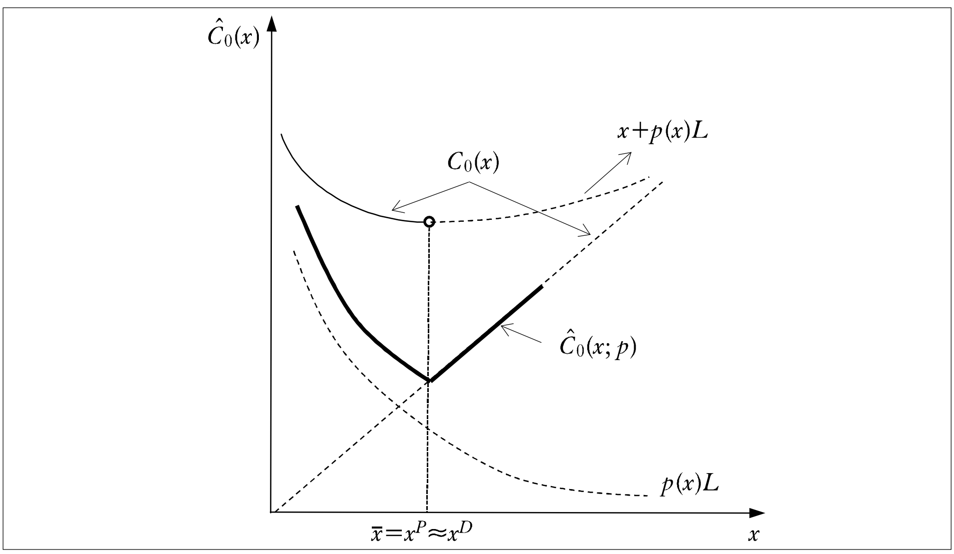
[19] This damage rule, $\frac{p(x)-p(\overline{x})}{p(x)}L$, is also called a "proportional rule." This rule has been used by Grady (1983), Kahan (1989), Gómez (2002), Schweizer (2009), and Stremitzer and Tabbach (2014) to model the *sine qua non* rule and the implied causation requirement. Alternatively, one can model the *sine qua non* rule by using a non-proportional rule, such as $L-p(\overline{x})L$, but this rule induces D to take under-precaution, as explained in Footnote 18.

$$\hat{C}_0(x;P)=\begin{cases} x+(p(x)-p(\overline{x}))L & \text{if } x<\overline{x} \\ x & \text{if } x\geq \overline{x}. \end{cases} \tag{13}$$

This cost function is continuous at $x=\overline{x}$, because $\lim_{x\to\overline{x}^-}\hat{C}_0(x;P)=\hat{C}_0(\overline{x};P)$. The *sine qua non* rule aims to make the defendant's compensation cost almost zero when he almost takes due care, so his cost function must be clearly continuous. Note, however, that $\hat{C}_0(x;P)$ is not differentiable at $x=\overline{x}$, because $\lim_{x\to\overline{x}^-}\hat{C}_0'(x;P)=0\neq 1=\lim_{x\to\overline{x}^+}\hat{C}_0'(x;P)$.

Under this modified rule, D still chooses $x=\overline{x}$ at which $\hat{C}_0(x;P)$ achieves its minimum. Figure 5 shows the continuous function $\hat{C}_0(x;P)$ and its minimum at $x=\overline{x}$ under the P-Rule. It is clear that D has no incentive to choose $x>\overline{x}$, because increasing a care level beyond $\overline{x}$ only incurs the care-taking cost without bringing any benefit at all. D has no incentive to reduce a care level at $x=\overline{x}$, because $\overline{x}=x^S$ is the care level that equates the marginal cost through an increase of the accident probability with the marginal benefit of saving the care-taking cost.

[Figure 5] P-Rule under the *sine qua non* rule



Meanwhile, if D bears the burden of proof, clearly, he is not likely to prove his own negligence if $x<\overline{x}$. Then, the cost of D depends on whether or not P proves D's negligence. This, in turn, relies on the court's belief about x if there is no evidence to be presented. Let x^e be the court's belief after no evidence is submitted. We assume the most pessimistic belief, i.e., that $x^e=0$. Then, if D does not prove his negligence, P does not prove D's negligence either, because $(1-\delta(x))L-c_p<(1-\delta(0))L$, i.e., P's payoff when he proves D's negligence is lower than his payoff when he does not. The inequality directly follows from the fact that $\delta(x)$ is strictly increasing in x. This implies that

$$\hat{C}_0(x;D) = x + p(x)(1-\delta(0))L \tag{14}$$

if $x < \overline{x}$.[20] If $x \geq \overline{x}$, then the total cost of the defendant is

$$\hat{C}_0(x;D) = x + p(x)\min\{c_d,(1-\delta(0))L\}, \tag{15}$$

because he will prove his non-negligence if $c_d < (1-\delta(0))L$ and he will not otherwise. Thus, if $c_d < (1-\delta(0))L$, D's cost function is expressed as

$$\hat{C}_0(x;D) = \begin{cases} x + p(x)(1-\delta(0))L & \text{if } x < \overline{x} \\ x + p(x)c_d & \text{if } x \geq \overline{x}. \end{cases} \tag{16}$$

