ABSTRACT

Faceless trading in a secondary stock market not only redistributes wealth among investors but also generates information that feeds back to real decisions. Using this observation we re-evaluate the “leveling-the-playing-field” rationale for disclosure to secondary stock markets. By partially preempting traders’ information advantage established from information acquisition, disclosure reduces private incentives to acquire information, resulting in two opposite effects on firm value. On one hand, this narrows the information gap between informed and uninformed traders and improves liquidity of firm shares. On the other hand, this reduces the informational feedback from the stock market to real decisions. This tradeoff determines the optimal disclosure policy. The model explains why firm value can be higher in an
environment that simultaneously promotes disclosure and private information production and why growth firms are endogenously more opaque than value firms.

1. Introduction

Disclosure has been an important component of corporate policy and the foundation of securities regulations in the United States since their inception in the 1930s. One major theoretical support for disclosure to a secondary market is that it levels the playing field. By making firms’ otherwise private information public, disclosure discourages traders from private information acquisition. The reduction in private information acquisition attracts liquidity to the secondary market and eventually results in a higher firm value in the primary market. At the heart of this theory is the idea that the private information guiding traders’ trading decisions is the root cause of adverse selection and illiquidity in the secondary market.

However, the same private information also guides real decisions and resource allocation when transmitted to relevant decision makers. That is, the secondary stock market has informational feedback effects. Through trading, the information traders acquire privately is impounded into the stock price, based on which real decisions are made by various stakeholders, including capital providers, major customers and suppliers, employees, and firm managers. In other words, the private information produced by traders for their own trading also makes the stock price more informative, which in turn feeds back to real decisions.

In this paper, we study a model of disclosure with the informational feedback effect. In the model, a firm sets a disclosure policy at the time it issues shares in the primary market. The shares are then traded between investors who have liquidity needs and a speculator who could acquire private information on her own. The firm’s disclosure partially preempts the speculator’s information advantage and makes the private information acquisition less profitable. As a result, the speculator acquires less information, which has two opposite effects on the firm value. On one hand, the reduction in private information acquisition results in a smaller informational gap between liquidity investors and the speculator. With a more level playing field, liquidity investors lose less to the informed speculator and are willing to pay more for shares in the primary market. Thus, disclosure raises firm value by enhancing liquidity. On the other hand, when the speculator acquires less information, the stock price may become less informative. When the firm looks to the stock price for guidance, the more it has disclosed, the less news it gleans from the stock price. As a result, the investment decisions that rely on the information in the stock price become less efficient. Thus, disclosure lowers the firm value by weakening the informational feedback from the stock price. Hence, the optimal disclosure policy trades off these two effects on firm value.
This tradeoff can also be viewed from an incentive provision perspective. When the speculator has a competitive advantage in generating certain information valuable to the firm, incentives must be provided to the speculator to generate such information. Tolerating more adverse selection in the secondary market enables the speculator to profit more from private information acquisition and thus provides her with stronger incentives to produce private information.

The explicit consideration of the informational feedback effect enriches the disclosure literature. Our comparative statics results suggest that the firm value is higher in an environment with a lower cost of private information acquisition if the informational feedback effect is sufficiently strong. This is consistent with the institutional feature of the securities regulations in the United States that simultaneously encourage private information production and promote disclosure. In contrast, if securities regulations focused mainly on leveling the playing field, encouraging private information production and promoting disclosure would be two contradictory policies.

Our model also generates new testable predictions on the relation between firm growth and equilibrium disclosure. In particular, the model predicts that growth firms can be endogenously more opaque than value firms. To the extent that learning from the stock price is more important for growth firms, ceteris paribus, growth firms disclose less to attract more private information production.

The critical assumption of our model is that the stock market could produce information new to firms and that the incremental information production by the market could be significant enough to influence firms’ disclosure policies. To some readers, this assumption is an immediate implication of the efficient market hypothesis that the stock price is the most informative source of information. Nonetheless, we provide further motivation for this assumption.

Theoretically, the stock market has a competitive advantage in producing some types of information, an idea that dates back to Hayek [1945]. First, while a manager has a great deal of information about his firm, his decisions also benefit from information about other firms and industries. Such information is dispersed among outsiders and can be aggregated through the trading process. Second, the corporate bureaucracy could be inefficient in collecting some information that exists within the firm’s scope, such as information that is difficult to standardize, hard to interpret, or incentive incompatible with the information possessors (e.g., Rajan and Zingales [2003]). The profit-driven trading in an anonymous stock market could have a competitive advantage in eliciting such information. Finally, given the dispersed nature of information, the stock market provides a venue for whoever is good at information production to supply her talents to the firm. Traders’ profit-seeking trading motive saves the firm extra search or incentive costs typically associated with other information sourcing mechanisms.

Empirically, Rajan and Zingales [2003] survey the evidence of the effect of the information in the stock price on the resource allocation in the
Chen, Goldstein, and Jiang [2007] show that the sensitivity of a firm’s investment decisions to its own stock price increases in the level of the information asymmetry in the secondary market, suggesting that the private information that creates the adverse selection problem among investors also guides firms’ investment decisions. For large-scale investments, firms tend to reverse merger and acquisition decisions when confronted by negative market reactions (e.g., Luo [2005]). Those who do not are more likely to become the next targets (e.g., Mitchell and Lehn [1990]). Zuo [2012] provides empirical evidence that managers learn new information from the stock price to improve their earnings forecasts. In addition, the development of prediction markets also lends indirect support to the importance of the informational feedback effect (e.g., Wolfers and Zitzewitz [2004]).

The informational feedback effect has also been contended to be significant enough to affect many other important corporate policies, as reviewed by Bond, Edmans, and Goldstein [2012]. These policies include insider trading (Fishman and Hagerty [1992]), public versus private financing (Subrahmanyam and Titman [1999]), project selection (Dye and Sridhar [2002], Goldstein, Ozdenoren, and Yuan [2013]), and market-based policy making (Sunder [1989], Bond, Goldstein, and Prescott [2010]). While ultimately an empirical issue, it is plausible that the informational feedback effect could be strong enough to affect disclosure policies.

The interactions between public disclosure and private incentives to acquire information have been studied in the literature (e.g., Diamond [1985], Kim and Verrecchia [1994], Demski and Feltham [1994], and McNichols and Trueman [1994]). This paper examines the consequences of such interactions for real decisions. Furthermore, the substitution between firm disclosure and the speculator’s private information production is not critical to our model. We have chosen this feature as a starting point because the level playing field is often advocated as one major rationale for disclosure. If disclosure is complementary to private information production, then more disclosure exacerbates the adverse selection problem while at the same time improving the firm’s investment decisions. The two sides of the tradeoff reverse direction but the tradeoff nevertheless remains.

Our paper complements the literature on the real effects of accounting disclosure that emphasizes the two-way impacts between a firm’s real decisions and the capital market pricing (e.g., Kanodia and Lee [1998], Sapra [2002], and Kanodia, Sapra, and Venugopal [2004]; see Kanodia [2007] for a review of the literature). Our paper introduces an additional link from the stock market to a firm’s subsequent real decisions: the real decisions respond to the stock price because it transmits traders’ private information to the decision makers through the faceless, profit-driven trading process.

There is a large literature on the monitoring benefit of the secondary stock market (e.g., Diamond and Verrecchia [1982], Holmstrom and Tirole [1993], and Govindaraj and Ramakrishnan [2001]). In this literature, the stock price influences managers’ decisions because their compensation
is linked to the stock price that is informative about managers’ past actions. 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 former relies mainly on backward-looking information in the stock price about managers’ past actions (see Govindaraj and Ramakrishnan [2001] for an exception), while the informational feedback role takes advantage of forward-looking information. In fact, forward-looking information in stock prices often impedes its monitoring role (see, e.g., Paul [1992]).

