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Disclosure Decisions by Firms and the Competition for Price Efficiency

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ABSTRACT

This paper develops a model of the relationship between investment decisions by firms and the efficiency of the market prices of their securities. It is shown that more efficient security prices can lead to more efficient investment decisions. This provides firms with the incentive to increase price efficiency by voluntarily disclosing information about the firm. Disclosure decisions are studied. It is shown that firms may expend more resources on disclosure than is socially optimal. This is in contrast to the concern implicit in mandatory disclosure rules that firms will expend too few resources on disclosure.

THIS PAPER DEVELOPS A model of the relationship between firms' investment decisions and the efficiency of the market prices of their securities. It is shown that more efficient security prices can lead to more efficient investment decisions. This provides firms with the incentive to increase price efficiency by voluntarily disclosing information about the firm. Disclosure decisions are studied.

The costs of disclosure are twofold. First, there are costs of producing and disseminating the information. Included here are opportunity costs of firms' employees, auditing and legal expenses, costs of printing and distribution, and costs associated with the release of any proprietary information. Second, there are traders' costs of assimilating the information. For instance, while it is not very costly to obtain a firm's $8-K$ and $10-K$ (once produced), it is quite costly to understand the implications of their contents. While the former costs have been recognized in the literature on disclosure, the latter costs have not. That is, while traders are sometimes viewed as having access to some costly information, the information contained in firms' disclosures is typically taken to be costlessly observed by all (see for instance Diamond (1985) and Dye (1987)).[1]

Taking traders' costs of learning the information content of firms' disclosures into account leads to new conclusions regarding incentives to expend resources on disclosure. In particular, it is shown that firms may spend more on disclosure than is socially optimal. This overdisclosure results from firms competing for the attention of traders. This is an interesting result given the public policy concern that firms, on their own, will spend less on disclosure than is socially optimal—

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[1] The distinction between producing and assimilating information is also made by Merton (1987). It is used to motivate the idea that firms have "limited investor bases," and the implications for asset pricing are analyzed.

witness the enactment and survival of the Securities Act of 1933 and the Securities Exchange Act of 1934. These securities laws form the basis for mandatory disclosure for publicly-held firms.

The nature of the model is as follows. Managers of firms make investment decisions that are not observed by the market. This unobservability induces less investment than is efficient. This underinvestment problem is less severe the more efficient is a firm's stock price. More efficient prices are more sensitive to the chosen investment level, and thus provide greater incentives to invest. Interestingly, the information contained in the stock price is itself, of no use to the management. It is the presence of the information in the market, and the efficient pricing of shares that is beneficial.[2]

In an attempt to increase price efficiency, firms expend resources on disclosure. A disclosure is a signal that contains information on future cash flows, and the greater the expenditure on disclosure, the more informative the signal. Once firms have made their disclosure decisions, traders determine which firms' disclosures to observe. It is assumed that it is too costly for a trader to study the disclosures of every firm. After traders observe firms' disclosures, trading in a securities market takes place. In the securities market, price efficiency is increasing in both the informativeness of the signal made available to traders and the number of traders who observe the signal.

The incentive for firms to spend too much on disclosure arises as a result of the interaction between firms' disclosure decisions, traders' information acquisition decisions, and price efficiency. While a firm independently determines how informative its own disclosure is, the determination of the number of traders who study its disclosure depends on the disclosure decisions of other firms. Since traders cannot study every firm, firms must compete for the attention of traders. Other things equal, the more informative the disclosure of a given firm, the more profitable it is for a trader to study the disclosure and trade on the information. So a given firm can attract traders from other firms, and makes its own share price more efficient, by making a more informative disclosure.[3] This competition for traders may lead to an equilibrium in which firms provide more informative disclosures than is socially optimal.[4]

The remainder of the paper is organized as follows. Section I presents the model and the securities market equilibrium. Section II analyzes firms' investment incentives. Section III analyzes firms' disclosure decisions. Section IV concludes the paper.

[2] This investment problem is similar to that studied by Grossman and Hart (1982). In both analyses, investment decisions are unobservable. There it is shown that if the manager faces a bankruptcy cost, the issuance of debt induces the manager to make a more efficient investment decision. Here, an increase in the efficiency of the market's pricing of the firm's shares induces the manager to make a more efficient investment decision.

[3] This is in contrast to Diamond (1985), Fama and Laffer (1971), and Hakansson (1977) where disclosure deters traders from expending resources on information collection for speculative purposes. This is because traders observe a firm's disclosure costlessly and are deterred from expending resources on other information sources. In these studies, price efficiency offers no social benefit so discouraging information collection is beneficial. See also Hirshleifer (1971).

[4] For discussions of positive externalities associated with disclosure, see Beaver (1977) and Easterbrook and Fischel (1984). These may arise if one firm's disclosure provides information about another firm.

