Informational Feedback Effect, Adverse Selection, and the Optimal Disclosure Policy *

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Abstract

Trading in a secondary stock market not only redistributes wealth among investors but also generates information that guides subsequent investment. We provide a positive theory of disclosure that reflects both functions of a secondary market. By making private information public, disclosure reduces incentives to acquire information and thus levels the playing field. However, a leveled playing field has two opposite effects on firm value. On one hand, it ameliorates adverse selection among investors and improves the liquidity of firm shares. On the other hand, it could also impede investment efficiency because less information is produced by the market and used by decision makers. This trade-off determines the optimal disclosure policy. Our theory generates new testable predictions and reconciles disclosure with other parts of securities regulation that encourage private information production.

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1 Introduction

Disclosure has been the foundation of securities regulation in the United State since its inception in 1930's. One major theoretical support for disclosure to a secondary market is that it levels the playing field (e.g., Diamond and Verrecchia (1991) and Easley and O'Hara (2004)). Since disclosure effectively makes otherwise private information public, it reduces the information advantage informed traders can gain from their information acquisition and thus reduces their incentive to acquire information. The reduced information gap among investors (i.e., a leveled playing field) improves the liquidity in the secondary market, which eventually results in a lower cost of capital and higher firm value in the primary market. At the heart of this theory is that private information production is the root cause of illiquidity and impedes the liquidity provision function of a secondary market.

While widely accepted, this theory of disclosure does not explain another prominent feature of securities regulation that encourages, rather than discourages, private information production. The triumph of the Efficient Market Hypothesis in 1970's has given rise to a new legal tenet that relies on two economic ideas.[1] First, traders' private information could be aggregated and transmitted to all market participants through the trading process, albeit partially.[2] Second, market participants, including managers of firms themselves, look into stock price for information to guide their decisions other than trading (e.g., project investment decisions) and the informational efficiency of prices feeds back to resource allocation. For example, a firm manager may possess superior firm-level information, but traders of the firm's stocks could, collectively, have superior information about the competition within the industry and other macro factors that are relevant for

[1] See the legal literature on the roles of securities regulation, e.g., Gilson and Kraakman (1984), Stout (1988) and Goshen and Parchomovsky (2005).

[2] The idea dates back at least to Hayek (1945). Its application to financial markets has received strong support in theoretical, empirical, and experimental work. Grossman and Stiglitz (1980), Verrecchia (1982), Glosten and Milgrom (1985), and Kyle (1985) provide models through which trading in financial markets transmit information acquired by traders into prices. Rajan and Zingales (2003) contains a survey of the empirical literatures on the informational role of stock market. Plott and Sunder (1982) and Plott and Sunder (1988) confirm the information aggregation function of prices in a laboratory.

the firm's investment decision.[3] As a result of this informational feedback effect, private information production is viewed as a proxy for the health of a secondary market and actively pursued.[4]

However, the leveling-the-playing-field theory for promoting disclosure and the informational feedback effect for promoting private information acquisition appear at odds with each other. The same private information production that exacerbates adverse selection and illiquidity in the secondary stock market is also the ultimate source of the information market participants look to guide their decisions. As an integral part of securities regulation, disclosure policy is expected to be coordinated with other parts of securities regulation.

We explain the joint promotion of disclosure and private information production in securities regulation with a model of disclosure that incorporates both the liquidity provision and the information production functions of the secondary market. In particular, we explicitly study the informational feedback effect in a disclosure model. We consider first the case where the firm is the decision maker who gleans information from stock price to improve its investment decision. In an extension, we also show that the main results do not depend on the assumption about who learns from the price. As along as the price is useful for the decision of some stakeholders of the firm, the same trade-off for disclosure as studied in the baseline model remains.

We start with a simple disclosure model that captures the role of preemptive disclosure in leveling the playing field. A firm with an asset-in-place sets a disclosure policy to maximize firm value when issuing shares in the primary market. Investors have rational expectations about their future uncertain liquidity needs that can only be satisfied by

[3] There is evidence that firms use information from their own stock prices in their investment decisions. For the large-scale investments, firms tend to reverse merger and acquisition decisions when confronted by negative market reactions (e.g., Luo (2005)) and those who do not are more likely to become the next targets (e.g., Mitchell and Lehn (1990)). For other less dramatic investments, Chen, Goldstein, and Jiang (2007) show that the amount of private information in a firm's stock price has a positive effect on the sensitivity of the firm's investment to its stock price.

[4] This doctrine has been employed in the public discourse of a wide array of prominent issues, such as insider trading, regulation FD, short sales, program trading, and the regulation of financial institutions.

trading in the secondary stock market. They also anticipate that they will be taken advantage of in the secondary market by a speculator who acquires costly information and trades anonymously. Anticipating this trading disadvantage investors demand a liquidity discount for the firm shares in the primary market. The firm could reduce this liquidity cost by committing more disclosure to the secondary market to preempt the speculator's information advantage. Thus, a leveled playing field increases firm value because the stock market provides better liquidity to the firm raising capital.

We then expand the model to incorporate the informational feedback role of the secondary market. First, the speculator acquires some information that could be new even to the firm. That is, the speculator's information set is not a subset of the firm's. The new information the speculator acquires is transmitted to stock price through trading. Second, in addition to the asset-in-place, the firm in our model has a growth opportunity whose future cash flow depends on an investment decision made by the firm after observing the stock price in the secondary market. Thus the firm could look into stock prices to guide its investment, making the stock price both *reflecting* and *affecting* firm value.

Our main result is that focusing narrowly on leveling the playing field could decrease firm value in the presence of the informational feedback effect. Preemptive disclosure reduces the information advantage of informed traders and results in less information production by traders. As a result, prices could become less informative *to the firm* (even though they may be more informative to outsiders due to the increased firm disclosure). When the firm looks into the prices for guidance on investment decisions, the more it has disclosed, the more it sees its own information and the less it learns from the prices. The reduced learning results in less informed investment decision and lower firm value. The optimal disclosure policy trades off the cost of disclosure from reducing investment efficiency and the benefit of disclosure from improving liquidity.

Built on the informational feedback, our paper reconciles two important features of securities regulation environment, namely, promoting both disclosure and private information acquisition at the same time. An environment that facilitates both disclosure and private information acquisition improves firm value only if the informational feedback effect is substantial. Further, disclosure is often advocated to both improve liquidity and enhance price discovery. We show that the forces underlying liquidity and price discovery are actually opposite. The former requires less private information production while the latter requires more private information production. Finally, our model generates new testable prediction on the relation between firm growth and equilibrium disclosure. In particular, the model predicts that growth firms are *endogenously* more opaque than value firms. Learning from the prices is more important for growth firms and as a result growth firms disclose less to attract more private information acquisition.

