Liability for Non-Disclosure in Equity Financing[*]

Albert H. Choi
University of Michigan Law School

Kathryn E. Spier
Harvard Law School

May 7, 2022

Abstract

This paper analyzes the effects of holding firms liable for non-disclosure of material information when raising capital. A privately-informed entrepreneur may choose to withhold material information from prospective investors. After cash flows are realized, investors may sue the firm ex post for the entrepreneur's (alleged) non-disclosure. Any damage award received by investors is partially offset by the reduced value of their equity stake. Absent liability, entrepreneurs have an excessive incentive to withhold bad news and pursue socially-wasteful projects. Liability for non-disclosure deters the entrepreneur and prevents misallocation of capital. The socially-optimal damage award may be supracompensatory, exceeding the overcharge paid by the investors. Court errors decrease social welfare by weakening deterrence while litigation costs may either increase social welfare by strengthening deterrence or decrease social welfare through wasteful litigation spending or by discouraging meritorious lawsuits. Liability and class-action waivers, holding entrepreneurs personally liable for investor losses, and empirical implications are also analyzed.

1   Introduction

On May 17, 2012, Facebook went public by selling more than 421 million shares of common stock at $38 per share to public investors on the Nasdaq and raised about $16 billion from the investors. Unlike many other initial public offerings that experience an initial price surge, Facebook's stock price declined shortly after the initial public offering (IPO), hitting a low of $18. It took more than a year for the stock price to rebound to the IPO price of $38. Many public investors, who bought Facebook's shares at the IPO or shortly after, were quite unhappy and brought class action suits against the company under the US Securities Act, claiming that Facebook failed to disclose the fact that more users were using their mobile phones to access Facebook's websites instead of their computers, and the company's advertising revenues were lower than as described in the IPO documents.[1] After more than five years of pre-trial procedures, immediately before the case was to go to trial, the litigants agreed to settle the case for $35 million in 2018.[2]

As the Facebook story demonstrates, when a company raises capital by selling securities to outside investors, the US securities laws require the company to disclose relevant material information it possesses to the prospective investors. In case the company fails to do so, the investors can bring suit against the company to recover compensatory damages. Presumably, such a liability regime ensures that the outside investors will receive necessary information from the company to make an informed decision as to whether to purchase the offered security. At the same time, though, critics have argued that the private enforcement regime, especially the class action system, is too costly and encourages indiscriminate lawsuits against even innocent companies.[3] To what extent does such a liability regime induce the company to disclose relevant material information to the investors? Does liability lead to a more efficient allocation of capital? Should the investors be allowed to bring class actions or be required to bring suit on an individual basis, as some advocates have argued? The objective of this paper is to answer some of these questions with the help of game theoretic modeling.

The paper presents a simple, stylized model of a resource-constrained entrepreneur

---

[1]See Atkins (2018) and Graf (2018).

[2]Id. Out of $35 million settlement, plaintiff's attorneys received almost $14 million as fees and costs. See Graf (2018). Although the size of settlement in the Facebook case was exceptionally small compared to the size of the IPO and the potential recovery, according to Lowry and Shu (2002), the average size of settlement in their sample was about 11% of the total proceeds raised in IPOs.

[3]See Scott (2017 and 2019). Scott has argued that most of the securities class actions are without merit and the companies should be allowed to bar securities class actions through a mandatory non-class arbitration provision in their charters or bylaws.

who seeks outside funding to pursue a risky business venture.[4] The capital market is competitive and investors are sophisticated. Before raising the necessary capital, the entrepreneur may observe a private signal revealing the project's future cash flow (high or low). High-value projects are socially worthwhile while low-value projects are socially wasteful. Both the arrival of the signal and its contents are privately observed by the entrepreneur. If the entrepreneur learns that the value is high, the entrepreneur discloses the good news to the investors and lowers the cost of capital. If the entrepreneur learns that the value is low, on the other hand, the entrepreneur is tempted to withhold the bad news and masquerade as having an "average" project to secure funding. Since low-value projects are socially wasteful, withholding bad news and raising outside funding leads to a misallocation of capital.

Firm liability for non-disclosure can deter the entrepreneur and prevent the misallocation of capital. After the cash flows are realized and evidence mounts that the entrepreneur hid material information from investors, the investors may sue the firm for monetary damages. Notably, any damage award received by the investors is offset in part by the reduced value of their equity stake in the firm. When the damage award is below a threshold, the entrepreneur is partially deterred and randomizes between pursuing and abandoning the low-type projects. Deterrence is stronger when the entrepreneur has a larger personal stake in the venture and when the likelihood that the entrepreneur is privately informed is larger.[5] When the damage award is above a threshold, the entrepreneur is fully deterred and first-best outcome is obtained. Full deterrence may require supra-compensatory damages, where the damage award collected by investors exceeds the overcharge that they paid for the equity stake.[6]

After presenting the baseline model, we consider several extensions. In the first extension, the entrepreneur may be held personally accountable for withholding material information from investors. Since the damage award is paid by the entrepreneur rather than the firm, the firm's equity value is unaffected by the lawsuit. We show that the level of liability required to deter socially-wasteful projects is smaller than in the baseline model. The second extension allows for the liability system to falsely find uninformed (and non-disclosing) entrepreneur liable. With false convictions, it becomes more difficult to deter the informed entrepreneur from pursing socially waste-

---

[4]If the entrepreneur has sufficiently deep pockets and can commit her own resources to the venture, then liability for non-disclosure is unnecessary. The entrepreneur has a private incentive to abandon socially wasteful projects. If the entrepreneur is sufficiently resource constrained, liability is necessary to deter the entrepreneur from withholding bad news from investors.

[5]If it is common knowledge that the entrepreneur has the private information, full unraveling occurs as in Grossman (1981) and Milgrom (1981) and we get full deterrence.

[6]This result is driven by the fact that the damage award received by investors is paid by the firm, and the firm's equity is held by both the entrepreneur and the investors.

ful projects. The third extension allows for positive litigation costs and shows that social welfare may rise or fall. On the one hand, insofar as the entrepreneur internalizes some of the firm's litigation costs, the entrepreneur's incentives will improve. On the other hand, litigation costs can discourage investors from bringing meritorious lawsuits, weakening the entrepreneur's incentives. Moreover, holding the level of deterrence constant, the higher litigation costs reflect a pure social waste.

Our analysis delivers both normative and positive insights. First, if the cost of litigation outweighs the deterrence benefits of firm liability, then it is socially desirable to eliminate firm liability altogether. Interestingly, the entrepreneur's private incentive to allow investor lawsuits can be socially excessive. The option to litigate serves as a type of warranty and signals to investors that the entrepreneur is not withholding any material information. Since the entrepreneur who possesses bad news mimics the uninformed entrepreneur, there may be too many lawsuits in equilibrium. We cannot rely upon market self-regulation to reduce the level of costly litigation. Our analysis also delivers empirical predictions. First, when the fraction of outside equity ownership rises, the number of private securities lawsuits will fall. Moreover, when lawsuits are brought, they will tend to be initiated by small retail investors rather than large institutional investors. Second, when the level of deterrence is weaker, the frequency of over-pricing at the IPO stage rises while the magnitude of the over-pricing shrinks.[7] Estimating the frequency and size of over-pricing may offer an indirect way of measuring the level of deterrence.

This paper extends the literature on the disclosure of information prior to the sale of an asset. Grossman (1981) and Milgrom (1981) introduced the famous unravelling result when sellers are privately informed about asset quality. Sellers of high quality assets have a clear incentive to disclose this information (to obtain a better selling price) and, as a consequence, sophisticated buyers draw adverse inferences when sellers *do not* disclose. Grossman and Hart (1981) explored the implications of full unravelling for disclosure laws in corporate takeovers.[8] Dye (1985), Farrell (1986), and Shavell (1994) show that complete unraveling does not occur when buyers are uncertain as to whether the sellers actually have private information. In their analyses, sellers with low quality assets have an incentive to withhold the information from the market and pool with the uninformed types.[9] These papers all assume that

---

[7]On the flip side, the frequency of under-pricing rises and the magnitude of the under-pricing grows.

[8]Grossman and Hart conclude that "the commonly held view that firms withhold information (which is free to release) in order to mislead traders into giving them better terms is false." (p. 333)

[9]Shavell (1994) focuses on the incentive of sellers to acquire information prior to a sale. Although mandatory disclosure may be socially desirable conditional on the seller acquiring the information,

disclosure, if mandated, is perfectly enforced and that the seller does not retain an equity stake in the asset.

Dye (2017) explores a model where mandatory disclosure is imperfectly enforced. If the seller fails to disclose material information, the court awards damages that are proportional to the over-payment by the buyer (relative to what they would have paid had the seller disclosed the information). Our analysis differs from Dye's core model in several important respects. First, in Dye (2017), the asset sale is assumed to always takes place (and efficient) and the seller simply chooses disclosure strategy to maximize the selling price. Liability for non-disclosure affects the seller's equilibrium disclosure strategy but does not affect the asset allocation.[10] In our analysis, whether or not the entrepreneur raises capital (sells equity) is a *choice variable*. Liability for non-disclosure is socially valuable because it deters the entrepreneur from selling equity in socially-wasteful projects and avoids the misallocation of capital. Second, in Dye (2017), the seller is personally liable for the damage payment. In our analysis, *the firm itself* is liable for the damage payment. The seller's accountability for non-disclosure is limited to their (endogenous) financial stake in the firm.[11] In our model, the damage award received by the buyers is paid, in part, by the buyers themselves: the buyers are in effect taking money out of one pocket and putting it into the other. Third, our analysis considers the possibility of false positives and the cost of litigation and the impact they have on disclosure and deterrence. This also allows us to examine the entrepreneur's incentive of managing the ex post verification process through liability and class action waivers.

Several scholars have also examined the impact on liability system on the securities markets, especially on the IPO market. Hughes and Thakor (1992), for instance, examine the idea of an underwriter deliberately under-pricing its stock at the IPO so as to avoid potential lawsuit ex post. In their analysis, over or under-pricing at IPO can happen because the underwriter can be either "myopic" or "nonmyopic"

---

mandatory disclosure may chill the collection of socially valuable information. Polinsky and Shavell (2012) show that when sellers are strictly liable for consumer harms stemming from defective products, and can take precautions to reduce product risks, then mandatory and voluntary disclosure are equivalent.

[10]Dye (2017) section 7 allows for inefficient delay and fractional ownership. Social welfare falls when the seller retains a larger fraction of the asset. In our model, increasing the seller's stake is socially efficient insofar as it deters sellers with low-value assets from participating. There are other differences. Dye (2017) does not allow for false positives (see section 3.2).

[11]Caskey (2014) develops a securities pricing model to explore the price effects of pending litigation, focusing on the role of litigation insurance. The damages received by investors is offset by a dilution of their equity stake. Caskey (2014) also does not consider the misallocation of capital. Spindler (2007) examines the put option feature of the liability regime and examines the entrepreneur's behavior post IPO.

in making its pricing decision.[12] Lowry and Shu (2002) empirically examines the litigation risk on IPO under-pricing and show that firms with higher legal exposure tend to under-price their offerings more and also that under-pricing decreases the expected litigation costs.[13] Focusing more on the class action securities lawsuits, Scott and Silverman (2013) have argued that the class action system has many deficiencies and we should allow firms to adopt mandatory individual arbitration when they go public.[14] This paper attempts to examine the issues of disclosure more closely and to shed some light on the optimal liability system, including whether allowing class action waivers can be beneficial.

The paper is organized as follows. Section 2 presents the baseline model. Absent liability, the entrepreneur has a socially insufficient incentive to disclose bad news to the investors. Firm liability improves disclosure incentives and leads to a more efficient allocation of capital. Section 3 examines various extensions, including (1) placing liability on the entrepreneur (rather than on the firm); (2) court errors where an uninformed, non-disclosing firm may be falsely held liable too; and (3) positive litigation costs. In section 4, we analyze the possibility of allowing firms to either waive the liability or class actions and examine the conditions under which the social welfare is aligned with the firms' incentives. Section 5 offers various empirical predictions that the analysis generates and the last section concludes with thoughts for future research.

2 The Model

Suppose that an entrepreneur E owns a firm that needs capital of $c > 0$. When E raises c and incurs a personal cost of $e > 0$, $c + e$ is invested and the cash-flow stream of $x > 0$ is realized, where $x \in \{x_h, x_l\}$ and $prob(x = x_l) = q \in (0, 1)$.[15] Let $k \equiv c + e$, where k stands for the total investment necessary for the project, and

---

[12]In an earlier paper, Hughes (1986) allows for a privately informed firm to disclose information to an underwriter who, in turn, verifies the disclosure. Alexander (1993) takes issue with Hughes and Thakor (1992) and argues that when we take into consideration the more complex legal issues, it is unlikely that the legal liability will lead to under-pricing of IPO shares.

[13]Prior studies showed little or no difference in returns in firms that were sued versus those who were not or little difference in characteristics among the cases that were filed. See Tinic (1988), Drake and Vetsuypens (1993), and Bohn and Choi (1996). See Ritter and Welch (2002) and Ritter (2011) for a more extensive review of the literature.

[14]See also Scott (2017, 2019). Webber (2015), on the other hand, argues that elimination of the class action system can lead to cross-subsidization by small, individual shareholders to large, institutional ones.

[15]We can think of E's personal cost of e as either E's costly effort or the amount of personal financial capital E has to pledge to get financing.

$\bar{x} \equiv q \cdot x_l + (1 - q) \cdot x_h$. We assume that $max\{e, c\} < x_l < k < x_h$ and $\bar{x} > k$ so that financing is efficient either when $x = x_h$ or when E is uninformed, but not when $x = x_l$.[16]

We assume that E raises capital from a competitive capital market by having the firm sell fraction $\alpha \in [0, 1]$ of the firm's equity to outside investors, whose reservation value is normalized to zero. For instance, with complete information and when $x = x_h$, with competitive capital markets, the outside investors would pay c for a fraction $\alpha = c/x_h$ of the equity of the firm. The outside investors break even in this complete information scenario, since $\alpha \cdot x_h - c = (c/x_h) \cdot x_h - c = 0$.

There are five periods in the game with no discounting, $t \in \{0, 1, 2, 3, 4\}$, and the timing of the game is as follows. At $t = 0$, Nature chooses $x = x_l$ with probability q and $x = x_h$ with probability $1 - q$. E learns the realized x with probability $\pi \in (0, 1)$. E who learns x is "informed" while E who does not learn x is "uninformed." Among the informed E, we denote E (and the firm) who knows that $x = x_h$ as the "h-type" and that $x = x_l$, the "l-type." We denote the uninformed E as the "u-type." Hence, there are three possible types of E (or the firm): u-type, h-type, and l-type.

At $t = 1$, E decides whether to participate and raise capital. If E chooses not to participate, then the game ends and both the investors and E get a return of zero. If E chooses to participate, then the game continues.[17]

At $t = 2$, the informed E chooses whether to disclose x or not disclose ("withhold") x. Following the literature, disclosures are accurate, i.e., E cannot present false evidence, and that the uninformed E cannot pretend to know x. The outside investors observe the entrepreneur's disclosure decision and the disclosed information, if any, and update their belief about x.

At $t = 3$, the firm attempts to raise capital c by issuing equity stake α to outside investors.[18] Outside investors are rational and forward looking and the capital market

---

[16]The assumption that $e < x_l$ rules out the uninteresting case where the l-type would never participate, even if $\alpha = 0$. Also, the assumption that $c < x_l$ is made for largely technical convenience. Taken together, our assumptions imply that $q < \bar{q} = \frac{x_h - k}{x_h - x_l} \in (0, 1)$.

[17]We are imagining that E's choice to participate or not participate is a commitment, and cannot change her mind later. This will get rid of the equilibria where investors make positive profits and simplifies the equilibrium characterization.

