Economic Effects of Increasing Litigation Risk on Corporate Disclosure and Innovation*

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Abstract

We study the endogenous relationship between corporate disclosure and costly, informed shareholder litigation. We establish that the equilibrium behavior structurally depends on the size of insiders' litigation costs. If litigation costs are small, then the equilibrium features disclosure all good news and weakly bad news and heightened litigation risk leads to less disclosure because shareholders consider the net value of future litigation upon nondisclosure in pricing the shares, mitigating incentives to disclose. If litigation costs are large, then all good news as well as weakly and very bad news are disclosed and heightened litigation risk leads to more disclosure due to deterrence. We also study the ex ante real effects of the disclosure-litigation relationship and show that, if insiders face small litigation costs, increasing litigation risk first decreases and then increases innovation. We reconcile our results with prior empirical evidence and discuss further empirical and regulatory implications.

Keywords: Private litigation, litigation risk, corporate disclosure, corporate innovation.

JEL: G18, K22, K41, K42, M41, M48

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1. Introduction

Does heightened litigation risk induce more or less disclosure of material information? This question is at the center of a long-standing debate in accounting research. Empirical evidence is mixed. Some studies find that heightened litigation risk is associated with less disclosure and, thus, provide evidence of a negative association (e.g., Johnson et al., 2001; Baginski et al., 2002; Bourveau et al., 2018), while other studies document a positive association (e.g., Naughton et al., 2019; Huang et al., 2020). Further a number of studies provide evidence that more timely disclosure of bad news is associated with a lower incidence of litigation and more favorable settlements (e.g., Francis et al., 1994; Skinner, 1997; Field et al., 2005; Donelson et al., 2012).

We develop a theory to provide detailed insights into the relation between corporate disclosure and shareholder litigation. A key finding is that insiders' litigation costs are crucial for equilibrium behavior and structurally determine the effect of litigation risk on disclosure. If these costs are small, firms disclose all good news and weakly bad news, and heightened litigation risk reduces disclosure. If they are large, firms disclose all good news as well as weakly and very bad news, and heightened litigation increases overall disclosure, Disclosure of very bad news further preempts litigation. We also provide results on the impact of litigation risk on price efficiency and derive conditions when the empirically well-documented pattern of the average market reaction to bad news is larger to good news disclosures obtains. In addition, we study the ex ante effects of the disclosure-litigation relationship with respect to corporate innovation and show that litigation risk only affects firms whose insiders face small litigation costs. Then corporate innovation first decreases and then increases in response to heightened litigation risk.

The model builds on a standard voluntary disclosure model with uncertain information endowment of an insider as in Dye (1985) and Jung and Kwon (1988) (henceforth DJK). The insider, in our setting the entrepreneur, sells the firm in a competitive capital market. She potentially holds material price-relevant information and decides whether to disclose this information. Disclosure is costless and must be truthful. Investors take the entrepreneur's disclosure (or nondisclosure) into account and price protect against expected losses arising from potential information asymmetries. We augment this standard model by considering shareholders' ex post litigation decision. After acquiring the firm, shareholders observe, with some probability, a signal about the information the entrepreneur might have withheld if she was informed. If the signal indicates that shareholders

paid an inflated price for the firm, they can bring a costly lawsuit against the entrepreneur under securities laws to claim damage compensation.[1] We show that shareholders only consider litigation if the subsequently observed signal is sufficiently unfavorable because then the expected value of the damage compensation outweighs the legal cost. If they sue, a court uncovers whether the entrepreneur was endowed with information but chose to withhold it. In this case, it requires the entrepreneur to compensate shareholders for their damage, and the entrepreneur additionally incurs a penalty. Overall, the litigation mechanism we model reflects four widely acknowledged features: (i) Litigation is costly to plaintiff shareholders and (ii), if successful, imposes costs on defendant insiders. (iii) It is triggered by fundamental information that arises ex post. (iv) Shareholders' compensation is a function of their losses.

We show that a key factor determining the structure of the disclosure and litigation equilibrium is the entrepreneur's litigation costs. If they are small, the equilibrium has the typical feature that only sufficiently favorable information (consisting of all good news and weakly bad news) is disclosed, whereas moderately bad news and very bad news are withheld. When pricing the firm upon nondisclosure, shareholders take into account that they will litigate if they observe a sufficiently unfavorable signal in the future. Thus, they include the expected value of the litigation option as a premium in pricing the firm.[2] This higher price upon nondisclosure strengthens the incentive of the entrepreneur to withhold weakly bad news. As a result, if shareholders' legal cost decreases and litigation risk increases, the entrepreneur discloses *less* in equilibrium.

In contrast, if the entrepreneur's litigation costs are large, then the equilibrium features disclosure of all good news as well as weakly and very bad news. Disclosure of very bad news is driven by the threat of litigation, and it completely prevents litigation in equilibrium, such that there is no litigation-related premium in the nondisclosure price. Only moderately unfavorable information, for which shareholders would not litigate, is withheld. This result is consistent with the notion that shareholder litigation disciplines disclosure through deterrence and that disclosure preemts future litigation (Skinner, 1994; 1997). We further show that an increase in the threat of litigation increases

[1] For example, under Rule 10b-5 of the Securities Exchange Act of 1934 or similar securities regulation in other countries shareholders can claim that they purchased shares at an inflated price because firms failed to disclose material adverse news.

[2] This is consistent with the reasoning by Trueman (1997, p. 197) in that "[a]*s long as there is a positive probability that shareholders will win a lawsuit under Rule 10b-5 and collect damages, investors will pay somewhat more for the firm's shares than their expectation of earnings.*" See also Dye (2017).

disclosure of verybad news and reduces the disclosure of weakly bad news. Nevertheless, overall disclosure increases. The average disclosure likelihood depends on the distribution of firms with insiders facing small and large litigation costs. For a high (low) proportion of small-litigation-cost firms an increase in litigation risk implies less (more) disclosure.

We perform a number of additional analyses. First, we study how changes in the information environment affect equilibrium strategies. An increase in ex ante information asymmetry between the entrepreneur and shareholders affects litigation incentives in that litigation risk increases for low-information-asymmetry scenarios and decreases for high-information-asymmetry scenarios. Intuitively, more information asymmetry implies more price protection and thus more disclosure, but it also implies a higher likelihood of winning in court. In addition, an increase in the arrival of information after the acquisition of shares leads to less information that is disclosed ex ante, if insiders face small litigation costs. This arises because a higher likelihood of ex post informedness leads shareholders to assign a higher premium to litigation ex ante, which in turn curbs disclosure. This result suggests that recent regulations to improve transparency and accountability, such as whistleblower regulation, can have unintended consequences.

Second, we provide insights on ex ante price efficiency, that is, how closely market prices reflect fundamentals on average. This is especially important if insiders' litigation costs are small since then shareholders include a litigation-related premium in the stock price, which then deviates from the conditionally expected fundamental value. We find that, in line with prior literature (e.g., Fishman and Hagerty, 1989), price efficiency is maximal when disclosure is maximal. In particular, price efficiency decreases for small-litigation-cost firms and increases for large-litigation cost firms for heightened litigation risk.

Third, prior empirical research documents that the average market reaction to bad news disclosures is larger than to good news disclosures (e.g., Skinner, 1994; Kothari et al., 2009). We find that the average market reaction to bad news is larger than to good news only in a scenario in which insiders' litigation costs are large and litigation risk is sufficiently high because then much of the very bad news is disclosed. In this case, the difference in the average market reactions to bad and good news first increases and decreases in litigation risk.

Finally, we study real effects arising from the disclosure-litigation relationship. Specifically, we examine how litigation risk affects firms' incentives to innovate. This is important because

innovation, for example, R&D, is a main driver of macroeconomic growth and, therefore, of primary interest to regulators (Arrow, 1962). We show that litigation influences innovation by firms only if insiders face small litigation costs so that litigation occurs in equilibrium. Then increasing litigation risk first hampers and then encourages innovation because the entrepreneur's ex ante net benefit from exerting innovative effort features a tradeoff between a higher ex ante price and larger litigation costs.

Collectively, our study provides new theoretical results and refined predictions on the relation between corporate disclosure and shareholder litigation, as well as insights on ex ante real effects of the disclosure-litigation relationship.

2. Literature Review

Our economic model is based on the literature on strategic disclosure, which assumes the existence of a disclosure friction in the form of uncertain information endowment of insiders (Dye, 1985; Jung and Kwon, 1988; henceforth, DJK). This literature assumes risk neutrality of all parties, an interest of an insider (e.g., managers, entrepreneurs) in influencing the short-term stock price through strategic disclosure, and competitive capital market pricing (if explicitly considered). In this case, the equilibrium disclosure strategy is to disclose sufficiently favorable information and to withhold unfavorable information. Our paper contributes to the subset of this literature, which considers the effects of shareholder litigation on corporate disclosure.

The earliest analysis of litigation in the theoretical disclosure literature is Trueman (1997), who uses a variant of DJK with discrete fundamentals and a rent-seeking lawyer who litigates in case that an unfavorable outcome occurs ex post. He assumes that the lawyer extracts the entire rent associated with litigation and also bears all costs such that shareholders price the firm at its posterior fundamental value. Trueman (1997) finds that firms disclose sufficiently favorable and sufficiently unfavorable information and withhold intermediate information. Disclosing favorable information increases the price, and disclosing unfavorable information prevents personal losses if the court detects the withholding of information. Dye (2017) studies costless litigation based on a fact finder's discovery that the firm withheld information. He finds that firms disclose only sufficiently favorable information if the firm's expected costs from withholding are small, whereas full unraveling occurs if they are large.

In line with Trueman (1997), Evans and Sridhar (2002), and Schantl and Wagenhofer (2020), we study costly litigation, whereas Dye (2017) assumes costless litigation. Different from Trueman (1997), who assumes that a lawyer decides on and exclusively benefits from litigation, and consistent with Evans and Sridhar (2002) and Schantl and Wagenhofer (2020), we examine the cost-benefit tradeoff made by shareholders directly. As in Evans and Sridhar (2002), we consider endogenous benefits of strategic disclosure and the ex ante pricing of litigation in case of nondisclosure, but we study a setting with continuous fundamentals and continuous (truthful) disclosure and in which litigation is based on fundamental information that arises ex post. This signal is informative about the fundamental value but, different from Dye (2017), it does not reveal whether the firm had private information and withheld it.[3] The latter is detected in the court proceedings after litigation is initiated. Thus, litigation is a strategic decision by shareholders based on a tradeoff between expected benefits and costs of litigation, where the cost introduces a friction into the mechanism. This enables us to study the endogenous relationship between disclosure and litigation and highlight the central role of insiders' litigation costs.

Evans and Sridhar (2002) consider misreporting by a manager and a product market entry threat by a rival that introduces proprietary costs in the spirit of Verrecchia (1983) and Wagenhofer (1990). They show that product markets and capital markets induce opposing incentives to misreport private information and that costly shareholder litigation, which is priced ex ante, can induce under- or overreporting in mixed strategies in their binary setting. Marinovic and Varas (2016) find a similar result in a dynamic binary voluntary disclosure model with costless litigation. Laux and Stocken (2012) also consider a binary misreporting setting with an overoptimistic entrepreneur and nonstrategic, costless litigation. They show that increasing shareholders' damage compensation can lead to more or less overreporting, where there is a tradeoff between deterrence and shareholder price protection. Schantl and Wagenhofer (2020) study a binary reporting problem with exogenous benefits of upward misreporting and noncompliance costs that arise if either strategic public enforcement or strategic private litigation uncover manipulation. They find that public enforcement crowds out private litigation and weakens, rather than strengthens, misreporting deterrence in strong private litigation regimes.

[3] Ebert et al. (2021) study voluntary disclosure contingent on whether information leaks include only fundamental information or information endowment. They do not consider litigation.

We also add to the recent literature on real effects of public information. Ben-Porath et al. (2018) find that an agent's disclosure choice is ex ante inefficient because the agent chooses excessively risky projects. Guttman and Meng (2021) establish that managers overinvest in ex ante information acquisition. Laux and Stocken (2018) highlight the consequences of ex post reporting regulation for firms' innovation incentives by studying a variant of Dye's (2002) classification model in which a regulator enforces a classification standard and imposes a penalty upon noncompliance. They find that an entrepreneur's innovative effort first increases and then decreases in the stringency of the classification standard. We consider the ex ante effects of the interaction between corporate disclosure and shareholder litigation and show that litigation risk affects corporate innovation through the expected shareholders' legal cost.

3. Model

3.1. Main Setting

We build on a standard disclosure model with uncertain information endowment of an insider as in DJK. There exists a firm whose terminal cash flow x is uncertain. For simplicity x is uniformly distributed over the support $(0,1)$.[4] The probability density function is denoted by $f(x) = 1$ and the cumulative distribution function is denoted by $F(x) = x$. The firm is owned by a risk neutral entrepreneur ("she") who, for exogenous liquidity reasons, aims to sell it to risk neutral shareholders ("they") in a perfectly competitive capital market.

At $t = 1$, the entrepreneur privately observes a signal about x with probability $p \in (0,1)$. For simplicity, we assume that the signal is perfectly informative about x, so that we need not distinguish between the future cash flow and the signal. We use an indicator variable, $\Phi \in \{0,1\}$, for the entrepreneur's information endowment, where $\Phi = 1$ indicates an informed and $\Phi = 0$ an uninformed entrepreneur. If the entrepreneur learns x, she decides whether to disclose or withhold x. Disclosure must be truthful and is costless. If the entrepreneur remains uninformed, she cannot credibly communicate her lack of information to the market.

