European Journal of Law and Economics (2022) 54:349–368
https://doi.org/10.1007/s10657-022-09737-6

Do presumptions of negligence incentivize optimal precautions?

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Accepted: 21 March 2022 / Published online: 31 March 2022 / Published online: 6 April 2022

Abstract

In most jurisdictions, the burden of producing evidence on a contested issue traditionally falls on plaintiffs. In a tort claim, this de facto creates a presumption of non-negligence in favor of injurers. Some legal systems in Europe placed renewed attention on "presumed liability" rules, which instead create a presumption of negligence against injurers. In this paper, we analyze the effects of alternative legal presumptions on parties' care incentives in the presence of discovery errors. Differently from what was suggested in prior research, we show that legal presumptions do affect primary behavior: presuming that the injurer was (not) negligent strengthens (weakens) his care incentives in situations where the plaintiff faces probatory difficulties. We analyze how these effects should inform the choice of evidence regimes to improve the robustness of liability rules, and to minimize the dilutive effect of imperfect discovery on individuals' care incentives.

Keywords Legal presumptions · Presumed liability · Care incentives · Discovery errors

JEL Classification K13 · D83

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1 Introduction

Legal presumptions play a central role in the law and practice of evidence. In most other jurisdictions, the burden of producing evidence on a contested issue traditionally falls on plaintiffs (Hay ,1997; Hay & Spier ,1997; Shin, 1998; Sanchirico, 2000, 2001; Talley, 2013). In a tort claim, this creates a *de facto* rebuttable presumption of non-negligence in favor of injurers. As a result of this presumption, the victim of an accident generally faces the burden of producing evidence showing the negligent behavior of her injurer as a condition for establishing liability and obtaining compensation.

Some legal systems in Europe have introduced exceptions to this general principle, adopting rules of "presumed negligence" in a variety of tort situations. In some jurisdictions, these rules have enjoyed broader application and support at the policy level, such as in tort cases involving traffic accidents and enterprise liability. For example, in the case of motor vehicle accidents, the shift of the burden of evidence production from victims to injurers seeks to protect more vulnerable road users, such as cyclists (in accidents with, e.g., motorcycles, cars, trucks) and pedestrians (in accidents with, e.g., cyclists, motorcycles, cars, trucks), as well as children, senior citizens, and disabled individuals (Boufous et al., 2017). In the case of enterprise liability, rules of presumed negligence have been advocated on the idea that liability should be considered as a cost of the activity and that the attribution of presumed negligence on the person carrying out the activity (or receiving the profit from it) should follow from a "risk theory of profit" (Loria, 1893). More general arguments in favor of legal presumptions of negligence rely on rationales of fairness and efficiency. Shifting the burden onto the injurer is fairer than the standard fault-based evidence rule, as it shields the more vulnerable victims from the burdensome task of proving the negligence of their injurer (Boufous et al., 2017). Some scholars have argued that presumptions of negligence may be desirable to lend support to victims in personal injury cases because "as a matter of policy it should not be made too difficult for the plaintiff to obtain relief."(Ulfbeck & Holle, 2009, p. 26). Legal presumptions of negligence have also been advocated for practical, access-to-justice reasons, such as when it can be unreasonably burdensome for the victim to satisfy the burden of proof, such as when evidence is in control of the injurer or when the accident occurred in the injurer's sphere of risk. Procedural economy rationales have been put forth in support of presumptions of negligence, when the injurer is more likely than not to be at fault, and legal presumptions can help minimize the number of incorrect decisions (Ulfbeck & Holle, 2009, p. 27).[1] Other arguments in support of the presumption of negligence have pointed to the widespread availability and rapid development of new evidence technologies, such as helmet cameras, black-box technology, and GPS location technologies, which have made it easier for injurers to record accident events and provide evidence to rebut a presumption of negligence (Frezza & Parisi, 2021; Guerra & Parisi, 2022; Parisi et al., 2022).

[1] This latter argument in favor of presumptions of negligence echoes the rationale of the "res ipsa loquitur" doctrine.

By shifting the burden of producing evidence from one party to the other, legal presumptions determine who should win the case in the event of uncertainty. In this paper, we study the extent to which shifting the burden of producing evidence from victims to injurers would affect their care incentives. Resolving this question is crucial for public policy: alternative allocations of the burden of producing evidence may affect the social cost of accidents differently. Notwithstanding the extensive legal literature on legal presumptions and their role in evidence law (see Allen, 1994 for a brief survey), only a few law and economics contributions have formally analyzed the economic incentives of alternative legal presumptions (Hay & Spier, 1997; Bernardo et al., 2000; Gomez, 2002; Demougin & Fluet, 2008; Kim, 2021). In a setting where the collection of evidence is complete and never erroneous, Hay and Spier (1997) established their "neutrality result:" changing legal presumptions has no impact on individuals' care behavior. A similar conclusion is reached by Demougin and Fluet (2008). The neutrality result crucially depends on the assumptions of both no discovery errors, and a peculiar shape of full liability with its discontinuity at efficient precaution. However, when relaxing those assumptions the neutrality result may break down. Indeed, Gomez (2002) has shown that it does not hold when full liability is replaced by Grady-Kahan liability. Here we further show that the neutrality result disappears when discovery errors are present, even under full liability (with its discontinuity that drives the neutrality result of Hay and Spier (1997)). Differently from what was suggested in prior works (Hay, 1997; Hay & Spier, 1997; Demougin & Fluet, 2008), we find that, in the presence of discovery errors parties' care investments *do* react to changes in legal presumptions. By developing a very simple framework, we show that under proper circumstances, shifting the burden of proof to the injurer strengthens care incentives. Support for our findings has been later provided by Kim (2021), who generalize our formal analysis for the case of continuous care levels.[2] The understanding of these effects should inform the choice of evidence regimes to improve the robustness of liability rules and to minimize the dilutive effect of probatory difficulties on the parties' care incentives.

