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Acquisition and Discretionary Disclosure of Private Information and Its Implications for Firms' Productive Activities

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1. *Introduction*

It is well known in the literature (e.g., Dye [1985] and Jung and Kwon [1988]) that when outside investors are unsure of the information endowment of a firm's manager (whose objective is to maximize the firm's current market price), a partial disclosure equilibrium prevails. In particular, a manager who has a private signal about the firm's future value discloses the signal if, and only if, it exceeds a cutoff value. This is in contrast with a full disclosure equilibrium, which would prevail if investors are sure the manager possesses private information (see Grossman [1981] and Milgrom [1981]).

The objective of this study is to examine the implications of discretionary disclosure for a firm's production efficiency when acquiring private information is costly.[1] In other words, we ask, "Why and how are a firm's

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[1] Firms must often spend resources to obtain private information. Furthermore, as suggested by Lev [1992], a firm's disclosure decision is important not only because it affects outsiders' perceptions but also because these perceptions potentially influence corporate decisions that affect economic outcomes.

productive activities interrelated with its costly acquisition and discretionary disclosure of private information?" To provide an answer to this question, this paper extends Jung and Kwon's [1988] discretionary disclosure model in two directions.[2] First, an entrepreneur provides costly effort that stochastically enhances the future income of his/her firm. Second, after providing the effort, the entrepreneur decides whether to acquire a costly private signal about the random state of nature that also affects the firm's future income. If a signal is acquired, the entrepreneur chooses whether to disclose the signal (i.e., the same decision as in Jung and Kwon [1988]).

Three results are derived. First, even if the entrepreneur is ex ante best off by not acquiring any information ex post,[3] s/he cannot credibly precommit to do so because whenever the information acquisition cost is sufficiently low, s/he has an unavoidable incentive to acquire a private signal and use discretionary disclosure to manipulate investors' beliefs about the firm's future prospects. Thus, there is an efficiency loss in terms of the expected information acquisition cost. Second, because of the ex post incentive associated with the acquisition and discretionary disclosure of private information, the entrepreneur's ex ante choice of productive effort is distorted, another efficiency loss. Specifically, it is shown that the entrepreneur overinvests effort (relative to the first-best level) because doing so reduces the expected information acquisition cost. Third, a less informative signal weakens the entrepreneur's ex post incentive to acquire a costly signal. This not only lowers the expected information acquisition cost but also improves the ex ante production efficiency since the equilibrium overinvestment in effort is reduced. In fact, the entrepreneur's ex ante welfare is maximized when the signal is completely uninformative. This is similar to a result in Verrecchia [1990].

The next section explains the basic elements of the model. Section 3 provides an analysis of the entrepreneur's costly acquisition and discretionary disclosure of private information. Section 4 examines how the entrepreneur's ex ante effort decision is linked to the ex post incentive problems.

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[2] Jung and Kwon [1988] consider a setting in which a firm's manager, who is potentially endowed with private information about the firm's future value, makes a disclosure decision to maximize the firm's current market price. Here, I consider a setting in which an entrepreneur wants to sell his/her firm at a maximum price and thus has the same disclosure objective as that of the manager in Jung and Kwon's model. However, as explained below, the key difference is that the entrepreneur in my model also decides how much effort to provide and whether to acquire private information before making any disclosure decision. See section 2 for a full description of the model.

[3] The information in this study, which is about the random state of nature that affects the firm's future income, has no intrinsic value since all parties in the model are risk-neutral and having such information does not improve the firm's productive efficiency. See section 3.1 for the first-best setting, in which the entrepreneur does not acquire any costly information and chooses the effort that maximizes the firm's expected future income net of the cost of effort.

2. *The Model*

Consider a setting in which a risk-neutral entrepreneur wants to sell his/her firm for a liquidity reason to risk-neutral investors in a competitive capital market. The firm's future income, x, is affected by the entrepreneur's effort, e, and the random state of nature, ε_x. In particular, assume that:

$$x = e + \varepsilon_x, \tag{1}$$

where $e \in [\underline{e}, \bar{e}]$ with $\underline{e} > 0$ and $\varepsilon_x \sim N(0, \sigma_x^2)$. The entrepreneur's productive effort e is provided before the sale of the firm, whereas ε_x is realized after the sale. The cost of effort is denoted by an increasing and convex function $C(e)$, which satisfies $C(\underline{e}) = C'(\underline{e}) = 0$ and $C'(e) \to \infty$ as $e \to \bar{e}$. To focus on the entrepreneur's acquisition and discretionary disclosure of private information and its consequences for the firm's production efficiency, we assume that e is publicly observable.