At $t = 2$, shareholders competitively price the firm conditional on publicly available information. If x is disclosed, the market price is $P_D(x)$; if there is no disclosure, the price is P_{ND}, where ND

[4] The assumption of a uniform distribution over a strictly positive support is not crucial for our results but facilitates some proofs. Such an assumption is also imposed, e.g., in Kim et al. (2020) among others.

stands for nondisclosure. Due to her objective of selling the firm, the entrepreneur wants to maximize the market price at $t = 2$. Given that prices weakly increase in the signal x, her incentive is to disclose sufficiently favorable information ($x \geq \tau$) and withholds sufficiently unfavorable information ($x < \tau$) at $t = 1$, where τ denotes the threshold for which she is indifferent.[5]

Withholding material unfavorable information harms shareholders because they pay an inflated price for the firm. A price is inflated if the actual price is higher than the hypothetical price they would have paid had an informed entrepreneur disclosed her private information. Consequently, the shareholders' damage is

$$\max\{P_{ND} - P_D(x), 0\}.$$

Securities and disclosure regulation requires full and truthful disclosure of all material information and endows shareholders with the right to file a lawsuit for damage compensation against the entrepreneur.[6]

To bring a lawsuit, shareholders must provide evidence to substantiate their damage claims to be admitted to court, which is the observation of a signal about the fundamental value, which arises at $t = 3$ with probability $\lambda \in (0, 1)$. For example, the signal can be an earnings announcement, a whistleblower report, a stock price drop, or an analyst report.[7] To simplify the analysis, we assume that the signal is the cash flow x directly.[8] If they observe $x < \tau$ but no disclosure occured at $t = 1$, shareholders consider it possible that the entrepreneur was informed and withheld unfavorable information. They then decide whether to file a lawsuit. In case they sue, the court perfectly uncovers whether the entrepreneur had in fact known x at $t = 1$ but chose to withhold this information.[9] Then, the entrepreneur will be ordered to compensate shareholders for their damage. If shareholders do not observe x (which occurs with probability $1 - \lambda$), they have no evidence to litigate and the game ends.

[5] We show below that such a disclosure threshold is the equilibrium strategy.

[6] For example, in the U.S. shareholders are endowed with litigation rights under Rule 10b-5 of the Securities Exchange Act of 1934.

[7] See, e.g., Marinovic and Varas (2016) or Frenkel et al. (2020).

[8] Assuming that shareholders observe x rather than a noisy signal of x simplifies the analysis without much loss of generality. In addition, the assumption on the probabilistic information endowment of shareholders at $t = 3$ prevents unravelling for sufficiently unfavorable information such that shareholder litigation occurs in equilibrium (see Section 5.2. for a further discussion). Alternatively one may impose the assumption that shareholders can only claim a fraction of the damages, e.g, $\gamma [P_{ND} - P_D(x)]$ with $0 < \gamma < 1$. This corresponds to casual observations of securities litigation in the U.S. in that settlement amounts are often less than 10 percent of estimated damages (Dye, 2017).

[9] This assumption is not critical. For example, if the court does not find evidence with some probability although the entrepreneur in fact was informed, the likelihood of a conviction declines by this probability (Trueman, 1997).

When deciding to litigate, shareholders trade off the expected damage compensation with a cost of litigation (e.g., Evans and Sridhar, 2002; Schantl and Wagenhofer, 2020). The damage compensation, if awarded, is equal to $\max\{P_{ND}-P_D(x),0\}$. Moreover, in case of successful litigation the entrepreneur is additionally penalized. We assume that the imposed penalty is proportional to shareholders' damages, that is,

$$\max\{k\left[P_{ND}-P_D(x)\right],0\}, \tag{1}$$

where $k \geq 0$ is the penalty multiple.

Litigation is privately costly to shareholders, and they incur a legal cost $c > 0$, whose magnitude is public knowledge. This cost includes shareholders' direct costs of litigation such as filing fees and attorney fees, which can be significant (Coffee, 2006), as well as costs of their effort and opportunity costs of time to make the case and to collect evidence.[10] A higher legal cost c reduces the propensity that shareholders sue, and therefore we also refer to an increase of c as a reduction of litigation risk. As we establish below, given that the legal cost is not excessive, shareholders will sue if the signal they observe is sufficiently unfavorable, that is $x \leq \rho$, where $\rho \in (0,\tau)$.

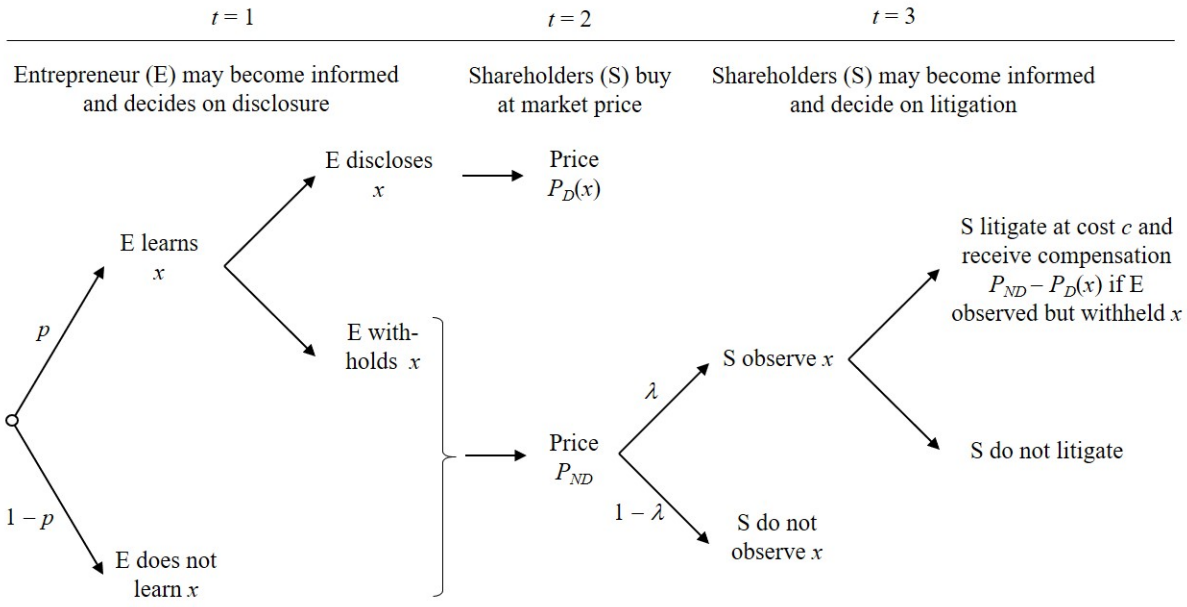
Figure 1 summarizes the sequence of events.

Equilibrium Definition. We search for Perfect Bayesian Equilibria in pure strategies, which we define as follows.

Definition: *An equilibrium consists of an informed entrepreneur's disclosure strategy at $t = 1$, the shareholders' pricing at $t = 2$, and the shareholders' litigation strategy at $t = 3$, such that:*
(i) *Conditional on whether the entrepreneur becomes informed, she discloses if her expected utility from disclosure is larger than from nondisclosure..*
(ii) *Conditional on observing whether the entrepreneur disclosed x or did not disclose, shareholders rationally conjecture an informed entrepreneur's disclosure strategy and competitively price the firm.*
(iii) *Conditional on observing a nondisclosure at $t = 2$ and x at $t = 3$, shareholders rationally conjecture an informed entrepreneur's disclosure strategy and decide whether to litigate.*
In equilibrium, the conjectured strategies equal the actual strategies.

[10] In practice, litigation may also depend on a hurdle of minimum evidence that is required to be admitted to courts and is thus subject to judicial materiality considerations. For example, the Private Securities Litigation Reform Act of 1995 increased the evidence burden for plaintiffs to file lawsuits in the United States, which is commonly believed to have weakened shareholder litigation (Ali and Kallapur, 2001; Johnson et al., 2001; Johnson et al., 2007). The legal cost c may therefore also be a function of such materiality considerations.

Figure 1: Timeline



Each player rationally conjectures the other player's unobservable or future strategies as well as their own future strategies, and uses all available information in their decisions. Rational conjectures are denoted with a hat ("^"). As we establish below, the disclosure and litigation equilibrium strategies are threshold strategies. We assume a zero interest rate and thus ignore discounting.

Further Discussion of Assumptions. Our setting features a parsimonious game between an entrepreneur and shareholders, in which the entrepreneur covers any damages her disclosure behavior causes if shareholders choose to litigate. In reality, damages and costs of settlements are typically borne by firms, whereas managers and directors personally contribute only in exceptional cases (Coffee, 2006). Corporate liability implies that the cost of damage compensation is borne by all shareholders relative to their share of ownership, which includes the plaintiff shareholders. The latter group therefore effectively only receive the damages that are paid by non-plaintiff shareholders (Caskey, 2013). In such a case, shareholders' propensity for litigation is attenuated, but the economics we show below continue to hold. For example, assuming that the entrepreneur only sells a fraction of the firm (e.g., because this is enough to cover her liquidity needs) and that the firm

compensates harmed shareholders yields qualitatively similar results.

4. The Relationship Between Corporate Disclosure and Shareholder Litigation

4.1. Equilibrium Without Entrepreneur's Penalty

We first consider the case of $k = 0$ (or sufficiently low k, as we show later) and solve the model by backward induction, begining with the litigation decision by shareholders.

Shareholders' Litigation Decision ($t = 3$). If the entrepreneur disclosed x at $t = 1$, then shareholders use this information to determine the market price of the firm, $P_D(x)$, at $t = 2$ and there is no basis for litigation at $t = 3$. If there was no disclosure, then shareholders observe x at $t = 3$ with probability λ. To make the litigation decision, they conjecture $\hat{P}_D(x)$, which is the price that they would have paid had x been disclosed.[11] They also conjecture that an informed entrepreneur would have disclosed sufficiently favorable information ($x \geq \hat{\tau}$), implying that if they observe $x \geq \hat{\tau}$, they conclude that the entrepreneur must have been uninformed at $t = 1$ and there is no basis for litigation. In contrast, if they observe $x < \hat{\tau}$, they infer that the entrepreneur was potentially informed but withheld the information,which opens up the possibility for litigation. The shareholders sue if the expected damage compensation outweighs the legal cost of a lawsuit. Formally,

$$\Pr(\Phi = 1 | x < \hat{\tau}, ND; \hat{\tau}) \left[P_{ND} - \hat{P}_D(x) \right] - c \geq 0, \tag{2}$$

where the probability that the entrepreneur had information at $t = 1$, conditional on observing x at $t = 3$ and nondisclosure at $t = 1$

$$\Pr(\Phi = 1 | x < \hat{\tau}, ND; \hat{\tau}) = p. \tag{3}$$

Based on the signal x realized at $t = 3$ and that $x < \hat{\tau}$ at $t = 3$, shareholders update their beliefs regarding the expected damage compensation in two ways. First, they can accurately estimate the

[11] Throughout the analysis we focus on equilibria with prices that are linear in x, i.e., $P_D(x) = x$ and $\hat{P}_D(x) = x$. This approach is consistent with that used in the extant voluntary disclosure literature.

amount of the damage that they might have suffered and thus the compensation that they might be awarded. Their compensation equals the market price P_{ND} less the hypothetical price $\hat{P}_D(x)$. Conjecturing that $\hat{P}_D(x)$ strictly increases in x, the damage also decreases in x, which implies that withholding worse news comes with larger damages such that a lawsuit becomes increasingly desirable.

Second, by observing $x < \hat{\tau}$, shareholders update their belief about the entrepreneur's information endowment. As we show below, upon nondisclosure at $t = 2$ they update their belief from their prior p to

$$\Pr(\Phi = 1|ND; \hat{\tau}) = \frac{p\hat{\tau}}{p\hat{\tau} + (1-p)}$$

and after observing x they revert back to their prior belief,

$$\Pr(\Phi = 1|x, ND; \hat{\tau}) = \Pr(\Phi = 1) = p,$$

where $\Pr(\Phi = 1|ND; \hat{\tau}) < \Pr(\Phi = 1|x, ND; \hat{\tau}) = \Pr(\Phi = 1)$. Intuitively, if shareholders observe any $x \geq \hat{\tau}$, then it must have come from an uninformed entrepreneur because an informed entrepreneur always discloses such favorable information. Upon nondisclosure, shareholders factor in that the entrepreneur was uninformed but the cash flow could be large (i.e., $x \geq \hat{\tau}$) such that the entrepreneur was informed with a lower likelihood. An informed but withholding entrepreneur pools with more realizations of the cash flow obtained by an uninformed entrepreneur, stopping full unraveling due to excessive price protection. Observing $x < \hat{\tau}$ alleviates this inference.[12] Formally, upon observing $x < \hat{\tau}$ the posterior probability with which the entrepreneur was informed is

$$\frac{f(x|x)p}{f(x|x)[p + (1-p)]} = p.$$

To determine whether litigation is desirable, shareholders compare the expected damage compensation with the legal cost c. If c is very high, then it outweighs even the highest expected benefit and litigation never occurs. We henceforth assume that necessary condition $c < \bar{c}$ holds.[13] Then shareholders litigate for sufficiently low realizations of x because the expected damage compensation

[12]We thank Robert Göx, Ulrich Schaefer, and Georg Schneider for invaluable discussions that helped us develop this intuition.

[13]We give a formal expression for $\bar{c}$ in the proof of Proposition 1.

strictly decreases in x. The threshold $x = \rho$ at which they are indifferent arises from the following condition:

$$p\left[P_{ND} - \hat{P}_D(\rho)\right] - c = 0. \tag{4}$$

Market Pricing ($t = 2$). If the entrepreneur became informed at $t = 1$ and chose to disclose x, shareholders price the firm at its conditionally expected value, which equals

$$P_D(x) = x, \tag{5}$$

because the entrepreneur's information is assumed to be perfect. Thus the disclosure price is linearly increasing in x with slope coefficient 1 and no intercept. This also implies that the conjectured pricing function is $\hat{P}_D(x) = x$.

