Endogenous Information Flows and the Clustering of Announcements [1]

by

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We consider the strategic timing of information releases in a dynamic disclosure model. Because investors don't know whether or when the firm is informed, the firm will not necessarily disclose immediately. We show that bad market news can trigger the immediate release of information by firms. Conversely, good market news slows the release of information by firms. Thus, our model generates clustering of negative announcements. Surprisingly, this result holds only when firms can preemptively disclose their own information prior to the arrival of external information. These results have implications for conditional variance and skewness of stock returns.

(JEL D8, G3, M4)

One of the most important ingredients to the process of price discovery in financial markets is the flow of new information. The importance of information flow is perhaps most apparent during times of market "crisis," when it often seems that bad news is being reported simultaneously from multiple sources. This clustering of news could occur because firms learn more during bad times, or because firms strategically time the release of information. Indeed, it has long been recognized in the literature that corporate news disclosures are controlled by self-interested agents, and a number of theoretical and empirical analyses have found support for the idea that given this discretion, managers may choose to delay the release of bad news.[2]

As hinted above, in addition to delays in the release of information, casual observation suggests that disclosures of bad news are often clustered in bad times. While it is not surprising that firms' news are affected by market and sector conditions (given the correlation of their cash flows), the *timing* of the announcements is suggestive that these disclosure decisions are not

[2] See for example Dye (1990), Rajan (1994), Dye and Sridhar (1995), Genotte and Trueman (1996), Burgstahler and Dichev (1997), and Shin (2003), among others. Empirical support can be found in Miller (2002) who compares voluntary disclosures by firms that enjoy strong earnings performance to firms that experience earnings declines. He finds an increase in voluntary disclosures during periods of increased earnings.

made independently. Indeed, recent empirical work by Tse and Tucker (2007), who employ a duration model to study whether managers "herd" in announcing earnings warnings, finds that earnings warnings within an industry are clustered and that firms speed up their warnings in response to poor market conditions. In contrast, they show that such clustering is asymmetric in that good news does not generate such clustering.

In this paper, we seek an endogenous explanation for this asymmetry in the clustering of disclosure of good and bad news. We study disclosure dynamics when a firm possesses information that is correlated with market conditions, and explore managers' incentives to delay the disclosure of bad news, as opposed to good news, until market conditions worsen and become public knowledge. In particular, we examine a dynamic game in which a manager of a firm decides when to report information regarding the value of the firm he manages. The manager maximizes the present value of her expected compensation, where the rate of compensation at each point in time is proportional to the market value of the firm conditional on public information. Because investors are uncertain whether a manager has learned the information, in equilibrium only those firms that have sufficiently positive news will release their information. Firms with more negative information will prefer to keep their market value higher – at least temporarily – by claiming that they do not yet have any information to report.

We then extend the model by supposing that in addition to the disclosure by the manager there is an external public signal about market conditions that will arrive at a future date. As alluded to earlier, while the timing of the firm's information is uncorrelated with market conditions, we assume the value of the firm is correlated with this market news. Therefore, the public news announcement will affect the market value of the firm. Our goal is to understand whether these interactions can lead to clustering in the *release* of information by firms even when the arrival of the underlying information is not clustered.

We begin our analysis in section I where we introduce a static framework which is the basis of our analysis. While our main contribution lies in the dynamic extension of the model, we provide a new characterization of the static equilibrium which is of independent interest. It is also useful in characterizing the equilibrium in a dynamic model which we next examine.

In Section I we also establish a negative benchmark result: We show that if public news is released before the firm is informed, then the external news has no effect on the firm's ex-post rate of disclosure. Thus, absent the firm's ability to preemptively disclose its information prior to the public news, there is no relation between the news announcement and the timing of disclosures.

This result might appear surprising. If the news about market conditions is bad, this will cause the market value of the firm to fall. This drop in value provides an incentive to release information if it is not as bad as the market now expects. That is, the release of negative external information lowers the threshold for disclosure, as the *relative* interpretation of the firm's news will become more favorable. However, we demonstrate that this simple intuition is not sufficient for the clustering of disclosures. This is because while negative news about market conditions does indeed lower the threshold for which the firm will disclose, it also lowers the posterior distribution of the firm's type. We show that generally, and perhaps surprisingly, these effects cancel out and there is no clustering; that is, the probability that the firm will disclose is independent of the level of the public news about the economy.

In Section II we introduce a simple dynamic model and assume that the probability that the firm is informed is fixed. The manager is either informed at $t = 0$ or not at all. Public news is released at date $t_1 > 0$. Thus, in contrast to the prior setting, the firm has the opportunity to disclose its information before or after the public news announcement. In the resulting dynamic disclosure game, because disclosure is irreversible, the firm faces a real options problem with regard to its disclosure decision: disclosing positive information may raise the stock price immediately, but gives up the option that the external public news would have had an even more positive impact on the stock price if the firm had not yet disclosed. As a result, information disclosure is delayed relative to the no news case. However, once the public news is released, we show that if it is sufficiently negative it may trigger an immediate disclosure by the firm. For sufficiently negative news the probability of disclosure is strictly decreasing in the news quality. Above this threshold the probability is zero, independent of the news' quality. Thus we have the first main result of the paper -- we show that the release of negative public news can trigger the release of information by the firm.

In Section III we consider a more realistic framework and assume that the firm learns its information at a random time (rather than only at date 0) so that the probability it is informed increases over time. We find that there will be an "information blackout" period prior to the news, when firms refrain from voluntary disclosures. When we consider the clustering effect, which is the focus of our paper, we find a stronger effect. The triggering of immediate disclosure following negative news is more pronounced. Because of the information blackout, the probability of disclosure is strictly decreasing in the news quality for the entire range of possible public news. Also, in addition to negative public news "triggering" an immediate disclosure, positive public news announcements will *slow* the rate of disclosure at future dates.

Thus, the possibility of clustering emerges in our setting only if the firm has at least some likelihood of receiving its information prior to the arrival of external information and the opportunity to preempt the release of external information by disclosing its own signal first. The results of Sections II and III show that clustering arises in a dynamic setting due to the endogeneity of the ordering of the disclosure decision. The key is that in such a setting, the distribution of types who have not yet disclosed when the public news about the state of the economy comes out is an endogenous subset of the original support. We show that in this case the threshold effects outweigh the distributional effects of the public news, and clustering emerges. The intuition for this asymmetry is that when market conditions are negative then it is likely that the firm's news was also negative and it is more probable that it did not yet disclose this information beforehand, whereas when market conditions are positive it is more likely the firm has already disclosed its information.

A. *Related Literature*

Milgrom (1981) and Grossman (1981) were the first to examine disclosure of verifiable information and showed that if it is common knowledge that an agent is informed then all types will disclose. Dye (1985) and Jung and Kwon (1988) showed that when it is not common knowledge then there will be only partial disclosure; our model builds on this observation.

Dye and Sridhar (1995) is perhaps the most closely related paper as it considers a model with *n* firms, each of which may or may not have privately observed a signal. If a firm gets a signal it can disclose it in period 1 or 2. These features of their model are similar to ours. However, they assume that whether firms observe a signal or not is positively correlated, but the signals themselves are independent. This is exactly the dual of our assumption that signals are correlated but their arrival process is independent. As a result, in their model, it is more disclosures in period 1 that leads to more disclosures in period 2 (since investors believe that non-disclosing firms have adverse information), whereas in our model, it is the nature of disclosure (good news or bad news) that delays or triggers disclosure by other firms. Hence, a key difference is that they assume the information arrival process is itself correlated. In contrast, in our model clustering of disclosures is due *only* to the strategic element and in particular not due to the correlated arrival of information. Another crucial difference between their results and ours is that in our model, clustering is not symmetric in the quality of news. Specifically, when information arrival is correlated as in Dye and Sridhar, there is no difference in clustering of good news or bad news; in contrast, when information is correlated but not its arrival as in our model, there is clustering of bad news but not of good news.

I. A Static Model of Disclosure

We begin with a simple static model of disclosure which will form the basis for our dynamic model. In particular, we show that when the firm does not disclose information, investors' beliefs about the firm are the "worst possible" beliefs given any disclosure rule. Finally, we consider the impact of ex ante news announcements on disclosure, and establish an irrelevance result regarding the probability of disclosure that will provide an important contrast to our main result in the dynamic setting.

