Interactive Discretionary Disclosures*

BJORN N. JORGENSEN, *University of Colorado at Boulder*

MICHAEL T. KIRSCHENHEITER, *University of Illinois at Chicago*

1. Introduction

Prior theoretical studies of discretionary disclosure concentrate on models of a single firm whose manager can issue a management forecast to the risk-neutral firm owners. However, prior literature is silent regarding the interaction of sequential discretionary disclosures across firms. Our research objective is to address this issue. More specifically, we investigate the equilibrium discretionary disclosure strategies of two managers with correlated forecasts who, for exogenous reasons, choose sequentially whether or not to disclose. Choosing sequentially means that one of the managers, "the leader", decides first whether to disclose his signal, whereas the other manager, "the follower", observes the leader's disclosures (if any) before choosing whether to disclose.

Our results can be summarized as follows. First, we consider a setting where both managers have imperfectly correlated signals. We show that, in equilibrium, the leader employs a disclosure threshold that differs, in general, from the disclosure threshold he chooses when the signals are uncorrelated and that depends on the disclosure threshold he expects the follower to choose. The follower's disclosure threshold depends on whether the leader discloses. If the signals are positively correlated, the follower's choice of disclosure threshold is increasing in the signal disclosed by the leader. In effect, the follower free-rides on the favorable news of the leader and chooses to not incur the costs associated with disclosure. If instead the signals are negatively correlated, the follower's choice of disclosure threshold is decreasing in the signal disclosed by the leader. In effect, the disclosure of favorable news by the leader causes a negative externality on the investors' beliefs regarding the future profitability of the follower, prompting the follower to disclose more to mitigate this externality.

Second, we study the setting of sequential disclosures where managers' private signals are perfectly correlated. This may arise, for example, if the disclosures involve industry or market-wide information. We find that the equilibrium disclosure strategies when signals are perfectly correlated differ from when the signals are imperfectly correlated. Further, the relative benefits to the leader and follower depend critically on whether the correlation is imperfect or perfect. With perfect positive correlation, the leader never discloses, preferring to free-ride on the subsequent disclosure by the other manager. With perfect negative correlation, we find that disclosure occurs for extreme values, and no disclosure will occur only for intermediate values of the signal.

* Accepted by Steven Huddart. An earlier version of this paper was presented at the *2002 Contemporary Accounting Research* Conference, generously supported by the **CGA-Canada Research Foundation, the Canadian Institute of Chartered Accountants, CMA Canada – Ontario, CGA Ontario, and the Institute of Chartered Accountants of Ontario,** Deloitte & Touche LLP, and Grant Thornton LLP. We appreciate the helpful comments of Ulf Schiller, Phillip Stocken, Robert Verrecchia, two anonymous referees, and participants at the 2002 Contemporary Accounting Research conference, University of California at Berkeley, Boston University, the Burton Workshop at Columbia University, Carnegie Bosch Institute Conference on Interdisciplinary Accounting Research, Columbia finance brown bag seminar, EIASM Workshop on Accounting and Economics, Emory, London School of Economics, NYU/Columbia accounting seminar, Northwestern, Purdue, and Tel Aviv. We thank Kelly Puig for editorial assistance.

Contemporary Accounting Research Vol. 29 No. 2 (Summer 2012) pp. 382–397 © CAAA
doi:10.1111/j.1911-3846.2011.01070.x

Our findings provide insights into existing empirical work and directions for future empirical work on voluntary disclosure. For example, our results show how the managers' disclosure strategies vary depending on the firms' characteristics, on whether the forecasts are positively or negatively correlated, and on the timing of the disclosure decisions. These results matter for the design and interpretation of empirical work studying voluntary management disclosures. Also, our results offer potentially testable empirical hypotheses that may be used to assess the validity of our model. We provide additional details relating our results to the design of empirical work in the final part of section 4 below.

The paper proceeds as follows. Section 2 summarizes the prior literature. In section 3 we present the model. In section 4, we present our main results, and relate them to empirical research design. Section 5 concludes the paper. All proofs are in the Appendix, with more comprehensive proofs available from the authors.

2. Background and literature review

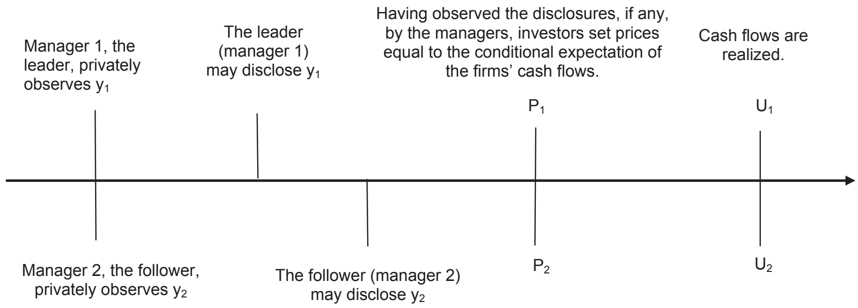
Our paper relates to prior research on costly discretionary disclosures and on the interaction of disclosures by multiple firms. We summarize these relations in turn.

The disclosure literature initially investigated a privately informed manager's discretionary disclosures of a signal about the realization of a liquidating dividend to the capital market in isolation from other firms. For example, Verrecchia (1983, 1990) characterizes the partial disclosure equilibrium when a manager incurs disclosure costs. Though subsequent research allows for endogenous disclosure costs, we follow Verrecchia 1990 and assume that the proprietary costs are exogenous and consider the case of two firms with correlated information environments and sequential disclosure. Similar to Verrecchia, we identify a partial disclosure equilibrium for any strictly positive disclosure cost in which the no-disclosure region is connected and lower-tailed. Our model differs from earlier studies because we consider a sequential setting with two firms where managers' disclosure decisions are interdependent. We show how the interaction in managers' incentives to voluntarily disclose forecasts depends on the correlation between managers' information and the sequencing of the managers' disclosures. Hence, our work also relates to research concerning multiple disclosures, which we discuss next.