Our model belongs to the growing literature on the feedback from stock market to real decisions. This literature explicitly models the informational feedback effect to shed new light on traditional issues, such as market-based policy making (Sunder (1989), Bond, Goldstein, and Prescott (2010)), project selection (Dye and Sridhar (2002), Goldstein, Ozdenoren, and Yuan (2010)), insider trading (Fishman and Hagerty (1992), Khanna, Slezak, and Bradley (1994)), public v.s. private financing (Subrahmanyam and Titman (1999)), securities design and capital structure (Fulghieri and Lukin (2001)), and ownership structure (Holmstrom and Tirole (1993)).

By including the role of disclosure on the informational feedback effect, our paper broadens the literature of disclosure to the secondary market[5]. One theme in this literature has also focused on the interactions between public disclosure and private incentive to acquire information. However, the informational feedback to the investment decisions subsequent to the trading in our model is new to this literature and this new extension expands the explanatory power of the disclosure theory.

Our paper also relates to a large literature on the monitoring benefit of the secondary stock market (Diamond and Verrecchia (1982), Holmstrom and Tirole (1993), and Baiman and Verrecchia (1995)). In this literature, the stock price influences the manager's deci-

[5] See, for example, Diamond (1985), Diamond and Verrecchia (1991), Baiman and Verrecchia (1996), Easley and O'Hara (2004), and Garleanu and Pedersen (2004). See Verrecchia (2001) and Leuz and Wysocki (2007) for surveys.

sions because the firm links his compensation to the stock price to exploit the informativeness of the stock price. The monitoring role is absent from our model because we assume away the intra-firm agency conflict. The major difference between the monitoring role and the informational feedback role of the stock price is that each exploits a different type of information. The monitoring role relies on the backward-looking information about the past action of the manager, while the informational feedback role takes advantage of the forward-looking information. In fact, information about the future often impedes the monitoring role of the stock price (Paul (1992)).

Section 2 describes the model. Section 3 highlights the basic trade-off of disclosure on liquidity cost and investment efficiency. We then use the trade-off to analyze its implications for securities regulation and the endogenous opaqueness of growth firms. In Section 4 we discuss two extensions to the baseline model. First, we consider decision makers outside the firm who glean information from stock prices. Second, we compare the informational feedback effect with other mechanisms of information production such as prediction markets. Section 5 concludes. Detailed proofs are presented in the Appendix.

2 The Model

We start with a model in which disclosure mitigates adverse selection among traders. We then incorporate the informational feedback role of the secondary market into the model to study its effects on the optimal disclosure policy. Towards this goal, we explicitly model two features of the secondary market. First, some information that is otherwise unknown to the firm could be produced by the market and transmitted to the firm through stock price. Second, the firm uses the information in stock price to guide its decisions that influence the distribution of its cash flow.[6]

Consider a firm that consists of one asset-in-place (AIP) and one growth opportunity.

[6] The assumption that it is the firm who learns from stock price is not crucial. In Section 4.1 we show that the basic trade-off of the model is preserved in a more general setting where decisions are made by outsiders.

The terminal cash flow from the AIP is $\widetilde{A} = A_0 + \widetilde{\mu}$, where A_0 is the certain component of the cash flow and $\widetilde{\mu}$ is the uncertain component. $\widetilde{\mu}$ is normally distributed with mean zero and variance σ_μ^2, i.e., $\widetilde{\mu} \sim N(0, \sigma_\mu^2)$. The terminal cash flow from the growth opportunity is

$$\widetilde{G} = \widetilde{\mu} K - \frac{1}{2g} K^2,$$

where K is the firm's investment decision to be specified later. By construction $\widetilde{A}$ and $\widetilde{G}$ share the same source of uncertainty $\widetilde{\mu}$.[7] The difference is that the distribution of $\widetilde{G}$ is endogenous to the investment decision K while the distribution of $\widetilde{A}$ is fixed exogenously.

All parties are risk neutral and the risk-free rate of gross return is normalized to be 1. There are four dates and the time line is as follows.

Date 1	2	3	4
The firm chooses a disclosure level to maximize firm value.	Speculator acquires a signal; The firm makes disclosure; Liquidity shocks realized; Firm shares traded in secondary market.	The firm observes stock price and chooses investment.	Cash flow is realized.

Figure 1: Time Line

At date 1, the firm sets the disclosure policy to maximize firm value. The disclosure policy commits the firm to fully disclose its information at date 2 with probability $\beta \in (0, 1)$ before the secondary market opens. With probability $1 - \beta$, nothing is disclosed. β thus measures the quality of disclosure. After setting the disclosure policy, the firm issues equity shares to a continuum of ex ante identical investors. At date 1 investors expect that they

[7] This assumption is only for simplicity and could be relaxed. What is necessary is that the sources of uncertainty for $\widetilde{A}$ and $\widetilde{G}$ are correlated.

will have stochastic liquidity shocks at date 2 that can only be satisfied by trading in the secondary market. Denote the aggregate liquidity shock as $\widetilde{n}$, which is assumed to be normally distributed with mean zero and variance σ_n^2, i.e., $\widetilde{n} \sim N(0, \sigma_n^2)$.[8] The aggregate liquidity shock $\widetilde{n}$ prevents prices in the secondary market at date 2 from fully revealing; investors' anticipation of their disadvantaged trading in the secondary market arising from their liquidity shocks allows them to price-protect themselves at date 1. As a result, the firm has incentives to mitigate the adverse selection in the secondary market even though the firm does not raise financing directly from the secondary market. The total mass of investors is normalized to be 1 and the total number of shares is normalized to be 1 share per capita.

At date 2, the secondary market opens after disclosure by the firm and the information acquisition by the speculator. Three parties (the speculator, investors, and a market maker) participate in the secondary market through a Kyle setting.[9] The speculator expends resources to acquire information at the same time or before the firm disclosure is made, and then the secondary market for firm shares opens. Specifically, the signal the speculator acquires is an unbiased signal of $\widetilde{\mu}$, *i.e.*, $\widetilde{y} = \widetilde{\mu} + \widetilde{\varepsilon}_y$ where $\widetilde{\varepsilon}_y$ is normally distributed with mean zero and variance σ_y^2, i.e., $\widetilde{\varepsilon}_y \sim N(0, \sigma_y^2)$. Defining the quality of signal $\widetilde{y}$ as $\gamma \equiv \sqrt{\frac{\sigma_\mu^2}{\sigma_\mu^2 + \sigma_y^2}}$, the cost of information acquisition is $C(\gamma) = \frac{c}{2}\gamma^2$. The more resources the speculator spends, the more precise her signal is. We assume that $c > \frac{\sigma_n \sigma_\mu}{2}$ so that the equilibrium information acquisition is interior, i.e., $\gamma^* \in (0, 1)$.

[8] One interpretation could be that the liquidity shock requires each investor i, $i \in [0, 1]$, to place a market order of $\widetilde{n} + \widetilde{\varepsilon}_i$ where $\widetilde{n}$ represents the market-wide shock and is common to all investors and $\widetilde{\varepsilon}_i$ represents non-systematic, mean-zero *iid* shocks. The market-wide shock $\widetilde{n}$ is normally distributed with mean zero and variance σ_n^2. The idiosyncratic shocks across investors sum to zero ($\int_{i \in [0,1]} \widetilde{\varepsilon}_i di = 0$ with probability one). Thus, the total order from investors sums to $\widetilde{n}$.