A. *The Model*

Consider a single firm whose manager may learn some information relevant to the firm's value. Let the manager's signal S be the value of the firm conditional on this new information.[3] The manager learns this information with probability $p \in [0,1]$. Once the manager is informed, with probability q both the manager's signal and the fact that the manager is informed remain private information. When privately informed, the manager has discretion regarding the release of the information: The manager may either disclose it or conceal it, but if it is disclosed it is verifiable and cannot be manipulated.[4] With probability $1-q$ the manager is "publicly" informed and so does not have discretion over the information's release; in that case, the

[3] This assumption is essentially without loss of generality and is equivalent to assuming the manager learns information I and the firm's value is V, and then defining $S = E[\ V \mid I\ ]$.
[4] This assumption of "verifiable reports" is common to the literature. See, for example, Shin (2003, 2006).

manager reports it immediately to the market.[5] We denote the events that the manager is uninformed, informed with discretion, and informed with no discretion as $\{U, D, ND\}$ The distribution of the signal S may depend on whether the manager is informed or not; we write S_i to represent the signal conditional on the event i. For convenience, we assume that S_D is non-degenerate and continuously distributed on some (possibly unbounded) interval, and that $E[S_U] \geq E[S_D]$. The latter ensures that an agent who holds negative information may benefit from pretending to be uninformed. We should also note that while our model is based on Dye (1985) and Jung and Kwon (1988), we let the distribution of the signal depend on whether the manager is informed, which is not allowed in their analysis. We introduce this more general setup as in a dynamic framework the set of agents with discretion to disclose at time t depends on who discloses beforehand. Hence the distribution of types differs from the distribution of agents who are uninformed.

The manager's objective is to maximize the firm's market value, which is its value conditional on the information available to investors. Because the signal S is the firm's expected value, if the manager discloses the signal the firm's market value will simply be S. If the manager does not disclose, the firm's market value will be based on the information contained in the fact that the manager did not disclose. Naturally, the manager is willing to disclose S if and only if it exceeds the value the firm would have without disclosing, and so the manager will disclose if

$$S \geq E[\, S \mid \text{nondisclosure} \,]. \qquad (1)$$

B. *Equilibrium and Worst Case Beliefs*

Equation (1) implies that only firms with a signal higher than some threshold x will disclose their information. Consider the case in which it is public knowledge that the manager is informed (i.e., $p = 1$ or $q = 0$), but investors do not know the manager's information. In that case the manager would not disclose only if $S \leq x^*$, so that from (1) the equilibrium threshold x^* satisfies

$$x^* = E[\, S \mid \text{nondisclosure} \,] = E[\, S \mid S \leq x^* \,]. \qquad (2)$$

[5] This case captures situations in which either (i) the information itself is public, (ii) the fact that the manager has learned the information is public (in which case immediate full disclosure will occur in equilibrium), or (iii) hiding the information would be too costly (perhaps due to legal concerns).

This equation has the unique solution that x^* is the minimum of the support of S, and all information is disclosed. This result replicates the standard "unraveling" result – noted, e.g., by Ross (1979), Grossman (1981), Milgrom (1981) and others – that if the market knows for sure that a firm holds some information then in equilibrium the firm will disclose its information.

When $p < 1$ and $q > 0$, however, investors do not know if the manager is informed. In that case the payoff in the event of non-disclosure can be calculated as

$$E\left[S \mid \text{nondisclosure}\right] = E\left[S \mid U \text{ or } \left(D \text{ and } S \le x^*\right)\right]$$

$$= \frac{\Pr(U)E[S_U] + \Pr(D)\Pr(S_D \le x^*)E\left[S_D \mid S_D \le x^*\right]}{\Pr(U) + \Pr(D)\Pr(S_D \le x^*)}.$$

Hence, letting $\rho \equiv \Pr(D)/\Pr(U) = \frac{pq}{1-p}$ be the relative likelihood that the manager is privately informed versus uninformed, we can write the equilibrium condition for the threshold x^* as

$$x^* = h_S(x^*, \rho) \equiv \frac{E[S_U] + \rho\Pr(S_D \le x^*)E\left[S_D \mid S_D \le x^*\right]}{1 + \rho\Pr(S_D \le x^*)}. \tag{3}$$

Note that the function $h_S(x, \rho)$ is decreasing in ρ, and because S is continuously distributed, is also differentiable.

Equation (3) expresses the equilibrium threshold as a fixed point of the function h. While the precise solution to (3) will depend on the distribution of S, we have the following useful characterization, which generalizes the intuition that in the absence of disclosure, investors will adopt the "worst case beliefs."

PROPOSITION 1. Equation (3) has a unique solution x^* which is the equilibrium disclosure threshold. This threshold is decreasing with ρ and satisfies

$$x^* = \min_x \; h_S(x, \rho) \tag{4}$$

The value of the firm in the event of non-disclosure is also equal to x^*, and this value is the lowest possible given any disclosure policy (threshold or not).

Proof of **PROPOSITION 1**: A fixed point $x^* = h_S(x^*, \rho)$ clearly exists given the continuity of h and $h_S(-\infty, \rho) = E[S_U] > -\infty$ while $h_S(\infty, \rho) = \frac{1}{1+\rho}E[S_U] + \frac{\rho}{1+\rho}E[S_D] < \infty$. Now consider any alternative disclosure policy Γ (threshold or not) and let $v(\Gamma) = E\left[S \,\middle|\, U \text{ or } \left(D \text{ and } S \in \Gamma\right)\right]$. If Γ differs from the policy with threshold x^*, then either it includes types greater than x^*, or excludes types less than x^*. In either case, $v(\Gamma) > x^*$. Thus the equilibrium x^* must uniquely satisfy (4). Finally, because $E[S_U] \geq E[S_D]$, h_S decreases with ρ, and therefore so does the threshold. \qed

Equation (4) can be interpreted as generalization of the intuition from the standard full-disclosure equilibrium in (2): Investors interpret non-disclosure as pessimistically as possible, so that the equilibrium threshold is the one that leads to the lowest value for the firm in the event of non-disclosure. Not surprisingly, because h declines with ρ, the threshold for disclosure decreases with the likelihood that the manager is privately informed. Thus, conditional on the manager being privately informed, the probability of disclosure $\Pr(S_D > x^*)$ increases.

C. *Ex Ante News: An Irrelevance Result*

Suppose that prior to the firm's opportunity to disclose its information, investors and the manager observe public information that is correlated with the firm's value. This information may be from a public news source such as disclosures by analysts covering the industry, or correspond to a mandated disclosure of private information such as an earnings announcement by another firm in the industry. We next consider the impact of such ex ante news on the likelihood of disclosure by the firm.

To capture this correlation between the news and the firm's signal, we denote the news announcement by the random variable Y, and suppose the firm's signal S and the news Y are positively correlated, and related as follows:

$$S = \mu(Y) + \sigma(Y)\, Z \tag{5}$$

where Z is a random variable with mean of zero and independent of Y, μ and σ are deterministic functions of Y, and μ is strictly increasing in Y. Note that this representation follows immediately from, but is more general than, an assumption that S and Y are joint normal.

We assume that the distribution of Y is independent of whether the manager is informed (the events $\{U, D, ND\}$). Note that the news announcement Y determines the conditional mean and variance of investors' beliefs regarding the firm's value prior to any disclosure.[6] How will this news affect the manager's disclosure decision?

First, the news announcement will have an immediate impact on the firm's stock price as investors revise their expectations. Because the manager will only disclose S in order to raise the stock price, holding fixed the manager's signal S, negative news will make it more likely that the manager will disclose this information. In other words, the equilibrium disclosure threshold will move with the quality of the news.

However, while the impact of the news on the disclosure threshold affects the probability of disclosure of a given type S, the distribution of the manager's type is also affected by the news. Specifically, the worse the news, the lower the likelihood that the manager's information S will exceed a given threshold. Indeed, as the following result demonstrates, this second effect completely offsets the first so that despite the change in the disclosure threshold, the probability of disclosure is independent of the news Y.

> **PROPOSITION 2.** Given the ex ante news announcement Y, the equilibrium disclosure threshold for the firm is given by
>
> $$x^*(Y) = \mu(Y) + \sigma(Y) z^* \tag{6}$$
>
> where z^* is the disclosure threshold that solves (4) given the signal Z. The probability that the firm discloses is independent of the news Y.