Studies of the interdependence of disclosures across firms include Dye 1990, Dye and Sridhar 1995 and Admati and Pfleiderer 2000. Dye (1990) considers ex ante disclosure decisions and compares the optimal, firm-value-maximizing disclosures managers would make to optimal mandated disclosures in a setting with multiple firms whose future values are correlated. Dye shows that disclosure precision depends on the nature of the externality associated with the disclosures and on the covariance between the cash flows of the two firms. Dye and Sridhar (1995) study managers' disclosure strategies when signals are uncorrelated and managers may receive private information and the probability of being informed is correlated. They provide conditions under which managers exhibit herding in their disclosure decisions. Herding, in their context, implies that the likelihood of a privately informed manager disclosing increases in the fraction of the other firms choosing to disclose. We presume that the firms' owners know that managers receive correlated signals and analyze how another firm's voluntary disclosure affects a manager's propensity to disclose in our sequential disclosure setting.

In addition to the spillover effects studied by these two papers, a free-rider problem arises because each firm manager prefers to save on the costs of information production or disclosure and can do so if another firm discloses. An example of this type of free riding is analyzed in Admati and Pfleiderer 2000, who consider a bilateral trading setting in which firm managers choose ex ante the precision of a public signal. Because higher precision is more costly to the firm, each manager benefits from choosing lower precision so that his firm is able to free ride on other managers' disclosures. Our setting differs from

Figure 1 Timeline of sequential discretionary disclosure setting.



Admati and Pfleiderer 2000 because they analyze investors' inferences regarding managers' ex ante choice of precision of the signal, while we consider managers' ex post discretionary disclosures of a signal.[1]

3. Model and discussion of modeling choices

In this section, we provide a description of our model and a discussion of the modeling choice that we make. We begin in the first subsection by introducing the model and follow in the next subsection by characterizing the equilibrium disclosure strategies of the managers in our sequential disclosure setting. Finally, in the third subsection we discuss our modeling choices, focusing on the costs of disclosure and the inferences made by investors and other managers.

Introduction of the model

We consider a setting with two firms. Each firm has a risky investment project in place that dictates the value of the firm. At time 0, the manager of each firm privately observes a signal concerning the future liquidating value of his firm that he can either publicly disclose or withhold. If the manager discloses, a pecuniary disclosure cost is incurred and is paid out of the firm's funds. At time 1, prices result after investors observe whether managers decided to either disclose or withhold their signal and the signals from any firm manager that did disclose. At time 2, firms' liquidating values are realized. We consider the setting where managers sequentially decide whether to disclose (as illustrated in Figure 1). We assume that managers seek to maximize the expected value of their firm conditional on their disclosures and net of the exogenously specified cost of disclosure. All assumptions, detailed below, are common knowledge.

We consider a market setting with two risky assets indexed by $j = 1,2$. The future liquidating dividend of each asset j is represented by a normally distributed random variable, $\tilde{U}_j$, with mean μ_j and precision h_j, that is, $\tilde{U}_j \sim N(\mu_j, h_j^{-1})$. Each risk-neutral manager privately observes a noisy signal of his firm's future liquidating value, $\tilde{Y}_j = \tilde{U}_j + \tilde{\varepsilon}_j$, with normally distributed measurement error, $\tilde{\varepsilon}_j \sim N(0, s_j^{-1})$, so that $\tilde{Y}_j \sim N(\mu_j, \sigma_j^2)$.[2] As in Verrecchia 1990, we view the precision of the measurement error, s_j, as a measure of the quality of the manager's information. The measurement errors are independent of the

1. Our paper is also part of the broader issues of whether the disclosures of an individual firm complement or substitute for other economic information. A related literature considers disclosures when investors possess private information, such as Boot and Thakor 2001, and multiple disclosures by a single firm, such as Einhorn 2005. We establish how the correlation between managers' private information affects managers' disclosure strategies and we extend studies of multiple disclosures by a single firm by showing how results differ when the multiple disclosures come from different sources.
2. To ease presentation, we denote the variance of the signals as $\sigma_j^2 \equiv (h_j^{-1} + s_j^{-1})$.

firms' future liquidating values, and hence they are uncorrelated, that is, $corr(\tilde{U}_j, \tilde{\varepsilon}_k) = 0$ for $j,k = 1,2$. However, we allow for dependence between the two firms' signals since their liquidating firm values have correlation $\rho_U = corr(\tilde{U}_1, \tilde{U}_2)$ and their measurement errors have correlation $\rho_\varepsilon = corr(\tilde{\varepsilon}_1, \tilde{\varepsilon}_2)$, so that $\rho_Y = corr(\tilde{Y}_1, \tilde{Y}_2)$ may also be nonzero.[3]

At time 0, the manager of firm j privately observes the realization of the signal, $\tilde{Y}_j = y_j$. Each manager chooses whether to truthfully disclose the signal, y_j, to maximize expected firm value; managers have no scope to distort their information, they may only withhold it. The manager incurs a cost of $c_j > 0$ if he discloses and no cost if he does not disclose. We characterize each manager's disclosure strategy by his no-disclosure region, that is, by the set of values of the private signal that he decides not to disclose. In every partial disclosure equilibrium that we study, each manager's no-disclosure region can be described by the signals below a disclosure threshold, $x_j \in \Re$. That is, the manager discloses when he observes a signal that exceeds the disclosure threshold.[4] At times we consider the symmetric case in which the firms are identical.[5]

We denote the market value of each stock by P_j. These time 1 prices equal expected liquidating cash flows (net of disclosure costs) where expectations are conditioned on the public information. We let $\hat{x}_j \in \Re$ denote the disclosure threshold that the investors believe that the manager of firm j is using, where the circumflex denotes investors' conjectures about the manager's disclosure strategy rather than his actual disclosure strategy. If investors expect full disclosure but a manager does not disclose, investors infer the worst. That is, when a manager is expected always to disclose and fails to do so, investors believe that the manager observed but did not disclose the lowest possible signal. Each manager holds the same prior beliefs about the other manager's disclosure strategy as the investors. We focus on equilibria where $x_j = \hat{x}_j$ for $j = 1,2$. We assume that the model described in this section applies throughout the remainder of the paper.