[9] We link the investors' expected liquidity loss at date 2 to the firm's objective function at date 1 through the assumption that the market-maker and the speculator do not participate in the pricing in the date-1 primary market. Since the market maker and the speculator are risk neutral and do not suffer from liquidity shocks on date 2, their participation in the date-1 market would drive out other investors and eliminate the liquidity discount in share prices, thus muting the incentives to use disclosure to address date-2 adverse selection concern. More elaborate mechanisms to induce illiquidity pricing have also been studied in the literature. For example, Diamond and Verrecchia (1991) use risk aversion of make makers to induce liquidity discount at date-1 markets. See also Garleanu and Pedersen (2004) in which liquidity discount is restored by the interaction of liquidity and information.

The firm privately learns a signal $\widetilde{z}$ at no cost. $\widetilde{z}$ reveals $\widetilde{\mu}$ perfectly with probability $f \in (0,1)$ and is uninformative at all with probability $1-f$. Exogenous parameter f measures the quality of the firm's internally available information. Since the firm's choice of disclosure level β commits the firm to disclose its information perfectly with probability β, the actual disclosure at date 2, denoted as $\widetilde{x}$, is

$$\widetilde{x} \equiv \begin{cases} \tilde{\mu} & \text{with probability } \beta f \\ \varnothing & \text{with probability } 1-\beta f \end{cases}$$

where $\varnothing$ denotes the empty set. Note that βf measures the total amount of information disclosed by the firm. We refer both β and βf as firm disclosure level and use them interchangeably whenever no confusion could arise. To avoid discussing various corner solutions, we assume that the firm incurs a cost $\frac{w}{2} f \beta^2$ with $w > \frac{\left[4c - g\sigma_\mu^2(1-f)\right](1-f)\sigma_n^2\sigma_\mu^2}{8c^2} > 0$.[10] [11]

The speculator submits an information-based order $d(\tilde{x}, \tilde{y})$. Investors who experience liquidity shocks submit an aggregated liquidity-motivated order $\widetilde{n}$. In addition to the disclosure x, the market maker also observes the total order flow $\widetilde{n} + \widetilde{d}$ but cannot distinguish the two components. The market maker then sets a price P to clear the market and to break even.

We use a modeling device from Subrahmanyam and Titman (1999) to circumvent a technical issue in this type of models that combine the information aggregation function of price and the informational feedback effect.[12] As in their model, we assume that only

[10] Our results are qualitatively the same when we use different cost functions $\frac{w}{2}\beta^2$ or $\frac{w}{2}(f\beta)^2$. The cost function $\frac{w}{2} f \beta^2$ has the nice interpretation that the firm only incurs the disclosure cost when the firm receives the information.

[11] The first part ensures that the equilibrium choice of β is always smaller than 1 and the second part ensures that the equilibrium choice of β is always positive.

[12] The technical issue is as follows. If the claim against the cash flow from growth opportunity is traded, its price would both reflect and affect the expected value of the growth opportunity. As a result, it would be non-linear in $\widetilde{\mu}$, making it not tractable to infer information about $\widetilde{\mu}$ from the price. In contrast, the price of AIP does not affect the cash flow from AIP and thus is linear in $\widetilde{\mu}$. The linearity makes the inference about $\widetilde{\mu}$ from the price tractable. Goldstein, Ozdenoren, and Yuan (2010) has sought to tackle this complex technical issues directly. Because we focus on the interaction between disclosure and the informational feedback effect, this complexity itself is of no interest to us.

claims against the AIP cash flow are traded in the secondary market. Since the terminal cash flows of the AIP and the growth opportunity are subjected to the same sources of uncertainty ($\widetilde{\mu}$), the inference about $\widetilde{\mu}$ made from the price of AIP is used in the investment decision for the growth opportunity. This assumption allows for closed-form solutions and to characterize the information content of stock prices explicitly.[13] One interpretation is that the firm spins off its AIP division to go public and retains control over the growth opportunity privately. The information in the stock price of the spin-off AIP is useful for the decisions about the growth opportunity given the correlation between the common factors that drive the two businesses. As a result the price of AIP set by the market maker is

$$P = E_{\widetilde{\mu}}[\widetilde{A}|\widetilde{n} + d(\widetilde{x}, \widetilde{y}),\ \widetilde{x}].$$

From the perspective at date 1 when the disclosure policy is made, the speculator's information is correlated with but not a subset of the firm's. This is the key of our information structure. First, firm disclosure $\widetilde{x}$ is correlated with the speculator's information $\widetilde{y}$. As shown in the first row of Table 1, with probability $f\beta$, $\widetilde{x}$ completely preempts the speculator's information advantage $\widetilde{y}$ and the information flows one-way from the firm to the market. Second, the speculator does have some information that could be new to the firm. In the last row of Table 1, with probability $1 - f$, the firm does not learn anything internally about $\widetilde{\mu}$ but the speculator has a noisy signal about $\widetilde{\mu}$. The information flows from the market (speculator) to the firm through the stock price. Ex ante (at date 1), the information flow is two-way between the firm and the market (speculator).

[13]Another solution to the technical issue is to focus on a restrictive setting with binary signals and actions (e.g., Goldstein and Guembel (2008), Bond, Goldstein, and Prescott (2010)). We have also verified that the basic trade-off between the liquidity cost and investment efficiency is preserved in a version of the model in which both the private signal and investment decision are binary. As a result, the price or the expected firm value is discrete and the inference could be made in the presence of the informational feedback effect. The downside of the alternative specification is that most analyses become binary and discrete as well.

Probability	Firm information $\widetilde{z}$	Firm disclosure $\widetilde{x}$	Speculator information $\widetilde{y}$	Price $\widetilde{P}$
$f\beta$	$\widetilde{\mu}$	$\widetilde{\mu}$	$\widetilde{\mu}+\widetilde{\varepsilon}_y$	$P(\widetilde{\mu})$
$f(1-\beta)$	$\widetilde{\mu}$	$\varnothing$	$\widetilde{\mu}+\widetilde{\varepsilon}_y$	$P(\widetilde{y})$
$1-f$	$\varnothing$	$\varnothing$	$\widetilde{\mu}+\widetilde{\varepsilon}_y$	$P(\widetilde{y})$

Table 1 Information Structure

At date 3, the firm chooses an investment level K based on all information available to the firm, *i.e.*, $(\tilde{z}, \widetilde{P})$. By our information structure, $\widetilde{P}$ is not always redundant to the firm in choosing K. As a result, the distribution of the cash flow from the growth opportunity could be influenced by the incremental information in $\widetilde{P}$. This is the informational feedback effect.

At date 4, the cash flow is realized and consumption takes place.