[18]Although the firm can raise capital by issuing debt and the liability system is not confined to equity securities, because debt tends to be (much) less "information sensitive" and most of the legal issues arise from stock sales, we focus on equity financing.

is competitive. The equity stake α allows investors to break even given their (endogenous) beliefs about the value of the firm x and their returns from future litigation. If the firm fails to raise capital, then the game ends.[19]

At $t = 4$, investments c and e are sunk and all returns are realized. Investors (now, shareholders of the firm) learn (1) value $x \in \{x_h, x_l\}$ and (2) whether E withheld information at $t = 2$, and can decide to bring a suit against the firm.[20] If E withheld information, the court awards damages $d \in [0, x_l]$.[21] Note that we are assuming that the limited liability principle applies and the firm cannot be responsible for more than its cash-flow (x_l). Also, while it is natural to assume that the damages are compensatory and equal to the overcharge paid by investors,[22] we also allow for no damages ($d = 0$) and punitive damages.

Our equilibrium concept is perfect Bayesian Nash equilibrium (PBNE). Several observations will simplify the analysis of this game. First, if the l-type chooses to participate, it will not disclose x_l to the market. To see why, suppose that the l-type did disclose x_l to the market. Investors would demand equity stake $\alpha_l = c/x_l$ in return for investing c in the business venture. The l-type's net return if it participates and discloses x_l is $(1 - \alpha_l)x_l - e = x_l - c - e < 0$: the l-type is losing money. So, if the l-type participates at $t = 1$, it will not disclose x_l to the capital market. (Depending on the parameter values, the l-type may or may not participate in equilibrium.)

Second, in any equilibrium where the l-type participates and raises capital with a positive probability, the u-type participates, too. To see why, let α^* be the equilibrium equity stake demanded by investors when there is no disclosure. The l-type's return, $(1 - \alpha^*)x_l - e$ (minus any damages owed to outside investors), is strictly smaller than the u-type's return, $(1 - \alpha^*)\bar{x} - e$. So, if the l-type's financial return is non-negative, then the u-type's return is strictly positive.

---

[19]Initially, we assume that the future litigation system is dictated by the legal system and the litigation parameters (such as the damages and the cost of litigation) are commonly known. Later, we will relax this assumption to allow the firm to choose a different liability system, for instance, through a liability waiver or a class action waiver.

[20]We are assuming here than the entrepreneur is not directly liable for non-disclosure. Technically, the security is being sold by and the representations are being made by the firm. Hence, imposing liability on the firm would seem natural. If we assume that the entrepreneur does not have sufficient assets to pay for monetary damages, such an assumption may also be realistic. Nevertheless, we later analyze the case of holding the entrepreneur directly liable for non-disclosure. See section 3.1.

[21]For now, we are assuming that there are no "false positives," the u-type cannot be found liable for non-disclosure after x_l has been realized. We also assume that there are no costs of litigation. Latter sections will relax these assumptions. See section 3.2

[22]Instead of fixed damages d, we can allow the investors to recover $max\{0, min\{\theta(\alpha x_l - c), x_l\}\}$ where $\theta \in [0, \infty)$. In that case, the analysis on the liability system will examine changes in θ instead of d. We are adopting d for its analytical simplicity.

Finally, in any equilibrium, the h-type will participate in the market, disclose its information (of x_h), and succeed in raising capital. Since the capital market draws adverse inferences from non-disclosure, the h-type firm has an incentive to disclose x_h to secure a better deal with investors. These observations are summarized in the following Lemma.[23]

Lemma 1. *In any PBNE where the u-type participates, the h-type participates, discloses x_h, and issues equity stake $\alpha_h = c/x_h$; the u-type issues equity stake $\alpha^* \geq c/\overline{x} > \alpha_h$; the l-type participates with probability $\beta^* \in [0, 1]$, does not disclose x_l, and pools with the u-type.*

In the analysis that follows, we will construct the PBNE where the h-type participates and discloses, the u-type participates and does not disclose, and the l-type partially pools with the u-type. In particular, we characterize values (α^*, β^*) where α^* is the associated equity stake demanded by investors (conditional on non-disclosure) and β^* is the l-type's participation probability.

2.1 Full-Information Benchmark

Since $x_l < k < \overline{x} < x_h$, it is socially efficient for the entrepreneur to raise capital and pursue the venture *unless* the project is known to have low value (x_l). If a social planner possessed the same information as the entrepreneur, the social planner would fund the project if the value was known to be high ($x = x_h$) or if the project had unknown value, but not if $x = x_l$. As the following proposition demonstrates, this outcome would be obtained in a competitive market if the investors have the same information as the entrepreneur.

Proposition 1. *Suppose that the capital market has the same information as the entrepreneur.*

1. *If the entrepreneur and capital market learn that $x = x_h$, then the investors pay c for equity stake $\alpha_h = c/x_h$. E's return is $x_h - c - e > 0$.*

2. *If the entrepreneur and capital market learn that $x = x_l$, then no capital is raised. E's return is zero.*

3. *If the entrepreneur and capital market do not learn x, then investors pay c for equity stake $\overline{\alpha} = c/\overline{x}$. E's return is $\overline{x} - c - e > 0$.*

---

[23]The formal proof is in the Appendix. Later, we will prove that an equilibrium with u-type participation always exists. For some parameter values, there will also exist trivial PBNE where the u-type does not participate, supported by the market's belief that if there is no disclosure then the firm is the l-type for sure. The additional assumption that $e < (1 - c/x_l)\overline{x} - e$ would rule out such equilibria.

The entrepreneur raises capital and pursues the business venture *unless* the project is commonly known to be of low value (i.e., unless the market knows $x = x_l$).[24] Finally, note that when x is not observed then the equity stake demanded by investors reflects the average value $(\overline{x})$.[25] E's equity stake $1 - \overline{\alpha}$ is just large enough to allow the investors to break even on average.

2.2 Equilibrium Characterization

We now characterize the PBNE where the outside investors demand an equity stake $\alpha^* \in [0, 1]$ and the l-types participate and raise capital with probability β^*. Let's begin with the l-type's decision to participate and raise capital. If the l-type participates, the outside investors will bring suit against the firm for damages d. After the payment of damages to the investors, the residual firm value of $x_l - d \geq 0$ is divided between the outside investors and the entrepreneur in proportions α^* and $(1 - \alpha^*)$. The l-type raises capital if the gross return for the entrepreneur, $(1 - \alpha^*)(x_l - d)$, exceeds the personal investment e. We have the following characterization of β^*:

$$
\begin{cases}
\beta^* = 0 & \text{if} \quad (1 - \alpha^*)(x_l - d) - e < 0 \\
\beta^* \in [0, 1] & \text{if} \quad (1 - \alpha^*)(x_l - d) - e = 0 \\
\beta^* = 1 & \text{if} \quad (1 - \alpha^*)(x_l - d) - e > 0
\end{cases}
\tag{1}
$$

Depending on the level of damages d, the equilibrium may involve full deterrence of the l-type ($\beta^* = 0$), partial deterrence ($\beta^* \in (0, 1)$), or no deterrence ($\beta^* = 1$).

Next, consider the equity stake demanded by outside investors. If the entrepreneur is the uninformed u-type, by assumption, there is no lawsuit and the investors get, in expectation, a net return of $\alpha^* \overline{x} - c$. If the entrepreneur is the informed l-type, the outside investors bring suit and collect damages of d from the firm. Because the damages are paid by the firm, the value of the outside investors' equity stake falls to $\alpha^*(x_l - d)$.[26] Thus, the damages awarded to the investors are paid, in part, by the investors themselves. The investors' break-even condition (from the *ex ante*

---

[24] If $x_l > k$ then raising capital when $x = x_l$ is socially efficient. Investors would be willing to pay c for equity stake $\alpha_l = c/x_l$.

[25] As $q \to 0$ then $\overline{x} \to x_h$ and $\overline{\alpha} \to \alpha_h$. As $q \to \overline{q} = \frac{x_h - k}{x_h - x_l}$ then $\overline{x} \to c + e$ and $\overline{\alpha} \to \frac{c}{c+e}$.

[26] We are assuming here that the investors have not sold their shares when they bring suit. We can relax this assumption later. When the parameters of the lawsuit are common knowledge and the financial market is sufficiently forward-looking, when the investors sell the stock, the stock price would reflect the returns from prospective lawsuits. When litigation is costly, however, the credibility constraint will differ depending on whether the investors have sold their stock. See section 3.3

perspective) is:[27]

$$(1 - \pi)(\alpha^*\overline{x} - c) + \pi q \beta^*(\alpha^* x_l - c + (1 - \alpha^*)d) = 0. \tag{2}$$

As the investors' break-even condition shows, the equilibrium α^* will depend on the equilibrium probability of participation by the l-type ($\beta^* \in [0, 1]$).

If the damage award d is above a threshold, l-type entrepreneur will be fully deterred from raising capital: $\beta^* = 0$. We now characterize this upper threshold, $\overline{d}$. First, consider the investors' willingness to supply capital. Setting $\beta^* = 0$ in the investors' break-even condition (2), we have $\alpha^*\overline{x} - c = 0$. Thus, if the outside investors believe that the l-type entrepreneur is fully deterred, they will demand equity stake of

$$\alpha^* = \overline{\alpha} = \frac{c}{\overline{x}} < 1. \tag{3}$$

The equity stake when no information is disclosed reflects the average value of the uninformed u-type only. Now, consider the l-type's decision to participate and raise capital. From (1), the l-type is fully deterred when $(1 - \overline{\alpha})(x_l - d) - e < 0$. Since the left-hand side is a decreasing function of d, the threshold damage award $\overline{d}$ satisfies this expression with equality. The following Lemma characterizes this threshold.

Lemma 2. *(Full Deterrence.) There exists a threshold $\overline{d} \geq 0$ such that the l-type is fully deterred, $\beta^*(d, \pi) = 0$, if $d > \overline{d}$. If $e \geq (1 - c/\overline{x})x_l$ then $\overline{d} = 0$.[28] If $e < (1 - c/\overline{x})x_l$ then*

$$\overline{d} = x_l - \frac{e}{1 - c/\overline{x}} > 0. \tag{4}$$

The full-deterrence threshold $\overline{d}$ in (4) has several notable properties. First, $\overline{d}$ is independent of π. With the complete deterrence of the l-type, the outside investors need not worry about the "degree" of adverse selection, represented by π. Second, $\overline{d}$ is a strictly decreasing function of e. Deterrence is easier to achieve when the entrepreneur has more at stake in the venture. Third, as e approaches 0, $\overline{d}$ approaches x_l. When the entrepreneur personally invests very little in the venture, full-deterrence requires damages that effectively liquidate the firm's assets with nothing remaining

---

[27]Conditional on non-disclosure by the entrepreneur, the investors' break-even constraint is:

$$\frac{1 - \pi}{(1 - \pi) + \pi q}(\alpha^*\overline{x} - c) + \frac{\pi q}{(1 - \pi) + \pi q}\beta^*(\alpha^* x_l - c + (1 - \alpha^*)d) = 0.$$

This is equivalent to (2). The investors' equilibrium ex ante return from the h-type is $\alpha_h x_h - c = 0$.
[28]Since $k = c + e$, we can rewrite $(1 - c/\overline{x})x_l = \frac{\overline{x} - k}{\overline{x} - x_l}x_l \equiv \widehat{e}$. Then, $\overline{d} < (>)0$ when $e > (<)\widehat{e}$.

11

for the entrepreneur. Interestingly, full deterrence may require supra-compensatory damages in the sense that the investors collect more in damages than the overcharge for the assets.[29] Fourth, when e approaches $(1 - c/\overline{x})x_l$, the full-deterrence threshold $\overline{d}$ approaches zero. If $e \geq (1 - \overline{\alpha})x_l$ then the l-type is fully deterred for all $d \geq \overline{d} = 0$, so liability is unnecessary for deterrence.[30] To streamline the analysis we make the following assumption.

Assumption 1: $e < (1 - \overline{\alpha})x_l$.

Assumption 1 implies that in the absence of liability, $d = 0$, the l-type is less-than-fully deterred.

At the opposite end of the spectrum, if the damage award d is below a threshold, the l-type entrepreneur will be completely undeterred, $\beta^* = 1$. Unlike the full deterrence case, with full participation by the l-type, now the degree of adverse selection (π) matters. The next Lemma characterizes the lower threshold, $\underline{d}(\pi)$. As the Lemma (along with its proof) demonstrates, full participation by the l-type (no deterrence) becomes more likely as d, π, or both get smaller.

Lemma 3. *(No Deterrence.) There exist thresholds $\underline{d}(\pi) \in [0, \overline{d}]$ and $\widehat{\pi}_0 \in (0, 1)$ such that the l-type is undeterred, $\beta^*(d, \pi) = 1$, if $d < \underline{d}(\pi)$. If $\pi > \widehat{\pi}_0$ then $\underline{d}(\pi) = 0$. If $\pi \leq \widehat{\pi}_0$ then*

$$\underline{d}(\pi) = x_l - \frac{e}{1 - c/\overline{x} - r(\pi)} \tag{5}$$

where

$$r(\pi) = \frac{\pi q}{1 - \pi} \cdot \frac{k - x_l}{\overline{x}}. \tag{6}$$

$\underline{d}(\pi)$ *is strictly decreasing in π with $\underline{d}(0) = \overline{d}$, $\underline{d}(\widehat{\pi}_0) = 0$, and $r(\widehat{\pi}_0) = 1 - c/\overline{x} - e/x_l$.*

While the formal details are in the proof of Lemma 3, the result may be understood intuitively. The function $r(\pi)$ defined in (6) is the incremental equity stake demanded by the outside investors when the l-type is (just) undeterred, $\beta^* = 1$. To just break even in expectation, the outside investors require equity stake $c/\overline{x} + r(\pi)$. Intuitively,

---

[29]This is true given that $\overline{d}$ is decreasing in e and $\overline{d} = x_l > c - \alpha x_l \ \forall \alpha \in (0, 1]$ when $e = 0$.

[30]In an initial public offering, the insiders (including the founders, officers, and venture capitalists) are often contractually prohibited from selling their stock for a certain period (the "lock-up" agreement). The entrepreneur making a personal investment of e can be thought of as being similar to such an arrangement, since without a lock-up agreement, the entrepreneur may be able to divest her investment quickly after raising capital from the outside investors before any of the informational issues are uncovered.

if the l-types are undeterred, the outside investors will demand a "premium" to compensate for the increased risk that they face. The risk premium demanded by outside investors, $r(\pi)$ in equation (6), is higher when the fraction of informed types, π, is larger.

Note also that the threshold $\underline{d}(\pi)$ in Lemma 3 is a decreasing function of π. When π rises, full participation of the l-types is unsustainable in equilibrium. It is not hard to see why this is true. When π rises and the outside investors demand a larger equity stake compensate them for the increased risk, the entrepreneur's cost of capital becomes higher, too. The higher cost of capital discourages the l-types from participating in the market. When π is above a threshold $\widehat{\pi}_0$, therefore, the l-type is partially deterred ($\beta^* < 1$) even when there is no liability ($d = 0$). At the same time, without any liability ($d = 0$), full deterrence is no longer feasible.

When the damage award is in an intermediate range ($\underline{d} < d < \overline{d}$) the l-type randomizes between participating and not: $\beta^* \in (0, 1)$. From (1), the l-type entrepreneur is indifferent between participating and not if:

$$(1 - \alpha^*)(x_l - d) - e = 0. \tag{7}$$

Notice that if e or d rise, the outside ownership stake α^* must fall. When the entrepreneur must make a larger personal investment in the venture, or faces greater liability for non-disclosure, it is necessary for the entrepreneur's ownership stake $(1 - \alpha^*)$ must be larger (to encourage participation).

Using (7) and allows us to rewrite the investors' break-even condition as:[31]

$$(1 - \pi)(\alpha^* \overline{x} - c) - \pi q \beta^*(c + e - x_l) = 0. \tag{8}$$

The expression, $\alpha^* \overline{x} - c > 0$, is the investors' net return from the uninformed u-type, and the expression, $c + e - x_l = k - x_l > 0$, is the investors' loss associated with the l-type. Notice that the expression $k - x_l > 0$ represents the social loss from the l-type's participation. Since the l-type is indifferent between participating and not, i.e., the l-type's expected return is equal to zero, the outside investors bear the entire social loss in expectation. Solving equations (7) and (8) gives unique closed-form solutions for α^* and β^*. The following Proposition formalizes the results.