We summarize our model as follows. If both managers disclose, investors set prices conditional on signals reported by the managers.[6] If either (or both) manager(s) refrains from disclosing, investors set prices using the inferred disclosure threshold(s).[7] The managers choose their disclosure strategy at time 0 to maximize the expected price of their firm. While this summary applies throughout our analysis, the order in which the managers disclose affects their choice of disclosure strategy and the equilibrium as we discuss next.

3. To improve accessibility, we relegate much of the formal discussion, including the description of the variance-covariance matrix, to a separate detailed appendix, which is available from the authors.
4. While we allow for the manager to contemplate defection to disclosure strategies that are not lower-tailed, each manager's optimal no-disclosure region is lower-tailed provided he believes that the no-disclosure set of the other manager is lower-tailed. Put formally, represent manager j's no-disclosure region by the set $N_j \subset \Re$, let $\hat{x}_2$ denote manager 1's inference concerning manager 2's choice of disclosure threshold, and let $\hat{N}_2(\hat{x}_2) = \{y_2 | y_2 \leq \hat{x}_2\}$ denote the inferred nondisclosure set given inferred threshold $\hat{x}_2$. Further suppose that there is imperfect correlation between the managers' private signals. Then, $\forall \hat{x}_2 \in \Re$, if manager 1 infers manager 2's nondisclosure set is given by $\hat{N}_2(\hat{x}_2)$, then this implies that $\exists x_1 \in \Re$ where $N_1(x_1) = \{y_1 | y_1 \leq x_1\}$ is optimal for manager one. As will be explained below, other equilibria may arise with perfect positive correlation between signals.
5. In the symmetric case, both firms have identical expected future cash flows ($\mu_1 = \mu_2$), precision of cash flows ($h_1 = h_2$), quality of information ($s_1 = s_2$), and disclosure costs ($c_1 = c_2$).
6. Specifically, $P_j = E[\tilde{U}_j | \tilde{Y}_1 = y_1, \tilde{Y}_2 = y_2] - c_j$ for $j = 1,2$.
7. There are three cases. First, if neither manager discloses then:
$P_j = E[\tilde{U}_j | \tilde{Y}_1 \leq \hat{x}_1, \tilde{Y}_2 \leq \hat{x}_2]$ for $j = 1, 2$.
Second if only manager 2 discloses then:
$P_1 = E[\tilde{U}_1 | \tilde{Y}_1 \leq \hat{x}_1, \tilde{Y}_2 = y_2]$
$P_2 = E[\tilde{U}_2 | \tilde{Y}_1 \leq \hat{x}_1, \tilde{Y}_2 = y_2] - c_2.$
Finally, the case where only manager 1 discloses is analogous to the second case.

Characterization of equilibrium

As stated earlier, we analyze the sequential disclosure setting depicted in Figure 1. First, the manager of firm 1 decides whether to disclose. Second, the manager of firm 2 decides whether to disclose after having observed whether and what, if anything, the manager of firm 1 disclosed. With this in mind, we next provide an informal definition of a credible equilibrium for this setting.[8]

(a) Each manager chooses whether to disclose to maximize the expected value of his firm, net of any disclosure cost, given the inferred disclosure strategies of the investors and the manager's information. The managers' disclosure strategies are characterized by disclosure thresholds. We denote the leader's threshold as x_1 and the follower's as $x_2(\bullet)$. The follower's threshold is a function, denoted as $x_2(y_1)$, when firm 1 discloses $\tilde{Y}_1 = y_1$, and it is a constant, denoted as $x_2(ND)$, when firm 1 does not disclose.
(b) Investors correctly anticipate the managers' disclosure strategies, so that $x_1 = \hat{x}_1$, $x_2(y_1) = \hat{x}_2(y_1)$ if manager 1 disclosed, and $x_2(ND) = \hat{x}_2(ND)$ otherwise.

When we refer to a credible equilibrium below, we focus on the endogenous disclosure strategies described by disclosure thresholds, (x_1,x_2), and stock prices, (P_1^*, P_2^*). In equilibrium, each manager chooses his disclosure strategy to maximize the value of his firm, net of any disclosure cost incurred, given the inferred strategies of the investors. Such an equilibrium is credible if, in addition, the investors correctly infer the managers' disclosure strategies.

Discussion of modeling choices

In this subsection, we describe in more detail the nature of the disclosure costs and our equilibrium concept.

First, as noted above, we assume that the manager incurs a cost if and only if he decides to disclose.[9] Related literature often argues that disclosure costs arise from the strategic consequences of disclosure of proprietary information. Costs associated with proprietary disclosure arise, for example, when firms face potential entry or imperfect product market competition. For example, Darrough and Stoughton (1990) and Wagenhofer (1990) study the voluntary disclosure strategies of a privately informed firm when the information, if disclosed, may prompt entry by another firm. Darrough (1993) and Gigler (1994) analyze a manager's voluntary disclosure strategy when disclosure may affect the action taken by a competitor.[10] Finally, Levine and Smith (2003) consider an informed manager's disclosures to maximize his own trading profits in an imperfect capital market where a strategic market maker sets the prices.