In summary, at date 1 when the firm chooses disclosure policy β to maximize firm value, the firm value could be written as follows:

$$V(\beta) \equiv E_{\widetilde{\mu}}[A] - \Pi(\beta) + \Psi(\beta) - \frac{w}{2} f\beta^2 \tag{1}$$

$E[A]$ is the expected cash flow of the AIP that is independent of firm disclosure policy. For a given level of disclosure, $\Pi(\beta)$ is the expected liquidity loss for investors as well as the expected gross profit for the speculator, due to the zero-sum nature of the trading process. Since investors are price-protected in the primary stock market, the firm bears the full consequences of investors' expected date-2 liquidity loss Π. With the details provided in the Appendix, we have

$$\Pi(\beta) = E_{\widetilde{x},\widetilde{y}}\left[\max_{d(x,y)} \ dE_{\widetilde{\mu}}[\widetilde{A} - P|\widetilde{y} = \widetilde{\mu} + \widetilde{\varepsilon}_y, \widetilde{x}, \gamma^*(\beta)]\right].$$

The third component $\Psi(\beta)$ in firm value is the expected value of the growth opportunity, taking into account the fact that the optimal investment decision would adjust to new information learned at date 3 (including both internal information $\widetilde{z}$ and stock price $\widetilde{P}$):

$$\Psi(\beta) = E_{\tilde{z},\tilde{P}}\left[\max_{K(z,P)} \; E_{\widetilde{\mu}}\left[\widetilde{\mu}K - \frac{K^2}{2g}|\widetilde{z}, \widetilde{P}, \gamma^*(\beta)\right]\right].$$

Finally, $\frac{w}{2}f\beta^2$ is the direct cost of disclosure.

Accordingly, the optimal disclosure policy is determined by the following first order condition[14]:

$$\frac{d}{d\beta}V(\beta) = -\frac{d\Pi(\beta)}{d\beta} + \frac{d\Psi(\beta)}{d\beta} - wf\beta = 0 \quad (2)$$

3 Main Analysis

3.1 The Basic Trade-off

Disclosure levels the playing field by preempting the speculator's information advantage. The leveled playing field reduces the liquidity cost on one hand but reduces the investment efficiency on the other hand. This is the basic trade-off of the disclosure policy.

Lemma 1 *Disclosure levels the playing field: Higher disclosure level leads to lower information acquisition by the speculator in equilibrium, that is,* $\frac{d\gamma^*(\beta)}{d\beta} < 0$.

The adverse selection is measured by the information asymmetry between the speculator and the market-maker. It is determined directly by the speculator's information acquisition and indirectly by the firm's disclosure. As the firm increases disclosure level β, it is more likely that the information the speculator acquires overlaps with the firm's disclosure and thus is less useful for trading. As a result, higher disclosure level lowers the level of information acquisition by the speculator and results in a smaller informational gap among investors in the secondary market.

[14] As we solve in the Appendix, $\Pi(\beta)$ and $\Psi(\beta)$ are both quadratic in β. Thus, the second order condition for maximization is satisfied.

As we show in the Appendix, the speculator chooses information quality γ in anticipation of her trading strategies at date 2. The optimal information quality is solved as $\gamma^* = (1 - \beta f)\frac{\sigma_n \sigma_\mu}{2c}$ and the liquidity loss for the firm expected at date 1 is

$$\Pi(\beta) = (1 - \beta f)\frac{\sigma_n \sigma_\mu}{2}\gamma^*(\beta) = c\left(\gamma^*(\beta)\right)^2 .$$

The leveled playing field, however, creates a trade-off for firm value, as summarized in the following proposition.

Proposition 1 *In addition to the effect on the direct cost, disclosure, by leveling the playing field, has two countervailing effects on firm value.*

1. *Higher disclosure level reduces the liquidity cost the firm incurs, that is,* $\frac{d\Pi(\beta)}{d\beta} < 0$*;*
2. *Higher disclosure level reduces the value of the growth opportunity, that is,* $\frac{d\Psi(\beta)}{d\beta} < 0$.

Disclosure's first effect on the firm value is positive as more disclosure reduces the liquidity cost. This is an immediate consequence of a more leveled playing field because $\frac{d\Pi}{d\beta} = 2c\gamma^* \frac{d\gamma^*(\beta)}{d\beta} < 0$. This benefit of disclosure has been well established in the literature, as we have discussed in Introduction. The trading driven by private information redistributes wealth from investors (and eventually from the firm) to the speculator and in the process the resources spent on information acquisition are wasted from the social perspective. By generating a negative externality on the firm, private information acquisition by the speculator is the root cause of illiquidity and the motivation for the preemptive disclosure.

The second effect of disclosure on firm value, resulting from the informational feedback effect, is new to the disclosure literature. As a result of more disclosure, the lower information acquisition by the speculator makes the price less informative to the firm when it looks into stock prices to guide its investment. As a result, the efficiency of the investment decision at date 3 is hurt.

To see the second effect more precisely in the context of our model, consider the optimal date-3 investment level, $K^*(z,P) = \arg\max_{K(z,P)} E_{\widetilde{\mu}}\left[\widetilde{\mu}K - \frac{K^2}{2g}|z,P\right] = gE[\widetilde{\mu}|z,P]$. Optimal investment responds to the firm's own internal information (z) and information in the stock price (P). The strength of the response is determined by the parameter g. With probability f, the firm chooses date-3 investment based only on internally generated information ($\widetilde{z} = \widetilde{\mu}$). The stock price P is redundant. However, with probability $1-f$, the firm does not learn $\widetilde{\mu}$ internally and does benefit from the information in the stock price P. Our information structure enables us to reach a closed-form solution for Ψ :

$$\Psi(\beta) = E_{\widetilde{z},\widetilde{P}}\left[\frac{g}{2}\left(E[\widetilde{\mu}|z,P,\gamma^*(\beta)]\right)^2\right] = \frac{g\sigma_\mu^2}{2}\left(f + (1-f)\frac{(\gamma^*(\beta))^2}{2}\right). \tag{3}$$

It is clear from equation (3) that more information acquired by the speculator (i.e., higher $\gamma^*(\beta)$) improves the value of the growth opportunity. By Lemma 1 it is straightforward to show that firm disclosure reduces investment efficiency:

$$\frac{d\Psi(\gamma(\beta))}{d\beta} = \frac{g\sigma_\mu^2}{2}(1-f)\gamma^*(\beta)\frac{d\gamma^*(\beta)}{d\beta} < 0. \tag{4}$$

The informational feedback effect creates a positive externality of private information acquisition on the firm. The speculator is motivated entirely by private benefits when deciding on information acquisition. However, the speculator's private information, which is used once to generate trading profit on date-2, can be used a second time (with some noise) by the firm when making the investment decision on date-3 through the informational feedback effect. Thus, the informational feedback effect imparts a positive social value to the profit-driven speculative information acquisition. Since preemptive disclosure reduces private information acquisition, disclosure has an endogenous cost arising from the foregone investment efficiency.