In case of nondisclosure, shareholders rationally conjecture that either the entrepreneur was uninformed (with probability $1-p$) or was informed but chose to withhold her private information (with probability $pF(\hat{\tau})$). The conditionally expected fundamental value upon nondisclosure is

$$E[x|ND;\hat{\tau}] = \Pr(\Phi = 1|ND;\hat{\tau})E[x|\Phi = 1, ND;\hat{\tau}] + \Pr(\Phi = 0|ND;\hat{\tau})E[x|\Phi = 0, ND;\hat{\tau}]$$

$$= \frac{pF(\hat{\tau})}{pF(\hat{\tau}) + (1-p)} \cdot \frac{\hat{\tau}}{2} + \frac{(1-p)}{pF(\hat{\tau}) + (1-p)} \cdot \frac{1}{2} = \frac{1}{2}\frac{p\hat{\tau}^2 + (1-p)}{p\hat{\tau} + (1-p)}.$$

Additionally, shareholders rationally anticipate that they will observe x at $t = 3$ with probability λ and will sue if $x \leq \hat{\rho} < \hat{\tau}$. Since the possibility of litigation affects their future payoffs, they price the expected value of future litigation as part of the price they are willing to pay upon nondisclosure. The value of litigation reflects both the shareholders' expected benefits and costs. Formally, the expected value of litigation is

$$\lambda \Pr(\Phi = 1, x \leq \hat{\rho}|ND;\hat{\tau},\hat{\rho})E[P_{ND} - \hat{P}_D(x)|\Phi = 1, x \leq \hat{\rho}, ND;\hat{\tau},\hat{\rho}] - \lambda \Pr(x \leq \hat{\rho}|ND;\hat{\tau},\hat{\rho})c,$$

which simplifies to

$$\frac{\lambda\hat{\rho}}{p\hat{\tau} + (1-p)}\left[p\left(P_{ND} - \frac{\hat{\rho}}{2}\right) - c\right], \tag{6}$$

applying the (linear) conjecture $\hat{P}_D(x) = x$ and forming the expectation over all realizations of x

for which shareholders conjecture to litigate, i.e., $x \leq \hat{\rho}$.

Summing up, the nondisclosure price P_{ND} that shareholders are willing to pay for the shares if the entrepreneur did not disclose at $t = 1$ follows from condition

$$P_{ND} = \frac{1}{2}\frac{p\hat{\tau}^2 + (1-p)}{p\hat{\tau} + (1-p)} + \frac{\lambda\hat{\rho}}{p\hat{\tau} + (1-p)}\left[p\left(P_{ND} - \frac{\hat{\rho}}{2}\right) - c\right]. \tag{7}$$

Entrepreneur's Disclosure Decision ($t = 1$). If the entrepreneur does not observe the cash flow x (with probability $1 - p$) she cannot disclose. If she observes x, she decides on whether to disclose this information. First, she conjectures that, upon disclosure, shareholders price the firm at $\hat{P}_D(x) = x$. Upon nondisclosure, she conjectures a price of $\hat{P}_{ND}$. The entrepreneur is aware that shareholders will observe x with probability λ at $t = 3$ and conjectures that, if they become informed, then they will file a lawsuit whenever $x \leq \hat{\rho}$. Knowing that the court will find out that she was informed but choose to withhold information, she anticipates paying damage compensation in the amount of $\max\{\hat{P}_{ND} - \hat{P}_D(x), 0\}$.

If $x > \hat{\rho}$, the entrepreneur rationally conjectures that litigation is unprofitable for the shareholders and discloses whenever

$$\hat{P}_D(x) \geq \hat{P}_{ND} \Leftrightarrow x \geq \hat{P}_{ND}.$$

If $x \leq \hat{\rho}$, she anticipates litigation with probability λ and discloses if

$$\hat{P}_D(x) \geq \hat{P}_{ND} - \lambda \max\{\hat{P}_{ND} - \hat{P}_D(x), 0\} \Leftrightarrow x \geq \hat{P}_{ND} - \lambda \max\{\hat{P}_{ND} - \hat{P}_D(x), 0\}.$$

Recognizing that she will only withhold x if $\hat{P}_{ND} \geq \hat{P}_D(x)$ (as long as her utility increases in x), this condition then simplifies to

$$(1-\lambda)x \geq (1-\lambda)\hat{P}_{ND} \Leftrightarrow x \geq \hat{P}_{ND}$$

because $\lambda \in (0, 1)$. Thus, the condition resembles that for the case of $x > \hat{\rho}$ above, implying that litigation does not directly affect her disclosure decision.[14]

[14] This finding corresponds to the result in Dye (2017) who shows that nondisclosure costs that depend on the difference between nondisclosure and disclosure prices, do not directly impact the disclosure decision as long as they are not excessive.

In total, the entrepreneur discloses sufficiently favorable information ($x \geq \tau$) and withholds sufficiently unfavorable information ($x < \tau$), where

$$\tau = \hat{P}_{ND} \tag{8}$$

is the value of x at which she is indifferent.

Equilibrium. In equilibrium, all conjectures must equal their actual strategies, i.e., $\hat{\tau} = \tau$, $\hat{\rho} = \rho$, $\hat{P}_D(x) = P_D(x)$ and $\hat{P}_{ND} = P_{ND}$. Proposition 1 establishes the existence of a unique equilibrium and explicitly states the equilibrium strategies for the case of no entrepreneur's penalties ($k = 0$).

Proposition 1: *There exists a unique threshold equilibrium with the following properties.*
(i) *Given that the entrepreneur observes x at $t = 1$, she discloses x if $x \geq \tau \in (0, 1/2)$, where*

$$\tau = P_{ND} = \frac{\Omega - (1 - p + \lambda c)}{p(1 - \lambda)} \tag{9}$$

and $\Omega \equiv \sqrt{(1 - p + \lambda c)^2 + (1 - \lambda)\left[p(1 - p) + \lambda c^2\right]}$.
(ii) *Conditional on the disclosure of x at $t = 1$, shareholders price the firm with $P_D(x) = x$ at $t = 2$.*
(iii) *Conditional on nondisclosure at $t = 1$, shareholders price the firm with P_{ND} at $t = 2$ as in (9).* (iv) *Conditional on nondisclosure at $t = 1$ and observation of x at $t = 3$, shareholders file a lawsuit if $x \leq \rho < \tau$, where*

$$\rho = \tau - \frac{c}{p} = \frac{\Omega - (1 - p + c)}{p(1 - \lambda)}. \tag{10}$$

Proposition 1 characterizes the unique equilibrium. The entrepreneur, if informed, discloses sufficiently favorable information ($x \geq \tau$) and withholds sufficiently unfavorable information ($x < \tau$), which is consistent with DJK and Dye (2017), among others. Withholding information yields a market price of P_{ND}. This price represents the reservation price at which the entrepreneur is indifferent between disclosure and nondisclosure ($\tau = P_{ND}$). The equilibrium litigation strategy is such that that shareholders sue for sufficiently unfavorable information which an informed entrepreneur would have withheld ($x \leq \rho < \tau$), and do not sue for modestly unfavorable information ($\rho < x < \tau$).

Besides the potential ex post informedness of shareholders, a feature that distinguishes our study from previous studies is the shareholders' legal cost c, whose consideration generates a setting in which litigation is an imperfect insurance mechanism. Our results reconcile with the literature as

follows. If the cost is excessive ($c \geq \bar{c}$), then shareholders never litigate and the disclosure threshold resembles that established in DJK, which is characterized by

$$\tau = P_{ND} = \frac{1}{2}\frac{p\tau^2 + (1-p)}{p\tau + (1-p)}.$$

In contrast, if litigation is costless ($c = 0$) then shareholders always litigate whenever an informed entrepreneur can rationally be expected to have withheld information (implying $\rho = \tau$). Then disclosure threshold is implicitly characterized by

$$\tau = P_{ND} = \frac{1}{2}\frac{(1+\lambda)p\tau^2 + (1-p)}{p\tau + (1-p)}.$$

Then there exists a premium associated with litigation.

We focus on the case in which the legal cost is moderate, $c \in (0, \bar{c})$, such that the shareholders nontrivially trade off expected benefits and cost of litigation. They sue only for sufficiently unfavorable information ($x \leq \rho < \tau$) but not for modestly unfavorable information even though they know that there is a chance that an informed entrepreneur withheld information ($\rho < x < \tau$). However, then the expected benefit does not outweigh the cost. Ex ante, upon nondisclosure, shareholders price both the expected damage and their legal cost if they litigate. Then the equilibrium threshold for the entrepreneur's disclosure decision is

$$\begin{aligned}\tau = P_{ND} &= \tfrac{1}{2}\tfrac{p\tau^2+(1-p)}{p\tau+(1-p)} + \tfrac{\lambda\rho}{p\tau+(1-p)}\left[p\left(P_{ND} - \tfrac{\rho}{2}\right) - c\right] \\ &= \tfrac{1}{2}\tfrac{p(\tau^2+\lambda\rho^2)+(1-p)}{p\tau+(1-p)},\end{aligned}$$

which follows from

$$\left[p\left(P_{ND} - \frac{\rho}{2}\right) - c\right] = \left[p\left(P_{ND} - \frac{\rho}{2}\right) - p\left(P_{ND} - \rho\right)\right] = p\frac{\rho}{2}$$

because $c = p\left(P_{ND} - \rho\right)$ from the shareholders' litigation indifference condition. Nevertheless, despite shareholders not only consider the expected benefits of litigation but also the associated costs, the premium associated with litigation is unambiguously positive.

Implicit in the equilibrium stated in Proposition 1 is a negative association between disclosure and litigation, which resembles a deterrence effect. It follows from equation (10) which states

that $\rho = \tau - \frac{c}{p}$, but it should be noted that both τ and ρ are endogenous equilibrium thresholds. Intuitively, because $\tau = P_{ND}$ in equilibrium, an increase in the disclosure threshold τ (implying less disclosure) is equivalent to a higher nondisclosure price P_{ND}, and vice versa. This implies a larger damage compensation in case of successful litigation, inducing shareholders to also litigate for information that is less unfavorable. The underlying reason for this relationship is not a direct effect but the observation that both the entrepreneur's disclosure decision and the shareholders' litigation decision are affected by the market price upon nondisclosure.

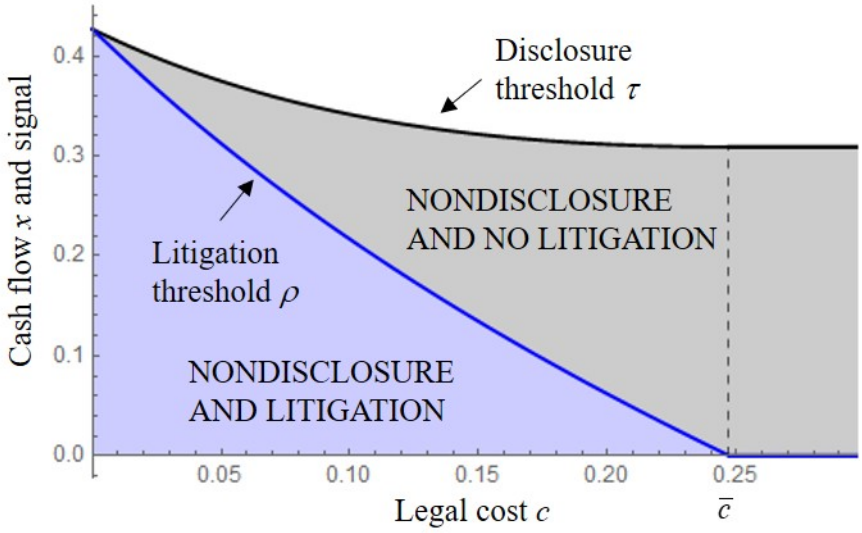
We next provide a first set of comparative statics results for the equilibrium established in Proposition 1. Our variables of interest are the three exogenous parameters in our model: the likelihood with which shareholders become informed at $t = 3$ (λ), the shareholders' legal cost (c), and the likelihood with which the entrepreneur becomes informed at $t = 1$ (p). The parameters λ and c determine the litigation risk in our model, whereas p captures the initial level of information asymmetry between the entrepreneur and shareholders.

Litigation Risk. A key parameter in the modeled litigation mechanism is the legal cost c of shareholders, which directly affects their propensity to litigate. The second parameter is the probability λ that the entrepreneur is known to have private information. The greater λ, the more likely shareholders receive the signal ex post, providing a basis for their litigation decision. In the following, we provide results on changes in these parameters on the equilibrium behavior.

Corollary 1: (i) *Litigation increases in the shareholders' likelihood of becoming informed* (λ) *and decreases in their legal cost* (c)*, i.e.,* $\frac{d\rho}{d\lambda} > 0$ *and* $\frac{d\rho}{dc} < 0$.
(ii) *Disclosure decreases in the shareholders' likelihood of becoming informed* (λ) *and increases in their legal cost* (c)*, i.e.,* $\frac{d\tau}{d\lambda} > 0$ *and* $\frac{d\tau}{dc} < 0$.

Corollary 1 states that both an increase in the shareholders' likelihood of becoming informed and/or a decrease in their legal cost leads to more litigation and to less disclosure. The shareholders' informedness λ affects the equilibrium strategies solely through the litigation-related premium in the nondisclosure price. The more likely shareholders anticipate to become informed the larger the premium and thus the nondisclosure price. Since withholding more information becomes desirable (because of the relation $\tau = P_{ND}$), the entrepreneur discloses less. An increase of the nondisclosure

Figure 2: The Effect of Litigation Risk on Corporate Disclosure



The figure shows the equilibrium disclosure strategy ($x \geq \tau$ are disclosed) and the equilibrium litigation strategy (litigation occurs for $x \leq \rho$) for a variation of the shareholders' legal cost c. For $c \geq \bar{c}$, litigation is too costly and litigation does not occur. The figure assumes the likelihood of an informed entrepreneur with $p = 0.8$ and the likelihood that shareholders receive the signal with $\lambda = 0.8$.

price further implies a higher expected damage compensation, prompting shareholders to sue more often. This is reflected in an increase in the litigation threshold ρ.

A change of the legal cost c directly affects shareholders' litigation-cost-benefit tradeoff. A lower cost induces shareholders to sue also for modestly unfavorable information, for which the expected damage compensation is relatively smaller (the litigation threshold ρ increases). Intuitively, one might reason that the increase in litigation risk would prompt more disclosure. However, Corollary 1 (ii) shows that the opposite is true. This arises because a lower legal cost increases the litigation-related premium in the nondisclosure price, making withholding moderately unfavorable information information more desirable. Overall, our results in Corollary 1 suggest that heightened litigation risk leads to less disclosure.

Figure 2 illustrates the equilibrium strategies as a result of a variation of the shareholders' legal cost.