Our paper is also related to Dow and Rahi [2003] and Fishman and Hagerty [1989]. Dow and Rahi [2003] study the effects of an exogenous increase in the amount of informed trading on the firm’s investment efficiency and the traders’ welfare. Neither disclosure nor private information acquisition is studied by Dow and Rahi [2003]. In Fishman and Hagerty [1989], disclosure reduces the information asymmetry between the entrepreneur and her investors in the primary market. As such, disclosure improves investment efficiency by mitigating the entrepreneur’s moral hazard problem.

The rest of the paper proceeds as follows. Section 2 describes the model. Section 3 highlights the basic tradeoff of disclosure on illiquidity cost and investment efficiency. We then use the tradeoff to analyze implications for the securities regulations and growth firms’ endogenous opaqueness. In section 4, we consider an extension in which decision makers outside a firm glean information from the stock price. Section 5 concludes. Detailed proofs are presented in the appendix.

2. The Model

We start with a model in which disclosure mitigates the adverse selection problem among traders and then incorporate the informational feedback effect. Toward this goal, we explicitly model two key features of a secondary stock market. First, some information that is otherwise unknown to a firm can be produced by the market and transmitted to the firm through trading. Second, the firm uses information in the stock price to guide its real decisions.

All parties are risk neutral and the risk-free rate of gross return is normalized to be 1. The time-line of the model consists of four dates, as depicted in figure 1.

At date 1, a firm owning a stochastic technology that produces cash flow at date 4 sets a disclosure policy $\beta$ and then issues equity shares to a continuum of ex ante identical investors (original investors) in the primary market at price $V$. The disclosure policy $\beta$ commits the firm to fully disclose its information at date 2 with probability $\beta \in [0, 1]$. With probability $1 - \beta$, nothing is disclosed. The parameter $\beta$ thus measures both the quantity and
quality of disclosure.\footnote{We assume that the firm has complete control over its disclosure quality and quantity. In the real world, regulators and public accountants also contribute to a firm’s disclosure quality, but their contribution is not considered here.} We normalize the mass of original investors to be 1 and the number of shares to be 1 share per capita. In pricing the shares at date 1, the original investors expect that they will have stochastic liquidity shocks at date 2 that can only be satisfied by trading in the secondary market.

At date 2, a speculator acquires information before the firm discloses. Then the secondary stock market opens and the speculator, original investors, and a market maker interact in a Kyle-type setting (to be specified later). The market maker and the speculator are assumed not to participate in the primary market at date 1.\footnote{This is a common simplification used in the literature to induce illiquidity pricing in the primary market (e.g., Baiman and Verrecchia [1995], Bertomeu, Beyer, and Dye [2011]). Since the market maker and the speculator are risk neutral and do not suffer from liquidity shocks at date 2, their participation in the date-1 market would drive out the original investors and eliminate the liquidity discount in share prices, thus muting the incentives to use disclosure to address date-2 adverse selection concern. Diamond and Verrecchia [1991] show that the same illiquidity pricing is preserved with the participation of the speculators and the market makers in the primary market, provided that the speculators experience stochastic liquidity shocks at date 2 and the market makers are risk averse.}

At date 3, the firm makes an investment decision based on all information available, including the stock price at date 2. At date 4, the cash flow is realized and consumption takes place.

Having completed the time-line, we elaborate on the technology and information structure. The firm consists of one asset-in-place (AIP) and one growth opportunity, whose profitabilities are governed by the same stochastic technology $\mu$; $\mu$ is either $H \equiv \mu_0 + \sigma_\mu$ or $L \equiv \mu_0 - \sigma_\mu$ with equal probability. $\sigma^2_\mu$ represents the variance of the profitability. We assume $\mu_0 > \sigma_\mu > 0$ so the low realization remains positive. In particular, the terminal cash flow

<table>
<thead>
<tr>
<th>Date</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm chooses a disclosure level $\beta$; then primary market makes disclosure $x$ and for firm shares opens.</td>
<td>Speculator acquires a signal $y$; then the firm observes $P$ and chooses investment $K$.</td>
<td>Firm observes liquidity shock $n$ is realized.</td>
<td>Cash flow is realized.</td>
<td></td>
</tr>
<tr>
<td>Firm shares traded in secondary market at price $P$.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1.—The time-line.
from AIP is \( A = \mu \) and from the growth opportunity is
\[
G = \mu \sqrt{2gK} - K,
\]
where \( K \) is the firm’s investment decision made at date 3.\(^3\) \( g > 0 \) is a parameter. A larger \( g \) means that the investment decision is more sensitive to information about \( \mu \). Thus, \( g \) is a measure of the firm’s growth prospects as well as the intensity of the informational feedback effect. Both \( A \) and \( G \) share the same source of uncertainty \( \mu \).\(^4\) The key difference is that the distribution of \( G \) is endogenous to the investment decision \( K \) while the distribution of \( A \) is fixed exogenously.

On the information structure, we assume the speculator can expend resources to acquire a signal \( y \in \{ h, l \} \):
\[
\Pr(y = h | \mu = H) = \Pr(y = l | \mu = L) = \frac{\gamma + 1}{2}, \quad \gamma \in [0, 1],
\]
at the cost of \( C(\gamma) = \frac{c}{2} \gamma^2 \). The more resources the speculator spends, the more precise is her signal. The choice of \( \gamma \) is publicly observable.

Next, the firm privately learns a signal \( z \) at no cost. \( z \) reveals \( \mu \) perfectly with probability \( f \in (0, 1) \) and is completely uninformative with probability \( 1 - f \). The exogenous parameter \( f \) measures the quality of the firm’s internally available information. Since the firm’s date-1 choice of the disclosure level \( \beta \) commits the firm to disclose its information (\( z \)) perfectly with probability \( \beta \), the actual disclosure at date 2, denoted as \( x \), has the following property:
\[
x = \begin{cases} 
\mu & \text{with probability } \beta f \\
\emptyset & \text{with probability } 1 - \beta f,
\end{cases}
\]
where \( \emptyset \) denotes the empty set. To avoid discussing various corner solutions in the text, we make two additional assumptions. First, the firm incurs a direct cost of disclosure \( W(\beta) \), which is increasing and convex with \( W(0) = W_0(0) = 0 \) and \( W_0(1) = \infty \), with the subscript denoting partial derivative. Second, \( 4c_\epsilon - g(1 - f)\sigma_\mu^2 > 0 \). In the proof of Proposition 2 in the appendix, we show \( \beta^* \) is interior under these two conditions.

After the speculator’s information acquisition \( y \) and the firm’s disclosure \( x \), shares are traded. The original investors experience liquidity shocks and have to trade. Their aggregate trade is denoted as \( n \); \( n \) is equal to \( -\sigma_n \) or \( \sigma_n \) with equal probability and \( \sigma_n > 0 \).\(^5\) As in a standard Kyle-type setting,

\(^3\) We assume that the firm finances the date-3 investment for growth out of its retained earnings to avoid the unnecessary complexity arising from the issuance of new equity. The introduction of new investors for the new issuance and their pricing could interact with the pricing and inference in date-1 and date-2 markets. By allowing the firm to use its own capital, we are able to capture the essential economic tension (between disclosure and private information acquisition) without unduly complicating the analysis. We thank one referee for this suggestion.

\(^4\) This assumption is only for simplicity and could be relaxed. What is necessary is that the sources of uncertainty for \( A \) and \( G \) are correlated.