Hence, roughly speaking, the cost function becomes discontinuous at $\overline{x}$ due to the most pessimistic belief leading to $p(x)(1-\delta(0)L = p(x)\frac{p(0)-p(\overline{x})}{p(0)}L \neq 0$ at $x = \overline{x}$. The discontinuity of $\hat{C}_0(x;D)$ is shown in Figure 6. Owing to the discontinuity, he will take $x^D = \tilde{x} < \overline{x}$ or $x^D = \overline{x}$, depending on $\tilde{x} + p(\tilde{x})(p(0)-p(\overline{x}))L \gtrless \overline{x} + p(\overline{x})c_d$, where $\tilde{x} \equiv \arg\min_{x<\overline{x}} x + p(x)(1-\delta(0))L$. On the one hand, if $\hat{C}_0(\tilde{x};D) = \tilde{x} + p(\tilde{x})(p(0)- p(\overline{x}))L$ is lower than $\overline{x} + p(\overline{x})c_d$, D takes under-precaution to avoid the burden of proof. This is illustrated in Figure 6. Notably, it is still possible for D to take due care if c_d is very small, because he would rather take due care and prove his negligence rather than compensate after taking under-precaution. The possible under-precaution result is due to the effect of avoiding the evidence cost, which corresponds with the insight provided by Gómez (2002). On the other hand, if $c_d \geq (1-\delta(0))L$, $\min\{c_d,(1-\delta(0))L\} = (1-\delta(0))L$. In this case, D does not prove his negligence due to the high proof cost. Thus, his total cost is

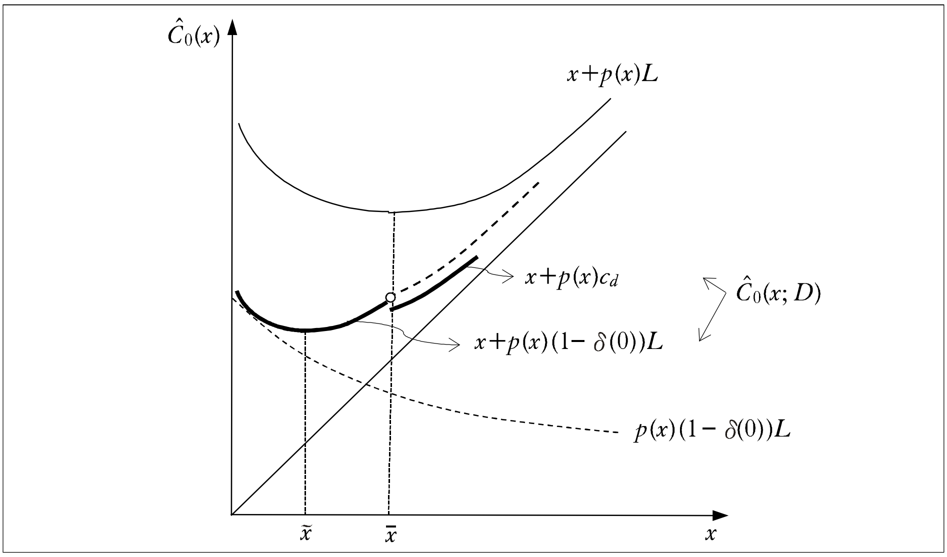
$$\hat{C}_0(x;D) = x + p(x)(1-\delta(0))L, \tag{17}$$

whether $x < \overline{x}$ or $x \geq \overline{x}$. Therefore, D is likely to choose $\tilde{x} < \overline{x}$, i.e., take under-precaution, because he does not want to prove his non-negligence even if he takes due care. The high proof cost makes D liable for any x; hence, the negligence rule is essentially the same as the strict liability rule. Thus, under the modified (discounted) award rule, the defendant's incentive to take care is reduced if D bears the burden of proof. Again, this is consistent with the insight of Gómez

[20] If we assume that $p(0)=1$, $1-\delta(0) \equiv \frac{p(0)-p(\overline{x})}{p(0)}$ is reduced to $1-p(\overline{x})$ as the non-proportional rule provided in Footnote 19.

(2002).

[Figure 6] D -Rule under the *sine qua non* rule



Now, if there is evidential error (judicial uncertainty), the court-awarded judgement becomes complicated, because the true value of x is not observable. In this case, the court may use z as a proxy for x. Then, the judgement becomes $w = \rho(z)L$, where $\rho(z) = 1-\delta(z)$ is the discount factor given that the court's interpretation of evidence x is z. Thus, if P bears the burden of proof, the defendant's cost function under the modified negligence rule can be calculated as

$$\hat{C}(x;P) = \begin{cases} x + p(x)F(\overline{x}-x)\Lambda(x)L & \text{if } F(\overline{x}-x)\Lambda(x)L \geq c_p \\ x & \text{otherwise} \end{cases}, \tag{18}$$

where $\Lambda(x) = \int_{-\infty}^{\infty} \rho(x+\varepsilon)dF(\varepsilon)$. Here, $F(\overline{x}-x)$ is the probability that D is found to be negligent, and $\Lambda(x)$ is the expected discount factor given that D takes a care level x. Thus, $F(\overline{x}-x)\Lambda(x)L$ is the expected award at trial when an accident occurs.