Information Asymmetry. Next, we consider the effects of the likelihood p that the entrepreneur becomes informed about x at $t = 1$. Consistent with prior literature, this likelihood can be interpreted as the level of information asymmetry at the disclosure date and thus the severity of the adverse selection problem (e.g., Kim et al., 2020). A variation of p can result from firm-specific reasons, such as better management accounting and reporting systems or major capital expenditures.

Corollary 2: *An increase of information asymmetry at $t = 2$ (p) has the following effects.*
(i) *Disclosure increases, i.e., $\frac{d\tau}{dp} < 0$.*
(ii) *Litigation first increases and then decreases, i.e., $\frac{d\rho}{dp} > 0$ if $p < p_T$ and $\frac{d\rho}{dp} < 0$ if $p > p_T$ where $p_T \in (0, 1)$ is uniquely defined.*

If the entrepreneur is more likely to be informed, shareholders believe upon a nondisclosure that it is more likely that she has received unfavorable information but chose to withhold it. This inference leads them to price protect more and reduce the price they are willing to pay in this case. Anticipating this effect, the entrepreneur discloses more information. In the extreme case, if the entrepreneur is informed with certainty ($p \to 1$), full unraveling occurs. This result was first established in DJK, and Corollary 2 (i) shows that it also holds in our setting with costly, informed shareholder litigation.

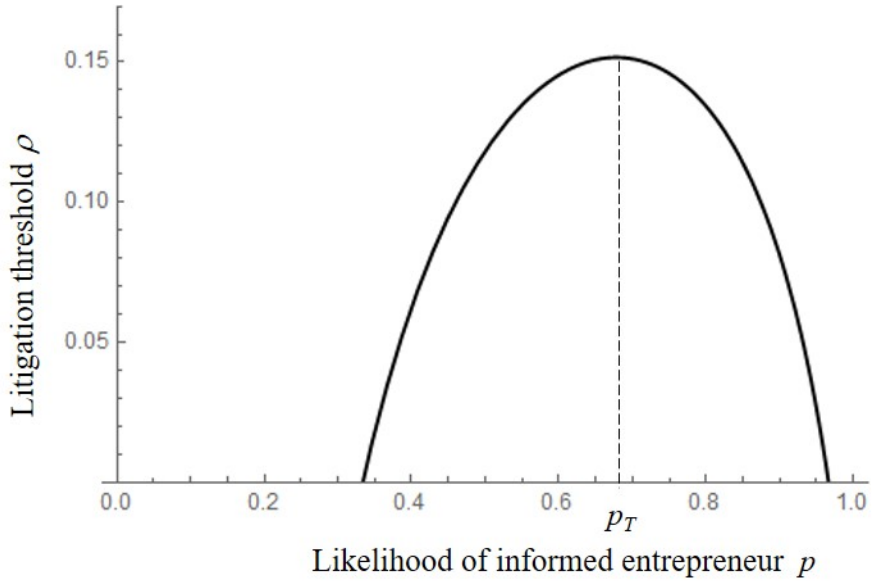
Corollary 2 (ii) establishes a nonmonotonic effect in that shareholders first litigate more and then less in response to an increase of information asymmetry. The underlying rationale for this result features two effects. As discussed above, the nondisclosure price decreases due to exacerbated price protection. This results in a smaller damage compensation, which in turn disincentivizes litigation. A countervailing effect is that an increase in the prior likelihood of the entrepreneur being informed implies a higher likelihood of success in court, such that shareholders sue more often. While the former effect is particularly pronounced for large levels of information asymmetry ($p > p_T$), the latter effect is strong for small levels of information asymmetry ($p < p_T$).

Figure 3 illustrates the litigation threshold for a variation of information asymmetry.

4.2. The Role of Penalties Incurred by the Entrepreneur

A common argument to explain the disclosure of unfavorable information is that shareholder litigation imposes significant costs on insiders, particularly managers, inducing them to disclose such

Figure 3: The Effect of Information Asymmetry on the Probability of Litigation



The figure shows the equilibrium litigation threshold ρ (such that for $x \leq \rho$ shareholders litigate) for a variation of the likelihood p that the entrepreneur is informed at $t = 1$,given a legal cost $c = 0.15$ and a likelihood that shareholders receive the signal of $\lambda = 0.8$. For intermediate p, the probability of litigation first increases and then decreases with a maximal litigation probability at $p = p_T = 0.68$ (rounded). The threshold ρ is undefined for very high and low p because the necessary condition $c < \bar{c}$ is not satisfied.

information to avert these costs (Skinner, 1994). Insider litigation costs can include monetary penalties and jail time, adverse labor market consequences, such as increased turnover risk or a lower likelihood of competitive future employment (Humphery-Jenner, 2012; Brochet and Srinivasan, 2014; Ali et al., 2019), or reputation risk more generally.

To study the role of additional costs of litigation, we assume that in addition to paying damage compensation when convicted of withholding information, the entrepreneur incurs a penalty of

$$\max\{k[P_{ND} - P_D(x)], 0\}.$$

In the following discussion we focus on the entrepreneur's disclosure decision as the main source of changes to the equilibrium structure.

Entrepreneur's Disclosure Decision ($t = 1$). Conjecturing that shareholders do not litigate if $x > \hat{\rho}$, an informed entrepreneur chooses to disclose if

$$\hat{P}_D(x) \geq \hat{P}_{ND} \Leftrightarrow x \geq \hat{P}_{ND},$$

which defines her strategy through $\tau = \hat{P}_{ND}$.

If $x \leq \hat{\rho}$, the entrepreneur anticipates that shareholders litigate with probability λ and that she has to compensate them for their damage and additionally incurs a penalty. Then the entrepreneur discloses if

$$\hat{P}_D(x) \geq \hat{P}_{ND} - \lambda \max\left\{(1+k)\left[\hat{P}_{ND} - \hat{P}_D(x)\right], 0\right\}.$$

Conjecturing that $\hat{P}_{ND} \geq \hat{P}_D(x)$ holds for $x \leq \hat{\rho}$, this condition is equivalent to

$$-\left[1 - \lambda(1+k)\right]\left[\hat{P}_{ND} - \hat{P}_D(x)\right] \geq 0.$$

The term $\lambda(1+k)$ represents the marginal cost of withholding information weighted by the probability that the signal x realizes in $t = 3$. If $\lambda(1+k) < 1$ or equivalently

$$k < \frac{1-\lambda}{\lambda}, \tag{11}$$

then the expected costs from withholding information are smaller than the benefit and the entrepreneur's disclosure decision boils down to the one outline in the previous section. Note that the threshold k is fully determined by the probability λ.

If the penalty is large ($k \geq \frac{1-\lambda}{\lambda}$), the marginal costs of withholding are larger than the marginal benefit, the entrepreneur's utility *decreases,* instead of increases, in x (assuming again that $\hat{P}_D(x)$ strictly increases in x).[15] She therefore has a strong incentive to disclose unfavorable information for which litigation is anticipated ($x \leq \hat{\rho}$). That is, whenever shareholders would credibly sue, the entrepreneur discloses to prevent litigation and to avoid the associated compensation and penalty.

Equilibrium. The next proposition characterizes the equilibrium for sufficiently large penalties.

[15] We adopt the common assumption in the theory literature that in case the entrepreneur is indifferent between disclosure and nondisclosure, she chooses to disclose. Note that later comparative statics results may not strictly hold for the boundary case of $k = \frac{1-\lambda}{\lambda}$.

Proposition 2: *Assume that the entrepreneur's penalty is sufficiently large* ($k \geq \frac{1-\lambda}{\lambda}$). *There exists a unique pure-strategies threshold equilibrium in which the entrepreneur withholds modestly unfavorable information* ($x \in (\rho, \tau)$) *and discloses sufficiently favorable* ($x \geq \tau$) *and very unfavorable information* ($x \leq \rho$). *Moreover, litigation never occurs in equilibrium.*

A salient feature of the equilibrium summarized in Proposition 2 is that, instead of only disclosing sufficiently favorable information—as is the case when the penalty is small—the entrepreneur discloses *both* sufficiently favorable and very unfavorable information and only withholds modestly unfavorable information ($\rho < x < \tau$) for which she anticipates no litigation due to the shareholders' cost of litigation. Shareholders never litigate in equilibrium, implying that the nondisclosure price P_{ND} does not include a litigation premium. The threat of litigation (and thus the threshold ρ) is still important, but it is an out-of-equilibrium strategy.

Dye (2017) reasons that very large penalties induce full unraveling if litigation is costless. Proposition 2 shows that this does not carry over to a situation with costly litigation, and it is in line with the key insight in Trueman (1997) and with the argumentation in Skinner (1994, 1997). More broadly, Proposition 2 is consistent with Becker (1968), who shows that misbehavior is entirely deterred if the marginal cost of misbehavior exceed the marginal benefits.

Litigation Risk. We next show how an increase in the legal cost (the risk, or in this case more precisely, the threat of litigation, since litigation is off-equilibrium) affects disclosure when penalties are sufficiently large.[16] To do so, we not only consider a change in the on- and off-equilibrium strategies but also provide insights on the overall level of disclosure. We define the ex ante likelihood of disclosure as

$$DL \equiv p\left[1 - \Pr(\rho < x < \tau)\right] = p\left[(1-\tau) + \rho\right].$$

Corollary 3: *Assume that the entrepreneur's penalty is sufficiently large* ($k \geq \frac{1-\lambda}{\lambda}$). *Increasing litigation risk* (*decrease in* c) *has the following effects on disclosure*:
(i) *More sufficiently unfavorable information is disclosed, i.e.,* $\frac{d\rho}{dc} < 0$.
(ii) *Less sufficiently favorable information is disclosed, i.e.,* $\frac{d\tau}{dc} < 0$.
(iii) *More information is disclosed, i.e.,* $\frac{dDL}{dc} < 0$.

[16] Note that we do not provide results for a change in the probability λ that a signal arises because λ does not affect the equilibrium characteristics. It has an effect on the equilibrium only through the required minimum penalty $k \geq \frac{1-\lambda}{\lambda}$.

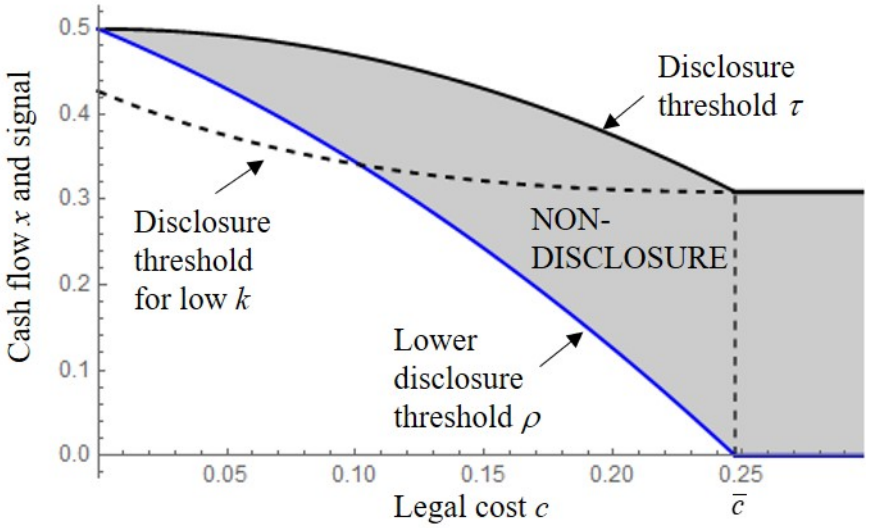
Corollary 3 establishes that, as the shareholders' legal cost c decreases, there is more disclosure of sufficiently unfavorable information, less disclosure of sufficiently favorable information, and more disclosure overall. A smaller c induces shareholders to consider litigation for more modestly unfavorable information (ρ increases). Since the entrepreneur anticipates that shareholders would sue for such information, she strategically chooses to disclose more of that information (Corollary 3 (i)). Another effect arises from the entrepreneur's decision to disclose sufficiently favorable information. In equilibrium, the nondisclosure price equals

$$P_{ND} = \frac{p(\tau-\rho)}{p(\tau-\rho)+(1-p)} \cdot \frac{(\tau+\rho)}{2} + \frac{(1-p)}{p(\tau-\rho)+(1-p)} \cdot \frac{1}{2}.$$

This price is a weighted average of case that the entrepreneur is uninformed and that she is informed but withholds information, where the latter occurs for x in the interval $\rho < x < \tau$. A smaller legal cost c increases the threat of litigation, which implies a higher conditionally expected fundamental value upon nondisclosure, $\frac{(\tau+\rho)}{2}$. At the same time, the posterior likelihood that the entrepreneur was informed increases (i.e., $\frac{d}{dc}\left(\frac{p(\tau-\rho)}{p(\tau-\rho)+(1-p)}\right) > 0$), but this effect is only of second order. Consequently, a decrease in c implies a higher nondisclosure price P_{ND}, which induces less disclosure of sufficiently favorable information (Corollary 3 (ii)). However, this decrease in disclosure of favorable information does not outweigh the increase in disclosure of unfavorable information. Therefore, overall more information is disclosed (Corollary 3 (iii)).

Figure 4 illustrates the equilibrium strategies for large penalties ($k \geq \frac{1-\lambda}{\lambda}$) and shows that the nondisclosure interval increases in the legal cost c, starting at $x = 0.5$ for $c = 0$,which is the boundary case that the informed entrepreneur fully discloses due to the threat of litigation. For comparision purposes, the figure also depicts the disclosure strategy in the case of small penalties. The cash flows below the dashed line are withheld by the informed entrepreneur. While nondisclosure decreases in the legal cost for low penalties, it increases for high penalties. Furthermore, it shows that for excessively high shareholder legal costs ($c > \bar{c}$), shareholders never litigate and the disclosure strategies for high- and low-penalty firms coincide.

Figure 4: The Effect of Litigation Risk on Corporate Disclosure When Penalties are Large



The figure shows the equilibrium disclosure strategy ($x \geq \tau$ and $x < \rho$ are disclosed) for a variation of the legal cost c. The figure assumes the likelihood of an informed entrepreneur with $p = 0.8$ and the likelihood that shareholders receive the signal with $\lambda = 0.8$, which are the same parameters as in Figure 2 above, and the dashed line is the disclosure threshold in the case of small penalties.