\(^5\) One interpretation is that the liquidity shock requires each investor \( i, i \in [0, 1] \), to place a market order of \( n + \varepsilon_i \), where \( n \) represents the market-wide shock and is common to all
the speculator camouflages her information-based trade $d(x, y)$ with the liquidity trade $n$. The market maker, who observes the total order flow $Q = n + d$, cannot distinguish between the two components. The speculator’s trade $d(x, y)$ can be either $-\sigma_n$ or $\sigma_n$. As a result, $Q$ takes three values: $\{-2\sigma_n, 0, 2\sigma_n\}$. The importance of this assumption of binary trade will be discussed later after we solve the model. Upon observing the disclosure $x$ and the total order flow $Q$, the market maker sets a price $P$ to clear the market and break even in expectation:

$$P = E_\mu[A + G - W | \{x, Q\}; \beta]. \quad (1)$$

Before proceeding, we briefly discuss how the informational feedback effect is operationalized through our information structure, summarized in Table 1. As shown by case 3 of Table 1, with probability $1 - f$, the firm does not learn anything internally about $\mu$, but the share price $P$ contains new information to the firm about $\mu$, which ultimately originates from the speculator’s privately acquired signal $y$. As a result, the stock price is not a redundant source of information to the firm. In addition, in case 1, with probability $f\beta$, $x$ preempts the speculator’s information advantage $y$. Thus, from the perspective at date 1 when the disclosure policy is made, the information produced by the speculator is correlated to but is not a subset of the firm’s information.

### 3. Results

#### 3.1 Preliminary Analysis

In this section, we use backward induction to solve the date-3 investment decision and the date-2 trading game in order to derive the firm value at date 1, when the disclosure choice is made.

At date 3, the firm observes information $(z, P)$ and chooses investment $K$ accordingly: $K^*(z, P) \equiv \arg \max_k \sqrt{2gKE[\mu | (z, P)]} - K = \frac{\xi}{\sqrt{2}} (E[\mu | (z, P)])^2$. The value of the growth opportunity could be viewed as

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**Table 1**

<table>
<thead>
<tr>
<th>Case</th>
<th>Probability</th>
<th>Firm Information</th>
<th>Firm Disclosure</th>
<th>Speculator Information</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$f\beta$</td>
<td>$\mu$</td>
<td>$\mu$</td>
<td>$y$</td>
<td>$P(\mu)$</td>
</tr>
<tr>
<td>2</td>
<td>$f(1 - \beta)$</td>
<td>$\mu$</td>
<td>$\emptyset$</td>
<td>$y$</td>
<td>$P(y)$</td>
</tr>
<tr>
<td>3</td>
<td>$1 - f$</td>
<td>$\emptyset$</td>
<td>$\emptyset$</td>
<td>$y$</td>
<td>$P(y)$</td>
</tr>
</tbody>
</table>
a random variable  

\[ G = gE[\mu(z, P)] - \frac{g}{2} (E[\mu(z, P)])^2. \]

A fixed point problem emerges when this expression of \( G \) and the expression of \( P \) in equation (1) are combined. In setting the growth portion of price \( P \), the market maker forecasts not only the underlying profitability \( \mu \) but also the firm’s belief about \( \mu \) at date 3 \( (E[\mu(z, P)]) \), which may be affected by \( P \). In other words, price both reflects and affects the expected firm value. In general, this fixed point problem does not generate a closed-form solution. Technically, the cash flow from the growth opportunity at date 4 depends not only directly on \( \mu \) but also on the investment decision at date 3, which in turn depends on the firm’s information about \( \mu \) in the price at date 2. As a result, the price of the growth opportunity at date 2 is nonlinear in \( \mu \), making it not tractable to infer information about \( \mu \) from the price. The assumption of binary trading structure in our model enables us to overcome this difficulty and obtain a closed-form solution.

We separately discuss the trading games at date 2 for the three cases listed in table 1. For case 1, in which the firm receives a perfect signal and discloses it, the firm does not learn any new information from the price and both the speculator and the market maker are perfectly informed, that is, \( z = x = \mu \), resulting in a trivial trading game. The speculator is indifferent in trading, earning 0 profit; the market maker sets the price \( P(x) = x + \frac{g}{2} x^2 - W \), \( x \in \{L, H\} \).

For case 2 and 3, the firm’s disclosure is uninformative \( (x = \emptyset) \) and thus, for notational ease, we drop \( x \) from both the speculator’s order function \( d \) and the price function \( P \). The speculator has an information advantage over the market maker and these games are similar to a standard Kyle model with the modification that the information advantage of the speculator extends to both the AIP and the growth opportunity. Lemma 1 identifies the speculator’s trading strategy and the market maker’s inference from the order flow.

**Lemma 1.** The unique pure strategy equilibrium for cases 2 and 3 in table 1 is as follows:

1) the speculator’s trading strategy is \( d(h) = \sigma_n \) and \( d(l) = -\sigma_n \);
2) the market maker infers \( y = h \) if \( Q = 2\sigma_n \), \( y = l \) if \( Q = -2\sigma_n \), and nothing if \( Q = 0 \).

The speculator’s trading strategy is intuitive. She buys when receiving favorable information and sells when receiving negative information. Given this trading strategy, the market maker’s inference is also straightforward. When \( Q = n + d = 2\sigma_n \), it must be the case that \( n = d = \sigma_n \); when \( Q = -2\sigma_n \), it must be the case that \( n = d = -\sigma_n \). In both cases, the speculator’s private information \( y \) is impounded into price \( P \), making the informational
feedback effect possible. When \( Q = 0 \), the market maker is unable to infer the speculator’s private signal; thus the price does not reflect the speculator’s private information \( y \). This enables the speculator to earn a profit that compensates for her costly information acquisition.

The complexity induced by the fixed point problem discussed above manifests itself in computing the speculator’s expected profit, a key step in the proof of Lemma 1. To do so, the speculator has to keep track of not only the market maker’s beliefs about \( \mu \) but also his (the market maker’s) beliefs about the firm’s beliefs about \( \mu \) and his beliefs about the speculator’s own beliefs about the firm’s beliefs about \( \mu \). The binary (discrete) trading structure allows us to obtain a closed-form solution to the fixed point problem. This, in turn, enables us to further study the firm’s disclosure choice at date 1 in a tractable setting.\(^6\) We relegate the details of the proof to the appendix and only present the relevant results here. The expected gross profit for the speculator (before information acquisition at date 2) is

\[
\pi(\beta; \gamma) = \frac{\sigma_n \sigma_\mu}{2} (1 - f\beta)(1 + g\mu_0)\gamma. \tag{2}
\]

Not surprisingly, the speculator’s expected gross profit is increasing in the quality of her private signal \( (\gamma) \) but decreasing in the firm’s disclosure policy \( (\beta) \). Also as expected, it is increasing in liquidity shock, firm profitability uncertainty, and growth parameters. We can also compare \( \pi \) to its counterpart from a model with exogenous cash flow in the literature (without feedback effects). Recall that the informational feedback effect disappears when \( g = 0 \). Thus, the presence of the informational feedback effect increases the speculator’s profit by \( \frac{\sigma_n \sigma_\mu}{2} (1 - f\beta) g\mu_0 \gamma \).\(^7\)

The speculator chooses information acquisition \( \gamma \) to maximize the net expected profit of \( \pi(\beta; \gamma) - c \gamma^2 \), resulting in

\[
\gamma^*(\beta) \equiv \arg \max_{\gamma \in [0,1]} \pi(\beta; \gamma) - \frac{c}{2} \gamma^2 = \frac{\sigma_n \sigma_\mu}{2c} (1 - f\beta)(1 + g\mu_0). \tag{3}
\]

We assume \( c > \frac{\sigma_n \sigma_\mu (1 + g\mu_0)}{2} \) to assure an interior \( \gamma \) in equilibrium.

Because of the zero-sum nature of trading at date 2, the speculator’s gross profit is equal to the original investors’ trading loss. Anticipating this loss on average, the original investors discount the firm shares at date 1 by the same amount to price-protect themselves. Thus, the liquidity discount in the primary market for the firm is

\[
\Pi(\beta) \equiv \pi(\beta; \gamma^*(\beta)) = \frac{\sigma_n \sigma_\mu}{2} (1 - f\beta)(1 + g\mu_0)\gamma^*(\beta) = c(\gamma^*(\beta))^2. \tag{4}
\]

\(^{6}\)Goldstein and Guembel [2008] use a similar discrete trading structure that enables them to further study the issue of price manipulation by speculators.