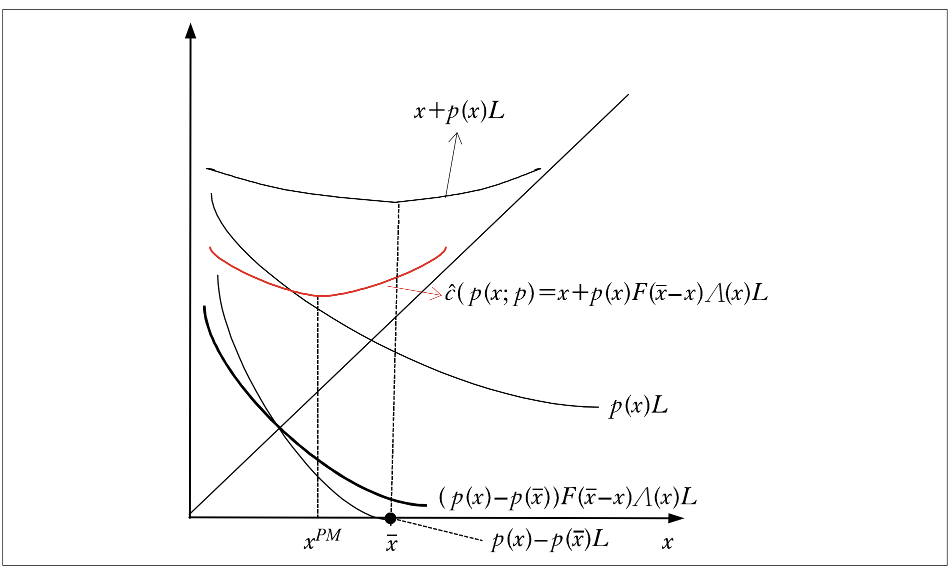
Assuming that the second-order condition is satisfied[21] and that c_p is very low, then the first-order condition implies that

[21] The second-order condition requires $\frac{\partial^2 \hat{C}(x;P)}{\partial x^2} = [h''\Lambda + (h+h')\Lambda' + h\Lambda'']L > 0$. If evidence is so accurate that $h\Lambda'$ becomes negligible, $\frac{\partial^2 \hat{C}(x;P)}{\partial x^2} \approx h''\Lambda L = [p''F - 2p'f + pf'(\overline{x}-x)]\Lambda L > 0$ for $x > \overline{x}$, because $|f'|$ is very small.

$$\frac{\partial \hat{C}(x;P)}{\partial x} = 1 + h'(x)\Lambda(x)L + h(x)\Lambda'(x)L = 0, \tag{19}$$

where $h(x) = p(x)F(\overline{x} - x)$. If evidence is very accurate, $\rho(z = \overline{x} + \varepsilon) = 1 - \frac{p(\overline{x})}{p(\overline{x}+\varepsilon)} \approx 0$, and accordingly $\rho(z = x + \varepsilon) \approx 0$ for all $x > \overline{x}$. Thus, $h(x)\Lambda'(x)L$ is negligible. Then, $\frac{\partial \hat{C}(x;P)}{\partial x} > \frac{\partial C(x;P)}{\partial x}$ for all $x \geq \overline{x}$, because $\Lambda(x) < 1$, thus implying that $x^{PM} \ngeq \overline{x}$, where x^{PM} satisfies (19). Therefore, we have $x^{PM} < \overline{x}$ (see Figure 7). Intuitively, increasing a care level involves the direct cost of taking care apart from the indirect compensatory cost. Under the negligence rule, if D increases x marginally due to the conduct of due care, the direct marginal cost is exceeded by the marginal benefit of saving the marginal indirect compensatory cost resulting from the judicial error. Under the *sine qua non* rule, the marginal benefit is smaller because of the discount in the compensation, so that increasing x above $\overline{x}$ simply increases the total cost. Similarly, reducing a care level does not increase the defendant's compensatory cost very rapidly due to judicial error. Therefore, a defendant has an incentive to take less care under this rule. This is the source of the under-precaution result. Figure 7 illustrates this. In Figure 7, $(p(x) - p(\overline{x}))L$ and $(p(x) - p(\overline{x}))F(\overline{x} - x)\Lambda(x)L$ are D's accident costs in the case of no judicial error and in the case of judicial error when the *sine qua non* rule is applied, respectively. The graphs show how judicial errors change D's cost under the *sine qua non* rule.

[Figure 7] P-Rule under the *sine qua non* rule and judicial errors



In this case, the possibility of judicial error plays a crucial role in the incentive to take due care. Intuitively, the effects of one unit more care and one unit less care from the due care are asymmetric in the sense that the effect of the latter is greater due to the possibility that he is found to be not liable (type II error).