I. The Model and Securities Market Equilibrium

A. The Model

Consider a three-date model with an investment and disclosure decision by firms, information acquisition and trading decisions by traders, and a price determination by a market maker. First consider the firms. There are I all-equity firms, each with a manager whose objective is to maximize the expected wealth of current shareholders, who are risk neutral. At date 1, firm i consists of m_i in cash, observed only by the manager, and a project which pays θ_i at date 3, where $\tilde{\theta}_i$ is normally distributed with mean $\overline{\theta}_i$ and precision (inverse of the variance) h_θ. The manager of firm i chooses $\overline{\theta}_i$ by investing $C(\overline{\theta}_i)$, where $C' \geq 0$, $C'' > 0$, $C'(0) = 0$, and $C'(\overline{\theta}_i) = 1$ for some $\overline{\theta}_i$; the expected marginal product of investment is positive but decreasing. The choice of $\overline{\theta}_i$ is observed only by the manager.

In addition to making this investment decision, a manager releases information. Specifically, the signal $\tilde{s}_i = \theta_i + \tilde{\varepsilon}_i$ is generated, where $\tilde{\varepsilon}_i$ is normally distributed with mean 0, precision τ_i, and $\mathrm{cov}(\tilde{\theta}_i, \tilde{\varepsilon}_j) = \mathrm{cov}(\tilde{\varepsilon}_j, \tilde{\varepsilon}_k) = 0$, for all $i, j, k \neq j$. The manager determines the precision of this disclosure. For simplicity, assume that τ_i takes one of two values, τ_H or τ_L where $\tau_H > \tau_L > 0$. The cost of precision τ_i is given by $D(\tau_i)$, where $D(\tau_H) > D(\tau_L) \geq 0$. The choice of τ_i is observed by all. The signal can be thought of as a corporate disclosure such as an annual report or quarterly earnings statement, whose informativeness increases as more resources are expended on its production.

The investment in the project and the expenditure on disclosure are made at date 1 out of the firm's cash holdings. Any remaining cash is distributed as a dividend to shareholders. Note that since initial cash holdings are unobservable, the market cannot directly infer the investment decision from the dividend. At date 2, after the investment and disclosure decisions are made, there is a market in firms' shares. Assume that in this market, current shareholders liquidate their positions in the firms. Thus a manager's objective is to maximize the dividend plus the expectation of the date 2 share price (discounting between dates is ignored).[5]

There are N risk-neutral traders who can study firms' disclosures prior to trading. Assume that a trader can observe the disclosure of one firm costlessly, but observing the disclosures of additional firms is prohibitively costly. This captures the idea that even though firms make their disclosures publicly available, it is increasingly costly to study these disclosures. If a trader studies firm i, he observes s_i. Note that all traders who study firm i observe the same signal. Traders decide which firm to study based on their ex ante assessments of the value of information, which is determined endogenously. Let n_i denote the number of traders who study firm i. After informed traders study firms' disclosures, they make trading decisions.

The modeling of the securities market follows Admati and Pfleiderer (1988) and Kyle (1984, 1985). Informed traders and liquidity traders (whose demands for shares are determined exogenously) submit market orders to a risk-neutral,

[5] If shareholders liquidate only a fraction of their holdings, then the manager would maximize the dividend plus a weighted average of the expectations of the date 2 and date 3 share values. The qualitative results of the analysis would be unchanged.

competitive market maker. The market maker observes the total order flow for the shares of each firm, takes the position that balances supply and demand, and sets the share prices. Prices are set so that the market maker earns a zero expected profit on all shares.

Assume that traders follow symmetric strategies. Let x_i denote the market order for the shares of firm i by a trader who studied firm i. (Informed traders trade only the shares of the firm that they have studied since trading the shares of other firms is unprofitable). Let z_i denote the net market order for the shares of firm i by the liquidity traders, where $\tilde{z}_i$ is normally distributed with mean zero, precision h_z, and $\text{cov}(\tilde{\theta}_j, \tilde{z}_i) = \text{cov}(\tilde{\varepsilon}_j, \tilde{z}_i) = \text{cov}(\tilde{z}_i, \tilde{z}_k) = 0$ for all $i, j, k \neq i$. Let p_i denote the price of shares of firm i.

The sequence of events is summarized as follows:

Date 1: Manager i chooses $\overline{\theta}_i$ and τ_i, and pays out the dividend $m_i - C(\overline{\theta}_i) - D(\tau_i)$.

Date 2: (i) Informed traders observe $\tau_1, \tau_2, \cdots, \tau_I$, and choose which firm to study. Traders who choose to study firm i, observe s_i and submit market order x_i.

(ii) Liquidity traders submit net market order z_i.

(iii) The market maker takes the position that balances the supply and demand for the shares of firm i and sets a price of p_i. Original shareholders of firm i receive p_i.

Date 3: The value θ_i is realized.

An overall equilibrium consists of three parts: (i) a solution to the manager's optimization problem, i.e., maximize $E[\tilde{p}_i] - C(\overline{\theta}_i) - D(\tau_i)$, (ii) an equilibrium distribution of traders across firms, i.e., $n_1, n_2, \cdots, n_I$, and (iii) a securities market equilibrium. We first consider the securities market equilibrium, taking $\overline{\theta}_i$, τ_i, and n_i, for all i, as given. Then we use the resulting securities market equilibrium to determine the equilibrium level of investment taking τ_i and n_i as given. Finally, we determine the equilibrium disclosure decisions by firms and the distribution of traders across firms.

