Unrequested Benefits, Damages Assessment, and Information Acquisition

Zhiyong (John) Liu[*], Ronen Avraham[†], Yue Qiao[‡]

[*] Scott College of Business, and Networks Financial Institute, Indiana State University, 30 N. 7th St., Terre Haute, IN, 47809. Email: John.liu@indstate.edu.

[†] University of Texas (Austin) Law School, and Tel Aviv University, Buchmann Faculty of Law. Email: ravraham@utexas.edu.

[‡] School of Economics, and Williamson Center for Law, Economics, and Organization, Shandong University, China. Email: qiaoyue@sdu.edu.cn.

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Abstract

We investigate the interactions of the law's disallowance of recovery for unrequested benefits and an actor's incentives, at the ex ante stage, to acquire information about the harm or benefits potentially caused by his or her conduct. We analyze the impact of these interactions on the efficiency of two legal regimes: ex ante damages versus ex post damages. We show that ex post damages induce information acquisition, thus potentially leading to more efficient decision-making. However, under ex post damages, the existence of, and the prohibition of recovery for, the unrequested benefits distort the actor's incentives of whether to acquire information and whether to engage in the activity. Taking into account the tradeoff of these effects, we show that the relative efficiency of ex ante versus ex post damages depends on the size of potential unrequested benefits, and on how the ex ante damages are calculated. When the calculation of ex ante damages is based on the full distribution of potential impact that includes the unrequested benefits, the ranking of the regimes of damages assessment depends on the extent of unrequested benefits. The larger the potential unrequested benefits, the more likely ex ante damages outperform the more flexible ex post damages. In contrast, when the calculation of ex ante damages excludes the unrequested benefits, ex post damages are more efficient.

Keywords: Externalities, Unrequested Benefits, Damages Assessment, Actual Damages, Ex Ante Damages, Information Acquisition

JEL Classifications: K12, K13, D83, D86, D01

1. Introduction

Consider a house that has a backyard that slopes toward the house, which is not good for water channeling and especially troublesome during heavy rainfalls. To address the problem, the homeowner plans to build a small water channel to direct water away from the house. This project, however, will have an uncertain impact on the neighboring house which was built on lower ground and is even more susceptible to water damages. The project might be beneficial to the neighboring house and improve its

water channeling as a byproduct (positive externality, or *unrequested benefits* in legal parlance). However, on the other hand, the project is as likely to harm the neighboring house and exacerbate its risk of water damage (negative externality). It takes time and money to evaluate the impact before construction of the project, and the question becomes: Will the homeowner have an incentive to do the evaluation? In this paper, we study the information acquisition incentives created by various legal rules and their efficiency implications.

The homeowner has an incentive to collect information in advance about the exact harmful impact only if that can reduce his or her potential liability derived from construction of the project. Therefore, the damages regime that the court applies to this type of litigations naturally influences the homeowner's information acquisition decisions. In this study, we focus on the impact of the accuracy of damages assessment on parties' information acquisition incentives and the consequent economic efficiency, especially in circumstances that potentially involve positive externalities, as in the above example of the water-channeling project. As Kaplow (1994), and Kaplow and Shavell (1990, 1994) illustrate, the accuracy with which the court assesses damages has a significant impact on individuals' behavior and social welfare. There is a continuum of degrees of possible accuracy in legal adjudication and assessment. For simplicity, we focus on two particular methods of damages assessment --- ex ante damages and ex post damages. Under the former, the court measures damages from the ex ante perspective, i.e., the damages awarded equal the expectation that parties had at the ex ante stage about the potential harm, ignoring information about the actual level of harm that the plaintiff suffered ex post. In contrast, under ex post damages, the court evaluates damages from the ex post perspective, i.e., the level of damages awarded is based on what the plaintiff actually suffered.

It is straightforward to anticipate that under ex ante damages, the homeowner has no incentive to acquire information since in that case his or her expected liability does not vary with the actual level of harm. On the other hand, one would expect that the homeowner will have an incentive to get informed in advance under the regime of ex post damages that depend on the actual harm assessed at the ex post stage, given a reasonable cost of information acquisition. Therefore, in terms of informational incentives the ex post damages regime has an advantage over the ex ante regime, as ex post damages induce information acquisition, potentially leading to more informed and/or efficient decision-making. This informational advantage of ex post damages, however, might be counterbalanced by the existence of positive externalities (unrequested benefits), due to the legal reality that recovery of unrequested benefits is often not supported by courts. In our opening example, if the project were completed and subsequently proven

to have exacerbated the neighboring house's risk of water damage, the neighbor has an option to seek redress for the damages through the tort liability system. In contrast, if the completed project turns out to have mitigated the neighboring house's risk of water damage, and the homeowner who built the project wants to get the neighbor to share a portion of his or her costs, the law typically has very limited support for such claims of recovery for unrequested benefits that a plaintiff conferred. In other words, there is a built-in asymmetry in the law: although a party is liable for the harm that he or she caused under tort liability, the party's rights for recovery of unrequested benefits are quite limited under the law of restitution (Adler, 2008; Dari-Mattiacci, 2009). Naturally, the non-recoverability of unrequested benefits discourages information acquisition, especially when an activity potentially generates significant positive externalities, because under those circumstances part of the value of information acquisition is dissipated away. The interactions of information acquisition and the existence of unrequested benefits are the principal focus of our study. We demonstrate that the asymmetry in the law's treatment of negative vis-à-vis positive externalities has a significant impact on the parties' ex ante incentives to acquire information about the potential damages and liability and, hence, on the efficiency ranking of various legal regimes of damages assessment.

We further show that the method the court applies in the calculation of ex ante damages matters. When the calculation of ex ante damages excludes the unrequested benefits, i.e., when the ex ante damages award equals the expectation of the *truncated* distribution of harm conditional on the harm being positive, ex post damages dominate ex ante damages. This result is related not only to the informational incentives provided by ex post damages, but also to the distortion caused from such truncated calculation of damages. This distortion, first exposed by Avraham and Liu (2012), refers to the fact that the truncated damages induce a party, in his or her decision of whether to engage in an activity, to disregard the truncated portion of the distribution of potential effects of the activity, thus leading to a socially inefficient level of activities. The disallowance of recovery of unrequested benefits under ex post damages effectively truncates the distribution of damages that are recoverable through litigation. Hence, ex post damages suffer from the incentive distortion due to unrequested benefits. Ex ante damages, when the calculation of them excludes the unrequested benefits, are not immune from this distortion either. Hence, in this case, ex post damages, because of the better incentives for information acquisition they provided, are superior to ex ante damages, which induce no information acquisition.

In contrast, when the calculation of ex ante damages is based on the full, rather than truncated, distribution of damages, the ex ante damages are not subject to the incentive distortion described above.

In this case, the informational incentive advantage of ex post damages might be offset by their disadvantage in terms of incentive distortion in the actor's decision of whether to engage in the activity. Which regime of damages assessment --- ex ante or ex post damages --- dominates depends on the tradeoff of these two effects. When the potential unrequested benefits are small, the incentive distortion plaguing ex post damages due to non-recoverability of such unrequested benefits is also small, and, thus, ex post damages may still dominate ex ante damages. However, when the potential unrequested benefits are large, ex post damages suffer from large incentive distortion effect, and, thus, in this case, their informational incentives advantage might be more than offset by their negative incentive distortion effect, rendering ex post damages inferior to ex ante damages.

The rest of the article proceeds as follows: We review the related literature in Section 2, and then set up the model and analyze the first-best benchmark in Section 3. In Section 4, we compare the economic efficiency of ex ante vis-à-vis ex post damages, taking into account the parties' ex ante option of information acquisition and the legal prohibition of recovery for unrequested benefits. Finally, we conclude in Section 5.

2. Related Literature

In this section, we put our study into context by briefly reviewing three strands of related literature. The first strand concerns externalities and unrequested benefits; the second focuses on the accuracy of damages assessment; and the third concerns information acquisition incentives.

Externalities have been a research topic of long-lasting interest among economists. Pigou (1920) proposed the use of taxes and/or subsidies as policy instruments to control externalities. The challenge in this solution is that the regulator may not have access to the information required to compute the correct level of the Pigouvian tax. Nevertheless, Varian (1994) finds a class of simple two-stage compensation mechanisms to elicit information so as to achieve efficient resource allocation in environments that involve externalities. Coase (1960) negated the necessity of either the Pigouvian prescription[1] or liability for damages imposed by law to control externalities, contending that the market mechanism itself could

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[1] Coase (1960) observes the reciprocal structure of externalities (the imposing and affected parties of an externality jointly contributed to the occurrence and social welfare impact of the externality), thus a Pigouvian tax/subsidy imposed on one side is likely to lead to resource misallocation. For more detail, see Coase (1960). Baumol (1972), however, shows that levying a tax solely on the generator of the externality, leaving the affected parties neither compensated nor taxed, would be compatible with the Pareto-optimal resource allocation. Hence, Baumol (1972) defended the Pigouvian program as a means to solve the externality problem.

rectify the problem via private bargaining, given that the property rights are clearly defined and negotiation costs are low.