In our model, the disclosure cost is exogenous.[11] We refrain from complicating the model with product market interactions or insider trading to focus on the effect on

8. We provide outlines of our results in the Appendix at the end of the paper; as mentioned earlier, detailed proofs are available from the authors.
9. In an alternative model, Dye (1985), Jung and Kwon (1988), and Dye and Sridhar (1995) assume no proprietary costs. Instead they study voluntary disclosures when the market is unsure whether managers have private information.
10. In a duopoly setting, Darrough (1993) finds, among other results, that managers engage in partial disclosure when the firms face Cournot competition and uncertainty about demand or Bertrand competition and uncertainty about marginal costs. Gigler (1994) establishes how proprietary costs, incurred from the action taken by competitors when a firm chooses to disclose, may persuade investors that unverifiable disclosures are credible. Hence, proprietary costs can increase the amount of voluntary disclosures by lending credibility to voluntary disclosures.
11. Direct costs of disclosure may include dissemination costs and costs to correct potential misinterpretation of the manager's disclosures, as well as potential litigation and reputation costs associated with failing to meet market expectations.

sequential disclosure choices of managers with correlated signals. Further, by extending a basic model with exogenous disclosure costs, our model offers opportunities for future research with endogenous disclosure costs based on, for example, proprietary information.

Second, regarding our equilibrium concept, we restrict our focus to equilibria where the disclosure strategy chosen by each manager is correctly inferred by all investors and the other manager, that is, we restrict our attention to Bayesian Nash equilibria. This equilibrium definition, often referred to as a credible equilibrium, is standard in the literature; see, for example, Kirschenheiter 1997. We further restrict our attention to partial disclosure equilibria.[12]

4. Results

In this section, we analyze managers' disclosure strategies first when signals are imperfectly correlated and then when they are perfectly correlated. However, before considering correlated signals, we initially consider the benchmark setting with independent signals in the initial part of the section. In subsequent discussion, we assume that one of the firms is designated as a leader in disclosure and consider the setting where managers choose strategies sequentially. Initially, we analyze imperfectly correlated signals and then we extend the analysis to consider a setting with perfectly correlated signals. Finally, we complete the discussion in this section when we discuss some of the implications of our results for research design.

Discretionary disclosure setting with uncorrelated signals

We begin our analysis by considering a benchmark case. In the benchmark case, we characterize the cut-off in the simple setting with independent and uncorrelated cash flows, that is, we assume $\rho_U = \rho_\varepsilon = 0$. In effect, uncorrelated cash flows reduce this benchmark to the single firm case from Verrecchia 1990; hence, we omit the firm subscript in this subsection. In the process, we introduce the "anti-hazard rate" of the distribution of the signal Y as the ratio of the probability density function of the signal to the cumulative density function of the signal.[13] More specifically, if $\tilde{Y} \sim N(\mu, \sigma^2)$, denote the "anti-hazard" rate as $\alpha(y) \equiv f(y)/F(y)$. Using the anti-hazard rate, we provide the following parsimonious representation of the equilibrium discretionary disclosure strategy in the benchmark case where signals are uncorrelated.

Observation 1. *Let assumptions from section 3 hold, and further assume* $\rho_U = \rho_\varepsilon = 0$. *Let x be the disclosure threshold chosen by the manager of firm 1, let c be his disclosure cost, and define functions* $z(y) \equiv (y - \mu)/(h^{-1} + s^{-1})$ *and* $Z(y) \equiv z(y) + \alpha(y)$ *where* $\alpha(y) \equiv f(y)/F(y)$ *is the anti-hazard rate defined above. Then the disclosure*

12. Two issues raised during the review process changed the paper. First, we originally analyzed a situation where managers chose their strategies simultaneously. Our solution was based on the managers optimizing over ex post verifiable information; that is, a setting where the manager optimized over the information as disclosed to the market. (We thank the referee for clarifying this point.) Proving existence in the more general setting proved quite complicated. We leave the analysis of the simultaneous case for future work. For tractability, we make the disclosure sequence exogenous, rather than building a model where the sequence is endogenously chosen by the two managers as, for example, in Gul and Lundholm 1995. This again is left for future work. While our results extend to the setting with risk-averse investors, to improve the readability and accessibility of our paper we restrict our analysis to a risk-neutral setting.
13. Anti-hazard rates have been used as a measure of the marginal cost of information. They play a role in the no-disclosure pricing of Verrecchia 1983 as well as in Kirschenheiter 1997. Further, a hazard rate, or the ratio of the probability density function over one minus the cumulative density function, is a common measure in operations research, while the inverse hazard rate measures the informational rent included in the "virtual surplus" of Myerson 1981.

threshold is $x = Z^{-1}(hc)$, *where* $h = 1/Var(\tilde{U})$ *and where* $Z^{-1}(\bullet)$ *indicates the inverse of the function* $Z(\bullet)$.

Observation 1 characterizes the manager's disclosure strategy decision in a simple way by introducing a function, $Z(x) \equiv z(x) + \alpha(x)$, that maps the set of possible disclosure thresholds, in essence a cutoff possibility curve.[14] Similar to Verrecchia 1983, this function identifies the equilibrium cut-off for each level of cost. The cutoff possibility curve, $Z(x)$, is the sum of two other functions, $z(x)$, which is the normalized deviation from the mean, and the anti-hazard rate $\alpha(x)$. The cutoff possibility curve is monotonically increasing, running from 0 at its lower limit and unbounded at its upper limit, and concave, ensuring the existence of a unique equilibrium. The cutoff possibility curve equation, $Z(x) = hc$, or equivalently, $x = Z^{-1}(hc)$, sets the cutoff possibility curve equal to the cost times the precision on the cash flow variable; Observation 1 identifies this equation as a particularly useful relation. We expand on this point in the discussion of subsequent results, especially in the discussion following Corollary 1 in the following subsection.