The basic trade-off of the disclosure policy highlights the dual functions of the secondary market. Not only does the secondary market provide liquidity to traders, it also generates new information that could improve investment efficiency. Preemptive disclosure could not serve both functions at the same time. A disclosure policy that maximizes firm value does not narrowly promote a more leveled playing field. Put differently, the information feedback is not provided to the firm for free. Eventually the firm pays for the information production service by the speculator in the form of the increased liquidity cost of its shares resulting from reduced disclosure. The more valuable the information provided by the speculator, the more the firm's disclosure policy is pulled back from fully addressing the liquidity concern.

We now examine the implications of the basic trade-off identified in Proposition 1. First, we use the model to reconcile policies that encourage firm disclosure and facilitate private information acquisition at the same time. Second, we analyze the determinants of the optimal disclosure policy to generate testable empirical implications.

3.2 Promoting Firm Disclosure and/or Private Information Acquisition

We reconcile the joint promotion of disclosure and private information acquisition in securities regulation, which is paradoxical when we focus only on the liquidity provision role of the secondary market. We do not model the rationales for securities regulation or the elaborate mechanisms through which securities regulation affect the stock market.Instead, we simply interpret parameters w (the firm's direct disclosure cost) and c (the speculator's information acquisition cost) as representing two related aspects of securities regulation. That is, in our partial equilibrium model, we assume securities regulation affects firm value through its influence on parameters w and c. A lower w indicates a policy of promoting firm disclosure because it induces the firm to disclose more (all else being equal). Similarly, a lower c indicates a policy of promoting private information acquisition.

Proposition 2 *By defining V^* as the firm value in equilibrium,*

$$\begin{aligned} \frac{d}{dw}V^* &< 0 \quad \text{for all } g \\ \frac{d}{dc}V^* &> 0 \quad \text{if } g < g^* \\ \frac{d}{dc}V^* &< 0 \quad \text{if } g > g^* \end{aligned}$$

When the informational feedback effect is strong ($g > g^*$), the firm value is improved by a lower w and a lower c at the same time. That is, a firm-value-maximizing environment promotes disclosure (lower w) and facilitates speculative information acquisition (lower c) at the same time. In contrast, when the informational feedback effect is weak ($g < g^*$), the firm value increases in w but decreases in c. In other words, a firm-value-maximizing environment promotes disclosure but discourages speculative information acquisition.

A lower w induces the firm to increase disclosure. The increased disclosure reduces information acquisition by the speculator, which leads to a lower liquidity cost and less learning by the firm. These two effects cancel out each other by the Envelop theorem. Further, a lower w also reduces the firm's direct cost of disclosure. Therefore, a lower w always increases firm value.

A lower c induces the speculator to increase information acquisition, which leads to a higher liquidity cost. Even though the firm could respond with more disclosure, the speculator in equilibrium acquires more information because disclosure is costly. More private information in the stock price increases firm value through investment efficiency and decrease firm value through liquidity cost. Whether the firm value increases as a result of a lower c thus depends on the strength of each effect. When the investment opportunity is important and the benefit for the firm to learn from the stock price is high, the investment efficiency dominates the liquidity cost and the firm is better off. Therefore, the importance of the informational feedback effect determines whether promoting disclosure and encouraging information acquisition should be pursued at the same time. Proposition 2 reconciles the dual efforts to promote information acquisition (lower c) and disclosure (lower w) at the same time by firms and regulators alike.

3.3 Growth and Disclosure Level

The basic trade-off in Proposition 1 points to growth factors that strengthen the informational feedback effect, which in turn create incentives for firms to reduce disclosure level in order to preserve the speculator's incentive to acquire information. In our model, growth is represented by

$$\Psi(\beta) = \frac{g\sigma_\mu^2}{2}\left(f + (1-f)\frac{(\gamma^*(\beta))^2}{2}\right).$$

Each of the relevant exogenous parameters, g, f, and σ_μ^2, captures one facet of a growth firm. Their effects on disclosure policy are summarized by the following proposition.

Proposition 3 *Ceteris paribus,*

1. *firms with higher growth prospect (higher g) disclose less;*
2. *firms that are more likely to learn information from the stock price (lower f) disclose less; and*
3. *firms with higher uncertainty (higher σ_μ^2) disclose less if and only if g is sufficiently large.*

Proposition 3 adds new predictions about the relation between growth and disclosure policy. As growth prospect g increases, information about the profitability of the growth opportunity becomes more valuable to a firm. Thus, the firm reduces disclosure level to make the information acquisition by the speculator more profitable, which in turn incentivizes her to acquire more information.

Not only is prospective information more important for growth firms, but also growth firms are more likely to have less information generated internally. Thus, growth firms have a low f. A low f makes the speculator's information more valuable to the firm, giving the firm an incentive to lower disclosure level to encourage the speculator's information acquisition. At the same time, a lower f increases liquidity costs by aggravating the adverse selection problem, which provides firms with incentives to increase disclosure level. As a result, disclosure level measured by β can be increasing or decreasing in parameter f. However, measured by total disclosure level $f\beta$, disclosure level is everywhere increasing in f, consistent with the idea that growth firms are more opaque overall.

Growth firms face more uncertainty relevant to its future decisions, parameterized by the variance of the uncertainty $\tilde{\mu}$ in our model. This parameter affects the value of the information to both the firm and the speculator. On one hand, as σ_μ^2 increases, the marginal benefit of learning by the firm becomes larger. The firm reduces disclosure to encourage more information acquisition by the speculator. On the other hand, as σ_μ^2 increases, the speculator's information acquisition becomes more profitable because her information gives her a bigger informational advantage. This leads to a higher liquidity cost for the firm and induces the firm to improve disclosure level. Since the first effect increases in g while the second is independent of g, the first effect dominates the second as g is large. Hence, the firm's disclosure level increases in σ_μ^2 if and only if g is small. In sum, growth firms may choose to be more opaque in the hope of learning more information from their own stock prices.

4 Extensions

4.1 Who Learns?

We have assumed that the firm is the decision maker who benefits from the information in its own stock price. However, the basic idea that preemptive disclosure could reduce firm value through its suppression of information production incentive is more general. As long as the information in the stock prices influences decisions, made by the firm or outsiders, that affect firm value, the firm's disclosure policy will consider its effect of on the incentive for information production in the market.

To illustrate, suppose an outsider takes an action K at date 3 to maximize his own payoff $\widetilde{G} = \widetilde{\mu}K - \frac{1}{2g}K^2$ and the firm benefits from the outsider's decision by an amount $H(\widetilde{G}) = h\widetilde{G}$ where $h > 0$. As in the baseline model, the action K is improved with better knowledge about $\widetilde{\mu}$ at date 3.