The entrepreneur, after providing e, can obtain imperfect information about x (actually about ε_x) at some cost $I \in [0, \bar{I}]$, whereas it is prohibitively costly for investors to acquire such information directly. In particular, we assume that if the entrepreneur invests I, s/he subsequently receives a private signal, y, which is defined by:

$$y = e + \varepsilon_y, \tag{2}$$

where $\varepsilon_y \sim N(0, \sigma_y^2)$ with $\sigma_y^2 > \sigma_x^2$ and $\rho \equiv \mathrm{Corr}(\varepsilon_y, \varepsilon_x) \in (0, 1)$. If disclosed, y is naturally interpreted as an earnings forecast. However, as is explained below, the entrepreneur has complete discretion over the acquisition and disclosure of this forward-looking information, i.e., signal y.

The information acquisition cost, I, is assumed to be a random variable ex ante (i.e., before the entrepreneur chooses effort). Let F be the cumulative distribution function of I. Ex post (i.e., after e is chosen but before the sale of the firm), the entrepreneur privately observes the realization of I. If the entrepreneur invests I, s/he receives private signal y, as specified in (2), which s/he may or may not disclose subsequently. Otherwise, the entrepreneur receives no signal and cannot make any disclosure. As is standard in the literature (e.g., Verrecchia [1983; 1990], Dye [1985], and Jung and Kwon [1988]), any disclosed information is assumed to be truthful. Even though investors do not observe the realization of I, they know the entrepreneur's ex post opportunity to acquire private information and the distribution of I, and they have rational expectations about his/her incentive associated with discretionary disclosure. Given disclosure or nondisclosure of y, the investors price the firm. After the firm is traded, the firm's income x is realized and the firm is liquidated.

3. *Analysis*

3.1 THE FIRST-BEST CASE

Before proceeding to a formal analysis of the model, first consider a hypothetical case in which the entrepreneur commits *not* to acquire private information for any realization of I. In this first-best case (as is shown below), there is no efficiency loss. Note that if the entrepreneur in this case provides effort e, which is the mean of the firm's future income, the risk-neutral investors in the competitive capital market will price the firm at e. Thus, the entrepreneur's optimal effort, denoted by e^{FB} and referred to as the first-best effort, is a solution to:

$$\max_{e} V(e) \equiv e - C(e). \tag{3}$$

Given the assumptions on C, the solution to (3) is characterized by the first-order condition:

$$C'(e^{FB}) = 1. \tag{4}$$

The question is, "Will the first-best welfare, $V(e^{FB}) = e^{FB} - C(e^{FB})$, be attainable?" Expressed differently, "Is the entrepreneur's precommitment credible?" The subsequent analysis shows that the answer is "No." The entrepreneur's inability to make a credible commitment is due to an unavoidable ex post incentive. That is, when the information acquisition cost is small, the entrepreneur always has an incentive to acquire a private signal and disclose it selectively, taking advantage of investors' uncertainty about the information acquisition decision. Since investors rationally anticipate this ex post incentive and price-protect themselves accordingly, the entrepreneur bears the expected information acquisition cost—an efficiency loss—without gaining any benefit ex ante. In addition, the presence of the ex post incentive distorts the entrepreneur's equilibrium effort away from the first-best effort level, which gives rise to another efficiency loss. These two efficiency losses are inevitable in equilibrium, thereby reducing the entrepreneur's ex ante equilibrium welfare.