Proof of **PROPOSITION 2**: The equilibrium condition becomes

$$x^*(Y) = h_{S|Y}(x^*(Y), \rho) \tag{7}$$

where "$S|Y$" denotes that the expectations in (3) are with respect to the conditional distribution of S. Using **PROPOSITION 1** and the fact that the function h is a conditional expectation and thus a linear operator, the equilibrium threshold $x^* = h_{S|Y}(x^*,\rho) = \min_z h_{S|Y}(\mu + \sigma z,\rho) = \mu + \sigma \min_z h_z(z,\rho) = \mu + \sigma z^*$, which implies (6). Moreover, the probability S exceeds the

[6] For simplicity, we assume that firm's signal S is a sufficient statistic for the firm's value (and the manager's payoff) given the news Y. For a more general setting in which Y may also have an independent effect on the manager's payoff, see Subsection IV.C.

threshold is $\Pr(S > x^*) = \Pr(\mu + \sigma Z > \mu + \sigma z^*) = \Pr(Z > z^*)$, which is independent of the conditional mean and volatility of the signal. \qed

Thus, **PROPOSITION 2** implies that ex ante news announcements should have no impact on disclosure rates. Voluntary disclosures should be observed with a similar frequency after good or bad public news. As we will show in the next section, this symmetry will no longer hold in a setting in which firms have the opportunity to disclose both before and after the public news is revealed.

Remark. In the special case of joint normality, where both the conditional and unconditional distributions of S are normal and thus differ only in terms of mean and variance, the probability that the firm discloses is not only independent of the news Y, but is also equal to the probability the firm discloses absent any news whatsoever.

II. Dynamic Disclosure: Delay and Downward Clustering

We now consider a simple dynamic version of the disclosure game, in which the manager has the opportunity to disclose his information either before or after the external news is revealed. By giving the manager discretion over the timing of the disclosure, two effects emerge. First, a manager with a sufficiently high signal will choose to preempt the news announcement and disclose immediately. However, a manager with a more intermediate signal may choose to delay disclosure, and wait to see if good external news will raise the stock price above his signal. If the external news is poor, however, the manager will then disclose his information immediately after the news announcement. Thus, relative to the static model, disclosures are delayed prior to the news, and disclosures tend to cluster just after negative news announcements.

A. *Basic Dynamic Model*

As before, the manager learns the firm's value S at date 0 with probability p, and with probability q the manager has discretion regarding whether to disclose his information to the market. Now, the manager can disclose his information at any time $t \in [0, T]$, after which the value becomes public information. At an interim date $t_1 \in (0, T)$, the news Y is announced.[7]

[7] For simplicity we assume in this section that the manager learns his information at date 0 if at all, and the timing of the news announcement is known. We consider the case in which the manager may learn his information at any time and the news may arrive at any time in Sections III and IV.

For simplicity, we assume that Y only affects the conditional mean of the signal S, so that $\sigma(Y)$ in (5) is a (positive) constant σ (as would be true with joint normality).

Let I_t be the information that is public at time t. Then, assuming risk-neutral investors and normalizing the interest rate to zero, the market value of the firm on date t is given by $\hat{s}_t = E[\, S \mid I_t \,]$. We assume the manager's payoff is increasing in the market value of the firm at any moment in time. The exact form of this payoff will not affect the qualitative results, and for simplicity we represent the payoff to the manager of the firm as

$$\int_{t=0}^{T} \lambda(t) u(\hat{s}_t) dt \tag{8}$$

where u is increasing and the weights $\lambda(t) \in (0,1)$ may reflect, e.g., discounting or fluctuations in the sensitivity of the manager's wage to the share price.

B. *Ex-Post Disclosure and Clustering*

Given our timing assumptions, information is only learned at date 0 and at the time of the news announcement. Thus, in equilibrium disclosure will occur, if at all, at date 0 or t_1.[8] Consider the optimal disclosure policy at date t_1, once the public news Y is revealed.

Suppose the date 0 disclosure decision can be characterized by some threshold x_0, so that types $S > x_0$ disclose at date 0. (We will analyze the determination of x_0 shortly.) As in the static model, at date t_1 a manager who has not yet disclosed will choose to do so only if his signal exceeds the firm's share price absent disclosure. Let $x_1(Y)$ be the disclosure threshold at date t_1 given Y. Then

$$x_1(Y) = E\left[S \,\middle|\, \text{nondisclosure, } Y\right] = h_{S|Y}(\min(x_0, x_1(Y)), \rho). \tag{9}$$

Note that in (9), we calculate the expected value of the firm given nondisclosure by recognizing that an informed manager with type $S > \min(x_0, x_1(Y))$ would have disclosed, either initially or after the news. As long as $x_1(Y) \le x_0$, condition (9) is the same fixed point condition as in the static model (see (7)), and thus the characterization in **PROPOSITION 2** applies. But if

[8] In other words, the model in this case is equivalent to a two-period model. We have set it up more generally, however, to accommodate important extensions in subsequent sections.

$x_1(Y) > x_0$, then a manager with type $S \in [x_0, x_1(Y))$ will have disclosed his type initially but will regret that decision once the public news is revealed. Because the static equilibrium minimizes the firm's nondisclosure share price (**PROPOSITION 1**), this "excessive" disclosure relative to the static case will raise the firm's nondisclosure share price relative to the static equilibrium. Thus we have the following characterization of the post-news disclosure threshold:

PROPOSITION 3. Suppose the date 0 disclosure threshold is x_0. Then the optimal disclosure threshold at date t_1 once the news Y is revealed is given by

$$x_1(Y) = x^*(Y) + k(Y) \tag{10}$$

where x^* is defined as in (6) and the function k is continuous and strictly increasing if $x^*(Y) > x_0$. If $x^*(Y) \le x_0$, or equivalently, $Y \le y_0 \equiv \mu^{-1}(x_0 - \sigma z^*)$, then $k(Y) = 0$.

Proof of **PROPOSITION 3**: Suppose $x^*(Y) \le x_0$. Then $x_1(Y) = \mu(Y) + \sigma z^* \le x_0$, and so (9) holds. For $x^*(Y) > x_0$,

$$\begin{aligned}
x_1(Y) &= h_{S|Y}(x_0, \rho) \\
&= \mu(Y) + \sigma h_Z\left(\frac{x_0 - \mu(Y)}{\sigma}, \rho\right) \\
&= \mu(Y) + \sigma z^* + \sigma\left[h_Z\left(\frac{x_0 - \mu(Y)}{\sigma}, \rho\right) - h_Z(z^*, \rho)\right] \\
&= \mu(Y) + \sigma z^* + \sigma\left[h_Z\left(z^* - \sigma^{-1}(x^*(Y) - x_0), \rho\right) - h_Z(z^*, \rho)\right] \\
&\equiv x^*(Y) + k(Y).
\end{aligned}$$

Because z^* is a unique minimum of h_Z, k is positive and strictly increasing. \qed

Note that firms who have not disclosed at date 0 will choose to once Y is revealed at date t_1 only if the ex-post threshold is sufficiently low so that $x_1(Y) < x_0$. Thus, we have the result that disclosures are likely to cluster immediately following negative news announcements, as summarized in the corollary to **PROPOSITION 3** below:

THEOREM I. When the manager learns private information at date 0 (if at all), then the manager will either disclose the information immediately at date 0, or just after the public news announcement at date t_1. A post news announcement will only occur if $Y \leq y_0$, with the likelihood of such an announcement being higher if the news Y is lower.

C. *Ex-Ante Disclosure and Delay*

Having characterized the optimal disclosure policy for the firm once the news Y has been released at date t_1, we consider next the equilibrium level of preemptive disclosure at date 0. In our prior analysis, we used the equilibrium condition that the manager would disclose if the signal S exceeded the firm's market value. In the case of preemptive disclosure, however, a real option problem emerges. If a firm with signal S discloses at date 0, then the market value of the firm will equal S from that point onward. If it does not disclose at date 0, there is a chance that the news Y will be sufficiently positive that its market value will exceed S for some time if it delays disclosure. Disclosing at date 0 forfeits this option. Thus, the firm will not disclose at date 0 unless its immediate gain from disclosing exceeds the value of this option.