Proposition 4 *When outsiders look to stock price to guide their decisions and improvement in these decisions indirectly benefits the firm* ($h > 0$)*, disclosure still has two countervailing effects on firm value, if either the firm's internal information is sufficiently limited* (f *is sufficiently small*) *or the speculative information acquisition is sufficiently efficient* (c *is sufficiently small*)*.*

Disclosure affects firm value through an additional channel when the decision maker is an outsider instead of the firm itself. Since outsiders do not have access to the undisclosed information, disclosure affects the outside decision maker through both his learning from the stock price and his receipt of disclosed information. The efficiency of the decision becomes $\frac{g\sigma_\mu^2}{2}\left(f\beta + (1 - f\beta)\frac{(\gamma^*(\beta))^2}{2}\right)$ instead of $\frac{g\sigma_\mu^2}{2}\left(f + (1 - f\beta)\frac{(\gamma^*(\beta))^2}{2}\right)$. One reason we chose to let the firm be the decision maker in the baseline model is to avoid this confounding effect of disclosure on investment efficiency.

The net effect of disclosure on the total information available to the outside decision maker thus depends on the relative importance of the direct and indirect channel. When the firm's internal information is scarce (low f) or the market information production is more efficient (low c), as disclosure increases, the information directly provided by increased disclosure is dominated by the reduced learning from stock price resulting from the reduced information acquisition by the speculator. As a result, the disclosure policy still trades off its benefit of saving liquidity cost against the cost of reduced learning from the stock price. On the other hand, if f is sufficiently large, then the direct channel dominates the indirect and more disclosure provides more information to outside decision makers. Therefore, full disclosure is optimal (except being constrained by the direct disclosure cost).

Decisions made by outsiders and guided by information in a firm's stock price could also reduce firm value, which amounts to $h < 0$. One example is that competitors and labor unions use information gleaned from the firm's disclosure and the stock price to the firm's disadvantage (e.g., the proprietary cost in Verrecchia (1983)). To illustrate we label $H(\widetilde{G})$ as proprietary cost for the firm by assuming that $h < 0$.

Corollary 1 *Disclosure reduces, rather than increases, proprietary cost, if the firm's internally generated information is sufficiently limited (f is sufficiently small) or the speculative information acquisition is sufficiently efficient (c is sufficiently small).*

The intuition is similar to that in Proposition 4. Nonetheless, this extension adds a novel perspective to the literature on the proprietary cost of disclosure. That is, more disclosure could lower proprietary cost, a similar result to Arya and Mittendorf (2005) but with a different mechanism. Even though disclosure provides information to the competitors, it also reduces the speculator's incentive to acquire information the competitors could learn from the stock price. The net effect of disclosure on the competitors learning should take into account of both channels.

4.2 Who is the Most Efficient Information Provider?

We have demonstrated that information production by the secondary market is not free for the firm in that the firm eventually pays for the information it learns from the stock price in the form of a higher liquidity cost. We assess the comparative efficiency of this market mechanism of information production. To start we establish a benchmark in which the firm has the same information production technology as the speculator.

Proposition 5 *If the firm could use the same technology the speculator has to acquire information, the firm chooses $\hat{\gamma}$. Compared with this benchmark case the information production in our baseline model is too low when the growth prospect is high and too high when the growth prospect is low.*

Proposition 5 reveals the suboptimal nature of the information production through the secondary stock market. The efficiency loss originates from the misalignment of the speculator's private incentive with the firm's. The speculator's profit-driven information acquisition has the negative externality on the firm value through the liquidity cost and the positive externality through the investment decision, but the speculator does not internalize either of them. Since in our model the investment value of information increases with growth prospect but the trading profit (or liquidity cost) do not, the speculator's incentive produces too little information when the net externality is positive and too much when the net externality is negative.

Despite its inefficiency, the advantage of information production through financial markets is highlighted in the comparison with its alternatives. One alternative is that the firm could hire outside consultants or set up internal organizations to produce information. These mechanisms suffer from the well-known and well-studied agency problems in a contractual relationship. Thus, the market mechanism has competitive advantage for information that is subject to severe agency issues, such as information that is difficult to be quantified, not incentive-compatible for direct revelation by the information owner/producer, and information whose most efficient provider could be not easily identified.

Another alternative is to use prediction markets to produce forward-looking information, a tool that has become increasingly popular (see Wolfers and Zitzewitz (2004) for a survey of prediction markets). Part of the demonstrated success of a prediction market is attributed to its ability to overcome the "comprehensiveness" problem (e.g., Bresnahan, Milgrom, and Paul (1992)) of the stock price, a problem abstracted away in our model.[15]

[15] Take as an example that the firm announces a merger proposal. The market participants' information about the size of synergy of the deal will be reflected in the stock price reaction. The comprehensiveness problem arises from two sources. First, the stock price reaction is also affected by other contemporary factors that are orthogonal to the merge proposal. This issue is absent because in our model the only source of uncertainty is relevant for both pricing and for the investment decision. Second, the stock price also anticipates the probability that the deal could go through, which is partly determined the market reaction. Thus, a mild reaction could indicate either that the synergy is believed to be moderate or that the market believe that the synergy is so negative that the deal will be abandoned or stopped. This is the technical difficulty discussion on page 8. A security in prediction markets could be defined narrowly over

However, the number one practical problem for prediction market is that they suffer lack of market depth and thus incentive for information acquisition (e.g., Wolfers and Zitzewitz (2006)). As illustrated in our model, for markets to produce information, it is indispensable to provide participants with incentive to acquire information. In financial market such incentive is provided mainly by trading profits that are affected by market depth and disclosure policy.

Two lessons from the predictions markets corroborate the importance of our result. First, the popularity and success of prediction markets attest to the importance of the informational feedback effect. Second, the incentive issue with prediction markets shows that the information production by market relies crucially on private incentives. Thus, leveled playing field could hurt firm value if the informational feedback effect is important for the firm.

5 Conclusion

Disclosure to a secondary market is an integral part of the broad market infrastructure and thus a positive theory of disclosure should capture the economic functions of the secondary market. Since the secondary market performs the dual roles of liquidity provision and information production, a value-maximizing disclosure policy balances the effects of disclosure on both functions. While it is often advocated that disclosure improves both liquidity and pricing accuracy, our model shows that this statement is not entirely true. To improve liquidity, it is imperative to reduce the information asymmetry among investors. As a result, either encouraging disclosure by the firm or discouraging private information acquisition by some investors is the desired policies to improve liquidity. However, for price to be accurate, it is important that traders actively acquire relevant information, some of which could be new to the firm. The firm learns less from price the more it discloses. Further, when firm discloses more, outsiders could receive less total information

the merge event to mitigate this comprehensiveness issue.

when combined with those learned from price. Therefore, there is a trade-off between the policy goal of improving liquidity and informational efficiency.

The interaction between the two secondary-market functions generates new insight on disclosure theory. The presence of informational feedback effect creates an endogenous cost for disclosure. In other words, the benefit of the informational feedback effect is not provided to the firm for free. The firm eventually pays for the information production service of the speculator through the otherwise suboptimal change in its disclosure policy.