Information Asymmetry. Next, we reexamine the effects of changing information asymmetry on equilibrium disclosure behavior for sufficiently large penalties.

Corollary 4: *Assume that the entrepreneur's penalty is sufficiently large* ($k \geq \frac{1-\lambda}{\lambda}$). *An increase of information asymmetry at* $t = 2$ (p) *has the following effects.*
(i) *First more and then less sufficiently unfavorable information is disclosed, i.e.,* $\frac{d\rho}{dp} > 0$ *if* $p < p_T^H$ *and* $\frac{d\rho}{dp} < 0$ *if* $p > p_T^H$ *where* $p_T^H \in (0,1)$ *is uniquely defined.*
(ii) *First less and then more sufficiently favorable information is disclosed, i.e.,* $\frac{d\tau}{dp} > 0$ *if* $p < 1/2$ *and* $\frac{d\tau}{dp} < 0$ *if* $p > 1/2$.
(iii) *More information is disclosed, i.e.,* $\frac{dDL}{dp} > 0$.

Some of the results in Corollary 4 are qualitatively similar to the ones presented in Corollary 2 for small penalties. The shareholders' litigation threshold that gives rise to the entrepreneur's disclosure of very unfavorable information, first increases and then decreases in information asymmetry for reasons similar to those under Corollary 2 (ii). In addition, overall disclosure increases (Corollary 4 (iii)), which is consistent with Corollary 2 (i). The entrepreneur's strategy to provide

sufficiently favorable information is more subtle. The nondisclosure price decreases in the likelihood of informedness of the entrepreneur for given strategies τ and ρ. However, changes in ρ have a more pronounced effect than under small penalties because ρ also codetermines the conditionally expected fundamental value, and any increase in ρ leads to an increase in the nondisclosure price. Corollary 4 (i) shows that ρ increases in information asymmetry for sufficiently low levels of information asymmetry ($p < p_T^H$), and it is this effect that can dominate and counteract the direct effect of a change of p. Then the entrepreneur discloses less sufficiently favorable information, instead of more.

4.3. Further Analyses

Differences in Disclosure Behavior. We have established that if the entrepreneur's (more generally, the insider's) penalties due to litigation (the penalty k) are sufficiently small, then the likelihood of disclosure decreases as litigation risk (measured by the shareholders' legal cost c) increases, whereas if the penalties are sufficiently large, the opposite result holds. While only high-penalty firms disclose sufficiently unfavorable information, both high- and low-penalty firms disclose sufficiently favorable information. Since the nondisclosure prices are determined differently, their disclosure strategy regarding sufficiently favorable information may differ. To provide more insights, we compare the corresponding disclosure thresholds. To distinguish between the cases, we introduce subscripts on the equilibrium strategies, where $i = H$ indicates a scenario with large penalty ($k \geq \frac{1-\lambda}{\lambda}$) and $i = L$ a scenario with small penalty ($k < \frac{1-\lambda}{\lambda}$).

Proposition 3: *Small-penalty firms disclose more sufficiently favorable information than large-penalty firms, i.e., $\tau_L < \tau_H$.*

One might expect that, because litigation is priced and leads to a premium when a firm has a small penalty, such firms disclose less sufficiently favorable information. Proposition 3 shows the opposite. The reason is that firms with high penalties disclose both sufficiently favorable and very unfavorable information, withholding only moderately unfavorable information. Upon nondisclosure, shareholders consider this in determining the nondisclosure price, which equals the threshold above which the entrepreneur discloses x. Assuming to the contrary that $\tau_L = \tau_H$, then upon observing nondisclo-

sure, shareholders would conjecture a lower likelihood that the entrepreneur was informed, implying a higher weight on the average expected cash flow $E[x]$ in the conditionally expected fundamental value. Proposition 3 establishes that the higher conditionally expected fundamental value more than outweighs the lack of a premium associated with litigation (since litigation is off-equilibrium) such that a small-penalty firm provides more sufficiently favorable information than a high-penalty firm.

Average Effect of Increasing Litigation Risk on Corporate Disclosure. An important question from a regulatory and an empirical perspective is how litigation risk affects the average firm's disclosure behavior. Consider an economy populated with heterogeneous firms that differ in their penalty k, where k (or whether k is below or above $\frac{1-\lambda}{\lambda}$) is publicly known.[17] Assume that a fraction $\alpha \in (0,1)$ of firms face small penalties ($k < \frac{1-\lambda}{\lambda}$), whereas $1-\alpha$ face large penalties ($k \geq \frac{1-\lambda}{\lambda}$).[18]

The average disclosure likelihood is the weighted average of the disclosure likelihood in the two scenarios. We disaggregate the likelihood into the disclosure likelihood of sufficiently favorable (subscript F) and of unfavorable information (subscript U) as follows:

$$ADL \equiv \underbrace{p\left[\alpha(1-\tau_L)+(1-\alpha)(1-\tau_H)\right]}_{\equiv ADL_F} + \underbrace{p(1-\alpha)\rho_H}_{\equiv ADL_U}.$$

Proposition 4: (i) *There exists a unique threshold $\alpha_T \in (0,1)$ such that the average disclosure likelihood decreases (increases) due to increasing shareholders' litigation risk (decrease in c) if $\alpha > \alpha_T$ ($\alpha > \alpha_T$), i.e., $\frac{dADL}{dc}|_{\alpha>\alpha_T} > 0$ ($\frac{dADL}{dc}|_{\alpha<\alpha_T} < 0$).*
(ii) *Increasing litigation risk (decrease in c) makes less (more) average disclosure more (less) likely, i.e., $\frac{d\alpha_T}{dc} > 0$.*
(iii) *Increasing litigation risk (decrease in c) decreases (increases) the disclosure of sufficiently favorable (unfavorable) information, $\frac{dADL_F}{dc} > 0$ ($\frac{dADL_U}{dc} < 0$).*

Proposition 4 (i) directly follows from Corollary 1 (ii) and Corollary 3 (iii). If the proportion of

[17] Note that the public knowledge assumption is stronger than just assuming that penalties follow a commonly known distribution. The reason is that additional uncertainty, without a signalling option, would yield an equilibrium that blends Propositions 1 and 2. However, a theoretical justification for such uncertainty is not straightforward.

[18] The weight α is all that matters for the subsequent results, as the specific penalties within the two scenarios do not directly affect the disclosure-pricing-litigation game in either scenario.

small-penalty firms is sufficiently large, heightened litigation risk induces less disclosure for the average firm, whereas if this proportion is sufficiently small, the opposite holds. Similarly, the results in Proposition 4 (iii) are a direct consequence of Corollary 1 (ii) and Corollary 3 (i) and (ii).

Proposition 4 (ii) is less straightforward because the result depends on the relative impact of a change in litigation risk. The proposition establishes that as the shareholders' legal cost declines and, thus, litigation risk increases for all firms, an average decline in disclosure becomes more likely. This arises because a change in litigation risk has a larger effect on firms with small penalties than on firms with large penalties. The primary reason is that for firms with high penalties, a lower shareholder legal cost implies a larger litigation threshold, so that firms ramp up their disclosure of sufficiently unfavorable information. However, this increase of the disclosure of unfavorable information is partly outweighed by a decrease in the disclosure of favorable information with a relatively small positive net effect (Corollary 3 (iii) and Figure 4).

Average Market Reactions to Good News Versus Bad News Disclosure. Several empirical studies find that the average stock market reaction to bad news disclosures is more more pronounceed than to good news disclosures (e.g., Skinner, 1994; Kothari et al., 2009). We next dervive the average market reactions to good versus bad news disclosures in the context of our model and additionally highlight differential effects.

The equilibrium disclosure strategies (Propositions 1 and 2) include disclosure of sufficiently favorable information and, for large penalties, very unfavorable information. Yet this does not simply translate into "good news" and "bad news" disclosures. Good news are commonly associated with positive, and bad news with negative *market reactions*. In order to derive the market reaction, we derive the ex ante price $E[P]$ that a competitive market would set at $t = 0$. The formal derivations are relegated to the appendix. There we show that the ex ante price in case of small penalties is strictly above the prior expectation of cash flows, i.e., $E[P_L] > E[x]$, because the premium associated with litigation not only ex post, but also ex ante, inflates prices. For large penalties, the ex ante price is equal to the prior mean of cash flows, i.e., $E[P_H] = E[x]$, because there is no litigation premium due to no litigation in equilibrium.

Since the threshold determining the disclosure of sufficiently favorable information (τ) is strictly below the prior mean ($E[x] = 1/2$) in either case, good news ($x \geq E[P]$) are always disclosed,

whereas only some bad news are disclosed. Specifically, $x \in [\tau, E[P])$ are disclosed in both cases and $x \in (0, \rho_H]$ are additionally disclosed in the case with large penalties. The next proposition compares the average market reactions to good and bad news disclosures.

Proposition 5: (i) *If the entrepreneur's penalty is sufficiently small* ($k < \frac{1-\lambda}{\lambda}$), *the average market reaction to good news is larger than to bad news.*
(ii) *If the entrepreneur's penalty is sufficiently large* ($k \geq \frac{1-\lambda}{\lambda}$), *there exists a unique threshold* $c_{MR} \in (0, \bar{c})$ *such that:*
(ii.a.) *If the shareholder's legal cost is sufficiently high* ($c > c_{MR}$), *the average market reaction to good news is larger than to bad news.*
(ii.b.) *If the shareholder's legal cost is sufficiently low* ($c < c_{MR}$), *the average market reaction to bad news is larger than to good news.*

Proposition 5 suggests that an asymmetric disclosure pattern as documented in empirical studies only arises in the scenario with large penalties and a high threat of litigation (low shareholders' legal costs). The underlying intuition for this result is as follows. In the case of small penalties, all good news but only weakly bad news are disclosed. Thus the average market reaction to good news, which includes very good news, is larger than to bad news since the bad news that are disclosed exclude moderately and very bad news. This is different in the scenario with large penalties in which very bad news are also disclosed and then pooled together with weakly bad news in deriving the average market reaction. If shareholders' legal costs are sufficiently low such that a large set of moderately and very bad news is disclosed, then the average market reaction to bad news disclosures becomes larger than to good news disclosures.

We next provide an additional result on the effect of a variation of shareholders' legal cost, and thus litigation risk, on the difference in average market reactions.

Corollary 5: *If the entrepreneur's penalty is sufficiently large* ($k \geq \frac{1-\lambda}{\lambda}$), *the difference in average market reactions to bad news and to good news disclosures first increases and then decreases in the shareholders' legal cost* c.

Corollary 5 establishes that the difference between the average market reaction to bad news disclosures and to good news disclosures is nonmonotonic in the shareholders' legal cost and, thus, in litigation risk. This nonmonotonic relationship is motivated by two observations. First, in Proposition 5 (ii) we establish that there exists an interior level of legal cost c_{MR} such that whenever

$c = c_{MR}$, the average market reactions are the same. Second, as the legal cost becomes low, litigation risk disproportionately increases and the entrepreneur discloses more bad news to a point where full unraveling occurs at $c = 0$. Then the average market reaction is also identical for good news and bad news disclosures.

Price Efficiency. We next consider the effect of litigation on ex ante price efficiency and, thus, on how well prices reflect fundamentals on average. Our measure of price efficiency is the expectation of the absolute deviation of prices from the fundamental cash flow x at $t = 2$, when the transaction between the parties occurs, i.e.,

$$PE \equiv -E[|x - P|].$$

If x is disclosed then $P_D(x) = x$ and the price fully reflects the fundamentals. Upon nondisclosure, the equilibrium price is P_{ND}, and differences between x and P_{ND} occur. As outlined above, whether disclosure occurs depends on the size of the entrepreneur's penalty. Price efficiency is

$$\begin{aligned} PE_L &= -\left[p\int_0^\tau |x - P_{ND}|dx + (1-p)\int_0^1 |x - P_{ND}|dx\right] \\ &= -\left[p\tfrac{\tau^2}{2} + (1-p)\left(\tfrac{1}{2} - (1-\tau)\tau\right)\right] \end{aligned}$$

for low penalties and

$$\begin{aligned} PE_H &= -\left[p\int_\rho^\tau |x - P_{ND}|dx + (1-p)\int_0^1 |x - P_{ND}|dx\right] \\ &= -\left[p\tfrac{(\tau-\rho)^2}{2} + (1-p)\left(\tfrac{1}{2} - (1-\tau)\tau\right)\right] \end{aligned}$$

for large penalties.

The following corollary characterizes the behavior of PE with respect to our main litigation risk parameters λ and c for small and large penalties.

Corollary 6: (i) *Assume that the entrepreneur's penalty is sufficient small* ($k < \frac{1-\lambda}{\lambda}$). *Price efficiency decreases in the likelihood that shareholders become informed at* $t = 3$ (λ) *and increases in the shareholders' legal cost* (c), *i.e.,* $\frac{dPE_L}{d\lambda} < 0$ *and* $\frac{dPE_L}{dc} > 0$.
(ii) *Assume that the entrepreneur's penalty is sufficient large* ($k \geq \frac{1-\lambda}{\lambda}$). *Price efficiency does not change with the likelihood that shareholders become informed at* $t = 3$ (λ) *and decreases in the shareholders' legal cost* (c) , *i.e.,* $\frac{dPE_H}{d\lambda} = 0$ *and* $\frac{dPE_H}{dc} < 0$.

Generally, price efficiency increases the more realizations of x are disclosed by an informed entrepreneur because disclosure implies $-E[|x - P_D|D] = 0$. For small penalties, disclosure decreases in the probabilty of an informed entrepreneur (λ) and increases in the legal cost (c) (Corollary 1). Yet, there is another effect: PE decreases in an increase of the litigation premium in the nondisclosure price. Corollary 6 establishes that the first effect dominates the second, implying that price efficiency is maximized when disclosure is maximized (i.e., PE decreases in τ). For large penalties, the equilibrium features no litigation, making the probability λ irrelevant for the disclosure strategy and, thus, for price efficiency. Moreover, there is no litigation premium in this case. Therefore, as disclosure decreases in c, higher litigation risk implies greater price efficiency.