In reality, however, often, these two conditions for facilitating smooth Coasian bargaining are not satisfied. To overcome the inefficiency caused by externalities, certain external interventions other than government taxes and/or subsidies are needed. In this regard, legal rules are essential institutional mechanisms to treat externalities, which might explain why externalities have been explored extensively in legal scholarship as well. The majority of such literature is devoted to negative rather than positive externalities, including how to compensate injured victims in torts. Recently, however, some legal scholars (e.g., Ben-Shahar & Mikos (2005), Porat (2009), and Porat & Posner (2014)) studied legal treatments of positive externalities ("unrequested benefits") and their efficiency implications. Adler (2008) questions the efficiency grounds for expectation damages as a universal default remedy for breach of contract. He argues that ignoring negative damages in contracts[2] can distort the incentives for efficient breach, especially when the breaching party gains from performance though he or she privately learned that breach is socially efficient. Adler further observes that parties to a contract may use liquidated damages (LD) or specific performance (SP) clauses to remedy the potential adverse effect of the prohibition on negative damages, and, thus, courts should cease their frequent insistence on an expectation remedy as well as their disregard of LD or SP clauses. Avraham and Liu (2012) demonstrate that prohibition of negative damages in contract breach leads to distortion in the incentives to breach, thus rendering the fixed ex ante damages to be better than the fine-tuned ex post actual damages.

Dari-Mattiacci (2009) observes that a party is obliged to pay for the harm that he or she caused under tort liability but that the right to recover from whom he or she benefited is more limited under the law of restitution. The author explains this equilibrium asymmetry in law from four aspects: (i) it can potentially improve efficiency, (ii) this asymmetry in law allows the legal process to better discern parties' intention to bypass the market based on whether achieving a contractual agreement has high transaction costs[3], (iii) this asymmetry, on average, improves the law's role in providing incentives to take care, and (iv) this asymmetry can result in economizing the costs in production of evidence. Dari-Mattiacci also

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[2] Negative damages in contracts refers to the circumstances in which a non-breaching party turns out to prefer breach over performance of the contract. Under those circumstances, in pure economic sense, the non-breaching party who is thankful for the breach initiated from the breacher should pay a damages award to the breacher rather than the other way around that we often observe: the breaching party pays a damages award to the non-breaching party for the breach. However, in legal reality, the law typically prohibits such negative damages.

[3] If the transaction costs in contracting are low, the law would deem that the parties intentionally bypassed the market, and, hence, the right to recover should be limited so that the parties will be discouraged from bypassing the market in low-transaction-costs cases.

observes that other legal instruments such as qualifications in tort liability, intellectual property, and regulation may complement the law of restitution in treating positive externalities.

Kaplow (1994) studied optimal accuracy in adjudication, taking into account the costs of seeking accuracy in adjudication or assessment. Particularly related to our research is his study on the impact of ex post accuracy in adjudication on parties' incentives to acquire information at ex ante. Kaplow and Shavell (1994, 1996) found that enhancing accuracy in damages assessment can incentivize efficient precaution but that this effect hinges on the extent to which the injurers have knowledge of the harm that their behavior might cause before deciding on the precaution. Further, accuracy-oriented adjudication might motivate excessive efforts toward proof of damages. Kaplow and Shavell did not, however, consider unrequested benefits and their effect on information acquisition and efficiency.

There have been many studies that compare the efficiency of the ex ante versus ex post damages assessment. For example, Taurman and Bodington (1992) reviewed the ex ante versus ex post measures of firms' antitrust damages due to their competitors' wrongful conduct. Porat (2014) contended that the law should hold individuals whose behaviors are ex ante wrong to be liable, even if they are ex post right, on the grounds of both efficiency and justice. None of these authors, however, discussed unrequested benefits and their impact on the desirability of ex ante versus ex post damages assessment. Avraham and Liu (2012) showed that the ex post measure of damages can induce distortions in the incentives to file a lawsuit, thereby leading to an inefficient level of breach in contracts or to an inefficient level of activities in torts. The law's prohibition on negative damages[4] further reinforces this distortion that is embedded in ex post damages. These studies did not, however, consider the situations in which the individuals have an option to acquire information about potential risk and liability before they commit to their course of action. In this paper we address this gap.

Among the third strand of literature on information acquisition, Kaplow (1990) investigated how individuals' ex ante options to acquire information about the legality of their acts affect optimal sanction strategies. Shavell (1994) studied the incentives for information acquisition prior to sales under voluntary versus under mandatory disclosure. Shavell (1992) studied how various liability rules --- including strict

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[4] This prohibition is documented, e.g., by Adler (2008) and Dari-Mattiacci (2009), and it is partially based on the principle that a wrongdoer should not be compensated for his or her wrongdoing even though his or her actions might have conferred benefits on another party. By the popular Holmesian view (Holmes, 1897), however, in contract law, a promisor's obligation to perform does not extend beyond financial compensation (paying damages for breach). Thus, in contract law, a breaching party is not characterized as a wrongdoer (morally), rather, the breacher is merely exercising his or her option to exit the contract by paying damages. See Adler (2008) for a more detailed analysis.

liability and negligence --- affect parties' incentives to acquire information about risk and to exercise care, and their welfare implications. Bebchuk and Shavell (1999, 1991) explored the limited liability rule of *Hadley v. Baxendale* and its information-forcing effect, contending that the *Hadley v. Baxendale* rule[5] is more important for brief, routine, and informal transactions in which the information about buyers' valuation of the transaction is less likely to be specified in the contract but is important for sellers as a means to differentiate the precautions that they need to take for various transactions. Kim and Rhee (2006) studied the incentives for information acquisition created by various damage measures, arguing that liquidated damages --- due to the weak incentives that they provide for information acquisition --- are not efficient when acquiring information is socially optimal. None of these studies, however, considered the interactions between different assessments of damages (ex ante versus ex post assessment) and unrequested benefits and their impact on information acquisition incentives and social welfare, which is the focus of our study.

3. The Setting

3.1 The Model

A risk-neutral individual (the defendant), denoted as D, decides whether to engage in an activity that will accrue him or her a benefit $b \in \mathbb{R}_{++}$. b is common knowledge. With probability $p \in (0,1)$ the activity results in "harm", $h \in [-h_0, h_1]$ (where $h_0, h_1 > 0$), to a counter party (the potential plaintiff, who could be a contracting party or a potential victim of injury in torts), denoted as V. The term "harm" is in quotation marks here since h has an uncertain sign: The activity might impose harm to the counter party ($h > 0$, e.g., the defendant injures a victim or breaches a contract that would have been gainful to the plaintiff),[6] or it may confer benefits to the counter party ($h < 0$, e.g., the defendant breaches a contract that would have been a losing one for the plaintiff)[7]. When h is negative, we refer to it as *unrequested benefits*, following Porat (2009)'s terms. We assume h is randomly distributed on $[-h_0, h_1]$ according to a positive probability density $f(\cdot)$ and a cumulative distribution function $F(\cdot)$. The actual harm evaluated in ex post, h, is assumed to be verifiable to the court.[8]

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[5] This rule limits contract liability to an extent based on how much information the defendant has about the transaction.
[6] The impact of accuracy in damages assessment in this type of settings is analyzed by Kaplow and Shavell (1994, 1996), and Shavell (1992).
[7] In this case the potential plaintiff will not file a lawsuit. To correctly specify the group of potential victims who ultimately sue the defendant turns out to significantly affect the efficiency ranking of legal remedies. For a study of comparative efficiency of contract remedies that takes into account the aggrieved party's option to not sue, see Avraham and Liu (2012).
[8] So that the ex-post damages regime is readily enforceable, as is the ex-ante fixed damages regime.

The expected unrequested benefit is

(1) $\quad -\mathbb{E}(h^-) \equiv -F(0)\mathbb{E}(h|h \leq 0) = -\int_{-h_0}^{0} h dF(h);$

while the expected positive harm is

(2) $\quad \mathbb{E}(h^+) \equiv [1 - F(0)]\mathbb{E}(h|h > 0) = \int_{0}^{h_1} h dF(h).$

We denote the *potential relative benefits* of the activity as

(3) $\quad \hat{r}_B \equiv -\int_{-h_0}^{0} h dF(h)/\int_{0}^{h_1} h dF(h) = -\mathbb{E}(h^-)/\mathbb{E}(h^+).$

Obviously, $\hat{r}_B > 0$. The greater $\hat{r}_B$ is, the more potentially beneficial the activity is to V. Before the decision of whether to engage in the activity, D has a chance to learn about h.[9] The cost of the (optional) information acquisition is c, which is, for simplicity, assumed to be drawn from a uniform distribution on $(0, \bar{c}]$, where $\bar{c} \in (0, \infty)$. c's realization is revealed to D before he or she chooses whether to acquire information about h.