Imperfectly correlated signals setting

In the following subsections, we consider a sequential disclosure setting starting, in this section, with imperfectly correlated signals. Recall that manager 1 discloses first and that manager 2 discloses after observing what disclosure, if any, was made by manager 1. Given that managers have different information available when they make their disclosure decisions, their disclosure strategies, as characterized by their disclosure thresholds, should also differ. In addition, one would expect that the correlation in managers' signals affects this difference in the managers' disclosure decisions. We address these issues below.

THEOREM 1. *Suppose the assumptions from section 3 hold. Then for any positive disclosure cost, there exists a unique partial disclosure equilibrium given as* $(x_1, x_2(\bullet))$.

The disclosure strategies of both leader and follower are interdependent. On the one hand, the leader solves for the follower's disclosure strategy, knowing that it will be either $x_2(y_1)$, if he discloses $y_1 \geq x_1$, or it will be $x_2(ND)$, if he refrains from disclosing. In this equilibrium, the leader chooses his threshold, x_1, based on his derivation of the follower's strategy. On the other hand, the follower relies on the disclosure decision of the leader in choosing his disclosure strategy, choosing $\{x_2(y_1)|y_1 \geq x_1\}$ and $x_2(ND)$ depending on whether the manager of firm 1 does or does not disclose. Again, we restrict attention to the set of threshold-type disclosure strategies, so that our uniqueness result means that there is no other pair of threshold strategies that support a credible equilibrium. Having established that the follower's strategy may depend on the leader's strategy, we wish to analyze how this dependence is related to the correlation between the signals. Corollary 1 shows that a form of free riding occurs when signals are positively correlated and that defensive disclosure behavior arises when the signals are negatively correlated.

COROLLARY 1. *Suppose the conditions of Theorem 1 hold. If firm 1 discloses the following comparative static results hold:*

(a) The threshold set by the follower is increasing, decreasing or unchanged in the level of the leader's threshold as the signals are positively correlated, negatively correlated, or uncorrelated, respectively. Formally, the following hold:

14. We prove this result by equating the prices when the disclosure is made and when it is not made, in the usual manner. These prices are conditional expectations of the cash flow variables conditioned on the disclosures. While, as mentioned earlier, the appendix contains outlines of the proofs, the details of the proof of Observation 1 and all results are available on request from the authors.

If $\rho_Y > 0$, *then* $\partial x_2(y_1)/\partial y_1 > 0$.

If $\rho_Y < 0$, *then* $\partial x_2(y_1)/\partial y_1 < 0$.

If $\rho_Y = 0$, *then* $\partial x_2(y_1)/\partial y_1 = 0$.

(b) The threshold chosen by the follower when the leader discloses is greater than, less than or equal to the threshold chosen by the follower when the leader refrains from disclosure as the signals are positively correlated, negatively correlated, or uncorrelated. Formally, the following hold:

If $\rho_Y > 0$, *then* $x_2(ND) < x_2(x_1)$.

If $\rho_Y < 0$, *then* $x_2(ND) > x_2(x_1)$.

If $\rho_Y = 0$, *then* $x_2(ND) = x_2(x_1)$.

Corollary 1 shows that when firm 1 discloses, the threshold set by the manager of firm 2 increases (decreases) in the disclosure by firm 1 when the firms' signals are positively (negatively) correlated. Furthermore, it can be shown that the effect is more pronounced the stronger the correlation.[15]

If the signals are positively correlated, the Corollary shows that the manager of firm 2 will disclose less for a higher disclosure by firm 1. We use the term "free riding" to describe this behavior as this phrase conveys the idea that, with positively correlated signals, a manager discloses less often in anticipation of the possible beneficial disclosures by another firm's manager. With positive correlation, a higher disclosure by firm 1 is better information for the stock price of firm 2. The disclosure of this favorable news reduces the impact of additional disclosure by the manager of firm 2, so he refrains from making this disclosure in order to save the disclosure cost.

Conversely, when the signals are negatively correlated, the manager of firm 2 will increase his disclosure as firm 1 reports a higher value. This means that the firm 2 manager will adopt a defensive disclosure strategy to mitigate the adverse impact on his firm's price from the disclosure by firm 1. Again, the intuition is straightforward. When the signals are negatively correlated, disclosure of a higher value by firm 1 is unfavorable news for the stock price of firm 2. The higher disclosure by firm 1 imposes additional pressure on the manager of firm 2 to disclose; he responds by disclosing more often to offset the adverse effect on investors' beliefs posed by firm 1's disclosure.

Admati and Pfleiderer (2000) show how the interaction between two firm managers' costly nondiscretionary disclosures can create a free-rider problem resulting in less frequent disclosures. This section extends their analysis to a sequential setting of costly discretionary disclosures. We find that the correlation of the managers' information is important for determining the nature of the interaction among disclosure decisions. More specifically, our results on the correlation of the signals indicate how the correlation between the cash flows, ρ_U, and the correlation between the noise terms, ρ_ε, affect the follower's disclosure strategy choice. By construction we have

$$\operatorname{cov}(\tilde{Y}_1, \tilde{Y}_2) = \rho_Y \sigma_1 \sigma_2 = \left(\rho_U h_1^{-1/2} h_2^{-1/2} + \rho_\varepsilon s_1^{-1/2} s_2^{-1/2}\right).$$

15. The role of the strength of the correlation follows from the details of the proof, which are available on request from the authors.

Hence, the free-rider effect will be more likely to hold the more positive the correlation of both cash flows and error terms, while defensive disclosure will be more likely to hold the more negative are these correlations. When the correlations differ in sign, the relative impact will depend on the precision of the cash flow and the quality of information. The smaller the cash flow precision or the larger the quality of the managers' information, the greater the relative impact of the cash flow correlation relative to the correlation on the noise terms.