Proposition 2. *Suppose that the firm is held liable for the l-type entrepreneur's non-disclosure. Consider thresholds $\overline{d}$ and $\underline{d}(\pi)$ defined in (4) and (5), respectively.*

---

[31]Expression (7) implies $\alpha^*(x_l - d)x_l - d - e$. Substituting this into equation (1) gives the result.

1. *Full Deterrence. If $d > \bar{d}$, then investors demand equity stake $\alpha^*(d, \pi) = \bar{\alpha} = c/\bar{x}$ and the l-type is fully deterred, $\beta^*(d, \pi) = 0$.*

2. *Partial Deterrence. If $\underline{d}(\pi) \leq d \leq \bar{d}$, then investors demand equity stake*

$$\alpha^*(d, \pi) = 1 - \frac{e}{x_l - d}, \tag{9}$$

where $\alpha^*(d, \pi)$ is decreasing in d and does not depend on π. The l-type is partially deterred,

$$\beta^*(d, \pi) = \frac{1 - \pi}{\pi q} \cdot \frac{\left(1 - \frac{e}{x_l - d}\right)\bar{x} - c}{c + e - x_l}, \tag{10}$$

where $\beta^*(d, \pi)$ is decreasing in d and π with $\lim_{d \to \bar{d}} \beta^*(d, \pi) = 0$ and, if $\pi \leq \hat{\pi}_0$, $\lim_{d \to \underline{d}(\pi)} \beta^*(d, \pi) = 1$.

3. *No Deterrence. If $d < \underline{d}(\pi)$, then investors demand equity stake*

$$\alpha^*(d, \pi) = \frac{(1 - \pi)c + \pi q(c - d)}{(1 - \pi)\bar{x} + \pi q(x_l - d)}, \tag{11}$$

where $\alpha^*(d, \pi)$ is decreasing in d and increasing in π. The l-type is undeterred, $\beta^*(d, \pi) = 1$.

The full deterrence and no deterrence equilibria were explained in the earlier Lemmas. Consider the second case of partial deterrence where $\underline{d}(\pi) < d < \bar{d}$. The equilibrium l-type participation rate $\beta^*(d, \pi)$ characterized (10) has some notable and intuitive properties. First, the l-type participation rate β^* is smaller when the damage award d is larger. In other words, the l-type is deterred by legal liability. This is intuitive. When the liability system is stronger then it becomes more costly for the l-type to not disclose the information, and therefore easier to partially deter the l-type from participating in the market. Second, the l-type's participation rate β^* is decreasing in π, the fraction of informed entrepreneurs.[32] When π is larger, the adverse selection problem is worse. To maintain investor indifference, fewer l-types participate. In the limit, when $\pi \to 1$, $\beta^* \to 0$: when the entrepreneur is perfectly informed, the full unraveling result (Grossman (1981) and Milgrom (1981)) obtains. For comparison, we know from Lemma 3 that when $\pi \to 0$, $\beta^* = 1 \; \forall d < \bar{d}$, and welfare loss again goes to zero. The equilibrium is illustrated in Figure 1.

---

[32]Recall that $\bar{x} = qx_l + (1 - q)x_h$ and does not depend on π.
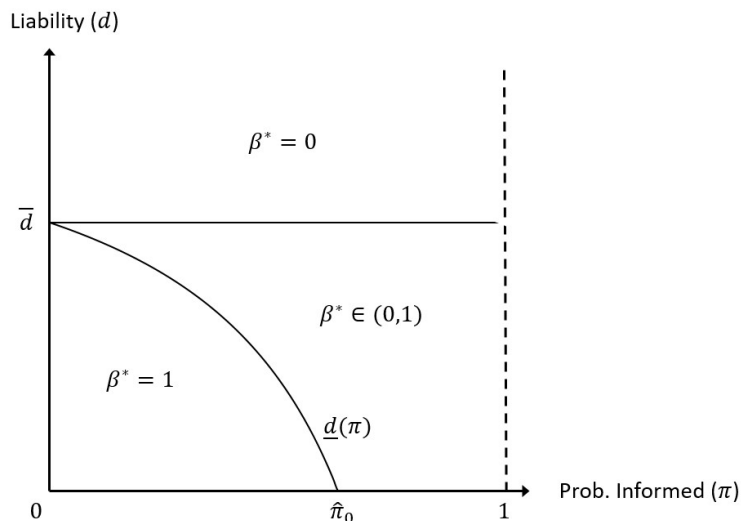
Figure 1: Equilibrium Characterization

Finally, it is worth emphasizing the importance of our assumption that the l-type's investment is socially wasteful: $x_l - c - e < 0$. According to Proposition 2, liability for non-disclosure deters the l-type entrepreneur from participating in the capital market and this leads to a more efficient allocation of capital. If instead the l-type investment was socially worthwhile, $x_l - c - e > 0$, it is easy to show that the l-type will always participate and raise capital *regardless of the liability rule*.[33] In that setting, when d is sufficiently large, the l-type will simply disclose the bad news, $x = x_l$, and sell equity stake of $\alpha_l = c/x_l$ to the outside investors. Thus, if the l-type investment was socially worthwhile, holding the entrepreneur liable for non-disclosure of material information would have no effect on the allocation of capital or on social welfare.

2.3 Welfare Implications

It is straightforward to evaluate the implications for private and social welfare. In the PBNE, the h-type and u-type participate with certainty while the l-type participates

---

[33]Consider a PBNE with full-disclosure by the l-type. If the l-type discloses, $\alpha_l = c/x_l$ and the l-type's payoff is $(1 - \alpha_l)x_l - e = x_l - c - e > 0$. If the l-type were to mimic the u-type and withhold information, investors demand $\overline{\alpha} = c/\overline{x}$ and the l-type's payoff becomes $(1 - c/\overline{x})(x_l - d) - e$. Setting these expressions equal gives the threshold $d = c(\overline{x} - x_l)/(\overline{x} - c) > 0$. When d is above the threshold then the equilibrium involves full disclosure by the l-type; when d is below the threshold the equilibrium involves no disclosure by the l-type. In both cases the l-type project is pursued, which is socially efficient.

15

with probability $\beta^*(d, \pi) \in [0, 1]$. From an ex ante perspective, the expected social welfare is $SW(d, \pi)$ is given by:

$$SW(d, \pi) = (1 - \pi)(\bar{x} - k) + \pi(1 - q)(x_h - k) + \pi q \beta^*(d, \pi)(x_l - k). \qquad (12)$$

The first and second terms, which are positive, reflect the value created by the u-types and h-types, respectively. The third term, which is negative, is the welfare loss associated with the l-type's participation: πq is the probability that the entrepreneur is the l-type and β^* is the probability of l-type's non-disclosure and participation. As assumed earlier, it is inefficient for the l-type entrepreneurs to participate in the market because the gross return from the venture, x_l, is smaller than the cost of the venture, $k = c + e$.

Equation (12) reveals some important comparative statics. First, since $\beta^*(d, \pi)$ is a (weakly) decreasing function of d, social welfare is also a (weakly) increasing function of d. Second, one can show that social welfare is (weakly) increasing in π, the proportion of informed entrepreneurs. When firm liability is low ($d < \underline{d}(\pi)$) and the l-type is undeterred ($\beta^*(d, \pi) = 1$), we have $SW(d, \pi) = \bar{x} - k$ and social welfare does not depend on π.[34] When firm liability is sufficiently high ($d > \bar{d}$) so that $\beta^*(d, \pi) = 0$, social welfare is increasing with respect to π. This is because, with the l-type's participation probability of zero, as π increases, the proportion of h-type increases, which increases social welfare since $x_h > \bar{x}$. Finally, with partial deterrence ($\beta^*(d, \pi) \in (0, 1)$), as we saw earlier, $\beta^*(d, \pi)$ decreases with respect to π, which increases social welfare. In the extreme, if the entrepreneur is informed with certainty ($\pi = 1$), there would be full unraveling and the first-best outcome would be obtained. More generally, the society is better off as the entrepreneur has more information.

Now consider the entrepreneur's payoff. Not surprisingly, as d gets larger, the l-type gets (weakly) worse off. More interestingly, as d gets larger, the u-type is better off. Suppose that the l-type participates with a positive probability. As d rises, investors expect to receive a larger "rebate" when they sue the l-types for non-disclosure. As a consequence, the equity stakes demanded by outside investors $\alpha^*(d, \pi)$ in equations (9) and (11) are decreasing in d. Higher levels of liability benefit the u-type. Finally, consider the effect of π on the entrepreneur's payoff. When $\beta^*(d, \pi) = 0$ or $\beta^*(d, \pi) \in (0, 1)$, the payoffs are independent of π. This is true in the latter case because $\alpha^*(d, \pi)$ is independent of π. When $d < \underline{d}(\pi)$, as π rises,

---

[34]Since the l-type participates with certainty, the average welfare from an informed entrepreneur, some of whom are h-types and disclose x_h and others who are l-types and do not disclose their types, is simply $\bar{x} - k$.

the investors are facing a larger risk from the l-types and therefore demand a larger equity stake ($\alpha^*(d, \pi)$ is larger). This reduces the payoff of both the u-type and the l-type.[35]

The following corollary summarizes the effect of d and π on both social welfare and private payoffs.

Corollary 1. *Suppose that the firm is held liable for the l-type's non-disclosure.*

1. *Full Deterrence. If $d > \overline{d}$, private payoffs and social welfare do not depend on d. Private payoffs are independent of π but social welfare increases as π increases.*

2. *Partial Deterrence. If $\underline{d}(\pi) \leq d \leq \overline{d}$, the l-type's payoff is independent of d and π, the u-type's payoff is increasing in d and π, and social welfare is increasing in d and π.*

3. *No Deterrence. If $d < \underline{d}(\pi)$, the l-type's payoff is decreasing in d and π, the u-type's payoff is increasing in d and decreasing in π, and social welfare is independent of d and π.*

3 Extensions

The previous section presented the baseline model. While the model delivered important insights, it also relied on several simplifying assumptions, such as no litigation costs and no false positives. In this section, we relax these assumptions and consider three extensions: (1) the possibility of holding the entrepreneur personally liable; (2) the possibility that the court can find u-type entrepreneur liable (false positives); and (3) positive litigation costs for both the defendant-firm and the plaintiff-shareholders.

3.1 Entrepreneur Liability

Suppose that an informed E may be held *personally* liable (and the firm is not held liable) for withholding evidence about x. The outside investors, after observing the realized x, can bring suit against the entrepreneur at $t = 4$ to recover damages d. Since the damage award is paid by the entrepreneur instead of the firm, the value of the firm's equity is unaffected by the lawsuit.

Not surprisingly, holding the entrepreneur personally liable creates stronger deterrence. To see why, consider the case of partial deterrence where the l-type is just

---

[35]Note that although the h-type is no worse off when π increases, there are more h-types when π and social welfare is unaffected.

indifferent between participating and not and the outside investors break even in expectation. The l-type is indifferent if

$$(1 - \alpha^*)x_l - e - d = 0. \tag{13}$$

Comparing this condition to (7) reveals an important difference. When the entrepreneur is personally liable he bears one hundred percent of the damage award d rather than bearing only their proportional share via the reduction in firm value, $(1 - \alpha^*)d$. The outside investors' break-even condition is the same as in (8) above.

As in the baseline model, if d is above a threshold, the l-type entrepreneur is fully deterred: $\beta^* = 0$. The investors' break-even condition in (8) implies that the outside investors demand equity stake $\alpha^* = c/\overline{x}$ as in (3). Equation (13) implies that the l-type is just indifferent between participating and not when $d > \overline{d}_{EL}(e)$ where

$$\overline{d}_{EL} = (1 - c/\overline{x})x_l - e. \tag{14}$$

Comparing this to equation (4), we see that $\overline{d}_{EL} < \overline{d}$, the threshold in the baseline model with firm liability. That is, the l-type is fully deterred for a broader range of parameter values than before.

Similarly, if the damages d are at the threshold where the l-type is (just) undeterred, $\beta^* = 1$, then the outside investors demand equity stake $c/\overline{x} + r(\pi)$ defined in (6). Using the l-type's indifference condition (13)

$$\underline{d}_{EL}(\pi) = (1 - c/\overline{x} - r(\pi))x_l - e. \tag{15}$$

Comparing this to equation (5) establishes $\underline{d}_{EL}(\pi) < \underline{d}(\pi)$, so the l-type is undeterred for a smaller range of parameter values than before. When $\pi = 0$ then the risk premium $r(\pi) = 0$ and $\underline{d}_{EL}(0) = \overline{d}_{EL}$, and when $\pi = \widehat{\pi}_0$ then $r(\widehat{\pi}_0) = 1 - c/\overline{x} - e/x_l$ and $\underline{d}_{EL}(\widehat{\pi}_0) = 0$. The following proposition presents these findings.

Proposition 3. *(Entrepreneur Liability.) Suppose that the entrepreneur is held personally liable for non-disclosure. Consider thresholds $\overline{d}_{EL}$ and $\underline{d}_{EL}(\pi)$ defined in (14) and (15), respectively.*

1. *Full Deterrence. If $d > \overline{d}_{EL}$, then investors demand equity stake $\alpha^*_{EL}(d, \pi) = c/\overline{x}$ and the l-type is fully deterred, $\beta^*_{EL}(d, \pi) = 0$.*

2. *Partial Deterrence. If $\underline{d}_{EL}(\pi) \leq d \leq \overline{d}_{EL}$, then investors demand equity stake*

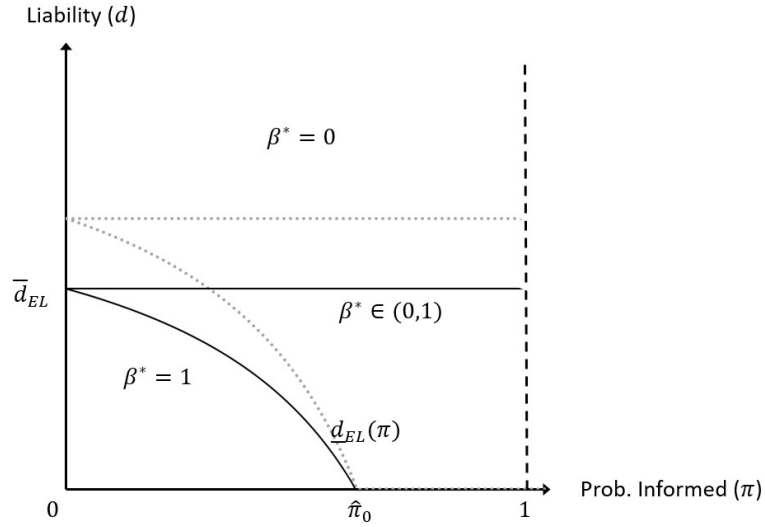$$\alpha^*_{EL}(d, \pi) = 1 - \frac{d + e}{x_l}. \tag{16}$$

18

Figure 2: Entrepreneur Liability

The l-type is partially deterred,

$$\beta^*_{EL}(d, \pi) = \frac{1-\pi}{\pi q} \cdot \frac{\left(1 - \frac{d+e}{x_l}\right)\overline{x} - c}{k - x_l} \in [0, 1]. \tag{17}$$

3. *No Deterrence. If $d < \underline{d}_{EL}(\pi)$, then investors demand equity stake*

$$\alpha^*_{EL}(d, \pi) = \frac{(1-\pi)c + \pi q(c-d)}{(1-\pi)\overline{x} + \pi q x_l}. \tag{18}$$

The l-type is undeterred, $\beta^*_{EL}(d, \pi) = 1$.

These results are illustrated in Figure 2. Notice that since $\overline{d}_{EL} < \overline{d}$, the *l*-type entrepreneur is fully deterred for a larger range of parameter values than in the baseline model. Furthermore, since $\underline{d}_{EL}(\pi) < \underline{d}(\pi)$, the range where there is no deterrence is smaller, too. When $d = 0$, since there is no liability against either the firm or the entrepreneur, we get the same cut-off point of $\widehat{\pi}_0$. For the middle range with partial deterrence, one can easily verify that $\beta^*_{EL}(d, \pi)$ in equation (17) is smaller than $\beta^*(d, \pi)$ in equation (10). So deterrence is stronger when the entrepreneur is held personally liable for non-disclosure to outside investors. Finally, although holding the entrepreneur personally liable changes the respective regions (full, partial, or no deterrence regions), within each region, a change in d or π have the same effects on

19

firm payoffs and social welfare as those in corollary 1. Formal statements are in the appendix.