B. The Securities Market Equilibrium

A Nash equilibrium among traders is considered. Let $X_i(s_i)$ denote an informed trader's trading strategy for the shares of firm i; X_i specifies the trader's market order as a function of the signal observed (x_i denotes the actual order). Let $P_i(n_i x_i + z_i)$ denote the pricing function used by the market maker; P_i specifies the share price as a function of the order flow (p_i denotes the actual price).

A securities market equilibrium in the shares of firm i consists of a trading strategy X_i and a pricing function P_i such that (i) X_i maximizes each informed trader's expected payoff taking the other traders' strategies and P_i as given, and (ii) P_i is the expected value of share i conditional on the information contained in the order flow. Note that informed traders take the effect of their trades on price into account (they take the pricing function, but not the price, as given).

The value of firm i's shares depends on $\overline{\theta}_i$. Since traders and the market maker do not observe the manager's choice of $\overline{\theta}_i$, they must form some conjecture about its value. Let $\bar{\theta}_i^c$ denote their conjecture. Assume that the market's conjecture is rational in the sense that even though the market does not observe a firm's investment decision, in equilibrium, the conjecture is correct.

As shown by Admati and Pfleiderer (1988) and Kyle (1984), there is a unique securities market equilibrium in which (i) informed traders' strategies are symmetric, linear functions of the signals they observe, and (ii) the pricing function for firm i is linear in the order flow for the shares of firm i. Lemma 1 presents this equilibrium.

LEMMA 1: *There is a unique symmetric, linear equilibrium with*

$$X_i(s_i) = \beta_{0i} + \beta_{1i}s_i, \tag{1}$$

$$P_i(n_ix_i + z_i) = \lambda_{0i} + \lambda_{1i}(n_ix_i + z_i), \tag{2}$$

where

$$\beta_{1i} = \left\{\frac{\tau_i h_\theta}{n_i h_z(\tau_i + h_\theta)}\right\}^{1/2},$$

$$\beta_{0i} = -\beta_{1i}\bar{\theta}_i^c,$$

$$\lambda_{0i} = \bar{\theta}_i^c,$$

$$\lambda_{1i} = \frac{1}{n_i + 1}\left\{\frac{\tau_i n_i h_z}{h_\theta(\tau_i + h_\theta)}\right\}^{1/2}.$$

Proof: See Appendix.

Informed traders take a long (short) position in the shares of firm i if the signal, s_i, is higher (lower) than the prior mean of share value, $\bar{\theta}_i^c$. The price of the shares of firm i, for realizations of $\tilde{s}_i$ and $\tilde{z}_i$, is found by substituting (1) into (2). The resulting price is:

$$p_i = \bar{\theta}_i^c\frac{h_\theta}{h_\theta + \phi(\tau_i, n_i, h_\theta)} + \left(s_i + \frac{z_i}{n_i\beta_{1i}}\right)\frac{\phi(\tau_i, n_i, h_\theta)}{h_\theta + \phi(\tau_i, n_i, h_\theta)}, \tag{3}$$

where

$$\phi(\tau_i, n_i, h_\theta) = \frac{\tau_i n_i h_\theta}{\tau_i + h_\theta + n_i h_\theta}.$$

In equilibrium, the order flow for the shares of firm i is $n_i\beta_{1i}(\tilde{s}_i - \bar{\theta}_i^c) + \tilde{z}_i$. Since the market maker knows traders' strategies, observing the order flow is equivalent to observing $s_i + z_i/n_i\beta_{1i}$. The equilibrium price is a weighted average of $\bar{\theta}_i^c$, the market's prior expectation of share value, and the signal derived from the order flow. The precision of the posterior distribution of $\tilde{\theta}_i$ equals the sum of the precision of the prior distribution of $\tilde{\theta}_i$, h_θ, and the precision of the distribution of the signal generated by the order flow conditional on $\tilde{\theta}_i$, $\phi(\tau_i, n_i, h_\theta)$.

Increases in τ_i and n_i increase the precision $\phi(\tau_i, n_i, h_\theta)$. An increase in the informativeness of the signal observed by informed traders has two effects. First, it increases the responsiveness of informed traders' orders to a given s_i. This makes the aggregate order flow a less noisy signal on s_i, since the orders of the liquidity traders become a smaller fraction of the total. Second, s_i becomes a less noisy signal on θ_i. Both effects serve to increase $\phi(\tau_i, n_i, h_\theta)$. An increase in the number of informed traders also increases the responsiveness of the aggregate order flow to s_i (though individual traders' orders become less responsive). By (3), an increase in $\phi(\tau_i, n_i, h_\theta)$ increases the weight given to the signal generated by trading.