Corollary 1 also shows that the follower's choice of disclosure threshold will differ depending on whether the leader chooses to disclose or not, and this difference depends on the correlation between the signals. If the leader is at his disclosure threshold, he is indifferent between disclosing and not disclosing. However, if he decides to disclose, this disclosure may impose an externality on the follower. If the signals are positively correlated, disclosure by the leader imposes a positive externality on the follower, enabling the follower to set a higher disclosure threshold than he would if the leader refrained from disclosing. The intuition is simple: the disclosure by the leader communicates information about the follower's signal, enabling the follower to free ride and save on the disclosure cost. Alternatively, if the signals are negatively correlated, the leader's disclosure imposes a negative externality, and the follower chooses a lower threshold (i.e., discloses more) than he would if the leader had not disclosed. Only with zero correlation is the follower's disclosure decision unaffected by the leader's decision.

The results of Corollary 1 follow from our analysis of the cutoff possibility curve relation, $Z(x) = hc$, introduced in Observation 1 earlier in this section. In words, this relation sets the cut-off possibility curve (on the left-hand side) equal to the product of the disclosure cost times the precision on the cash flow variable. Besides helping to describe the intuition behind the general result in Theorem 1, this relation provides a path to subsequent results. For example, in Theorem 2 we will find that the manager faces another cutoff possibility curve that has the same structure, where he finds the equilibrium cutoff using the product of the disclosure cost and a constant based on signal parameters. The cutoff possibility curve is again the sum of two functions, an anti-hazard rate plus the function represented by the standardized deviation from the mean for the signal. The factor for multiplying the costs is a function of the variances and covariances of the signals, and the anti-hazard rate is from a complicated, conditional distribution, but the structure of the manager's decision problem is the same.

Setting with perfectly correlated signals

Next, we extend the analysis of the sequential disclosure setting to the case where the signals are perfectly correlated. The case where each signal is perfect and where the two signals are perfectly correlated is useful for two reasons. First, there may be situations where the signals are perfectly correlated. For example, if the signal refers to an industry or economy-wide phenomenon, such as industry demand or labor supply, then we would expect perfectly correlated signals. Second, the results in the perfectly correlated case provide evidence that researchers, especially model builders, need to exercise caution in extrapolating from their models. We show in the perfectly correlated case that managers behave in a manner that is diametrically opposed to the behavior characterized when the signals were imperfectly correlated. Our next theorem summarizes our results assuming perfectly correlated signals.

THEOREM 2. *Consider the symmetric case where the quality of both managers' information is perfect ($s_1 = s_2 = \infty$) and the future firm values are perfectly correlated. Then the following are true:*

(*a*) *If the firm 1 manager discloses, then the firm 2 manager will not disclose.*

(*b*) *In the setting with perfect positive correlation, $\rho_U = 1$, the leader never discloses in the unique credible partial disclosure equilibrium, while the follower chooses the same threshold as in the single-firm benchmark setting.*

(*c*) *In the setting with perfect negative correlation, $\rho_U = -1$, there exists a credible partial disclosure equilibrium determined by two disclosure thresholds, x_1 and x_2 for firms 1 and 2, respectively. In this equilibrium, each manager discloses when the information is favorable to his own firm, that is, when $\tilde{Y}_j \geq x_j$ for firm $j = 1,2$.*

Part (a) of Theorem 2 shows the mechanism through which free riding arises: each manager saves on disclosure by not disclosing if he anticipates that the other manager will disclose. While an obvious result, part (a) is included here as it assists in explaining parts (b) and (c).

Part (b) shows that, in the sequential disclosure setting with perfect positive correlation, the leader engages in an extreme form of free riding and never discloses. The follower's equilibrium disclosure strategy is the standard strategy of picking a disclosure cutoff that balances the exogenous disclosure cost against the reduction in price from not disclosing, and then not disclosing if he observes a signal below this cutoff. Because the signals are perfectly positively correlated, the leader finds the follower's strategy to be the exact strategy that the leader would adopt were he, the leader, the only firm in the market. Because the leader would disclose if and only if the follower discloses, the leader has no incentive to ever disclose, as part (a) made clear. Part (c) is a little more complicated.

Part (c) shows that the disclosure strategy may have an unusual structure if the correlation is negative. In this case, favorable news for the first firm is unfavorable news for the second firm. What we find is that, because each firm discloses news that is favorable for itself, each firm will face a situation where both very good or very bad news will be disclosed. To see this, consider the situation from the first firm's perspective. If the manager of the first firm observes very good news, he discloses it while the manager of the second firm does not. If the manager of the first firm observes very bad news, he refrains from disclosing it. However, since this is very good news to the manager of the second firm, that manager discloses it. The only situation where the news is not disclosed is when neither firm finds it worthwhile to disclose, that is, when the news is neither very good nor very bad. Dutta and Trueman (2002) also show that no-disclosure of intermediate news can arise in a single-firm setting but for a very different reason; their result follows when managers are unsure of investors' interpretation of a manager's disclosure.

As unusual as the disclosure strategies in part (c) of Theorem 2 may seem, part (b) is even more unexpected. This result, in which one manager engages in extreme free riding, seems to be similar to the free riding exhibited with imperfectly positively correlated signals (see Corollary 1 above), but now the roles have reversed. Whereas the follower was the free-rider with imperfect correlation, the leader free-rides in the setting with perfect correlation. We interpret this equilibrium behavior by the manager, which reverses the behavior of the manager in the previous equilibrium with imperfect correlation, as a warning signal to researchers who wish to apply theory. Applying theory is desirable; however, overgeneralizing a result derived in a narrow, stylized context is a risk. Our result highlights this risk, as we explain next.