\(^{7}\)In our binary structure, the speculator expects a profit if and only if the market maker does not learn from the price. As a result, the speculator’s expected profit is a function of the average level of investment \((g\mu_0)\), not of the investment’s sensitivity to information in price per se \((g)\).
In addition, the date-1 expected value of the growth opportunity, taking into account the feedback effect at date 3, is derived in the appendix as

$$\Psi(\beta) = E_{\mu}[G] = \frac{g}{2} \left[ \mu^2 + f\sigma^2 + (1 - f) \frac{(\gamma^*(\beta))^2}{2} \sigma^2_{\mu} \right]. \tag{5}$$

As expected, it increases in the amount of information internally available to the firm ($f$) and information the firm could glean from the stock price ($\gamma^* \sigma^2$). Anticipating the speculator’s information acquisition response $\gamma^*(\beta)$ and its resulting effects on the liquidity discount $\Pi$ and the growth opportunity $\Psi$, the firm chooses disclosure quality $\beta$ to maximize firm value $V$ at date 1:

$$V(\beta) \equiv E_{\mu}[A] + \Psi(\beta) - \Pi(\beta) - W(\beta). \tag{6}$$

$V$ is the expected cash flow from the firm $E_{\mu}[A] + \Psi(\beta) - W(\beta)$ minus the liquidity discount $\Pi(\beta)$ demanded by original investors. Thus, the optimal disclosure policy is determined by the following first-order condition:

$$\frac{d}{d\beta} V(\beta) = -\frac{d\Pi(\beta)}{d\beta} + \frac{d\Psi(\beta)}{d\beta} - \frac{dW(\beta)}{d\beta} = 0.$$

Before analyzing the results, we comment on the role of the binary trade structure and the generality of the results. The binary trade structure is used as a solution to the complexity in the fixed point problem. Another solution in the literature is proposed by Subrahmanyam and Titman [1999]. They assume that the AIP is publicly traded but the growth opportunity is not. Since the terminal cash flow of the AIP and the growth opportunity are subjected to the same sources of uncertainty ($\mu$), the inference about $\mu$ made from the price of AIP could be used in the investment decision for the growth opportunity at date 3. They argue that this assumption allows for closed-form solutions and the explicit characterization of the information content of stock prices without substantive effect on the main results. In an earlier version of our paper, we adopted their modeling device and a standard continuous trade structure, and showed that the main results were almost unchanged. However, it is still an open question whether the results can be generalized to a setting with both the explicit pricing of growth option and the continuous trade structure.

3.2 THE BASIC TRADEOFF

With the preparation above, we examine in detail the firm’s disclosure policy at date 1.

**Lemma 2.** The firm’s disclosure reduces the speculator’s information acquisition in equilibrium, that is, $\frac{d\gamma^*(\beta)}{d\beta} < 0$.

Lemma 2 is straightforward from equation (3). The speculator’s acquisition of signal $y$ gives her an informational advantage in trading only if the
firm’s disclosure $x$ is not informative. When the firm’s disclosure improves, the costly private information acquisition becomes less profitable and the speculator acquires less information.

This reduction in private information acquisition, resulting from the firm’s disclosure, has two opposite effects on the firm value. It levels the playing field among traders on one hand but reduces the firm’s investment efficiency on the other. This is the basic tradeoff of the disclosure policy at date 1.

**Proposition 1.** By reducing the speculator’s information acquisition, the firm’s disclosure has two countervailing effects on the firm value:

1) It reduces the firm’s liquidity cost, that is, $\frac{d\Pi(\beta)}{d\beta} < 0$;
2) It also reduces the firm’s investment efficiency, that is, $\frac{d\Psi(\beta)}{d\beta} < 0$.

Proposition 1 is proved by differentiating equations (4) and (5) with respect to $\beta$. Part 1 is the familiar result that disclosure improves liquidity by “leveling the playing field.” In our model, disclosure reduces not only the likelihood that the speculator has an informational advantage (i.e., $1 - f\beta$ is lower) but also the magnitude of the informational advantage when it exists (i.e., $\gamma^*(\beta)$ is lower). As a result, a higher disclosure level reduces the adverse selection problem among investors in the secondary market at date 2, which in turn reduces the liquidity discount original investors require in the primary market at date 1. In essence, the speculator’s costly information acquisition redistributes wealth from some investors (and eventually from the firm) to the speculator and generates a negative externality on the firm.

However, part 2 of Proposition 1 suggests that a higher disclosure level also reduces investment efficiency exactly because disclosure suppresses the speculator’s private information acquisition. The firm’s investment decision turns out to be more efficient when the speculator acquires more information. In case 3 of table 1, when the firm does learn from the stock price $P$, the equilibrium informativeness of $P$, from the firm’s perspective, can be measured by the explained portion of variance of $\mu$:

$$\text{Var}[\mu] - \text{Var}[\mu|P(x = z = \emptyset, y)] = (\gamma^*(\beta))^2\sigma^2_{\mu}. \quad (7)$$

Thus, the speculator’s private information is the ultimate source of the information the firm learns from the stock price and thus generates a positive externality on the firm. As a result, a higher disclosure level, by reducing the speculator information acquisition (Lemma 2), makes the firm’s own investment decision less efficient.

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8 See, for example, Diamond and Verrecchia [1991] and Easley and O’Hara [2004]. Leuz and Wysocki [2007] provide a survey of this literature.
The basic tradeoff of the disclosure policy highlights the secondary market’s dual functions in both providing liquidity and producing information. Preemptive disclosure to the market could not serve both functions at the same time. A disclosure policy that maximizes firm value does not necessarily promote a more level playing field. Put differently, the informational feedback is costly to the firm. Eventually the firm pays for the information production service by the speculator in the form of the increased liquidity cost of its shares. The more valuable the information provided by the speculator, the greater the firm’s incentives to cut back on its disclosure and the less the firm is able to address the liquidity concerns.

To see the significance of incorporating the informational feedback effect to the consideration of disclosure policies, we explore two implications of the basic tradeoff identified in Proposition 1. First, we use the model to reconcile the institutional feature of U.S. securities regulations that simultaneously promote firm disclosure and facilitate private information acquisition. Second, we use the model to explain why growth firms can be endogenously more opaque.

3.3 PRIVATE INFORMATION ACQUISITION AND FIRM VALUE

Does the firm benefit from an increase in parameter $c$, the speculator’s cost of private information acquisition? From the perspective of leveling the playing field alone, the answer is in the affirmative because the adverse selection problem in the secondary market is mitigated by an increase in the cost of the private information acquisition. However, when the informational feedback effect is taken into account, the answer changes. To put it differently, leveling the playing field increases firm value unambiguously only if the firm’s real decisions are treated as fixed. Define $V^*$ as the date-1 firm value in equilibrium and

$$\hat{g} = \frac{1}{\bar{c}\sigma^2(1-f)}.$$ 

PROPOSITION 2. The firm value is decreasing in the cost of the speculator’s information acquisition if and only if the informational feedback effect is sufficiently strong. That is, $\frac{d}{dc} V^* < 0$ if and only if $g > \hat{g}$.

The firm value actually decreases in $c$ if and only if the growth prospect ($g$) is sufficiently large (and thus the informational feedback effect is sufficiently strong). A higher $c$ induces the speculator to decrease her information acquisition, which, by Proposition 1, leads to both a lower liquidity cost and lower investment efficiency. Whether the firm value increases in $c$ thus depends on the strength of each effect. When the investment opportunity is important and the benefit of the feedback from the stock price is large, the investment efficiency dominates the liquidity cost and the firm is better off with a lower, rather than a higher, $c$.

This result is significant for understanding a firm’s disclosure policy in a broader context. Securities regulations in the United States simultaneously
promote firm disclosure and encourage private information acquisition.\textsuperscript{9} This feature is paradoxical from the perspective that narrowly focuses disclosure on leveling the playing field, but consistent with Proposition 2. Alternatively, to the extent that the private information production is viewed as a proxy for the health of a stock market and actively pursued as a desirable goal by firms and regulators alike, the informational feedback effect can be inferred to be significant in practice.