The probability of the harm/benefits incidence, p, is also a random variable whose realization is the defendant's private information that he or she learns before making the decision whether to acquire information about the harm and whether to engage in the activity. Other parties know only that p is uniformly distributed on $(0,1)$. To encompass the contingencies as broadly as possible and to focus on the interesting cases, we make the following assumption:

Assumption 1 $b < \mathbb{E}(h)$.

As will become apparent later, Assumption 1 implies that the activity is not always socially desirable and that D might or might not engage in the activity if he or she makes the decision after learning about h. Thus, acquiring information at ex ante can be valuable.

The sequence of the events is as follows:

a) The regime of damages assessment is determined;
b) Nature chooses c and p, and they are revealed to D;

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[9] For example, the extent of the resulting harm may depend on the population density of the potentially affected area (see Daughety and Reinganum, 2010), or it may depend on the preparedness or prevention efforts of potential victims. All of these factors may be unknown to the defendant before his or her information acquisition.

c) *D* decides whether to acquire information about the potential harm of the activity;

d) *D* decides whether to engage in the activity;

e) If *D* engaged in the activity and *V* suffered harm from it, *V* may file a lawsuit against *D*, and damages will be assessed according to the predetermined regime.

3.2 The First-Best Benchmark

We are interested in analyzing the effect of the different methods used in damages assessment, especially the ex ante versus ex post measurement of damages, on parties' information acquisition incentives and on the overall social welfare. Prior to doing this, it is helpful to lay out the first-best as a benchmark. Under the first-best, a welfare-maximizing social planner, initially informed only of (c, p), decides on information acquisition and on whether to engage in the activity. First, suppose that the social planner does not acquire information about harm. In this case, he or she will engage in the activity if $b > p\mathbb{E}(h)$, and not otherwise. The *relative riskiness threshold of activities from a social perspective* is defined as

(4) $\hat{p}^* \equiv b/\mathbb{E}(h)$.

In other words, a welfare-maximizing social planner will deem any activity with $p < \hat{p}^*$ as being relatively safe and will engage in it even if he or she is uninformed about the size of harm potentially caused by the activity. In contrast, activities with $p \geq \hat{p}^*$ will be deemed as relatively risky by an uninformed social planner, and, hence, he or she will refrain from engaging in those activities.

If the social planner acquired information about the potential harm in advance, whether the informed social planner engages in a relatively-safe activity (with $p < \hat{p}^* = b/\mathbb{E}(h)$) depends on the magnitude of h that he or she learned. There are three cases: (i) *Case 1*: $h \leq \mathbb{E}(h)$. In this case, $ph \leq p\mathbb{E}(h) < b$, therefore, both an informed and an uninformed social planner will engage in the activity. (ii) *Case 2*: $\mathbb{E}(h) < h \leq b/p$. In this case, $p\mathbb{E}(h) < ph \leq b$, therefore, both an informed and an uninformed social planner will engage in the activity. (iii) *Case 3*: $h > b/p$. Since in this case, $ph > b > p\mathbb{E}(h)$, an uninformed social planner will, but an informed social planner will not, engage in the activity. In sum, the information acquisition has an impact on the social planner's choice only in *Case 3* when $h > b/p$. Therefore, for relatively-safe activities ($p < \hat{p}^*$), the difference between the expected payoff of a social planner who decides to acquire information and that of a social planner who decides to not acquire information is

$$\Delta \pi_S = \int_{b/p}^{h_1}[0 - (b - ph)]dF(h) - c = \int_{b/p}^{h_1}(ph - b)dF(h) - c.$$

Similarly, when $p \geq \hat{p}^* = b/\mathbb{E}(h)$, an uninformed social planner will not engage in the activity. Whether an informed social planner will engage in the activity depends on the magnitude of h that he or she learned. There are three cases: (i) *Case 1*: $h < b/p$. In this case, $ph < b \leq p\mathbb{E}(h)$; therefore, an informed social planner will, but an uninformed social planner will not engage in the activity. (ii) *Case 2*: $b/p \leq h \leq \mathbb{E}(h)$. In this case, $b \leq ph \leq p\mathbb{E}(h)$, hence, neither an informed nor an uninformed social planner will engage in the activity. (iii) *Case 3*: $h > \mathbb{E}(h)$. In this case, $ph > p\mathbb{E}(h) \geq b$; therefore, neither an informed nor an uninformed social planner will engage in the activity. In sum, the information acquisition has an impact on the social planner's choice only in *Case 1* when $h < b/p$. Therefore, when $p \geq \hat{p}^*$, the difference between the expected payoff of an informed and of an uninformed social planner is

$$\Delta \pi_S = \int_{-h_0}^{b/p}(b - ph)dF(h) - c.$$

Define c_{social}^{p-} (defined for the case of $p < \hat{p}^*$) and c_{social}^{p+} (defined for the case of $p \geq \hat{p}^*$), respectively, as

(5) $\quad c_{social}^{p-} \equiv \int_{b/p}^{h_1}(ph - b)dF(h).$

(6) $\quad c_{social}^{p+} \equiv \int_{-h_0}^{b/p}(b - ph)dF(h).$

c_{social}^{p-} is the socially optimal threshold for the cost of information acquisition in the case when $p < \hat{p}^*$ (in this case, the social planner will engage in the activity had he or she not learned about h in advance). This represents the *expected social value of information acquisition on relatively-safe activities*, which is the net social loss that could have been avoided had the social planner learned that h is high and, thus (rightly), refrained from engaging in the activity under those contingencies. Similarly, c_{social}^{p+} is the socially optimal threshold for the cost of information acquisition in the case when $p \geq \hat{p}^*$ (in this case an uninformed social planner will not engage in the activity). c_{social}^{p+} represents the *expected social value of information acquisition on relatively-risky activities*, which is the net social benefits of the activity that should have been engaged in had the social planner collected information in advance and found that the harm is low relative to the benefits.

This proves Proposition 1 below, which describes the socially optimal incentives to acquire information.

Proposition 1 (*socially optimal information acquisition*) *When $p < \hat{p}^* = b/\mathbb{E}(h)$ it is socially optimal to acquire information about the potential harm if $c < c_{social}^{p-}$, and to not collect information otherwise. When $p \geq \hat{p}^*$ it is socially optimal to acquire information about the potential harm if $c < c_{social}^{p+}$, and to not collect information otherwise.*

4. Ex Ante versus Ex Post Damages with Information Acquisition: A Comparative Analysis

4.1 Fixed Ex-Ante Expected Damages

We will compare the information production incentives provided by and the welfare implications of the two methods used in the assessment of damages --- ex ante versus ex post measurement of damages. We start with the cases where the applicable damages regime is the fixed expected damages, under which the damages award does not adjust with the level of ex post harm, rather it equals the ex ante expectation of the potential harm. Under this regime, it clearly does not make sense for the defendant to exert effort to learn about h. We consider two variations to calculating ex ante damages. Under the first variation, courts exclude the positive externalities due to the legal prohibition on negative damages. In other words, under this variation of ex ante damages, the court requires a plaintiff to prove that he or she actually suffered positive harm to qualify for any damages. The awarded ex ante damages --- $\mathbb{E}(h^+)$ --- equal the expectation of the truncated distribution of damages. Thus, under this variation, the defendant will compare b with the expected liability --- $p\mathbb{E}(h^+)$ --- to decide whether to engage in the activity. When $b > p\mathbb{E}(h^+)$, or equivalently, when $p < b/\mathbb{E}(h^+)$, the defendant will engage in the activity, while when $p \geq b/\mathbb{E}(h^+)$, the defendant will not. We define $\hat{p}$ as the *relative riskiness threshold of activities from a private perspective*,

(7) $\quad \hat{p} \equiv b/\mathbb{E}(h^+).$

Accordingly, the expected social payoff under this variation of (truncated) fixed ex ante damages is:

(8) $\quad \hat{\pi}_{ED}^S = \int_0^{\hat{p}} [b - p\mathbb{E}(h)]dp.$

Under the second variation of ex ante damages, courts award ex ante damages based on the *full* distribution of potential damages, and, thus, are not affected by the currently prevailing legal prohibition on recovery for unrequested benefits. Conditional on a plaintiff's proof that the defendant's conduct had an impact on him or her, the defendant will be awarded the ex ante expected damages --- $\mathbb{E}(h)$.[10] Hence, under this variation, the defendant will engage in the activity when $b > p\mathbb{E}(h)$, or equivalently, when $p < \hat{p}^*$,[11] and will not engage in the activity otherwise. In other words, under (the full-distribution) fixed expected damages a defendant acts exactly in the same way as does an uninformed social planner. Therefore, the expected social payoff under the fixed expected damages is

(9) $\quad \pi_{ED}^S = \int_0^{\hat{p}^*} [b - p\mathbb{E}(h)]dp.$

4.2 Ex Post Actual Damages

Now we assume that the applicable damages regime is ex post actual damages. Under this regime, a plaintiff will be awarded damages equal to the ex post actual harm, given that the activity indeed caused positive harm to him or her, i.e., $h > 0$. It follows that the unrequested benefits ($h < 0$) caused by the defendant's action would be ignored and not redressed under the actual damages regime. In other words, when the defendant's action afforded positive externalities to the "victim," under the actual damages regime, the defendant is not entitled to any compensation and the plaintiff would not be liable for compensating for the unrequested benefits. This reflects the legal reality that, typically, the litigation system bars a party from recovering unrequested benefits that he or she afforded to another party.[12]

First, suppose that D does not acquire information about h. In this case, he or she will decide whether to engage in the activity on the basis of the expected damages. Because a counter party with $h \leq 0$ will not file a lawsuit under ex post damages, the defendant will compare b with the expected liability --- $p\mathbb{E}(h^+)$ --- to decide whether to engage in the activity. If $b > p\mathbb{E}(h^+)$, or equivalently, $p < \hat{p}$, he or she will go ahead, and, hence, his or her expected payoff under actual damages without information acquisition is $b - p\mathbb{E}(h^+)$. If $p \geq \hat{p}$, the defendant will not engage in the activity, resulting in a zero expected payoff. In sum, under ex post damages, an uninformed defendant will engage in the activity when $p < \hat{p}$ and not

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[10] In Section 4, we will compare the efficiency of ex post damages vis-à-vis the two types of ex ante damages illustrated above.
[11] Recall that $\hat{p}^*$, defined in equation (4), denotes the probability threshold that distinguishes whether an uninformed defendant will or will not engage in the activity upon observing the likelihood of the potential incidence.
[12] See Adler (2008), Dari-Mattiacci (2009), Porat (2009), Avraham and Liu (2012), Porat and Posner (2014), and Bar-Gil and Porat (2014) on the impact of the asymmetric legal treatment on unrequested benefits versus on uninvited harm.

otherwise. [13] Obviously, $\hat{p} = b/\mathbb{E}(h^+) < b/\mathbb{E}(h) = \hat{p}^*$. In other words, due to the existence of unrequested benefits and the law's prohibition of recovery from such benefits, under actual damages an uninformed defendant participates in the activities less frequently than does an uninformed social planner. [14]

Now suppose that D learned about h in advance (with a cost). In that case, he or she will decide whether to engage in the activity on the basis of his or her actual liability to potential victims should the harm occur. If $b > ph$, he or she will engage in the activity [15], otherwise, he or she will not. Therefore, given his or her information set $\{c, p\}$, the expected payoff of an informed defendant is [16]

$$F(b/p)b - p \int_0^{b/p} h dF(h) - c.$$

The question then becomes: Does the defendant have an incentive to acquire information about the potential harm at the ex-ante stage? He or she will decide by comparing his or her expected payoffs with information acquisition versus without, both of which depend on his or her private information about the realized values of c and p (a defendant of type (c, p)).

When $p < \hat{p} = b/\mathbb{E}(h^+)$, an uninformed defendant will engage in the activity. If a defendant learned about h in advance, whether the informed defendant will engage in the activity depends on the magnitude of h that he or she learned. There are three cases: (i) *Case 1*: $h \leq \mathbb{E}(h^+)$. In this case, $ph \leq p\mathbb{E}(h^+) < b$; therefore, both the informed and the uninformed defendant will engage in the activity. (ii) *Case 2*: $\mathbb{E}(h^+) < h \leq b/p$. In this case, $p\mathbb{E}(h^+) < ph \leq b$; again, both the informed and the uninformed defendants will engage in the activity. (iii) *Case 3*: $h > b/p$. Since in this case, $ph > b > p\mathbb{E}(h^+)$, an uninformed defendant will, but an informed defendant will not engage in the activity. In sum, information acquisition has an impact on the defendant's choice only in *Case 3* when $h > b/p$. Therefore, when $p < \hat{p}$, the difference between the expected payoff of a defendant of type (c, p) who decides to acquire information and that of a defendant who decides to not acquire information is

$$\Delta\pi_D = \int_{b/p}^{h_1} [0 - (b - ph)] dF(h) - c = \int_{b/p}^{h_1} (ph - b) dF(h) - c.$$

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[13] In other words, if $p < \hat{p}$, the activity is relatively safe from the ex-ante perspective and an uninformed defendant will engage in the activity. Otherwise, the activity is relatively risky from the ex-ante perspective and an uninformed defendant will choose to not engage in the activity.

[14] For the case of $\hat{p} < p < \hat{p}^*$, an uninformed social planner will, but an uninformed defendant will not engage in the activity.

[15] Notice that if $h \leq 0$, then this always holds and D will engage in the activity.

[16] Recall that the defendant is barred from compensation for unrequested benefits.

Similarly, when $p \geq \hat{p} = b/\mathbb{E}(h^+)$, an uninformed defendant will not engage in the activity. Whether an informed defendant engages in the activity depends on the magnitude of h that he or she learned. There are three cases: (i) *Case 1*: $h < b/p$. In this case, $ph < b \leq p\mathbb{E}(h^+)$; therefore, an informed defendant will, but an uninformed defendant will not engage in the activity. (ii) *Case 2*: $b/p \leq h < \mathbb{E}(h^+)$. In this case, $b \leq ph < p\mathbb{E}(h^+)$; hence, neither the informed nor the uninformed defendant will engage in the activity. (iii) *Case 3*: $h > \mathbb{E}(h^+)$. In this case, $ph > p\mathbb{E}(h^+) \geq b$; thus, neither the informed nor the uninformed defendant will engage in the activity. In sum, information acquisition has an impact on the defendant's choice only in *Case 1* when $h < b/p$. Therefore, when $p \geq \hat{p}$, the difference between the expected payoff of a defendant of type (c, p) who decides to acquire information and that of a defendant who decides to not acquire information is

$$\Delta\pi_D = F(0)b + \int_0^{b/p}(b - ph)dF(h) - c.$$

We define the thresholds of the cost of information acquisition --- c_{AD}^{p-} (defined for the case of $p < \hat{p}$) and c_{AD}^{p+} (defined for the case of $p \geq \hat{p}$), respectively, --- as follows:

(10) $c_{AD}^{p-} \equiv \int_{b/p}^{h_1}(ph - b)dF(h).$

(11) $c_{AD}^{p+} \equiv F(0)b + \int_0^{b/p}(b - ph)dF(h).$

c_{AD}^{p-} is the defendant's optimal threshold for the cost of information acquisition in the case when $p < \hat{p}$ (in this case an uninformed defendant will engage in the activity). It represents *the defendant's expected value of information acquisition on relatively-safe activities*,[17] which is the liability loss that the defendant could have avoided by learning that h is greater than the optimal stopping threshold b/p and, thus, (rightly) refraining from engaging in the activity under those contingencies.[18] Similarly, c_{AD}^{p+} is the threshold cost of information acquisition in the case when $p \geq \hat{p}$ (in this case an uninformed defendant will not engage in the activity). c_{AD}^{p+} also represents *the defendant's expected value of information acquisition for relatively-risky activities*, namely, the net benefit of the activities that should have been engaged in had

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[17] As defined before, by a "relatively-safe" activity we mean an activity with $p < \hat{p}$, i.e., the probability of incidence is relatively low, but the consequence of the activity is uncertain.

[18] Committing the act under those high-harm contingencies ($h > b/p$) would result in a (net) liability loss of $ph - b$. Acquiring information beforehand would result in the defendant's avoidance of this liability loss by not engaging in the activity.

the defendant acquired information in advance and found that the potential harm was low. This proves Proposition 2 below.