If the manager discloses if and only if the signal S exceeds a threshold x_0, then from the analysis in Section I the firm's market value absent disclosure is given by $h_S(x_0, \rho)$. In that case, the immediate gain from disclosing at date 0 given signal S is $u(S) - u(h_S(x_0,\rho))$. Because the market value of a non-disclosing firm on date $t \geq t_1$ is $x_1(Y)$, the potential gain from not disclosing at date t is $(u(x_1(Y)) - u(S))^+$. Then, from (8), a firm with signal S prefers to disclose if

$$\int_0^1 \lambda(t)\left[u(S) - u\left(h_S(x_0,\rho)\right)\right]dt > E\left[\int_1^\infty \lambda(t)\left[u\left(x_1(Y)\right) - u(S)\right]^+ dt \,\middle|\, S\right]. \qquad (11)$$

If we define $\alpha \equiv \int_1^\infty \lambda(t)dt \Big/ \int_0^1 \lambda(t)dt$, then the equilibrium disclosure threshold satisfies[9]

$$u\left(x_0\right) = u\left(h_S(x_0,\rho)\right) + \alpha E\left[\left(u\left(x_1(Y)\right) - u(x_0)\right)^+ \,\middle|\, S = x_0\right]. \qquad (12)$$

[9] Guaranteeing a threshold strategy is optimal requires showing that if (11) holds for S, then it holds for all $S' > S$. In the appendix we demonstrate weak sufficient conditions for this result, but as a practical matter, we can solve for x_0 assuming a threshold, and then verify optimality ex post (which is the case for all examples we have considered). In any case, none of our qualitative results depend on the optimality of a threshold strategy prior to the news announcement.

The real option component thus implies the following result for the firm's ex-ante disclosure policy:

PROPOSITION 4. The ex-ante disclosure threshold x_0 exceeds the firm's non-disclosure share price $h_S(x_0,\rho)$, which exceeds the static disclosure threshold absent news $x*$. That is,

$x_0 > h_S(x_0,\rho) > x^*$.

Thus, the ex-post news announcement delays disclosure relative to the setting without news.

Proof: The first inequality follows immediately from (12) and the fact that $\alpha > 0$, u is strictly increasing, and $Pr(x_1(Y) > s) > 0$. The second inequality follows directly from the characterization of x^* in **PROPOSITION 1**. \qed

The preceding result implies that, because of the real option effect, the anticipation of an external news announcement reduces the likelihood of an initial disclosure relative to the case with no news. A natural question to consider is how this real option effect depends on the correlation between the news Y and the firm's signal S. Interestingly, this relation is not monotone. To see why, note that if the news Y is independent of, and thus uninformative about S, then the real option effect disappears and $x_0 = x^*$ (as in the case with no news). On the other hand, if S and Y are perfectly correlated ($\sigma = 0$), then the news will perfectly reveal the manager's signal and again the real option has no value and $x_0 = x^*$. Only in the intermediate case when the news is informative, but not perfectly so, will x_0 exceed the no news case. We illustrate this result in Figure 1, which shows the disclosure threshold and the non-disclosure share price for the case in which S and Y have joint standard normal distributions, the likelihood ratio that the manager is informed $\rho = 9$, and the manager puts a relative weight of $\alpha = 30$ on the firm's future stock price.[10]

[10] These parameters correspond to a setting in which the manager is very likely to be informed a few days prior to the news announcement, but might be able to delay disclosing any information for many weeks.

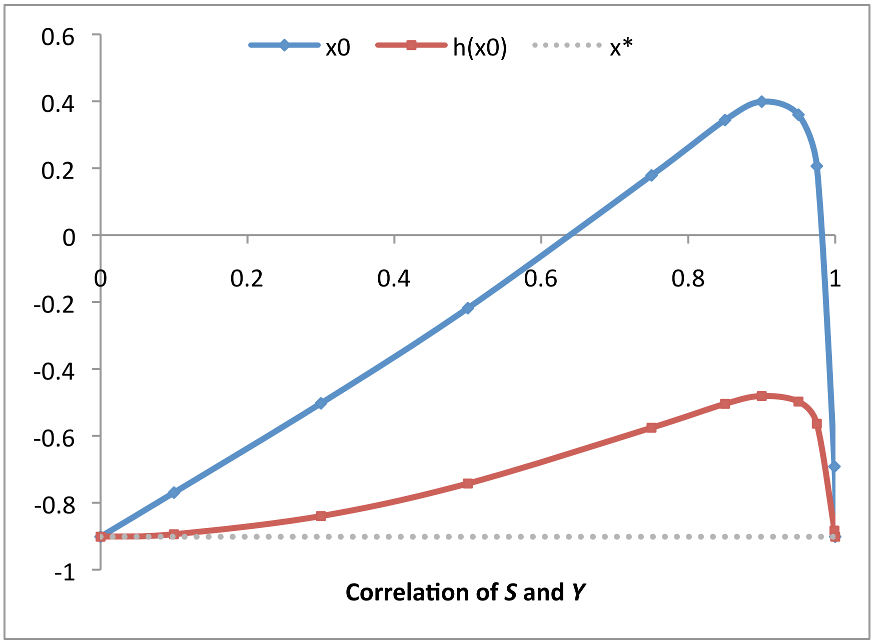

Figure 1: **The Effect of Pending News Announcements on Ex-ante Disclosure Thresholds**

But while the presence of news reduces the likelihood of an initial disclosure, it has an opposite effect on the ultimate rate of disclosure. In particular, note that the probability that the firm would disclose if the news were revealed ex ante is independent of the news *Y*, and in the case of joint normality, equal to the disclosure rate with no news. However, when the news is good, some firms that disclosed at date 0 will regret their decision, so that in these states the overall disclosure rate exceeds the no news case. Thus, while the initial disclosure rate declines, the ultimate disclosure rate is increased by the presence of external news. And of course, the total amount of information ultimately released is improved, as investors will learn the news even in the absence of any disclosure.

III. Stochastic Information Arrival

In the basic dynamic model in Section II, the manager learns the signal *S* at date $t = 0$ or not at all. As a result, disclosures only occurred at date 0 or immediately after sufficiently negative public news. In this section we examine the case where the *date* at which the manager may learn the signal *S* is itself stochastic, and thus the manager may learn the firm's type at any time. Specifically, we let $p(t)$ denote the cumulative probability that the firm is informed by date t, and assume that $p(t)$ is weakly increasing and converges to 1 (so the manager eventually learns the firm's type). In this case, disclosures can occur at any time. We will show two new effects that arise when there is an external news announcement: (i) there will be an "information blackout" period prior to the news, when firms refrain from voluntary disclosures; and (ii) in addition to negative public news "triggering" an immediate disclosure, positive public news announcements will slow the rate of disclosure.

A. *The No Preemption Benchmark*

As a useful benchmark, we begin by examining the case in which the public news announcement occurs at date 0, so there is no possibility for the firm to preempt the news. Recall that in the static model in Section I, we established that in this case the public news has no impact on the probability of disclosure. Here we characterize the equilibrium and extend that result to the dynamic setting when $p(t)$ increases over time.

Recall from the static model in Section I that the disclosure threshold is decreasing in ρ, the relatively likelihood that the manager is privately informed. When $p(t)$ increases over time, the relevant likelihood is given by

$$\rho(t) \equiv \frac{p(t)q}{1-p(t)}. \tag{13}$$

As $\rho(t)$ increases, the fact that the manager has not disclosed is more likely due to the manager's unwillingness to disclose rather than his ignorance. Thus, we would expect investors' valuation of the firm, conditional on nondisclosure, to decline over time. Absent future news, this anticipated price decline implies that there is no option value to waiting to disclose, and the optimal disclosure decision is again the myopic one: The manager will disclose if and when his signal exceeds the share price in the event of nondisclosure. As a result, we have the following natural extension of our prior characterization of the equilibrium disclosure threshold, which we prove in the appendix:

PROPOSITION 5. Suppose the public news Y is revealed at date 0 and the probability $p(t)$ that the manager is informed increases over time. Then the disclosure threshold,

$$x_{np}^{*}(Y,t) = \min_x h_{S|Y}(x,\rho(t)) \tag{14}$$

is the unique equilibrium of the dynamic disclosure game, and decreases in t.