II. Investment Decisions

This section examines the effect of price efficiency on investment incentives. At date 1, managers make disclosure and investment decisions. Although the decisions are made simultaneously, it is easier to consider the managers' investment problem first, taking τ_i and n_i as given. This yields an optimal investment policy as a function of τ_i and n_i. Then firms' choices of τ_i and the determination of n_i is considered.

Consider manager i's investment problem taking τ_i, n_i, and the market's conjecture, $\bar{\theta}_i^c$, as given. His or her objective is to maximize expected share price less outlays. That is, using (3),

$$\max_{\bar{\theta}_i} \bar{\theta}_i^c \frac{h_\theta}{h_\theta + \phi(\tau_i, n_i, h_\theta)} + \bar{\theta}_i \frac{\phi(\tau_i, n_i, h_\theta)}{h_\theta + \phi(\tau_i, n_i, h_\theta)} - C(\bar{\theta}_i) - D(\tau_i). \tag{4}$$

The benefit of increasing $\bar{\theta}_i$ is that it raises the expected share price. The manager's optimal choice of $\bar{\theta}_i$ satisfies

$$\frac{\phi(\tau_i, n_i, h_\theta)}{h_\theta + \phi(\tau_i, n_i, h_\theta)} = C'(\bar{\theta}_i). \tag{5}$$

Let $\bar{\theta}^*(\tau_i, n_i)$ denote this optimal choice. The manager's choice is below the first-best level which satisfies $C'(\bar{\theta}_i) = 1$. The marginal benefit of investment equals the weight placed on the signal generated by the trading process. Since the signal is noisy, this weight is less than one. This is why price efficiency is important for investment decisions. The more sensitive share price is to investment, the greater is the incentive to invest. This is reflected in the fact that $\bar{\theta}^*$ is increasing in $\phi(\tau_i, n_i, h_\theta)$, and thus increasing in τ_i and n_i.

As mentioned above, the market's conjecture is rational. Therefore, for a given τ_i and n_i, the market's conjecture satisfies $\bar{\theta}_i^c = \bar{\theta}^*(\tau_i, n_i)$. The expected share price less outlays, given this investment policy, is found by substituting $\bar{\theta}^*(\tau_i, n_i)$ in for $\bar{\theta}_i^c$ and $\bar{\theta}_i$ in the objective function of (4). This yields

$$V(\tau_i, n_i) = \bar{\theta}^*(\tau_i, n_i) - C(\bar{\theta}^*(\tau_i, n_i)) - D(\tau_i). \tag{6}$$

Since investment is below the first-best level, and since $\bar{\theta}^*$ is increasing in τ_i and n_i, it follows from (6) that if a firm could costlessly increase the informativeness of its disclosure (holding the number of traders constant) it would benefit from doing so. Also, a firm benefits from more informed traders trading in its shares. Now consider firms' choices of τ_i and the determination of n_i.[6]

[6] This investment problem is similar to the incentive problem studied by Holmstrom (1982). There, a worker's output is a function of ability, effort, and a random shock. The market, however, only

III. Disclosure Decisions and the Competition for Price Efficiency

Prior to trading, informed traders decide which firm to study. Their decisions depend on the expected profitability of studying the various firms, which depends on the securities market equilibrium. Lemma 2 gives the expected trading profits as a function of τ_i and n_i.

LEMMA 2: *If n_i traders study firm i and the precision of $\tilde{\varepsilon}_i$ is τ_i, then the expected payoff to each of these traders equals*

$$\pi(\tau_i, n_i) = \frac{1}{n_i + 1}\left\{\frac{\tau_i}{n_i(h_\theta + \tau_i)h_\theta h_z}\right\}^{1/2}.$$

Proof: See Appendix.

A trader's expected payoff is increasing in τ_i and decreasing in n_i. An increase in the precision of the disclosure augments the informational advantage of informed traders, and thus makes informed trading more profitable. The greater the number of informed traders, the more responsive the aggregate order flow is to the firm's disclosure. This links price more closely to the disclosure and thus makes informed trading less profitable.

In equilibrium, all traders study some firm and no trader has the incentive to study a different firm. Since $\pi(\tau_i, n_i)$ is decreasing in n_i and $\pi(\tau_i, 0) = \infty$, there is a unique equilibrium distribution of traders in which expected trading profits are equal across firms (ignoring the integer problem). That is, $\pi(\tau_i, n_i) = \pi(\tau_j, n_j)$ for all i and j, and $\sum n_i = N$. Let $n^*(\tau_i, I')$ denote the equilibrium number of traders that study a firm when it chooses τ_i and a total of I' firms choose τ_H. Notice that if firms make symmetric disclosure decisions, then informed traders evenly distribute across firms, i.e., $n^*(\tau_L, 0) = n^*(\tau_H, I) = N/I$. Also notice that holding other firms' disclosure decisions fixed, more traders study a given firm if it chooses τ_H as compared to τ_L, i.e., $n^*(\tau_H, I' + 1) > n^*(\tau_L, I')$. Finally, holding a given firm's disclosure decision fixed, more traders study that firm if fewer other firms choose τ_H, i.e., $n^*(\tau_i, I') > n^*(\tau_i, I'')$ if and only if $I' < I''$.