By incorporating the informational feedback effect, the extended theory of disclosure reconciles the joint promotion of disclosure and private information production in securities regulation. The advantage of modeling the informational feedback effect explicitly is that it highlights the importance of details in the way informational efficiency is transformed to allocational efficiency. Therefore, such an effect has implications for other securities regulation policies. Take insider trading as an example. One argument for insider trading is that it improves economic efficiency by impounding more information to stock price (Manne (1966)). However, our model implies that whether the increased informational efficiency leads to allocational efficiency depends on the specifics of the informational feedback effect. If the firm's internal (undisclosed) information is the basis of the trading, the firm is better served with a policy of more disclosure and restricting insider trading. However, if the insider trades on information that cannot be solicited otherwise, such trading might be justified on the ground of economic efficiency because the firm's investment could be improved.

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6 Appendix

6.1 Proof of Lemma 1 and Proposition 1

For notation, we use subscripts to denote partial derivatives, *i.e.*, $X_Y \equiv \frac{\partial X}{\partial Y}$ and $X_{YY} \equiv \frac{\partial^2 X}{\partial Y^2}$, and write the total derivative as $\frac{dX}{dY}$. The firm value at date 1 is expressed in eqn. 1. We solve for each component in turn.

$\Pi(\beta)$ is the expected liquidity cost for the firm at date 1 as a function of the firm's disclosure policy β evaluated at the speculator's optimal information acquisition policy $\gamma^*(\beta)$. It is equal to the expected gross profit of the speculator and solved backwards. At date 2 after the firm's disclosure x and the speculator's acquisition of y, the speculator submit an order $d(x, y)$ to maximize its expected gross profit. It is a standard Kyle model with one speculator, one market-maker, and liquidity traders. The trading equilibria could be obtained by using standard solution techniques for Kyle-model (details available upon request). If $x = \varnothing$, which occurs with probability $1 - f\beta$, the speculator expects a gross profit of $\frac{\sigma_n \sigma_\mu}{2}\gamma$ and the price is $P(x = \varnothing, y) = A_0 + \frac{\gamma^2}{2}y + \frac{\gamma}{2}\frac{\sigma_\mu}{\sigma_n}n$. Otherwise if the disclosure reveals μ perfectly, the speculator does not trade and expects zero gross profit.

Before the revelation of x and y when the speculator decides on the information acquisition policy $\gamma(\beta)$, the expected gross profit as a function of β and γ is $\pi(\beta; \gamma) = (1 - f\beta)\frac{\sigma_n \sigma_\mu}{2}\gamma$. The speculator's information acquisition decision is to choose γ to maximize the *net* profit $\pi(\beta; \gamma) - \frac{c}{2}\gamma^2$. Thus, $\gamma^*(\beta) \equiv \arg\max_{\gamma \in [0,1]} \pi(\beta; \gamma) - \frac{c}{2}\gamma^2 = (1 - \beta f)\frac{\sigma_n \sigma_\mu}{2c}$. Note that $\gamma^*(\beta)$ is non-negative. The assumption on c on page 7 ensures that $\gamma^*(\beta) < 1$ because $\gamma^*(\beta)|_{\beta=0} < 1$ (and because $\gamma^*(\beta)$ is decreasing in β as shown in Lemma 1).

The speculator's expected gross profit at date 1 as a function of firm disclosure β is $\Pi(\beta)$:

$$\Pi(\beta) \equiv \pi(\beta; \gamma^*(\beta)) = c\gamma^{*2}(\beta).$$

Lemma 1 is proved because $\gamma^*_\beta \equiv \frac{\partial \gamma^*(\beta)}{\partial \beta} = -f\frac{\sigma_n \sigma_\mu}{2c} < 0$. The first part of Proposition 1 is proved because $\frac{d\Pi(\beta)}{d\beta} = \Pi_\beta = 2c\gamma^*\gamma^*_\beta < 0$.

We now turn to $\Psi(\beta)$, the expected value of the growth opportunity at date 1 as a function of β. It is also solved backwards. At date 3, based on its information set $\{z, P\}$, the firm chooses K to maximize $\psi(\beta; K) \equiv E[\tilde{G}(K)|z, P] = KE[\tilde{\mu}|z, P] - \frac{1}{2g}K^2$. Therefore $K^*(z, P) \equiv \arg\max_K \psi(\beta; K) = gE[\tilde{\mu}|z, P]$ and $\psi(\beta; K^*(z, P)) = \frac{g}{2}\left(E[\tilde{\mu}|z, P]\right)^2$. Our information structure allows us to solve $\psi(\beta; K^*(z, P))$ in closed-form. When the firm receives the information internally, *i.e.*, $z = \mu$, which occurs with probability f, the firm ignores P in making the investment decision. Thus, $\psi(\beta; K^*(\mu, P)) = \frac{g}{2}\left(E[\tilde{\mu}|z = \mu, P]\right)^2 = \frac{g}{2}\mu^2$. When the firm does not receive any information internally, *i.e.*, $z = \varnothing$, its disclosure x is uninformative as well. Thus, $\psi(\beta; K^*(\varnothing, P(x = \varnothing, y))) = \frac{g}{2}E_{\tilde{P}}[(E[\tilde{\mu}|P(x = \varnothing, y)])^2]$. Together, the expected value of the growth opportunity at date 1 is $\Psi(\beta)$:

$$\begin{aligned}
\Psi(\beta) &\equiv E_{\{\tilde{z},\tilde{P}\}}[\psi(\beta; K^*(z, P))] \\
&= f\frac{g}{2}E_{\tilde{\mu}}[(E[\tilde{\mu}|\mu])^2] + (1 - f)\frac{g}{2}E_{\tilde{P}}[(E[\tilde{\mu}|P(x = \varnothing, y)])^2]) \\
&= \frac{g\sigma_\mu^2}{2}\left(f + (1 - f)\frac{{\gamma^*}^2}{2}\right)
\end{aligned}$$

The second part of Proposition 1 is proved because $\frac{d\Psi(\beta)}{d\beta} = \Psi_\beta = \frac{g\sigma_\mu^2}{2}(1 - f)\gamma^*\gamma^*_\beta < 0$.

6.2 Proof of Proposition 2

We now analyze the firm disclosure choice (β) at date 1. The firm's decision problem at date 1 is

$$\max_{\beta \in (0,1)} V(\beta) = A_0 - \Pi(\beta) + \Psi(\beta) - \frac{w}{2}\beta^2 f$$

The first-order condition determines the optimal disclosure policy β^* :

$$\begin{aligned} 0 &= V_\beta^* \equiv \frac{\partial V(\beta)}{\partial \beta}|_{\beta=\beta^*} \\ &= \Psi_\beta^* - \Pi_\beta^* - \beta^* w f \\ &= -\frac{\left(g\sigma_\mu^2(1-f) - 4c\right)}{2} f(1-\beta^* f)\frac{\sigma_n^2\sigma_\mu^2}{4c^2} - fw\beta^* \end{aligned} \tag{5}$$

Similar to the definition of V_β^*, Ψ_β^* and Π_β^* are defined as Ψ_β and Π_β being evaluated at $\beta = \beta^*$.