Again, $x^*_{np}(Y,t)$ decreases over time as it becomes clearer that the reason for nondisclosure is that the firm's type is low. In the limit as $p(t)$ approaches one, all types would disclose and $x^*_{np}(Y,t)$ drops to $-\infty$. Following **PROPOSITION 2** and assuming $\sigma(Y) = \sigma$ (for example, when the news and the manager's signal are joint normal), we have

$$x^*_{np}(Y,t) = \mu(Y) + \sigma z^*(t) \tag{15}$$

where $z*(t)$ is the equilibrium threshold at date t given signal Z. Because μ is increasing in Y, *for a given signal S*, the firm will disclose more quickly in the event of bad news. Still, just as in Section I, the *probability* of disclosure is unaffected by Y:

COROLLARY. When the public news is announced at date 0, the probability of disclosure over any time interval is independent of the realization of the news Y, and coincides with the no news case.

B. *Dynamic Model with Preemption*

We now examine the case where the public news is revealed at date t_1 so a firm can preempt the news by disclosing its signal beforehand. We let $x(t)$ denote the threshold for disclosure for $t < t_1$ before the public news is revealed, and $x(Y,t)$ denote the post-news disclosure threshold for $t > t_1$.

Given the firm's equilibrium disclosure strategy, absent disclosure the firm's market value will be its expected value given that it has not yet disclosed, which we denote in this case by $v(t)$. Then a firm with signal S will benefit from disclosing at date $\tau < t_1$ rather than wait until after the news announcement only if

$$\int_\tau^{t_1} \lambda(t)\left[u(S) - u\big(v(t)\big)\right] dt > E\left[\int_{t_1}^{\infty} \lambda(t)\left[u\big(x^*(Y,t)\big) - u(S)\right]^+ dt \,\middle|\, S\right]. \tag{16}$$

By the same real option argument as in Section II, the disclosure threshold exceeds the nondisclosure share price, which exceeds the no preemption threshold: $x(t) > v(t) > x^*_{np}(t)$. Now, while the right-hand side of (16) is strictly positive and independent of τ, the left-hand side of (16) tends to 0 as τ approaches 1. Therefore, for any signal, there is a point in time such that the firm would rather wait for the release of the public news before deciding whether to disclose its information. Intuitively, the option value of waiting exceeds the benefit of increasing its stock price for a very short interval of time.

This observation implies that the equilibrium threshold strategy, $x(t)$, prior to the release of public news satisfies $x(t) \to \infty$ as $t \to t_1$. We refer to this as an *information blackout*, as it states that voluntary disclosures should be very rare just prior to public news announcements whose timing is known.[11]

Turning to the post-news strategy, recall from Section II that the post-news disclosure threshold will coincide with the no preemption case when it is below the pre-news disclosure threshold. We can extend this result to case with stochastic news arrival as follows (see appendix):

> **Proposition 6.** Let $x_{\min} \equiv \min\{x(t) \mid t < t_1\}$ be the lowest ex-ante disclosure threshold. Then the equilibrium ex post disclosure threshold can be characterized as follows:
>
> $$x(Y,t) = x^*_{np}(Y,t) + K(Y,t) \qquad (17)$$
>
> where $K(Y, t) = 0$ if $x^*_{np}(Y,t) \le x_{\min}$, and otherwise, $K(Y, t)$ is strictly increasing in Y.

We illustrate **Proposition 6** in Figure 2 below. Note that prior to the news announcement at date t_1, $x(t)$ exceeds the threshold in the no preemption/no news case due to the real option effect. This effect grows as t_1 becomes near. Once the public news is revealed, the threshold coincides with the no preemption case $\left(x(y_L,t)\right)$ when it is below x_{min}. Above x_{min}, the threshold is elevated $\left(x(y_H,t)+K(y_H,t)\right)$ due to the possibility that firms below the threshold may have disclosed early.

[11] We note that in this case the equilibrium disclosure threshold is likely to be non-monotonic on [0,1]. For t near 0, the disclosure threshold may fall as $p(t)$ increases, and then rise as t approaches 1 and the option value of delaying dominates.

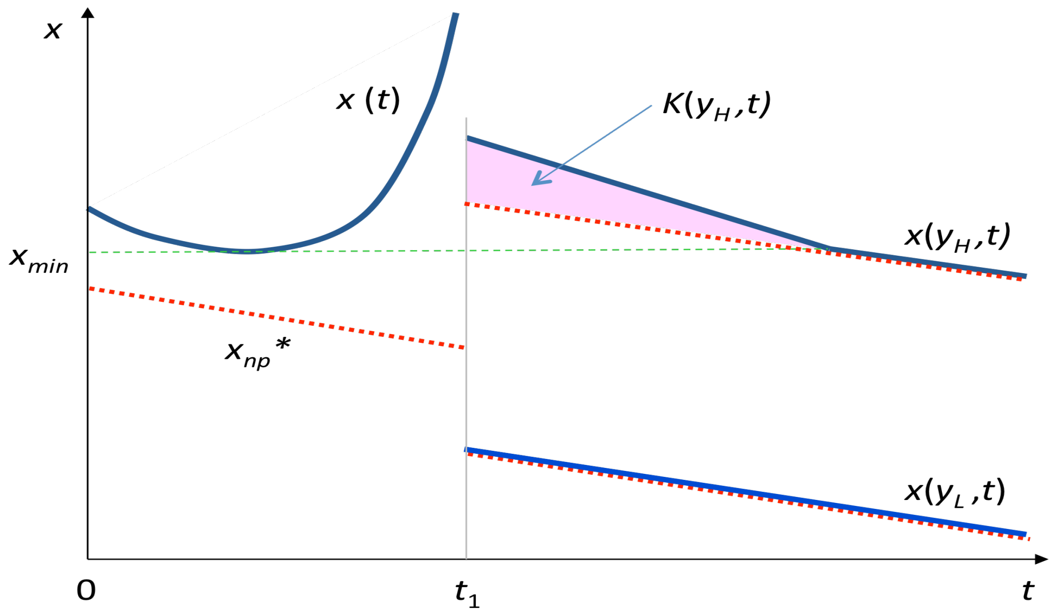

Figure 2: **Ex-ante and Ex-post Disclosure Thresholds with Stochastic Information Arrival**

Given this characterization of the disclosure threshold, we have the following implications. First, because of the "information blackout" effect, the disclosure threshold will *always* drop once the news is released. Thus we have the following generalization of the clustering effect in Section II:

> **THEOREM II.** There is a positive probability of an immediate disclosure at date t_1 when the public news is released. This probability strictly decreases with the quality of the news Y.

Note that this result is stronger than the result in Theorem I in that the probability of immediate disclosure is decreasing in the quality of the news for all Y, not just for Y sufficiently low.

There is a second, new effect which arises in this case. Because $p(t)$ is increasing, there is a positive probability of disclosure after date t_1. This probability is independent of Y if $x(Y,t) < x_{\min}$. But for Y such that $x(Y,t) > x_{\min}$, because $K(Y,t)$ increases with Y, the probability of disclosure decreases with Y. Hence, positive public news will slow the rate of ex-post disclosure:

THEOREM III. For $t > s > t_1$ with $p(t) > p(s)$, the probability of disclosure in the interval (s, t) decreases in Y if $x(Y,s) > x_{\min}$, and is independent of Y otherwise.

IV. Additional Extensions

A. *Stochastic News Arrival*

Until now we assumed the arrival date of the public news is common knowledge, as is often the case for government news releases and other forms of aggregate data. A natural question is how our results would change if the timing of the public news is random.

Suppose, for example, the arrival date of the public news has an exponential distribution with arrival rate γ, so that the probability that the news will arrive in the interval between t and $t + dt$, given that it has not yet arrived, is $\gamma\, dt$.

Consider a firm's decision whether to preempt the external information and release its information at time t as compared to the alternative of waiting until $t + dt$. The gain from preempting at time t is given by

$$\lambda(t)\left[u(S) - u\left(v(t)\right)\right] dt.$$

The potential loss is that the public news is released between t and $t + dt$ and is sufficiently positive that the firm regrets having disclosed its signal. The expected loss is given by:

$$\gamma\, dt\, E\left[\int_{t+dt}^{\infty} \lambda(t)\left[u\left(x^*(Y,t)\right) - u(S)\right]^+ dt \,\middle|\, S\right].$$

The equilibrium disclosure threshold should therefore satisfy

$$u\left(x^*(t)\right) = u\left(v(t)\right) + \gamma\lambda(t)^{-1} E\left[\int_{t}^{\infty} \lambda(\tau)\left[u\left(x^*(Y,t)\right) - u(S)\right]^+ d\tau \,\middle|\, S = x^*(t)\right].$$

This equation is very similar to the equation we obtained in (12). If, for example, the weights λ correspond to standard exponential discounting, then the only change over time comes from the increase in $p(t)$. In that case, the disclosure threshold $x^*(t)$ would gradually decline as $p(t)$ increased prior to the public news release; that is, there would be no information blackout effect.