Consider a Nash equilibrium where each manager makes a disclosure decision taking other managers' disclosure decisions as given. In equilibrium, none of the firms that choose τ_H have an incentive to switch to τ_L and none of the firms that choose τ_L have an incentive to switch to τ_H. Formally, for $0 < I' < I$, it is a pure-strategy equilibrium for I' firms to choose τ_H and $(I - I')$ firms to choose τ_L if and only if

$$V(\tau_L, n^*(\tau_L, I')) \geq V(\tau_H, n^*(\tau_H, I' + 1)) \tag{7a}$$

and

$$V(\tau_H, n^*(\tau_H, I')) \geq V(\tau_L, n^*(\tau_L, I' - 1)). \tag{7b}$$

observes output and based on output, the market updates its beliefs about the worker's ability. The worker has the incentive to provide effort since it influences the market's beliefs about his ability. The greater the effect of output on the market's beliefs, the greater the incentive to work. Thus the worker works harder when there is more uncertainty about his ability. Here, the firm invests more when its cash flows are riskier, i.e., when h_θ is lower.

For $I' = 0$, only condition (7a) must be satisfied and for $I' = I$, only condition (7b) must be satisfied.

PROPOSITION 1: *There is always at least one pure-strategy equilibrium.*

Proof: Suppose there is no pure-strategy equilibrium. Then $V(\tau_L, n^*(\tau_L, 0)) < V(\tau_H, n^*(\tau_H, 1))$, or it would be an equilibrium for all firms to choose τ_L. This implies that (7b) is satisfied for $I' = 1$. Thus $V(\tau_L, n^*(\tau_L, 1)) < V(\tau_H, n^*(\tau_H, 2))$, or it would be an equilibrium for 1 firm to choose τ_H and $I - 1$ firms to choose τ_L. Repeating this argument $I - 2$ times leads to $V(\tau_L, n^*(\tau_L, I - 1)) < V(\tau_H, n^*(\tau_H, I))$. This implies that it is an equilibrium for all firms to choose τ_H, which is a contradiction. Q.E.D.

Equilibrium disclosure decisions can be compared to the social optimum. If I' firms choose τ_H and $I - I'$ choose τ_L, then the social surplus is given by

$$I' V(\tau_H, n^*(\tau_H, I')) + (I - I')V(\tau_L, n^*(\tau_L, I')). \tag{8}$$

Note that trading profits are not included in the social surplus since they are transfers between traders. Let I^* denote the value of $I' \in \{0, 1, \cdots, I\}$ that maximizes (8). Proposition 2 compares an equilibrium outcome to the social optimum.

PROPOSITION 2: *Firms' expenditures on disclosure either equal or exceed the socially optimal amount. That is, if it is an equilibrium for I' firms to choose τ_H and $I - I'$ firms to choose τ_L, then $I' \geq I^*$.*

Proof: If $I^* = 0$, then $I' \geq I^*$. Say $I^* > 0$. Since I^* is the social optimum,

$$I^* V(\tau_H, n^*(\tau_H, I^*)) + (I - I^*)V(\tau_L, n^*(\tau_L, I^*)) \geq IV(\tau_L, n^*(\tau_L, 0)),$$

which implies

$$I^* V(\tau_H, n^*(\tau_H, I^*)) + (I - I^*)V(\tau_L, n^*(\tau_L, 0)) > IV(\tau_L, n^*(\tau_L, 0)).$$

This implies that $V(\tau_H, n^*(\tau_H, I^*)) > V(\tau_L, n^*(\tau_L, 0))$. Thus, for $I' < I^*$, $V(\tau_L, n^*(\tau_L, I')) \leq V(\tau_L, n^*(\tau_L, 0)) < V(\tau_H, n^*(\tau_H, I^*)) \leq V(\tau_H, n^*(\tau_H, I' + 1))$. Therefore, it is not an equilibrium for I' firms to choose τ_H and $I - I'$ firms to choose τ_L. Q.E.D.

To understand this result, notice the negative externality. In choosing τ_i, manager i considers not only the direct effect of τ_i on $\phi(\tau_i, n_i, h_\theta)$, but also the indirect effect on $\phi(\tau_i, \mathrm{n}_i, \mathrm{h}_\theta)$ through n_i. A higher τ_i leads to more traders studying firm i, and fewer traders studying other firms. In effect, firms attempt to attract traders away from other firms. So while firm i's share price becomes more efficient with an increase in expenditure on disclosure, other firms' share prices become less efficient. This competition for price efficiency is responsible for the possible overdisclosure.[7]

[7] Similar effects would be obtained with more general specifications of traders' costs as long as the cost of studying additional firms is increasing. The specification used here, i.e., studying one firm is costless and studying additional firms is prohibitively costly, simplifies the analysis. The discussion of the social optimum would have to be modified though. If traders incur direct costs (here, a traders' cost of studying a firm is only the opportunity cost of not studying a different firm), these costs must be accounted for in the calculation of the social surplus.