3.2 DISCRETIONARY DISCLOSURE OF PRIVATE INFORMATION AND EQUILIBRIUM FIRM VALUES

We derive the equilibrium of the model by using backward induction. In this section, assuming that the entrepreneur has provided effort e, we examine the informed entrepreneur's discretionary disclosure decision and the investors' pricing decision when they are unsure of the entrepreneur's informedness. First, suppose that signal y is disclosed. Observing y, the investors price the firm accordingly. It follows that the firm's competitive equilibrium price when y is disclosed, $P(y)$, is given by:

$$P(y) = E[x|y] = E[x] + \beta(y - E[y]) = \beta y + (1-\beta)e,^{4} \tag{5}$$

where $\beta \equiv \frac{\rho\sigma_x}{\sigma_y}$. The first equality holds because investors earn a zero expected profit in the competitive market, the second equality is due to the normality of (x, y), and the last equality is due to $E[x] = E[y] = e$.

[4] To be precise, the firm's market price is given by $P(y)$ in (5) if, and only if, $P(y)$ is nonnegative. We implicitly assume that e is sufficiently large so that the set of y such that $P(y) < 0$ has a negligibly small probability measure.

Since $\sigma_y^2 > \sigma_x^2$ and $\rho \in (0, 1)$, we must have $\beta \in (0, 1)$, which implies that the equilibrium price is a convex combination of the disclosed signal, y, and the entrepreneur's effort, e, where the weight to y is β.[5] Note that as $\beta \to 1$, $P(y) \to y$ for any given e, because $y = x$ almost surely; and as $\beta \to 0$, $P(y) \to e$ for any given y, because y conveys no information about x.[6] I refer to β as the informativeness of signal y about x, which varies from zero (the least informative case) to one (the most informative case).

If no signal is disclosed, investors cannot distinguish between the nondisclosure of an informed entrepreneur who withholds signal y and the nondisclosure of an uninformed entrepreneur. For a moment, let $q \in (0, 1]$ be the investors' belief that the entrepreneur has *not* acquired information (note that a full disclosure equilibrium prevails when $q = 0$). Given q, note that the competitive equilibrium firm value in the case of nondisclosure, P_n, is given by:

$$P_n = E[x \mid \text{nondisclosure}] = \frac{qe + (1-q)\int_{y \in ND} E[x|y]\, d\Phi(y)}{q + (1-q)\int_{y \in ND} d\Phi(y)}, \tag{6}$$

where (i) ND is the set of signals *not* disclosed by the informed entrepreneur, (ii) $E[x \mid y]$ is given by (5), and (iii) Φ is the cumulative distribution function of y. It follows from Jung and Kwon [1988] that, given e and $q \in (0, 1]$, there exists a unique cutoff value $y^o \equiv y^o(q, e) \in (-\infty, e)$, characterized by:

$$y^o = e - \frac{1-q}{q} \int_{-\infty}^{y^o} \Phi(y)\, dy, \tag{7}$$

such that the informed entrepreneur discloses signal y if, and only if, $y \geq y^o$. That is, the informed entrepreneur whose signal is favorable (in the sense of $y \geq y^o$) discloses it and sells the firm at the price of $P(y)$ given in (5), whereas the informed entrepreneur whose signal is unfavorable (i.e., $y < y^o$) withholds it and sells the firm at the price of P_n given in (6), where $ND = (-\infty, y^o)$. Note that since the cutoff value y^o is such that the informed entrepreneur whose signal is y^o is indifferent between disclosing and withholding that signal, i.e., $P(y^o) = E[x \mid y^o] = P_n$, (6) can be written as:

$$P_n = \beta y^o + (1-\beta)e, \tag{8}$$

where y^o is characterized by (7). Similarly to $P(y)$ given in (5), (8) shows that P_n is a convex combination of the cutoff signal, y^o, and the prior mean, e.

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[5] A caveat is that we take e as given here. As is shown later, e hinges upon β in equilibrium.

[6] From the definition of β, it is clear that $\beta \to 1$ if $\rho \to 1$ and $\sigma_y^2 \to \sigma_x^2$, and $\beta \to 0$ if $\rho \to 0$ or $\sigma_y^2 \to \infty$.