Our consideration of price efficiency is based on the pricing of shares at $t = 2$, when the entrepreneur discloses, or is expected to disclose, and the transaction between the entrepreneur and shareholders takes place. Some regulations aims to increase the probability of a signal, λ, e.g., by protecting whistleblowers. Corollary 6 shows that this has an adverse effect on PE for small penalties but no effect for large penalties.[19]

5. The Effects of Litigation Risk on Corporate Innovation

Our model features a pure exchange setting with a focus on the relationship between corporate disclosure and shareholder litigation. However, litigation can also have real effects. For example, there are concerns that shareholder litigation has undesirable incentive effects on corporate innovation (Lin et al., 2020). Since research and development is a main driver of micro- and macroeconomic growth, creating an environment that fosters innovation is of importance to regulators (Arrow, 1968; Stokey, 1995).

We extend our setting to gain insights into how litigation risk affects the entrepreneur's ex ante incentives to innovate. To parsimoneously include innovation, assume that, at $t = 0$, the entrepreneur chooses innovative effort $a \in (0, 1)$, which reflects the probability that a new product or technology emerges that generates the future cash flow x. The entrepreneur incurs a private (unobservable) cost $a^2/2$. The innovative effort is unsuccessful with probability $(1 - a)$, and in this case the entrepreneur cannot sell the firm, and the game ends. The success of the innovative

[19] Including the arrival of the signal x at $t = 3$ would alter this conclusion, but there is no relevant price effect at that time.

effort becomes public knowledge at $t = 1$. For instance, the firm is able to produce or offer a new product or service that would not be feasible without R&D, but its financial value is still uncertain. Since the innovative effort is chosen at $t = 0$ and the result is observable at the beginning of $t = 1$, all equilibrium strategies established in Propositions 1 and 2 continue to hold. To decide on the innovative effort, the entrepreneur considers her ex ante expected utility, given innovation is successful, which depends on the equilibrium that evolves. If the entrepreneur's penalty k is small ($k < \frac{1-\lambda}{\lambda}$), the expected utility at $t = 0$ comprises the expected price less the expected compensation and penalty the entrepreneur incurs upon successful litigation, formally,

$$\begin{aligned} EU_L = \{(1-p)E[P_{ND}] + p\Pr(x \geq \tau_L)E[P_D(x)|x \geq \tau_L] + p\Pr(x < \tau_L)E[P_{ND}|x < \tau_L]\} \\ -p\lambda(1+k)\Pr(x \leq \rho_L)E[P_{ND} - P_D(x)|x \leq \rho_L]. \end{aligned} \tag{12}$$

The first three terms comprise the expected price the entrepreneur obtains from selling the firm. The expected price includes the prices she would obtain if she remains uninformed, becomes informed and discloses, and becomes informed but withholds. The fourth term is the expected compensation in case she becomes informed but withholds and shareholders decide to litigate. The expected utility increases in the expected price, which itself increases in the disclosure threshold τ.[20] The optimal innovative effort results from maximizing the expected benefit less the cost of effort, which yields

$$a_L = [p\tau_L + (1-p)]\,\tau_L + p\frac{(1-\tau_L^2)}{2} - \lambda(1+k)p\rho_L\left(\tau_L - \frac{\rho_L}{2}\right), \tag{13}$$

where we use the relation $\tau_i = P_{ND}$.

If the penalty k is sufficiently large ($k \geq \frac{1-\lambda}{\lambda}$), the expected utility comprises only the expected price since there is no litigation in equilibrium (Proposition 4), resulting in

$$\begin{aligned} EU_H = (1-p)E[P_{ND}] + p\Pr(x \geq \tau_H)E[P_D(x)|x \geq \tau_H] \\ +p\Pr(x \leq \rho_H)E[P_D(x)|x \leq \rho_H] + p\Pr(\rho_H < x < \tau_H)E[P_{ND}|x < \tau_H]. \end{aligned} \tag{14}$$

[20] This holds regardless of whether she remains uninformed or becomes informed at $t = 1$. If she remains uninformed, the equilibrium price P_{ND} coincides with τ. If she learns x, she will disclose sufficiently favorable $x \geq \tau$, resulting in the price $P_D(x) = x$, which, in expectation, equals $E[x|x \geq \tau] = \frac{1+\tau}{2}$. If $x < \tau$, she will withhold, and the price is again P_{ND}. The average price, given that the entrepreneur becomes informed, simplifies to

$$\Pr(x \geq \tau)E[x|x \geq \tau] + \Pr(x < \tau)E[P_{ND}|x < \tau] = (1-\tau)\frac{1+\tau}{2} + \tau^2 = \frac{1}{2}(1+\tau^2),$$

which unambiguously increases in τ.

The optimal innovative effort then equals

$$a_H = \frac{1}{2}. \tag{15}$$

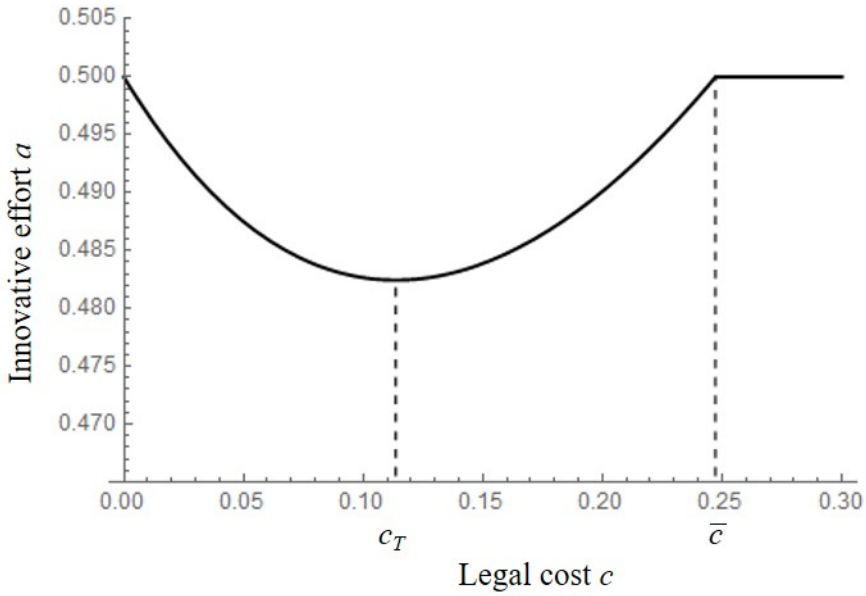
The next proposition characterizes the effects of shareholder litigation on corporate innovation.

Proposition 6: (i) *Costly, informed shareholder litigation does not affect innovation by large-penalty firms, i.e.,* $a_H(c = \bar{c}) = a_H(c \in (0, \bar{c}))$.
(ii) *Costly, informed shareholder litigation discourages innovation by small-penalty firms, i.e.,* $a_L(c = \bar{c}) > a_L(c \in (0, \bar{c}))$.
(iii) *Increasing litigation risk by reducing the shareholders' legal cost* (c) *first decreases and then increases innovation by small-penalty firms, i.e.,* $\frac{da_L}{dc} < 0$ *if* $c > c_T$ *and* $\frac{da_L}{dc} < 0$ *if* $c < c_T$, *where* $c_T \in (0, \bar{c})$ *is uniquely defined.*

Proposition 6 (i) establishes that, perhaps surprisingly, litigation has no ex ante effect on the entrepreneur's innovative effort incentives if her associated penalty is sufficiently large. The reason is that the equilibrium disclosure strategy fully prevents litigation and, therefore, avoids any costs incurred by both the entrepreneur and shareholders.

In contrast, costly, informed litigation induces a lower innovative effort relative to the extreme scenario with no litigation if the entrepreneur's penalty is small (Proposition 6 (ii)). In this case, a variation of the legal cost c affects innovative effort nonmonotonically, depending on the shareholders' legal cost and, thus, the preexisting level of litigation risk (Proposition 6 (iii)). The relation is U-shaped and is a result of the entrepreneur trading off a higher price and a higher damage compensation and penalty. If the shareholders' legal cost is sufficiently small and the level of litigation risk is high ($c < c_T$), the expected penalties are very large and a change in the shareholders' legal cost impacts the entrepreneur's costs resulting from a lawsuit (damage compensation and penalty) relatively more than the expected price. Then innovative effort increases in litigation risk. Conversely, the innovative effort decreases if the level of litigation risk is low ($c \geq c_T$) because a change in c has a larger impact on the expected price. Figure 5 illustrates the effect of litigation risk on innovation for a sufficiently small penalty.

Figure 5: The Effect of Litigation Risk on Corporate Innovation for Small-Penalty Firms



The figure shows how the level of litigation risk (a smaller shareholder legal cost c) affects the incentives of an entrepreneur with a small penalty to engage in innovative effort a to generate the project that promises the uncertain future cash flow x. Increasing litigation risk first decreases and then increases innovative effort. The minimum effort arises at $c = c_T = 0.114$. The figure assumes the likelihood of an informed entrepreneur with $p = 0.8$, the likelihood that shareholders receive information with $\lambda = 0.8$ and no penalty ($k = 0$).

6. Implications

6.1. Reconciliation with Empirical Evidence on Disclosure and Litigation

We reconcile our main results with empirical evidence from a broad set of studies that mostly use U.S. data. The U.S. are commonly considered a country with strong shareholder litigation rights and generally a litigious environment, but the firm-level litigation risk nevertheless varies with factors such as ownership structure, industry classification (Kim and Skinner, 2012), state of incorporation (Bourveau et al., 2018), or the circuit in which a firm has its headquarter (Huang et al., 2020).

A first association in our model is that, in equilibrium, more disclosure is associated with *less* litigation, and we provide two reasons for this association. First, as in DJK, the insider discloses sufficiently favorable information (and thus all good news and some weakly bad news) if the nondisclosure price exceeds the price obtained from disclosure. A lower nondisclosure price makes disclo-

sure of weakly bad news more desirable. However, it also makes litigation less desirable since the damages that can be claimed in court are smaller. Second, if insider litigation costs are large, then the insider discloses the information for which shareholders would rationally litigate, namely very bad news. However, then there is no basis for litigation ex post. This litigation-prevention argument for disclosure, which is in line with the concept of deterrence by Becker (1968), goes back to Skinner (1994, 1997). Many studies use the prevention argument to explain their results, although it is not clear whether this is really the case (e.g., Field et al. 2005; Donelson et al. 2012).

Second, we show that the effect of litigation on disclosure structurally depends on insiders' litigation costs. While insiders facing small costs disclose less information in response to an increases in litigation risk, insiders facing large costs disclose more. These differentiated results arise because litigation affects insiders facing various litigation costs differently. While an insider with high litigation costs is disciplined by litigation such that she chooses its disclosure to completely avoid litigation in equilibrium, an insider with a small cost is not sufficiently disciplined by litigation. Instead, litigation affects disclosure indirectly through market pricing. Upon nondisclosure, shareholders know that there may be an opportunity to litigate and receive a reimbursement for their damages in the future, leading to a litigation-related premium in the nondisclosure price that codetermines disclosure. If shareholders' legal cost decreases (and thus litigation risk increases), the premium increases, leading to less disclosure. The argument that litigation is priced is also consistent with evidence by Ali and Kallapur (2001).[21] They study the stock market reaction to the Private Securities Litigation Reform Act (PSLRA) in 1995, which is commonly believed to have weakened shareholder litigation rights, and find a negative average market reaction.[22]

Our differentiated results may serve to explain the mixed evidence of studies that analyze disclosure behavior in response to changes in litigation risk. Baginski et al. (2002) provide a cross-sectional comparison of the more litigious environment in the U.S. with the less litigious environment in Canada and find that Canadian firms disclose more information. Several studies examine the impact on disclosure by regulatory events such as the PSLRA, the staggered adoption of Universal Demand (UD) laws between 1989 and 2005, and the Morrison v. National Australia Bank Supreme

[21] However, Johnson et al. (2000) provide opposite results but, as Ali and Kallapur (2001) argue, these arise largely from confounding events.

[22] For further supporting evidence that litigation is a determining factor in price formation see, e.g., Griffin et al. (2004).

Court ruling in 2010 in the U.S. Johnson et al. (2001) and Bourveau et al. (2018) provide evidence consistent with a negative effect of litigation risk on disclosure, whereas Naughton et al. (2019) and Huang et al. (2020) provide evidence of a positive effect. In Proposition 4, we establish that whether firms disclose more or less depends on the composition of the sample population along firm insiders' litigation costs.

We also provide an analysis on the difference in average market reactions to bad news and good news disclosures. Notable studies such as Skinner (1994) and Kothari et al. (2009) find that the average market reaction to bad news is larger than to good news. In our model, this only arises if insider litigation costs are large and litigation risk is sufficiently high, that is, litigation is an effective deterrent, prompting firms to disclose very bad news. In addition, we show that, for the case with large insider litigation costs, the difference in average market reactions to bad news and good news disclosures first increases and then decreases in litigation risk.

6.2. Further Empirical and Regulatory Implications

Our results suggest additional empirical predictions and regulatory implications. First, we provide more nuanced predictions on the impact of changes in litigation risk on corporate disclosure. We show that the direction of the relation depends on insiders' litigation costs. In particular, large costs imply a positive effect, whereas small costs imply a negative effect, and the overall effect in a heterogenous population of firms depends on the weight of either type in the population. We also find that the average firm reduces disclosure of sufficiently favorable information but increases disclosure of sufficiently unfavorable information. As discussed earlier the analysis on asymmetric market reactions to good and bad news, these findings do not simply translate into changes in "good news" and "bad news" when benchmarking the disclosure of cash flows against an a priori market price since, in our model, the threshold for the disclosure of sufficiently favorable information, is always below the benchmark price. Consequently, the set of sufficiently favorable information includes all good news and some bad news. Thus in general in our model good news disclosures are always more likely than bad news disclosures. Future empirical studies on the effects of litigation risk on disclosure might wish to focus on bad news and distinguish between very bad news, moderately bad news, and weakly bad news. Our model predicts that, as litigation risk increases, insiders decrease the disclosure of weakly bad news, regardless of their litigation costs. In addition, insiders with

large litigation costs increase the disclosure of very bad to moderately bad news. Complementing these results, we also show that the effect of heightened litigation risk on price efficiency is in the same direction as that on overall disclosure. Thus, price efficiency increases if insider litigation costs are large and decreases if they are small.