For an example of overdisclosure, consider the two-firm case and suppose

$$V(\tau_H, n^*(\tau_H, 1)) > V(\tau_L, n^*(\tau_L, 0)) > V(\tau_H, n^*(\tau_H, 2)) > V(\tau_L, n^*(\tau_L, 1)).$$

Since $V(\tau_L, n^*(\tau_L, 0)) > V(\tau_H, n^*(\tau_H, 2))$, both firms would be better off if they choose τ_L as compared to both choosing τ_H. However, since $V(\tau_H, n^*(\tau_H, 1)) > V(\tau_L, n^*(\tau_L, 0))$, each firm has the incentive to choose τ_H if the other firm chooses τ_L. The only equilibrium is for both firms to choose τ_H.

Equilibria may be symmetric or asymmetric.[8] Since firms are ex ante identical, they all have the same value in a symmetric equilibrium. This is is not the case in an asymmetric equilibrium.

PROPOSITION 3: *In an asymmetric equilibrium, firms that spend more on disclosure have higher market values.*

Proof: Consider an asymmetric equilibrium in which I' firms choose τ_H. Condition (7b) and the fact that $V(\tau_L, n^*(\tau_L, I'-1)) > V(\tau_L, n^*(\tau_L, I'))$, imply that $V(\tau_H, n^*(\tau_H, I')) > V(\tau_L, n^*(\tau_L, I'))$. Q.E.D.

This result is similar to a standard disclosure result that more valuable firms disclose more information than less valuable firms; see, for instance, Verrecchia (1983). The causality is reversed though. Here, firms are ex ante identical and more disclosure leads to a more valuable firm by inducing more efficient investment. In Verrecchia, firms are not ex ante identical, and more valuable firms choose to disclose more information.

In general, it is difficult to say much about the effect of parameter changes on the equilibrium. This is illustrated by the following examples. Consider the two-firm case, where $C(\bar{\theta}_i) = c\bar{\theta}_i^2/2$ and $c > 0$. For this case,

$$\bar{\theta}^*(\tau_i, n_i) = \frac{\phi(\tau_i, n_i, h_\theta)}{c(h_\theta + \phi(\tau_i, n_i, h_\theta))},$$

and

$$V(\tau_i, n_i) = \frac{\phi(\tau_i, n_i, h_\theta)}{c(h_\theta + \phi(\tau_i, n_i, h_\theta))}\left\{1 - \frac{\phi(\tau_i, n_i, h_\theta)}{2(h_\theta + \phi(\tau_i, n_i, h_\theta))}\right\} - D(\tau_i),$$

where $\pi(\tau_1, n_1) = \pi(\tau_2, n_2)$, and $n_1 + n_2 = N$. Figure 1 shows $V(\tau_L, N/2)$ and $V(\tau_H, N/2)$, firm values in symmetric equilibria, for $\tau_L = 1$, $\tau_H = 2$, $h_z = 1$, $c = 0.01$, $N = 50$, $D(\tau_L) = 1$, and $D(\tau_H) = 10$, and for a range of values of $1/h_\theta$. The equilibria are indicated. For low-risk firms (i.e., low values of $1/h_\theta$), the equilibrium is one in which both firms choose τ_L. For intermediate-risk firms, both firms choose τ_H. For high-risk firms, the equilibrium is again, one in which both firms choose τ_L.

Figures 2 and 3 show $V(\tau_L, N/2)$ and $V(\tau_H, N/2)$ and show how the equilibrium varies depending on the number of traders. In Figure 2, $\tau_L = 1.9$, $\tau_H = 2.8$, $h_\theta = 5$, $h_z = 1$, $c = 0.01$, $D(\tau_L) = 0.99$, and $D(\tau_H) = 6.65$, and in Figure 3, $\tau_L = 1.5$, $\tau_H = 3$, $h_\theta = 1$, $h_z = 1$, $c = 0.01$, $D(\tau_L) = 1$, and $D(\tau_H) = 6$. For the parameter values

[8] Since firms are ex ante identical, if there is an asymmetric equilibrium, then there are multiple equilibria. For in an equilibrium where I' firms choose τ_H, the identity of the I' firms does not matter. More fundamentally, there may exist multiple equilibria in which aggregate expenditures on disclosure differ.