3.2 False Positives

In the baseline model, we assumed that only the l-type could be found liable when the investors observe x_l while the u-type, when it generates the revenue of x_l is not found liable. This is tantamount to assuming that when x_l is observed, the investors (and the court) can distinguish whether it is the l-type or the u-type that has generated that cash-flow x_l or, equivalently, the investors (and the court) to know whether the entrepreneur had earlier concealed the information on future cash-flow. Such informational assumption, of course, may be strong especially when the investors (and the court) need to verify whether the entrepreneur, in fact, concealed information at the time of financing. In this section, we relax that assumption and allow for the possibility of the court holding also the u-type (falsely) liable.

Suppose, after the investors have financed the project conditional on non-disclosure and x_l has been observed, the investors do not know whether they are facing the l-type or the u-type, and can bring lawsuit against either one. As before, if the lawsuit is brought against the l-type, the l-type will be liable (in expectation) for d. On the other hand, we assume that the liability for the u-type is given by λd where $\lambda \in [0,1]$. The court is (weakly) competent at distinguishing the types. If $\lambda = 0$, for instance, we're back to the baseline model. To focus on the impact of allowing false positives, we'll continue to assume that litigation is costless.[36]

It is not difficult to imagine that once the court (and the investors) can falsely hold the u-type liable (after x_l is realized), it becomes more difficult to deter the l-type from participating. For instance, the region where the l-type participates in equilibrium will be larger and in the region where the l-type is partially deterred, the l-type will participate with a higher probability. As will be demonstrated more formally in the following proposition and the proof, the l-type is fully deterred, $\beta^* = 0$, when the damages exceed the threshold

$$\overline{d}_{FP} = x_l - \frac{e}{1 - \overline{\alpha}_{FP}} \tag{19}$$

where $\overline{\alpha}_{FP} = \frac{c - q\lambda d}{\overline{x} - q\lambda d}$. Since the investors expect a "rebate" λd from the u-type, they

---

[36]The baseline model implicitly takes into account the possibility of false negatives through a reduction in d, but we can make this more express by letting the l-type to be liable for μd, with $0 \le \lambda \le \mu \le 1$, where μ can stand for the probability of finding l-type liable. The main results will stay the same.

demand a smaller fraction of the firm, $\overline{\alpha}_{FP} < \overline{\alpha} = c/\overline{x}$. Comparing the formula for $\overline{d}_{FP}$ in (19) to the formula for $\overline{d}$ in (4) we see that $\overline{d}_{FP} > \overline{d}$ whenever $\lambda > 0$. The l-type is totally undeterred, $\beta^* = 1$, when the damages are below the threshold

$$\underline{d}_{FP}(\pi) = x_l - \frac{e}{1 - \overline{\alpha}_{FP} - r_{FP}(\pi)} \tag{20}$$

where $r_{FP}(\pi)$ is the risk premium required by the investors when $d = r_{FP}(\pi)$,

$$r_{FP}(\pi) = \frac{\pi q}{1 - \pi} \cdot \frac{k - x_l}{\overline{x} - q\lambda d}. \tag{21}$$

Comparing these expressions with (5) and (6) verifies that $\underline{d}_{FP}(\pi) > \underline{d}(\pi)$. The following proposition, along with the proof, demonstrates this more formally.

Proposition 4. *(False Positives.) Suppose that the firm is erroneously held liable for λd when the entrepreneur is uninformed and x_l is realized, where $\lambda \in [0, 1]$. Consider thresholds $\overline{d}_{FP}$ and $\underline{d}_{FP}(\pi)$ defined in (19) and (20), respectively.*

1. *Full Deterrence. If $d > \overline{d}_{FP}$, then investors demand equity stake $\alpha^*_{FP}(d, \pi) = \frac{c - q\lambda d}{\overline{x} - q\lambda d}$ and the l-type is fully deterred, $\beta^*_{FP}(d, \pi) = 0$.*

2. *Partial Deterrence. If $\underline{d}_{FP}(\pi) \leq d \leq \overline{d}_{FP}$, then investors demand equity stake*

$$\alpha^*_{FP}(d, \pi) = 1 - \frac{e}{x_l - d}. \tag{22}$$

and the l-type is partially deterred,

$$\beta^*_{FP}(d, \pi) = \frac{1 - \pi}{\pi q} \cdot \frac{\left(1 - \frac{e}{x_l - d}\right)(\overline{x} - q\lambda d) - (c - q\lambda d)}{k - x_l} \in [0, 1]. \tag{23}$$

3. *No Deterrence. If $d < \underline{d}_{FP}(\pi)$, then investors demand equity stake*

$$\alpha^*_{FP}(d, \pi) = \frac{(1 - \pi)(c - q\lambda d) + \pi q(c - d)}{(1 - \pi)(\overline{x} - q\lambda d) + \pi q(x_l - d)}. \tag{24}$$

The l-type is undeterred, $\beta^*_{FP}(d, \pi) = 1$.

While the general attributes of the equilibrium is similar to that in the baseline case, when the court can falsely find the u-type liable ($\lambda > 0$), there are three notable differences. First, compared to the baseline case, now it becomes more difficult to achieve full deterrence: $\overline{d}_{FP}(e) > \overline{d}(e) \ \forall \pi \in [0, 1]$ whenever $\lambda > 0$. Because the
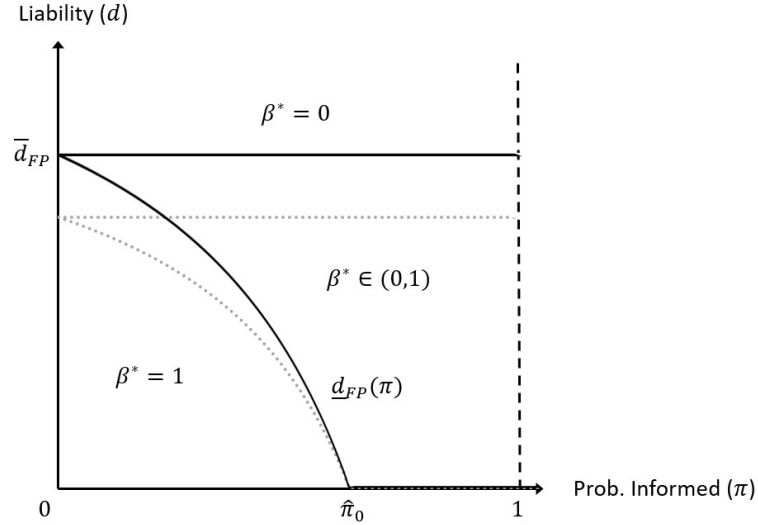
Figure 3: False Positives

investors collect some damages (λd) from the u-type when x_l is observed, ex ante, they demand a lower fraction of the firm (α^* is smaller) and this provides a stronger incentive for the l-type to not disclose and participate. Second, and for similar reasons, the region where there is no deterrence ($\beta^* = 1$) is larger: $\underline{d}_{FP}(e, \pi) > \underline{d}(e, \pi)$ $\forall \pi \in [0, \widehat{\pi}_0(e))$ whenever $\lambda > 0$. Third, when the l-type is partially deterred ($\beta^* \in (0, 1)$), even with the same level of liability (the same d), with false positives, the l-type participates with a higher probability. Conditional on d, because the investors collect damages from the u-type, their expected return will be higher with false positives. In order to satisfy their break-even condition, therefore, the l-type has to participate with a higher probability. When compared to the baseline case, all three results will tend to lower social welfare. A formal analysis of comparative statics are in the appendix.

3.3 Litigation Costs

In the baseline model and the two extensions we have analyzed so far, we have assumed that litigation was costless, so the investors brought suit against the firm whenever the l-type participated (and x_l is observed). This section relaxes this assumption, and assumes that the investors and the firm must pay litigation costs of $\phi_p \geq 0$ and $\phi_d \geq 0$, respectively. We let $\phi = \phi_p + \phi_d$.

When litigation is costly, the outside investors may not have a financial interest to bring suit against the firm even after discovering the l-type's non-disclosure. The

investors' net return from the litigation is (weakly) positive whenever $d - \phi_p \geq 0$.[37] However, the market value of the equity stake held by the investors falls. After the payment of damages d and defense costs ϕ_d, the value of the firm's equity is $x_l - d - \phi_d$. Since the outside investors own fraction α of the equity, their stake falls by $\alpha(d + \phi_d)$. The outside investors will bring suit if and only if the net return from litigation exceeds the the lost equity value:

$$\alpha \leq \frac{d - \phi_p}{d + \phi_d}. \tag{25}$$

The outside investors' incentive to sue the firm is stronger when the damages d are higher, their equity stake α is smaller, or the litigation costs ϕ_p and ϕ_d smaller. Notice that the credibility constraint does not depend on π, c, or e.[38]

Suppose that (25) is satisfied so the investors' have an incentive to bring the lawsuit. As in the baseline model, there exists a threshold $\overline{d}_{LC}$ above which the l-type entrepreneur is fully deterred: $\beta^* = 0$. In an equilibrium with full deterrence, there is no litigation and the outside investors demand equity stake $\overline{\alpha} = c/\overline{x}$, just as in the baseline model. The l-type is just indifferent between participating and not when $(1 - c/\overline{x})(x_l - d - \phi_d) - e = 0$, so the l-type does not participate when

$$\overline{d}_{LC} = x_l - \phi_d - \frac{e}{1 - c/\overline{x}}. \tag{26}$$

Comparing this to equation (4) establishes $\overline{d}_{LC} < \overline{d}$ since $\phi_d > 0$. In other words, when litigation is costly for the firm, the l-type is fully deterred for a broader range of parameter values than before. Before we proceed, we make the following assumption:

Assumption 2: $\quad \overline{\alpha} < \dfrac{\overline{d}_{LC} - \phi_p}{\overline{d}_{LC} + \phi_d}.$

This assumption ensures that when the damages are large enough ($d \geq \overline{d}_{LC}$), litigation is credible to fully deter the l-type from participating. The assumption is made to simplify the analysis and also to make the case more interesting.

---

[37]If the plaintiff-investors have no stake in the firm (e.g., because they have sold their shares before filing suit) or if they are trying to hold the entrepreneur personally liable, this inequality will determine the credibility constraint.

[38]Note that in the conventional litigation model (with no fee-shifting), plaintiffs bring suit (lawsuit is credible) whenever $d - \phi_p > 0$. Since $\alpha^* \in (0,1)$ and $d + \phi_d > d - \phi_p$, the credibility constraint is more likely to bind in our setup. See Choi and Spier (2018) for a more general discussion on how the plaintiff's short or long position on the defendant can affect the litigation credibility and outcome.

The boundary for the partial deterrence region is:

$$\underline{d}_{LC}(\pi) = x_l - \phi_d - \frac{e}{1 - c/\overline{x} - r_{LC}(\pi)}, \tag{27}$$

where $r_{LC}(\pi)$ is the risk premium demanded by investors when $d = \underline{d}_{LC}$,

$$r_{LC}(\pi) = \frac{\pi q}{1 - \pi} \cdot \frac{k + \phi - x_l}{\overline{x}}. \tag{28}$$

Comparing these expressions with (5) and (6) verifies that $\underline{d}_{LC}(\pi) < \underline{d}(\pi)$.

If (25) is not satisfied then investor's incentive to bring the lawsuit is not credible. Intuitively, this situation is similar to our baseline model without litigation costs when $d = 0$. Following the logic surrounding Lemma 3, when $\pi < \widehat{\pi}_0$ then $\underline{d}(\pi) > 0$ and so the l-type is undeterred, $\beta^* = 1$. When π is small, the investors face little risk of financing an l-type and so the risk premium that they demand is small. This implies that the (rare) l-types have access to cheap capital, and participate fully in raising capital. When $\pi > \widehat{\pi}_0$ then $\underline{d}(\pi) < 0$ and so the l-type is partially deterred. Intuitively, when π is large, the investors face considerable risk when supplying capital. Since capital is more expensive, the l-types are partially deterred.

Proposition 5. *Suppose that the investors and the firm bear costs ϕ_p and ϕ_d, respectively, in litigation. There exists a continuous, weakly increasing function $d_0(\pi)$ ("litigation credibility threshold"). If $d < d_0(\pi)$, then investors do not have a credible threat to sue and the PBNE is the same as the baseline model with $d = 0$ (Proposition 2). If $d \geq d_0(\pi)$, then there exists a PBNE where the investors have a credible threat to sue.[39] Thresholds $\overline{d}_{LC}$ and $\underline{d}_{LC}(\pi)$ are defined in (26) and (27), respectively.*

1. *Full Deterrence. If $d > \overline{d}_{LC}$, then investors demand equity stake $\alpha^*_{LC}(d, \pi) = \overline{\alpha} = c/\overline{x}$ and the l-type is fully deterred, $\beta^*_{LC}(d, \pi) = 0$.*

2. *Partial Deterrence. If $\underline{d}_{LC}(\pi) \leq d \leq \overline{d}_{LC}$, then investors demand equity stake*

$$\alpha^*_{LC}(d, \pi) = 1 - \frac{e}{x_l - d - \phi_d}. \tag{29}$$

The l-type is partially deterred,

$$\beta^*_{LC}(d, \pi) = \frac{1 - \pi}{\pi q} \cdot \frac{\left(1 - \frac{e}{x_l - d - \phi_d}\right)\overline{x} - c}{k + \phi - x_l} \in [0, 1]. \tag{30}$$

---

[39]There is a second PBNE where investors do not have a credible threat to sue for a certain range of parameter values with $d \geq d_0(\pi)$.
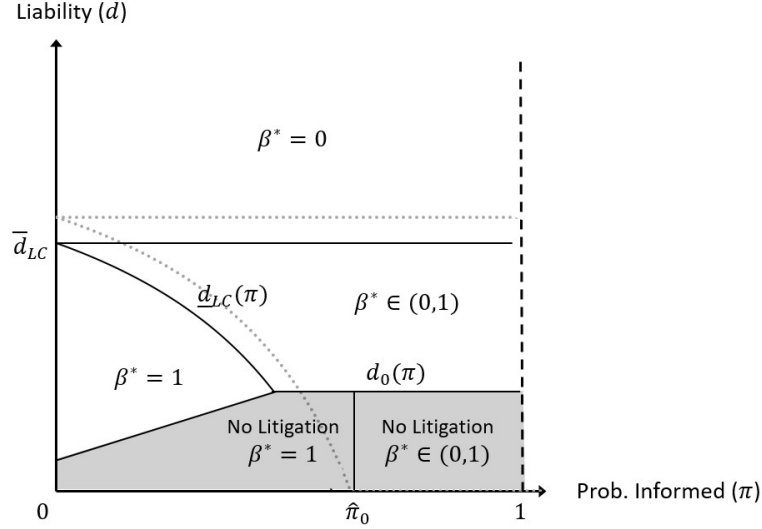
Figure 4: Litigation Costs

3. No Deterrence. If $d < \underline{d}_{LC}(\pi)$, then investors demand equity stake

$$\alpha^*_{LC}(d, \pi) = \frac{(1 - \pi)c + \pi q(c + \phi_p - d)}{(1 - \pi)\overline{x} + \pi q(x_l - d - \phi_d)}. \tag{31}$$

The *l*-type is undeterred, $\beta^*_{LC}(d, \pi) = 1$.

When damages are below the litigation credibility threshold, $d < d_0(\pi)$, in equilibrium, the investors decline to bring lawsuits against the firm; the direct cost of litigation, ϕ_p, plus the dilution in the value of their equity stake (which also reflects the firm's litigation cost ϕ_d), outweigh the damage award d. The entrepreneur and the investors are forward-looking and anticipate that there will be no litigation in the future. Thus, if $d < d_0(\pi)$, the *l*-type's participation rate β^*_{LC} and equity stake α^*_{LC} demanded by investors follow the analysis of our baseline model with no litigation costs and $d = 0$ (see Proposition 2). As illustrated in the gray region of Figure 4, the equilibrium involves no deterrence when $d < \widehat{\pi}_0$ and partial deterrence if $d \geq \widehat{\pi}_0$.