Proposition 2 (*private incentives of information acquisition under actual damages*) *Given the actual damages regime, when $p < \hat{p}$ the defendant will acquire information about the potential harm of the activity if $c < c_{AD}^{p-}$, and not collect information otherwise. When $p \geq \hat{p}$ the defendant will acquire information about the potential harm of the activity if $c < c_{AD}^{p+}$, and not collect information otherwise.*

Remark: The value of information acquisition to the defendant is embodied in two scenarios: The first is one in which the defendant's gain from engaging in the activity is relatively high with regard to the expected liability, i.e., when $b > p\mathbb{E}(h^+)$, or equivalently, when $p < \hat{p}$. In this case, an uninformed defendant will engage in the activity, while acquiring information will deter him or her from engaging in those activities that he or she discovered to have a high level of potential harm ($h > b/p$), thereby avoiding the liability loss under those high-harm contingencies. The second scenario is one in which the likelihood of potential harm is relatively high, i.e., when $p \geq \hat{p}$. In such cases, an uninformed defendant will not engage in the activity, while acquiring information will encourage the defendant to engage in those activities that he or she discovered to have a low level of potential harm ($h < b/p$), thus reaping the benefits that would have been foregone had he or she not acquired information in advance. When the cost of acquiring information is lower than the informational value to the defendant in the respective scenarios, he or she will choose to acquire information at the ex ante stage.

Corollary 1 below specifies the upper limits for those thresholds of the cost of information acquisition.

Corollary 1 (*caps for the threshold costs of information acquisition*) $c_{AD}^{p-} < b \int_{\mathbb{E}(h^+)}^{h_1} \left(\frac{h}{\mathbb{E}(h^+)} - 1 \right) dF(h)$ and $c_{AD}^{p+} \leq b \left[F(0) + \int_{0}^{\mathbb{E}(h^+)} \left(1 - \frac{h}{\mathbb{E}(h^+)} \right) dF(h) \right]$.

Proof: In the Appendix. ∎

Together, Proposition 2 and Corollary 1 imply the following two corollaries:

Corollary 2 *Under actual damages, if $p < b/\mathbb{E}(h^+)$ and $c > b \int_{\mathbb{E}(h^+)}^{h_1} \left(\frac{h}{\mathbb{E}(h^+)} - 1 \right) dF(h)$, the defendant will choose to engage in the activity without information acquisition. If $p \geq b/\mathbb{E}(h^+)$ and*

$c > b\left[F(0) + \int_0^{\mathbb{E}(h^+)}\left(1 - \frac{h}{\mathbb{E}(h^+)}\right)dF(h)\right]$, *the defendant will choose to not acquire information and to not engage in the activity.*

Corollary 3 *Under actual damages, if* $\int_0^{h_1}\frac{h}{\mathbb{E}(h^+)}dF(h) \leq 1$ *and* $c > b\left[F(0) + \int_0^{\mathbb{E}(h^+)}\left(1 - \frac{h}{\mathbb{E}(h^+)}\right)dF(h)\right]$, *a defendant will never acquire information, regardless of what the value of p is.*

Proof: In the Appendix. ∎

By comparing the defendant's incentives to acquire information with the first-best benchmark, we have the following proposition.

Proposition 3 (*information production incentives under actual damages relative to the first best*) *Given the actual damages regime, the following hold:*

(i) *When there are no unrequested benefits, the defendant has socially optimal incentives for information production.*

(ii) *Given that there are positive potential unrequested benefits, when $p < \hat{p}$, the defendant's information production incentives are socially optimal. When $p \geq \hat{p}$, the defendant under-produces risk information. Further, when $p \geq \hat{p}^*$, with a probability of at least $\frac{b}{\bar{c}}\frac{\hat{r}_B}{1-\hat{r}_B}$ the defendant will not choose to acquire information before committing the act, but a social planner will.*

(iii) *Given that there are positive potential unrequested benefits, the higher the potential relative benefits of the act, or the higher the probability of incidence, or the larger magnitude of the potential unrequested benefits, the more severe the problem of weak incentives of information production is.*

Proof: In the Appendix. ∎

Remarks: (a) When there are no unrequested benefits, the private and the social payoffs coincide with each other, and the defendant's information production is socially optimal.

(b) When an activity generates sufficient benefits so as to incentivize an uninformed defendant to engage in it, the value of risk information concentrates on certain high-harm contingencies, whereby an

informed defendant would not engage in the activity to avoid the liability. On the right tail of the harm distribution the private and social payoffs coincide with each other, and this leads to the efficient result of information production. In contrast, when an activity accrues such small benefits that an uninformed defendant would not engage in it, the value of risk information concentrates on certain low-or-even-negative-harm states (i.e., on the left tail of the harm distribution), whereby an informed defendant would engage in the activity because, even though the benefits accruing to the defendant are small, the harm is even lower, rendering the activity worthwhile to pursue. On the left tail of the harm distribution, however, the private payoff is lower than the social payoff because the defendant is barred from collecting compensation for unrequested benefits. Therefore, in these cases, from the society's perspective, the defendant's incentives of information production are not strong enough. An illustration is depicted in Figure 1 below.
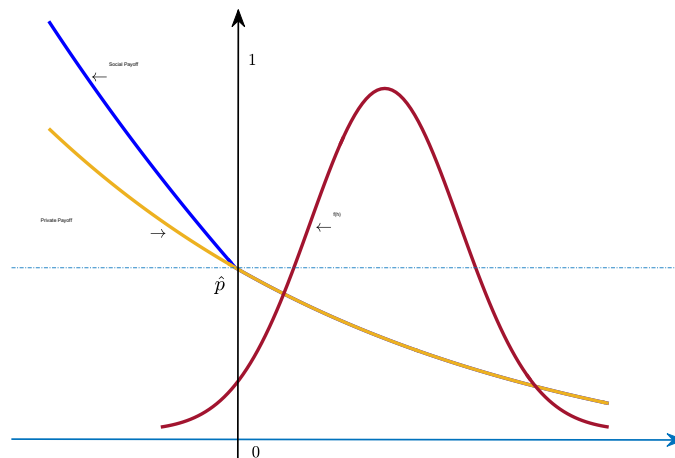
Figure 1 A graphical illustration of the distributions of potential harm,

the social payoff, and the defendant's private payoff

(c) The under-provision of risk information occurs only on the left tail of the harm distribution, where there exist unrequested benefits. Therefore, the higher the probability of the incidence or the larger the size of the unrequested benefits, the more severe the problem of under-provision of risk information will become.

Comparative Statics

From Equations (5), (6), (9), and (10), we can study how the threshold values of the information acquisition costs change in response to changes in exogenous variables. The results are summarized in Corollary A.1 in the appendix, and we discuss the comparative statics analyses below:

Remarks: (a) For activities with relatively low benefits to the defendant, or, equivalently, for relatively risky activities (with p greater than the relative riskiness threshold from a private perspective), we have explained that the defendant is under-incentivized to acquire risk information. One particular scenario occurs when the private benefits that he or she derives from the activity approach zero, and the defendant never wants to acquire information about harm. In contrast, under this scenario, a welfare-maximizing social planner sometimes still wants to learn about the consequence of the activity because it might generate significant unrequested benefits to others.

(b) In the relatively-safe-activity zone, as discussed, the value of information lies in the high-harm contingencies under which an informed defendant will choose to not engage in the activity to avoid the liability. When the likelihood of incidence gets higher, this informational value is higher, providing more powerful incentives for the defendant to acquire information ex ante. Similarly, since the informational value in this case is that it prevents a defendant from engaging in the activity when the harm is high, this value is higher when the private benefits that the defendant can derive from the activity become smaller or when the harm imposed on potential victims is greater, because it is more worthwhile to stop the defendant from engaging in the activity in those situations. Because the informational value lies on the right tail of the harm distribution in this case, the extent of unrequested benefits, which are located at the left tail of the harm distribution, does not have an impact on the information production incentives. Similar remarks for the relatively risky activities from a social perspective can be made.

Social Welfare under Actual Damages

From Proposition 2 we know the expected social payoff under ex post actual damages is

$$(12) \quad \pi_{AD}^S = \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)} \left[\int_{-h_0}^{b/p} (b - ph) dF(h) - c \right] \frac{1}{\bar{c}} dc + \int_{c_{AD}^{p-}(p)}^{\bar{c}} \int_{-h_0}^{h_1} (b - ph) dF(h) \frac{1}{\bar{c}} dc \right\} dp$$

$$+ \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[\int_{-h_0}^{b/p} (b - ph) dF(h) - c \right] \frac{1}{\bar{c}} dc dp.$$

The first integral over p (over the interval $(0, \hat{p})$) in the right-hand-side of equation (12) is the expected social payoff for the relatively-safe activities, for which, if $c < c_{AD}^{p-}$, a defendant will figure out the actual

harm of a potential incidence and consequentially only engage in the activity when $h < b/p$. This constitutes the first component of the integral over p. If $c \geq c_{AD}^{p-}$, the defendant will not acquire information and will engage in the activity, as it is relatively safe ($p < \hat{p}$). This constitutes the second component of the integral over p. The last integral over p (over the interval $(\hat{p}, 1)$) is the expected social payoff for the relatively-risky activities, for which if $c < c_{AD}^{p+}$, a defendant will acquire information and engage in the activity only when $h < b/p$. If $c \geq c_{AD}^{p+}$ the defendant will not acquire information and will not engage in the activity, as it is relatively risky ($p \geq \hat{p}$).