B. *Multiple firms*

A natural extension is a model with no external signal but with multiple firms. In that case the "news" might correspond to the information released by another firm in the same industry. Indeed, our analysis can be directly applied if the news is a non-discretionary information release, such as an earnings announcement. Our model would then predict that after a negative earnings announcement, we should be more likely to observe discretionary announcements by other firms in the same industry.

While more complicated, one could also extend our model to the case of multiple firms in which all firms have discretion. For simplicity suppose there are two symmetric firms: A and B whose signals are given by S^A and S^B. As we shall see the equilibrium is similar to the equilibrium of stochastic news arrival that we have just examined. However, the construction of the equilibrium presents a significant computational challenge.

The key observation is the fact that from firms A's perspective, B's signal is an external signal. Let $\gamma^B(t \mid S^B)$ denote the equilibrium arrival density of B's disclosure conditional on B's signal, so that the probability that B will disclose in the interval between t and $t + dt$, given that it has not yet disclosed, is $\gamma^B(t \mid S^B)dt$.

Consider firm A's decision whether to preempt and release its information at time t as compared to the alternative of waiting until $t + dt$. A's decision to disclose is similar to the case of stochastic arrival of an external signal:

$$u\left(x^*(t)\right) = u\left(v(t)\right) + \lambda(t)^{-1} E\left[\gamma^B(t \mid S^B) \int_t^\infty \lambda(\tau)\left[u\left(x^*(S^B, t)\right) - u(S)\right]^+ d\tau \,\middle|\, S^A = x^*(t)\right].$$

Once the threshold $x^*(t)$ is determined, it will then determine the arrival density of A's announcement, $\gamma^A(t \mid S^A)$. A symmetric equilibrium then requires the solution of the additional fixed point problem ($\gamma^A = \gamma^B$), which is computationally quite challenging. In such a setting, we conjecture that our qualitative results regarding immediate disclosure would continue to apply and would lead to the clustering of news announcements by firms, with clustering more likely the more negative the news.

C. *Alternative Payoffs and Relative Performance*

We have assumed so far that the manager's payoff depends only upon the expected value of the firm conditional on the manager's information. This setting corresponds, for example, to a situation in which the firm's value is a sufficient statistic for the manager's ability, and this ability determines the manager's outside option.

A natural alternative setting to consider is one in which the manager's ability determines the firm's *relative* rather than absolute performance. For example, suppose $S = Y + \alpha$, where Y represents a measure of industry performance and α represents the manager's ability. In that case, the news Y provides information in addition to S regarding the manager's ability and appropriate compensation. Nonetheless, we argue that the qualitative conclusions of our model continue to apply in this alternative setting.

To see why, let Y and α be independent and joint normal. Suppose first that Y is revealed at $t = 0$ and there is no possibility of preemption. Because $\alpha = S - Y$, we can reinterpret the manager's signal as α and it is immediate that the disclosure threshold $\alpha^*(t)$ and therefore the disclosure rate will not depend on Y. Thus, our results in Subsection I.C carry through as before.

Now suppose that Y is realized at $t = 1$ so that S can be disclosed before Y is revealed. The equilibrium in this case will be similar to our analysis in Section II. Note that the conditional expectation of α given S is a linear function of S. The disclosure threshold $x^*(0)$ at date 0 will reflect a real option premium (i.e., $x^*(0) > v(0)$), as the agent with type $S = v(0)$ would regret disclosing if Y is sufficiently high (specifically, if $S - Y < \alpha^*(1)$). As in our current model, at date $t = 1$ there will be a positive probability of immediate disclosure if the market news Y is sufficiently low (so that $Y + \alpha^*(1) < x^*(0)$). On the other hand, if Y is high, disclosure will be delayed. Thus, all of the qualitative conclusions of our model continue to hold if the agent is compensated based on relative rather than absolute performance.

V. Implications for Asset Pricing

There is some empirical evidence about the link between voluntary disclosure and stock price reactions. This literature faces the challenge that unlike mandatory disclosures (e.g. earning announcements) there is not a readily available dataset for voluntary disclosures. Few papers rely on hand collected data while others rely just on asset pricing data. Miller (2002) examines a comprehensive set of disclosures from a sample of firms experiencing an extended period of earnings increases that is followed by a decline in earning. He finds an increase in disclosure during the period of increased earnings. This increase is pervasive across all types of disclosure and tends to be bundled with earnings announcements. The market responds positively to these disclosures. Once the earnings start to decline there is also a decline in the disclosure rate; again the market reacts accordingly. Tse and Tucker (2007) estimate duration model for earning warnings. They find that earnings warnings within industries are clustered and that firms speed up their warnings in response to peer firms' warnings. A more recent paper by Kothari, Shu and Wysocki (2009) focuses on asset pricing and finds evidence consistent with the view that managers accumulate and withhold bad news up to a certain threshold, but leak and immediately reveal good news to investors and that the market reacts accordingly – specifically, prices tend to drift downward absent disclosure, and jump upward with the announcement of good news. Finally, Salomon (2009) presents interesting evidence that investor relations firms "spin" their client firms' news, generating greater media coverage of positive press releases relative to neutral or negative press releases, increasing announcement returns around news.

An important implication of our results is that with strategic timing of disclosures by managers, the process of information arrival to markets is different from the process of information arrival to firms and managers. For instance, the underlying information process may have constant variability over time and no skewness, but this need not be true of the process describing disclosed information. Below, we discuss the specific implications of our dynamic disclosure model for the skewness and volatility of observed stock returns.

Return Skewness. The dynamic model of strategic delay developed in Section III of the paper implies that individual stock returns will tend to exhibit positive skewness, as firms tend to release good news quickly but delay the disclosure of bad news until the price drifts down sufficiently that the news no longer is a negative surprise. The average positive skewness in individual stock returns was documented early by Beedles (1979) and is reproduced for more recent data in Figure 4. Such positive skewness should disappear in our model at the point that $p(t) = 1$ and full disclosure occurs. This pattern is consistent with McNichols (1988), who finds less positive skewness in earnings announcement periods (when disclosures are likely to be involuntary) compared to non-announcement periods (when disclosures are more likely to be strategic).

While this effect of disclosure timing on average positive skewness of individual stock returns has been suggested elsewhere (for example, in Damodaran, 1985), our model with public news implies an important, additional *conditional* pattern. In periods without public news, stock returns will be positively skewed as the firm voluntarily releases good news. When public news is announced, however, returns will be negatively skewed. The reason is that when the public news is good, it is more likely that the firm would have preemptively released good news, mitigating the effect of the news on the stock price. When the public news is bad, however, the firm is less likely to have previously disclosed its information, in which case the stock's return will respond to the public news fully. Figure 3 illustrates this result, showing the skewness of the stock's returns prior to the news release as well as on the release date, for different levels of correlation between the stock and the news (and the same parameters as in Figure 1).