Second, we provide predictions on how the level of information asymmetry (the likelihood that the entrepreneur has information) and, thus, the severity of adverse selection affects disclosure and litigation. We confirm the finding in the prior theoretical literature (in particular, DJK) that an increase in information asymmetry induces more disclosure overall. We additionally show that such an increase has an ambiguous effect on shareholder litigation. In particular, low-information-asymmetry firms face more and high-information-asymmetry firms face less litigation risk.

Third, we show effects of varying the likelihood with which fundamental information arises later. Strengthening whistleblower protection is a regulation that leads to a richer ex post information environment.[23] According to Dyck et al. (2010), almost half of all exposed misconduct cases were uncovered by corporate insiders, including management, board, and employees. Regulators around the world have increasingly enacted regulations to better protect and even reward whistleblowers. Examples of such regulations include Section 806 of the Sarbanes-Oxley Act (SOX) of 2002 in the U.S. and the Whistleblowing Directive 2019/1937 in the European Union. Assuming that such regulations are effective in exposing misconduct more often and thus improving transparency and accountability, we predict that whistleblowing regulation leads to less disclosure and to lower price efficiency for firms whose insiders face small litigation costs. This should be of interest to regulators since it works against the objective of encouraging disclosure.

Fourth, we establish that shareholder litigation can have consequences for ex ante incentives of firms to engage in innovative activities such as R&D. We find that changes in litigation risk only affect innovation by firms whose insiders do not expect large costs associated with litigation. Then we document a U-shaped relationship in that increasing litigation risk leads to less innovation by low-litigation-risk firms but to more innovation by high-litigation-risk firms.[24]

[23] Note that the application of our model to whistleblowers assumes that a whistleblower brings out the information but not whether the firm had information but intentionally withheld it.

[24] Lin et al. (2020) study the impact of litigation risk on corporate innovation using the staggered adoption of UD laws, which is believed to reduce litigation risk. They find that firms on average innovate more and that this effect is driven by high-volatility firms (who are generally regarded as facing high litigation risk).

7. Conclusions

We develop a model to gain insights into the relationship between corporate disclosure and shareholder litigation and into potential real effects of litigation. Our model features endogenous disclosure, competitive market pricing, and costly, informed litigation. The main takeaway of our study is that the equilibrium disclosure and litigation behaviors and the effects of changes in litigation-risk-related factors are structurally determined by insiders' litigation costs. If their litigation costs are small, then all good news and weakly bad news are disclosed. Shareholders litigate in equilibrium if sufficiently bad news arrive, and they ex ante price the value of litigation as a premium. Increasing litigation risk increases the price premium, leading to *less* disclosure (specifically, of weakly bad news). If insiders' litigation costs are large, then all good news and weakly and very bad news are disclosed. Disclosure of very bad news prevents litigation in equilibrium, but the threat of litigation nevertheless disciplines disclosure.[25] An increase of litigation risk by decreasing shareholders' legal cost increases disclosure overall. In particular, firms disclose more very bad news and less weakly bad news. The latter effect arises because nondisclosure implies a higher conditionally expected fundamental value, rather than a change in a litigation-related premium (as is the case with small insider litigation costs), which increases in litigation risk.

Further key results are as follows. First, increasing information asymmetry between firm insiders and outsiders first increases and then decreases litigation. Second, corporate innovation first decreases and then increases in litigation risk for firms whose insiders face small litigation costs, and it is unaffected by changes in litigation risk otherwise. Third, the well-documented larger average market reaction to bad news than to good news disclosures only arises if insiders' litigation costs are large and litigation risk is high (implying that a large set of bad news is disclosed). The difference in market reactions is nonmonotonic in litigation risk if insiders' litigation costs are large. Fourth, regulations intended to improve corporate transparency (e.g., whistleblowing regulation) can have unintended conseqences and can induce less disclosure by firms whose insiders face small litigation costs. This also curbes price efficiency.

Our study has limitations, which open up avenues for future theoretical research. We consider a standard one-period model with one piece of relevant private information, which the entrepreneur

[25] This is in line with the litigation prevention argument established by Skinner (1994, 1997).

can credibly and truthfully disclose at no direct cost and which may later be observed by shareholders. An extension may consider that the firm obtains a noisy signal, whereas the signal investors observe later is more precise. Then, even in the case of large insider litigation costs, litigation should arise in equilibrium and shareholders price the value of future litigation upon nondisclosure. In addition, managers have discretion not only over whether to disclose but also when to disclose and whether to bias their disclosures,[26] both of which may also affect managers' liability in court.

[26] See, e.g., Trueman (1990); Einhorn and Ziv (2012).

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Appendix

Proofs of Proposition 1 and Corollaries 1 and 2

The uniqueness of the equilibrium follows from the explicit model solution stated in Proposition 1. Here we focus on deriving the necessary condition $c < \bar{c}$. For this and subsequent proofs we first define the following conditions that obtain from rearranging conditions (7) and (4) and acknowledging the relations (5) and $\tau = P_{ND}$:

$$g_\tau(\tau, \rho) \equiv p\lambda\rho^2 + (1-\tau)(1-p) - \tau\left[(1-p) + p\tau\right],$$
$$g_\rho(\tau, \rho) \equiv p(\tau - \rho) - c.$$

Together, $g_\tau(\tau, \rho)$ and $g_\rho(\tau, \rho)$ implicitly determine τ and ρ. It can be shown that the determinant of the Jacobian matrix (the matrix of first-order partials),

$$\frac{\partial g_\tau(\tau,\rho)}{\partial \tau}\frac{\partial g_\rho(\tau,\rho)}{\partial \rho} - \frac{\partial g_\tau(\tau,\rho)}{\partial \rho}\frac{\partial g_\rho(\tau,\rho)}{\partial \tau} = 2p\left[(1-p) + p(\tau - \lambda\rho)\right]$$

is unambiguously positive, where

$$\tfrac{\partial g_\tau(\tau,\rho)}{\partial \tau} = -2\left[(1-p) + p\tau\right] < 0,$$
$$\tfrac{\partial g_\tau(\tau,\rho)}{\partial \rho} = 2p\lambda\rho > 0,$$
$$\tfrac{\partial g_\rho(\tau,\rho)}{\partial \tau} = p > 0,$$
$$\tfrac{\partial g_\rho(\tau,\rho)}{\partial \rho} = -p < 0.$$

The limits are

$$\lim_{\tau\to 0} g_\tau(\tau,\rho) = p\lambda\rho^2 + (1-p) > 0,$$
$$\lim_{\tau\to 1/2} g_\tau(\tau,\rho) = -p(\tfrac{1}{4} - \lambda\rho^2) < 0,$$
$$\lim_{\rho\to 0} g_\rho(\tau,\rho) = p\tau - c,$$
$$\lim_{\rho\to \tau} g_\rho(\tau,\rho) = -c < 0.$$

Given that $\lim_{\rho\to 0} g_\rho(\tau,\rho) > 0$, this suggests again uniqueness according to the inverse function theorem. In the limit, when $\rho \to 0$, τ can be explicitly calculated by solving $g_\tau(\tau, \rho = 0) = 0$, which yields the following unique interior solution:

$$\tau = \frac{\sqrt{1-p} - (1-p)}{p}.$$

Inserting this expression for τ into $\lim_{\rho\to 0} g_\rho(\tau,\rho)$ leads to

$$\lim_{\rho\to 0} g_\rho(\tau,\rho) = \bar{c} - c,$$

where

$$\bar{c} = \sqrt{1-p} - (1-p).$$

The comparative statics results in Corollaries 1 and 2 follow directly from a multivariable version of the implicit function theorem, which implies that the following conditions must be satisfied with respect to any variable $z \in \{c, p, \lambda\}$:

$$\tfrac{\partial g_\tau(\tau,\rho)}{\partial \tau}\tfrac{d\tau}{dz} + \tfrac{\partial g_\tau(\tau,\rho)}{\partial \rho}\tfrac{d\rho}{dz} = -\tfrac{\partial g_\tau(\tau,\rho)}{\partial z},$$
$$\tfrac{\partial g_\rho(\tau,\rho)}{\partial \tau}\tfrac{d\tau}{dz} + \tfrac{\partial g_\rho(\tau,\rho)}{\partial \rho}\tfrac{d\rho}{dz} = -\tfrac{\partial g_\rho(\tau,\rho)}{\partial z}.$$

Simultaneously solving for $\frac{d\tau}{dz}$ and $\frac{d\rho}{dz}$ yields

$$\frac{d\tau}{dz} = \frac{\frac{\partial g_\tau(\tau,\rho)}{\partial \rho}\frac{\partial g_\rho(\tau,\rho)}{\partial z} - \frac{\partial g_\rho(\tau,\rho)}{\partial \rho}\frac{\partial g_\tau(\tau,\rho)}{\partial z}}{\frac{\partial g_\tau(\tau,\rho)}{\partial \tau}\frac{\partial g_\rho(\tau,\rho)}{\partial \rho} - \frac{\partial g_\tau(\tau,\rho)}{\partial \rho}\frac{\partial g_\rho(\tau,\rho)}{\partial \tau}},$$
$$\frac{d\rho}{dz} = \frac{\frac{\partial g_\rho(\tau,\rho)}{\partial \tau}\frac{\partial g_\tau(\tau,\rho)}{\partial z} - \frac{\partial g_\tau(\tau,\rho)}{\partial \tau}\frac{\partial g_\rho(\tau,\rho)}{\partial z}}{\frac{\partial g_\tau(\tau,\rho)}{\partial \tau}\frac{\partial g_\rho(\tau,\rho)}{\partial \rho} - \frac{\partial g_\tau(\tau,\rho)}{\partial \rho}\frac{\partial g_\rho(\tau,\rho)}{\partial \tau}}.$$

Since the denominators are the determinant of the Jacobian matrix, and we already established that the determinant is unambiguously positive. Therefore, the conditions are proportional to the numerators,

$$\begin{gathered}
\tfrac{d\tau}{d\lambda} \propto p^2\rho^2 > 0, \\
\tfrac{d\tau}{dc} \propto -2p\lambda\rho < 0, \\
\tfrac{d\tau}{dp} \propto -p\left[(1-\tau)^2 - \lambda\rho(2\tau-\rho)\right] < 0, \\
\tfrac{d\rho}{d\lambda} \propto p^2\rho^2 > 0, \\
\tfrac{d\rho}{dc} \propto -2\left[1+p(1-\tau)\right] < 0, \\
\tfrac{d\rho}{dp} \propto 2\left[(1-p)+p\tau\right](\tau-\rho) - p\left[(\tau^2-\lambda\rho^2)+(1-2\tau)\right].
\end{gathered}$$

Using the explicit solutions for ρ and τ provided in Proposition 1, $\frac{d\rho}{dp}$ can be rewritten as:

$$\frac{d\rho}{dp} \propto \frac{\Gamma}{p(1-\lambda)} \propto \Gamma$$

where

$$\Gamma \equiv 2(1+c)\sqrt{(1-p)\left[(1-p\lambda)+2\lambda c\right]+\lambda c^2} - \left[2-(1+\lambda)p+2\lambda c(2-p)+2\lambda c^2\right].$$

We next analyze Γ with respect to p. Note that to obtain the equilibrium in Proposition 1 we imposed two constraints, namely $p \in (0,1)$ and $0 < c < \bar{c} \equiv \sqrt{1-p} - (1-p)$. Since $\bar{c}$ is a function of p and we want to evaluate Γ with respect to p we reformulate these two constraints so that they are not violated. We solve

$$c = \sqrt{1-p} - (1-p)$$

with respect to p, which yields two bounds for an alternative feasible range of p:

$$\begin{aligned}
\overline{p} &\equiv \tfrac{1}{2}\left[1+2c+\sqrt{1-4c}\right], \\
\underline{p} &\equiv \tfrac{1}{2}\left[1+2c-\sqrt{1-4c}\right],
\end{aligned}$$

Note that $0 < \underline{p} < \overline{p} < 1$ holds as long as $c < 1/4$. The properties of Γ with respect to p are as follows:

$$\begin{aligned}
&\lim_{p\to\overline{p}} \Gamma < 0, \\
&\lim_{p\to\underline{p}} \Gamma > 0, \\
&\tfrac{d\Gamma}{dp} < 0.
\end{aligned}$$

There must therefore exist a unique threshold $p_T \in (\underline{p}, \overline{p})$ such that $\frac{d\rho}{dp}_{|p<p_T} > 0$ and $\frac{d\rho}{dp}_{|p>p_T} < 0$. □

Proofs of Proposition 2 and Corollaries 3 and 4

For large penalties ($k \geq \frac{1-\lambda}{\lambda}$), the disclosure price is the same as in (5). However, in the event of nondisclosure shareholders conjecture that an informed entrepreneur will withhold whenever $\hat{\rho} < x < \hat{\tau}$, and at $t = 2$ they set a nondisclosure price of

$$P_{ND} = \frac{p(\hat{\tau}-\hat{\rho})}{p(\hat{\tau}-\hat{\rho})+(1-p)} \cdot \frac{(\hat{\tau}+\hat{\rho})}{2} + \frac{(1-p)}{p(\hat{\tau}-\hat{\rho})+(1-p)} \cdot \frac{1}{2}.$$

At $t = 3$ they observe x with probability λ and, given $\hat{\rho} < x < \hat{\tau}$, they litigate if

$$p\left[P_{ND} - P_D(x)\right] - c \geq 0.$$

At $x = \rho$ they are indifferent.

Enforcing all conjectures, the equilibrium conditions are as follows:

$$g_\tau(\tau, \rho) \equiv p\rho(2\tau - \rho) + (1-p)(1-2\tau) - p\tau^2,$$
$$g_\rho(\tau, \rho) \equiv p(\tau - \rho) - c.$$

These conditions can be simultaneously solved for τ and ρ, leading to

$$\tau = \tfrac{p(1-p)-c^2}{2p(1-p)},$$
$$\rho = \tfrac{p(1-p)-c^2-2c(1-p)}{2p(1-p)}.$$

It is straightforward to show that $0 < \rho < \tau$ as long as $c < \bar{c}$.

