Information Leaks and Voluntary Disclosure

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Abstract. We study managers' decisions to disclose information to the capital market when they face a risk of information leakage. Our analysis offers three main insights. First, we find that leaks that are less informative create market discipline and motivate more voluntary disclosure. Second, an increasing likelihood of information leakage has ambiguous effects. It fosters market discipline but increases managers' rewards from successful non-disclosure. Consequently, a higher likelihood of leakage impedes disclosure if leaks represent rare events and fosters voluntary disclosure if leaks are sufficiently probable. Third, we find that market discipline is more effective for myopic managers who focus on short-term prices and cannot react to information leaks on a timely basis. Such managers are willing to preempt information leakage and to disclose their private information.

Keywords: voluntary disclosure, information leaks, market discipline, managerial myopia

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We appreciate valuable comments of Tim Baldenius, Jeremy Bertomeu, Davide Cianciaruso, Edwige Cheynel, Eti Einhorn (discussant), Pascal Frantz, Robert F. Göx, Moritz Hiemann, Lisa Liu, Beatrice Michaeli, Christoph Pelger, Suresh Radhakrishnan, Joshua Ronen, Bharat Sarath, Ulf Schiller, Dirk Simons, Jack Stecher, Alfred Wagenhofer and Amir Ziv and seminar participants at the EIASM Workshop on Accounting and Regulation in Siena, the 42nd annual congress of the EAA, the 12th Accounting Research Workshop, the Otto-von-Guericke University Magdeburg, the WU Vienna, the Columbia Business School, the BI Norwegian Business School, and the University of Passau. Michael Ebert acknowledges funding by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 403041268 – TRR 266 Accounting for Transparency.

I. INTRODUCTION

The ongoing digital transformation and increasing connectedness of firms has resulted in considerable risks of information leakage.[1] This development also affects firms' disclosure choices, with one recent example being Apple's disclosure management in early 2020. In light of the onset of the COVID-19 pandemic, investors faced substantial uncertainty about delays in Apple's production schedule. Although Apple decided not to enter the dialogue, the capital market received information through a series of leaks. For instance, investors learned that Apple's employees were unable to travel to important suppliers in order to support the production process. Another source revealed that one of Apple's major suppliers, Foxconn, halted its hiring of new employees. The fact that Apple had not shared their updated plans led to wild speculations about production delays of several months (e.g., Kubota 2020; Spence 2020). In an unusual press event in July 2020, Apple reacted to the market pressure and announced a delay of only a few weeks (Kelly 2020).

This example illustrates the economic setting of our theoretical analysis. We consider information leaks as probabilistic events beyond the control of firm management. Apple's management arguably had limited influence on the information revealed at its suppliers and business partners. When a leak occurs, investors learn two types of information. First, they receive a more or less informative signal about the management's private information. Second, information leaks also reveal that the management is endowed with private information but has decided not to share its insights. This distinguishes leaks from other information sources such as analyst reports, which do not reveal the management's strategic behavior. In the above example, investors not only found out about potential production delays but also learned that Apple's management had decided not to disclose their internal expectations to the capital market. The latter information is relevant for interpreting the signal. Because Apple's management attempted to conceal information, the business press assumed that the information was unfavorable and speculated about significant production delays and financial losses.

[1] Despite the considerable amounts spent on data security (Deloitte Center for Financial Services 2021), there is abundant empirical evidence on information leakage into capital markets (Khan and Lu 2013; Hendershott et al. 2015; Kacperczyk and Pagnotta 2019; Huang et al. 2020).

We study a voluntary disclosure model to understand how the risk of information leaks affects disclosure behavior. A firm manager receives private information with a given probability. If informed, he can either preempt potential leaks via ex ante disclosure or wait and respond to leaks with ex post disclosure that contextualizes the leaked information.[2] In the aforementioned example, Apple's management decided not to share any information ex ante. As a result, ex post disclosure was necessary to correct the unfavorable market beliefs that followed information leakage. We examine how anticipated price reactions to leaks affect the manager's incentives to provide ex ante disclosures and how these incentives depend on his ability to react to leaks by ex post disclosures. The strategic interplay of ex ante and ex post disclosures is crucial to understanding how information leaks affect the total amount of information available to investors.

In a nutshell, our analysis shows how voluntary disclosure depends on the informativeness of leaks, the likelihood of leakage, and the manager's time horizon. First, if information leaks do not perfectly reveal the manager's private information, the manager faces the threat of adverse market reactions. With some probability, investors learn that the manager withholds unfavorable news. Therefore, leaks strengthen market discipline and motivate more ex ante disclosure. This effect becomes more pronounced if the leaked signals are less informative because investors increasingly base their valuation on their inference from the manager's strategic behavior. Second, an increasing likelihood of leakage amplifies this disciplining effect but also causes a countervailing force. Given a higher frequency of leakage, it is more difficult for the manager to successfully hide his private information. Thus, investors deem strategic managerial behavior less likely and assign higher market prices. This, in turn, renders strategic withholding more profitable for the manager. Overall, we find that a higher likelihood of leakage has a U-shaped effect on disclosure. Third, we show that the disciplining effect of information leaks is more effective for myopic managers interested in short-term market prices. Managers who maximize long-term prices are less vulnerable to adverse market reactions because they can revise initial non-disclosure decisions in response to leaks.

[2] Although investors have access to multiple information sources, firms' voluntary disclosures are still a major source of value-relevant information (e.g., Beyer et al. 2010; Miller and Skinner 2015), and it is crucial to understand how firms' disclosure choices depend on the information environment.

We consider a risk-neutral manager who receives private information about the firm's value with positive probability. If informed, the manager has the opportunity to disclose his information at two sequential dates. He can disclose the information at the outset of the game before information leaks occur or react to a leak by disclosing the information ex post. To consider the effect of managerial time horizon, we assume that the manager maximizes a weighted sum of the firm's short-term and long-term capital market prices. The short-term price reflects the investors' valuation after information leakage but before the manager had the opportunity to revise his disclosure. The long-term price represents the investors' valuation after a potential disclosure revision. Managers with a longer time horizon assign relatively more weight to the long-term price. For those managers, the opportunity to react to information leaks is more valuable.

Our analysis adopts a model of partially verifiable voluntary disclosure introduced by Dye (1985) and Jung and Kwon (1988). An informed manager can either truthfully disclose or withhold his information. An uninformed manager cannot credibly convey that he is uninformed. Under these conditions, it is a well-established result that a manager conceals his signal if it represents sufficiently unfavorable news. We study a repeated version of this model assuming that the manager's information endowment is stable and his private information may leak into the capital market after the initial disclosure decision. More specifically, we distinguish two characteristics of leaks. The likelihood of information leakage is the probability that the firm's private information leaks into the capital market.[3] The informativeness of leaks reflects the probability that investors understand the economic implications of the leaked information conditional on the fact that a leak occurs. Practical examples show that understanding the economic consequences of leaked information can be difficult. For instance, information on top managers' order-flows represents a rather coarse signal of future firm performance (McNally et al. 2017; DiMaggio et al. 2019). In contrast, the timing of new product launches or contractual terms with retail customers convey more details about a firm's future financial surpluses. To account for this fact, we distinguish

[3] We consider leaks as random events and not as strategic decisions. This is in line with empirical findings that mainly point at negligence and third party involvement as causes of leaks. Even if managers face incentives to deliberately leak information, such behavior can be very costly. Leaks create legal risks and cause proprietary costs. Managers who deliberately leak internal information face high risks of adverse career consequences.

uninformative leaks and perfect leaks. The signal revealed in an uninformative leak represents pure noise and cannot be used to learn about the firm value, for instance, because investors do not understand the economic implications of the leaked information. In contrast, perfect leaks reveal the manager's private information without noise. The informativeness of leaks is given by the probability distribution over these two events. A higher probability of a perfect leak renders leaks more informative from an ex ante perspective.[4]

In equilibrium, an informed manager follows a threshold strategy. He discloses sufficiently favorable information and withholds unfavorable news. The structure of the partial-pooling equilibrium is reminiscent of prior studies (e.g., Dye 1985; Dye and Hughes 2018; Cheynel and Levine 2020; Friedman et al. 2020) and can be aligned with empirical evidence on firms' actual disclosure behavior (see Kothari et al. 2009; Bao et al. 2019; Bertomeu et al. 2022).[5] Our equilibrium analysis yields three main findings.

First, a lower informativeness of leaks disciplines the manager and fosters voluntary disclosure. If investors observe an uninformative leak, they cannot directly infer any information about the firm value, but they understand that the manager is informed and withholds bad news. Accordingly, they assign a low market price. Ex ante, a manager who observes an intermediate firm value anticipates the risk of adverse market reactions induced by uninformative leaks. He extends his disclosures in order to separate himself from managers with even worse information. In contrast, perfect leaks reveal the manager's private information without noise. They induce the same market price as disclosure and, therefore, do not affect the manager's disclosure incentives. With decreasing informativeness, there is a higher probability of uninformative leaks and a lower probability of perfect leaks. As a consequence, the manager extends his voluntary disclosures in response to the increasing market discipline.

4 We show in a model extension that our results are qualitatively unaffected if we consider leaks as noisy signals about the manager's private information.

5 A number of studies identify disclosure equilibria with multiple pooling regions. This might be the case if managers are uncertain about the market reaction to their reports (Suijs 2007), if they can distort disclosures by real decisions (Beyer and Guttman 2012), if the quality of their information is not publicly known (Hummel et al. 2023), if investors have access to competing information sources (Einhorn 2018), and if firm owners use disclosures as performance measures to mitigate moral hazard (Versano 2020).

This result has noteworthy implications for the interpretation of the disclosure threshold. In the standard disclosure model of Dye (1985) and Jung and Kwon (1988) the equilibrium disclosure threshold minimizes the no-information price—a result which is known as minimum principle (Acharya et al. 2011; DeMarzo et al. 2019). The interpretation is that the equilibrium market price expresses maximal skepticism. The possibility of uninformative leaks allows for equilibria with more voluntary disclosure than suggested by the minimum principle. Intuitively, uninformative leaks create additional market discipline complementing investors' skepticism. This result distinguishes our model from related work such as Frenkel et al. (2020).

Second, we find that a higher likelihood of leaks has ambiguous effects. It amplifies the disciplining effect of uninformative leaks and thus causes a *revelation effect*. At the same time, there is a countervailing *concealment effect* that motivates the manager to withhold his information. Consider the investors' inferences on firm value if they do not receive any information, neither from the manager nor through a leak. This might be the case because the manager is uninformed or because he hides unfavorable news. With increasing likelihood of leakage, it is less probable that a strategic manager can hide his private information. Investors therefore deem it more likely that the manager is uninformed and assign a higher market price. Paradoxically, this provides incentives for an informed manager to withhold his information. If leaks constitute rare events, the concealment effect is the dominant force and an increasing likelihood of leaks reduces disclosure. If leaks are sufficiently probable, further increases in their likelihood foster voluntary disclosure due to the revelation effect. We find that there may be more or less voluntary disclosure compared to a world without information leakage.

Third, our results suggest that market discipline is more effective if the manager is myopic, i.e., if he maximizes short-term prices. We assume that the manager can react to leaks by revising a non-disclosure decision, and he maximizes the weighted average of the market prices before and after a disclosure revision. Intuitively, the opportunity to react to an uninformative leaks attenuates the threat of adverse market reactions. Instead of preempting leaks by voluntary disclosure, the manager can always counter an adverse market reaction and share his private information retroactively. The opportunity to react to an information leak therefore obviates market discipline. Note however that this rationale only applies if the manager is interested in the long-term market price. If managers are more myopic and assign higher weight to short-term prices, they are more forthcoming and increase theirs disclosures. These results indicate that managerial myopia fosters market discipline and increases firms' voluntary disclosure.

In a model extension, we consider the effects of proprietary costs in the presence of information leaks. If information is disclosed or leaked into the capital market, the firm incurs a cost that reduces the firm value. This assumption reflects the fact that proprietary information can be used by rivals or other related parties to take harmful actions (e.g., Verrecchia 1983; Darrough and Stoughton 1990; Wagenhofer 1990). In our setting, proprietary costs are triggered not only by firm disclosures but also by information leaks. Thus, proprietary costs penalize both disclosure and non-disclosure decisions, and their total effect depends on the likelihood and informativeness of leaks. Our analysis sheds light on the nuanced effects of proprietary costs in the presence of information leaks.

Our study contributes to three strands of literature. First, our results relate to the literature on firms' voluntary disclosure in the presence of additional information sources (e.g., Dye 1998; Einhorn 2018; Frenkel et al. 2020; Petrov 2020; Libgober et al. 2023). In line with our results, Dye (1998) finds that managers extend their voluntary disclosures if there is a higher probability that their strategic behavior is exposed to the capital market. Since information leaks bundle information about managers' strategic behavior with information about firm value, we find that a higher probability of leakage can increase or decrease voluntary disclosure. Perhaps most closely related to our analysis, Frenkel et al. (2020) study the interplay of voluntary disclosure and analyst reports. They allow for correlation between managers' and analysts' information endowments. The information structure resembles perfect information leaks in our model. Analysts learn firms' private information and reveal their signal without noise. In an extension, Frenkel et al. (2020) discuss the possibility that analyst reports reveal firms' private information with noise, but they conclude that this assumption is intractable in their capital market setting (p. 187).[6]

[6] To consider noisy analyst reports, Frenkel et al. (2020) study a modified setting, where managers observe leaks *before* they decide on firm disclosure. This assumption differs from our analysis.