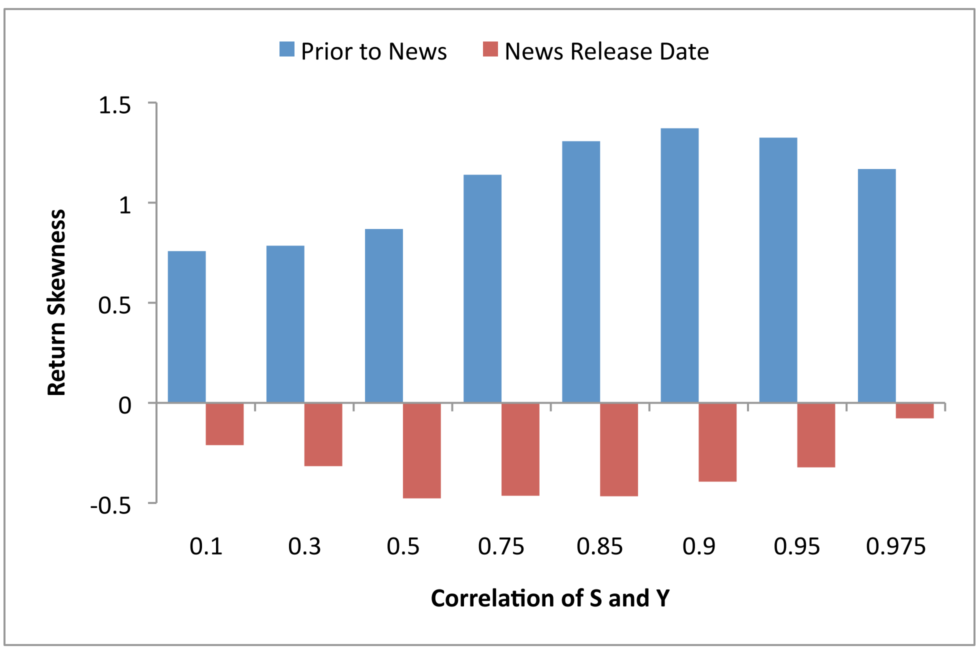

Figure 3: **Skewness of Stock Return Prior to News and Upon Announcement**

Conditional Correlation (Beta). This asymmetry in the response of disclosures to the nature of public news implies that individual stock returns will be more sensitive to aggregate market news when the market news is negative. This implication also finds empirical support. Ang and Chen (2002) document that correlations between U.S. stocks and the aggregate U.S. market are much greater for downside moves, especially for extreme downside moves, than for upside moves, and that these correlations differ from the conditional correlations implied by a normal distribution. Interestingly, they find that the downside correlation is stronger for small stocks, where managerial ability to strategically time disclosures may be greater due to investor inattention, and for past loser stocks, where there may be greater adverse information that is being delayed for release until market news arrives.

Further, the asymmetry in response to public news and the resulting downside correlation of firm returns helps explain the empirical result that while individual stock returns tend to be positively skewed on average, stock market indices tend to have negatively skewed returns (Alles and Kling, 1994, and also see Figure 4 for recent evidence regarding index returns).[12] The existing literature has found it hard to reconcile the differential nature of skewness in firm-level and market-level stock returns, and in fact, often interpreted the difference as lack of consensus on evidence of skewness. In contrast, this differential pattern of skewness in returns arises naturally in our model.

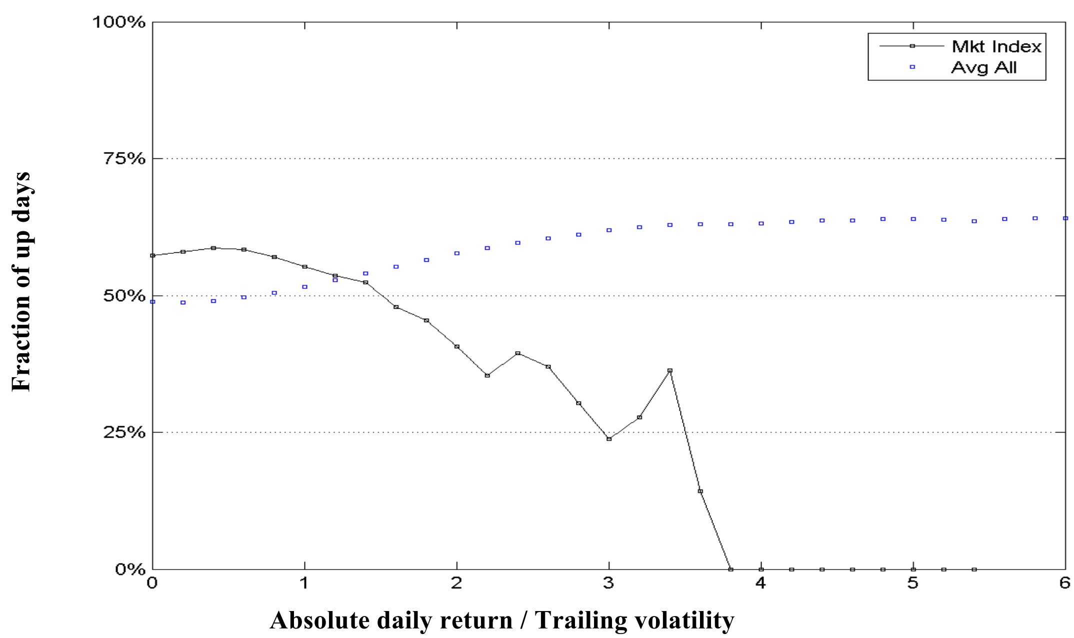

Figure 4: Positive skewness of individual stock returns and negative skewness of index returns

[12] Consistent with this asymmetry in skewness of returns between individual stocks and the market, Tauchen and Zhu (2009) document that realized jumps for individual stock returns are on average slightly positive, whereas for the market equity returns are on average negative.

The figure shows the fraction of up (positive stock return) days as a function of absolute stock return divided by the trailing volatility of stock returns (computed as the standard deviation of returns over the prior 100 days). The dotted line shows the fraction of up days for each stock on the New York Stock Exchange over the period 1998-2007 and averaged across all stocks. The solid line plots the fraction calculated for a value-weighted index of stock returns over the same period. Note that the majority of large moves for individual stocks tend to be positive, whereas large moves in the index tend to be negative.

Volatility and the Leverage Effect. Finally, our result regarding the acceleration of disclosure after bad market news implies that return volatility will increase after negative shocks. This is consistent with the so-called "leverage effect" (Black, 1976) that conditional on negative returns, return volatility is higher. In the most striking evidence of this effect, Officer (1973) and Schwert (1989, 1990) document that the stock market's return variability has been unusually high during downturns such as the Great Depression of 1929-33 and the stock market crash of 1987. They contend that the amplitude of the fluctuations in aggregate stock volatility is difficult to explain using simple models of stock valuation, especially during downturns. Furthermore, the feature that stock return volatility is stochastic and negatively correlated with the level of returns, is now considered essential in explaining observed option prices. For example, Heston (1993) shows that a stochastic volatility model where shocks to volatility are negatively correlated to shocks to returns can fit index option prices well in that it can explain the (Black-Scholes model-based) implied volatility "skew" in index option prices.[13]

Our model provides a potential explanation for these findings since the arrival of adverse public news during market downturns should accelerate the disclosure of information by firms and result in greater volatility. That is, our model treats the disclosure of information by firms as an endogenous response to market downturns which causes volatility to rise. An alternative explanation of these effects is the "volatility feedback" hypothesis, formalized by Campbell and Hentschel (1992), which assumes that it is market volatility - rather than the market return - which receives exogenous, permanent shocks, that in turn, cause expected market return to rise, producing a contemporaneous negative return on the market. A differentiating feature of our

[13] Implied volatility "skew" in index option prices describes the pattern that volatility numbers required in the Black-Scholes model to fit observed index option prices exhibit a declining relationship with the option strike price. This is now universally considered to be a violation of the Black-Scholes assumption that stock return volatility is constant over time or is deterministic.

explanation relative to the volatility feedback channel is that we can simultaneously explain the positive skewness of individual stock returns (as explained above) and the negative skewness of market returns. In contrast, the volatility feedback implies negative skewness of market returns and lower negative skewness of individual stock returns: individual stock volatility also consists of idiosyncratic risk which does not command a risk premium, and hence, as Campbell and Hentschel note, is less affected by rise in market volatility.[14]

To summarize, skewness and volatility related patterns observed in stock returns are consistent with the dynamics of disclosures by firms and the incentives of managers who have discretion over disclosure timing. In contrast to the existing literature which has often treated such patterns as a statistical artifact of data, our model provides a common information-theoretic foundation for their existence.[15]

VI. Conclusion

In this paper, we provided a dynamic disclosure model in which the announcement of bad news hastens the disclosure of information by firms, resulting in bunching of disclosures. Since positive correlation of public news and firms' private information is a critical factor driving this result, our model implies that disclosures should be more clustered within industries and geographies, as empirically found by Tse and Tucker (2007) and Kedia and Rajgopal (2007), respectively.