4.3 Comparison of the Two Damages Regimes

4.3.1 Ex Post Damages versus Truncated Ex Ante Damages

Using equations (8) and (12), we can rank the two damages regimes --- ex post damages and the truncated ex ante damages --- by comparing the expected social surplus to which they lead. We summarize this in the following proposition.

Proposition 4 *(ranking of the two damages regimes) With unrequested benefits and the option of information acquisition, ex post actual damages perform better than do fixed ex ante damages that are computed based on the positive-harm portion of the distribution of potential damages. The larger the magnitude of potential unrequested benefits, or the less costly it is to acquire information, the larger this performance gap between the two damages regimes will be.*

Proof: In the Appendix. ∎

Remarks: Considering the legal prohibition on negative damages, the (truncated) fixed ex ante damages lead the defendant to behave like an uninformed defendant will do under actual damages: engaging in all relatively-safe activities, and not engaging in any relatively-risky activities.

When the calculation of ex ante damages excludes the unrequested benefits, the ex ante damages are also plagued with the incentives distortion problem described above (only parties with positive harm will file a lawsuit, thus the defendant does not get to internalize the positive benefits that the activity may confer on a potential plaintiff, and, thereby, will not engage in those activities that can be socially beneficial). Further, the insensitivity of ex ante damages to ex post information leads to a chilling effect on the incentives for information acquisition, implying that ex ante damages have an informational disadvantage compared to ex post damages. These two effects work jointly to result in the superiority of

ex post damages over ex ante damages when there is an opportunity of information acquisition before the party commits to an action.

4.3.2 Ex Post Damages versus Full-Distribution Ex Ante Damages

Using equations (9) and (12), we can rank the two damages regimes --- ex post damages and the full-distribution ex ante damages --- by comparing the expected social surplus to which they lead. We define a threshold value of the potential relative benefits as follows:

$$(13) \quad \bar{r}_B \equiv \frac{\mathbb{E}(h)}{b^2} \int_0^{\hat{p}} \left[\int_0^{c_{AD}^{p-}(p)} \left(c_{AD}^{p-}(p) - c \right) \frac{1}{\bar{c}} dc \right] dp + \frac{\mathbb{E}(h)}{b^2} \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[c_{AD}^{p+}(p) - c \right] \frac{1}{\bar{c}} dc dp$$

$$+ \frac{\mathbb{E}(h)}{b^2} \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \int_{-h_0}^0 (-ph) dF(h) \frac{1}{\bar{c}} dc dp + \left[\frac{\mathbb{E}(h)}{b} \right]^2 \int_{\hat{p}}^{\hat{p}^*} p \, dp.$$

We have the following proposition.

Proposition 5 *(ranking of the two damages regimes) When the potential relative benefits is large, specifically, when $\hat{r}_B \geq \bar{r}_B$, the ex post damages is inferior to the full-distribution ex ante damages $(\pi_{AD}^S \leq \pi_{ED}^S)$; otherwise, the ex post damages perform better $(\pi_{AD}^S > \pi_{ED}^S)$.*

Proof: In the Appendix. ∎

<u>*Remarks:*</u> Under fixed ex ante damages, the defendant has no incentive to acquire information. In contrast, actual damages motivate a defendant to acquire information when the cost of information production is low, so that the defendant, on the one hand, refrains from engaging in those activities that were perceived ex ante as relatively-safe but for which he or she finds that the potential harm from the activities is actually high; and, on the other hand, chooses to engage in the activities that were perceived ex ante as relatively-risky yet for which he or she finds the potential harm from those activities to be low. In other words, the information space is further partitioned under actual damages, and this enhances efficiency, because some inefficient activities are cut off and some socially desirable activities are undertaken, all thanks to the information acquisition incentivized by the ex post damages.

The legal prohibition of recovering unrequested benefits from recipients, however, distorts the information production incentives under actual damages. Proposition 3 indicates that the higher the potential relative benefits, the more severe this problem of undermined incentives of information production is. Proposition 5 further explicates the influence of unrequested benefits on the efficiency of

damage regimes. When the potential unrequested benefits are so significant that they substantially distort the incentives to acquire information, this will leave actual damages inferior to the full-distribution fixed ex ante damages. *In this case, the unrequested-benefits-caused distortion negates the informational incentive advantage of actual damages over the ex ante damages*. Intuitively, the more unrequested benefits that the activity could generate, the less important the pre-activity information production becomes to the defendant due to the disallowance of negative damages, and, thus, the more likely ex post damages are to lose their information-producing advantage and become inferior to ex ante damages.

This result is different from what is seen in the literature. For example, Liu and Avraham (2012) proved, in a contract setting, that ex ante fixed damages are superior to ex post actual damages due to the distortion on the incentives to breach caused by ex post damages. Similarly, Porat (2014) argued that liability should be imposed on behaviors that are ex-post reasonable but ex-ante negligent because an ex post liability rule induces injurers to consider only partial risk consequences of their behavior when making decisions. In other words, ex post rules lead to under-deterrence.

We agree with their rationales. Nonetheless, when there is a chance of costly information acquisition before the activity, ex ante damages, by their rigidness, do not encourage the parties to acquire information in advance, thus ridding themselves of an opportunity to cut off some inefficient activities that should not have been engaged in and an opportunity to engage in some activities that were perceived ex ante not worthwhile to undertake but that, in actuality, turn out to be socially desirable had the defendant acquired information in advance. In comparison, ex post actual damages, by their differentiation of realized damages, reward information acquisition, through which some inefficient activities are avoided and some missed efficient activities are undertaken. Therefore, on the one hand, rigid ex ante damages avoid the distortionary effect in regard to the selective litigation over harm under ex post damages but, on the other hand, also stifle efficient information acquisition incentives. These two effects, upon which the ranking of the two damages regimes depends, balance each other out.

5. Concluding Remarks

We investigate the interactions of the law's disallowance of recovery for unrequested benefits and the option of information acquisition at the ex ante stage, and analyze their impact on the efficiency of ex ante damages vis-à-vis ex post damages. We find that when the calculation of ex ante damages is based on the full distribution of potential damages that include the unrequested benefits, the ranking of the regimes of damages assessment depends on the extent of unrequested benefits. The larger the potential

unrequested benefits, the more likely ex ante damages outperform the more flexible ex post damages. In contrast, when the calculation of ex ante damages excludes the unrequested benefits, ex post damages perform better than do ex ante damages.

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Appendix

A.1 Proof of Corollary 1

Proof: $c_{AD}^{p-}(p)$ is defined for $p < \hat{p} \equiv b/\mathbb{E}(h^+)$. From equation (10), we know $\partial c_{AD}^{p-}/\partial p = \int_{b/p}^{h_1} h dF(h) > 0$. Therefore,

$$c_{AD}^{p-} \equiv c_{AD}^{p-}(p)\big|_{p<b/\mathbb{E}(h^+)} < c_{AD}^{p-}(p)\big|_{p=b/\mathbb{E}(h^+)} = b\int_{\mathbb{E}(h^+)}^{h_1}\left(\frac{h}{\mathbb{E}(h^+)}-1\right)dF(h).$$

Similarly, $c_{AD}^{p+}(p)$ is defined for $p \geq \hat{p} \equiv b/\mathbb{E}(h^+)$. From equation (11), we know $\partial c_{AD}^{p+}/\partial p = -\int_0^{b/p} h dF(h) < 0$. Therefore,

$$c_{AD}^{p+} \equiv c_{AD}^{p+}(p)\big|_{p\geq b/\mathbb{E}(h^+)} \leq c_{AD}^{p+}(p)\big|_{p=b/\mathbb{E}(h^+)} = b\left[F(0) + \int_0^{\mathbb{E}(h^+)}\left(1-\frac{h}{\mathbb{E}(h^+)}\right)dF(h)\right]. \quad \blacksquare$$

A.2 Proof of Corollary 3

Proof: $b\int_{\mathbb{E}(h^+)}^{h_1}\left(\frac{h}{\mathbb{E}(h^+)}-1\right)dF(h) - b\left[F(0) + \int_0^{\mathbb{E}(h^+)}\left(1-\frac{h}{\mathbb{E}(h^+)}\right)dF(h)\right]$