3.4. GROWTH AND DISCLOSURE LEVEL

The basic tradeoff in Proposition 1 points to certain growth factors that strengthen the informational feedback effect, which in turn create incentives for firms to reduce their disclosure level in order to preserve the speculator’s incentive to acquire information. In our model, the growth opportunity is represented by equation (5) and reproduced here:

\[
\Psi(\beta) \equiv E_\mu[G] = \frac{g}{2} \left[ \mu_0^2 + f \sigma_\mu^2 + (1 - f) \frac{(\gamma^*(\beta))^2}{2} \sigma_\mu^2 \right].
\]

Each of the relevant exogenous parameters, \(g\), \(f\), and \(\sigma_\mu^2\), captures one facet of a growth firm.\textsuperscript{10} Their effects on disclosure policy are summarized by the following proposition.

PROPOSITION 3. \textit{Ceteris paribus,}

1) firms with a higher uncertainty (higher \(\sigma_\mu^2\)) disclose less if and only if \(g\) is sufficiently large,
2) firms with higher growth prospects (higher \(g\)) disclose less if \(g\) is sufficiently large, and
3) firms that are more likely to learn information from the stock price (lower \(f\)) disclose less.

Proposition 3 adds new predictions about the relation between growth and disclosure policies. Growth firms’ investment is riskier, captured by a larger \(\sigma_\mu^2\) in our model (the variance of profitability \(\mu\)). \(\sigma_\mu^2\) affects the value of information to both the firm and the speculator. On one hand, \(\sigma_\mu^2\) increases the marginal benefit of learning from the stock price, inducing the firm to reduce disclosure. On the other hand, a higher \(\sigma_\mu^2\) also makes the speculator’s information acquisition more profitable and increases liquidity.

\textsuperscript{9}The legal literature has established that the tenet of securities regulation in the United States has shifted to the “efficiency enhancement model” since the 1970s as part of the triumph of the efficient market hypothesis (e.g., Stout [1988], Mahoney [1995]). Under the guidance of this new doctrine, institutions and policies have been designed to facilitate information production in the secondary market. This doctrine has been employed in the public discourse in a wide array of prominent issues, such as insider trading and short sales.

\textsuperscript{10}While the growth opportunity could be available to both growth firms and mature firms, it is on average more important for growth firms.
cost, inducing the firm to increase disclosure. Since the first effect increases in \( g \) while the second is independent of \( g \), the first effect dominates the second if \( g \) is sufficiently large. Hence, the firm’s disclosure decreases in \( \sigma^2_\mu \) if and only if \( g \) is sufficiently large.

The growth prospect \( g \) has two effects on the firm’s optimal disclosure policy. On one hand, as the growth prospect \( g \) increases, information about the profitability of the growth opportunity becomes more valuable to the firm, inducing the firm to reduce disclosure to incentivize the private information acquisition. On the other hand, \( g \) also indexes the size of new investment. A larger \( g \), by making the speculator’s information more scalable, increases her profit and thus the liquidity discount, inducing the firm to increase disclosure as a counteraction. The net effect of \( g \) on the firm’s disclosure policy is thus determined by this tradeoff. The first effect becomes dominant and the firm’s disclosure decreases in \( g \) if \( g \) is sufficiently large.

Not only is the prospective information more important for growth firms, but growth firms are also more likely to generate less information internally, or a lower \( f \) in our model. A lower \( f \) makes the speculator’s information more valuable to the firm, giving it an incentive to lower disclosure in order to encourage the speculator’s information acquisition.

In sum, growth firms choose to be more opaque in order to encourage more private information acquisition in the secondary market.

4. Extension: Who Learns?

So far, we have assumed that the firm (the manager) is the decision maker who benefits from the information gleaned from the stock price. However, the basic idea that preemptive disclosure could reduce the firm value through its suppression of information production incentives is more general. As long as information in the stock price influences decisions that affect the firm value, the firm’s disclosure policy will balance its effects on liquidity enhancement and decision efficiency, regardless of the identity of the decision maker.\(^\text{11}\)

To illustrate, suppose an outsider takes an action \( K \) at date 3 to maximize his own payoff \( G = \mu \sqrt{2gK} - K \) and the firm benefits from the decision by an amount \( J(G) = jG \) where \( j > 0 \). The main difference between this extension and the baseline model is that the undisclosed information (case 2 in table 1) remains useful for the investment decision in the baseline model but is no longer available to the outsiders in this new setup. In other words, in this extension disclosure affects the decision maker’s information.

\(^\text{11}\) For example, Goldstein, Ozdenoren, and Yuan [2013] show capital providers may learn from the stock price and make decisions influencing a firm’s access to credit. In Bond, Goldstein, and Prescott [2010], outside agents, such as activists or regulators, may also learn from stock price when taking corrective actions that affect the firm value. Various government actions in the banking and other industries during the recent financial crisis are ready examples.
set through two channels: the direct channel of providing the firm’s own information and the indirect channel of reducing the speculator’s information in the stock price. The net effect of disclosure on the outsider’s decision making then depends on the relative importance of the direct and indirect channels. Since the paper’s focus is on the indirect channel, we have chosen the firm (or the manager) to be the decision maker in the baseline model to make the model “cleaner.”

**Proposition 4.** When an outsider looks to the stock price to guide his decisions, the firm’s disclosure reduces the efficiency of the outsider’s decision if both the firm’s internal information is sufficiently limited ($f$ is sufficiently small) and the speculative information acquisition is sufficiently efficient ($c$ is sufficiently small).

Proposition 4 shows that, when the firm’s internal information is scarce (a low $f$) and the market information production is efficient (a low $c$), the information provision to outsiders through the direct channels is dominated by that through the indirect channel. As a result, more disclosure by the firm actually results in less information available to the outside decision maker. To the extent that the firm benefits from these decisions ($j > 0$), the disclosure policy still trades off its benefit of saving the liquidity cost against the cost of reducing the outsider’s learning from the stock price.

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

**Corollary 1.** When competitors learn information from the firm’s stock price ($j < 0$), the firm’s disclosure reduces, rather than increases, its proprietary cost if both the firm’s internal information is sufficiently limited ($f$ is sufficiently small) and 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 can lower the proprietary cost endogenously, a result similar to Arya and Mittendorf [2005] but with a different mechanism. Even though disclosure provides information to the competitors, it also reduces the information the competitors could learn from the stock price. The net effect of disclosure on the competitors, learning should take both channels into account.
5. Conclusion

Disclosure has been an important component of securities regulations in the United States since their inception in the 1930s. One major theoretical support for disclosure to a secondary market is that it levels the playing field. By partially preempting investors’ information advantage established from information acquisition, disclosure reduces private incentives to acquire information and results in a more level playing field among investors. We re-evaluate this commonly accepted rationale by observing that trading in a secondary stock market not only redistributes wealth among investors but also generates information that guides subsequent real decisions. That is, 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 real decisions. When the informational feedback from the stock market to real decisions is taken into account, disclosure, by reducing private information acquisition, has two opposite effects on the firm value. On one hand, it narrows the information gap between informed and uninformed investors and reduces the liquidity discount required by uninformed investors. On the other hand, it reduces the informational feedback from the stock market to real decisions. This tradeoff determines the optimal disclosure policy.

One major benefit of explicitly considering the informational feedback effect in a theory of disclosure to secondary stock markets is that it reconciles the joint promotion of disclosure and private information acquisition in securities regulations, which appears paradoxical when we focus only on the liquidity provision function of the secondary market. It also explains why growth firms are endogenously more opaque.