This is in contrast with the over-precaution result under the standard negligence rule in the presence of judicial error. Under the standard negligence rule, reducing a care level from $\overline{x}$ is detrimental, because the cost jumps up discontinuously at the point. However, the continuity at $\overline{x}$ that is recovered by the modified rule significantly reduces the negative effect of reducing a care level. That is, the continuity imposed by the modified negligence rule induces the defendant to take less care than due care in the face of judicial error.

If D bears the burden of proof, his cost function is slightly modified by adding the proof cost c_d as follows:

$$\hat{C}(x;D) = x + p(x)F(\overline{x}-x)\Lambda(x)L + p(x)c_d\,, \tag{20}$$

assuming that c_d is so low that D always prefers proving his non-negligence. If we compare Equation (20) with Equation (16), which is D's cost function without judicial errors, the only difference is the second term in Equation (20). This indicates that even if he proves his non-negligence, D may pay for the losses due to judicial error. As $\frac{\partial \hat{C}(x;D)}{\partial x} = \frac{\partial \hat{C}(x;P)}{\partial x} + p'(x)c_d < \frac{\partial \hat{C}(x;P)}{\partial x}$ due to $p'(x) < 0$, it follows from the second-order condition that $x^{DM} > x^{PM}$, i.e., D takes more care when he bears the burden of proof than when P bears the burden of proof. Thus, D may take over-precaution due to the evidence cost. Again, the intuition is that D has an additional incentive to avoid an accident if he has to bear the cost of proof.

Proposition 4 *In the presence of judicial error, the defendant takes more care when the burden of proof is placed on him than when it is on the plaintiff under the sine qua non rule.*

Before we close this section, we must compare our result with that of Gómez (2002), arguing that that D takes under-precaution when he has the burden of proof if the *sine qua non* rule is adopted. His main intuition is that it costs more if he takes due care because of the proof cost. Note, however, that his result is obtained under the assumption of no judicial uncertainty. With judicial error, the defendant's proof cost is incurred whether or not he takes due care. Furthermore, the proof cost is incurred only if an accident occurs. Therefore, he has an incentive to take more care to avoid the accident, thereby saving the proof cost in the presence of judicial uncertainty. Due to this additional effect, D takes more care when he bears the burden of proof. However, it is not certain that he would take more care than due care under the D-Rule. Both $x^{DM} > \overline{x}$ and $x^{DM} < \overline{x}$ are possible, depending on c_d. Hence, it is ambiguous which of the two rules, P-Rule and D-Rule, yields a lower social cost under the *sine qua non* rule.

V. Discussions

In this section, we discuss how various modifications of our burden of proof model affect the results stated in Propositions 2 and 3.

5.1. Bilateral Accident

So far, we only considered unilateral accidents by assuming that the probability of an accident depends on the care level of D. However, it is more realistic to assume that P can reduce the accident probability by taking more care. Thus, in this subsection, we consider bilateral accidents whose probability depends on the care level by P as well as the care level by D.[22] Let y be the care level of P and $p(x,y)$ be the accident probability. We assume that $p_x, p_y < 0$ and $p_{xx}, p_{yy} > p_{xy} > 0$. The last inequality $(p_{xy} > 0)$ implies that the cares by D and P are substitutes for each other. The other inequality, $p_{xx}, p_{yy} > p_{xy}$, is just a technical assumption for the second-order condition of social optimum.

The total social cost in the case of a bilateral accident can be defined by

$$C(x,y) = x + y + p(x,y)L .$$

Then, social optimum requires the following:

$$\frac{\partial C(x,y)}{\partial x} = 1 + p_x(x,y)L , \tag{21}$$

$$\frac{\partial C(x,y)}{\partial y} = 1 + p_y(x,y)L . \tag{22}$$

Socially optimal care levels, denoted as x^S and y^S, can be obtained by solving the two Equations (21) and (22), respectively. These can be expressed as the point at which the two implicit functions $x^*(y)$ and $y^*(x)$ intersect, thus satisfying Equations (21) and (22), respectively.

It is well known that if there is no judicial error, the simple negligence rule whereby D is liable if and only if $x < \overline{x}$ regardless of y achieves the social optimum, i.e., $x^N = x^S$ and $y^N = y^S$, if $\overline{x} = x^S$, where x^N and y^N are the

[22] The formal analysis for bilateral accidents was first provided by Brown (1973) and slightly modified by Diamond (1974) in a subsequent work.

Nash care levels of D and P, respectively.[23] What if we consider the possibility of judicial error in the case of bilateral accidents? We thus compare the two cases that the burden of proof is placed on P and D, respectively.