One technique that modelers often use to help explain equilibrium behavior is to solve for the equilibria under idealized conditions, such as perfect correlation, and extrapolate from these results to make inferences about the equilibrium behavior under more realistic situations. Theorem 2 demonstrates that such an approach, in the current case, produces misleading results. The equilibrium behavior in Theorem 2 is due to the fact that the disclosure by one firm allows investors to perfectly infer the information of the other firm manager, and perfect inference significantly changes the investors' choice set. In our setup, moving from perfect to imprecise inference causes a discontinuity in the managers' equilibrium behavior. Comparing the results of Theorem 2 with those of Corollary 1 suggests that we need to exercise caution in using results with perfect signals to interpret behavior with imperfect signals. With this caution in mind, we next consider the implication of our results to empirical research design.

Relation to empirical research and implications for research design

In this subsection, we discuss four empirical applications of our analytical results. First, correlation matters. We see this in work on intraindustry information transfer. Baginski (1987) finds evidence that voluntary management forecasts of earnings affect the market value of other firms in the same industry, even though those firms' managers do not forecast. We provide theoretical support for these findings, because the spillover effects from one manager's discretionary disclosures depends on the correlations among earnings forecasts. This effect arises because correlation in either the error terms or the substance of management forecasts provides information about the value of other firms. Disclosure by one firm manager decreases the information asymmetry between investors and other firm managers. We show that this decrease is increasing in the magnitude of the correlation.

Second, sequence matters. Additional studies relating to intraindustry information transfers illustrate this point.[16] For example, Corollary 1 shows that follower firms may free ride off of voluntary forecasts made by leader firms when managers' private signals are positively correlated and adopt defensive disclosure strategies for negatively correlated private information. Empirical studies may test the predictions that the disclosure strategies relate to the correlation of the disclosures and to whether the disclosing manager is the leader or follower. Brown, Gordon, and Werner (2009) document evidence consistent with herding in voluntary disclosure decisions concerning capital expenditure forecasts. They show that managers are more likely to disclose planned expenditures when peers signal a decrease in future capital spending. While the herding behavior in their model and the defensive disclosure behavior in our model arguably arise due to different economic influences, the empirical evidence of increased incidence of disclosure is consistent with multiple theories.

Third, the disclosure decision matters. Prior empirical research mainly investigates how managers' disclosures affect subsequent stock returns. In a notable exception, Sletten (2011) studies how stock returns affect managers' incentives to subsequently disclose. Sletten posits that unfavorable news (regarding earnings restatements) disclosed by one firm is an exogenous event that negatively affects other firms' stock returns. Our model leads us to view the initial disclosure of earnings restatements as endogenous and predicts that the resulting decrease in stock market value by the leader will prompt other firms to disclose additional information. Consistent with our prediction, Sletten (2011) finds that firm managers voluntarily initiate disclosure of previously withheld information. Our results emphasize the role that correlation and the sequence of the disclosure decisions play in managerial reporting strategies.

Fourth, nondisclosure matters. Clement, Frankel, and Miller (2003) find that confirmatory forecasts result in a *positive* stock price reaction. This empirical finding is surprising because theory developed in a single firm setting predicts a *negative* stock price reaction to a confirmatory management forecast.[17] With interactive disclosures, however,

16. Experimental evidence in Maletta and Zhang 2011 also indicates that the sequence of managers' disclosures of preannouncements matter. They study investor reaction to sequential disclosures of peer firms and find that investor reaction to one firm's disclosure cannot be determined in isolation. Rather, the extent and nature of the disclosures by both firms must be considered in the analysis.

17. For more details about the derivation of the prices involved, see Observation 2 in the Appendix.

such a positive stock market reaction could arise even in the absence of disclosures by other firm managers.[18] This may occur because refraining from voluntarily disclosing is informative per se. If the correlation between firms' information is negative, then the absence of disclosure by one firm can induce a rise in another firm's stock price. Conversely, positive correlation in managers' information can exacerbate the predicted negative price reactions following confirmatory forecasts. Therefore, information may be transferred among market participants even absent identifiable confounding news events.

5. Summary and future research

We study managers' discretionary disclosures in a two-firm setting when managers sequentially choose whether to disclose. We first investigate equilibrium disclosure strategies with imperfectly correlated signals and show that the disclosure decision of the leader creates spillover effects on the disclosure decision of the follower. When managers' signals are positively correlated, the follower free rides by disclosing less frequently, thereby avoiding the exogenously specified cost of disclosure. When the managers' signals are negatively correlated, the follower discloses defensively, disclosing more frequently to mitigate the adverse impact of the leader's disclosure. Next, we investigate the equilibrium strategies with perfectly correlated signals. We show that the optimal disclosure strategy with perfect positive correlation differs drastically from the case with imperfect positive correlation. With perfect correlation, it is the leader (not the follower) who free rides. The results also differ between imperfect and perfect negative correlation. With perfectly negative correlation, the equilibrium disclosure strategies result in the disclosure region being two-tailed, with the intermediate outcomes forming the nondisclosure set.

Our results provide a framework for interpreting empirical studies of managers' voluntary disclosures in the presence of intraindustry information transfers. In addition, our results suggest that a manager's discretionary disclosures to the capital market may affect his own, and other, firms' operating or investment decisions. Our model design can serve as a framework that may be extended to address these issues.

18. By "interactive disclosure" we mean a situation, such as is modeled in this study, where managers decide whether to disclose correlated information.

Appendix

Proofs of results

We present outlines of the proofs in this appendix; full details of the proofs are available upon request from the authors.

Proof of Observation 1. This is available from the authors. It closely follows the result in Verrecchia 1990.

Outline of proof of Theorem 1. The proof of Theorem 1 is in two parts. The first derives the strategy for the follower and the second derives the strategy for the leader.