A second strand of literature addresses managers' legal obligation to share value-relevant information and studies the effects of shareholder litigation (see Trueman 1997; III and Sridhar 2002; Dye 2017; Schantl and Wagenhofer 2023). Trueman (1997) and Schantl and Wagenhofer (2023) study a manager's disclosure decision if the firm's shareholders can litigate. Litigation is costly and yields uncertain damages payments. Dye (2017) considers the disclosure decision of a seller who may be privately informed about an asset and is liable for buyers' damages. If the seller does not share his information with the buyer, this behavior is revealed with some probability, and the seller must make a damages payment. Our results do not arise from shareholder litigation and legal damages payments but from rational price reactions to information leaks.

Third, our analysis is related to models of dynamic voluntary disclosure such as Einhorn and Ziv (2008), Acharya et al. (2011), Beyer and Dye (2012), Guttman et al. (2014), Cianciaruso and Sridhar (2018), and Aghamolla and An (2021). As in Bagnoli and Watts (2021), we consider a manager's decision to revise a previous non-disclosure decision after the arrival of public information. In contrast to our analysis, they assume that the manager generally observes private information but faces proprietary costs of early and late disclosure. The manager's willingness to revise his initial decision depends on the favorability of the public information. According to our results, the manager's decision depends on the informativeness of the leaked signal.

Our model allows for novel empirical predictions. We show that a higher likelihood of information leakage fosters voluntary disclosure if investors can hardly gauge the economic implications of the leaked information. This is presumably the case in industries with complex business models and products, where leaked information requires interpretation. In contrast, if investors can easily infer the value implications of leaked information, our results predict that a higher likelihood of leakage will impede voluntary disclosure. Heterogeneity with regard to the likelihood of information leaks may be associated with different legal and enforcement standards. Moreover, our results suggest that the effects of information leakage depend on managers' time horizon. Leaks discipline managers whose wealth is sensitive to short-term price reactions. These managers tend to preempt information leakage by more extensive voluntary disclosures.

The remainder of the paper is structured as follows. We introduce the model in section II. In section III, we study the effects of information leaks on voluntary disclosure and present our main results. In section IV, we extend our model and highlight the robustness of our results. In section V, we show empirical predictions before we conclude our study in section VI.

II. MODEL SETUP

We study the disclosure decision of a manager who is endowed with private information about firm value and faces the risk of information leaks. Disclosures are made towards a competitive capital market, modelled as a representative investor. All players are risk neutral.

The uncertain value of the firm is given by the random variable $\tilde{x}$. The manager and investors share prior beliefs about $\tilde{x}$ given by a continuous probability distribution with bounded support $[\underline{x}, \overline{x}]$, where f and F denote the p.d.f. and c.d.f., respectively. For $y \in [\underline{x}, \overline{x}]$, we use $\mu \equiv E[\tilde{x}]$ and $E(y) \equiv E[\tilde{x} \mid x \leqslant y]$ to denote the mean and truncated mean of the firm value. In line with prior literature, we assume that the distribution of $\tilde{x}$ is log-concave (e.g., Cianciaruso and Sridhar 2018; Bagnoli and Watts 2021).[7]

We build on a model of partially verifiable voluntary disclosure (e.g., Dye 1985; Jung and Kwon 1988). The manager of the firm privately learns the firm value x with probability $p \in (0, 1)$ and remains uninformed otherwise.[8] We denote the manager's information set as $\Omega_M \in \{x, \varnothing\}$, where $\Omega_M = x$ signifies an informed manager and $\Omega_M = \varnothing$ indicates a lack of private information.[9] The manager's disclosure is a function of the available information, $d = d(\Omega_M)$. If the manager observes x, he can either disclose it in a credible and costless manner, $d(x) = x$, or remain silent, $d(x) = ND$, where ND denotes non-disclosure. If the manager is uninformed, he cannot credibly claim that he has not observed x but must remain silent, i.e., $d(\varnothing) = ND$.

7 Many common distributions (such as normal, exponential, and uniform distributions) share this property. Log-concavity implies that $dE(y)/dy < 1$ (see Bagnoli and Bergstrom 2005).

8 We consider perfect information for ease of exposition. The insights from our analysis are unaffected if we assume that the manager observes an imperfect signal about the firm value.

9 With a slight abuse of notation, we identify the realization of the firm value x and the singleton set $\{x\}$.

The innovation of our model is the possibility of a (more or less informative) leak. Similar to Frenkel et al. (2020) and Bagnoli and Watts (2021), we study information leaks as probabilistic arrival of public information. Conditional on the fact that the manager is privately informed but decides not to disclose his information, a leak occurs with probability $\pi \in [0, 1)$. With probability $1 - \pi$, no information is leaked and investors remain uninformed. We interpret π as the likelihood of information leakage. If leaks occur with probability 1, there is full revelation in equilibrium. We exclude this case from our analysis.

Ex ante, there is uncertainty not only about whether a leak occurs but also about the information conveyed. Some leaks provide extensive information, such as details of new products or contractual terms with customers. Other leaks are less extensive and difficult to interpret for outsiders. In our model, we allow for two types of leaks. In case of a *perfect leak*, investors learn the firm value x, i.e., the economic implications of the leaked information are well understood. In contrast, the signal that is observed in case of an *uninformative leak* represents pure noise and cannot be used to make any inferences on the firm value. This assumption reflects the fact that investors may be unable to understand the economic implications of the leaked information.[10] Conditional on the fact that a leak occurs, it is perfect with probability ψ and uninformative with probability $1 - \psi$. We use $\psi \in [0, 1]$ as a measure of informativeness.[11] Low levels of ψ are descriptive of settings in which it is unlikely that leaks reveal the firm value. As ψ approximates 1, leaks tend to reveal the manager's private information without noise. A common feature of both types of leaks is that investors learn the manager's information endowment. By definition, leaks can only occur if the manager is privately informed. Thus, investors who observe a leak understand that the manager deliberately withholds his information. This insight provides a context for the leaked signal and can be used by investors to improve their inferences on the firm value.[12]

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[10] If there was no strategic disclosure by the manager, uninformative leaks would be ignored by investors.

[11] We consider a mixture of two extreme events to simplify the mathematical exposition. In section **??**, we consider an alternative notion of informativeness assuming that investors observe a noisy version of the manager's private information. The qualitative insights from both analyses are identical.

[12] If additional information is provided by an external source independent of the manager's information endowment, it is easy to see that stochastic information arrival does not affect the manager's equilibrium disclosure strategy.

After observing a potential disclosure and information leak, the competitive market forms a market price for the firm.[13] Let Ω_I denote the risk-neutral investors' information set. The price $P(\Omega_I)$ coincides with the expected firm value conditional on the available information and investors' beliefs about the disclosure strategy, $P(\Omega_I) = E[\tilde{x} \mid \Omega_I]$. It is sufficient to distinguish three realizations of the investors' information set. The investors potentially learn the actual firm value through firm disclosure or a perfect leak ($\Omega_I = x$). If the manager keeps quiet and there is no leak ($\Omega_I = \emptyset$), investors consider the possibility that the manager is either uninformed or he knows x but avoids disclosure. Finally, in case of an uninformative leak ($\Omega_I = \bigcirc$), investors know that the manager has observed the firm value but they don't learn the realized value.

After the market price is formed, the manager can react by revising his initial disclosure as denoted by $d^r(\Omega_M^r)$, where $\Omega_M^r = \Omega_M \times \Omega_I$ describes his information set at this point in time. This option can only be used by informed managers who have not shared their information at the initial disclosure stage. Uninformed managers still cannot credibly reveal that they lack information, i.e., $d^r(\Omega_M^r) = ND$ for $\Omega_M = \emptyset$. However, informed managers who have initially decided to remain silent can provide additional information choosing $d^r(\Omega_M^r) \in \{x, ND\}$ for $\Omega_M = x$. The investors observe the revised disclosure decision and adjust the market price $P^r(\Omega_I^r) = E[\tilde{x} \mid \Omega_I^r]$ to the updated information set $\Omega_I^r \in \{x, \emptyset, \bigcirc\}$. $\Omega_I^r = x$ denotes the case that the investors learn the actual firm value either via firm disclosures or through a perfect leak. The information set $\Omega_I^r = \emptyset$ is realized either if the manager is uninformed or if he withholds his private signal in the initial and revised disclosure decision and no leak occurs. If investors observe an uninformative leak and the manager remains silent at the disclosure revision stage, $\Omega_I^r = \bigcirc$ is realized.

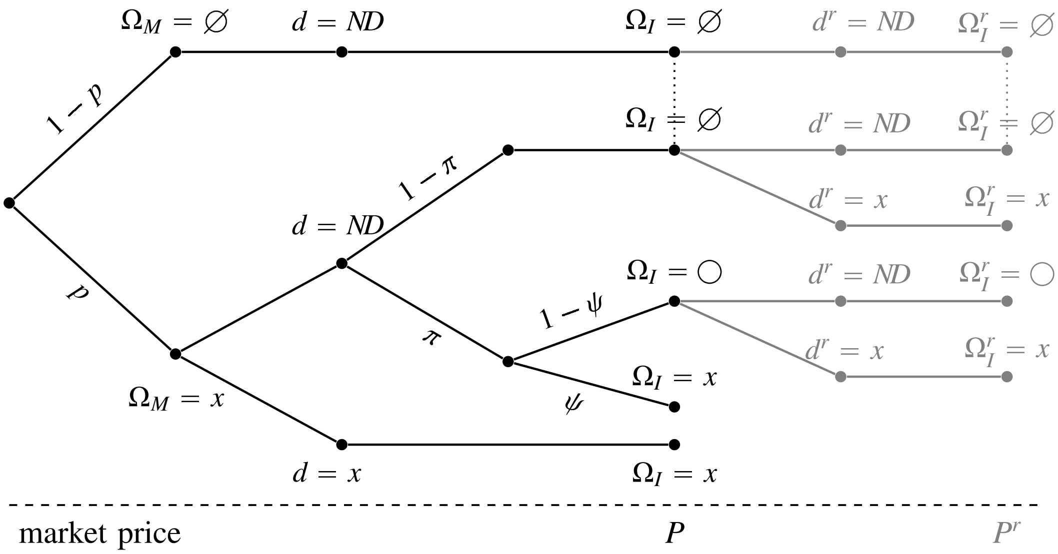
The risk-neutral manager uses his disclosure decisions to maximize his utility, which is the weighted sum of the short-term and long-term market prices,[14]

$$U = \lambda \cdot P + (1 - \lambda) \cdot P^r, \tag{1}$$

[13] In line with Frenkel et al. (2020), we assume that leaks provide public information. For studies that consider the dissemination of leaked information within capital markets see Brunnermeier (2005) and Indjejikian et al. (2014).

[14] This assumption coincides with Bagnoli and Watts (2021). In line with prior literature, we abstract from potential agency problems between current shareholders and the manager (see Dye 1985).

FIGURE 1
Decision tree of the disclosure game



where $\lambda \in (0, 1]$ represents the degree of managerial myopia. For low values of λ, the manager is mainly interested in the long-term market price P^r, which reflects the public information after disclosure revision. Increasing values of λ imply higher degree of myopia. For $\lambda = 1$, the manager is completely myopic and maximizes the short-term price P with his disclosure decision. We assume that an indifferent manager generally discloses his private information for simplicity.

Figure 1 depicts the complete game.[15] We study the equilibrium in two steps. First, we consider the case that the manager is perfectly myopic (i.e., $\lambda = 1$). In a second step, we show how the manager's time horizon affects the results.

15 The information structure is common knowledge. Note that we do not consider leaks that follow a decision to disclose because the leaked information is redundant.

III. RESULTS

Equilibrium with a myopic manager

In a first step, we study the special case of a perfectly myopic manager, i.e., $\lambda = 1$. His disclosure decision at the initial stage aims to maximize the short-term price P. Because the pricing function is myopic as well, we can focus on the initial disclosure decision and neglect potential disclosure revisions at a later point in time. Lemma 1 characterizes the equilibrium of the disclosure game.