Finally, both the recent successes and problems of prediction markets illustrate the main tension in our paper. On one hand, prediction markets have been increasingly used by corporations as a tool to generate information about their own firms, reflecting the gradual acceptance of our assumption that markets can have a competitive advantage over a firm in generating some information about the firm itself. On the other hand, the number one practical problem for a prediction market is that it is often too thin to attract traders to actively acquire information (see Wolfers and Zitzewitz [2006]). In financial markets, such incentives for information acquisition are provided to traders exclusively through the trading profits they can generate from their information advantage. Thus, the fact that providing traders with incentives to acquire information is a first-order issue in prediction markets supports our contention that the adverse effects of disclosure on private information acquisition and on the informational feedback function of the stock market can be substantial.
APPENDIX

Proof of Lemma 1 and Expression (2) and (5). We prove Lemma 1 in two steps. First, given the speculator’s trading strategy, we verify that the market maker’s belief is consistent with the Bayes rule. This step is straightforward and thus omitted. Second, given the market maker inference, we verify that the speculator does not have an incentive to deviate from the trading strategy. In the process of the second step, we also derive the speculator’s trading profits (equation (2)) and the value of the firm’s growth opportunity (equation (5)) in the text.

The following calculations are used later. The first and second moments of $\mu$, conditional on the signal $y$ or on the prior, are

\[ E[\mu|y = h] = \mu_0 + \sigma_\mu \gamma, \quad E[\mu|y = l] = \mu_0 - \sigma_\mu \gamma, \]  

(A1)

\[ E[\mu^2|y = h] = Var[\mu|y = h] + (E[\mu|y = h])^2 = \sigma_\mu^2 (1 - \gamma^2) + (\mu_0 + \sigma_\mu \gamma)^2 = \sigma_\mu^2 + \mu_0^2 + 2\mu_0 \sigma_\mu \gamma, \]  

(A2)

\[ E[\mu^2|y = l] = Var[\mu|y = l] + (E[\mu|y = l])^2 = \sigma_\mu^2 (1 - \gamma^2) + (\mu_0 - \sigma_\mu \gamma)^2 = \sigma_\mu^2 + \mu_0^2 - 2\mu_0 \sigma_\mu \gamma, \]  

(A3)

\[ E[\mu] = \mu_0, \quad E[\mu^2] = \sigma_\mu^2 + \mu_0^2. \]  

(A4)

Define $F = A + G - W = \mu + gE[\mu|(z, P)] \mu - \frac{g}{2} (E[\mu|(z, P)])^2 - W$. The proof differs slightly for case 2 and case 3 and thus proceeds separately.

Case 2: The firm learns $\mu$ perfectly ($z = \mu$). Thus $E[\mu|(z, P)] = \mu$ and $F = \mu + \frac{g}{2} \mu^2 - W$. We verify that, anticipating the market maker’s inference from $Q$, the speculator has no incentives to deviate from the trading strategy in part 1 of the Lemma. The speculator’s profit is the difference between her expectation of $F$ and the price $P$ set by the market maker and we compute them in turn. By using equation (A1) and (A2), the speculator’s expectation of $F$ is

\[ E[F|h] = E \left[ \mu + \frac{g}{2} \mu^2 - W|y = h \right] = \mu_0 + \sigma_\mu \gamma \]

\[ + \frac{g}{2} (\sigma_\mu^2 + \mu_0^2 + 2\mu_0 \sigma_\mu \gamma) - W, \]  

(A5)

\[ E[F|l] = E \left[ \mu + \frac{g}{2} \mu^2 - W|y = l \right] = \mu_0 - \sigma_\mu \gamma \]

\[ + \frac{g}{2} (\sigma_\mu^2 + \mu_0^2 - 2\mu_0 \sigma_\mu \gamma) - W. \]

The market maker sets price $P(Q)$ according to the inference in part 2:

\[ P(2\sigma_a) = E[F|h], \quad P(-2\sigma_a) = E[F|l], \quad P(0) = E[F] = \mu_0 + \frac{g}{2} (\sigma_\mu^2 + \mu_0^2) - W. \]  

(A6)
Given her expectation of $F$ and the set of prices, the speculator compares the profits from two trading options and picks the one with the higher profit. Suppose she receives $y = h$. She could choose either $d(h) = \sigma_n$ or $d(h) = -\sigma_n$. If she chooses $d(h) = \sigma_n$, she expects to receive cash flow $E[F|h]$ from the position and pay $P(Q)$ for the position, with an expected profit of

$$
\sum_{n \in \{-\sigma_n, \sigma_n\}} \Pr(n)\sigma_n(E[F|h] - P(Q))
= \frac{1}{2}\sigma_n(E[F|h] - P(2\sigma_n)) + \frac{1}{2}\sigma_n(E[F|h] - P(0))
= \frac{1}{2}(1 + g\mu_0)\sigma_n\sigma_\mu > 0.
$$

The first equality writes out the summation with two equal possibilities: the noise trade is $\sigma_n$, $Q = 2\sigma_n$ and thus the speculator pays $P(2\sigma_n)$; or the noise trade is $-\sigma_n$, $Q = 0$ and thus the speculator pays $P(0)$. The second equality utilizes expression (A5) and (A6).

In contrast, if the speculator deviates to $d(h) = -\sigma_n$, she expects to receive $P(Q)$ from the position (the proceeds of shorting) and pay $E[F|y = h]$ for the position, with an expected profit of

$$
\sum_{n \in \{-\sigma_n, \sigma_n\}} \Pr(n)\sigma_n(P(Q) - E[F|h])
= \frac{1}{2}\sigma_n(P(-2\sigma_n) - E[F|h]) + \frac{1}{2}\sigma_n(P(0) - E[F|h])
= -\frac{3}{2}(1 + g\mu_0)\sigma_n\sigma_\mu \gamma < 0.
$$

Therefore, given the market maker’s inference in part 2 of Lemma 1, upon receiving $y = h$, the speculator expects a profit from $d(h) = \sigma_n$ and a loss from $d(h) = -\sigma_n$ and thus has no incentives to deviate from $d^*(h) = \sigma_n$. Similarly, we could prove $d^*(l) = -\sigma_n$ and show that the expected profit from trading $d^*(l) = -\sigma_n$ is

$$
\sum_{n \in \{-\sigma_n, \sigma_n\}} \Pr(n)\sigma_n(P(Q) - E[F|l]) = \frac{1}{2}(1 + g\mu_0)\sigma_n\sigma_\mu \gamma.
$$

Thus, the stated equilibrium is the unique pure strategy equilibrium, which proves Lemma 1 for case 2.

**Case 3:** The firm does not receive information internally ($z = \emptyset = x$) and conditions the investment only on the information from price $P(Q)$. $E[\mu|z, P] = E[\mu|Q]$ and $F = \mu + gE[\mu|Q]\mu - \frac{g}{2}(E[\mu|Q])^2 - W$. The first step of the proof is again straightforward. Given the speculator’s strategy in part 1 of Lemma 1, the market maker infers $y = h$ from $Q = 2\sigma_n$, $y = l$ from $Q = -2\sigma_n$, and does not change the prior from $Q = 0$. The second step is to verify that, anticipating the market maker’s inference, the speculator has no incentives to deviate. Similar to case 2, we first calculate
the speculator’s expectation of $F$ and the market maker’s pricing decisions and then compare the speculator’s profits under different trading strategies. The difference from case 2 is that these calculations are more complex due to the fixed point problem discussed in the text. Consider the first case in which the speculator receives $y = h$. Her expectation of $F$ is

$$E[F|h] = \frac{1}{2} E[F|y = h, Q = 2\sigma_n] + \frac{1}{2} E[F|y = h, Q = 0].$$

The equality writes out two equal possibilities: either $Q = 2\sigma_n$ or $Q = 0$. Because the investment decisions differ in these two subcases, the expected cash flows in these two subcases need to be calculated separately. When $Q = 2\sigma_n$, the firm learns $y = h$ and thus the speculator’s expectation of the firm’s belief of $\mu$ is $E[E[\mu|Q]|y = h, Q = 2\sigma_n] = E[\mu|y = h]$. Thus,

$$E[F|y = h, Q = 2\sigma_n] = E[\mu|y = h] + \frac{g}{2}(E[\mu|y = h])^2 - W = \mu_0 + \sigma_\mu \gamma + \frac{g}{2}(\mu_0 + 2\sigma_\mu \gamma)^2 - W.$$