This paper is structured as follows. In Sect. 2, we frame the scope of our analysis (Sect. 2.1), we discuss the legal reforms that have reversed legal presumptions in some areas of tort law (Sect. 2.2), and we review the related literature (Sect. 2.3). In Sect. 3, we use a simple analytical model to analyze the effects of alternative legal presumptions on individuals' care incentives in the presence of discovery errors. In Sect. 4, we discuss our results in conjunction with the existing findings in the evidence literature, and we consider how courts could assign the burden of proof in practice. In Sect. 5, we propose possible extensions of our basic framework and ideas for future research, including the interaction of other fact-finding issues with legal presumptions.

[2] See Kim (2021) for a detailed discussion on the analytical differences between our theoretical frameworks. Our analysis is more focused on the legal than the economic side, adding "legal flesh" and a discussion of the policy implications of the analytical model.

2 Presumptions and burdens of proof: theory and practice

2.1 Framing and terminology

In order to frame the scope of our analysis, we should clarify some of the terminology that will be used in our analysis, distinguishing some interrelated concepts that are commonly associated with the notion of "burden of proof." These concepts are operationally interdependent but theoretically distinct: "legal presumptions," "burden of production," and "burden of persuasion." Legal presumptions are rules that allocate the initial burden of evidence production, specifying which party is required to "produce" the evidence (or, as Adler & Michael 1931, p. 63 put it, which party has the "burden of coming forward with the evidence"). A favorable presumption shifts the burden of producing evidence on the other party.[3] The concept of burden of persuasion, instead, defines how evidence should be weighted and how much probative evidence should be offered to convince the fact finders. Standards of proofs, such as "more likely than not," "preponderance of evidence," "clear and convincing evidence," or "beyond a reasonable doubt," are examples of standards that determine the applicable burden of persuasion.[4]

In this paper, we compare the traditional rules that place the initial burden of producing evidence on the plaintiff ("presumptions of non-negligence"), to the alternative rules that place the burden of producing evidence on the defendant ("presumptions of negligence"). As it will be discussed in Sect. 3, an important effect of a shift in the initial burden of production is in (re)allocating the accident loss when parties face probatory difficulties. Presumptions of negligence (non-negligence) lead to a default judgment in favor of victims (injurers) when the party who bears the burden of proof is unable to provide sufficient evidence to overcome the legal presumption according to the applicable standard of persuasion. Under either presumptions, default judgments rendered in the absence of conclusive evidence may lead to inaccurate legal outcomes. Non-negligent injurers could face liability under a presumption of negligence, and negligent injurers could avoid liability under a presumption of non-negligence. These are not decision errors that can be attributed to a mistaken evaluation of the evidence by the court, but errors that result from the non-verifiability of the events. We examine the effect of alternative legal presumptions—and the effect of alternative default allocations of the accident loss—on parties' care incentives.

Similar to what would occur in the case of unitary evidence considered by Hay and Spier (1997) and Gomez (2002),[5] we assume that under either presumptions when the burdened party is unable to prove the negligence of her injurer, there is

[3] For a general, positive economic theory of the institutions of the legal system, see also Posner (1973).

[4] For an extensive analysis of these concepts, see Talley (2013).

[5] Relaxing the assumption of unitary evidence is a possible extension left for future exploration. We expect that, similar to what would occur in the case of unitary evidence, when evidence is not unitary and many pieces of evidence could be offered by the opposing parties, the allocation of the burden of production would determine the outcome of the case when the available evidence is inconclusive or does not meet the required standard of persuasion.

no need for the other party to produce any evidence: the presumption entirely liberates the non-burdened party, without any need for him to offer contrary evidence to support his case. For example, under a presumption of non-negligence (negligence), when the victim (injurer) is unable to prove the injurer's negligence (his non-negligence), the case will be decided in favor of the injurer (victim), without any need for him to produce evidence. Given this effect, following previous economic modeling of legal presumptions (e.g., Hay & Spier, 1997; Gomez, 2002), we will bracket off from our analysis the shifts in the burden of production that may occur between the parties during a tort case.

2.2 Presumptions of negligence: a brief survey

In the twentieth century, following the increase in accident rates triggered by the use of new technologies in the management of business and the rise of the automotive industry, some legal systems in Europe introduced presumptions of negligence in various categories of torts. Rules of presumed liability for enterprise liability were endorsed at the academic level by scholars such as Achille Loria (1857–1943) and other scholars belonging to the so-called "legal socialism," which grounded the idea of presumed liability on what became known as the "risk theory of profit." Their idea was that tort liability should be considered as a cost of running a profitable activity, and there should be a presumed attribution of liability on the person carrying out the activity or generating the risk, unless proven otherwise (Frezza & Parisi 2005). The 2005 "Principles of European Tort Law" identify presumptions of negligence as the recommended tort principle for the "harmonization, rationalization and innovation of tort law at national and EU level" in the field of enterprise liability. The recommended rule reads as follows: "Art. 4:202. Enterprise Liability. (1) A person pursuing a lasting enterprise for economic or professional purposes who uses auxiliaries or technical equipment is liable for any harm caused by a defect of such enterprise or its output unless he proves that he has conformed to the required standard of conduct."

In the field of traffic accidents, Germany adopted a mix of strict liability and presumed negligence rules, as early as 1909. Specifically, the Liability Provisions of §7 of the German Road Traffic Act (*Strassenverkehrsgesetz*, hereinafter StVG) provides the central rule establishing a form of semi-strict liability for the owner or keeper (e.g., lessor) of a motor vehicle, for the damage caused by the operation of the vehicle killing, injuring, or creating material damage to third parties. In such cases, liability can only be avoided showing that the accident was the result of force majeure, or the vehicle was used without the knowledge and permission of the owner.[6] When the driver is not the owner, the Traffic Act introduces a second ground for avoiding liability under §18 StVG, allowing the operator to prove that the loss was not due to

[6] See §7 StVG: "If a person is killed or injured or material damage incurred from the operation of a motor vehicle, the owner of the vehicle is obligated to compensate the injured party for the resulting loss, unless the accident was the result of force majeure, or the vehicle was used without the knowledge and permission of the owner.".