Lemma 1. *There is a unique equilibrium given by a disclosure threshold y such that*

$$d(x) = \begin{cases} x & \text{if } x \geqslant y \\ ND & \text{else} \end{cases} \quad and \quad P(\Omega_I) = \begin{cases} x & \text{if } \Omega_I = x \\ E(y) & \text{if } \Omega_I = \bigcirc \\ \frac{1-p}{1-p+p\cdot(1-\pi)\cdot F(y)} \cdot \mu + \frac{p\cdot(1-\pi)\cdot F(y)}{1-p+p\cdot(1-\pi)\cdot F(y)} \cdot E(y) & \text{if } \Omega_I = \varnothing \end{cases}.$$

The threshold level $y \in (\underline{x}, \mu)$ satisfies the equilibrium condition

$$y = \left(1 - \frac{1-\pi}{1-\pi\cdot\psi}\right) \cdot E(y) + \frac{1-\pi}{1-\pi\cdot\psi} \cdot P(\varnothing). \tag{2}$$

Lemma 1 shows that, in equilibrium, an informed manager follows a *threshold strategy*. He discloses favorable information, $x \geqslant y$, and remains silent otherwise. To understand this result, consider the decision of a manager who learns the firm value x. He discloses his information whenever the market price upon disclosure $P_D(x)$ exceeds the expected non-disclosure price $P_{ND}(x) = E[P(\tilde{\Omega}_I) \mid d(x) = ND]$. While the disclosure price perfectly reflects the realized firm value, $P_D(x) = x$, the expected non-disclosure price

$$P_{ND}(x) = \pi \cdot [\psi \cdot P(x) + (1-\psi) \cdot P(\bigcirc)] + (1-\pi) \cdot P(\varnothing) \tag{3}$$

is the weighted sum of the price reactions to a perfect and uninformative leak, $P(x)$ and $P(\bigcirc)$, and the no-information price, $P(\varnothing)$, absent any leaks. The weights $\pi \cdot \psi$, $\pi \cdot (1-\psi)$, and $1-\pi$ reflect the probabilities of the three possible information events. Note that the price reaction $P(\bigcirc)$ to an uninformative leak and the no-information price $P(\varnothing)$ do not depend on the realized firm value x. Still, the expected non-disclosure price depends on the firm value because investors might learn x from a perfect leak, $P(x) = x$. As perfect leaks occur with probability $\pi \cdot \psi < 1$, the non-disclosure price increases in x at a lower rate than the disclosure price. There must be a threshold y such that $P_{ND}(x) \leqslant P_D(x)$ if and only if $x \geqslant y$, i.e., the manager only reveals favorable information.

The investors hold rational beliefs about the manager's strategy. Firm disclosures and perfect leaks imply a correct market valuation, $P(x) = x$. If the investors observe an uninformative leak, they understand that the manager withholds information $x < y$. The appropriate price is $P(\bigcirc) = E[\tilde{x} \,|\, x \leqslant y] = E(y)$. If the investors remain uninformed, they consider two possible reasons. First, the manager might not be endowed with private information. Hence, the absence of disclosure does not convey any information, and the expected firm value is the prior mean μ. Second, a strategic manager might withhold unfavorable news. Accordingly, the firm value falls below the threshold y, and the expected firm value is $E(y)$. The investors cannot distinguish the two events. Therefore, the market price $P(\varnothing)$ is the sum of μ and $E(y)$ weighted according to the posterior probabilities $\text{pr}(\Omega_M = \varnothing \,|\, \Omega_I = \varnothing)$ and $1 - \text{pr}(\Omega_M = \varnothing \,|\, \Omega_I = \varnothing)$ stated in Lemma 1.

An equilibrium requires that the investors' beliefs about the disclosure threshold are correct. If the investors' conjecture the threshold level y, a manager who observes the firm value $x = y$ must be indifferent between disclosing or withholding his information. We refer to this manager as the marginal type. The indifference condition $P_D(y) = P_{ND}(y)$ yields the equilibrium characterization in Lemma 1. It is easy to see that the condition in Lemma 1 has a unique solution $y \in (\underline{x}, \mu)$.

The structure of the equilibrium is intuitive. If an informed manager remains silent, he is pooled with all other manager types who do not provide disclosures—either for strategic reasons or because they are uninformed. This pooling is undesirable for managers who observe high firm values. Such managers separate themselves by revealing their information. However, managers who observe low firm values benefit from pooling with uninformed types. In our setting, pooling is unsuccessful with probability π. This affects the threshold level y but not the structure and general properties of the equilibrium identified by Dye (1985) and Jung and Kwon (1988).

Lemma 2. *As the probability p of an informed manager increases, there is more voluntary disclosure, i.e., $dy/dp < 0$.*

An increasing probability p affects the disclosure threshold via the no-information price $P(\varnothing)$. According to Lemma 1, this price is the weighted sum of the prior mean, μ, and the price reaction to an uninformative leak, $E(y) < \mu$. With increasing probability p of being informed, investors deem it more likely that their lack of information results from the manager's strategic behavior. Consequently, they assign a higher weight to $E(y)$, and the no-information price $P(\varnothing)$ decreases. This in turn reduces the manager's incentives to withhold his private information.

Next, we study how the informativeness and likelihood of leaks affect the equilibrium disclosure. We use the equilibrium condition in Lemma 1 to derive comparative statics results of the disclosure threshold with regard to ψ and π. Proposition 1 shows how the informativeness of information leaks affects equilibrium disclosure.

Proposition 1. *As information leaks become more informative, there is less voluntary disclosure, i.e., $dy/d\psi > 0$ for $\pi > 0$.*

A main result of our analysis is that a manager increasingly withholds his information if leaks become more informative. To understand this finding, consider the equilibrium condition in Lemma 1. This condition ensures that a marginal type with firm value $x = y$ is indifferent between disclosing and withholding, i.e., $P_D(y) = P_{ND}(y)$. It is sufficient to study how the disclosure incentives of a marginal type depend on the informativeness of leaks.

A key observation is that a marginal type strictly prefers a perfect leak over an uninformative leak. For a marginal type, the price following a perfect leak is $P(y) = y$. This is exactly the price reaction that the manager expects from disclosing or withholding his information, $P_D(y) = P_{ND}(y) = y$. In other words, the anticipation of perfect information leaks does not affect the disclosure decision of the marginal type. However, if the marginal type is exposed by an uninformative leak, he is pooled with all lower types, $x < y$, which results in a strictly lower price, $P(\bigcirc) = E(y) < y$. The market price falls short of the actual firm value, and the manager regrets his non-disclosure decision. This threat of underpricing creates market discipline and increases the manager's ex ante incentives to provide disclosure. He preempts uninformative leaks by sharing his private information. As leaks become more informative, there is a higher likelihood of a perfect leak and a lower likelihood of an uninformative leak. Thus, the disciplining effect of uninformative leaks is mitigated with increasing ψ.

A well-known feature of the voluntary disclosure model introduced by Dye (1985) and Jung and Kwon (1988) is the *minimum principle*. The equilibrium disclosure threshold minimizes the no-information price $P(\varnothing)$ (Acharya et al. 2011; Guttman et al. 2014). An interpretation of this finding is that investors draw the least favorable inference on firm value if they observe a non-disclosure decision. In this sense, the minimum principle generalizes the unraveling result (see DeMarzo et al. 2019). Our results show that the minimum principle no longer holds if uninformative information leaks occur with positive probability.

Corollary 1. *Let $y_{\min} \in [\underline{x}, \overline{x}]$ denote the threshold level that minimizes the no-information price $P(\varnothing)$. We find that $y \leqslant y_{\min}$, where equality holds if and only if uninformative leaks do not occur with positive probability (i.e., for $\pi = 0$ or $\psi = 1$).*

Whenever there is a positive probability of uninformative leaks, the equilibrium threshold y falls below the value $y_{\min}$, which minimizes the no-information price. This result immediately follows from Proposition 1 and the fact that $y_{\min} = y|_{\psi=1}$. The intuition is that uninformative leaks create additional market discipline complementing investors' skepticism. Consequently, the presence of information leaks allows for equilibria with more voluntary disclosure than suggested by the minimum principle. This result distinguishes our model from related work such as Frenkel et al. (2020) who focus on the case that investors perfectly learn a manager's private information.

Another focal question of our analysis is how π, the likelihood of leaks, affects voluntary disclosure. According to Proposition 1, uninformative leaks motivate additional disclosure. This finding seems to suggest that a higher likelihood of leaks amplifies market discipline and fosters disclosure—a result which would be in line with prior literature (see Dye 1998). However, Proposition 2 shows that the effect of π is ambiguous.

Proposition 2. *There is a critical value $\pi^\dagger \in [0,1]$ such that the threshold y increases in π for $\pi < \pi^\dagger$ and decreases in π for $\pi > \pi^\dagger$. That is, $\pi^\dagger$ minimizes voluntary disclosure.*[16]

We identify a critical probability of leakage, $\pi^\dagger$, which maximizes the equilibrium threshold y and minimizes voluntary disclosure. For sufficiently high likelihood of leakage, $\pi > \pi^\dagger$, further increases in π foster disclosure. In contrast, higher levels of π reduce voluntary disclosure if leaks are less probable events, $\pi < \pi^\dagger$.

Once again, it is instructive to study the considerations of a manager who observes a firm value $x = y$ and is indifferent between disclosing and withholding his information. An increasing likelihood π affects this marginal type in two ways. First, there is a higher likelihood of uninformative leaks. Accordingly, the manager faces stronger incentives to preempt leaks by ex ante disclosure, and a higher likelihood of leaks has a *revelation effect*. Second, it is easy to see that the no-information price $P(\varnothing)$ increases in π. As Lemma 1 shows, $P(\varnothing)$ is the weighted average of the prior mean, μ, and the expected firm value conditional on deliberate non-disclosure, $E(y)$. While neither of the two valuations directly depends on π, the probability weights do. Consider the case that investors remain uninformed, i.e., $\Omega_I = \varnothing$. If there is a high probability of leakage, it is less likely that an informed manager was able to successfully withhold his information. The investors deem it more likely that the manager is uninformed, and $P(\varnothing)$ approximates μ. Conversely, for a low likelihood π, it is reasonable to assume that the manager withholds unfavorable information, and the investors assign a low price. As a consequence, the no-information price $P(\varnothing)$ increases with π, which reduces the manager's incentives to disclose his private information. A higher likelihood of leakage has a *concealment effect*.

Proposition 3. *The disclosure-minimizing likelihood $\pi^\dagger$ is increasing in the informativeness of leaks, i.e., $d\pi^\dagger/d\psi > 0$. In particular, we find that*

(i) $\pi^\dagger\big|_{\psi=1} = 1$*, i.e., the threshold y is strictly increasing in π for perfect leaks, and*

(ii) $\pi^\dagger\big|_{\psi=0} = 0$*, i.e., the threshold y is strictly decreasing in π for uninformative leaks.*

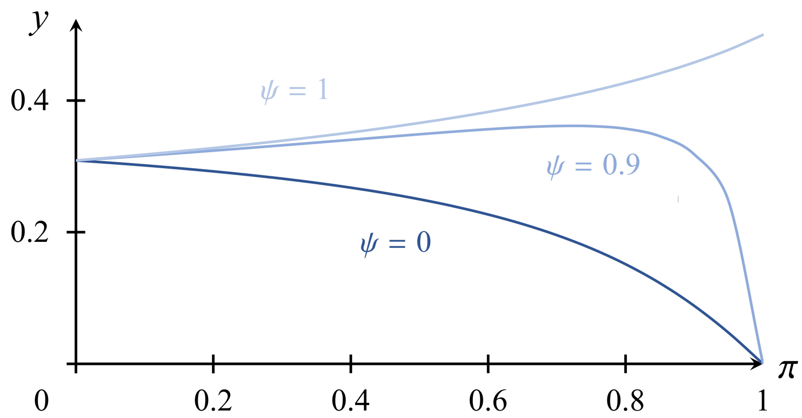
[16] For $\pi^\dagger = 0$, the threshold y is a monotone increasing function of π. For $\pi^\dagger = 1$, it is monotone decreasing.

According to Proposition 3, the critical probability $\pi^{\dagger}$ increases as leaks become more informative. It approaches 1 if all leaks are perfect. In this case, a higher likelihood of leakage generally reduces the amount of voluntary disclosure. If leaks are uninformative with probability 1 and only reveal the manager's information endowment, the opposite is true. There is generally more voluntary disclosure if the likelihood of leakage increases.

Proposition 3 shows that the total effect of higher likelihood π on the disclosure threshold depends on the informativeness ψ of information leaks, which can be explained by the revelation effect. If leaks tend to reveal only the manager's information endowment, there is a higher risk of being underpriced and a marginal type faces strong incentives to separate himself from lower types. In contrast, the risk of adverse market reactions is negligible if information leaks tend to reveal the firm value. Thus, the revelation effect is attenuated by increasing informativeness ψ. In contrast, the concealment effect relies on the no-information price, $P(\emptyset)$, which does not directly depend on ψ. In line with this reasoning, Proposition 3 shows that the revelation effect dominates the concealment effect for $\psi = 0$. In this case, a higher likelihood of leakage generally increases the manager's willingness to disclose his information. Conversely, for $\psi = 1$, leaks do not create market discipline. An increasing likelihood π implies higher no-information prices, $P(\emptyset)$, and hence strictly decreases disclosure incentives.

We conclude the analysis with a numerical illustration for a uniformly distributed firm value, $\tilde{x} \sim U[0, 1]$. Figure 2 depicts the disclosure threshold as a function of the likelihood of leakage π. The shaded graphs represent three cases that differ with regard to the informativeness of leaks, $\psi \in \{0, 0.9, 1\}$. In line with Proposition 1, the disclosure threshold y is increasing in the informativeness ψ. If information leaks are perfect with probability 1 (i.e., $\psi = 1$), the disclosure threshold is strictly increasing in π. In contrast, if leaks only reveal the manager's information endowment ($\psi = 0$), a higher likelihood of leakage fosters disclosure. For $\psi = 0.9$, the disclosure threshold is increasing up to a likelihood of $\pi^{\dagger} = 0.72$ with a maximum value of $y = 0.36$.