When $Q = 0$, the firm learns no information and thus the speculator’s expectation of the firm’s belief of $\mu$ is $E[E[\mu|Q]|y = h, Q = 0] = \mu_0$. Thus,

$$E[F|y = h, Q = 0] = E\left[\mu + g\mu_0 \left(\mu - \frac{g}{2} \mu_0^2\right) - W|y = h, Q = 0\right] = \mu_0 - \sigma_\mu \gamma + \frac{g}{2}(\mu_0 + 2\sigma_\mu \gamma) - W.$$

Collecting the two components, $E[F|y = h, Q = 2\sigma_n]$ and $E[F|y = h, Q = 0]$, we have the speculator’s expectation of $F$ upon receiving $y = h$:

$$E[F|h] = \frac{1}{2} E[F|y = h, Q = 2\sigma_n] + \frac{1}{2} E[F|y = h, Q = 0] = \mu_0 + \sigma_\mu \gamma + \frac{g}{4}(\sigma_\mu^2 \gamma^2 + 4\sigma_\mu \mu_0 \gamma + 2\mu_0^2) - W.$$

Similarly, the speculator’s expectation of $F$ upon receiving $y = l$ is

$$E[F|l] = \frac{1}{2} E[F|y = l, Q = -2\sigma_n] + \frac{1}{2} E[F|y = l, Q = 0] = \mu_0 - \sigma_\mu \gamma + \frac{g}{4}(\sigma_\mu^2 \gamma^2 - 4\mu_0 \sigma_\mu \gamma + 2\mu_0^2) - W.$$

Its two components are

$$E[F|y = l, Q = -2\sigma_n] = \mu_0 - \sigma_\mu \gamma + \frac{g}{2}(\mu_0 - \sigma_\mu \gamma)^2 - W,$$

$$E[F|y = l, Q = 0] = \mu_0 - \sigma_\mu \gamma + \frac{g}{2}\mu_0(\mu_0 - 2\sigma_\mu \gamma) - W.$$
Using the inference in part 2 of Lemma 1, the market maker sets the price conditional on $Q$. When $Q \neq 0$, the market maker has the same expectations as the speculator. Thus,

$$P(2\sigma_n) = E[F|y = h, Q = 2\sigma_n], P(-2\sigma_n) = E[F|y = l, Q = -2\sigma_n].$$

When $Q = 0$, neither the market maker nor the firm learns of the speculator’s information and the market maker’s expectation of the firm’s belief of $\mu$ is $E[E[\mu|Q]|Q = 0] = \mu_0$.

$$P(0) = E[F|Q = 0] = E[\mu + g\mu_0\mu - \frac{g}{2}\mu_0^2 - W] = \mu_0 + \frac{g}{2}\mu_0^2 - W.$$

Given her expectation of $F$ and the set of prices, the speculator compares the profits from two trading options and picks the one with the higher profit, similar to the procedure in case 2. Upon receiving $y = h$, she could choose either $d(h) = \sigma_n$ or $d(h) = -\sigma_n$. If she chooses $d(h) = \sigma_n$, she expects to receive cash flow $E[F|h]$ from the position and pay $P(Q)$ for the position, with an expected profit of

$$\sum_{n \in \{-\sigma_n, \sigma_n\}} \text{Pr}(n)\sigma_n(E[F|h] - P(Q))$$

$$= \frac{1}{2}\sigma_n(E[F|y = h, Q = 2\sigma_n] - P(2\sigma_n)) + \frac{1}{2}\sigma_n(E[F|y = h, Q = 0] - P(0))$$

$$= \frac{1}{2}(1 + g\mu_0)\sigma_n\mu \gamma > 0. \quad \text{(A9)}$$

In contrast, if the speculator deviates to $d(h) = -\sigma_n$, she expects to receive $P(Q)$ from the position (the proceeds of shorting) and pay $E[F|h]$ for the position, with an expected profit of

$$\sum_{n \in \{-\sigma_n, \sigma_n\}} \text{Pr}(n)\sigma_n(P(Q) - E[F|h])$$

$$= \frac{1}{2}\sigma_n(P(-2\sigma_n) - E[F|y = h, Q = -2\sigma_n])$$

$$+ \frac{1}{2}\sigma_n(P(0) - E[F|y = h, Q = 0])$$

$$= -\sigma_n\gamma (3g\mu_0 - 2g\sigma_\mu\gamma + 3) < 0.$$

The last inequality is due to $\mu_0 > \sigma_\mu$. $E[F|y = h, Q = -2\sigma_n]$ is the speculator’s expectation of $F$ when she receives $y = h$, chooses $d(h) = -\sigma_n$, and observes and $Q = -2\sigma_n$. In this case, the speculator’s expectation of the firm’s belief of $\mu$ is $E[E[\mu|Q]|y = h, Q = -2\sigma_n] = E[\mu|y = l]$. Thus,

$$E[F|y = h, Q = -2\sigma_n] = E[\mu + gE[\mu|Q]\mu$$

$$- \frac{g}{2}(E[\mu|Q])^2|y = h, Q = -2\sigma_n]$$
\[ E[\mu|y = h] + gE[\mu|y = l]E \left( \mu - \frac{1}{2} E[\mu|y = l]|y = h \right) - W \]
\[ = \mu_0 + \sigma_\mu \gamma + g(\mu_0 - \sigma_\mu \gamma) \left( \mu_0 + \sigma_\mu \gamma - \frac{1}{2} (\mu_0 - \sigma_\mu \gamma) \right) - W. \]

Therefore, given the market maker’s inference in part 2 of Lemma 1, upon receiving \( y = h \), the speculator expects a profit from \( d(h) = \sigma_n \) and a loss from \( d(h) = -\sigma_n \) and thus has no incentives to deviate from \( d^*(h) = \sigma_n \). Similarly, we could prove \( d^*(l) = -\sigma_n \) and show that the expected profit from trading \( d^*(l) = -\sigma_n \) is

\[ \sum_{n \in \{-\sigma_n, \sigma_n\}} \Pr(n) \sigma_n (P(Q) - E[F|y = l]) = \frac{1}{2} (1 + g\mu_0) \sigma_n \sigma_\mu \gamma. \quad (A10) \]

Thus, the stated equilibrium is the unique pure strategy equilibrium, which proves Lemma 1 for case 3.

In addition, we derive expressions (2) and (5). Collecting the speculator’s profit in various scenarios (expressions (A7)–(A10)) and weighting them by the probability of each scenario, the speculator’s expected gross profit at date 1 (before the realization of \( (z, x, y, n) \)), or expression (2) in the text, is

\[ \pi(\gamma; \beta) = f(1 - \beta) \frac{1}{2} (1 + g\mu_0) \sigma_n \sigma_\mu \gamma + (1 - f) \frac{1}{2} (1 + g\mu_0) \sigma_n \sigma_\mu \gamma = \frac{\sigma_n \sigma_\mu}{2} (1 - f\beta)(1 + g\mu_0) \gamma. \]

When the firm receives the perfect signal \( z \), which occurs with probability \( f \), \( G = \frac{g}{2} \mu^2 \). Thus, the expected value at date 1 is \( \frac{g}{2} (\mu_0^2 + \sigma^2_\mu) \). When the firm does not receive the private signal, the firm learns from \( P(Q) \). In this case, the expected value of the growth opportunity at date 1 is

\[ E[G] = \frac{1}{4} E[G|Q = 2\sigma_n] + \frac{1}{2} E[G|Q = 0] + \frac{1}{4} E[G|Q = -2\sigma_n] \]
\[ = \frac{1}{4} g \left( E[\mu|y = h] \right)^2 + \frac{1}{2} g \left( E[\mu] \right)^2 + \frac{1}{4} g \left( E[\mu|y = l] \right)^2 \]
\[ = \frac{g}{2} \left( \mu_0^2 + \sigma^2_\mu \gamma^2 \right). \]