3.3 ENDOGENOUS ACQUISITION OF COSTLY PRIVATE INFORMATION

To investigate the entrepreneur's information acquisition decision, I derive the equilibrium probability that the entrepreneur is informed, $1-q$, which was taken as given in section 3.2. Suppose that the entrepreneur has provided effort e and privately observes information acquisition cost I. Since the entrepreneur does not know investors' beliefs about his/her informedness, let q^c be the entrepreneur's conjecture of q. Given q^c, define $y^c \equiv y^o(q^c, e)$, where $y^o(\cdot)$ is given by (7). Then, given y^c, it follows that the entrepreneur invests I to acquire signal y if, and only if:

$$P_n^c \leq [\Phi(y^c)P_n^c + \int_{y^c}^{\infty} P(y)\, d\Phi(y)] - I, \tag{9}$$

where $P(y)$ is given by (5) and $P_n^c \equiv P_n(y^c)$, with $P_n(\cdot)$ being given by (8). In words, (9) states that given his/her subsequent discretionary disclosure decision and investors' corresponding valuation of the firm, the entrepreneur will acquire signal y if, and only if, the expected firm value in the case of information acquisition less the information acquisition cost exceeds P_n^c. Rearranging (9) by using (5) and (8) yields:

$$I \leq I^o(y^c) \equiv \beta \int_{y^c}^{\infty} (y - y^c)\, d\Phi(y). \tag{10}$$

It is clear from (10) that the entrepreneur invests I if, and only if, the incremental benefit of acquiring signal y, represented by $I^o(y^c)$, exceeds the information acquisition cost. Therefore, $I^o(y^c)$ defines a cutoff value of the information acquisition cost, below which the entrepreneur obtains signal y.

In equilibrium, the entrepreneur's and investors' conjectures must be self-fulfilling, i.e., $q^c = q$. This implies that $y^o(q^c, e) = y^o(q, e)$, that is, $y^c = y^o$, which further implies that $I^o(y^c) = I^o(y^o) \equiv I^o$, and hence $q = 1 - F(I^o)$. Consequently, it follows from (7) and (10) that the equilibrium pair of cutoff values, which is denoted by (I^{o*}, y^{o*}), is characterized by:

$$y^{o*} = e - \frac{F(I^{o*})}{1 - F(I^{o*})} \int_{-\infty}^{y^{o*}} \Phi(y)\, dy \tag{11}$$

$$I^o = \beta \int_{y^{o*}}^{\infty} (y - y^{o*})\, d\Phi(y). \tag{12}$$

PROPOSITION 1. The equilibrium cutoff value for acquiring private signal y must be in the interior: That is, $I^{o*} \in (0, \bar{I})$.

The significance of Proposition 1 is that when the information acquisition decision is endogenous, the cases in which the entrepreneur is always informed (i.e., $I^{o*} = \bar{I}$) or never informed (i.e., $I^{o*} = 0$) cannot prevail in equilibrium. The proof goes as follows.[7] Suppose that $I^{o*} = \bar{I}$. This cannot be sustained in a rational expectations economy. To see why,

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[7] The proof presumes that, in the case of a full disclosure equilibrium, any unexpected nondisclosure of a signal induces investors to price the firm at $E[P(y)] = e$, as assumed in

note that if the entrepreneur is always informed, we must have a full disclosure equilibrium, in which case the expected value of the firm is equal to e (recall that $E[P(y)] = E[E[x \mid y]] = e$). However, if the signal—whatever it will be—is always disclosed, the entrepreneur has no incentive to acquire the costly signal since, by not acquiring any signal and making no disclosure, s/he can sell the firm for e. On the other hand, suppose $I^{o*} = 0$. Then, note that we must have $y^{o*} = e$ in (11) since $F(0) = 0$. However, when $I^{o*} = 0$ and $y^{o*} = e$, we must have $0 = \beta\int_e^\infty (y - e)\,d\Phi(y) > 0$ in (12), which is a contradiction.

Proposition 1 formalizes why the entrepreneur, before observing the information acquisition cost, cannot credibly commit not to acquire information, as informally discussed in section 3.1. The intuition is that, as shown in the proof, the entrepreneur has an incentive to renege on his/her initial commitment whenever the information acquisition cost is less than $\beta\int_e^\infty (y - e)\,d\Phi(y) > 0$, which is the incremental benefit from acquiring and disclosing signal y if, and only if, $y \geq e$.