Suppose the burden of proof is placed on P. If c_p is so low that P would want to submit evidence, then the corresponding cost functions of D and P are as follows:

$$C^D(x,y;P) = x + p(x,y)F(\overline{x}-x)L\,, \tag{23}$$
$$C^P(x,y;P) = y + p(x,y)[(1-F(\overline{x}-x))L + c_p]\,. \tag{24}$$

The best response of D to $y, x^P_{BR}(y)$ is then obtained from the first-order condition of (23) given by

$$C^D_x(x,y;P) = 1 + (p_x F - pf)L = 0\,. \tag{25}$$

To determine the slope of the best response function, we differentiate (25) with respect to y to obtain

$$C^D_{xx}(x,y;P)dx + (p_{xy}F - p_y f)Ldy = 0\,. \tag{26}$$

Given that $C^D_{xx} > 0$ from the second-order condition, we have $dx^P_{BR}/dy = -(p_{xy}F - p_y f)L / C^D_{xx} < 0$, implying that $x^P_{BR}(y)$ is downward sloping. Further, note that $x^P_{BR}(y^N) > x^N$ if z is very informative due to the over-precaution result, which we obtained in Section 3.

Similarly, the best response of P to $x, y^P_{BR}(x)$, can be obtained from the first-order condition of (24) expressed as

$$C^P_y(x,y;P) = 1 + p_y[(1-F(\overline{x}-x))L + c_p] = 0\,. \tag{27}$$

If $c_p \ll L$, we have $(1-F(\overline{x}-x))L + c_p < L$, such that $y^P_{BR}(x) < y_{BR}(x)$ for all $x \le x^N$.[24] Figure 8 illustrates the equilibrium care levels, which are denoted by x^{PE} and y^{PE}.[25] The figure shows that $x^{PE} > x^S$ and $y^{PE} < y^S$. In other words, under the P-Rule, D takes over-precaution and P takes under-precaution in the presence of judicial error.[26] It now becomes intuitively clear why D takes

[23] See Shavell (1987) for this result.

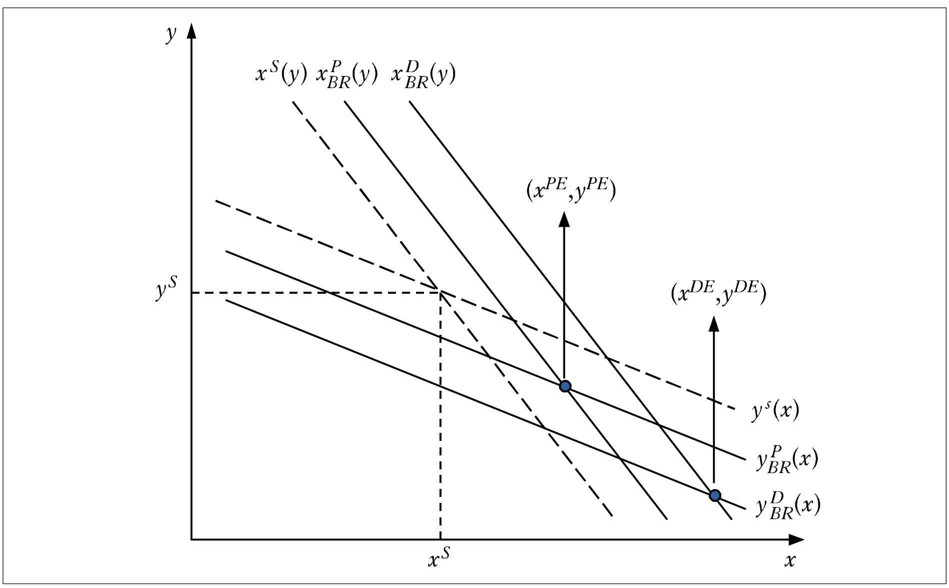
[24] For $x > x^N$, it is possible that $y^P_{BR}(x) > y_{BR}(x)$, but the result remains unaffected insofar as $x^P_{BR}(y)$ is downward sloping.

[25] Note that we abuse notation for the sake of parsimony.

[26] Of course, the result of D's over-precaution holds only when z is very informative.

over-precaution once the possibility of judicial error is introduced. In contrast, P takes under-precaution for two reasons. First, the possibility of judicial error lowers P's cost when D chooses to exactly follow the legal standard of due care $(x=\overline{x})$. This is because P now enjoys the possibility of winning at court due to judicial error. On the other hand, P's new source of cost savings from reduced expenditure on the care level comes at the expense of extra proof cost, c_p. However, if c_p is small enough that the effect of the cost increase is dominated by the former effect of the cost decrease, then P will take less care than when there is no error. Second, $\overline{x}$ is no longer the individually optimal care for D. Given that the other party takes more care than $\overline{x}$, P must respond optimally to $x>\overline{x}$ by lowering his care level due to the substitutability between x and y, especially if the accident-preventing effect of y, $|p_y|$, is small.[27]

[Figure 8] Care levels in a bilateral accident when P (or D) bears the burden of proof



Now, let us consider the D-Rule. If c_d is so small that D submits evidence, the costs of D and P are as follows:

$$C^D(x,y;D)=x+p(x,y)[F(\overline{x}-x)L+c_d], \tag{28}$$

$$C^P(x,y;D)=y+p(x,y)(1-F(\overline{x}-x))L. \tag{29}$$

[27] If y is very effective in preventing an accident, P may increase y as an optimal response to an increase in x (thereby increasing P's losing probability) in order to reduce the likelihood of an accident.