$= b\int_{\mathbb{E}(h^+)}^{h_1}\frac{h}{\mathbb{E}(h^+)}dF(h) - b[1-F(\mathbb{E}(h^+))] - b\left[F(\mathbb{E}(h^+)) - \int_0^{\mathbb{E}(h^+)}\frac{h}{\mathbb{E}(h^+)}dF(h)\right]$

$= b\int_{\mathbb{E}(h^+)}^{h_1}\frac{h}{\mathbb{E}(h^+)}dF(h) - b + b\int_0^{\mathbb{E}(h^+)}\frac{h}{\mathbb{E}(h^+)}dF(h)$

$= b\left[\int_0^{h_1}\frac{h}{\mathbb{E}(h^+)}dF(h) - 1\right].$

Therefore, $\int_0^{h_1}\frac{h}{\mathbb{E}(h^+)}dF(h) \leq 1$ implies that $b\left[F(0) + \int_0^{\mathbb{E}(h^+)}\left(1-\frac{h}{\mathbb{E}(h^+)}\right)dF(h)\right] \geq b\int_{\mathbb{E}(h^+)}^{h_1}\left(\frac{h}{\mathbb{E}(h^+)}-1\right)dF(h)$. Then by Corollary 1,

$c > b\left[F(0) + \int_0^{\mathbb{E}(h^+)}\left(1-\frac{h}{\mathbb{E}(h^+)}\right)dF(h)\right]$ implies that $c > \max\left(c_{AD}^{p-}(p), c_{AD}^{p+}(p)\right)$, for any p. $\quad \blacksquare$

A.3 Proof of Proposition 3

Proof: (i) When there are no unrequested benefits, $h_0 = 0$. This implies that $\mathbb{E}(h^+) = \mathbb{E}(h)$, $\hat{p} = \hat{p}^*$, and $c_{social}^{p+}(p) = c_{AD}^{p+}(p)$. Since we also have $c_{social}^{p-}(p) = c_{AD}^{p-}(p)$, by Propositions 1 and 2, the defendant has a socially optimal incentive for information acquisition.

(ii) With positive potential unrequested benefits, $h_0 > 0$. This implies that $\hat{p} \equiv b/\mathbb{E}(h^+) < b/\mathbb{E}(h) \equiv \hat{p}^*$. There are three cases: (ii-a) When $p < \hat{p}$, since we have $c_{social}^{p-}(p) = c_{AD}^{p-}(p)$, by Propositions 1 and 2, the defendant's information production incentive is socially optimal. (ii-b) When $\hat{p} \leq p < \hat{p}^*$, $c_{social}^{p-} - c_{AD}^{p+} = \int_{b/p}^{h_1}(ph-b)dF(h) - F(0)b - \int_0^{b/p}(b-ph)dF(h) = p\mathbb{E}(h^+) - b = (p-\hat{p})\mathbb{E}(h^+) \geq 0$. Therefore, the defendant (weakly) under-produces risk information. (ii-c) When $p \geq \hat{p}^*$, $\Delta c^{p+} \equiv c_{social}^{p+}(p) - c_{AD}^{p+}(p) = \int_{-h_0}^{b/p}(b-ph)dF(h) - F(0)b - \int_0^{b/p}(b-ph)hdF(h) = -p\int_{-h_0}^0 h dF(h) > 0$ given $h_0 > 0$. Therefore, the defendant underinvests in information acquisition. When $p \geq \hat{p}^*$, with a probability of $c_{AD}^{p+}/\bar{c}$, the defendant will acquire information, while a social planner will acquire

information with a probability of $c_{social}^{p+}/\bar{c}$. $\Delta c^{p+} = -p \int_{-h_0}^{0} h dF(h) \geq -\hat{p}^* \int_{-h_0}^{0} h dF(h) =$
$-b \int_{-h_0}^{0} h dF(h) / \int_{-h_0}^{h_1} h dF(h) = b \frac{\hat{r}_B}{1-\hat{r}_B} \cdot (c_{social}^{p+}/\bar{c}) - (c_{AD}^{p+}/\bar{c}) = \Delta c^{p+}/\bar{c} \geq \frac{b}{\bar{c}} \frac{\hat{r}_B}{1-\hat{r}_B}$.

(iii) Given $h_0 > 0$, $(c_{social}^{p+}/\bar{c}) - (c_{AD}^{p+}/\bar{c}) = \Delta c^{p+}/\bar{c} \geq \frac{b}{\bar{c}} \frac{\hat{r}_B}{1-\hat{r}_B}$. $\quad \partial\left(\frac{\hat{r}_B}{1-\hat{r}_B}\right)/\partial\hat{r}_B = \frac{1}{(1-\hat{r}_B)^2} > 0$.

$\partial\Delta c^{p+}/\partial p = \int_{-h_0}^{0} h dF(h) < 0$; $\partial\Delta c^{p+}/\partial h_0 = -p h_0 f(-h_0) < 0$. $\quad\blacksquare$

A.4 Corollary A.1 and Its Proof

Corollary A.1 *(comparative statics) Under actual damages, the following hold:*

(i) *A defendant acquires information about the potential harm at ex ante stage less frequently than the socially optimal level when the defendant's gain from engaging in the activity is smaller than the expected impact on the plaintiff, i.e., $b \leq p\mathbb{E}(h)$. Particularly, when this gain approaches zero the defendant will never invest in information production, while a social planner would.*

(ii) *For activities that are relatively-safe from a private perspective ($p < \hat{p}$, where the defendant's information production incentives are socially optimal) a defendant is more motivated to acquire information about the extent of potential harm when (a) the probability of incidence in the activity gets higher, and this effect is stronger as the riskiness of the activity further increases; or (b) the activity is less beneficial to the defendant him- or herself, although this effect is marginally diminishing as the benefits to the defendant further decrease; or (c) the harm the activity might impose upon a victim is greater. The extent of unrequested benefits generated by the activity has no impact on the defendant's information acquisition incentives in the relatively-safe-activities zone.*

(iii) *For activities that are relatively-risky from a private perspective ($p \geq \hat{p}$), a defendant is more motivated to acquire information about the extent of potential harm when (a) the probability of incidence in the activity gets lower, although this effect is marginally diminishing as the riskiness of the activity further decreases; or (b) the activity is more beneficial to the defendant him- or herself, and this effect gets stronger as the benefits to the defendant further increase; or (c) the extent of unrequested benefits gets greater. The extent of harm the activity might impose upon a victim has no impact on the defendant's information acquisition incentives in the relatively-risky-activities zone.*

(iv) *For activities that are relatively-risky from a social perspective ($p \geq \hat{p}^*$), it is socially optimal to acquire information about the extent of potential harm more frequently when (a) the activity is more beneficial to the defendant, and this effect gets stronger as the benefits to the defendant further increase; or (b) the extent of unrequested benefits gets greater. The extent of harm that the activity might impose upon a victim has no impact on the social planner's information acquisition incentives in the relatively-risky-activities zone. (c) The effect of increased riskiness of the activity on the social planner's information acquisition incentives is ambiguous.*

Proof: (i). $b \leq p\mathbb{E}(h)$ implies that $p \geq \hat{p}^* = b/\mathbb{E}(h) > b/\mathbb{E}(h^+) = \hat{p}$. By Propositions 1 and 2, a defendant will collect information if $c < c_{AD}^{p+}$, while the welfare-maximizing social planner will acquire information if $c < c_{social}^{p+}$. We have shown in the proof of Proposition 3 above that $c_{AD}^{p+} < c_{social}^{p+}$, implying that a defendant will collect information less frequently than will a social planner. Moreover, it is straightforward to verify that $\lim_{b\to 0} c_{AD}^{p+} = 0$. $\lim_{b\to 0} c_{social}^{p+} = -p \int_{-h_0}^{0} h dF(h) > 0$.

(ii). The cost threshold of information acquisition in the relatively-safe-activities zone is $c_{AD}^{p-} = c_{social}^{p-}$. It is straightforward to verify that:

(ii-a). $\partial c_{AD}^{p-}/\partial p = \int_{b/p}^{h_1} h dF(h) > 0$; and $\partial^2 c_{AD}^{p-}/\partial p^2 = (b^2/p^3)f(b/p) > 0$.

(ii-b). $\partial c_{AD}^{p-}/\partial b = F(b/p) - 1 < 0$; and $\partial^2 c_{AD}^{p-}/\partial b^2 = f(b/p)/p > 0$.

(ii-c). $\partial c_{AD}^{p-}/\partial h_1 = (ph_1 - b)f(h_1) > 0$. $\quad \partial c_{AD}^{p-}/\partial h_0 = 0$.