Thus, the value of the growth opportunity expected at date 1, or expression (5) in the text, is derived as

\[ \Psi(\beta) = f \frac{g}{2} (\mu_0^2 + \sigma^2_\mu) + (1 - f) \frac{g}{2} \left( \mu_0^2 + \sigma^2_\mu \gamma^2 \right) \]
\[ = \frac{g}{2} (\mu_0^2 + f\sigma^2_\mu + (1 - f) \frac{\gamma^2}{2} \sigma^2_\mu). \]
Proof of Proposition 2. For notation, we use subscripts to denote partial derivatives, that is, $X_t \equiv \frac{dX}{dt}$ and $X_{xy} \equiv \frac{d^2X}{dy^2}$, and write the total derivative as $\frac{dX}{dt}$. We analyze the firm’s disclosure choice $(\beta)$ at date 1. From equation (6), the firm’s decision problem at date 1 is

$$
\max_{\beta \in [0,1]} V(\beta) = \mu_0 - \Pi(\beta) + \Psi(\beta) - W(\beta).
$$

The first-order condition determines the optimal disclosure policy $\beta^*:

$$
V^*_\beta = \Psi^*_\beta - \Pi^*_\beta - W^*_\beta = (4c - g(1 - f)\sigma^2_\mu) f(1 - f\beta^*) \sigma^2_\mu (1 + g\mu_0)^2 \sigma^2_\mu (1 - f_\mu)^2 - W^*_\beta. \tag{A11}
$$

$\Psi^*_\beta$, $\Pi^*_\beta$, and $W^*_\beta$ are defined as $\Psi_\beta$, $\Pi_\beta$, and $W_\beta$ being evaluated at $\beta = \beta^*$. If $4c - g(1 - f)\sigma^2_\mu \leq 0$, $V_\beta \leq 0$ for any $\beta \in [0, 1]$ with the equality true only at $\beta = 0$. Thus $\beta^* = 0$ and the optimal disclosure policy is obtained at the corner. If $4c - g(1 - f)\sigma^2_\mu > 0$, we have the second-order condition $V_{\beta\beta} = -(4c - g(1 - f)\sigma^2_\mu) f(1 + g\mu_0)^2 \sigma^2_\mu (1 + g\mu_0)^2 - W_{\beta\beta} < 0$, $V_{\beta|\beta=0} > 0$ and $V_{\beta|\beta=1} < 0$ (because $W_\beta(1) - \gamma = \infty$). Therefore, there exists a unique interior $\beta^* \in (0, 1)$ such that $V^*_\beta = 0$.

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

$$
\frac{dV^*}{dc} = V^*_c = \frac{\gamma^*(\beta^*)^2}{2c} (2c - (1 - f) g\sigma^2_\mu).
$$

Define $\hat{g}$ as

$$
\hat{g} \equiv \frac{2c}{\sigma^2_\mu (1 - f)}. \tag{A12}
$$

We conclude that $\frac{dV^*}{dc} > 0$ if and only if $g < \hat{g}$. $\square$

Proof of Proposition 3. We now study the determinants of the optimal disclosure policy $\beta^*$. The impact of growth prospect $g$ on the optimal disclosure policy $\beta^*$, $\beta^*_g$, is determined by

$$
\beta^*_g = \frac{1}{V^*_{\beta g}} (\Psi^*_{\beta g} - \Pi^*_{\beta g}) = - \frac{1}{V^*_{\beta g}} \frac{\gamma^* f\sigma_\mu}{4c} \left[ 8c\mu_0 - (1 - f) (1 + 3g\mu_0)\sigma^2_\mu \right]
$$

$$
\quad \quad - \frac{1}{V^*_{\beta g}} \frac{\gamma^* f\sigma_\mu}{4c} \left[ \mu_0 (8c - 3(1 - f) g\sigma^2_\mu) - (1 - f) \sigma^2_\mu \right].
$$

When $8c - 3(1 - f) g\sigma^2_\mu < 0$, or equivalently, $g > \frac{8c}{3(1 - f)} \sigma^2_\mu$, $[8c\mu_0 - (1 - f) (1 + 3g\mu_0)\sigma^2_\mu]$ is negative and so is $\beta^*_g$. This proves part 1 of Proposition 3.

$$
\beta^*_{\sigma^2_{\beta}} = \frac{\Psi^*_{\sigma^2_{\beta}} - \Pi^*_{\sigma^2_{\beta}}}{V^*_{\beta g}} = \frac{1}{V^*_{\beta g}} \frac{\sigma^2_\mu f(1 - f\beta)(1 + g\mu_0)^2}{4c^2} (2c - g(1 - f)\sigma^2_\mu).
$$

$\beta^*_{\sigma^2_{\beta}} > 0$ if and only if $g < \hat{g}$. $\hat{g}$ is defined in equation (A12).
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 \( \beta^* \) alone.

\[
(f\beta^*)_f = \beta^* + f\beta^*_f = \beta^*(\Psi^*_\beta - \Pi^*_\beta - W^*_\beta) - f(\Psi^*_\beta_f - \Pi^*_\beta_f)
\]

\[
= \beta^*(\Psi^*_\beta - \Pi^*_\beta) - f(\Psi^*_\beta_f - \Pi^*_\beta_f)
\]

\[
= \frac{1}{V^*_\beta\beta}(\sigma^2_\alpha \sigma^2_\mu (1 - \beta^* f) f(1 + g\mu_0)^2){8c^2} (4c - (1 - f) g\sigma^2_\mu + f g\sigma^2_\mu)
\]

\[
= \frac{\beta^* W^*_\beta}{V^*_\beta\beta} > 0.
\]

**Proof of Proposition 4.** When the decision maker is not the firm, the only difference in the computation of \( \Psi \) 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 \( \Psi' \), is

\[
\Psi' = E_c, p \left[ \frac{g}{2} (E[\mu|z, P])^2 \right] = \frac{g}{2} \left( \mu_0^2 + \sigma^2_\mu \left( f\beta + (1 - f\beta) (\gamma^*(\beta))^2 \right) \right).
\]

The ex ante benefit to the firm is

\[
E[J] = E[jG] = j\Psi'.
\]

Thus,

\[
\frac{dE[J]}{d\beta} = \frac{jg\sigma^2_\mu}{2} \left[ f - f \left( \frac{(\gamma^*(\beta))^2}{2} \right) + (1 - f\beta) \gamma^*(\beta) \right]
\]

\[
= \frac{jfg\sigma^2_\mu}{2} \left( 1 - \frac{3}{2} (\gamma^*)^2 \right).
\]

So we have

\[
\frac{dE[J]}{d\beta} < 0 \text{ if and only if } (\gamma^*)^2 = \left( \frac{\sigma^2_\sigma^2_\mu}{2c} (1 - f\beta) (1 + jg\mu_0) \right)^2 > \frac{2}{3}.
\]

Notice that the optimal information acquisition is adjusted to reflect the change in the growth option part of the total firm value (\( \Psi' \) instead of \( \Psi \)). Now it is straightforward that

\[
0 < \frac{c}{(1 - f)} < \frac{(1 + jg\mu_0)\sigma^2_\sigma^2_\mu \sqrt{3}}{2}
\]

is a sufficient condition for \( \frac{dE[J]}{d\beta} < 0 \) given the value of \( \beta \) is bounded between zero and one. This condition is satisfied when both parameters \( f \) and \( c \) are small enough. Finally, one can verify that there exist parameter regions with positive measures where the above condition and the following
maintained assumptions are jointly satisfied:

\[
c > \max \left\{ \frac{g(1 - f)\sigma_{\mu}^2}{4}, \frac{\sigma_{\mu}(1 + g\mu_0)}{2} \right\}.
\]

REFERENCES