his or her fault.[7] Under this rule, liability can be avoided also by the owner and the keeper by showing that due care was exercised or that the accident was not caused by the failed adoption of non-negligent precautions.[8] Under the German Traffic Act §17, when an accident occurs between two motor vehicles, a rule of presumed liability applies. In such cases, liability is apportioned according to the circumstances and the principles of comparative negligence, and can only be entirely avoided by the parties by proving they have acted with due care.[9]

The Italian rules of presumed joint negligence in traffic accidents are a bit more elaborate. The Italian Civil Code of 1942 applies a rule of presumed liability for accidents caused by a motorized vehicle causing harm to non-motorized vehicle, persons, or things, and establishes a rule of "presumed joint liability" (or, "presumed joint negligence") for accidents between motorized vehicles. Under the Italian rule, in the event of a collision between motorized vehicles, drivers are presumed jointly negligent.[10] Each party is presumed to have contributed equally to the accident and bears the burden of producing evidence to overcome the presumption and avoid their share of liability. If only one party can produce satisfactory evidence about their non-negligent behavior, the other party is held unilaterally negligent and bears the entire loss, as injurer (facing full liability) or as victim (facing the full loss, with no compensation). When neither party can prove his or her non-negligent behavior, the Italian rule leads to a sharing of the loss, similar to a rule of comparative negligence.

The shift in legal presumptions has not affected the standards of persuasion that apply to those areas of the law.[11] Regardless of who is burdened with the production

[7] §18 StVG: "In the cases of §7(1), the operator is also liable to pay compensation pursuant to § §8-15, unless the loss is not the fault of the operator." This amounts to a reversal of the burden of proof (Beweislastumkehr) on the issue of negligence.

[8] Van Dam (2013), p. 412 point out that German case law has found drivers not negligent when they prove to have taken the level of due care of "the ideal driver who takes into account the considerable chance that other people make mistakes." BGH 17 March 1992, BGHZ 117, 337; BGH 28 May 1985, NJW 1986, 183.

[9] Although not explicitly stating so, §17 StVG de facto introduces a rebuttable presumption of joint negligence, like the Italian rule of presumed joint liability discussed in the text. In the Netherlands, a stronger presumption applies in favor of victims of motor vehicle accidents. See Article 185 (1), Wegenverkeerswet (Road Law), 1994: "If a vehicle driven on the road is involved in a road accident causing damage to persons or things (not to another motor vehicle), the owner or keeper of the vehicle is liable to compensate the harm, unless he can be proved that the accident was due to force majeure or by a person, for whom the owner or the keeper are not responsible.".

[10] In Italy, legal presumptions in favor of victims were introduced in 1942: injurers are presumed liable to compensate the harm they caused, unless they can prove that they acted non-negligently. See Article 2043, Italian Civil Code (*Codice Civile*), 1942.

[11] The standards of persuasion necessary for the rebuttal of presumed negligence generally specify that the burdened party should provide evidence to have adopted reasonable care to avoid the accident. Under Article 1903 of the Spanish Civil Code, "The liability provided in the present article shall cease if the persons mentioned therein should evidence that they acted with all the diligence of an orderly [good family man] to prevent the damage." In applying the standard of persuasion to overcome the presumptions of negligence for traffic accidents, Italian case law has affirmed that "the burdened party must provide evidence to have undertaken a reasonable level of precautions ... demonstrating sufficient diligence, i.e., behavior free of negligence and in compliance with the traffic laws, as evaluated by the judge accounting for the circumstances of the specific case." (Trib. Grossetto, 7 maggio 2020, n. 324).

of evidence, the evidence needed to rebut the presumption should meet the applicable standard of persuasion. For this reason, in our analysis we focus on the effects of changes in legal presumptions and burdens of production on care incentives, without considering the effect of hypothetical changes to the applicable standards of persuasion.[12]

2.3 Related literature

The law and practice of evidence place an important weight on the role of legal presumptions. Although legal presumptions have spawned a vast literature within legal scholarship (e.g., Allen, 1981, 1994; Wilkinson, 1992), this topic has received surprisingly little attention within the literature of comparative law and economics. Only a few recent attempts to explore the theoretical quagmire of legal presumptions have analyzed their incentive effects (Hay & Spier, 1997; Daugherty & Reinganum, 2000; Bernardo et al., 2000; Gomez, 2002; Demougin & Fluet, 2006; Sanchirico, 2008; Talley, 2013).[13] The standard evidence rule—placing the burden of proof upon the victim, even though the required evidence relates to the activity of the injurer—rests on a variety of rationales often embedded in notions of procedural economy (Hay, 1997; Hay & Spier 1997; Shin, 1998; Sanchirico, 2000, 2001), reliability of evidence in the face of the risk of contamination (Sanchirico 2004, 2008), and more general concerns of procedural justice and the logical foundations of the law of proof (Talley, 2013).

One argument put forth for the standard evidence rule is that the burden of proof should be placed on the person making an assertion or claim because shifting the burden of proof to the other party would constitute a logical fallacy—it would presume the claim to be true unless otherwise disproven. In other words, the person defending against a tort claim would face the formidable burden of providing a negative proof showing a lack of negligence on his part.[14] Despite the logical soundness of this argument, the factual premises of the negative-proof fallacy do not generally hold in a tort setting, especially after the transformations brought about by new evidence technology. Proving a lack of negligence by the injurer (or, for this matter, proving that any other element of the tort was not present at the time of the accident) does not entail the proof of a universal negative, but instead simply amounts to proving that the injurer acted non-negligently. While at times it may be easier for

[12] In Sect. 5, we discuss possible extensions of the analysis to other dimensions of the "burdens of proof.".

[13] See also the contributions by Louis Kaplow on the burden of proof and standards of evidence (Kaplow, 1994, 2011, 2012, 2014).

[14] The proof of a universal negative is what ancient Romans called *probatio diabolica* (literally, "devil's proof"), to signify its heinous difficulty. Consider as an example the allegation of a fact: "Defendant signed a contract promising X." A signed document and a few additional pieces of corroborating evidence produced by the plaintiff would suffice to establish the probability of such an assertion. On the contrary, the negative claim by defendant "I have never signed a contract promising X" would entail the proof of a universal negative, ultimately requiring the examination of a potentially infinite amount of evidence by the fact-finder.

a victim to prove the negligence of her injurer, at other times it may be easier for the injurer to prove his non-negligence.