(iii). The cost threshold of information acquisition for a defendant in the non-safe-activities zone is c_{AD}^{p+}. It is easy to verify that:

(iii-a). $\partial c_{AD}^{p+}/\partial p = -\int_0^{b/p} h\, dF(h) < 0$; and $\partial^2 c_{AD}^{p+}/\partial p^2 = (b^2/p^3)f(b/p) > 0$.

(iii-b). $\partial c_{AD}^{p+}/\partial b = F(b/p) > 0$; and $\partial^2 c_{AD}^{p+}/\partial b^2 = f(b/p)/p > 0$.

(iii-c). $\partial c_{AD}^{p+}/\partial h_0 = h_0 f(-h_0) > 0$. $\partial c_{AD}^{p+}/\partial h_1 = 0$.

(iv). The cost threshold of information acquisition for a social planner in the relatively-risky-activities zone is c_{social}^{p+}. It is easy to verify that:

(iv-a). $\partial c_{social}^{p+}/\partial b = F(b/p) > 0$; and $\partial^2 c_{social}^{p+}/\partial b^2 = f(b/p)/p > 0$.

(iv-b). $\partial c_{social}^{p+}/\partial h_0 = (b + ph_0)f(h_0) > 0$. $\partial c_{social}^{p+}/\partial h_1 = 0$.

(iv-c). $\partial c_{social}^{p+}/\partial p = -\int_{-h_0}^{b/p} h\, dF(h)$.   ∎

A.5 Proof of Proposition 4

Proof: $\Delta \equiv \pi_{AD}^S - \hat{\pi}_{ED}^S$

$$= \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)} \left[\int_{-h_0}^{b/p}(b - ph)dF(h) - c \right] \frac{1}{\bar{c}} dc + \int_{c_{AD}^{p-}(p)}^{\bar{c}} \int_{-h_0}^{h_1}(b - ph)dF(h)\frac{1}{\bar{c}} dc \right\} dp$$

$$+ \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[\int_{-h_0}^{b/p}(b - ph)dF(h) - c \right]\frac{1}{\bar{c}} dc\, dp - \int_0^{\hat{p}} \int_{-h_0}^{h_1}(b - ph)dF(h)\, dp$$

$$= \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)} \left[\int_{-h_0}^{b/p}(b - ph)dF(h) - c \right] \frac{1}{\bar{c}} dc + \int_{c_{AD}^{p-}(p)}^{\bar{c}} \int_{-h_0}^{h_1}(b - ph)dF(h)\frac{1}{\bar{c}} dc \right\} dp$$

$$+ \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[\int_{-h_0}^{b/p}(b - ph)dF(h) - c \right]\frac{1}{\bar{c}} dc\, dp - \int_0^{\hat{p}} \int_0^{\bar{c}} \int_{-h_0}^{h_1}(b - ph)dF(h)\frac{1}{\bar{c}} dc\, dp$$

$$= \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)} \left[-\int_{b/p}^{h_1}(b - ph)dF(h) - c \right]\frac{1}{\bar{c}} dc \right\} dp$$

$$+ \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[\int_{-h_0}^0 (-ph)dF(h) + F(0)b + \int_0^{b/p}(b - ph)dF(h) - c \right]\frac{1}{\bar{c}} dc\, dp$$

$$= \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)}[c_{AD}^{p-}(p) - c]\frac{1}{\bar{c}} dc \right\} dp + \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[\int_{-h_0}^0 (-ph)dF(h) + c_{AD}^{p+}(p) - c \right]\frac{1}{\bar{c}} dc\, dp$$

$$> 0.$$

$$\partial\Delta/\partial h_0 = \int_{\hat{p}}^1 \left\{ \int_0^{c_{AD}^{p+}(p)} \left[ph_0 f(-h_0) + \frac{\partial c_{AD}^{p+}(p)}{\partial h_0} \right]\frac{1}{\bar{c}} dc + \frac{1}{\bar{c}}\frac{\partial c_{AD}^{p+}(p)}{\partial h_0}\int_{-h_0}^0 (-ph)dF(h) \right\} dp$$

$$= \int_{\hat{p}}^1 \left\{ \int_0^{c_{AD}^{p+}(p)}[ph_0 f(-h_0) + bf(-h_0)]\frac{1}{\bar{c}} dc + \frac{1}{\bar{c}}bf(-h_0)\int_{-h_0}^0 (-ph)dF(h) \right\} dp$$

$$= \frac{f(-h_0)}{\bar{c}} \int_{\hat{p}}^1 \left\{ \int_0^{c_{AD}^{p+}(p)}(ph_0 + b)\, dc + b\int_{-h_0}^0 (-ph)dF(h) \right\} dp$$

$$> 0.$$

It is straightforward to verify that $\partial\Delta/\partial\bar{c} < 0$.   ∎

A.6 Proof of Proposition 5

Proof: $\Delta \equiv \pi_{AD}^S - \pi_{ED}^S$

$$= \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)} \left[\int_{-h_0}^{b/p}(b - ph)dF(h) - c \right]\frac{1}{\bar{c}} dc + \int_{c_{AD}^{p-}(p)}^{\bar{c}} \int_{-h_0}^{h_1}(b - ph)dF(h)\frac{1}{\bar{c}} dc \right\} dp$$

$$+ \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[\int_{-h_0}^{b/p}(b - ph)dF(h) - c \right]\frac{1}{\bar{c}} dc\, dp - \int_0^{\hat{p}^*} \int_{-h_0}^{h_1}(b - ph)dF(h)\, dp$$

$$= \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)} \left[\int_{-h_0}^{b/p}(b - ph)dF(h) - c \right]\frac{1}{\bar{c}} dc + \int_{c_{AD}^{p-}(p)}^{\bar{c}} \int_{-h_0}^{h_1}(b - ph)dF(h)\frac{1}{\bar{c}} dc \right\} dp$$

$$+ \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[\int_{-h_0}^{b/p}(b - ph)dF(h) - c \right]\frac{1}{\bar{c}} dc\, dp$$

$$- \int_0^{\hat{p}} \int_0^{\bar{c}} \int_{-h_0}^{h_1} (b - ph) dF(h) \frac{1}{\bar{c}} dc dp - \int_{\hat{p}}^{\hat{p}^*} \int_0^{\bar{c}} \int_{-h_0}^{h_1} (b - ph) dF(h) \frac{1}{\bar{c}} dc dp$$

$$= \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)} \left[- \int_{b/p}^{h_1} (b - ph) dF(h) - c \right] \frac{1}{\bar{c}} dc \right\} dp$$

$$+ \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[\int_{-h_0}^0 (-ph) dF(h) + F(0)b + \int_0^{b/p} (b - ph) dF(h) - c \right] \frac{1}{\bar{c}} dc dp$$

$$- \int_{\hat{p}}^{\hat{p}^*} \int_0^{\bar{c}} \int_{-h_0}^{h_1} (b - ph) dF(h) \frac{1}{\bar{c}} dc dp$$

$$= \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)} \left[c_{AD}^{p-}(p) - c \right] \frac{1}{\bar{c}} dc \right\} dp + \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[c_{AD}^{p+}(p) - c \right] \frac{1}{\bar{c}} dc dp$$

$$+ \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \int_{-h_0}^0 (-ph) dF(h) \frac{1}{\bar{c}} dc dp - \int_{\hat{p}}^{\hat{p}^*} [b - p\mathbb{E}(h)] dp$$

$$= \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)} \left[c_{AD}^{p-}(p) - c \right] \frac{1}{\bar{c}} dc \right\} dp + \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[c_{AD}^{p+}(p) - c \right] \frac{1}{\bar{c}} dc dp$$

$$+ \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \int_{-h_0}^0 (-ph) dF(h) \frac{1}{\bar{c}} dc dp + \mathbb{E}(h) \int_{\hat{p}}^{\hat{p}^*} p \, dp - b(\hat{p}^* - \hat{p})$$

$$= \int_0^{\hat{p}} \left\{ \int_0^{c_{AD}^{p-}(p)} \left[c_{AD}^{p-}(p) - c \right] \frac{1}{\bar{c}} dc \right\} dp + \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \left[c_{AD}^{p+}(p) - c \right] \frac{1}{\bar{c}} dc dp$$

$$+ \int_{\hat{p}}^1 \int_0^{c_{AD}^{p+}(p)} \int_{-h_0}^0 (-ph) dF(h) \frac{1}{\bar{c}} dc dp + \mathbb{E}(h) \int_{\hat{p}}^{\hat{p}^*} p \, dp - \frac{b^2}{\mathbb{E}(h)} \hat{r}_B$$

$$= \frac{b^2}{\mathbb{E}(h)} (\bar{r}_B - \hat{r}_B).$$