The first-order conditions of τ, ρ, and DL with respect to c and p are as follows:

$$\tfrac{d\tau}{dc} = -\tfrac{c}{p(1-p)} < 0,$$
$$\tfrac{d\rho}{dc} = -\tfrac{c+(1-p)}{p(1-p)} < 0,$$
$$\tfrac{dDL}{dc} = -1 < 0,$$
$$\tfrac{d\tau}{dp} = \tfrac{c^2(1-2p)}{2p^2(1-p)^2},$$
$$\tfrac{d\rho}{dp} = \tfrac{c\left\{2(1-p)^2+c(1-2p)\right\}}{2p^2(1-p)^2},$$
$$\tfrac{dDL}{dp} = 1 > 0.$$

Regarding $\frac{d\tau}{dp}$, the condition is positive if $p < 1/2$ and negative if $p > 1/2$. As for $\frac{d\rho}{dp}$, the condition is proportional to the curly bracket in the numerator. Through a similar proof than in Corollary 2 (ii), we can show that there exists a unique threshold $p_T^H \in (0,1)$. □

Proof of Proposition 3

Comparing $\tau = \tau_L$ from Proposition 1 with $\tau = \tau_H$ from Proposition 2 we have

$$\tau_H - \tau_L = \tfrac{p(1-p)-c^2}{2p(1-p)} - \tfrac{\Omega-(1-p+\lambda c)}{p(1-\lambda)}$$
$$= \tfrac{\left\{(1-\lambda)\left[p(1-p)-c^2\right]-2(1-p)\{\Omega-(1-p+\lambda c)\}\right\}}{2p(1-p)(1-\lambda)} > 0. \qquad \square$$

Proof of Proposition 4

To prove Proposition 4 (i), it is sufficient to show that there exists an interior level $\alpha \in (0,1)$ at which the countervailing effects from the differential disclosure behavior stated in Corollaries 1 (ii) and 3 (iii) balance each other, i.e.,

$$-\alpha\tfrac{d\tau_L}{dc} + (1-\alpha)\left\{\tfrac{d\rho_H}{dc} - \tfrac{d\tau_H}{dc}\right\} = 0$$
$$\Leftrightarrow \alpha\tfrac{\lambda\rho_L}{[(1-p)+p(\tau_L-\lambda\rho_L)]} - (1-\alpha)\tfrac{1}{p} = 0.$$

Rearranging yields

$$\alpha = \alpha_T \equiv 1 - \lambda\frac{p\rho_L}{1-p+p\tau_L} \in (0,1).$$

To prove Proposition 4 (ii), the first-order condition of α_T with respect to c is

$$\frac{d\alpha_T}{dc} = \frac{\partial \alpha_T}{\partial \tau_L}\frac{d\tau_L}{dc} + \frac{\partial \alpha_T}{\partial \rho_L}\frac{d\rho_L}{dc} = \lambda\left\{\frac{1}{(1-p)+p(\tau_L-\lambda\rho_L)} - \frac{2\lambda p^3 \rho_L^2}{[1-p+p\tau_L]^2}\right\} > 0.$$

Proposition 4 (iii) directly follows from Corollaries 1 (ii) and 3 (ii). □

Proofs of Proposition 5 and Corollary 5

In order to define what good news and bad news are and also to arrive at a market reaction to disclosure at $t = 2$, we first derive the ex ante market values for small and large penalties, respectively, are as follows:

$$E_L[P] = \{p\Pr[x < \tau_L] + (1-p)\}P_{ND} + p\Pr[x \geq \tau_L]E[P_D(x)|x \geq \tau_L] = [p\tau_L + (1-p)]\tau_L + p\tfrac{(1-\tau_L)^2}{2},$$
$$E_H[P] = \{p\Pr[\rho_H < x < \tau_H] + (1-p)\}P_{ND} + p\Pr[x \geq \tau_L]E[P_D(x)|x \geq \tau_L] + p\Pr[x \leq \rho_H]E[P_D(x)|x \leq \rho_H] = E[x] = 1/2.$$

Note that $E_H[P] = E[x]$ results from inserting the explicit values for τ_H and ρ_H and simplifying the expression. Moreover, it can be shown that $E_L[P] > E[x]$.

Next, we know that τ in either setting is below $E[x] = 1/2$, implying that good news, defined as $x \geq E[P]$, are always disclosed. Moreover, it is necessary to consider that in equilibrium bad news ($x \in [\tau, E[P])$) are also disclosed. In addition, the entrepreneur also discloses very bad news ($x \leq \rho$) when $k \geq \frac{1-\lambda}{\lambda}$.

The average market reaction to good news is

$$E\left[|P_D(x) - E[P]|\,|x \geq E[P]\right] = \frac{\int_{E[P]}^{1}(x - E[P])dx}{\int_{E[P]}^{1}dx} = \frac{1-E[P]}{2}.$$

The average market reaction to bad news structurally depends on the entrepreneur's penalty being small or large:

$$E\left[|P_D(x) - E[P_L]|\,|\tau_L \leq x < E[P_L]\right] = \frac{\int_{\tau_L}^{E[P_L]}(E[P_L]-x)dx}{\int_{\tau_L}^{E[P_L]}dx} = \frac{E[P_L]-\tau_L}{2},$$
$$E\left[|P_D(x) - E[P_H]|\,|\tau_H \leq x < E[P_H] \cup x \leq \rho_H\right] = \frac{\int_{\tau_H}^{E[P_H]}(E[P_H]-x)dx + \int_0^{\rho}(E[P_H]-x)dx}{\int_{\tau_H}^{E[P_H]}dx + \int_0^{\rho_H}dx} = \frac{\{E[P_H]-\tau_H\}^2 + \rho_H\{2E[P_H]-\rho_H\}}{2\{\{E[P_H]-\tau_H\}+\rho_H\}},$$

Comparing the average market reactions in case of small penalties, we obtain:

$$E\left[|P_D(x) - E[P_L]|\,|x \geq E[P_L]\right] > E\left[|P_D(x) - E[P_L]|\,|\tau_L \leq x < E[P_L]\right]$$

since

$$\frac{1-E[P_L]}{2} > \frac{E[P_L]-\tau_L}{2} \Leftrightarrow \frac{1+\tau_L-2E[P_L]}{2} > 0$$

holds. For large penalties, the average market reaction to bad news minus that to the good news is

$$\Delta MR \equiv E\left[|P_D(x) - E[P_H]|\,|\tau_H \leq x < E[P_H] \cup x \leq \rho_H\right] - E\left[|P_D(x) - E[P_H]|\,|x \geq E[P_H]\right]$$
$$= \tfrac{p^2(1-p)-4c^3-4c^2(1-p)}{4p(1-p)(p-2c)} - \tfrac{1}{4}.$$

This difference is negative if

$$c > c_{MR} \equiv \frac{\sqrt{1-p^2}-(1-p)}{2}$$

and positive otherwise.

To prove Corollary 5, consider the first-order condition of ΔMR with respect to c:

$$\frac{d\Delta MR}{dc} = \frac{\Theta}{p(1-p)(p-2c)^2},$$

where $\Theta \equiv \left[p^2(1-p) - 4c^3 - 4c^2(1-p)\right] - 2c(p-2c)\left[3c + 2(1-p)\right]$. Note that $\frac{d\Delta MR}{dc} \propto \Theta$. Consider the following properties of Θ with respect to c:

$$\begin{gathered}\lim_{c\to 0}\Theta = p^2(1-p) > 0,\\ \lim_{c\to c_{MR}}\Theta = (1-p)\left\{-2\left(1-\sqrt{1-p^2}\right) + p\left[\sqrt{1-p^2} - (1-p)\right]\right\} < 0,\\ \tfrac{d\Theta}{dc} = -4(p-2c)\left[3c + (1-p)\right] < 0.\end{gathered}$$

Hence there must exist a threshold $c^{\bullet}_{MR} \in (0, c_{MR})$ such that $\frac{d\Delta MR}{dc} > 0$ if $c < c^{\bullet}_{MR}$ and $\frac{d\Delta MR}{dc} < 0$ if $c > c^{\bullet}_{MR}$. □

Proof of Corollary 6

The partial derivative of PE_L with respect to τ_L is

$$\frac{\partial PE_L}{\partial \tau_L} = (1-p)(1-\tau_L) - \tau_L.$$

To show that this partial is unambigously negative, we check whether the local maximum that obtains when $\frac{\partial PE_L}{\partial \tau_L} = 0$, i.e.,

$$\tau = \tau_{PE} \equiv \frac{(1-p)}{1+(1-p)},$$

is in the feasible range of τ_L. This is not the case, and therefore $\frac{\partial PE_L}{\partial \tau_L} < 0$. he effects of changes in λ and c on PE_L are inversely proportional to the effects on τ_L as stated in Corollary 1 (i).

For large penalties, we insert the explicit solutions for τ_H and ρ_H into the expression of PE_H derived in the text. This results in

$$PE_H = -\frac{\left[p(1-p) + c^2\right]^2}{4p^2(1-p)}.$$

It is straightforward to see that PE_H is independent of λ and unambiguously decreases in c. □

Proof of Proposition 6

The disclosure-pricing-litigation game is solved in the main text both for high and low penalties. The entrepreneur's expected utilities when facing small ($k < \frac{1-\lambda}{\lambda}$) and large ($k \geq \frac{1-\lambda}{\lambda}$) penalties can be simplified to

$$\begin{aligned}&p\left\{\textstyle\int_{\tau_L}^1 x dx + \int_0^{\tau_L}\tau_L dx - \lambda\int_0^{\rho_L}(\tau_L - x)dx\right\} + (1-p)\int_0^1 \tau_L dx\\ &\quad = p\left[\tfrac{1}{2}(1-\tau_L^2) + \tau_L^2 - \lambda\rho(1+k)\left(\tau_L - \tfrac{\rho_L}{2}\right)\right] + (1-p)\tau_L\end{aligned}$$

and

$$\begin{aligned}&p\left\{\textstyle\int_{\tau_H}^1 x dx + \int_{\rho}^{\tau_H}\tau_H dx + \int_0^{\rho_H} x dx\right\} + (1-p)\int_0^1 \tau_H dx\\ &\quad = p\left[\tfrac{(1-\tau_H^2)}{2} + \tau_H(\tau_H - \rho_H) + \tfrac{\rho_H^2}{2}\right] + (1-p)\tau_H,\end{aligned}$$

respectively. Note that the entrepreneur's expected utility is strictly positive in both settings for any $c \in (0, \bar{c})$.

To choose innovative effort, the entrepreneur solves the following problem:

$$\max_a aEU - \frac{a^2}{2}.$$

Since the disclosure-pricing-litigation games are not a function of a and have unique equilibria, the optimal a is

$a = EU$ and is unique. Inserting the explicit solutions for τ_i and ρ_i yields

$$a_H = \frac{1}{2}$$

if $k \geq \frac{1-\lambda}{\lambda}$ and

$$\begin{aligned} a_L &= p\left[\tfrac{1}{2}(1+\tau_L^2) - \lambda\rho_L(1+k)\left(\tau_L - \tfrac{\rho_L}{2}\right)\right] + (1-p)\tau_L \\ &= \tfrac{1}{2} - \lambda\tfrac{\Omega-(1-p+c)}{p(1-\lambda)}\left[c + k\tfrac{1}{2}\tfrac{\Omega-(1-p+\lambda c)+c(1-\lambda)}{(1-\lambda)}\right] \end{aligned}$$

if $k < \frac{1-\lambda}{\lambda}$.

It is straightforward to show that absent litigation ($c \to \bar{c}$), innovative effort is 1/2, proving Proposition 6 (i). To prove Proposition 6 (ii), note that the second term in a_L is unambigously negative such that the statement holds.

To prove Proposition 6 (iii), we use the expression for a_L as a function of τ_L and ρ_L and make use of the implicit function theorem as follows:

$$\frac{da_L}{dc} = \frac{\partial a_L}{\partial \tau_L}\frac{d\tau_L}{dc} + \frac{\partial a_L}{\partial \rho_L}\frac{d\rho_L}{dc} \propto \frac{\partial a_L}{\partial \rho_L}\frac{\partial g_\tau(\tau_L,\rho_L)}{\partial \tau_L} - \frac{\partial a_L}{\partial \tau_L}\frac{\partial g_\tau(\tau_L,\rho_L)}{\partial \rho_L},$$

where $g_\tau(\tau_L,\rho_L) = g_\tau(\tau,\rho)$ from the proof of Proposition 1. This results in

$$\frac{da_L}{dc} \propto 2p\lambda\Lambda,$$

where $\Lambda \equiv [(1-p)+p\tau_L]\{(1+k)(\tau_L-\rho_L)-\rho_L\} + p\lambda\rho_L^2(1+k)$.

The properties of Λ with respect to c are:

$$\begin{aligned} \lim_{c\to 0}\Lambda \triangleq \lim_{\rho_L\to\tau_L}\Lambda &= -\tau_L\{[(1-p)+p\tau_L] - p\lambda\tau_L(1+k)\} < 0, \\ \lim_{c\to\bar{c}}\Lambda \triangleq \lim_{\rho_L\to 0}\Lambda &= [(1-p)+p\tau_L](1+k)\tau_L > 0, \\ \tfrac{d\Lambda}{dc} = \tfrac{\partial\Lambda}{\partial\tau_L}\tfrac{d\tau_L}{dc} + \tfrac{\partial\Lambda}{\partial\rho_L}\tfrac{d\rho_L}{dc} &\propto \tfrac{\partial\Lambda}{\partial\rho_L}\tfrac{\partial g_\tau(\tau_L,\rho_L)}{\partial\tau_L} - \tfrac{\partial\Lambda}{\partial\tau_L}\tfrac{\partial g_\tau(\tau_L,\rho_L)}{\partial\rho_L} > 0. \end{aligned}$$

From these properties it must follow that there exists a unique threshold $c_T \in (0,\bar{c})$ such that $\frac{da_L}{dc}_{|c<c_T} < 0$ and $\frac{da_L}{dc}_{|c>c_T} > 0$. □