Solving (11) and (12) explicitly for the equilibrium pair of cutoff values, (I^{o*}, y^{o*}), is not tractable in general. However, assuming that the equilibrium is stable and using the implicit function theorem, one can show that I^{o*} is decreasing in e, i.e., $\frac{dI^{o*}}{de} < 0$. For the economics behind this result, it is useful first to note that I^{o*} and y^{o*} are inversely related. To explain why, suppose that the entrepreneur is more likely to be informed, i.e., I^{o*} increases. Then, in the absence of disclosure, investors price the firm at a lower value, which motivates the informed entrepreneur to disclose the signal more often, i.e., y^{o*} decreases. Conversely, suppose that y^{o*} increases, which implies that the informed entrepreneur is less likely to disclose his/her signal after receiving one. This reduces the entrepreneur's incentive to acquire the costly signal, which results in a decrease in I^{o*}. Now consider a change in e, which is the prior mean of the firm's future income. Holding I^{o*} constant, note that an increase in e has a positive effect on the right-hand side of (11), which results in an increase in y^{o*} that satisfies (11). The intuition is as follows. Note that, ceteris paribus, the firm value in the case of nondisclosure is larger when e is higher (see P_n in (8) with y^o being fixed). This implies that when e is higher, the informed entrepreneur has more leeway to withhold unfavorable private signals, which translates into an increase in y^{o*}. On the other hand, holding y^{o*} constant, observe that the right-hand side of (12), which is the incremental benefit of acquiring signal y, is not affected by a change in e. The reason is that, given the cutoff value, the effects of an

Grossman [1981] and Milgrom [1981]. On the other hand, in the case of a nondisclosure equilibrium, any unexpected disclosure of signal y induces investors to price the firm at $P(y)$ in (5), which must be the case since any disclosed signal is assumed to be truthful.

increase in e on $P(y)$ and P_n are the same (see (5) and (8)), which implies that the incremental benefit of acquiring private information is independent of e, as shown in (10). Therefore, it follows that an increase in e results in an increase in y^{o*}, and this in turn reduces I^{o*} due to y^{o*}'s inverse relation with I^{o*}.

4. *Entrepreneur's Effort Choice*

The information acquisition and discretionary disclosure equilibrium derived in the previous section hinges upon the entrepreneur's productive effort, e. In this section, I examine how the entrepreneur's ex post acquisition and discretionary disclosure of private information affect his/her ex ante effort choice, which determines the mean of the firm's future income. Formally, note that the entrepreneur's ex ante effort choice is a solution to the following program:

$$\max_e \Pi = \{F(I^{o*})[\Phi(y^{o*})P_n + \int_{y^{o*}}^{\infty} P(y)\, d\Phi(y)] + [1 - F(I^{o*})]P_n\} - C(e) - \int_0^{I^{o*}} IdF(I)$$

subject to: (y^{o*}, I^{o*}) solves (11) and (12).

The expression in the curly brackets in the objective function is the weighted average of the firm's expected market prices, reflecting that (i) the entrepreneur invests I when, and only when, I is less than I^{o*}; and (ii) the expected market price in the case of acquiring signal y is $[\Phi(y^{o*})P_n + \int_{y^{o*}}^{\infty} P(y)\, d\Phi(y)]$ (recall that y is disclosed if, and only if, $y \geq y^{o*}$), whereas the firm value is P_n if I is not invested. The remaining terms are the entrepreneur's effort cost and the expected information acquisition cost. The constraint requires that the entrepreneur's information acquisition and disclosure decisions be sequentially rational, given investors' rational pricing of the firm in the competitive capital market.

Substituting (5) and (8) into the objective function and using (6) along with $q = 1 - F(I^{o*})$, $ND = (-\infty, y^{o*})$, $E[x \mid y] = P(y)$ for $y \geq y^{o*}$, and $E[P(y)] = e$, the above program reduces to:

$$\max_e \Pi = e - C(e) - \int_0^{I^{o*}} IdF(I) = V(e) - \int_0^{I^{o*}} IdF(I)$$

subject to: I^{o*} solves (11) and (12).