When $d \geq d_0(\pi)$, investors have a credible threat to sue, where the direct cost of litigation (ϕ_p) and the dilution in value of the investors' equity stake from litigation are small enough (when compared to damages) to make litigation credible. As shown in Proposition 5 and illustrated in Figure 4, with $d \geq d_0(\pi)$, we may get full deterrence, partial deterrence, or no deterrence. As in our baseline model, when the damages are large enough, $d \geq \overline{d}_{LC}$, we get the full deterrence and the *l*-type does not participate

25

(case 1) and when $d < \bar{d}_{LC}(\pi)$ we get either partial deterrence (case 2) or no deterrence (case 3). Notice that equilibrium strategies (α^*_{LC} and β^*_{LC}) depend on the litigation costs (ϕ_p and ϕ_d). It is easy to check that as litigation costs go to zero in these expressions, we get the earlier equilibrium in Proposition 2.

Litigation costs have nuanced effects on social welfare. There are three factors to consider with positive litigation cost: deterrence, credibility, and the social cost of litigation. First, assuming that litigation is credible, because the firm has to pay more in litigation (they have to pay litigation cost ϕ_d in addition to damages d), this creates stronger deterrence incentives for the l-type and increases social welfare. Indeed, as shown in Figure 4, the full deterrence region is larger and the no-deterrence region is smaller than in the baseline model ($\bar{d}_{LC} > \bar{d}$ and $\underline{d}_{LC} < \underline{d}$). Second, when litigation becomes too expensive for the investors, then the investors will no longer bring suit, compromising deterrence and generally reducing social welfare. This is illustrated by the gray region in Figure 4. Finally, holding all else equal, the litigation costs are a social waste and thus increasing litigation costs reduces social welfare. In the no-deterrence region of Figure 4, increasing the litigation costs (on the margin) has no offsetting social benefits. The local comparative statics are described in the following corollary.

Corollary 2. *(Local Comparative Statics.) Suppose that the investors and the firm bear costs ϕ_p and ϕ_d, respectively. If $d < d_0(\pi)$ then private payoffs and social welfare do not depend on ϕ_p, ϕ_d, or d. If $d \geq d_0(\pi)$, we have the following:*

1. *Full Deterrence. If $d > \bar{d}_{LC}$, private payoffs and social welfare do not depend on ϕ_p, ϕ_d, or d.*

2. *Partial Deterrence. If $\underline{d}_{LC}(\pi) \leq d \leq \bar{d}_{LC}$, the l-type's payoff is independent of ϕ_d and d, the u-type's payoff is increasing in ϕ_d and d, and social welfare is increasing in ϕ_d and d. Private payoffs and social welfare do not depend on ϕ_p.*

3. *No Deterrence. If $d < \underline{d}_{LC}(\pi)$, the l-type's payoff, the u-type's payoff, and social welfare are decreasing in ϕ_p and ϕ_d. The l-type's payoff is decreasing in d, the u-type's payoff is increasing in d, and social welfare does not depend on d.*

4 Liability and Class Action Waivers

In the baseline model and the extensions we have analyzed so far, we have assumed that the liability system (d and ϕ) is predetermined and known by the players. (The case of no liability was implicitly analyzed along the horizontal axis in Figure 1 where $d = 0$.) The liability system was also assumed to be mandatory. One of

the important debates in this area (particularly with respect to the federal securities laws) is whether to allow the firms to choose a different liability system. As alluded to briefly in the introduction, one prominent discussion is over whether to allow the firms (notably, at the time of their initial public offerings) to opt out of class actions by contractually requiring individual arbitration on the investors. We can analyze this issue by giving the firm a choice (at $t = 3$) over the liability system. Given that a mandatory individual arbitration system can lead to de facto liability waiver and that an examination of a different litigation format necessitates an assumption of positive litigation cost, we divide the discussion into two parts: liability waivers and class action waivers.

Before we proceed to a more detailed discussion, we start with a few general observations. Whether the firm will adopt either type of waiver and whether the firm's choice is welfare increasing depends on a few factors. With respect to the firm's incentive, given that the l-type wants to pool with the u-type in equilibrium, the l-type will mimic the u-type choice (over waiver) and the firm's equilibrium choice depends on the u-type's incentive.[40] Given that the u-type's return is given by $(1 - \alpha^*)\overline{x} - e$, the u-type will prefer a policy that will generate a lower α^*. From the social welfare perspective, however, the welfare depends on the l-type's equilibrium participation rate (β^*) and the cost of litigation (ϕ): by decreasing β^* and ϕ, the social welfare will increase. Note here the potential divergence between the private (u-type's) incentive and the social welfare. Whether the u-type's incentive coincides with improving social welfare depends on the equilibrium that we operate in.

4.1   Liability Waivers

Suppose, at the time of offering its equity to outside investors (at $t = 3$), the firm (and the entrepreneur) can opt out of the liability system through a liability waiver. From the model, this would be equivalent to setting $d = 0$. For the h-type, having the option of waiving liability doesn't matter, since the entrepreneur will disclose her information to the investors and there would be no ex post liability. As briefly discussed earlier, given that the l-type's incentive is to mimic the u-type and get financed, whether the firm will impose a liability waiver depends on the u-type's incentive, which may or may not align with maximizing social welfare. We now discuss the incentives of the u-type and l-type to waive liability, and the divergence between their private incentives and the social incentives. The discussion is divided into two settings: when litigation is costless ($\phi = 0$) and when litigation is costly ($\phi > 0$).

---

[40]If the l-type did not mimic the u-type, then the market would rationally infer that it is a socially wasteful venture.

Suppose that litigation is costless ($\phi = 0$) as in Proposition 2. As described in Corollary 1, the u-type's payoff is (weakly) increasing (i.e., α^* is (weakly) decreasing) in d. This is the case for two reasons. First, when the investors can recover higher damages d from the l-type, this can lower the l-type's participation rate (β^* falls) and, as a result, the investors would demand a lower α^* from the non-disclosing entrepreneur. Second, even if the l-type is undeterred and participates with certainty ($\beta^* = 1$), the investors know that they can recover damages d from the l-type and they will demand a lower fraction of the firm (α^*) ex ante.[41] Thus, when $\beta^* = 1$, the liability system shifts rents from the l-type to the u-type. Note that the l-type has an incentive to mimic and pool with the u-type. If the l-type demanded a liability waiver while the u-type did not, this would signal to the capital market that the firm is withholding bad news. In sum, when litigation is costless, neither the l-type nor the u-type will waive liability in equilibrium. The private incentives are aligned with the social incentives, since social welfare is higher (β^* is weakly lower) with liability than without it.[42]

When litigation is costly (Proposition 5), there is the third factor that comes into play: the potential deadweight loss from litigation, measured by ϕ. Given that a positive litigation cost imposes a litigation credibility constraint, we need to examine two regions (two sub-cases) separately. As shown in Corollary 2, when litigation is not credible, $d \leq d_0(\pi)$, both the u-type and the l-type are indifferent to the possibility of waiving liability, since both types know that lawsuits will not be brought. Social welfare is also unaffected by their choice. With non-credible litigation, it is as if liability waiver has been imposed on the firm and the investors.

When litigation is credible ($d > d_0(\pi)$), on the other hand, the effects are more complicated. When there is no deterrence and the l-type is participating with certainty ($\beta^* = 1$), as shown in case 3 of Corollary 2, the the u-type's return is higher (equilibrium α^* is lower) with liability than without. Hence, the u-type would not waive liability and the l-type will mimic. However, given that the l-type is undeterred ($\beta^* = 1$) with or without liability, imposing liability reduces social welfare by imposing a deadweight loss of ϕ. When $\beta^* = 1$, the private incentives to waive liability are socially insufficient and there is too much costly litigation in equilibrium.

Now suppose litigation is credible ($d > d_0(\pi)$), but we have partial deterrence against the l-type's participation ($\beta^* \in (0, 1)$). Similar to the previous case of no

---

[41]In fact, if the firm were also allowed to choose the damages, the u-type will choose $d \geq \bar{d}$ so as to completely deter the l-type from pooling with the u-type.

[42]If $\beta^*(0) = \beta^*(d) = 1$, social welfare is the same with or without liability, since liability simply shifts rents from the l-type to the u-type. The private parties will not waive liability, as the u-type's preferences prevail.

deterrence, here the u-type will generally prefer having the liability system (i.e., not waiving liability). With a positive return from ex post litigation, the investors will demand a lower α^* for investing c and this will increase the u-type's equilibrium return. As shown in the proof of Proposition 5, with liability, the l-type's equilibrium participation rate (β^*) will also decrease. Social welfare is also aligned with the u-type's incentive. As seen in the proof for Corollary 2, social welfare goes up with liability than without. Because the investors break even and, with partial deterrence, the l-type is indifferent about participating, the u-type becomes the de facto residual claimant, thereby aligning its incentive with social welfare.

4.2   Class Action Waivers

Another important policy tool is to allow the firm to waive class actions or to choose the dispute resolution forum (instead of opting out of the liability system altogether).[43] One particular mechanism that has received much attention over the years is to allow the firm to impose a mandatory individual arbitration or class action waiver provision on the investors and thereby prohibit investors from bringing a class action lawsuit (Scott and Silverman (2013) and Webber (2015)). While there are numerous legal differences between class and individual (arbitration) actions, one important benefit of class actions is the economies of scale: it allows individual plaintiffs to aggregate their claims and lower the per-plaintiff cost of litigation (Choi and Spier (2021, 2022)). In our setup, by allowing class actions (i.e., by not imposing class action waivers), the firm allows future investor-plaintiffs to aggregate their claims and lower their litigation cost (from ϕ_p to ϕ_p^c, where $\phi_p^c < \phi_p$). For simplicity, we will assume that the class action system has no effect on the defendant's litigation cost (ϕ_d remains unchanged).

Given that a class action waiver affects the plaintiff's litigation cost (ϕ_p), the analysis is done in the setting where litigation cost is positive. In terms of the firm's incentive of allowing class actions (or imposing a class action waiver), as with the liability waiver case, the h-type will be indifferent with respect to class actions since it will not be found liable ex post. Similarly, whether the u-type and the l-type will impose a class action waiver depends on the u-type's incentive (in trying to lower α^*). When litigation is not credible ($d \leq d_0(\pi)$), since there is no litigation in equilibrium, the u-type would be indifferent to allowing class actions (class action waivers are irrelevant) and the l-type will mimic. Social welfare is also unaffected.

Now, suppose, without class actions, litigation is credible ($d > d_0(\pi)$). Suppose,

---

[43]See Aggarwal et al. (2020) on the analysis of firms' confining federal Securities Law litigation to federal forum.

29

first, that the l-type is undeterred ($\beta^* = 1$). As shown in the proof of Corollary 2, by decreasing ϕ_p, because the investors' litigation return increases, they demand a lower α^*. That is, the u-type will strictly prefer to allow class actions (i.e., lower the plaintiff's litigation cost to ϕ_p^c) and the l-type will follow. This is good for social welfare as well, since with the certain participation by the l-type ($\beta^* = 1$), lowering the plaintiff's litigation cost reduces the deadweight loss. On the other hand, if the l-type is only partially deterred ($\beta^* \in (0,1)$), as shown in Proposition 5, in equilibrium, α^* is independent of ϕ_p. With this, the u-type would be indifferent to class action waivers. Furthermore, as shown in Corollary 2, social welfare is independent of ϕ_p. Hence, the u-type's (and the mimicking l-type's) decision is aligned with social welfare.

One complicating issue is what happens when litigation becomes credible when class action is allowed (i.e., there is a shift in equilibrium). From the proof of Proposition 5 and not surprisingly, we know that when ϕ_p decreases, $d_0(\pi)$ decreases.[44] Hence, for a given (π, d), it is possible that when we lower the plaintiff's litigation cost from ϕ_p to ϕ_p^c, litigation becomes credible. It is fairly straightforward to see that, when this shift happens, investors will demand a lower α and the u-type will benefit. At the same time, social welfare may actually fall, especially when we are initially in the no deterrence region, since allowing litigation in equilibrium without any deterrence benefit will only impose a deadweight loss. In such case, the u-type's (and the mimicking l-type's) decision to allow class actions is socially excessive.

5   Empirical Predictions

In addition to the normative implications regarding liability and class action waivers, the analysis also renders a number of empirical predictions. The first prediction is with respect to private securities litigation. The results imply that as the fraction of outside ownership (α) rises, holding constant the (expected) recovery, investors are less inclined to bring private securities lawsuits against the firm. Griffith and Lund (2020), for instance, found that even though shareholder litigation offers potential benefits for large mutual funds with buy-and-hold strategy, they have essentially "forfeited" their right to bring litigation.[45] From the model, when an institutional shareholder owns a large fraction of a firm's outstanding equity, the shareholder would be much less inclined to file or actively participate in a lawsuit since the net return from litigation would be much smaller or even non-existent. In fact, when class action

---

[44]We also know that, when class action is imposed, $\overline{d}_{LC}$ does not change while $\underline{d}_{LC}(\pi)$ increases (except when $\pi = 0$). The reason for the latter is that, with partial deterrence, a marginal decrease in ϕ_p increases the investors' ex ante return and to maintain the investors' break-even condition, the l-type has to participate with a higher probability.

[45]See also Webber (2015).

lawsuits are filed by other investors, such as retail investors with little or no ownership stake in the firm, the institutional investors with a large ownership interest may be more inclined to have the lawsuits dismissed or be settled relatively quickly.[46]

The second set of implications is with respect to initial public offering and a possible way of estimating the size of the deterrence effect. As the analysis shows, as the level of deterrence gets weaker, because the probability with which the l-type participates in financing (without disclosing bad news) gets (weakly) higher, over-pricing at the initial offerings becomes more frequent (while the fraction IPOs that is under-priced gets lower).[47] At the same time, while the frequency of over-pricing goes up with lower deterrence, as the rational investors begin to discount the stock more (i.e., demand a larger α in the model), the (average) size of over-pricing should become smaller (and the (average) size of under-pricing becomes larger). In addition to making implications about IPO over and under-pricing, this implication also offers a way of (indirectly) measuring the level of deterrence, i.e., by estimating the frequency and size of over-pricing (or under-pricing) at IPOs.

The third set of empirical implications deals with when we may be able to observe better or worse deterrence. Foremost, the model shows that when the size of litigation recovery (d) is small and/or the degree of adverse selection (π) is small, the firms (and the entrepreneurs) are much less likely to be deterred (they participate with a high β^*). As the Facebook example in the introduction shows, most of securities class actions are settled and many are settled for relatively small amount (compared to the potential recovery).[48] If we think that the investors expect to receive relatively little from future securities litigation, they expect that the small damages will produce little or no deterrence and will simply take strategic non-disclosure as given. On the other hand, as analyzed in the extensions, as more liability is imposed not on the

---

[46]Choi and Spier (2018), for instance, discuss scenarios where shareholders with a long position on the firm would be more willing to accept relatively low settlement amount.

[47]Using a sample of IPOs from 1965 through 2005, Lowry, Officer, and Schwert (2010) show that while on average, IPOs are under-priced, about one-third of IPOs are over-priced (had a negative return, measured over twenty trading days after the IPO). Our model is constructed using the fraction of the firm (α) sold to the investors, but we can easily translate the result using per-share price. Suppose both the l-type and the u-type firms have n total number of shares and sell m shares to the outside investors, so that $m/n = \alpha$. Conditional on non-disclosure, if the investors' expected valuation of the firm is v, we get $p = v/n$, where p stands for the IPO price. We also have $v = \gamma x_l + (1 - \gamma)\overline{x}$, where γ stands for the conditional probability of facing the l-type (which depends on β). As γ rises (when β rises), the fraction of IPOs that are over-priced increases but because v falls, the size of over-pricing (measured by $(v - x_l)/n$) decreases.

[48]According to Bohn and Choi (1996), over 90% of securities class actions end in settlement. See also Choi, Choi, and Pritchard (2022). Lowry and Shu (2002) shows that the average settlement size, which did not include litigation costs, is about 11% of the total proceeds raised at IPOs.

firm but on the entrepreneur, we get better deterrence. Also, the possibility of false positives will lead not only to lower deterrence but also to more "innocent" firms being prosecuted.