Although there may be many ways in which an injurer could have been negligent, with modern technology parties can prove that they lived up to their duty of care and provide visual or electronic evidence that their activities complied with reasonable levels of non-negligence. New evidence technology provides users with instruments that can keep record of events, such as dashcams, black-box technology, and other instruments installed and carried on human bodies or vessels, which can record and track the activity of the owner or third parties in the event of an accident. These developments suggest that the conventional wisdom—according to which positive proofs can be more easily satisfied than negative proofs, and the burden of proof should therefore always be placed on the plaintiff making the assertion or claim (Adler and Michael, 1931)—no longer applies in the contemporary world of judicial discovery. Indeed, policymakers have argued that nowadays, injurers' ability to prove that an accident was not caused by their negligence is greatly facilitated by these modern technologies.[15]

Under U.S. tort law, the exceptions to the traditional presumption of non-negligence seem, at least as far as current case law goes, more limited in scope—though evidence is not systematic—and conventionally explained as instrumental to reducing the cost of discovery when facts are self-evident. One such exception to the presumption of non-negligence arises when the accident could not have normally happened absent the injurer's negligence. Under this rule, known as the *res ipsa loquitur* doctrine ("the facts speak for themselves"), courts depart from the traditional presumption of non-negligence because the facts are so obvious that requiring parties to argue any further would seem redundant (Carpenter, 1934; Shain, 1943; Prosser, 1949; Grady, 1994; Porat & Stein, 2001).[16] In negligence trials, this doctrine *de facto* shifts the burden of producing evidence onto the injurer, leading to an implicit move towards strict liability (Demougin & Fluet, 2005; Cooter & Porat, 2008; Salvador-Coderch et al., 2009; Ulfbeck & Holle, 2009).

In this paper, we examine the effect of these two alternative legal presumptions, i.e., presumption of negligence (or, presumed liability) *versus* presumption of non-negligence, on parties' care investments. Our analysis departs from much of the previous literature on burdens of proof which linked the choice of presumptions to

[15] As discussed in Guerra and Parisi (2022), several legal systems in Europe, by extending the application of some of their evidence rules, have fostered investments in evidence technologies, with a reduction in the cost of fact-finding during adjudication. Along this line, in some European countries, the introduction of legal presumptions of negligence has led to widespread adoption of these evidence technologies, also greatly encouraged and subsidized through insurance premium discounts. Almost all insurance companies in Europe encourage the use of video evidence technology by offering premium discounts. Some insurance companies in the U.S. offer usage-based insurance which utilizes installed device in the vehicle, or an application installed on a user smartphone, but only to record a user's driving habits, without video recording, and they reward good driving behavior by reducing premium costs. See Guerra and Parisi (2022) for more details.

[16] The *res ipsa loquitur* doctrine was first formulated by Baron Pollock in the 1863 English case *Byrne v. Boadle*, 2 H. & C. 722, 159 Eng. Rep. 299 (Exch. 1863). See also Cal. Evidence Code 646(b) stating that "The judicial doctrine of *res ipsa loquitur* is a presumption affecting the burden of producing evidence.".

parties' relative cost of discovery, truth-finding by the court, and litigation incentives. Closely related to our paper is Hay and Spier (1997), which analyzed the effects of alternative evidence rules on parties' care incentives within a complete-information accident model.[17] In a setting of full liability without judicial error, Hay and Spier (1997) have established their "neutrality result:" the injurer chooses efficient precaution independent of whether the injurer or the victim has the burden of proof. However, placing the burden of proof on the plaintiff is socially desirable because, in equilibrium, the costs of presenting evidence will be saved. A similar conclusion is reached by Demougin and Fluet (2008). This neutrality result is based on two crucial assumptions: (i) the peculiar shape of full liability with its discontinuity at efficient precaution; (ii) the absence of discovery errors. Relaxing those assumptions may yield different conclusions. In fact, Gomez (2002) has shown that the neutrality result may disappear when full liability is replaced by Grady-Kahan-liability. Here we further show that, in the presence of discovery errors the neutrality result may disappear even under full liability (with its discontinuity that drives the neutrality result of Hay and Spier (1997)). Our findings reveal that alternative allocations of the burden of evidence production do affect care investments and deterrence when parties face probatory difficulties. We contrast our results to those put forth by Hay and Spier (1997) and Demougin and Fluet (2008), showing the relevance of legal presumptions on the social cost of accidents.

3 Legal presumptions and the robustness of care incentives

In this section, we consider the effects of alternative legal presumptions on the care incentives of a potential injurer (he) and a prospective victim (she) in the presence of probatory difficulties, in a simple negligence regime.[18] Negligence law provides a good example of the interdependence between evidence rules and substantive rules and how they affect parties' incentives. Under a negligence rule, liability hinges upon proof that the injurer's behavior was negligent. In some situations, the injurer may have better knowledge than his victim on whether he engaged in negligent behavior. Yet, when the victim bears the burden of proof, the victim still must prove her injurer's negligence. In other situations, the victim may have better information about her conduct, yet, under traditional evidence rules, when contributory

[17] Our paper is also related to Bernardo et al. (2000), which explored how legal presumptions can mediate between costly litigation and ex-anteincentives within corporate and commercial contexts. Our focus on accident law does not preclude the extension of our results to other fields of law. In company law, for example, the "business judgment rule" creates a strong presumption of care favoring defendants (i.e., officers and directors of corporations) who allegedly acted negligently. Similarly, in employment discrimination litigation (Title VII of the 1964 Civil Rights Act), the burden of evidence production can shift to the defendant if the plaintiff was a qualified, but rejected, applicant and a member of a historically oppressed group (*McDonell-Douglas v. Green*, 411 U.S. 792, 1973). For a review of these doctrines, see Hay and Spier (1997) and Bernardo et al. (2000).

[18] By symmetry, a similar analysis applies to study the effects of legal presumptions of contributory or comparative negligence, in the regimes of presumed joint negligence introduced by Article 2054 of the Italian Civil Code and by §17 of the German Traffic Act. For details, see Sect. 2.2.

negligence is involved, the injurer bears the burden of proving the victim's negligence. Satisfying the burden of proof while lacking information about the other party's conduct can adversely affect the care level incentives of the party without the burden.