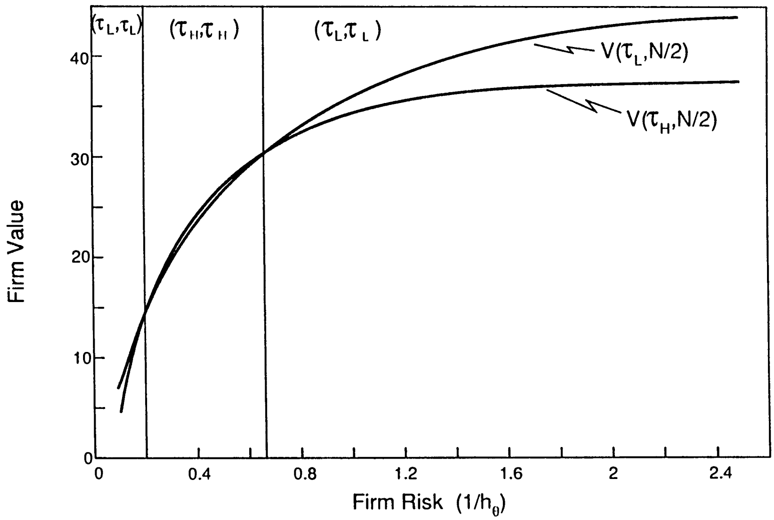

Figure 1. Two-firm example #1. Firm value as a function of the precision of its disclosure, $\tau_L = 1$ or $\tau_H = 2$, the number of traders who observe the disclosure, $N/2 = 25$, and firm risk, $1/h_\theta$, is shown. The equilibria for the various ranges of firm risk are indicated.

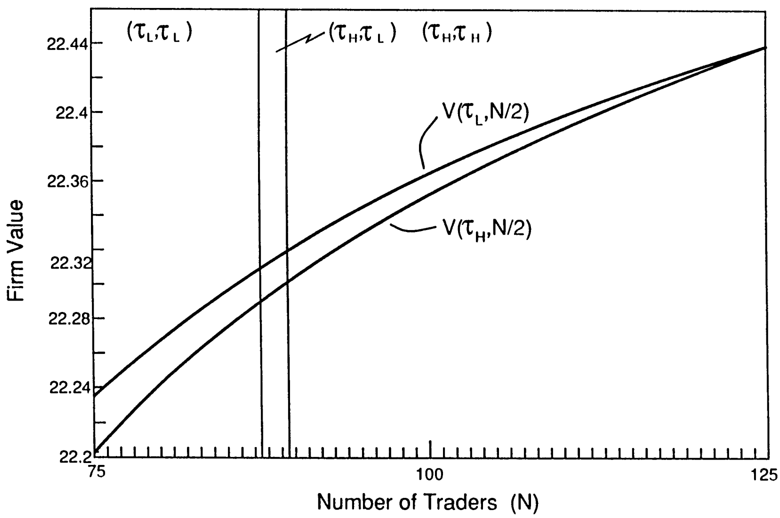

Figure 2. Two-firm example #2. Firm value as a function of the precision of its disclosure, $\tau_L = 1.9$ or $\tau_H = 2.8$, the number of traders who observe the disclosure, $N/2$, and firm risk, 0.2, is shown. The equilibria for the various ranges of the total number of traders, N, are indicated.

of Figure 2, when there are not many traders, both firms choose τ_L. For an intermediate range of traders, the equilibrium is asymmetric. When there are a large number of traders, both firms choose τ_H.

For the parameter values of Figure 3, it is almost the reverse situation. When there are not many traders, both firms choose τ_H. For an intermediate range of traders, there are two equilibria. It is an equilibrium for both firms to choose τ_L

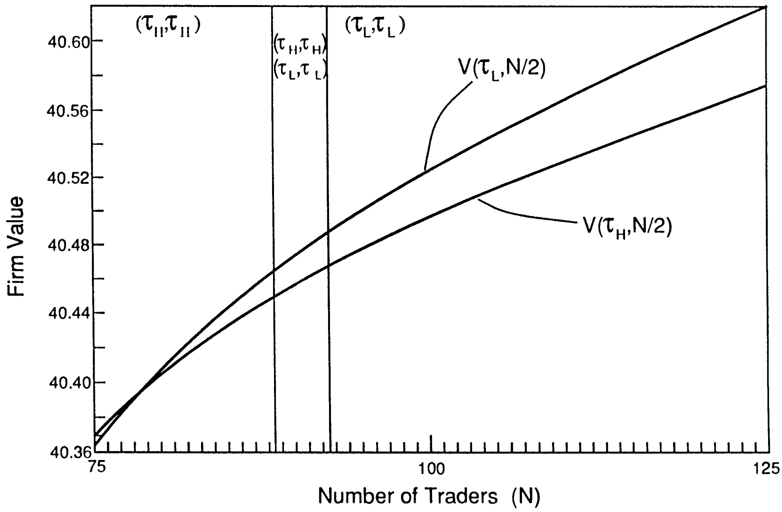

Figure 3. Two-firm example #3. Firm value as a function of the precision of its disclosure, $\tau_L = 1.5$ or $\tau_H = 3$, the number of traders who observe the disclosure, $N/2$, and firm risk, 1, is shown. The equilibria for the various ranges of the total number of traders, N, are indicated.

and it is an equilibrium for both firms to choose τ_H. When there is a large number of traders, both firms choose τ_L.