6 Conclusion

Under the current legal system, when a firm sells its stock (or other securities) to outside investors to raise capital, the firm can be held liable to the investors for non-disclosure of material information. Although the general objective of the liability system is to discourage firms from withholding material information and to promote better functioning capital markets, including the IPO market, the system has also attracted criticism for being inefficient and too costly. Is firm liability an effective deterrent? Do the benefits of firm liability outweigh the costs? Instead of having a one-size-fits-all mandatory system, should the firm be able to design their own liability system?

The paper has analyzed how the liability system affects a firm's incentive to disclose material information using a simple game-theoretic model. In the model, the firm can sell stock to the outside investors to raise capital while deciding whether to withhold material information from the prospective investors, and the investors can bring a lawsuit against the firm to recover damages. Investors are rational and forward looking, and anticipate being plaintiffs in future litigation in case non-disclosure is uncovered. The paper has shown that the equilibrium (non-disclosure and financing) depends on a number of factors, including the amount of personal capital that the entrepreneur needs to invest, the size of damages that the investors can recover, the frequency with which the entrepreneur is privately informed (the degree of adverse selection), and the cost of litigation.

Building on the analysis, the paper examined several policy proposals, in particular, whether to allow firms to choose their own liability system with either a liability waiver or a class action waiver. We showed that the firms' choice of liability system may or may not align with the socially optimal choice. The reason for the divergence comes from the fact that while the firms care about maximizing their own profits (and not about disclosure per se), social welfare depends on deterring strategic non-disclosure and minimizing the deadweight loss from litigation. The analysis showed that the firms may have an excessive incentive to opt into a costly litigation system to reduce their cost of capital.[49] The divergence is especially pronounced when litigation is costly and the level of deterrence is already low (because damages are small,

---

[49]Intuitively, if investors are fully rational and expect the future returns from litigation, they would be willing to finance a firm's investment at a lower cost.

adverse selection isn't as severe, or both), and promoting litigation will lead to a larger welfare loss. When such divergence is likely, shrinking or eliminating liability for non-disclosure can potentially increase social welfare.

Our simple model abstracted from several relevant factors, including externalities on third parties and the bounded rationality of investors. If the returns from litigation are captured in part by non-investing third parties, such as the lawyers representing investor class, the link between ex post liability and ex ante financing cost becomes more tenuous. Other factors, such as investor myopia and settlement (that benefits third parties at the expense of investors), can also come into play. When these factors are taken into account, the private incentives to opt out of costly litigation (with liability waivers or class action waivers) may be socially excessive rather than socially insufficient. We intend to analyze these factors in future research.

References

[1] Aggarwal, Dhruv, Albert H. Choi, and Ofer Eldar. "Federal Forum Provisions and the Internal Affairs Doctrine." *Harvard Business Law Review*, Vol. 10 (2020), pp. 383–434.

[2] Alexander, Janet. "The Lawsuit Avoidance Theory of Why Initial Public Offerings are Underpriced." *UCLA Law Review*, Vol. 41 (1993), pp. 17–73.

[3] Atkins, Dorothy. "Facebook's $35M Deal to End IPO Suit Gets Initial OK." *Law360*, 26 February 2018.

[4] Bohn, James and Stephen Choi. "Fraud in the New-Issues Market: Empirical Evidence on Securities Class Actions." *University of Pennsylvania Law Review*, Vol. 144 (1996), pp. 903–982.

[5] Caskey, Judson. "The Pricing Effects of Securities Class Acton Lawsuits and Litigation Insurance." *The Journal of Law, Economics, & Organization*, Vol. 30 (2014), pp. 493–532.

[6] Choi, Albert H., Stephen Choi, and Adam Pritchard. "Just Say No? Shareholder Voting on Securities Class Actions." *forthcoming* in *University of Chicago Business Law Review* (2022).

[7] Choi, Albert H. and Kathryn Spier. "Class Actions and Private Antitrust Litigation." *forthcoming* in *American Economic Journal: Microeconomics* (2022).

[8] Choi, Albert H. and Kathryn Spier. "The Economics of Class Action Waivers." *Yale Journal on Regulation*, Vol. 38 (2021), pp. 543–565.

[9] Choi, Albert H. and Kathryn Spier. "Taking a Financial Position in Your Opponent in Litigation." *American Economic Review*, Vol. 108 (2019), pp. 3636–3650.

[10] Drake, Philip and Michael Vetsuypens. "IPO Underpricing and Insurance against Legal Liability." *Financial Management*, Vol. 22 (1993), pp. 64–73.

[11] Dye, Ronald. "Disclosure of Nonproprietary Information." *Journal of Accounting Research*, Vol. 23 (1985), pp. 123–145.

[12] Dye, Ronald. "Optimal Disclosure Decisions When There Are Penalties for Nondisclosure." *The RAND Journal of Economics*, Vol. 48 (2017), pp. 704–732.

[13] Farrell, Joseph. "Voluntary Disclosure: Robustness of the Unraveling Result." In R. Grieson, ed. *Antitrust and Regulation.* New York: Lexington Books, 1986.

[14] Graf, Rachel. "Attys in $35M Facebook Deal Seeks $14M in Fees, Costs." *Law360*, 2 August 2018.

[15] Griffith, Sean and Dorothy Lund "A Mission Statement for Mutual Funds in Shareholder Litigation." *University of Chicago Law Review*, Vol. 87 (2020), pp. 1149–1240.

[16] Grossman, Sanford J. "An Introduction to the Theory of Rational Expectations under Asymmetric Information." *Review of Economic Studies*, Vol. 48 (1981), pp. 541–559.

[17] Grossman, Sanford J. and Oliver Hart. "Disclosure Laws and Takeover Bids." *The Journal of Finance*, Vol. 35 (1981), pp. 323–334.

[18] Hughes, Patricia. "Signalling by Direct Disclosure under Asymmetric Information," *Journal of Accounting and Economics*, Vol. 8 (1986), pp. 119–142.

[19] Hughes, Patricia and Anjan Thakor. "Litigation Risk, Intermediation, and the Underpricing of Initial Public Offerings," *Review of Financial Studies*, Vol. 5 (1992), pp. 709–742.

[20] Kim, Moonchul and Jay Ritter. "Valuing IPOs." *Journal of Financial Economics*, Vol. 53 (1999), pp. 409–437.

[21] Lowry, Michelle, Micah Officer, and William Schwert. "The Variability of IPO Initial Returns." *Journal of Finance*, Vol. 65 (2010), pp. 425–465.

[22] Lowry, Michelle and Susan Shu. "Litigation Risk and IPO Underpricing," *Journal of Financial Economics*, Vol. 65 (2002), pp. 309–335.

[23] Milgrom, Paul. "Good News and Bad News: Representation Theorems and Applications," *The Bell Journal of Economics*, Vol. 12 (1981), pp. 380–391.

[24] Polinsky, A. Mitchell and Steven Shavell. "Mandatory Versus Voluntary Disclosure of Product Risks." *The Journal of Law, Economics, & Organization*, Vol. 28 (2012), pp. 360–379.

[25] Ritter, Jay. "Equilibrium in the Initial Offerings Market." *Annual Review of Financial Economics*, Vol. 3 (2011), pp. 347–374.

[26] Ritter, Jay and Ivo Welch. "A Review of IPO Activity, Pricing, and Allocations," *Journal of Finance*, Vol. 57 (2002), pp. 1795–1828.

[27] Scott, Hal. "Shareholders Deserve Right to Choose Mandatory Arbitration." *Columbia BlueSky Blog*, 28 July 2017. Available at https://clsbluesky.law.columbia.edu/2017/08/21/shareholders-deserve-right-to-choose-mandatory-arbitration/.

[28] Scott, Hal. "The SEC's Misguided Attack on Shareholder Arbitration." *The Wall Street Journal*, 21 February 2019.

[29] Scott, Hal and Leslie Silverman. "Stockholder Adoption of Mandatory Individual Arbitration for Stockholder Disputes." *Harvard Journal of Law and Public Policy*, Vol. 36 (2013), pp. 1187–1230.

[30] Shavell, Steven. "Acquisition and Disclosure of Information Prior to Sale." *The RAND Journal of Economics*, Vol. 25 (1994), pp. 20–36.

[31] Spindler, James. "IPO Liability and Entrepreneurial Response." *University of Pennsylvania Law Review*, Vol. 155 (2007), pp. 1187–1228.

[32] Tinic, Seha. "Anatomy of Initial Public Offerings of Common Stock." *Journal of Finance*, Vol. 43 (1988), pp. 789–822.

[33] Webber, David. "Shareholder Litigation without Class Actions." *Arizona Law Review*, Vol. 57 (2015), pp. 201–267.

Appendix

Proof of Lemma 1. Consider an equilibrium where the u-type participates with positive probability. Suppose there is no disclosure and let b_h, b_u, b_l be the capital market's conditional beliefs where $b_h + b_u + b_l = 1$ where $b_u \in (0, 1]$. Since outside investors break even, α^* satisfies

$$b_h \alpha^* x_h + b_u \alpha^* \overline{x} + b_l(d + \alpha^*(x_l - d)) - c = 0. \tag{32}$$

We will prove $b_h = 0$ (the h-type does not pool with the u-type) and that $\alpha^* \geq c/\overline{x}$.

First consider a PBNE where the l-type does not participate, $b_l = 0$. Suppose that conditional no disclosure, the market believes $b_h > 0$ and $b_u > 0$. In this case, $\alpha^* \in \left(\frac{c}{x_h}, \frac{c}{\overline{x}}\right)$. This isn't a PBNE since the h-type would disclose and secure $\alpha_h = \frac{c}{x_h}$. Suppose instead that the market believes $b_u = 0$ and $b_h = 1$. In this case, $\alpha^* = \alpha_h = c/x_h$. This isn't a PBBE since the u-type would participate. Therefore in a PBNE with $b_l = 0$ we have $b_h = 0$, $b_u = 1$, and $\alpha^* = c/\overline{x}$.

Next consider a PBNE where the l-type participates with positive probability, $b_l > 0$. The l-type's payoff is $(1 - \alpha^*)(x_l - d) - e \geq 0$. Rearranging gives $d + \alpha^*(x_l - d) \leq x_l - e$. Substituting into the investors' break-even condition (32),

$$b_h \alpha^* x_h + b_u \alpha^* \overline{x} + b_l(x_l - e) - c \geq 0. \tag{33}$$

We can prove $\alpha^* \geq c/\overline{x}$ by contraction. Suppose first that that $\alpha^* \leq c/x_h < c/\overline{x}$. Substituting into (33),

$$b_h c + b_u \frac{\overline{x}}{x_h} c + b_l(x_l - e) - c \geq 0. \tag{34}$$

Since $\frac{\overline{x}}{x_h} < 1$, this implies

$$b_h c + b_u c + b_l(x_l - e) - c = b_l(x_l - e - c) > 0. \tag{35}$$

This is a contradiction since $x_l - e - c < 0$. Therefore $\alpha^* > c/x_h$. Next, suppose $\alpha^* \in (c/x_h, c/\overline{x})$. The h-type will disclose and secure $\alpha_h = c/x_h < \alpha^*$ and so $b_h = 0$. Substituting into (33),

$$b_u c + b_l(x_l - e) - c = b_l(x_l - e - c) > 0, \tag{36}$$

a contradiction. Therefore $\alpha^* \geq c/\overline{x}$. This completes the proof that if the u-type participates with positive probability then the h-type discloses and the equity stake conditional on non-disclosure is $\alpha^* \geq c/\overline{x}$. $\qquad \square$

Proof of Lemma 2. Note that $\beta^* = 0$, $\alpha^* = \overline{\alpha} = c/\overline{x}$ defined in (3), and $d = \overline{d}$ defined in (4) satisfy equilibrium conditions (1) and (2) with equality.

Suppose that $d > \overline{d}$. We will prove that $\beta^* = 0$ by contradiction. Suppose not: $\beta^* > 0$. Condition (1) implies that $(1 - \alpha^*)(x_l - d) - e \geq 0$, and so $\alpha^* < \overline{\alpha}$. Condition (1) also implies that $\alpha^*(x_l - d) \geq x_l - d - e$. Substituting this into (2) gives $(1 - \pi)(\alpha^*\overline{x} - c) + \pi q\beta^*(x_l - k) \geq 0$. Solving for α^* and using the definition of $\overline{\alpha}$ in (3) gives

$$\alpha^* \geq \overline{\alpha} + \frac{\pi q\beta^*}{1 - \pi} \cdot \frac{k - x_l}{\overline{x}}. \tag{37}$$

If $\beta^* > 0$ then $\alpha^* > \overline{\alpha}$, a contradiction. Thus, if $d > \overline{d}$ then $\beta^* = 0$. □

Proof of Lemma 3. We will prove that if $d < \underline{d}(\pi)$ defined in (5) then $\beta^* = 1$. To do this, we will prove that if $\beta^* < 1$ then $d \geq \underline{d}(\pi)$.

Suppose $\beta^* < 1$. Condition (1) implies $(1 - \alpha^*)(x_l - d) - e \leq 0$. Rearranging, $\alpha^*(x_l - d) \geq x_l - d - e$. Substituting into (2) gives $(1 - \pi)(\alpha^*\overline{x} - c) + \pi q\beta^*(x_l - k) \leq 0$. Solving for α^* gives:

$$\alpha^* \leq \frac{c}{\overline{x}} + \frac{\pi q\beta^*}{1 - \pi} \cdot \frac{k - x_l}{\overline{x}}.$$

Since $\beta^* < 1$ by assumption, and using the definition of $r(\pi)$ in (6),

$$\alpha^* < \frac{c}{\overline{x}} + r(\pi).$$

Next, since condition (1) implies $(1 - \alpha^*)(x_l - d) - e \leq 0$ we have

$$d \geq x_l - \frac{e}{1 - \alpha^*}.$$

Substituting $\alpha^* < c/\overline{x} + r(\pi)$, gives

$$d > x_l - \frac{e}{1 - c/\overline{x} - r(\pi)}.$$

The right-hand side is $\underline{d}(\pi)$ defined in (5). This establishes that if $\beta^* < 1$ then $d \geq \underline{d}(\pi)$. Therefore if $d < \underline{d}(\pi)$ then $\beta^* = 1$.

Note that the right-hand side may be positive or negative. Since $r(\pi)$ in (6) is an increasing function of π with $r(0) = 0$ and $\lim_{\pi \to 1} r(\pi) = \infty$, there exists a unique threshold $\widehat{\pi}_0$ where the right-hand side equals zero. □

Proof of Proposition 2. *Case 1.* The full deterrence result follows from Lemma 2.

Case 2. The partial deterrence result may be found by solving (7) and (8) simultaneously. The comparative statics are immediate.

Case 3. In the no-deterrence range, the equilibrium $\alpha^*(d, \pi)$ in (11) may be found by setting $\beta^* = 1$ in the investors' break-even condition (2). Notice that $\alpha^*(d, 0) = \overline{\alpha} = c/\overline{x} > 0$ and $\alpha^*(0, \pi) > 0$ for all $\pi \in (0, 1)$. We will show that $\alpha^*(d, \pi)$ is decreasing in d and increasing in π. Letting $z = \pi q/(1 - \pi)$, rewrite (11)

$$\alpha^*(d, \pi) = \frac{c + z(c - d)}{\overline{x} + z(x_l - d)}.$$

First, we show that α^* is an increasing function of x. When we differentiate with respect to z, we get:

$$\frac{\partial \alpha^*(d, \pi)}{\partial z} = \frac{(\overline{x} + z(x_l - d))(c - d) - (c + z(c - d))(x_l - d)}{(\overline{x} + z(x_l - d))^2}$$

$$= \frac{\overline{x}(c - d) - c(x_l - d)}{(\overline{x} + z(x_l - d))^2}$$

$$= \frac{c(\overline{x} - x_l) - d(\overline{x} - c)}{(\overline{x} + z(x_l - d))^2}.$$

The numerator is positive if

$$d < \frac{c(\overline{x} - x_l)}{\overline{x} - c}$$

The right-hand side is larger than $\overline{d}$ defined in (4) above. To prove this,

$$\frac{c(\overline{x} - x_l)}{\overline{x} - c} < \overline{d} = x_l - \frac{e}{1 - c/\overline{x}} = x_l - \frac{e\overline{x}}{\overline{x} - c} = \frac{x_l(\overline{x} - c) - e\overline{x}}{\overline{x} - c}$$

This is true if and only if

$$c(\overline{x} - x_l) < x_l(\overline{x} - c) - e\overline{x} = c\overline{x} - x_l\overline{x} + e\overline{x} = \overline{x}(c + e - x_l) < 0,$$

which is true because $c + e + x_l = k - x_l < 0$ by assumption. So the numerator is positive for all $d < \overline{d}$. Thus α^* is an increasing function of z and by extension π.