The second-order condition is

$$V_{\beta\beta}^* \equiv \Psi_{\beta\beta}^* - \Pi_{\beta\beta}^* - wf \tag{6}$$

$$= \frac{\left(g\sigma_\mu^2(1-f) - 4c\right)}{2} f^2 \frac{\sigma_n^2\sigma_\mu^2}{4c^2} - fw. \tag{7}$$

The first part of the assumption on w on page 8 ensures that $V_{\beta\beta}^* < 0$.

Further, the same assumption also ensures that $\beta^* \in (0,1)$ because

$$V_\beta|_{\beta=0} = \frac{\left(g\sigma_\mu^2(1-f) - 4c\right)}{2}\left(\frac{\sigma_n\sigma_\mu}{2c}\right)\left(-\frac{f\sigma_n\sigma_\mu}{2c}\right) > 0 \tag{8}$$

and

$$V_\beta|_{\beta=1} = \frac{\left(g\sigma_\mu^2(1-f) - 4c\right)}{2}\left((1-f)\frac{\sigma_n\sigma_\mu}{2c}\right)\left(-\frac{f\sigma_n\sigma_\mu}{2c}\right) - fw < 0.$$

Define $V^* \equiv V(\beta^*)$. Now we compute comparative statics of V^* with respect to c. By the envelope theorem,

$$\frac{dV^*}{dc} = V_c^* = \frac{\gamma^{*2}(\beta^*)}{2c}\left(2c - g\sigma_\mu^2(1-f)\right)$$

Define $\hat{g}$ as

$$\hat{g} \equiv \frac{2c}{\sigma_\mu^2(1-f)}. \tag{9}$$

We conclude that:

$$\begin{aligned} \frac{d}{dc}V^* &\geq 0 \quad \text{if } g \leq \hat{g} \\ \frac{d}{dc}V^* &< 0 \quad \text{if } g > \hat{g} \end{aligned}$$

Also by the envelope theorem,

$$\frac{dV^*}{dw} = V_w^* = -\beta^* w f < 0.$$

6.3 Proof of Propositions 3

We now study the determinants of the optimal disclosure policy β^* by the implicit function theorem: differentiating the first-order condition (eqn. 5) with respect to relevant parameters.

The impact of growth prospect g on the optimal disclosure policy β^*, β_g^*, is determined by

$$\Psi_{\beta g}^* + V_{\beta\beta}^* \beta_g^* = 0.$$

Thus, $\beta_g^* < 0$ because $\Psi_{\beta g}^* = \frac{\sigma_\mu^2}{2}(1-f)\gamma^*\gamma_\beta^* < 0$ and because $V_{\beta\beta}^* < 0$ by the second-order condition.

$$\begin{aligned} \beta_{\sigma_\mu^2}^* &= -\frac{\Psi_{\beta\sigma_\mu^2}^* - \Pi_{\beta\sigma_\mu^2}^*}{V_{\beta\beta}^*} \\ &= -\frac{1}{V_{\beta\beta}^*}\frac{\sigma_n^2(1-\beta^* f)f}{4c^2}(2c - g(1-f)\sigma_\mu^2). \end{aligned}$$

$\beta_{\sigma_\mu^2}^* > 0$ if $g < \hat{g}$ and $\beta_{\sigma_\mu^2}^* < 0$ if $g > \hat{g}$. $\hat{g}$ is defined in eqn. 9.

For the impact of the firm's own information endowment f on its disclosure quality, we consider the total amount of disclosure by the firm $f\beta^*$, instead of β^* alone.

$$\begin{aligned} (f\beta^*)_f &= \beta^* + f\beta_f^* = \frac{\beta^*(\Psi_{\beta\beta}^* - \Pi_{\beta\beta}^* - wf) - f(\Psi_{\beta f}^* - \Pi_{\beta f}^* - w\beta^*)}{V_{\beta\beta}^*} \\ &= \frac{\beta^*(\Psi_{\beta\beta}^* - \Pi_{\beta\beta}^*) - f(\Psi_{\beta f}^* - \Pi_{\beta f}^*)}{V_{\beta\beta}^*} \\ &= -\frac{1}{V_{\beta\beta}^*}\frac{\sigma_n^2\sigma_\mu^2(1-\beta^* f)f}{8c^2}(4c - (1-f)g\sigma_\mu^2 + fg\sigma_\mu^2) \\ &> 0 \end{aligned}$$

6.4 Proof of Propositions 4

If the firm could use the same technology the speculator has to acquire information the firm solves

$$\max_{\gamma} \frac{g\sigma_\mu^2}{2}\left(f+(1-f)\gamma^2\right)-\frac{c}{2}\gamma^2.$$

Within the parameter regime defined by Assumption 1 and 2, its solution is binary:

$$\widehat{\gamma}=\begin{cases} 1 & \text{if } \frac{c}{\sigma_\mu^2(1-f)}<g<\frac{4c}{\sigma_\mu^2(1-f)} \\ 0 & \text{if } 0<g<\frac{c}{\sigma_\mu^2(1-f)} \end{cases}.$$

Recall in the baseline model, $\gamma^* \in (0,1)$. Thus, compared with the benchmark $\hat{\gamma}$, the information production in our baseline model γ^* is too low when the growth prospect is high and too high when the growth prospect g is low.

6.5 Proof of Propositions 5

When the decision maker of investment K is not the firm, the only difference in the computation of Ψ is that with probability $f\beta$, not f, the decision maker has perfect information and with probability $1-f\beta$, not $1-f$, the decision benefits from the information in price. So the ex ante value to the outside decision maker, denoted Ψ', is

$$\Psi'=E_{\widetilde{z},\widetilde{P}}\left[\frac{g}{2}\left(E[\mu|z,P]\right)^2\right]=\frac{g\sigma_\mu^2}{2}\left(f\beta+(1-f\beta)\frac{(\gamma^*(\beta))^2}{2}\right).$$

The ex ante benefit to the firm is

$$E[\widetilde{H}]=E\left[h\widetilde{G}\right]=h\Psi'.$$

Thus,

$$\begin{aligned}\frac{dE[\widetilde{H}]}{d\beta} &= \frac{hg\sigma_\mu^2}{2}\left[f-f\frac{(\gamma^*(\beta))^2}{2}+(1-f\beta)\gamma^*\gamma^*_\beta\right] \\ &= \frac{hg\sigma_\mu^2}{2}\left(f-\frac{3}{2}\left(\gamma^*\right)^2 f\right) \\ &= \frac{fhg\sigma_\mu^2}{2}\left(1-\frac{3}{2}(1-\beta f)^2(\frac{\sigma_n\sigma_\mu}{2c})^2\right)\end{aligned}$$

So we have

$$\frac{dE[\widetilde{H}]}{d\beta} < 0 \quad \text{if and only if } (\gamma^*)^2 = \left((1-\beta f)\frac{\sigma_n \sigma_\mu}{2c}\right)^2 > \frac{2}{3}$$

Since liquidity loss Π is unrelated to the investment decision K, $\frac{d\Pi}{d\beta} < 0$ still holds. Thus the firm continues to face the trade-off between the liquidity cost and the investment efficiency when setting the disclosure policy.