The first-order condition of the optimization problem (28) implies that D must take more over-precaution than when the burden of proof is on P, because of the extra term $p(x,y)c_d$. Intuitively, if D takes an additional unit of care, it saves his proof cost. This savings on proof cost is the reason why he takes more care. Thus, the best response curve of D shifts outward. Similarly, the first-order condition of P's optimization problem (29) implies that P takes more under-precaution due to the absence of the term, $p(x,y)c_p$. Intuitively, when the burden of proof is placed on P, an increase in y has the effect of reducing the accident probability, thereby reducing his proof cost. However, if P does not bear the burden of proof, this effect disappears; thus, P has less incentive to take care, which shifts his best response curve downward. As a result, it follows that $x^{PE} < x^{DE}$ and $y^{PE} > y^{DE}$. Figure 8 illustrates this point. The upshot is that it is socially better to place the burden of proof on P, because otherwise, D's over-precaution and P's under-precaution may be aggravated.

5.2. Positive Filing Cost

A case is initiated only when P files it. Thus far, we have implicitly assumed that the filing cost is negligible, implying that whenever an accident occurs, P always files the case. In this subsection, we assume alternatively that the cost of filing a case is $c > 0$; thus, P's decision to file a case becomes non-trivial.

The interaction between P and D can be modelled by the following extended game. First, D chooses his care level x. Then, an accident may occur with probability $p(x)$. If the accident occurs, P decides whether to file the case. If the case is filed, it goes to trial. During the trial, the party who bears the burden of proof decides whether or not to submit evidence, and the court makes a judicial decision, based on the evidence presented. For simplicity, we assume that there is no judicial error.

We first consider the case that $c_p, c_d < L$. In Section 2, we obtained the neutrality result that $x = \overline{x}$ regardless of whether the burden of proof is placed on P or D, if $c = 0$. If $c > 0$, the neutrality result does not hold.

Under the D-Rule, if D takes $x = \overline{x}$ in equilibrium, P will not file because he knows that even if he files, he will lose the case by the evidence D submits. But if D takes $x < \overline{x}$, P will file. Thus, D will prefer taking due care $\overline{x}$ because $\overline{x} < x + p(x)L$ for all $x < \overline{x}$.

The situation is similar under P-Rule, although the equilibrium outcome differs whether $L > c_p + c$ or $L < c_p + c$. Consider the case that $L < c_p + c$ so that not filing is a credible option for P. If $x = \overline{x}$, P would prefer not filing the case, because D will submit evidence and so P will lose if filing the case. If D takes $x < \overline{x}$, P would not file due to the high filing cost, because P's payoff when he files is $L - c_p - c < 0$. Therefore, if D knows that P will not file whether or not he takes due care, he will take $x = 0$. If $L > c_p + c$, P will file the case only when D takes $x < \overline{x}$. Knowing this, D will take due care.

If $c_d > L$, under the D-Rule, D chooses $x = \overline{x}$, because D knows that P will file the case and then he will always be found liable due to failure to submit evidence, which is the same situation as that under the strict liability rule. Under the P-Rule, however, D's large proof cost cannot be a problem, because P bears the burden of proof. Thus, on the one hand, as in the case where $c_d < L$, D chooses $x = \overline{x}$ if $c_p + c < L$, because P will choose to file.[28] On the other hand, if $c_p + c > L$, D will take $x = 0$, as P will choose not to file, which is the same situation as that under the no liability rule. Therefore, in this case, it is better for D to bear the burden of proof for the same reason that the strict liability rule is socially better than the no liability rule.

5.3. Incomplete Information about the Plaintiff's Cost

Often, it is more difficult (even impossible) for the plaintiff to prove the defendant's negligence than for the defendant to prove his own negligence. Aware of this reality, in this section, we consider the possibility that $c_p > c_d$. In particular, we assume that P's cost of gathering evidence is either c_H or c_L, where $c_H > L > c_L$, c_d. It is not known to the defendant whether c_p is c_H or c_L, whereas the plaintiff knows it. The assumption that $c_H > L$ implies that it is too costly to prove that D is negligent. The probability that $c_p = c_H$ is $\alpha \in (0,1)$. This probability is common knowledge among players. For the time being, we assume that there is no judicial error.

Suppose the burden of proof is placed on P. The low-type plaintiff with $c_p = c_L$ will gather and present evidence if and only if $x < \overline{x}$, whereas the high-type plaintiff with $c_p = c_H$ will not gather evidence, as the net benefit from gathering evidence is $L - c_H < 0$. Knowing this, D will choose x to minimize as follows:

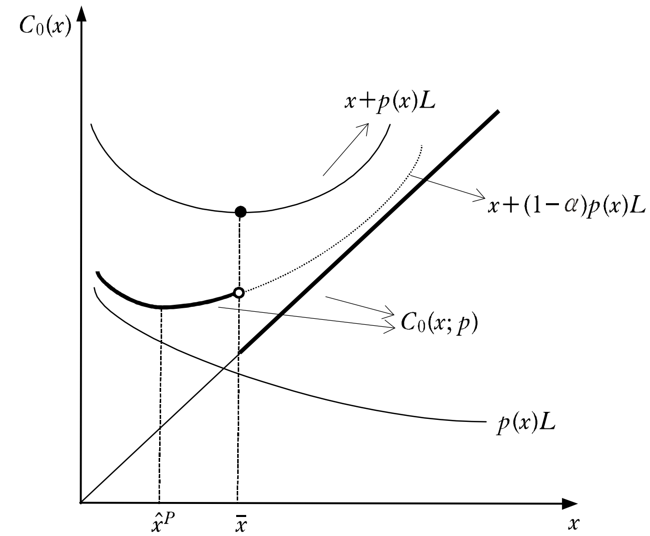
$$C_0(x;P) = \begin{cases} x + (1-\alpha)p(x)L & \text{if } x < \overline{x} \\ x & \text{if } x \geq \overline{x}. \end{cases} \tag{30}$$

Under this rule, D who chooses $x < \overline{x}$ will be liable for L only if the accident occurs and P presents evidence that $x < \overline{x}$. The former probability is just $p(x)$, and the latter probability is $1-\alpha$. Therefore, if α is large enough, i.e., P is very likely to fail to present evidence, then D may take less care than $\overline{x}$. In this case, due to the possibility of high proof cost, the liability rule cannot fully internalize the

[28] If we consider other trial costs k, P will file if $c_p + c + k < L$, i.e., P is less likely to file, and D will choose $x^*(k)$ to minimize $x + p(x)(L + k)$, where $x^*(k)$ is slightly higher than x^S due to the extra cost k.

negative externality from the accident (see Figure 9).

[Figure 9] Care-taking incentive when $c_p = c_H$ or c_L



The analysis when the burden of proof is placed on D is not affected by the possibility that $c_p = c_H$ (see Figure 1). Therefore, we have the following proposition:

Proposition 5 *In the absence of judicial error, if the plaintiff's cost of proof is either* c_L *or* c_H *with* $c_H > L$, *there exists* $\bar{\alpha} > 0$, *such that for all* $\alpha \geq \bar{\alpha}$, *it is socially efficient to place the burden of proof on* D. *In particular, the equilibrium care level of the defendant is lower and the social cost is higher when the burden of proof is on* P, *i.e., (i)* $x^P < x^D$ *and (ii)* $SC^P > SC^D$.

Proof. (i) It is clear because $x^P < \bar{x} = x^D$. (ii) $SC^P(x^P) = x^P + p(x^P)L > \bar{x} + p(\bar{x})L > \bar{x} + p(\bar{x})c_d = SC^D(\bar{x})$. The first inequality is due to the fact that $\bar{x} = x^S$ minimizes the social cost by the definition of x^S and the second inequality is due to the assumption that $c_d < L$.

This proposition implies that if there is a possibility that c_p is very high (for example, it is very difficult to prove the negligence of experts, such as surgeons, lawyers, mechanics, etc.), it is socially better for the defendant to bear the burden of proof, because the possibility itself induces D to take under-precaution otherwise. That is, the neutrality result does not hold under this possibility of high c_p.

Certainly, this result depends on the assumption of no judicial error. In the presence of judicial error, if the burden of proof is on P, he will submit evidence if

$F(\overline{x}-x)L > c_p$. Given that $c_L < L < c_H$, a high-type P will not file and a low-type P will file only if $F(\overline{x}-x)L \geq c_L$, i.e., $x \leq \hat{x}^P(c_L) \equiv \overline{x} - F^{-1}(\frac{c_L}{L})$. Thus, D's cost function is expressed as

$$C(x;P) = \begin{cases} x + (1-\alpha)p(x)F(\overline{x}-x)L & \text{if } x \leq \hat{x}^P(c_L) \\ x & \text{if } x > \hat{x}^P(c_L). \end{cases} \tag{31}$$

Only the low-type P submits evidence when $x \leq \hat{x}^P(c_L)$, and neither type of P submits evidence when $x > \hat{x}^P(c_L)$. If c_L is low enough to guarantee the interior solution for minimizing (31), then the optimal care level x^{PE} must satisfy the following first-order condition:

$$\frac{\partial C(x;P)}{\partial x} = 1 - (1-\alpha)[p(x^{PE})f(\overline{x}-x^{PE}) - p'(x^{PE})F(\overline{x}-x^{PE})]L = 0\,. \tag{32}$$

Again, if z is very informative, we have $[\frac{\partial C(x;P)}{\partial x}]_{x=\overline{x}} < 0$, implying that $x^{PE} > \overline{x}$. In comparison, if the burden of proof is placed on D, then the incomplete information of c_p does not affect the cost function of D, so D's decision will not be affected. Therefore, the ambiguous result obtained in Section 3 will remain unaffected.

VI. Conclusion

In this paper, we compared the two rules of assigning the burden of proof. We showed that if the burden of proof is assigned to plaintiffs, it can save the trial costs (cost of proof) when there is no possibility of judicial error and alleviate the defendant's incentive to take too much care when there is some possibility of judicial error if the proof costs are low. We also argued that if it is too costly for a plaintiff to prove the defendant's negligence, then it may be socially better to place the burden of proof on the defendant, because otherwise the defendant could have the incentive to take too little care. This is especially the case when the defendant is an expert, like a doctor, lawyer, or manufacturer. Thus, the finding suggests that it is desirable to apply different rules of the burden of proof assignment to areas requiring either high or little expertise.