Next we show that $\alpha^*(d, \pi)$ is a decreasing in d. Differentiating with respect to d, we get:

$$\frac{\partial \alpha^*(d, \pi)}{\partial d} = \frac{(\overline{x} + z(x_l - d))(-z) - (c + z(c - d))(-z)}{(\overline{x} + z(x_l - d))^2}.$$

The denominator is positive. The numerator is negative if

$$-\overline{x} - z(x_l - d) + c + z(c - d) < 0$$

$$-\overline{x} - zx_l + c + zc < 0$$

$$-z(x_l - c) - (\overline{x} - c) < 0.$$

Recall that $z = \pi q/(1-\pi) > 0$ for all $\pi \in (0,1)$ and our assumption that $\max\{e, c\} < x_l$ implies that $\overline{x} - c > x_l - c > 0$. Therefore the left-hand side is negative. We have established that α^* is a decreasing function of d and this completes the proof. $\square$

Proof of Corollary 1. Consider the three cases in Proposition 2.

Case 1. The l-types are fully deterred, $\beta^*(d, \pi) = 0$, and $\alpha^* = c/\overline{x}$. From (12), social welfare

$$SW(d, \pi) = (1 - \pi)(\overline{x} - k) + \pi(1 - q)(x_h - k).$$

Differentiating with respect to π,

$$\frac{\partial SW(d, \pi)}{\partial \pi} = -(\overline{x} - k) + (1 - q)(x_h - k).$$

Substituting $\overline{x} = qx_l + (1 - q)x_h$, we get:

$$= -qx_l - (1 - q)x_h + k + (1 - q)x_h - k + qk$$

$$= -qx_l + qk = q(k - x_l) > 0.$$

Therefore social welfare is an increasing function of π in case 1.

Case 2. The l-type is indifferent and therefore gets a payoff of zero for all d and π. The u-type's payoff is $(1 - \alpha^*(d, \pi))\overline{x} - e > 0$. Since $\alpha^*(d, \pi)$ in (9) is decreasing in d and invariant to π. Using $\beta^*(d, \pi)$ in (10), social welfare in (12) becomes

$$SW(d, \pi) = (1 - \pi)(\overline{x} - k) + \pi(1 - q)(x_h - k) + (1 - \pi)\left[c - \left(1 - \frac{e}{x_l - d}\right)\overline{x}\right].$$

$$\frac{\partial SW(d, \pi)}{\partial \pi} = -(\overline{x} - k) + (1 - q)(x_h - k) - \left[c - \left(1 - \frac{e}{x_l - d}\right)\overline{x}\right].$$

The right-hand side is a decreasing function of d for all $d < x_l$. So if the right-hand side is positive when $d = \overline{d}$, it is positive for all $d < \overline{d}$. The third term is equal to zero when $d = \overline{d}$ defined in (4), so

$$\frac{\partial SW(0, \pi)}{\partial \pi} = -(\overline{x} - k) + (1 - q)(x_h - k).$$

Substituting for $\bar{x}$ and rearranging confirms that this is positive (see the proof in case 1). This confirms that social welfare is increasing in π in case 2.

Case 3. Since $\beta^*(d, \pi) = 1$ and there is full participation of l-type, social welfare in (12) is $SW(d, \pi) = \bar{x} - k$; it does not depend on d or π. $\alpha^*(d, \pi)$ defined in (11) is decreasing in d and increasing in π. Therefore the u-type's payoff, $(1 - \alpha^*(d, \pi))\bar{x} - e > 0$, is increasing in d and decreasing in π. The l-type's payoff is $(1 - \alpha^*(d, \pi))(x_l - d) - e > 0$. This is decreasing in d. Since social welfare $SW(d, \pi)$ is independent of d, and the h-type aggregate payoff is independent of d, it follows that the l-type payoff is decreasing in d. □

Proof of Proposition 3. *Case 1.* As in Lemma 1, investors demand $\alpha^* \geq c/\bar{x}$. The l-type is fully deterred if $(1 - \alpha^*)x_l - e - d < 0$ or $d > \bar{d}_{EL}$ in equation (14).

Case 2. The investors' break-even condition is

$$(1 - \pi)(\alpha^*\bar{x} - c) + \pi q \beta^*(\alpha^* x_l - c + d) = 0. \tag{38}$$

The expressions for α^*_{EL} in (16) and $\beta^*_{EL}(d, \pi)$ in (17) may be found by solving the l-type's break-even condition (13) and the investors' break-even condition (38) simultaneously. The comparative statics are immediate.

Case 3. In the no-deterrence range, the equilibrium $\alpha^*_{EL}(d, \pi)$ in (18) may be found by setting $\beta^* = 1$ in the investors' break-even condition (38). Rearranging,

$$\alpha^*[(1 - \pi)\bar{x} + \pi q x_l] = (1 - \pi)c + \pi q(c - d).$$

Dividing through by $(1 - \pi)\bar{x} + \pi q x_l$ gives (18). □

Corollary 3 (**Comparative Statics on Entrepreneur Liability Case**). *Suppose that the entrepreneur is held personally liable for non-disclosure.*

1. *The l-type's payoff is (weakly) decreasing in d, the u-type's payoff is (weakly) increasing in d, and social welfare is (weakly) increasing in d.*

2. *Compared to the baseline model where the investors collect damages from the firm, the l-type entrepreneur's payoff is (weakly) lower, the the u-type's payoff is (weakly) higher, and social welfare is (weakly) higher.*

Proof of Corollary 3. Consider the three cases in Proposition 3.

Case 1. Since $\beta^*_{EL}(d, \pi) = 0$ social welfare and private payoffs do not depend on d.

Case 2. Since $\beta^*_{EL}(d, \pi)$ in (17) is decreasing in d we have that social welfare in (12) is increasing in d. Since $\alpha^*_{EL}(d, \pi)$ in (16) is decreasing in d, the u-type is better off when d rises. The l-type is indifferent and gets a payoff of zero.

Case 3. Since $\beta^*_{EL}(d, \pi) = 1$ social welfare does not depend on d. Since $\alpha^*_{EL}(d, \pi)$ in (18) is decreasing in d, the u-type is better off when d increases. Since social welfare does not depend on d, the l-type is worse off when d increases.

$\square$

Proof of Proposition 4. Let's first start with the full deterrence case ($\beta^* = 0$). When only the u-type participates in financing, the investors' equilibrium break-even condition is given by:

$$(1 - \pi)(\alpha^* \overline{x} - c + q(1 - \alpha)\lambda d) = 0.$$

Compared to the case without any false positives ($\lambda = 0$), in equilibrium, the investors receive a litigation return of $(1 - \alpha)\lambda d$ from the u-type when x_l is realized, which happens with probability q. From this, we get the equilibrium fraction for the investors:

$$\alpha^* = \frac{c - q\lambda d}{\overline{x} - q\lambda d}$$

Whenever $\lambda > 0$, $\frac{c - q\lambda d}{\overline{x} - q\lambda d} < \frac{c}{\overline{x}}$. Also, $\frac{\partial \alpha}{\partial \lambda} = \frac{-qd(\overline{x} - c)}{(\overline{x} - q\lambda d)^2} < 0$ and $\frac{\partial \alpha}{\partial d} = \frac{-q\lambda(\overline{x} - c)}{(\overline{x} - q\lambda d)^2} < 0$. Compared to the baseline case ($\lambda = 0$), because the investors get additional return from the u-type through litigation, the equilibrium fraction for the investors is lower.

To ensure that the l-type is fully deterred, we need: $(1 - \alpha^*)(x_l - d) - e < 0$. Let $\overline{d}$ be given by: $(1 - \alpha^*)(x_l - d) - e = 0$. When we substitute in the expression for α^* and simplify, we get:

$$\overline{d}_{FP}(e) = \frac{(\overline{x} - c)x_l - e\overline{x}}{\overline{x} - c - eq\lambda}.$$

When $\lambda = 0$, we get $\overline{d}_{FP}(e) = \frac{(\overline{x} - c)x_l - e\overline{x}}{\overline{x} - c - eq\lambda} = x_l - \frac{e\overline{x}}{\overline{x} - c} = \overline{d}(e)$. Compared to the baseline case, a stronger liability is necessary to fully deter the l-type from participating.

Now, suppose we are in the partial deterrence region ($\beta^* \in (0, 1)$). The l-type's indifference condition is given by $(1 - \alpha^*)(x_l - d) - e = 0$, from which we get: $\alpha^* = 1 - \frac{e}{x_l - d}$. We can see that when the l-type is indifferent, the u-type strictly

42

prefers to participate: $(1 - \alpha^*)(\overline{x} - q\lambda d) - e > 0$. The investors' break-even condition is given by:

$$(1 - \pi)(\alpha^*\overline{x} - c + q\lambda d(1 - \alpha^*)) + \pi q \beta^*(\alpha^* x_l - c + (1 - \alpha^*)d) = 0.$$

When we use the equality $\alpha^*(x_l - d) = x_l - d - e$ and simplify, we get the equilibrium participation rate by the l-type:

$$\beta^* = \frac{1 - \pi}{\pi q} \cdot \frac{\alpha^*(\overline{x} - q\lambda d) - c + q\lambda d}{k - x_l}.$$

Recall that, in the baseline case, we had: $\alpha^* = 1 - \frac{e}{x_l - d}$ and $\beta^* = \frac{1 - \pi}{\pi q} \cdot \frac{\alpha^*\overline{x} - c}{k - x_l}$. Compared to the baseline case, therefore, conditional on d, whenever $\lambda > 0$, the l-type's participation rate is strictly higher and, therefore, the social welfare lower. Although the equilibrium fraction (α^*) that the investors receive from the l-type (conditional on d) is the same, because the investors get a positive litigation return from the u-type, compared to the baseline case, their return is strictly higher. To satisfy their break-even condition, therefore, the l-type's equilibrium participation rate (β^*) has to be higher. Finally, we see that: $\frac{\partial \alpha^*}{\partial d} = -\frac{e}{(x_l - d)^2} < 0$, $\frac{\partial \alpha^*}{\partial \pi} = 0$, $\frac{\partial \beta^*}{\partial d} = \frac{e}{(x_l - d)^2}(-\overline{x} + q\lambda x_l) < 0$, and $\frac{\partial \beta^*}{\partial \pi} = -\frac{1}{\pi q} \cdot \frac{\alpha^*(\overline{x} - q\lambda d) - c + q\lambda d}{k - x_l} < 0$. As in the baseline case, when the liability gets stronger, social welfare improves.

To establish $\underline{d}_{FP}(e, \pi)$, let's examine the no deterrence case $(\beta^* = 1)$. When $\beta^* = 1$, the investors' break-even condition is given by:

$$(1 - \pi)(\alpha^*(\overline{x} - q\lambda d) - c + q\lambda d) + \pi q(\alpha^*(x_l - d) - c + d) = 0,$$

from which, we get $\alpha^* = \frac{(1 - \pi)(c - q\lambda d) + \pi q(c - d)}{(1 - \pi)(\overline{x} - q\lambda d) + \pi q(x_l - d)}$.

A few preliminary observations regarding the α^*. From the equation $(1 - \pi)(\alpha(\overline{x} - q\lambda d) - c + q\lambda d) + \pi q(\alpha(x_l - d) - c + d) = 0$, we see that the left hand side is strictly increasing with respect to α. We also know that, in equilibrium, $\alpha^*\overline{x} - c + q\lambda d(1 - \alpha^*) > 0$ and $\alpha^* x_l - c + (1 - \alpha^*)d < 0$. Hence, when π increases, investors' return goes down, and to restore equality, α^* must increase. Hence, $\frac{\partial \alpha^*}{\partial \pi} > 0$. Also, $(1 - \pi)(\alpha(\overline{x} - q\lambda d) - c + q\lambda d) + \pi q(\alpha(x_l - d) - c + d)$ is strictly increasing with respect to d. When d rises, therefore, to restore the equality, α must decrease. In other words, $\frac{\partial \alpha^*}{\partial d} < 0$. In sum, the equilibrium α^* is increasing with respect to π and decreasing with respect to d.

To establish $\underline{d}_{FP}(e, \pi)$, from the partial deterrence case, we know that:

$$\beta^* = \frac{1 - \pi}{\pi q} \cdot \frac{\left(\frac{x_l - \underline{d} - e}{x_l - \underline{d}}\right)(\overline{x} - q\lambda d) - c + q\lambda d}{k - x_l}$$

When we set $\beta^* = 1$ and simplify, we get:

$$\frac{1 - \pi}{\pi q} \cdot \frac{(x_l - \underline{d} - e)(\overline{x} - q\lambda\underline{d}) - (x_l - \underline{d})(c - q\lambda\underline{d})}{(x_l - \underline{d})(k - x_l)} = 1.$$

When we solve for $\underline{d}$, we get:

$$\underline{d}_{FP}(e, \pi) = \frac{(1 - \pi)(x_l(\overline{x} - c) - e\overline{x}) - \pi q x_l(k - x_l)}{(1 - \pi)((\overline{x} - c) - eq\lambda) - \pi q(k - x_l)}.$$

It's straightforward (but somewhat messy) to establish that this expression is decreasing with respect to π. When $\pi = 0$, we get:

$$\underline{d}_{FP}(e, 0) = \frac{x_l(\overline{x} - c) - e\overline{x}}{(\overline{x} - c) - eq\lambda} = \overline{d}.$$

When $\underline{d}_{FP}(e, \pi) = 0$, we need: $(1 - \pi)(x_l(\overline{x} - c) - e\overline{x}) - \pi q x_l(k - x_l) = 0$, from which we get:

$$\frac{1 - \widehat{\pi}_0}{\widehat{\pi}_0 q} \cdot \frac{x_l(\overline{x} - k) - e(\overline{x} - x_l)}{x_l(k - x_l)} = 1.$$

Note that this expression is the same as the baseline case and $\widehat{\pi}_0 < 1$. Therefore, $\underline{d}_{FP}(e, \pi) \in [0, \overline{d}]$ when $\pi \in [0, \widehat{\pi}_0]$. $\qquad\square$

Corollary 4 (Comparative Statics in False Positives Case). *Suppose that the firm is erroneously held liable for λd when the entrepreneur is uninformed.*

1. *The l-type's payoff is (weakly) decreasing in d, the u-type's payoff is (weakly) increasing in d, and social welfare is (weakly) increasing in d.*

2. *The l-type's payoff is (weakly) increasing in λ, the u-type's payoff is (weakly) decreasing in λ, and social welfare is (weakly) decreasing in λ.*

Proof of Corollary 4. Consider the three cases in Proposition 4.

Case 1. Since $\beta^*_{FP}(d, \pi) = 0$ social welfare and the l-type and u-type payoffs do not depend on d or λ.

Case 2. $\beta^*_{FP}(d, \pi)$ in (23) is increasing in λ because

$$-\left(1 - \tfrac{e}{x_l - d}\right) + 1 = \tfrac{e}{x_l - d} > 0.$$

Therefore social welfare is decreasing in λ. $\beta^*_{FP}(d, \pi)$ in (23) is decreasing in d if

$$\frac{\partial}{\partial d}\left(\left(1 - \tfrac{e}{x_l - d}\right)(\overline{x} - q\lambda d) - (c - q\lambda d)\right) < 0.$$

$$\frac{\partial}{\partial d}\left(\overline{x} - c - \left(\tfrac{e}{x_l - d}\right)(\overline{x} - q\lambda d)\right) < 0.$$

Differentiating, and dividing by e,

$$-\frac{(x_l - d)(-q\lambda) - (\overline{x} - q\lambda d)(-1)}{(x_l - d)^2} < 0.$$

$$-\frac{\overline{x} - q\lambda x_l}{(x_l - d)^2} < 0$$

Therefore, social welfare is increasing in d. The l-type is indifferent and gets zero profits. It follows that the u-type's payoff is decreasing in λ and increasing in d.