FIGURE 2
The likelihood of leaks and voluntary disclosure ($\tilde{x} \sim U[0,1]$, $p = 0.8$, $\lambda = 1$)



Disclosure revision and managerial time horizon

Next, we extend our analysis to cases where the manager is not completely myopic ($\lambda < 1$). Based on his knowledge of the realized information sets $\Omega_M^r = \Omega_M \times \Omega_I$, the manager uses the disclosure revision $d^r(\Omega_M^r)$ to maximize the long-term price P^r. When choosing the initial disclosure $d(\Omega_M)$, he anticipates his subsequent choices. Given that the manager's information endowment is stable over time, disclosure at the revision stage is irrelevant if the firm value has been revealed by ex ante disclosure or by a perfect leak. Lemma 3 characterizes the disclosure equilibrium.

Lemma 3. *Equilibrium of the sequential disclosure game*

a) *At the revision stage, a manager, who withheld his information at the initial stage, discloses in response to uninformative leaks, i.e., $d^r(x, \bigcirc) = x$, and remains silent in the absence of leaks, i.e., $d^r(x, \varnothing) = \varnothing$.*

b) *At the initial stage, there is a disclosure threshold $y \in [\underline{x}, \overline{x}]$ such that $d(x) = x$ if and only if $x \geqslant y$. The threshold level y satisfies the condition*

$$y = \left(1 - \frac{1-\pi}{1-\pi \cdot \psi^{\dagger}}\right) \cdot E(y) + \frac{1-\pi}{1-\pi \cdot \psi^{\dagger}} \cdot P(\varnothing),$$

with $\psi^{\dagger} \equiv 1 - (1-\psi) \cdot \lambda$ and $P(\varnothing)$ as defined in Lemma 1.

Part a) characterizes the subgame at the disclosure revision stage after potential leaks have been realized. Ex post disclosure can only be relevant if an informed manager withheld his information at the initial stage and there is either an uninformative leak ($\Omega_I = \bigcirc$) or no information leak ($\Omega_I = \emptyset$). Consider the case that the investors observe an uninformative leak, $\Omega_I = \bigcirc$. They learn the manager's information endowment, and the manager can no longer pretend to be uninformed. As a consequence, a marginal type who observes the firm value $x = y$ is pooled with all lower types $x < y$. He chooses to separate himself by disclosing his information at the revision stage. Following the logic of the unraveling result (Grossman 1981; Milgrom 1981), all types disclose their information in equilibrium. We conclude that the disclosure game collapses to the case, where both perfect and uninformative leaks imply full revelation. All leaks are perfect in the long run.

If the manager withholds his private information at the initial disclosure stage, and his strategic behavior is not detected ($\Omega_I = \emptyset$), he can either revise his initial decision or continue to pool with uninformed types. He shares his information whenever the disclosure price $P^r_D(x) = x$ exceeds the non-disclosure price $P^r_{ND} = P^r(\emptyset)$. According to Lemma 3 a), this case cannot occur in equilibrium. This result follows from the facts that i) the expected non-disclosure price at the initial stage is lower than the non-disclosure price at the revision stage, i.e., $P_{ND} < P^r_{ND}$, and ii) the manager has not disclosed his information at the initial stage, i.e., $x < P_{ND}$.

Part b) of Lemma 3 characterizes the unique equilibrium at the initial disclosure stage. The equilibrium condition is structurally identical to condition (2) with a completely myopic manager. Any difference results from the fact that the parameter $\psi^\dagger$ differs from the informativeness of leaks ψ. We refer to $\psi^\dagger \in [\psi, 1]$ as effective informativeness parameter. Apparently, $\psi^\dagger$ weakly exceeds ψ and is decreasing in managerial myopia λ. Thus, the manager's long-term orientation has the same effect as a higher informativeness of leaks. For $\lambda = 1$, the manager does not benefit from the opportunity to revise his initial disclosure decision. He is fully exposed to short-term price reactions and extends his disclosures to preempt uninformative leaks. With decreasing myopia, the manager assigns higher weight to P^r. For $\lambda \to 0$, he only cares about the long-term market price after the disclosure revision, and information leaks lose their disciplining effects.

Proposition 4. *If uninformative leaks occur with positive probability (i.e., if $\pi > 0$ and $\psi < 1$), increasing managerial myopia motivates more disclosure, $dy/d\lambda < 0$.*

We can conclude that managerial myopia strengthens the disciplining effect of information leakage. With higher myopia, the manager is increasingly exposed to the threat of adverse market reactions and preempts uninformative leaks.

IV. MODEL EXTENSIONS

Proprietary disclosure costs

Thus far, we have assumed that disclosures provide decision-useful information without affecting firm value. In many practical settings, publicly available information about a firm's strategy, its assets, and contractual relationships can harm profitability. Such information may be used by rivals to gain a competitive advantage or by suppliers and customers to improve their positions in contract negotiations. If firms expect proprietary costs of disclosure, they adjust their disclosure strategy accordingly (e.g., Jovanovic 1982; Verrecchia 1983; Wagenhofer 1990; Cheynel and Ziv 2021).

We extend our model to study the effects of proprietary costs and to illustrate the robustness of our findings. We assume that the firm incurs proprietary costs $\kappa(\Omega_I)$, which vary with the publicly available information, $\Omega_I \in \{x, \varnothing, \bigcirc\}$. The market price at the initial disclosure stage is $P(\Omega_I) = E[\tilde{x}|\Omega_I] - \kappa(\Omega_I)$. Let $\kappa(x) = c > 0$ denote the proprietary costs following full revelation of the firm value either by disclosure or via perfect leaks. In case of an uninformative leak, outsiders learn that the manager hides unfavorable information which allows for less accurate inferences on the firm value. We therefore assume lower proprietary costs $\kappa(\bigcirc) = \delta \cdot c$, where $\delta \in [0, 1]$ measures the relative size of the costs relative to full revelation. If investors do not receive any information, we normalize the costs to zero, $\kappa(\varnothing) = 0$. Our assumptions ensure that $\kappa(x) \geqslant \kappa(\bigcirc) \geqslant \kappa(\varnothing)$, which reflects the fact that more precise public information causes higher costs.[17] To avoid cases where an informed manager always withholds his information, we assume

[17] Note that it is irrelevant at which time the costs $\kappa(\Omega_I)$ are realized. For given information Ω_I, investors anticipate the proprietary costs and incorporate this information in their pricing decision.

$c < \overline{x} - \mu$. For simplicity, we assume that disclosures at the revision stage arrive too late to be used against the firm and do not cause proprietary costs.[18]

We follow the procedure in the main analysis and first study a setting with a completely myopic manager, i.e., $\lambda = 1$. There is a unique equilibrium characterized by a disclosure threshold $y \in (\underline{x}, \overline{x})$. The price reactions to perfect and uninformative leaks are $P(x) = x - c$ and $P(\bigcirc) = E(y) - \delta \cdot c$, respectively. The no-information price $P(\varnothing)$ is unaffected by proprietary costs and given by Lemma 1. The threshold y is characterized by the indifference condition for a marginal type who observes the firm value $x = y$ and can be stated as

$$y - C = \left(1 - \frac{1 - \pi}{1 - \pi \cdot \psi}\right) \cdot E(y) + \frac{1 - \pi}{1 - \pi \cdot \psi} \cdot P(\varnothing), \tag{4}$$

where $C \equiv \left(1 - \frac{\pi \cdot (1-\psi) \cdot \delta}{1 - \pi \cdot \psi}\right) \cdot c$. A comparison with (2) shows that the effect of proprietary costs can be summarized in the effective cost term $C \in [0, c]$. Increasing effective costs C imply a higher threshold y and hinder voluntary disclosure. Note that C is increasing in c and decreasing in δ. Higher costs of full revelation c reduce disclosure. In contrast, increasing costs of uninformative leaks foster disclosure. To understand this result, note that the costs c penalize the manager if he discloses but also if he is exposed by a perfect leak. Perfect leaks only occur with probability $\pi \cdot \psi < 1$. As a consequence, the price upon disclosure is more sensitive to c than the expected non-disclosure price. In contrast, higher values of δ reduce the market price upon uninformative leaks and only penalizes non-disclosure. Increasing levels of δ therefore induces more disclosure.

Interestingly, the size of the effective costs C also depends on the likelihood and informativeness of information leaks. It is not obvious whether the presence of proprietary costs changes the comparative statics with regard to π and ψ. We therefore revisit the results of the previous section in Proposition 5.

[18] Intuitively, a timelier disclosure is more useful to third parties and causes higher proprietary costs. We find similar results if proprietary costs at the revision stage are positive but do not exceed the costs at the initial stage.

Proposition 5. *Effects of π and ψ with a completely myopic manager ($\lambda = 1$)*

a) *Increasing informativeness ψ reduces disclosure, i.e., $dy/d\psi > 0$ for $\pi > 0$.*

b) *There is $\pi^{\ddagger} \in [0, 1]$ such that y increases in π for $\pi < \pi^{\ddagger}$ and decreases in π for $\pi > \pi^{\ddagger}$. The value $\pi^{\ddagger}$ weakly decreases in δ. It may increase or decrease in c.*

Intuitively, the effective proprietary costs C are increasing as leaks become more informative. Thus, higher levels of ψ not only reduce market discipline (see Proposition 1) but also raise the disclosure costs. Consequently, a higher informativeness of leaks reduces voluntary disclosure.

An increasing likelihood of leakage reduces the effective costs, $dC/d\pi < 0$. Our analysis shows that the comparative statics results in Proposition 2 are qualitatively unaffected by proprietary costs. A higher likelihood of leaks hinders disclosure if leaks are rare events, i.e., for $\pi \in [0, \pi^{\ddagger}]$, and fosters disclosure if leaks are sufficiently probable, i.e., for $\pi \in [\pi^{\ddagger}, 1)$. Intuitively, the region $\pi \in [\pi^{\ddagger}, 1)$ where information leaks foster voluntary disclosure is increasing in the costs of uninformative leaks. Recall that higher δ strengthens disclosure incentives. This effect is amplified by a higher probability π of leakage. The costs of full revelation c affect both the disclosure price and the non-disclosure price. As a consequence, the effects on the critical value $\pi^{\ddagger}$ are ambiguous.

Next, we study the effects of managerial myopia and allow for $\lambda \leqslant 1$. An informed manager maximizes the weighted sum of the initial price P and the revised price P^r.

Lemma 4. *Equilibrium of the dynamic disclosure game*

a) *At the revision stage, the manager reveals the firm value in response to uninformative leaks, i.e., $d^r(x, \bigcirc) = x$. In the absence of leaks, the manager follows a threshold strategy and only discloses sufficiently favorable information. There is $y^r \in (\underline{x}, y]$ such that $d^r(x, \varnothing) = x$ if and only if $x \geqslant y^r$.*

b) *At the initial stage, there is a threshold* $y \in (\underline{x}, \overline{x})$ *such that* $d(x) = x$ *if and only if* $x \geqslant y$. *We identify a level of myopia* $\lambda^{\ddagger} \in (0, 1]$ *such that* y *satisfies the condition*

$$y = C^{\ddagger} + \left(1 - \tfrac{1-\pi}{1-\pi\cdot\psi^{\ddagger}}\right) \cdot E(y) + \tfrac{1-\pi}{1-\pi\cdot\psi^{\ddagger}} \cdot P(\varnothing),$$

with $P(\varnothing)$ *as defined in Lemma 1,*

$$C^{\ddagger} \equiv \begin{cases} \frac{1-\pi\cdot(\psi+(1-\psi)\cdot\delta)}{(1-\pi\cdot\psi)\cdot\lambda} \cdot c & \text{if } \lambda < \lambda^{\ddagger} \\ \frac{1-\pi\cdot(\psi+(1-\psi)\cdot\delta)}{1-\pi\cdot\psi^{\ddagger}} \cdot c & \text{else} \end{cases}, \text{ and } \psi^{\ddagger} \equiv \begin{cases} \psi & \text{if } \lambda < \lambda^{\ddagger} \\ 1 - (1-\psi)\cdot\lambda & \text{else} \end{cases}.$$

Lemma 4 shows that proprietary costs do not considerably change the structure of the equilibrium. Again, an informed manager reacts to uninformative leaks by disclosing the firm value. As in our main analysis, this affects the disclosure decision at the initial stage. However, proprietary costs have an additional effect in our dynamic setting. Some managers remain silent at the initial stage and postpone their disclosure to the revision stage to avoid proprietary costs.

In line with this argument, we identify cases where a manager revises an earlier non-disclosure decision even though he is not exposed by a leak. A necessary condition for this result is that the manager is not too myopic, i.e., $\lambda < \lambda^{\ddagger}$ for a critical level $\lambda^{\ddagger} \in (0, 1]$. In this case, there is a threshold $y^r < y$ such that a manager who observes $x \in [y^r, y)$ remains silent at the initial stage but shares his information at the revision stage. In contrast, a more myopic manager, $\lambda \geqslant \lambda^{\ddagger}$, has a higher interest in the short-term market price and accepts the proprietary costs in order to be able to influence the price P at the initial stage. Such managers never delay the disclosure decision to the revision stage, i.e., $y^r = y$.