IV. Conclusion

Critics of mandatory disclosure regulations argue that firms have the incentive to disclose the appropriate amount of information—hence mandatory disclosure is a wasteful use of corporate resources. The main result of this paper reinforces this argument in the sense that firms may actually have the incentive to disclose too much information, and mandatory disclosure of additional information only aggravates the problem. Additional disclosure does increase the efficiency of prices, but the benefits do not justify the costs.[9]

The key feature of our model is a recognition of the costs traders incur when making use of publicly available information. It is assumed that traders face increasing costs in studying firms' disclosures. In practice, traders' costs may be more complicated. There may be costs of learning about a firm's industry as well as costs of learning about the firm itself. If so, then traders may face decreasing costs when studying firms in the same industry and increasing costs when studying firms in different industries. In such a case, both positive and negative externalities may be present. When one firm spends more on disclosure, other firms in the same industry may gain traders, while firms in other industries may lose traders.

[9] In practice, disclosure regulations not only specify the amount of information that should be disclosed, but also the type of information that should be disclosed. This paper deals only with the former issue. For an analysis of the latter issue, see Fishman and Hagerty (1989).

Appendix

Proof of Lemma 1: The subscript i, referring to firm i is suppressed in order to simplify the notation. Consider a pricing function

$$P(\textstyle\sum_j \tilde{x}_j + \tilde{z}) = \lambda_0 + \lambda_1(\textstyle\sum_j \tilde{x}_j + \tilde{z}), \tag{A1}$$

where λ_0 and λ_1 are constants, and trading strategies

$$X(\tilde{\theta} + \tilde{\varepsilon}) = \beta_0 + \beta_1(\tilde{\theta} + \tilde{\varepsilon}), \tag{A2}$$

where β_0 and β_1 are constants. Trader k, taking (A1) and (A2), for $j \neq k$, as given, solves the following problem:

$$\max_{x_k} E[x_k(\tilde{\theta} - \lambda_0 - \lambda_1((n-1)(\beta_0 + \beta_1(\tilde{\theta} + \tilde{\varepsilon})) + x_k + \tilde{z})) \mid \tilde{\theta} + \tilde{\varepsilon}],$$

which can be rewritten as

$$\max_{x_k} x_k\left[\frac{h_\theta \bar{\theta}^c + \tau(\tilde{\theta} + \tilde{\varepsilon})}{h_\theta + \tau} - \lambda_0 - \lambda_1((n-1)(\beta_0 + \beta_1(\tilde{\theta} + \tilde{\varepsilon})) + x_k)\right].$$

The solution to this problem is given by

$$x_k = \frac{\left[\dfrac{h_\theta \bar{\theta}^c}{h_\theta + \tau} - \lambda_0 - \lambda_1(n-1)\beta_0\right] + \left[\dfrac{\tau}{h_\theta + \tau} - \lambda_1(n-1)\beta_1\right][\tilde{\theta} + \tilde{\varepsilon}]}{2\lambda_1},$$

with the second-order conditions being satisfied if $\lambda_1 > 0$. The Nash equilibrium for the traders is found by setting

$$\beta_0 = \frac{\dfrac{h_\theta \bar{\theta}^c}{h_\theta + \tau} - \lambda_0 - \lambda_1(n-1)\beta_0}{2\lambda_1}$$

and

$$\beta_1 = \frac{\dfrac{\tau}{h_\theta + \tau} - \lambda_1(n-1)\beta_1}{2\lambda_1}$$

Solving these two equations yields

$$\beta_0 = \frac{\dfrac{h_\theta \bar{\theta}^c}{h_\theta + \tau} - \lambda_0}{\lambda_1(n+1)}$$

and

$$\beta_1 = \frac{\dfrac{\tau}{h_\theta + \tau}}{\lambda_1(n+1)}. \tag{A3}$$

Now consider the market maker's problem. Since he or she is competitive, the pricing rule must satisfy, using (A2),

$$\lambda_0 + \lambda_1\left(\sum_j \tilde{x}_j + \tilde{z}\right) = E[\tilde{\theta} \mid n(\beta_0 + \beta_1(\tilde{\theta} + \tilde{\varepsilon})) + \tilde{z}]. \tag{A4}$$

Substituting (A3) into (A4) and using Bayes' rule yields

$$\lambda_0 = \bar{\theta}^c$$

and

$$\lambda_1 = \frac{1}{n+1}\left[\frac{\tau n h_z}{h_\theta(h_\theta + \tau)}\right]^{1/2}. \tag{A5}$$

Substituting (A5) into (A3) yields

$$\beta_0 = -\bar{\theta}^c\left[\frac{h_\theta \tau}{n(h_\theta + \tau)h_z}\right]^{1/2}$$

and

$$\beta_1 = \left[\frac{h_\theta \tau}{n(h_\theta + \tau)h_z}\right]^{1/2}, \tag{A6}$$

which gives the unique linear symmetric equilibrium. Q.E.D.

Proof of Lemma 2: The proof follows directly from the substitution of β_{0i}, β_{1i}, λ_{0i}, and λ_{1i} into $E[(\beta_{0i} + \beta_{1i}(\tilde{\theta}_i + \tilde{\varepsilon}_i))(\tilde{\theta}_i - \lambda_{0i} - \lambda_{1i}(n_i(\beta_{0i} + \beta_{1i}(\tilde{\theta}_i + \tilde{\varepsilon}_i)) + \tilde{z}_i))]$. Q.E.D.

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