Case 3. Since $\beta^*_{FP}(d, \pi) = 1$ social welfare does not depend on d or λ. Letting $z = \pi q/(1 - \pi)$, the equity stake is

$$\alpha^*_{FP}(\cdot) = \frac{(c - q\lambda d) + z(c - d)}{(\overline{x} - q\lambda d) + z(x_l - d)}$$

Consider first the comparative statics with respect to λ. Differentiating $\alpha^*_{FP}(\cdot)$ with respect to λ, the slope has the same sign as

$$[(\overline{x} - q\lambda d) + z(x_l - d)](-qd) - [(c - q\lambda d) + z(c - d)](-qd)$$

which has the same sign as

$$-(\overline{x} - q\lambda d) - z(x_l - d) + (c - q\lambda d) + z(c - d)$$

$$= -\overline{x} - zx_l + c + zc$$

$$= -(\overline{x} - c) - z(x_l - c) < 0$$

Therefore $\alpha^*_{FP}(\cdot)$ is decreasing in λ. The l-type's payoff is $(1 - \alpha^*_{FP})(x_l - d) - e > 0$. Since $\alpha^*_{FP}(\cdot)$ is decreasing in λ, the l-type's payoff is increasing in λ. Since social welfare is constant in λ, the u-type's payoff $(1 - \alpha^*_{FP})(\overline{x} - \lambda d) - e > 0$ must be

decreasing in λ.

Now consider the comparative statics with respect to d. Differentiating $\alpha^*_{FP}(\cdot)$ with respect to d, the slope has the same sign as

$$[(\overline{x} - q\lambda d) + z(x_l - d)](-q\lambda - z) - [(c - q\lambda d) + z(c - d)](-q\lambda - z).$$

The same analysis as was just done for λ verifies that $\alpha^*_{FP}(\cdot)$ is decreasing in d. Now let's evaluate the entrepreneur's payoffs. I will do this indirectly. The slope of the l-type's payoff with respect to d is smaller than the slope of the u-type's payoff function:

$$-(1 - \alpha^*_{FP}) - \frac{\partial \alpha^*_{FP}(\cdot)}{\partial d}(x_l - d) < -(1 - \alpha^*_{FP})\lambda - \frac{\partial \alpha^*_{FP}(\cdot)}{\partial d}(\overline{x} - \lambda d)$$

$$\frac{\partial \alpha^*_{FP}(\cdot)}{\partial d}(\overline{x} - x_l + (1 - \lambda)d) - (1 - \alpha^*_{FP})(1 - \lambda) < 0$$

This is true since $\frac{\partial \alpha^*_{FP}(\cdot)}{\partial d} < 0$. Since the slope of the social welfare function with respect to d is zero, it must be that the partial derivative of the l-type's payoff function is negative and the partial derivative of the u-type's payoff function is positive. $\square$

Proof of Proposition 5. We start with the construction of the full deterrence threshold, $\overline{d}_{LC}$. In order to have a sufficiently high d so as to fully deter the l-type (with litigation), we need: $(1 - \overline{\alpha})(x_l - d - \phi_d) - e < 0$. When we let $d = \overline{d}_{LC}$ and solve $(1 - \overline{\alpha})(x_l - \overline{d}_{LC} - \phi_d) - e = 0$ for $\overline{d}_{LC}$, we get:

$$\overline{d}_{LC} = x_l - \phi_d - \frac{e\overline{x}}{\overline{x} - c}.$$

Note that $\overline{d}_{LC} < x_l - \frac{e}{1 - c/\overline{x}}$. Because of the positive litigation cost (ϕ_d), compared to the case without litigation cost, a weaker liability is necessary to achieve full deterrence. Hence, when $d > \overline{d}_{LC}$, the investors demand $\alpha^*_{LC} = \frac{c}{\overline{x}}$ and the l-type is fully deterred: $\beta^*_{LC} = 0$.

Second, suppose that we are in the partial deterrence region. Suppose, first, that the litigation is credible. For the l-type's indifference, we need: $(1 - \alpha)(x_l - d - \phi_d) - e = 0$. The investors' break-even condition is: $(1 - \pi)(\alpha\overline{x} - c) + \pi q\beta(\alpha x_l - c + d - \phi_p - \alpha(d + \phi_d)) = 0$. From the l-type indifference condition, we get the equilibrium α:

$$\alpha^*_{LC}(d, \pi) = \frac{x_l - d - \phi_d - e}{x_l - d - \phi_d}.$$

Note that $\alpha^*_{LC}(d, \pi)$ is independent of π but is decreasing with respect to d. With $\alpha^*_{LC}(d, \pi)$, the investors' break-even condition can be written as: $(1 - \pi)(\alpha\overline{x} - c) +$

$\pi q \beta(x_l - k - \phi) = 0$ and we get the equilibrium participation rate for the l-type:

$$\beta_{LC}^*(d, \pi) = \frac{1 - \pi}{\pi q} \cdot \frac{\alpha_{LC}^*(d, \pi) \cdot \overline{x} - c}{k + \phi - x_l}$$

$$= \frac{1 - \pi}{\pi q} \cdot \frac{(x_l - d - \phi_d - e)\overline{x} - c(x_l - d - \phi_d)}{(x_l - d - \phi_d)(k + \phi - x_l)}.$$

Given the litigation credibility condition of $\alpha \leq \frac{d - \phi_p}{d + \phi_d}$, this implies that $\exists\, d_0 > \phi_p$ such that the litigation credibility constraint binds: $\frac{x_l - d_0 - \phi_d - e}{x_l - d_0 - \phi_d} = \frac{d_0 - \phi_p}{d_0 + \phi_d}$. When we solve for d_0, we get:

$$d_0^{pd}(\pi) = \frac{x_l \phi - \phi_d(e + \phi)}{e + \phi}.$$

The superscript "pd" stands for the fact that we are defining d_0 in the partial deterrence region. In the partial deterrence region, therefore, litigation is credible only when $d \geq \frac{x_l \phi - \phi_d(e + \phi)}{e + \phi}$. When $d < d_0^{pd}(\pi)$, we get: $\alpha_{LC}^*(d, \pi) = \frac{x_l - e}{x_l}$ and $\beta_{LC}^*(d, \pi) = \frac{1 - \pi}{\pi q} \cdot \frac{(x_l - e)\overline{x} - cx_l}{x_l(k - x_l)}$.

Third, suppose we are in the no deterrence region. Suppose, initially, that the litigation is credible. In equilibrium, the l-type participates with probability one $(\beta_{LC}^*(d, \pi) = 1)$ and makes, in expectation: $(1 - \alpha)(x_l - d - \phi_d) - e > 0$. From the investors' break-even condition of $(1 - \pi)(\alpha\overline{x} - c) + \pi q(\alpha x_l - c + d - \phi_p - \alpha(d + \phi_d)) = 0$, we get:

$$\alpha_{LC}^*(d, \pi) = \frac{(1 - \pi)c + \pi q(c - d + \phi_p)}{(1 - \pi)\overline{x} + \pi q(x_l - d - \phi_d)}.$$

Though a bit tedious, it is straightforward to show that $\frac{\partial \alpha_{LC}^*(d, \pi)}{\partial \pi} > 0$ and $\frac{\partial \alpha_{LC}^*(d, \pi)}{\partial d} < 0$. In the no deterrence region, the litigation credibility condition is given by:

$$\frac{(1 - \pi)c + \pi q(c - d + \phi_p)}{(1 - \pi)\overline{x} + \pi q(x_l - d - \phi_d)} \leq \frac{d - \phi_p}{d + \phi_d}.$$

When we solve for d, we find the expression for $d_0^{nd}(\pi)$ (superscript "nd" standing for "no deterrence"):

$$d_0^{nd}(\pi) = \frac{((1 - \pi)c + \pi qc)\phi_d + ((1 - \pi)\overline{x} + \pi qx_l)\phi_p}{(1 - \pi)(\overline{x} - c) + \pi q(x_l - c)}.$$

Though bit tedious, it is straightforward to show that $\frac{\partial d_0^{nd}(\pi)}{\partial \pi} > 0$. Note that when $\pi = 0$, we get $d_0^{nd}(0) = \frac{c\phi_d + \overline{x}\phi_p}{\overline{x} - c} > \phi_p$. Hence, to satisfy the litigation credibility constraint, damages will always be higher than ϕ_p. Also, when $d < d_0^{nd}(0)$, the

equilibrium is given by: $\beta_{LC}^*(d, \pi) = 1$ and $\alpha_{LC}^*(d, \pi) = \frac{(1-\pi)c+\pi qc}{(1-\pi)\bar{x}+\pi q x_l}$. Note that, from $\beta_{LC}^*(d, \pi) = \frac{1-\pi}{\pi q} \cdot \frac{(x_l - e)\bar{x} - cx_l}{x_l(k - x_l)}$ in the partial deterrence region, when we let $\beta_{LC}^*(d, \pi) = 1$ and rearrange, we get:

$$\frac{1 - \pi}{\pi q} = \frac{x_l(k - x_l)}{(x_l - e)\bar{x} - cx_l}.$$

This is the same expression that defined $\widehat{\pi}_0$. Therefore, conditional on no credible litigation, we get partial deterrence when $\pi > \widehat{\pi}_0$, and no deterrence when $\pi \leq \widehat{\pi}_0$.

So far, we have established the function $d_0(\pi)$ in two separate regions: one in partial deterrence ($d_0^{pd}(\pi)$), and the other in no deterrence ($d_0^{nd}(\pi)$) region. To establish the continuity, we first find the expression for $\underline{d}_{LC}(\pi)$ and then show that $d_0(\pi)$ is continuous. In order to find $\underline{d}_{LC}(\pi)$, from the partial deterrence region, we know that

$$\beta_{LC}^*(d, \pi) = \frac{1 - \pi}{\pi q} \cdot \frac{(x_l - d - \phi_d - e)\bar{x} - c(x_l - d - \phi_d)}{(x_l - d - \phi_d)(k + \phi - x_l)}.$$

When $\beta_{LC}^*(d, \pi) \to 1$ and we rearrange, we get:

$$\frac{\widehat{\pi}(d)q}{(1 - \widehat{\pi}(d))} = \frac{(x_l - d - \phi_d - e)\bar{x} - c(x_l - d - \phi_d)}{(x_l - d - \phi_d)(k + \phi - x_l)}.$$

This equality implicitly defines $\underline{d}_{LC}(\pi)$. It is straightforward to establish that $\frac{\partial \widehat{\pi}(d)}{\partial d} < 0$ or, equivalently, $\frac{\partial \underline{d}_{LC}(\pi)}{\partial \pi} < 0$. When $\widehat{\pi} = 0$, for instance, we get $\underline{d}_{LC}(0) = x_l - \phi_d - \frac{e\bar{x}}{\bar{x}-c} = \bar{d}_{LC}$.

To show that $d_0(\pi)$ is continuous across the two regions, first, when we can rewrite the expression for $d_0^{nd}(\pi)$ and get:

$$\left(\frac{1 - \pi}{\pi q}\right)^{nd} = \frac{c\phi_d + x_l\phi_p - (x_l - c)d_0^{nd}(\pi)}{(\bar{x} - c)d_0^{nd}(\pi) - c\phi_d - \bar{x}\phi_p}.$$

The superscript "nd" on the left hand side is to indicate that the ratio is being evaluated in the no deterrence region. From the partial deterrence region, we know that $d_0^{pd}(\pi) = \frac{x_l\phi - \phi_d(e+\phi)}{e+\phi}$. When we let $d_0^{nd}(\pi) = \frac{x_l\phi - \phi_d(e+\phi)}{e+\phi}$ and rearrange the above expression, we get:

$$\left(\frac{1 - \pi}{\pi q}\right)^{nd}_{d=d_0^{pd}(\pi)} = \frac{x_l(e + \phi - x_l + c)}{x_l(\bar{x} - c) - \bar{x}(e + \phi)}.$$

We also know that, from the partial deterrence region, when $\beta^* = 1$, we have

$$\left(\frac{1-\pi}{\pi q}\right)^{pd} = \frac{(x_l - d - \phi_d)(k + \phi - x_l)}{(x_l - d - \phi_d - e)\overline{x} - c(x_l - d - \phi_d)}.$$

When we substitute in the expression $d_0^{pd}(\pi) = \frac{x_l \phi - \phi_d(e+\phi)}{e+\phi}$ for d, after some algebra, we get:

$$\left(\frac{1-\pi}{\pi q}\right)^{pd}_{d=d_0^{pd}(\pi)} = \frac{x_l(e + \phi - x_l + c)}{x_l(\overline{x} - c) - \overline{x}(e + \phi)}.$$

This establishes the continuity of $d_0(\pi)$, which is weakly increasing with respect to π since $d_0(\pi)$ is independent of π in the partial deterrence region but is strictly increasing with respect to π in the no deterrence region. $\square$

Proof of Corollary 2. If $d > d_0(\pi)$ then litigation is credible. Adapting equation (12) in the baseline model, social welfare is given by:

$$SW_{LC}(d, \pi) = (1 - \pi)(\overline{x} - k) + \pi(1 - q)(x_h - k) + \pi q \beta^*_{LC}(d, \pi)(x_l - k - \phi).$$

Case 1: $\beta^*_{LC}(d, \pi) = 0$. This is case 1 of Proposition 5. The third term in the social welfare function is zero. Therefore, social welfare and each type's payoffs are independent of the parameters (ϕ and d).

Case 2: $\beta^*_{LC}(d, \pi) \in (0, 1)$. This is case 2 of Proposition 5. $\alpha^*_{LC}(d, \pi) = \left(1 - \frac{e}{x_l - d - \phi_d}\right)$ is a decreasing function of ϕ_d and d, and is independent of ϕ_p. Therefore, the u-type's return increases when ϕ_d or d increase but is independent of ϕ_p. Using the expression for $\beta^*_{LC}(d, \pi)$, the social welfare function can be written as:

$$SW_{LC}(d, \pi) = (1-\pi)(\overline{x} - k) + \pi(1-q)(x_h - k) - (1-\pi)\left(\left(1 - \frac{e}{x_l - d - \phi_d}\right)\overline{x} - c\right).$$

From the expression, it is clear that social welfare rises when ϕ_d or d increases but is independent of ϕ_p. Given the l-type's indifference, the l-type's return is unaffected by ϕ and d.

Case 3: $\beta^*_{LC}(d, \pi) = 1$. This is case 3 of Proposition 5. Social welfare is strictly decreasing in ϕ_p and ϕ_d and does not depend on d. Since $\alpha^*_{LC}(d, \pi)$ is an increasing function of both ϕ_p and ϕ_d, it follows that the u-type and the l-type payoffs are also decreasing in ϕ_p and ϕ_d.

We will now prove that $\alpha^*_{LC}(d, \pi)$ is a decreasing function of d. The u-type's and l-type's payoffs are $(1-\alpha^*_{LC}(d, \pi))\overline{x} - e$, and $(1-\alpha^*_{LC}(d, \pi))(x_l - d - \phi_d) - e$, respectively.

Differentiating with respect to d gives the slopes of the payoff functions: $-\frac{\partial \alpha^*(\cdot)}{\partial d}\overline{x}$ and $-\frac{\partial \alpha^*(\cdot)}{\partial d}(x_l - d - \phi_d) - (1 - \alpha^*_{LC}(d, \pi))$.

We will now prove $\frac{\partial \alpha^*(\cdot)}{\partial d} < 0$ by contradiction. If $\frac{\partial \alpha^*(\cdot)}{\partial d} > 0$ then the payoffs of the u-type and l-type would both be decreasing in d. This is a contraction, as social welfare does not depend on d. Therefore $\frac{\partial \alpha^*(\cdot)}{\partial d} < 0$. This implies that the u-type's payoff is an increasing function of d and, since social welfare is independent of d, that the l-type's payoff is decreasing in d. $\qquad\square$