References

Berger, M. (1992), "When, if Ever, Does Evidentiary Error Constitute Reversible Error," *Loyala of Los Angeles Law Review*, Vol. 25, 893–908.

Calfee, J. E. and R. Craswell (1984), "Some Effects of Uncertainty on Compliance with Legal Standards," *Virginia Law Review*, Vol. 70, 965–1004.

Cooter, R. D. and T. S. Ulen (1986), "An Economic Case for Comparative Negligence," *New York University Law Review*, Vol. 61, 1067–1110.

Craswell, R. and J. E. Calfee (1986), "Deterrence and Uncertain Legal Standards," *Journal of Law, Economics and Organization*, Vol. 2, 279–303.

Demougin, D. and C. Fluet (2005), "Deterrence Versus Judicial Error: A Comparative View of Standards of Proof," *Journal of Institutional and Theoretical Economics*, Vol. 161, 193–206.

______________________ (2008), "Rules of Proof, Courts, and Incentives," *Rand Journal of Economics*, Vol. 39, 20–40.

Diamond, P. (1974), "Single Activity Accidents," *Journal of Legal Studies*, Vol. 3, 107–164.

Edlin, A. S. (1994), "Efficient Standards of Due Care: Should Courts Find More Parties Negligent under Comparative Negligence?" *International Review of Law and Economics*, Vol. 14, 21–34.

Farrell, J. (1986), "Voluntary Disclosure: Robustness of the Unraveling Result, and Comments on Its Importance," In Proceedings of the U.C. Santa Cruz Conference on Regulation and Antitrust, eds. R. Grieson, Lexington, Ma.: Heath-Lexington, 91–103.

Gómez, F. (2002), "Burden of Proof and Strict Liability: An Economic Analysis of a Misconception," in H.-B. Schäfer and H.-J. Lwowski, "Konsequenzen wirtschaftsrechtlicher Normen," Part of the Series Ökonomische Analyse des Rechts, 367–389.

Grady, M. (1983), "A New Positive Economic Theory of Negligence," *Yale Law Journal*, Vol. 92, 799–829.

Grossman, S. (1981), "The Role of Warranties and Private Disclosure about Product Quality," *Journal of Law and Economics*, Vol. 24, 461–483.

Guerra, A., B. Luppi and F. Parisi (2019), "Presumption of Negligence and the Robustness of Liability Incentives," Available at SSRN: http://dx.doi.org/10.2139/ssrn.3334448.

Haddock, D. and C. Curran (1985), "An Economic Theory of Comparative Negligence," *Journal of Legal Studies*, Vol. 16, 49–72.

Hay, B. and K. Spier (1997), "Burdens of Proof in Civil Litigation: An Economic Perspective," *Journal of Legal Studies*, Vol. 26, 413–431.

Kahan, M. (1989), "Causation and Incentives to Take Care under the Negligence Rule," *Journal of Legal Studies*, Vol. 18, 427–447.

Kaplow, L. (2011), "Optimal Burden of Proof," *Journal of Political Economy*, Vol. 119, 1104–1140.

Kim, J.-Y. (2016), "A Note on Burdens of Proof in Civil Litigation," *European Journal of Law and Economics*, Vol. 42, 325–337.

Milgrom, P. (1981), "Good News and Bad News: Representation Theorems and Applications," *Bell Journal of Economics*, Vol. 12, 380–391.

Salvador-Coderch, P., N. Garoupa and C. Gómez-Ligüerre (2009), "Scope of Liability: The Vanishing Distinction between Negligence and Strict Liability," *European Journal of Law and Economics*, Vol. 28, 257–287.

Sanchirico, C. (2008), "A Primary-Activity Approach to Proof Burdens," *Journal of Legal Studies*, Vol. 37, 273–313.

Savchyn, N. (2014), "Judicial Errors in Civil Proceedings: Concept, Causes, and Procedural Methods of Their Prevention," *Jurisprudence*, Vol. 21, 484–505.

Schweizer, U. (2009), "Legal Damages for Losses of Chances," *International Review of Law and Economics*, Vol. 29, 153–160.

Shavell, S. (1994), "Acquisition and Disclosure of Information Prior to Sale," *Rand Journal of Economics*, Vol. 25, 20–36.

Shin, H.-S. (1998), "Adversarial and Inquisitorial Procedures in Arbitration," *Rand Journal of Economics*, Vol. 29, 378–405.

Sobel, J. (1985), "Disclosure of Evidence and Resolution of Disputes: Who Should Bear the Burden of Proof?" Game-Theoretic Models of Bargaining, eds. A. Roth, Cambridge, MA: Cambridge University Press, 341–361. Stremitzer, A. and A. Tabbach (2014), "The Robustness Case for Proportional Liability," B.E. Journal of Theoretical Economics, Vol. 14, 1–25.