We assumed throughout our analysis that delaying disclosure is costless for firms. In practice, non-disclosure might entail real costs since the firm would have to bypass observable activities warranted by this information, for example, continue to make investment even in response to adverse information about its prospects.[16] Another possibility is that there may be litigation risk associated with delay in releasing information. Some researchers (Skinner, 1994,

[14] See also Albuquerque (2010) who proposes an alternative explanation for differences between individual and aggregate skewness based on the discounting of cash flows between information release dates.
[15] Shin (2003, 2006) also represent contributions that share this theme. Both papers consider single-firm (one-time) disclosure models with verifiable reports where a manager attempts to maximize the current share price and the markets rationally anticipate manager's disclosure policy. The models generate implications such as the appearance of short-run momentum and long-run reversal in returns and the higher return variance following a poor disclosed outcome. Rogers, Schrand and Verrecchia (2007) find evidence for some of the implications of Shin's models for firm-level and market-level return and return volatility.
[16] Rajan (1994), for example, examines coordination and strategic delay in the recognition of bad loans by banks. He assumes that in order to hide bad loans, banks must continue lending or make new loans to the defaulted borrowers, which is costly in real terms.

Trueman, 1997) have argued that litigation risk can explain why firms voluntarily disclose bad news.[17] Conversely, there might also be strategic benefits to a firm from not disclosing information when such information has not yet reached its competitors or the market as a whole. Dierker (2002) analyzes a dynamic disclosure model with such considerations. Modeling more explicitly the cost or benefits of non-disclosure within our framework could potentially lead to further empirical predictions. We leave such an extension for future work.

An alternative motive for delayed disclosure that has been proposed is managerial short-termism. While our model of the manager's objective is general enough to include such features, it is interesting to note that in our setting the impact of short-termism is ambiguous. For example, decreasing the weight $\lambda(t)$ that the manager puts on the stock price after the public announcement ($t > 1$) will reduce the real option effect of delay and lead to greater disclosure in period 0.

Finally, we argued that our dynamic disclosure game has interesting asset-pricing implications for skewness and volatility of firm-level and market-wide stock returns. Fully establishing the empirical link between strategic timing of disclosures and these features of stock returns appears to be a promising line of enquiry for further work.

[17] Such effects are captured to some extent in a reduced-form fashion in our model by the parameter q, which represents the likelihood with which the firm has no discretion over the release of its information.

Appendix

Proof of PROPOSITION 5: Because the payoff from non-disclosure does not depend on the firm's true type, it is immediate that the optimal strategy can be expressed as a threshold. Because $p(t)$ is increasing, the optimal threshold in **(14)** is decreasing with t. As a result, only the current threshold is relevant in determining the firm's market value absent disclosure, which is given by $v(t) = h_S(x^*(t), \rho(t))$. Finally, because $v(t)$ also declines with t, it is optimal for the firm to disclose if and only if S exceeds $v(t)$, and so $x^*(t)$ is indeed an equilibrium threshold.

To see that the equilibrium is unique, note that by the same reasoning as in the static case, any equilibrium must involve a threshold strategy (the gain from disclosure is increasing in type). Let $x(t)$ be some other disclosure policy, and let $v(t)$ be the market value of the firm in the event of non-disclosure under this policy. Note first that if $x(t)$ is an equilibrium, and if $t' > t$, then

$$x(t) \geq v(t) \geq x^*(t) \geq x^*(t'). \qquad (18)$$

The first inequality follows because the manager would not disclose if it would lower the current share price. The second follows because, from **PROPOSITION 1**, the share price $x^*(t)$ is the lowest possible share price under any beliefs regarding the manager's disclosure policy. Finally, the last follows because $x^*(t)$ is weakly decreasing.

Next we claim that

$$x(t) = v(t) \text{ if and only if } x(t) = x^*(t). \qquad (19)$$

To see the "if," note with this disclosure threshold at date t, because $x(t) = x^*(t) < x(s)$ for all $s < t$ from (18), the set of non-disclosing firms is precisely the same as the set that is privately informed with $S < x^*(t)$, and thus $x^*(t) = h(x^*(t), \rho(t)) = v(t)$. The "only if" follows because, as in the static case, this fixed point is unique (lowering the threshold from any fixed point must raise the share price).

Finally, note that if $x(t) > v(t)$, it must be that $v(t^*) = \sup\{ v(t') : t' > t \} > x(t)$ (it pays to delay disclosure only if a higher price can be obtained in the future from not disclosing). But then because $x(t^*) = v(t^*)$ (there is no reason to delay at t^*), we have from (18) and (19) that $v(t^*) = x^*(t^*) \le x(t)$, a contradiction. \qed

Proof of PROPOSITION 6: Let $v(Y,t)$ denote the expected value in equilibrium of a type that does not disclose at some $t > t_1$. Following the same reasoning as in **PROPOSITION 5**, we know that there is no real option value after the news is revealed, so this expected value equals the threshold for disclosure, $x(Y,t) = v(Y,t)$. Also, because $\rho(t)$ is increasing, $x(Y,t)$ and therefore $v(Y,t)$ is decreasing in t for $t > t_1$.

A firm that has not disclosed prior to t_1 will choose to do so at $t > t_1$ if its type exceeds $x(Y,t)$. When $x^*_{np}(Y,t) < x_{\min}$, one equilibrium is $x(Y,t) = x^*_{np}(Y,t)$; in this case the ex-ante disclosure decision has no impact on the set firms that have disclosed by date t. Furthermore, following Proposition 1, we know that this equilibrium is unique. In contrast, when $x^*_{np}(Y,t) > x_{\min}$ we do find types that may have disclosed prior to t_1 for whom $v(Y,t) > S$. Since $x^*_{np}(Y,t)$ represent the worst belief we have that $x(Y,t) = x^*_{np}(Y,t) + K(Y,t)$ for some positive $K(Y,t)$. $K(Y,t)$ is increasing in Y by the same reasoning as **PROPOSITION 3**. \qed

Sufficient Conditions for the Optimality of an Ex-Ante Threshold (Subsection II.C):

Here we demonstrate optimality of a threshold strategy prior to the public news announcement for a special case in which the news and signal are joint normal and the manager's payoff function $u(v) = v$. While a general proof of optimality is beyond our scope here, it is easy to verify numerically the optimality of a threshold strategy for a broad range of examples. Moreover, note that none of the qualitative results in the paper depend on a threshold strategy prior to the news announcement.

We need to show that if condition (11) holds for some type S, it holds for all higher types. Now, the left hand side of (11) clearly increases with *S*. Thus, it is sufficient to show that the right hand side of (11) weakly decreases with *S*. Without loss of generality let *Y* and *Z* be standard normal with $S = \beta Y + \sigma Z$, so that $Y = \frac{\beta}{\beta^2+\sigma^2} S + \eta$ where S and $\eta \sim N\left(0, \frac{\sigma^2}{\beta^2+\sigma^2}\right)$ are independent. Therefore,

$$\begin{aligned} x^*(Y) - S &= \beta Y + \sigma z^* + k(Y) - S \\ &= \eta + \sigma z^* + k\left(\frac{\beta}{\beta^2+\sigma^2} S + \eta\right) - \frac{\sigma^2}{\beta^2+\sigma^2} S \end{aligned}$$

and so the result follows if

$$\frac{\beta}{\beta^2+\sigma^2} k'(Y) - \frac{\sigma^2}{\beta^2+\sigma^2} \le 0 \text{ or equivalently } k'(Y) \le \frac{\sigma^2}{\beta} \tag{19}$$

This condition obviously holds if $Y \le y_0$, since then $k' = 0$. Consider the case $Y = y > y_0$ and therefore $x^*(y) > x_0^*$. Using the expression for k in the proof of **Proposition 3**, letting $z = \frac{x_0 - \beta Y}{\sigma}$, and letting R^2 be the regression R-squared from a regression of S and Y, we can write (19) as

$$h_Z'(z,\rho) \ge -\frac{\sigma^2}{\beta^2} \text{ or equivalently } R^2 \le \frac{1}{1 - h_Z'(z,\rho)} \tag{19}$$

Thus, a weak sufficient condition for the optimality of the threshold policy is

$$R^2 \le \min_z \frac{1}{1 - h_Z'(z,\rho)} \tag{19}$$

The right-hand side of (19) is decreasing in ρ, and is equal to 0.51 for $\rho = 20$. Thus, the condition is satisfied for $\rho \in [0, 20]$ if $R^2 < 0.5$.

Of course, this condition is extremely weak, in part because we have required monotonicity of the right-hand side of (11) state-by-state, rather than in expectation. Indeed, in the extreme alternative case $R^2 = 1$, it is easy to see that a threshold strategy is optimal: Y is then a perfect signal of S, and the option value of waiting disappears. \qed

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