Note that the entrepreneur's ex ante effort choice is linked to the ex post information acquisition and disclosure decisions because of the expected information acquisition cost, $\int_0^{I^{o*}} IdF(I)$, where I^{o*} depends on e through (11) and (12). Thus, when choosing an effort level, the entrepreneur not only considers its effect on the firm's expected future income less the cost of effort, $V(e) = e - C(e)$, but also takes into account its consequences on the ex post information acquisition and discretionary disclosure decisions.

It is evident that two kinds of efficiency loss arise from the entrepreneur's ex post opportunity to acquire private information and exercise discretion over disclosure. The first is the expected information acquisition cost, which cannot be zero since $I^{o*} > 0$ for any given e (see Proposition 1). The second efficiency loss arises because the entrepreneur's effort is distorted away from the first-best effort e^{FB} that maximizes $V(e)$. Specifically, assuming that C is sufficiently convex in e so that the objective function is concave in e, note that the equilibrium effort, e^*, is characterized by the first-order condition:

$$C'(e^*) = 1 - I^{o*}f(I^{o*})\frac{dI^{o^*}}{de}, \tag{13}$$

where $f \equiv F'$ is the probability density function of I. Given the comparative static result at the end of section 3.3, $\frac{dI^{o^*}}{de} < 0$, we obtain:

PROPOSITION 2. The entrepreneur's equilibrium effort, e^*, is strictly greater than the first-best effort, e^{FB}.

Comparing the right-hand side of (13) with that of (4) shows that the overprovision of effort (compared with the first-best effort) is driven by the marginal savings on the expected information acquisition cost. As explained earlier, the entrepreneur has an unavoidable ex post incentive to acquire and make a discretionary disclosure of private information. Since rational investors price the firm in anticipation of such an incentive, the entrepreneur bears the expected information acquisition cost without any benefit, ex ante. This motivates the entrepreneur to choose effort in a way that leads to less frequent information acquisition, ex post. Given that an increase in effort reduces the cutoff value of the information acquisition cost, the entrepreneur overprovides effort. Note that even though the equilibrium effort optimally trades off its effects on $V(e)$ and the expected information acquisition cost, the entrepreneur's equilibrium welfare is strictly less than that in the first-best case, i.e., $\Pi(e^*) < V(e^{FB})$.

PROPOSITION 3. The entrepreneur's ex ante welfare is maximized when the signal is least informative.

This result is intuitive given the incentive structure of the model. Recall that the entrepreneur is ex ante best off if s/he does not acquire any private information ex post (section 3.1), but s/he cannot credibly precommit to do so (Proposition 1). This not only imposes the expected information acquisition cost on the entrepreneur but also gives rise to an efficiency loss in the effort choice (Proposition 2). Nonetheless, it is noteworthy that the entrepreneur's incentive to acquire a costly signal becomes weaker as the signal becomes less informative. Formally, it can be readily seen in (12) that $I^{o*} \to 0$ as $\beta \to 0$, because the incremental benefit from acquiring costly signal y diminishes as $\beta \rightarrow 0$. This implies that the expected information acquisition cost is reduced to zero. Furthermore, as $I^{o*} \rightarrow 0$, it is evident in (13) that the equilibrium effort e^* approaches the first-best effort e^{FB}, given by (4). This eliminates the inefficiency in the entrepreneur's productive effort choice. It thus follows that the entrepreneur's ex ante welfare is maximized when the signal is completely uninformative.

In a different setting, Proposition 3 parallels corollary 5 in Verrecchia [1990]. Verrecchia shows that if the manager in his model (whose objective is to maximize the firm's market price) can choose the quality of a signal (measured by the precision of the signal), it is optimal for the manager to precommit to a zero precision. That is, if the manager is given an option to choose whether to be informed, s/he is ex ante best off by choosing to be uninformed, as is the entrepreneur in the first-best case of this paper. The driving force in Verrecchia's [1990] result is that the more informative the manager's private signal, the more likely s/he is to disclose it. However, disclosure of the private signal reduces the firm value in Verrecchia's model by an exogenous amount, referred to as proprietary costs. On the other hand, the efficiency gain from a less informative signal in the present study is due to the fact that, as the signal becomes less informative, the entrepreneur acquires costly information less often, thereby lowering the expected information acquisition cost and improving the efficiency in the entrepreneur's productive effort choice.

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