Overall, the manager's motive to avoid proprietary costs reinforces the findings of our main analysis. In line with Proposition 4, higher managerial myopia fosters voluntary disclosures at the initial disclosure stage. Corollary 2 shows that this result even holds in the absence of uninformative leaks. This underpins the robustness of our findings.

Corollary 2. *Given that public information causes proprietary costs, increasing managerial myopia motivates more disclosure even in the absence of uninformative leaks* ($\psi = 0$)*. Specifically, we find that* $dy/d\lambda < 0$ *for* $\lambda < \lambda^{\ddagger}$ *and* $dy/d\lambda = 0$ *for* $\lambda \geqslant \lambda^{\ddagger}$.

Leaks reveal noisy information

Thus far, we have considered informativeness as the conditional probability distribution over perfect and uninformative information leaks. While this assumption improves the tractability of the model, it may be unclear whether our results are robust to alternative modelling choices. In this section, we show the robustness of our results to an alternative notion of informativeness. Specifically, we consider leaks as noisy signals of the firm's private information and study informativeness as the precision of the leaked signal.

For simplicity, we consider a uniformly distributed firm value, $\tilde{x} \sim U[\underline{x}, \overline{x}]$, and focus on the case of a perfectly myopic manager, $\lambda = 1$. The manager observes x with probability $p \in [0, 1]$, and information is leaked with probability $\pi \in [0, 1)$. In contrast to our main analysis, we do not distinguish perfect and uninformative leaks. Instead, any leak reveals a signal $\tilde{s} = \tilde{x} + \tilde{n}$, where $\tilde{n} \sim U[-\varepsilon, \varepsilon]$ is independent and uniformly distributed noise with mean zero. The parameter $\varepsilon > 0$ determines the variance of the noise term.[19] For $\varepsilon \to 0$, information leaks reveal the manager's private information with certainty, which corresponds to the case $\psi = 1$ in our main analysis. For $\varepsilon > \overline{x} - \underline{x}$, information leaks do not directly convey any information about the firm value. This resembles the case $\psi = 0$. In line with these observations, we define $\overline{\psi} \equiv 1/\varepsilon$ as measure of informativeness. We restrict the analysis to threshold equilibria with a disclosure threshold $y \in [\underline{x}, \overline{x}]$ such that $d(x) = x$ for $x \geqslant y$ and $d(x) = ND$ for $x < y$.

When making his disclosure decision, an informed manager must compare the expected price reactions upon disclosure and non-disclosure. If he discloses his private information, the market price is $P_D(x) = x$. If he remains silent, the investors may receive a signal $s \in [x - \varepsilon, x + \varepsilon]$ and price the firm based on their beliefs about the manager's disclosure strategy. A marginal type who observes $x = y$ must be indifferent between disclosure and non-disclosure, i.e.,

$$y = \pi \cdot P(\ell, y) + (1 - \pi) \cdot P(\varnothing), \tag{5}$$

[19] The variance of the noise term $Var[\tilde{n}] = \varepsilon^2/3$ is a strictly increasing function of ε with $Var[\tilde{n}] = 0$ for $\varepsilon = 0$.

where $P(\ell, x) = E_s[E[\tilde{x}|s, y]|x]$ denotes the expected price reaction to an information leak for a given firm value x. Condition (5) mirrors the equilibrium condition (2) in our main analysis. The no-information price is given by

$$P(\varnothing) = \frac{1-p}{1-p+p\cdot(1-\pi)\cdot\frac{y-\underline{x}}{\overline{x}-\underline{x}}}\cdot\mu + \frac{p\cdot(1-\pi)\cdot\frac{y-\underline{x}}{\overline{x}-\underline{x}}}{1-p+p\cdot(1-\pi)\cdot\frac{y-\underline{x}}{\overline{x}-\underline{x}}}\cdot\frac{\underline{x}+y}{2} \tag{6}$$

with $\mu = (\overline{x} + \underline{x})/2$. Lemma 5 delineates the expected price reaction $P(\ell, y)$ to a leak.

Lemma 5. *For given market beliefs about the disclosure threshold y, a manager who observes $x = y$ expects the following market price in response to a leak:*

$$P(\ell, y) = \begin{cases} y - \dfrac{1}{2\cdot\overline{\psi}} & if\ y \geqslant \underline{x} + 2\cdot\varepsilon \\ \dfrac{\underline{x}+y}{2} + \dfrac{(y-\underline{x})^2\cdot\overline{\psi}}{8} & else \end{cases}.$$

Note that $P(\ell, y)$ is increasing in the informativeness $\overline{\psi}$ of leaks.

Lemma 5 shows that a decreasing informativeness of leaks motivates an adverse market reaction. As in our main analysis, the investors discount the observed signal realization s. As investors receive a less precise signal about the manager's private information, the market price $P(\ell, y)$ increasingly reflects the fact that the manager withholds bad news. Based on Lemma 5, we show the robustness of our main results.

Proposition 6. *There exists a unique equilibrium with disclosure threshold $y \in [\underline{x}, \overline{x}]$ such that $d(x) = x$ for $x \geqslant y$ and $d(x) = ND$ for $x < y$. We find that:*

(i) There is less voluntary disclosure if leaks become more informative, i.e., $dy/d\overline{\psi} > 0$.

(ii) There is a critical value $\overline{\pi} \in [0, 1]$ such that the threshold y increases in π for $\pi < \overline{\pi}$ and decreases in π for $\pi > \overline{\pi}$, i.e., $\overline{\pi}$ minimizes voluntary disclosure.

(iii) The disclosure-minimizing likelihood, $\overline{\pi}$, is increasing in informativeness, i.e., $d\overline{\pi}/d\overline{\psi} > 0$.

V. EMPIRICAL PREDICTIONS AND POLICY IMPLICATIONS

Empirical measurement of the likelihood and informativeness of leaks

Our findings suggest that the amount of voluntary disclosure depends on the characteristics of information leaks. If leaks are less informative, i.e., the economic consequences of the leaked information are difficult to understand, a higher likelihood of leaks fosters disclosure. We therefore expect that an increasing threat of information leakage induces more disclosure in industries with complex business models and innovative products. In contrast, if the economic consequences of the leaked information are easy to understand, we expect a higher likelihood to reduce disclosure.

To test these predictions, it is important to identify empirical measures consistent with our model analysis. We consider both the likelihood and informativeness of leaks as conditional probabilities. In our model analysis, the likelihood of leaks π is defined as the probability that information is leaked conditional on the fact that a firm is privately informed. The informativeness of leaks ψ represents the probability that investors understand the economic implications of the leaked information conditional on the fact that a leak occurred. To illustrate the relevance of the empirical measurement, we consider an alternative model specification with a different notion of informativeness. Let ψ_P and ψ_U denote the *unconditional* probabilities of perfect and uninformative leaks. Empirical studies might interpret increases in ψ_P and decreases in ψ_U as higher informativeness of leaks. Note that there is a one-to-one mapping between these probabilities and the parameter values in our main analysis. The total probability that a leak occurs is $\pi = \psi_P + \psi_U$. The probability that a leak reveals the firm value conditional on information leakage is $\psi = \psi_P/(\psi_P + \psi_U)$.

Variations in ψ_P or ψ_U simultaneously affect the likelihood and informativeness of leaks in our main analysis. For instance, increasing ψ_P not only implies a higher value of ψ but also a higher likelihood π. Given our results in Proposition 1 and 2, the total effect on voluntary disclosure is not obvious and requires further analysis. Proposition 7 summarizes the comparative static results.

Proposition 7. *We establish the following results for the alternative model specification:*

(i) As the unconditional probability of uninformative leaks increases, there is more voluntary disclosure, i.e., $dy/d\psi_U < 0$.

(ii) There is a critical value $\psi_P^\dagger \in [0,1]$ *that minimizes voluntary disclosure. The disclosure threshold* y *is increasing in* ψ_P *for* $\psi_P < \psi_P^\dagger$ *and decreasing in* ψ_P *for* $\psi_P > \psi_P^\dagger$.

The disclosure threshold y is strictly decreasing in the unconditional probability ψ_U of uninformative leaks which is in line with the intuition of our main analyis. In contrast, a higher unconditional probability ψ_P of a perfect leak has ambiguous effects.

These results have subtle but important empirical implications. If the informativeness of information leakage is measured as the unconditional probability of leaks, our theoretical predictions differ from those in the main analysis. Specifically, a higher unconditional probability of perfect leaks, ψ_P, does not necessarily reduce voluntary disclosure but can have the opposite effect. Ceteris paribus, higher levels of ψ_P also reflect a higher likelihood of leaks. In line with Proposition 2, this causes a revelation effect and induces more disclosure if the likelihood $\psi_P + \psi_U$ is sufficiently high. Proposition 7 shows that the empirical analysis of information leaks and voluntary disclosure requires caution. Empirical studies that aim to confirm the findings of Proposition 1 need to control for the total likelihood of leaks.

Implications for price efficiency

In our previous analysis, we show that the probabilistic arrival of public information via leaks can foster or hinder firms' voluntary disclose. From an policy perspective, it is important to assess how leaks affect the total amount of information available to investors. If information leaks crowd out voluntary disclosure and deteriorate investors' inferences on firm value, they might compromise capital market efficiency. Accordingly, regulators could take actions to help firms protect their private information. An example is the recent initiative of the U.S. Securities and Exchange Commission to define cybersecurity requirements for publicly traded companies, see Acebo (2023).

To study the total amount of public information, we use an analytical measure of price efficiency that has been considered by prior literature (e.g., Frenkel et al. 2020). We measure price efficiency in terms of the negative squared difference between a firm's value and its long-term market price, $PE = -E[(\tilde{x} - \tilde{P}^r)^2]$. Intuitively, more information reduces expected differences between a firm's intrinsic value and its market price.[20]

Proposition 8. *If leaks occur with positive probability ($\pi > 0$), price efficiency is decreasing in the informativeness of information leaks, i.e., $dPE/d\psi < 0$.*

Perhaps surprisingly, our results suggest that a higher informativeness of leaks reduces the total amount of public information. To understand this finding, note that in the long-run both perfect and uninformative leaks reveal the firm value. In case of a perfect leak, investors directly observe the firm value. If an uninformative leak occurs, the manager discloses his information at the revision stage. A higher informativeness ψ increases the probability of a perfect leak and reduces the probability of an uninformative leak. Since both types imply the same price reaction, $P^r = x$, the results in Proposition 8 cannot be explained by the direct information effects but reflect the manager's ex ante disclosure incentives.

We have established in Proposition 1 that higher informativeness ψ reduces disclosure at the initial stage. Accordingly there is a higher ex ante probability that investors do not receive any information, $\Omega_I = \varnothing$, and, according to Lemma 3, also a higher probability that investors remain uninformed after the revision stage, $\Omega_I^r = \varnothing$. Overall, more informative leaks decrease the probability of full revelation and increase the likelihood of the no-information case. In expectation, the investors' valuation is a less precise estimator of firm value and price efficiency decreases.

Although a higher likelihood of information leakage may crowd out voluntary disclosure if information leaks represent rare events (Proposition 2), our results suggest that a higher probability π generally increases price efficiency, i.e., $dPE/d\pi > 0$. The additional information provided by information leaks outweighs the information loss following from reduced voluntary disclosure.

[20] Related measures of price efficiency have been studied by Grossman and Stiglitz (1980), Fischer and Verrecchia (2000), Fischer and Stocken (2004), and Goldstein and Yang (2017).

VI. CONCLUSION

This study explores the effects of information leakage on managers' voluntary disclosure decisions when investors are uncertain about their information endowment. In contrast to external information sources, information leaks generally reveal that the management is endowed with private information but has decided not to share its insights. This has a considerable impact on managers' strategic disclosure decisions. Depending on the informativeness and likelihood of information leaks, managers reduce or extend their voluntary disclosures.

We find that leaks expose manager to adverse market reactions. As a consequence, managers extend their voluntary disclosures to preempt leakage. This disciplining effect is more pronounced if information leaks become more informative about the firm value. The reason is that investors increasingly rely on their observation that the management deliberately withholds information–a behavior which indicates bad news. Increasing the likelihood of leakage increases market discipline but also brings up a countervailing concealment effect. Uninformed investors assign higher market prices because it is less likely that managers can successfully hide unfavorable information. This provides additional incentives to withhold information and undermines market discipline. We find that the total effect of a higher likelihood of leaks on voluntary disclosure is U-shaped.

Moreover, we show that the disciplining effect of information leakage depends on the fact that a manager cares about short-term capital market prices. Such myopic managers are penalized by adverse market reactions to information leaks. In contrast, managers who care for long-term prices can react to information leaks by additional disclosures and thereby correct unfavorable market beliefs. We conclude that managerial myopia fosters voluntary disclosure.

These findings offer novel empirical predictions. Our results suggest that the effects of information leakage depend on the informativeness of potential leaks. If the economic consequences of leaked information are difficult to understand for outsiders, which is particularly the case in industries with complex business models and innovative products, information leaks foster voluntary disclosure. In contrast, if the value implications of the leaked information are easy to understand, we expect that a higher likelihood of leakage reduces voluntary disclosure.

Moreover, we expect that information leaks motivate more extensive voluntary disclosures if managers benefit from short-term price increases and cannot react to information leaks by additional disclosures in a timely manner.