Following the notation used in Hay and Spier (1997), let $p_H \in [0,1]$ and $p_L \in [0,1]$ denote the accident probability when the potential injurer acts either non-negligently or negligently, respectively; $k_I \in \{0, \bar{k}_I\}$ denote the injurer's care investment, with $\bar{k}_I > 0$ being the cost of the socially optimal care investment. The due-care level is assumed to be set at the socially optimal level, where the social objective is to implement high (i.e., socially optimal) care by minimizing the sum of precautionary costs and expected losses (Shavell, 1980, 1987). Our efficiency notion does not take the costs of presenting evidence into account. Let $j > 0$ denote the victim's loss from an accident. As in Hay and Spier (1997), we consider a binary care choice—i.e., either undertaking no care or socially optimal care—[19]where the social objective is to implement socially optimal care, i.e.,

$$\bar{k}_I < (p_L - p_H)j \tag{1}$$

Under a presumption of non-negligence (NN), the victim must prove the injurer's negligence at costs c_V. She can do so only when the injurer was actually negligent. Moreover, even if he was negligent, the victim may fail to prove it with probability $\alpha_{NN} \in [0,1]$. Since presenting evidence is costly, she will present it only if $c_V + \alpha_{NN} j < j$, i.e., only if

$$\alpha_{NN} < 1 - {}^{c_V}/_{j} \tag{2}$$

The injurer's objective function can be described as:

$$I_{NN} = \begin{cases} (1-\alpha_{NN})p_L j & \text{if } k_I = 0 \\ k_I & \text{if } k_I = \bar{k}_I \end{cases} \tag{3}$$

Under a presumption of non-negligence, the injurer chooses the negligent act $k_I = 0$ if

$$p_L(1-\alpha_{NN})\, j < \bar{k}_I. \tag{4}$$

and (2) is also met (see Lemma 3.1).

Lemma 3.1 *Under the presumption NN of non-negligence, the injurer chooses socially optimal care investments $k_I = \bar{k}_I$ if and only if*

[19] In the standard continuous care model, the potential injurer faces a continuous sequence of similar binary choices: to undertake socially optimal care investment $\bar{k}_I$ or to invest at a marginally lower level $\bar{k}_I - \epsilon$. Kim (2021) assumed continuous care levels, obtaining results similar to ours.

$$\alpha_{NN} < min\left[1 - \frac{c_V}{j},\ 1 - \frac{\bar{k}_I}{p_L j}\right]$$

Lemma 3.1 shows that the injurer is never liable when α_{NN} is large and, in this case, he has no incentives to invest in precaution. If, however, α_{NN} is small enough, then he has the incentive to invest because, in case of an accident, he is close to being fully liable.

Let us now consider the use of a presumption of negligence (N). In this case, the victim does not need to present evidence. Instead, the injurer is the one who needs to prove his non-negligence at costs $c_I > 0$. In the interest of clarity, let us begin by assuming that the defendant can prove his non-negligence only if he actually invested in due care, i.e., if he spent $k_I = \bar{k}_I$.[20] Moreover, even if he did so, he may fail to prove his non-negligence with probability $\beta_N \in [0, 1]$. In that case, he would bear full liability notwithstanding his undertaking due care. Since presenting evidence is costly, he will present it only if $c_I + \beta_N j < j$, i.e., if

$$\beta_N < 1 - {}^{c_I}/_{j} \tag{5}$$

which can only be satisfied when $c_I < j$. The injurer's objective function can be described as follows:

$$I_N = \begin{cases} p_L j & \text{if } k_I = 0 \\ \beta_N p_H j + p_H c_I + k_I & \text{if } k_I = \bar{k}_I \end{cases} \tag{6}$$

Under a presumption of negligence, the injurer chooses the non-negligent act $k_I = \bar{k}_I$ if

$$\bar{k}_I + p_H(\beta_N j + c_I) < p_L j. \tag{7}$$

and (5) is also met (see Lemma 3.2). Note that if $\bar{k}_I + p_H\, c_I < p_L\, j$, then values of β_N exist that satisfy both (5) and (7), with no error $\beta_N = 0$ being among them.

Lemma 3.2 *Under the presumption N of negligence, the injurer chooses socially optimal care investments $k_I = \bar{k}_I$ if and only if*

$$\textit{either } \beta_N < min\left[1 - \frac{c_I}{j}, \frac{p_L}{p_H} - \frac{c_I}{j} - \frac{\bar{k}_I}{p_H j}\right] \textit{ or } 1 - \frac{c_I}{j} < \beta_N.$$

Lemma 3.2 shows that, if β_N is sufficiently large, the regime N is close to strict liability and, under strict liability, the injurer has the incentive to invest in precaution. If β_N is sufficiently low, then he also has the incentive to invest because, in this case, he will not provide evidence of his non-negligence and so the regime N is again close to strict liability. Since we consider a unilateral accident model, strict liability is efficient.

[20] We relax this assumption later in this section, to discuss the possibility that injurers who invested in due care may be found negligent.

Overall, the analysis shows that, in the absence of probatory difficulties, $\alpha_{NN} = \beta_N = 0$, our results reconcile with the analysis of Hay and Spier (1997), where shifts in legal presumptions do not change the parties' care incentives. However, probatory difficulties can change the relative price of negligent versus non-negligent behavior, and their effects under the two legal presumptions are diametrically opposite, as shown in Fig. 1. As probatory difficulties increase, under presumptions of non-negligence, negligence rules degenerate into no liability rules; under presumptions of negligence, negligence rules consolidate into strict liability rules.