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PROOFS

Proof of Lemma 1

The market price upon disclosure and the expected market price upon non-disclosure are given by

$$P_D(x) = x \quad \text{and} \quad P_{ND}(x) = \pi \cdot [\psi \cdot P(x) + (1-\psi) \cdot P(\bigcirc)] + (1-\pi) \cdot P(\varnothing), \tag{7}$$

respectively. An informed manager discloses his private information if

$$P_D(x) \geqslant P_{ND}(x) \quad \Leftrightarrow \quad x \geqslant \left(1 - \frac{1-\pi}{1-\pi \cdot \psi}\right) \cdot P(\bigcirc) + \frac{1-\pi}{1-\pi \cdot \psi} \cdot P(\varnothing). \tag{8}$$

Note that $P(\bigcirc)$ and $P(\varnothing)$ do not depend on the realized value x. As the left-hand side of (8) is strictly increasing in x, the manager discloses whenever x exceeds a threshold value y, which is determined by the investors' beliefs. The fact that the manager follows a threshold strategy with cut-off value y helps us to specify the equilibrium market prices $P(\bigcirc)$ and $P(\varnothing)$:

$$P(\bigcirc) = E(y),\ P(\varnothing) = \text{pr}[\Omega_M = \varnothing \,|\, \Omega_I = \varnothing] \cdot \mu + (1 - \text{pr}[\Omega_M = \varnothing \,|\, \Omega_I = \varnothing]) \cdot E(y), \tag{9}$$

where

$$\text{pr}[\Omega_M = \varnothing \,|\, \Omega_I = \varnothing] = \frac{\text{pr}[\Omega_M = \Omega_I = \varnothing]}{\text{pr}[\Omega_I = \varnothing]} = \frac{1-p}{1-p+p \cdot (1-\pi) \cdot F(y)}. \tag{10}$$

A manager who observes $x = y$ must be indifferent between disclosing and withholding his information. Using the results in (7) and (9), the equilibrium condition $P_D(y) = P_{ND}(y)$ can be rearranged to:

$$y = \pi \cdot [\psi \cdot y + (1-\psi) \cdot E(y)] + (1-\pi) \cdot P(\varnothing). \tag{11}$$

For $y = \underline{x}$, the right-hand side becomes $\pi \cdot \underline{x} + (1 - \pi) \cdot \mu$ and strictly exceeds the left-hand side, $\underline{x}$. For $y = \mu$, the left-hand side equals μ, which exceeds the weighted average of μ and $E(\mu)$ on the right-hand side. Due to continuity, there exists $y \in (\underline{x}, \mu)$ that satisfies (11). To prove uniqueness, it is sufficient to show that $P_D(y)$ is increasing in y at a higher rate than $P_{ND}(y)$. This is the case if

$$\frac{dP_{ND}}{dy} < \frac{dP_D}{dy} = 1. \tag{12}$$

Rearranging yields

$$P_{ND}(y) = y - (1 - \pi) \cdot (y - P(\varnothing)) - \pi \cdot (1 - \psi) \cdot (y - E(y)). \tag{13}$$

We can therefore conclude that

$$\frac{dP_{ND}}{dy} = 1 - (1 - \pi) \cdot \left(1 - \frac{dP(\varnothing)}{dy}\right) - \pi \cdot (1 - \psi) \cdot \left(1 - \frac{dE(y)}{dy}\right). \tag{14}$$

Log-concavity of the firm value guarantees $dE(y)/dy < 1$. To prove the inequality in (12), it is sufficient to show that $dP(\varnothing)/dy < 1$, which can be confirmed using the result in equation (9):

$$\frac{dP(\varnothing)}{dy} = \frac{p \cdot (1-p) \cdot (1-\pi) \cdot f(y)}{(1-p+p \cdot (1-\pi) \cdot F(y))^2} \cdot \underbrace{(E(y) - \mu)}_{<0} + \underbrace{\frac{p \cdot (1-\pi) \cdot F(y)}{1-p+p \cdot (1-\pi) \cdot F(y)}}_{<1} \cdot \underbrace{\frac{dE(y)}{dy}}_{<1}. \tag{15}$$

□

Proof of Lemma 2

Consider the equilibrium threshold y as a function of p, i.e., $y = y(p)$. The equilibrium condition (2) is equivalent to

$$y - P_{ND}(y, p) = 0, \tag{16}$$

where $P_{ND}(y, p)$ is a continuously differentiable function of y and p. Using the implicit function theorem, we find

$$\frac{dy}{dp} = \frac{\partial P_{ND}/\partial p}{1 - \partial P_{ND}/\partial y}. \tag{17}$$

In the proof of Lemma 1, we establish $\partial P_{ND}/\partial y < 1$. Thus, the sign of dy/dp equals the sign of

$$\begin{aligned}\frac{\partial P_{ND}}{\partial p} &= (1-\pi) \cdot \frac{\partial P(\varnothing)}{\partial p} \\ &= -\frac{(1-\pi)^2 \cdot F(y)}{(1-p+p \cdot (1-\pi) \cdot F(y))^2} \cdot (\mu - E(y)) < 0.\end{aligned} \tag{18}$$

□

Proof of Proposition 1

Applying the implicit function theorem to the equilibrium condition $y - P_{ND}(y, \psi) = 0$ yields

$$\frac{dy}{d\psi} = \frac{\partial P_{ND}/\partial \psi}{1 - \partial P_{ND}/\partial y}. \tag{19}$$

In the proof of Lemma 1, we establish $\partial P_{ND}/\partial y < 1$. Thus, the sign of $dy/d\psi$ equals the sign of

$$\frac{\partial P_{ND}}{\partial \psi} = \pi \cdot (y - E(y)), \tag{20}$$

which is strictly positive for $\pi > 0$.

□

Proof of Corollary 1

Using integration by parts, the price $P(\varnothing)$ as characterized in Lemma 1 can be stated as

$$P(\varnothing) = \frac{(1-p) \cdot \mu + p \cdot (1-\pi) \cdot \left(F(y) \cdot y - \int_{\underline{x}}^{y} F(x)dx\right)}{1-p+p \cdot (1-\pi) \cdot F(y)}. \tag{21}$$

Differentiation with regard to y yields

$$\frac{dP(\varnothing)}{dy} = 0 \quad \Leftrightarrow \quad y_{\min} = \mu - \frac{p \cdot (1-\pi)}{1-p} \cdot \int_{\underline{x}}^{y} F(x)dx. \tag{22}$$

It is easy to see that $y_{\min}$ minimizes $P(\varnothing)$. Next, evaluate the condition (2) for $\psi = 1$:

$$y = P(\varnothing) = y_{\min}. \tag{23}$$

Thus, the result of the Corollary follows directly from Proposition 1.

□

Proof of Proposition 2

Applying the implicit function theorem to the equilibrium condition $y - P_{ND}(y, \pi) = 0$ yields

$$\frac{dy}{d\pi} = \frac{\partial P_{ND}/\partial \pi}{1 - \partial P_{ND}/\partial y} \tag{24}$$

with $\partial P_{ND}/\partial y < 1$. The sign of $dy/d\pi$ therefore corresponds to the sign of

$$\frac{\partial P_{ND}}{\partial \pi} = -\underbrace{\frac{(1-p)^2 \cdot (\mu - E(y))}{(1-p+p\cdot(1-\pi)\cdot F(y))^2}}_{\equiv A} + \underbrace{\psi \cdot (y - E(y))}_{\equiv B}. \tag{25}$$

We first consider the special cases $\psi = 0$ and $\psi = 1$. For $\psi = 0$, equation (25) yields

$$\left.\frac{\partial P_{ND}}{\partial \pi}\right|_{\psi=0} = -\frac{(1-p)^2 \cdot (\mu - E(y))}{(1-p+p\cdot(1-\pi)\cdot F(y))^2} < 0, \tag{26}$$

i.e., we can conclude that $\pi^{\dagger}|_{\psi=0} = 0$. For $\psi = 1$, condition (2) can be rearranged to

$$y - E(y) = \frac{1-p}{1-p+p\cdot(1-\pi)\cdot F(y)} \cdot (\mu - E(y)). \tag{27}$$

Substitution into (25) yields

$$\left.\frac{\partial P_{ND}}{\partial \pi}\right|_{\psi=1} = \frac{(1-p)\cdot(\mu - E(y))}{1-p+p\cdot(1-\pi)\cdot F(y)} \cdot \left(1 - \frac{1-p}{1-p+p\cdot(1-\pi)\cdot F(y)}\right) > 0, \tag{28}$$

that is, we find $\pi^{\dagger}|_{\psi=1} = 1$. Finally, we turn to the case $\psi \in (0,1)$. For $\pi \to 1$, condition (2) yields $y \to E(y)$ which can only be satisfied if y approaches $\underline{x}$. We therefore find that

$$\lim_{\pi \to 1} \frac{\partial P_{ND}}{\partial \pi} = -(\mu - \underline{x}) < 0. \tag{29}$$

Due to continuity, there is a $\underline{\pi} < 1$ such that P_{ND} is decreasing in $\pi \in [\underline{\pi}, 1]$. Define

$$\pi^{\dagger} = \inf \left\{ \underline{\pi} \in [0,1] \;\middle|\; \frac{\partial P_{ND}}{\partial \pi} < 0 \text{ for all } \pi \in [\underline{\pi}, 1) \right\}. \tag{30}$$

It remains to show that $\partial P_{ND}/\partial \pi \geqslant 0$ for $\pi \in [0, \pi^{\dagger})$. For $\pi^{\dagger} = 0$, there is nothing left to prove. Consider the case $\pi^{\dagger} > 0$. Due to continuity, we can conclude that

$$\left.\frac{\partial P_{ND}}{\partial \pi}\right|_{\pi=\pi^{\dagger}} = 0. \tag{31}$$

Assume that there is $\pi^{*} \in [0, \pi^{\dagger})$ with $\partial P_{ND}/\partial \pi|_{\pi=\pi^{*}} < 0$. Due to continuity, there must be a $\overline{\pi} \in (\pi^{*}, \pi^{\dagger})$ and $\partial P_{ND}/\partial \pi|_{\pi=\overline{\pi}} = 0$ such that

$$\frac{\partial P_{ND}}{\partial \pi} \leqslant 0 \qquad \text{for all } \pi \in [\pi^{*}, \overline{\pi}]. \tag{32}$$

According to (24), y must be weakly decreasing in $\pi \in [\pi^{*}, \overline{\pi}]$. This observation helps us to make inferences on the slope of A and B as defined in equation (25). Note that A is strictly decreasing in y and increasing in π whereas B is increasing in y. Altogether, we can conclude that (i) $\partial P_{ND}/\partial \pi|_{\pi=\overline{\pi}} = 0$ and (ii) $\partial P_{ND}/\partial \pi$ is strictly decreasing in the range $\pi \in [\pi^{*}, \overline{\pi}]$. As a consequence, we have

$$\frac{\partial P_{ND}}{\partial \pi} > 0 \qquad \text{for all } \pi \in [\pi^*, \overline{\pi}), \tag{33}$$

which contradicts (32).

□

Proof of Proposition 3

In the proof of Proposition 2, we have already established that $\pi^\dagger|_{\psi=0} = 0$ and $\pi^\dagger|_{\psi=1} = 1$. We therefore turn to the case $\psi \in (0,1)$. Consider $\pi^\dagger$ as a function of ψ, i.e., $\pi^\dagger = \pi^\dagger(\psi)$. Moreover, let $y(\pi, \psi)$ denote the disclosure threshold as a function of π and ψ. The critical likelihood $\pi^\dagger$ is characterized by the condition

$$F(\pi^\dagger(\psi), \psi) \equiv \frac{\partial P_{ND}}{\partial \pi}(y(\pi^\dagger(\psi), \psi), \pi^\dagger(\psi), \psi) = 0. \tag{34}$$

By use of the implicit function theorem, we obtain

$$\frac{d\pi^\dagger(\psi)}{d\psi} = -\frac{\frac{\partial F(\pi^\dagger(\psi),\psi)}{\partial \psi}}{\frac{\partial F(\pi^\dagger(\psi),\psi)}{\partial \pi}}. \tag{35}$$

We find

$$\frac{\partial F(\pi^\dagger(\psi), \psi)}{\partial \psi} = \underbrace{\frac{\partial^2 P_{ND}}{\partial \pi \partial y}}_{>0} \cdot \underbrace{\frac{\partial y}{\partial \psi}}_{>0} + \underbrace{\frac{\partial^2 P_{ND}}{\partial \pi \partial \psi}}_{>0} > 0 \tag{36}$$

$$\text{and} \quad \frac{\partial F(\pi^\dagger(\psi), \psi)}{\partial \pi} = \underbrace{\frac{\partial^2 P_{ND}}{\partial \pi \partial y}}_{>0} \cdot \underbrace{\frac{\partial y}{\partial \pi}}_{=0} + \underbrace{\frac{\partial^2 P_{ND}}{\partial \pi^2}}_{<0} < 0. \tag{37}$$

The sign of the components can be easily confirmed using the expression in (25) as well as Proposition 1 and the fact that $\partial y / \partial \pi (\pi^\dagger(\psi), \psi) = 0$.