We can now extend our analysis introducing a probability $\delta_{NN} \in [0, 1]$ that the victim succeeds in proving the injurer's fault, notwithstanding his non-negligence under a presumption of non-negligence. Similarly, we can introduce a probability $\gamma_N \in [0, 1]$ that the injurer succeeds in proving his non-negligence, notwithstanding his negligence under a presumption of negligence.[21] Adjudication errors could in this way arise for two different reasons: with probabilities α_{NN} and β_N errors are made because the burdened party is unable to provide the necessary evidence; with probabilities δ_{NN} and γ_N errors are made because the burdened party is able to produce false evidence. The results derived above hold also in the presence of these latter errors, as long as the adjudication errors caused by insufficient evidence are more frequent than the errors caused by false evidence, i.e., $\alpha_{NN} > \delta_{NN}$ and $\beta_N > \gamma_N$. If parties could generate court errors by producing false evidence with greater probability, the effect of legal presumptions on the underlying negligence rule could possibly be reversed. A presumption of non-negligence would lead to a consolidation of the negligence rule into a strict liability rule when $\delta_{NN} > \alpha_{NN}$ (when the victim can easily provide false evidence of her injurer's negligence). Similarly, a presumption of negligence would lead to a degeneration of the negligence rule into a no liability rule when $\gamma_N > \beta_N$ (when the injurer can easily provide false evidence of his non-negligence).[22]

These results are summarized in Proposition 3.3 and Corollary 3.4.

[21] We could think of α_{NN} and γ_N as a Type I errors, and δ_{NN} and β_N as a Type II errors. Unlike false convictions and false acquittals in criminal law, adjudication errors in tort cases have zero-sum wealth effects. The main social cost of these errors is the dilution of the incentives created by the liability rule: both Type I errors (negligent individuals avoiding liability) and Type II errors (non-negligent individuals facing liability) contribute reducing the payoff wedge between non-negligent behavior and negligent behavior, diluting incentives. However, as discussed in this section, the relative magnitude of different types of error leads to different results under alternative legal presumptions.

[22] In real-life cases, the probability of adjudication errors due to false evidence is reduced by the adversarial discovery process. Under a presumption of non-negligence, the injurer has no burden of proof. However, an injurer who is falsely shown to be negligent has the opportunity to scrutinize the opponent's evidence (e.g., through cross-examination or expert testimony) and to produce contrary evidence to challenge his victim's proof. Likewise, under a presumption of negligence, a victim has no burden of proof. However, an injurer who falsely proves his non-negligence is likely to face the victim's production of contrary evidence. Production of false evidence triggers adversarial discovery, reducing the probability of this type of adjudication error.

Proposition 3.3 *Given Lemmas 3.1 and 3.2, when errors due to insufficient evidence are present and errors due to false evidence are sufficiently contained, a presumption of negligence against the injurer strengthens his care incentives.*

Corollary 3.4 *In the absence of discovery errors, the analysis of Hay and Spier (1997) holds: the choice between the two alternative legal presumptions leaves care incentives unchanged.*

Proof See Appendix A. □

In a hypothetical world of perfect evidence production, legal presumptions can be created to minimize truth-finding costs without altering incentives. As shown above, with probatory difficulties, legal presumptions have an effect on the allocation of liability and the parties' incentives. Changes in legal presumptions can have strengthening or weakening effects on liability rules. An ineffective rule of simple negligence can be strengthened by introducing a presumption of negligence against the injurer. An ineffective defense of contributory or comparative negligence can be strengthened by introducing a presumption of joint negligence when the injurer faces probatory difficulties.[23] In sum, rules of presumed negligence and presumed joint negligence prevent probatory difficulties from corroding the incentive effects of the applicable negligence regimes.

4 Discussion

When the determination of liability hinges upon a factual issue concerning the behavior of one party, the opposing party typically bears the burden of proving such behavior. This has conventionally been shown to generate optimal care incentives (Sanchirico, 2008), explaining the general application of a presumption of non-negligence. In this paper, we extend the theoretical framework proposed in Hay and Spier (1997) to account for discovery errors, and show that a presumption of non-negligence does not always provide optimal care incentives. We identify the conditions under which it is optimal to shift evidentiary burdens to insulate the parties' care incentives from evidentiary difficulties—by creating a presumption of negligence, which the injurer must affirmatively rebut.

Our results show some critical factors that should guide the optimal allocation of the burden of proof, explaining long-standing doctrines within the law of evidence, in addition to providing ways of improving them. In some cases, it is desirable to lend support to victims when it is unreasonably burdensome for them to satisfy their

[23] Rules of simple negligence can apply to situations of both unilateral and bilateral care. Indeed, simple negligence rules create optimal care level incentives for both victims and injurers in bilateral care situations. The main point for our analysis is that the effect of legal presumptions can only be seen on the person who bears the burden of proof, and whose liability (or compensation) hinges upon the proof of non-negligence or negligence, depending on the applicable legal presumption.

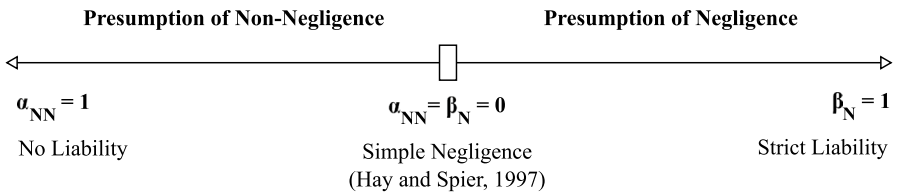

Fig. 1 Effect of legal presumptions under negligence

burden of proof. This happens, for instance, if the injury occurred in the injurer's sphere of risk. For example, in malpractice cases and products liability cases for defective products, prospective victims are more likely to fall short in proving the defendant's negligence because they do not readily have access to the information or knowledge of how the tort occurred to sufficiently establish the defendant's negligence. Other examples include accidents involving vulnerable road users, defined as "non-motorized road users, such as pedestrians and cyclists as well as motorcyclists and persons with disabilities or reduced mobility and orientation" (Regulation EC No 78/2009; Directive 2010/40/EU). For this user category—which is heterogeneous and disproportionately represented in statistics of road traffic injuries—the application of presumed liability likely reduces expected accident costs. In these cases, shifting the burden of proof onto defendants is based upon practical and procedural reasons, considerations of fairness, and deterrence objectives. Indeed, shifting the burden onto the defendant minimizes probatory difficulties for the victim, thus strengthening the robustness of the defendant's care investment incentives.