□

Proof of Lemma 3

First, consider the equilibrium at the revision stage. If an informed manager faces an uninformative leak, i.e., $(\Omega_M, \Omega_I) = (x, \bigcirc)$, the investors know that the manager is informed. Thus, the unraveling result applies and the manager discloses his information in equilibrium. Next, consider the case that a strategic manager has not been exposed by a leak, $(\Omega_M, \Omega_I) = (x, \varnothing)$. Assume that there is an equilibrium, where some managers withhold information initially but disclose at the revision stage. This implies that there is less strategic withholding at the revision stage than at the initial disclosure stage. As a consequence, the no-information prices must satisfy $P^r(\varnothing) > P(\varnothing)$. However, if a manager of type x found it optimal to remain silent in the first place, it must hold that $x \leqslant P_{ND}(x) < P(\varnothing)$. This implies $x < P^r(\varnothing)$. The manager has no incentive to revise his initial non-disclosure decision. This yields a contradiction and completes the proof of part a).

In his initial disclosure decision, an informed manager anticipates future disclosure revisions. He compares his utility from disclosure, $\lambda \cdot P(x) + (1 - \lambda) \cdot P^r(x) = x$, with the expected utility from non-disclosure,

$$\lambda \cdot P_{ND}(x) + (1 - \lambda) \cdot E[P^r(x) \mid d(x) = ND], \tag{38}$$

with $P_{ND}(x)$ according to (3), and

$$E[P^r(x) \mid d(x) = ND] = \pi \cdot x + (1 - \pi) \cdot P(\varnothing). \tag{39}$$

With the same arguments as above, there is a unique threshold equilibrium. The threshold $y \in (\underline{x}, \mu)$ satisfies the indifference condition

$$y = \lambda \cdot P_{ND}(y) + (1 - \lambda) \cdot [\pi \cdot y + (1 - \pi) \cdot P(\varnothing)]. \tag{40}$$

Simplifying the right-hand side yields the condition in part b).

□

Proof of Proposition 4

Apparently, $\psi^\dagger$ is decreasing in λ because $d\psi^\dagger/d\lambda = -(1-\psi) < 0$. Thus, higher myopia has the same effect as decreasing informativeness of leaks with a completely myopic manager. According to Proposition 1, it induces more voluntary disclosure.

□

Proof of Proposition 5

First, we establish that there is a unique equilibrium with disclosure threshold $y \in (\underline{x}, \overline{x})$. A manager who observes the firm value x compares the disclosure price $P_D(x) = x - c$ with the expected non-disclosure price

$$P_{ND}(x) = \pi \cdot [\psi \cdot (x-c) + (1-\psi) \cdot (E(y) - \delta \cdot c)] + (1-\pi) \cdot P(\varnothing), \tag{41}$$

with $P(\varnothing)$ according to Lemma 1. The threshold y is characterized by the indifference condition $P_D(y) = P_{ND}(y)$ and can be rearranged to

$$y - C = \left(1 - \frac{1-\pi}{1-\pi\cdot\psi}\right) \cdot E(y) + \frac{1-\pi}{1-\pi\cdot\psi} \cdot P(\varnothing), \tag{42}$$

where $C \equiv \left(1 - \frac{\pi\cdot(1-\psi)\cdot\delta}{1-\pi\cdot\psi}\right) \cdot c$. For $y = \underline{x}$, the right-hand side of this condition exceeds the left-hand side. The slope of the left-hand side is steeper than that of the right-hand side. Thus, increasing levels of C imply higher threshold values y. Note that y is maximized for $\delta = 0$ and $\psi = 1$. Even in this case, the assumption $c < \overline{x} - \mu$ ensures that $y < \overline{x}$. That is, there are always some managers with sufficiently high firm values who disclose their private information.

Next, we study the comparative statics of y with regard to π. As shown in the proof of Proposition 2, the sign of $dy/d\pi$ is identical to the sign of $\partial P_{ND}/\partial\pi$. Based on (41), we obtain

$$\frac{\partial P_{ND}}{\partial \pi} = -\frac{(1-p)^2 \cdot (\mu - E(y))}{(1-p+p\cdot(1-\pi)\cdot F(y))^2} + \psi \cdot (y - E(y) - (1-\delta)\cdot c) - \delta \cdot c. \tag{43}$$

We use the same arguments as in the proof of Proposition 2 to show that there is $\pi^\ddagger \in [0,1]$ such that $\partial P_{ND}/\partial\pi > 0$ for $\pi < \pi^{\ddagger}$ and $\partial P_{ND}/\partial\pi < 0$ for $\pi > \pi^{\ddagger}$. The critical value $\pi^{\ddagger}$ is either a boundary value, i.e., $\pi^{\ddagger} \in \{0, 1\}$, or it is characterized by the condition

$$G(\delta, \pi, y(\delta, \pi)) \equiv \frac{\partial P_{ND}}{\partial \pi}(\delta, \pi, y(\delta, \pi)) = 0 \tag{44}$$

for all $\delta \in [0, 1]$. Differentiating this equation for δ and rearranging yields

$$\frac{d\pi^{\ddagger}}{d\delta} = -\frac{\frac{\partial G}{\partial \delta}\Big|_{\pi=\pi^{\ddagger}} + \frac{\partial G}{\partial y}\Big|_{\pi=\pi^{\ddagger}} \cdot \frac{dy}{d\delta}\Big|_{\pi=\pi^{\ddagger}}}{\frac{\partial G}{\partial \pi}\Big|_{\pi=\pi^{\ddagger}}}. \tag{45}$$

We know that $\pi^{\dagger}$ maximizes the disclosure threshold y, i.e.,

$$\frac{\partial G}{\partial \pi}\Big|_{\pi=\pi^{\ddagger}} < 0. \tag{46}$$

Note that $dy/d\delta < 0$. Moreover, it is straightforward to see that

$$\frac{\partial G}{\partial \delta}\Big|_{\pi=\pi^{\ddagger}} = -(1-\psi)\cdot c < 0 \text{ and } \frac{\partial G}{\partial y}\Big|_{\pi=\pi^{\ddagger}} > 0 \tag{47}$$

We can conclude that $d\pi^{\ddagger}/d\delta < 0$. Moreover, Numerical examples show that the comparative statics of $\pi^{\ddagger}$ with regard to c are ambiguous.

Next, we study the comparative statics of y with regard to ψ. As shown in the proof of Proposition 1, the sign of $dy/d\psi$ equals the sign of $\partial P_{ND}/\partial\psi$. Based on (41), we establish

$$\frac{\partial P_{ND}}{\partial \psi} = \pi \cdot (y - E(y) - (1-\delta)\cdot c). \tag{48}$$

This expression is positive if and only if $y - E(y) > (1-\delta)\cdot c$, where $y - E(y)$ is increasing in y. The comparative statics analysis with regard to π shows that the threshold y is minimized either by $\pi = 0$ or for $\pi \to 1$. For $\pi \to 1$, the equilibrium condition yields $\lim_{\pi\to 1} y - E(y) = (1-\delta)\cdot c$. For

$\pi = 0$, we find that

$$y - E(y) = c + \frac{1-p}{1-p+p\cdot F(y)} \cdot (\mu - E(y)) > (1-\delta)\cdot c. \tag{49}$$

We can conclude that the derivative (48) is strictly positive for $\pi > 0$.

□

Proof of Lemma 4

Note that disclosure revisions do not cause any proprietary costs. If a strategic manager experiences an uninformative leak, unraveling ensures that he shares his private information, i.e., $d^r(x, \bigcirc) = x$.

Next, consider an informed manager who withholds his private information at the initial stage and is not exposed by a leak. Because the manager remains silent at the initial stage, he must have observed unfavorable information, $x < y$. At the revision stage, the manager compares the disclosure price x with the expected non-disclosure price $P^r(\varnothing)$. Any equilibrium must be a threshold equilibrium. The equilibrium threshold y^r satisfies the condition $y^r = \min\{y^*, y\}$, where $y^* \in [\underline{x}, \overline{x}]$ satisfies the indifference condition

$$y^* = P^r(\varnothing) = \frac{1-p}{1-p+p\cdot(1-\pi)\cdot F(y^*)} \cdot \mu + \frac{p\cdot(1-\pi)\cdot F(y^*)}{1-p+p\cdot(1-\pi)\cdot F(y^*)} \cdot E(y^*). \tag{50}$$

For $y^* \geqslant y$, we have $y^r = y$, i.e., the manager does not revise his non-disclosure decision at the revision stage. For $y^* < y$, there is a region of firm values $y \in [y^r, y)$, which are not disclosed at the initial stage but revealed at the revision stage even in the absence of leaks.

We first consider an equilibrium that satisfies $y^* < y$. The equilibrium threshold y at the initial disclosure stage is given by the indifference condition of a marginal type who observes the firm value $x = y$. If he discloses his information, the firm's market price in both periods is $y - c$. If he remains silent, the non-disclosure price $P_{ND}(y)$ at the initial stage is given by equation (3). The price at the revision stage is $y - c$ or $y - \delta \cdot c$ if a perfect or an uninformative leak occurs. If there is no leak, the marginal type discloses his information at the revision stage because we have assumed

$y^* < y$. The market price is y. Hence, the indifference condition of the marginal manager is

$$y = \lambda \cdot P_{ND}(y) + (1-\lambda) \cdot E[\tilde{P}^r(y) \mid d(y) = ND], \tag{51}$$

where $E[\tilde{P}^r(y) \mid d(y) = ND] = \pi \cdot (\psi \cdot (y - c) + (1-\psi) \cdot (y - \delta \cdot c)) + (1-\pi) \cdot y$. Rearranging this condition yields

$$y = C^{\ddagger} + \left(1 - \frac{1-\pi}{1-\pi \cdot \psi}\right) \cdot E(y) + \frac{1-\pi}{1-\pi \cdot \psi} \cdot P(\varnothing), \tag{52}$$

with $P(\varnothing)$ according to Lemma 1 and $C^{\ddagger} = \frac{1-\pi\cdot(\psi+(1-\psi)\cdot\delta)}{(1-\pi\cdot\psi)\cdot\lambda} \cdot c$. Note that $C^{\ddagger}$ is decreasing in λ and $C^{\ddagger} \to \infty$ for $\lambda \to 0$. Thus, the assumption $y^* < y$ is satisfied for low levels of myopia, $\lambda < \lambda^{\ddagger}$. For reasons of continuity, $\lambda^{\ddagger}$ is given by the condition $y = y^*$ or equivalently

$$\lambda^{\ddagger} = \frac{1-\pi \cdot (\psi + (1-\psi) \cdot \delta)}{\pi \cdot (1-\psi)} \cdot \frac{1 - p + p \cdot (1-\pi) \cdot F(y^*)}{1-p} \cdot \frac{c}{\mu - E(y^*)} > 0. \tag{53}$$

Next, consider an equilibrium where $y^* \geqslant y$, i.e., in the absence of information leakage, the manager does not revise his earlier non-disclosure decision. A manager who withholds his information at the initial stage anticipates that he will also remain silent at the revision stage if no leak occurs. We therefore find $E[\tilde{P}^r(y) \mid d(y) = ND] = \pi \cdot (\psi \cdot (y - c) + (1-\psi) \cdot (y - \delta \cdot c)) + (1-\pi) \cdot P(\varnothing)$, which yields the equilibrium condition

$$y = C^{\ddagger} + \left(1 - \frac{1-\pi}{1-\pi \cdot \psi^{\ddagger}}\right) \cdot E(y) + \frac{1-\pi}{1-\pi \cdot \psi^{\ddagger}} \cdot P(\varnothing), \tag{54}$$

with $C^{\ddagger} = \frac{1-\pi\cdot(\psi+(1-\psi)\cdot\delta)}{1-\pi\cdot\psi^{\ddagger}} \cdot c$ and $\psi^{\ddagger} = 1 - (1-\psi) \cdot \lambda$. It is easy to see that y is decreasing in λ, i.e., the assumption $y^* \geqslant y$ is satisfied for sufficiently high levels of myopia. Again, the critical level of λ is given by the condition $y = y^*$, which yields the same expression as in equation (53). This completes the proof.

□

Proof of Corollary 2

Consider the equilibrium threshold y according to Lemma 4 for $\psi = 1$. Apparently, y is decreasing in λ for $\lambda < \lambda^{\ddagger}$ because $C^{\ddagger}$ is decreasing in λ. For $\lambda > \lambda^{\ddagger}$, y is independent of λ. Moreover, it is easy to see that y is continuous at $\lambda = \lambda^{\ddagger}$, which completes the proof.