Most importantly, our comparative legal analysis of both modern and contemporary legal systems, suggests that there is nothing deterministic about the optimal choice of legal presumptions in the presence of discovery errors. By shifting the burden of proof, legal presumptions shift the probability of errors from one party to the other party. For example, a presumption in favor of defendants—i.e., the traditional presumption of non-negligence—gives them an advantage and leads to a margin of error in their favor (i.e., cases with insufficient evidence are by default decided in favor of defendants). The adoption of a presumption in favor of plaintiffs—i.e., a presumption of negligence—may create a mirror-image problem, giving them an evidentiary advantage that may lead to a margin of error in their favor. Despite this symmetry, our analysis shows that the social costs associated with these errors differ. When parties expect difficulties in the proof of negligence, legal presumptions shift care incentives from one party to another. When shielded by a presumption of non-negligence, injurers may strategically rely on their victims' difficulty in producing evidence against them. As probatory difficulties increase, a negligence rule gradually degenerates into a no liability rule. This effect may entirely dilute potential injurers' care incentives. The adoption of legal presumptions of negligence corrects this problem, since probatory difficulties shift the expected accident loss on injurers. As probatory difficulties increase, a negligence rule consolidates into a strict liability rule, inducing injurers to undertake efficient care. In environments characterized by high levels of probatory difficulties, the choice of presumptions of negligence can

thus be desirable to mitigate the diluting effects of discovery errors on injurers' care incentives.

The same reasoning applies with respect to the legal presumptions applicable to victims. When shielded by a presumption of non-negligence in their favor, prospective victims may strategically rely on their injurers' difficulty in producing evidence. This may dilute their care incentives. As probatory difficulties increase, the effects of a defense of contributory or comparative negligence may gradually disappear. The adoption of legal presumptions of *joint negligence*—like those adopted by Article 2054 of the Italian Civil Code and by §17 of German Road Traffic Act for traffic accidents—corrects this problem. Under a presumption of joint negligence, probatory difficulties shift the burden of proof back on victims. As probatory difficulties increase, prospective victims will fear being barred from receiving full compensation, inducing them to undertake efficient care. The choice of presumptions of joint negligence can thus be desirable to mitigate the effects that discovery errors may have on victims' care incentives. On both grounds, our analysis thus supports the legal solutions adopted by some jurisdictions in Europe.

Our results complement the existing literature on evidence law. In Sect. 3, we saw that care incentives can be strengthened by shifting evidentiary burdens. However, the cost and ability to produce evidence may differ between the parties. In our model the formulation of the injurer's incentive in (3) implicitly includes the cost of evidence production. If c_V is very high, there will be no production of evidence, and so there will be no incentive for the injurer. Formally, (4) holds only if (2) is also met (Lemma 3.1). Similarly for (6) and related analysis (Lemma 3.2). In this vein, we shall also mention that if costs of evidence production are very high, the neutrality result of Hay and Spier (1997) does not hold. Overall, this suggests that, from an aggregate welfare point of view, the relative cost of evidence production should be considered as a possible countervailing factor when using legal presumptions for the creation of care incentives. Previous contributions in the literature tackled this question from the point of view of procedural economy, starting from the premise that the burden of proof should be placed on the party who can provide reliable evidence at the lowest cost. One important formulation of this principle can be found in Hay (1997) and Hay and Spier (1997), who include the goal of accuracy in fact-finding, and conclude that the burden of proof should be placed on the party with better access to relevant information as a way to minimize the cost of obtaining accurate results. A subsequent incarnation of the "cheapest evidence-producer" principle can be found in Shin (1998) who formulated the argument that the burden of proof should be placed on the party with better knowledge regarding the relevant facts.

In this paper, we have shown that legal presumptions can be effectively used to improve the robustness of liability rules and to minimize the dilutive effect of probatory difficulties on the parties' care incentives. Presumptions of negligence can eliminate the problem present under negligence rules, when injurers can strategically rely on the hidden (unprovable) nature of their acts of negligence. Just like strict liability, presumptions of negligence incentivize the injurer to meet the due standard of care even when his acts cannot be observed by the victim. We suggest to properly account for the incentive effects of legal presumptions in the social cost calculation when applying the "cheapest-evidence-producer" criterion. The incentive-creation

effect of legal presumptions may at times come at the higher cost of evidence production triggered by the legal presumption. From an efficiency point of view, in those cases, a shift of the burden onto the injurer is still justified, when the social gains from the reduced discovery errors and the resulting reduction in the cost of accidents are higher than the increase in the cost of evidence production caused by the shift in the burden of proof.

5 Future research

Our analysis opens the discussion on legal presumptions in accident law and leaves the door open to several other lines of future research. To begin with, the extent to which legal presumptions actually affect care incentives is ultimately an empirical question, for which our theoretical predictions can serve as testable hypotheses. Comparative empirical research could shed valuable light on these important questions.

A natural extension of our model is considering the effect of legal presumptions on the parties' incentives to invest in private evidence and the resulting accuracy of adjudication. Under the rules of presumed negligence and presumed joint negligence adopted by some jurisdictions in Europe, parties benefit from investments in evidence technology, since such technology allows them to show a lack of negligence in their behavior. Future research, both theoretical and empirical, should examine whether jurisdictions that utilize presumptions of negligence in tort cases also exhibit higher production of evidence and discovery of evidence technology in court cases. Preliminary evidence examined by Frezza and Parisi (2021) and Parisi et al. (2022) supports this inference, showing that the presumptions of negligence adopted by some European countries have incentivized the adoption of private evidence technology—such as dashcams and other internal and external video recording devices on private and commercial cars. From a social point of view, greater use of evidence technology entails greater availability of information to the factfinders and a beneficial increase in the accuracy in adjudication. In turn, this may lead to strengthening care incentives.