□

Proof of Lemma 5

Consider the disclosure decision of a marginal type, $x = y$. When determining the expected market price in response to a leak, we must distinguish two cases. First assume that $y - \underline{x} < 2 \cdot \varepsilon$. In this case, we have

$$\begin{aligned} E_s[E[\tilde{x}|s,y]|x=y] &= \frac{1}{2 \cdot \varepsilon} \cdot \left(\int_{y-\varepsilon}^{\underline{x}+\varepsilon} \frac{\underline{x}+y}{2} ds + \int_{\underline{x}+\varepsilon}^{y+\varepsilon} \frac{s-\varepsilon+y}{2} ds \right) \\ &= \frac{4 \cdot \varepsilon \cdot (\underline{x}+y) + (\underline{x}-y)^2}{8 \cdot \varepsilon}. \end{aligned} \tag{55}$$

The first integrals represents all cases with $s-\varepsilon < \underline{x}$ and the second integral the cases with $s-\varepsilon > \underline{x}$. Because of $y - \underline{x} < 2 \cdot \varepsilon$, both cases are possible. Given $x = y$, the lowest possible signal is $y - \varepsilon$. Given a signal realization $s = y - \varepsilon$, the lowest possible value of x is $s - \varepsilon = y - 2 \cdot \varepsilon$. For $y - \underline{x} \geqslant 2 \cdot \varepsilon$, we have

$$E_s[E[\tilde{x}|s,y]|x=y] = \frac{1}{2 \cdot \varepsilon} \cdot \int_{y-\varepsilon}^{y+\varepsilon} \frac{s-\varepsilon+y}{2} ds = y - \frac{\varepsilon}{2}. \tag{56}$$

If we combine both cases and substitute $\overline{\psi} = 1/\varepsilon$, we obtain the market price $P(\ell, y)$ according to the Lemma. Apparently, both (55) and (56) are increasing in informativeness $\overline{\psi}$.

□

Proof of Proposition 6

First, note that the market price $P(\ell, y)$ according to Lemma 5 is continuously differentiable and satisfies $\frac{\partial}{\partial y} P(\ell, y) \leqslant 1$. As a consequence, the equilibrium condition (5) has a unique solution y. We have to show that this is in fact an equilibrium. That is, all managers observing $x \leqslant y$ have an incentive not to disclose, and all managers with $x > y$ will disclose. The difficulty is that the expected price reaction to a leak $P(\ell, x)$ is a function of the observed firm value x. A manager of type x will disclose if and only if

$$x > \pi \cdot P(\ell, x) + (1 - \pi) \cdot P(\varnothing). \tag{57}$$

For $\overline{x} - \underline{x} \leqslant 2 \cdot \varepsilon$, it is easy to see that

$$\begin{aligned} P(\ell, x) &= \frac{1}{2 \cdot \varepsilon} \cdot \left(\int_{x-\varepsilon}^{\overline{x}-\varepsilon} \frac{\underline{x} + s + \varepsilon}{2} \, ds + \int_{\overline{x}-\varepsilon}^{\underline{x}-\varepsilon} \frac{\underline{x} + \overline{x}}{2} \, ds + \int_{\underline{x}+\varepsilon}^{x+\varepsilon} \frac{s - \varepsilon + \overline{x}}{2} \, ds \right) \\ &= \frac{2 \cdot x \cdot (\overline{x} - \underline{x}) - (\overline{x} + \underline{x}) \cdot (\overline{x} - \underline{x} - 4 \cdot \varepsilon)}{8 \cdot \varepsilon}. \end{aligned} \tag{58}$$

As a consequence, we establish $\frac{\partial}{\partial x} P(\ell, x) = \frac{\overline{x} - \underline{x}}{4 \cdot \varepsilon} \leqslant 1$. Next, we consider the case $2 \cdot \varepsilon < \overline{x} - \underline{x} \leqslant 4 \cdot \varepsilon$. Here, we consider three subcases.

For $\overline{x} - x \leqslant 2 \cdot \varepsilon$ and $x - \underline{x} \leqslant 2 \cdot \varepsilon$, we find

$$\begin{aligned} P(\ell, x) &= \frac{1}{2 \cdot \varepsilon} \cdot \left(\int_{x-\varepsilon}^{\underline{x}+\varepsilon} \frac{\underline{x} + s + \varepsilon}{2} \, ds + \int_{\underline{x}+\varepsilon}^{\overline{x}-\varepsilon} s \, ds + \int_{\overline{x}-\varepsilon}^{x+\varepsilon} \frac{s - \varepsilon + \overline{x}}{2} \, ds \right) \\ &= \frac{2 \cdot x \cdot (\overline{x} - \underline{x}) - (\overline{x} + \underline{x}) \cdot (\overline{x} - \underline{x} - 4 \cdot \varepsilon)}{8 \cdot \varepsilon}. \end{aligned} \tag{59}$$

It follows that $\frac{\partial}{\partial x} P(\ell, x) = \frac{\overline{x} - \underline{x}}{4 \cdot \varepsilon} \leqslant 1$. For $\overline{x} - x \leqslant 2 \cdot \varepsilon$ and $x - \underline{x} \geqslant 2 \cdot \varepsilon$, we find

$$\begin{aligned} P(\ell, x) &= \frac{1}{2 \cdot \varepsilon} \cdot \left(\int_{x-\varepsilon}^{\overline{x}-\varepsilon} s \, ds + \int_{\overline{x}-\varepsilon}^{x+\varepsilon} \frac{s - \varepsilon + \overline{x}}{2} \, ds \right) \\ &= \frac{2 \cdot x \cdot (\overline{x} + 2 \cdot \varepsilon) - (\overline{x} - 2 \cdot \varepsilon)^2 - x^2}{8 \cdot \varepsilon}. \end{aligned} \tag{60}$$

Again, it follows that $\frac{\partial}{\partial x}P(\ell, x) \leqslant 1$. For $\overline{x} - x \geqslant 2 \cdot \varepsilon$ and $x - \underline{x} \leqslant 2 \cdot \varepsilon$, we have

$$P(\ell, x) = \frac{1}{2 \cdot \varepsilon} \cdot \left(\int_{x-\varepsilon}^{\underline{x}+\varepsilon} \frac{\underline{x} + s + \varepsilon}{2} \, ds + \int_{\underline{x}+\varepsilon}^{x+\varepsilon} s \, ds \right)$$
$$= \frac{(x - \underline{x})^2 + 4 \cdot (x + \underline{x}) \cdot \varepsilon + 4 \cdot \varepsilon^2}{8 \cdot \varepsilon}. \tag{61}$$

It is easy to see that $\frac{\partial}{\partial x}P(\ell, x) \leqslant 1$.

It remains to consider the case $4 \cdot \varepsilon < \overline{x}$, which again requires the analysis of three subcases. The analysis of these subcases is analogous to the prior derivations. We therefore omit a detailed analysis. We generally find that $\frac{\partial}{\partial x}P(\ell, x) \leqslant 1$.

These results show that a manager who observes $x \leqslant y$ never finds it optimal to disclose his information. It remains to show that all managers who observe $x > y$ have an incentive to disclose. Apparently, Bayesian updating is not possible for signal realizations $s > y + \varepsilon$ because this observation is not consistent with the equilibrium. For such signal realizations, we assume the most pessimistic belief $s - \varepsilon$. This assumption is consistent with the concept of a perfect Bayesian equilibrium. We only consider the case $y - \underline{x} \geqslant 2 \cdot \varepsilon$. The case $y - \underline{x} < 2 \cdot \varepsilon$ is analogous. Given this assumption, we find for $x \leqslant y + 2 \cdot \varepsilon$ that

$$P(\ell, x) = \frac{1}{2 \cdot \varepsilon} \cdot \left(\int_{x-\varepsilon}^{y+\varepsilon} \frac{s - \varepsilon + y}{2} \, ds + \int_{y+\varepsilon}^{s-\varepsilon} (s - \varepsilon) \, ds \right)$$
$$= \frac{(x - y)^2 + 4 \cdot (x + y) \cdot \varepsilon - 4 \cdot \varepsilon^2}{8 \cdot \varepsilon}. \tag{62}$$

Again, we confirm $\frac{\partial}{\partial x}P(\ell, x) \leqslant 1$. This also holds for $x > y + 2 \cdot \varepsilon$. In this case, we obtain $P(\ell, x) = x - \varepsilon$.

As in our main analysis, we are interested in the comparative statics of $y(\pi, \overline{\psi})$ with respect to π and $\overline{\psi}$. First, it can easily be established that $y(\pi, \overline{\psi})$ is increasing in $\overline{\psi}$. The proof is analogous to the proof of Proposition 1. Key here is that the equilibrium condition (5) depends on $\overline{\psi}$ only via the market price $P(\ell, y)$. Therefore, we can conclude that

$$\frac{\partial P_{ND}}{\partial \overline{\psi}}(y) = \pi \cdot \frac{\partial}{\partial \overline{\psi}} P(\ell, y), \tag{63}$$

and the comparative static result follows from the comparative statics of $P(\ell, y)$.

Next, we study the comparative statics with respect to π. It is important to find an analogue to equation (25). As in the main analysis, it can be shown that

$$\frac{\partial P_{ND}}{\partial \pi}(y(\pi), \pi) = -\underbrace{\frac{(1-p)^2 \cdot (\mu - E(y))}{(1-p+p\cdot(1-\pi)\cdot F(y))^2}}_{\equiv A} + \underbrace{P(\ell, y) - E(y)}_{\equiv B}. \tag{64}$$

The expression A is exactly the same as in (25). Furthermore, the expression B has the same properties as in (25). For example, $P(\ell, y)$ is non-decreasing in y. Using this result, it is easy to show that $y(\pi)$ has an inverted U-shape.

□

Proof of Proposition 7

After substituting $\pi = \psi_P + \psi_U$ and $\psi = \psi_P/(\psi_P + \psi_U)$ into the non-disclosure price (7), a comparative statics analysis of the equilibrium condition $y = P_{ND}(y)$ yields

$$\frac{dy}{d\psi_P} = \frac{\partial P_{ND}/\partial \psi_P}{1 - \partial P_{ND}/\partial y} \quad \text{and} \quad \frac{dy}{d\psi_U} = \frac{\partial P_{ND}/\partial \psi_U}{1 - \partial P_{ND}/\partial y}. \tag{65}$$

As shown in the proof of Lemma 1, the denominators are positive. The numerators are given by

$$\frac{dP_{ND}}{d\psi_P} = -\frac{(1-p)^2}{(1-p+p\cdot(1-\psi_P-\psi_U)\cdot F(y))^2} \cdot (\mu - E(y)) + y - E(y), \tag{66}$$

$$\frac{dP_{ND}}{d\psi_U} = -\frac{(1-p)^2}{(1-p+p\cdot(1-\psi_P-\psi_U)\cdot F(y))^2} \cdot (\mu - E(y)). \tag{67}$$

Since $dP_{ND}/d\psi_U$ is strictly negative, we find $dy/d\psi_U < 0$ which proves the first part of Proposition 7. Voluntary disclosure is increasing in the unconditional probability of uninformative leaks.

Note that the sign of $dy/d\psi_P$ is ambiguous which immediately follows from an analysis of the extreme cases $\psi_U \in \{0, 1-\psi_P\}$. For $\psi_U = 0$, we find

$$\left.\frac{dP_{ND}}{d\psi_P}\right|_{\psi_U=0} = \left(1 - \frac{1-p}{1-p+p\cdot(1-\psi_P)\cdot F(y)}\right)\cdot(y - E(y)) > 0. \tag{68}$$

For $\psi_U = 1-\psi_P$, it holds that

$$P_{ND}(y) = (1-\psi_U)\cdot y + \psi_U \cdot E(y). \tag{69}$$

Then, the equilibrium condition, $y = P_{ND}(y)$, requires $y = \underline{x}$. This in turn implies that

$$\left.\frac{dP_{ND}}{d\psi_P}\right|_{\psi_U=1-\psi_P} = (\mu - \underline{x}) < 0. \tag{70}$$

Finally, we consider the case $\psi_U \in (0, 1-\psi_P)$. Applying similar arguments as in the proof of Proposition 2, we find that there is a critical value $\psi_P^\dagger$ such that the disclosure threshold y is increasing in ψ_P for $\psi_P < \psi_P^\dagger$ and decreasing in ψ_P for $\psi_P > \psi_P^\dagger$. □

Proof of Proposition 8

Note that all leaks induce a market price $P^r = x$. While perfect leaks directly reveal the firm value, imperfect leaks prompt the manager to disclose his information (Lemma 3). Differences between the firm value x and the stock price P^r only occur if the manager is uninformed or if he withholds his information and no leak occurs. Both cases induce a price reaction $P^r = P(\varnothing)$. We obtain

$$PE = -(1-p)\cdot\int_{\underline{x}}^{\overline{x}}(x - P(\varnothing))^2\cdot f(x)dx - p\cdot(1-\pi)\cdot\int_{\underline{x}}^{y}(x-P(\varnothing))^2\cdot f(x)dx. \tag{71}$$

This expressions depends on the informativeness ψ via the no-information price $P(\varnothing)$ and the disclosure threshold y:

$$\frac{dPE}{d\psi} = \frac{\partial PE}{\partial P(\varnothing)}\cdot\frac{dP(\varnothing)}{d\psi} + \frac{\partial PE}{\partial y}\cdot\frac{dy}{d\psi}. \tag{72}$$

It is easy to see that $\partial PE/\partial P(\varnothing) = 0$. Using the Leibniz integral rule, we find that

$$\frac{dPE}{dy} = -p \cdot (1-\pi) \cdot (y - P(\varnothing))^2 \cdot f(y). \tag{73}$$

Substituting these expressions into (72) yields

$$\frac{dPE}{d\psi} = -p \cdot (1-\pi) \cdot (y - P(\varnothing))^2 \cdot f(y) \cdot \frac{dy}{d\psi}, \tag{74}$$

which is strictly negative given our result in Proposition 1. □