Another important implication of our analysis relates to the effects of legal presumptions on the parties' choice of activity levels. In the absence of probatory difficulties, a simple negligence rule will create socially optimal activity levels for the victim. However, the injurer will engage in excessive activity levels, under both legal presumptions. This is because, the victim expects to bear the entire loss in the non-negligence equilibrium, while the injurer expects to avoid liability by undertaking due care, i.e., when the victim is the sole bearer of the "residual liability" (Dari-Mattiacci and Parisi, 2021). The introduction of probatory difficulties changes these results. The party who fails to satisfy the burden of proof bears the "residual liability." Under a presumption of negligence, an injurer who fails to prove his non-negligence will pay for the accident loss even if he acted non-negligently. Similarly, under a presumption of non-negligence, a victim will remain uncompensated for harm caused by her negligent injurer if she fails to meet the burden of proof. A presumption of negligence increases the cost of the injurer's activity because of his

potential inability to prove his due care. In contrast, a presumption of non-negligence increases the risk of uncompensated loss for the victim because of her potential inability to prove her injurer's negligence. As a result of these risks, the activity level of the party faced with the burden of proof may be reduced. The costs associated with the burden of proof can, in some way, be analogized to a tax imposed on the activity of the burdened party. Legal presumptions could thus be used to create a tax on activity levels to reduce the excessive activity level of the party who does not bear the accident loss in equilibrium.[24]

The focus of our analysis has been on the effects of alternative legal presumptions on care incentives. Legal presumptions of negligence or non-negligence only apply to the parties whose liability (or right to obtain compensation) hinges upon their negligent (or non-negligent) behavior. The model has been intentionally kept simple to allow a direct comparison with the results reached in the previous literature (especially, Hay & Spier, 1997). Extensions of our model should consider the possibility to utilize different combinations of legal presumptions to incentivize socially optimal precautions, when evidentiary problems are likely to occur and both parties can invest in precautions with different access to evidence technology.

Future work should also consider the possibility of more nuanced changes in the "burdens of proof," with mixed changes in the "burdens of production" and in the "burdens of persuasion." The problem of allocating legal presumptions is interconnected with the problem of defining the applicable standard of proof. Generally, the higher the standard of proof, the greater the effects of shifting the burden of proof from one person to another, and this marks the limits in the use of legal presumptions in other areas of law where standards of proof are systematically higher than simple preponderance of evidence (e.g., *in dubio pro reo* and other pro-defendant presumptions in other areas of law; Nicita & Rizzolli, 2014). Standards of proof could be modeled as endogenous to the error variables and/or to the relative ability of the parties to access evidence (e.g., a party who has direct access to evidence technology may be required to meet higher standards).

Litigation considerations further represent an important extension of our analysis. Reversing the burden of proof may affect the plaintiff's decision of whether to sue or not. As pointed out by Demougin and Fluet (2005), a marginal change of the legal presumption in favor of the defendant can lead to a higher litigation rate and even a higher win rate for plaintiffs in equilibrium. Future research can build upon our framework to explore litigation incentives and the possibility of pretrial settlement under alternative legal presumptions. We expect that the conditions we identified in this paper optimally guide the allocation of legal presumptions to minimize not only accident rates but also litigation rates, especially for wrongful claims.

[24] As per Shavell's activity level theorem, no negligence-based regime can incentivize socially optimal activity levels for both parties (Shavell, 1980). This proposition has become known in the law and economics literature as "Shavell's activity level theorem." See also, e.g., Carbonara et al. (2016); Dari-Mattiacci and Parisi (2021). The activity level tax created by legal presumptions in the presence of probatory difficulties could mitigate this problem.

Appendix A

Proof of Proposition 3.3 and Corollary 3.4 Suppose there are no probatory difficulties (i.e., $\alpha_{NN} \to 0$ and $\beta_N \to 0$; Hay & Spier, 1997). Under a presumption of non-negligence, the injurer chooses the non-negligent act if

$$k_I < p_L j \tag{A.1}$$

which is true anytime (1) holds. Under a presumption of negligence, the injurer chooses the non-negligent act if

$$k_I + p_H c_I < p_L j \tag{A.2}$$

which is always true. These findings reconcile with Hay and Spier (1997).

Let us introduce discovery errors. Under a presumption of non-negligence, the injurer chooses the non-negligent act if

$$k_I < \left(1 - \alpha_{NN}\right) p_L j \tag{A.3}$$

which holds if

$$\alpha_{NN} \leq {}^{p_H}/_{p_L} \tag{A.4}$$

Under a presumption of negligence, the injurer chooses the non-negligent act if (7) is satisfied. Given Lemmas 3.1 and 3.2 and (A.4), by comparing (A.3) and (7) the injurer has a greater incentive to act non-negligently under a presumption of negligence rather than under a presumption of non-negligence if

$$p_H c_I < \left(\alpha_{NN} p_L - \beta_N p_H\right) j \tag{A.5}$$

where $\alpha_{NN} p_L j$ is the victim's expected share of the loss which remains uncompensated notwithstanding the injurer's negligence, and $\beta_N p_H j$ is the victim's expected share of the loss notwithstanding her non-negligent behavior. As probatory difficulties increase, i.e, $\alpha_{NN} \to 1$ and $\beta_N \to 1$, Condition (A.3) tends towards never being satisfied and Condition (7) tends towards always being satisfied.

□

Acknowledgements A previous version of this paper was circulated under the title "Presumption of Negligence." Minnesota Legal Studies Research Paper No. 15-08, Available at SSRN: http://dx.doi.org/10.2139/ssrn.2577416. Two self-standing papers were created out of the original manuscript: one focusing on the effects of evidence rules on the adoption of evidence technology (Guerra & Parisi, 2022); and the current paper, analyzing the effects of legal presumptions on care incentives. We are indebted to Alain Marciano and the anonymous referees for their insightful and valuable comments. We thank Ronen Avraham, Emanuela Carbonara, Giuseppe Dari-Mattiacci, Samuel Ferey, Ryan Fitzgerald, Luigi Alberto Franzoni, Giampaolo Frezza, Julien Jacob, Jonathan Klick, Shmuel Leshem, Peter Lewisch, Marie Obidzinski, Daniel Pi, Ram Singh, Jane Stapleton, and Louis T. Visscher for helpful suggestions, and Eamonn Gallagher for editorial assistance.

Funding Open access funding provided by Alma Mater Studiorum - Università di Bologna within the CRUI-CARE Agreement.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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