In the first part, we derive the disclosure strategy for the follower and show that the follower's choice of cutoff can be characterized by setting his disclosure and nondisclosure prices equal when the leader discloses as well as when the leader does not disclose. We show that, in each of these cases, the equation with the prices set equal to one another can be rewritten as equating the disclosure cost, multiplied by some factor, equal to an appropriately defined cutoff possibility function that has the similar structure (i.e., it is the sum of a standardized deviation from the mean plus an anti-hazard rate). More specifically, we first assume the leader discloses and find the follower's cutoff, $\hat{x}_2 = x_2 = y_2$, as the solution to the following equation:

$$\frac{c}{\lambda_2 \sigma^2_{2|1}} = \frac{(x_2 - \mu_{2|1})}{\sigma^2_{2|1}} + \alpha(x_2|y_1).$$

Here we denote the parameters of the conditional distribution using "|" in the subscript, so, for example, $\mu_{2|1}$ denotes the conditional mean of the random variable $\tilde{Y}_2$ conditioned on realization $\tilde{Y}_1 = y_1$, and λ_2 is a constant based on the values of the variance-covariance matrix of the problem. We then extend this situation to the case when the leader does not disclose, and derive the optimal cutoff for the follower in that case.

In the second part of the proof, we derive the strategy for the leader (manager 1) in three steps. In the first step we derive manager 1's decision rule in a manner analogous to that done for the follower, but now integrated over the possible disclosures by the follower. Formally, we assume the follower always discloses and then show that the leader's cutoff is given by setting $\hat{x}_1 = x_1 = y_1$ in the following equation:

$$\frac{c}{\lambda_1 \sigma^2_{1|2}} = \int_{-\infty}^{\infty} \left(\frac{(x_1 - \mu_{1|2})}{\sigma^2_{1|2}} + \alpha(x_1|y_2) \right) f(y_2|x_1) dy_2.$$

Here the parameters are analogous to those in the equation for the follower.

To show that an equilibrium exists, it suffices to show that the right-hand side (RHS) of the equation is always positive, has a lower limit equal to zero, and is unbounded above. We show that these conditions hold in step 2 of our proof. In the third and final step of the proof, we extend the analysis to consider the case where manager 2 adopts a partial disclosure strategy. We then show that manager 1 solves a problem exactly analogous to the one described above. More specifically, we show that manager 1 solves a decision problem with cost equal to a RHS that is again always positive, has a lower limit equal to zero, and is unbounded above.

In this step, the leader chooses his threshold to equate his expected prices when he does and does not disclose, or so that the following equation holds.

$$\int_{-\infty}^{\hat{x}_2} P(x_1, n) f(y_2|x_1) dy_2 + \int_{\hat{x}_2}^{\infty} P(x_1, y_2) f(y_2|x_1) dy_2$$

$$= \int_{\infty}^{\hat{x}_2} P(n, n) f(y_2|x_1) dy_2 + \int_{\hat{x}_2}^{\infty} P(n, y_2) f(y_2|x_1) dy_2$$

Here we use $P(x_1, n)$ to denote the leader's price when he discloses but the follower does not, we use $P(x_1, y_2)$ to denote the price when both disclose, use $P(n, n)$ for the price when neither discloses and $P(n, y_2)$ for the price when the follower discloses but not the leader.

Outline of proof of Corollary 1. These derivations are similar to comparative static results derived to prove Observation 1.

Outline of proof of Theorem 2. Here, $\tilde{Y}_1 = \tilde{Y}_2 = \tilde{U}$ and $\rho_Y = 1$. Part (a) follows immediately from the assumption of perfect correlation. Given that the first manager disclosed, the investors know the signal of the second firm, so the manager of the second firm refrains from disclosing to save on the disclosure cost.

In part (b), if the leader wishes to disclose, he infers that the follower also wants to disclose since, by symmetry, their optimal disclosure threshold level is the same. Hence, the leader free rides on the follower's disclosures. The follower knows the leader did not disclose when he had his only opportunity to do so. The follower therefore has no spillover effect to contend with and so chooses his disclosure threshold as if he were the only firm in the economy.

For part (c), $\rho_Y = -1$. Normalize the variables by letting $\tilde{U} = \tilde{Y}_1 = -\tilde{Y}_2$. In this case, the leader wishes to disclose when $\tilde{Y}_1 = \tilde{U}$ is high and the follower wishes to disclose when $\tilde{Y}_2 = -\tilde{U}$ is low. If costs are sufficiently high (and assuming $\tilde{U}$ has a zero mean), the disclosure threshold will be a positive value of $\tilde{U}$ for the leader and a negative value for the follower. In this case, the no-disclosure region will be the region bounded by these two thresholds. Otherwise, the leader sets his disclosure threshold at the lower of the threshold he would set with no follower and the threshold that the follower would adopt if there were no leader. Both cases ensure that each manager discloses his information when $\tilde{Y}_j \geq x_j$ for firm $j = 1,2$, as required.

Our final result, Observation 2, concerns the relation between voluntary earnings forecasts and stock returns made at the end of section 4 in the text. The claim that a confirmatory disclosure would result in a negative price reaction is shown to follow immediately from the application of this result.

Observation 2. *Initial price is* $P^{Initial} = \mu - \Pr[\tilde{Y} \geq x]c$.

Proof of Observation 2. The initial price is just the expectation of the cash flow variable, with the disclosure cost subtracted when disclosure occurs. To simplify the presentation, let $1_{\{\tilde{Y} \geq x\}}$ denote the indicator function for the event of disclosure by the manager of the firm. Then the initial price is

$$P^{Initial} = E\left[\tilde{U} - 1_{\{\tilde{Y} \geq x\}} c\right] = \mu - \Pr[\tilde{Y} \geq x]c.$$

This completes the proof of Observation 2, but to show that the expected price from a confirmatory report is negative when we consider a single firm, we need to compare the initial price to the expected price once the information is observed and the disclosure is either made or not made, depending the manager's disclosure strategy.

When the manager discloses, that is, when $x \leq \tilde{Y}$, the price is

$$P(\tilde{Y} = y) = \mu + (y - \mu)\frac{s}{h+s} - c.$$

When the manager does not disclose, that is, when $x \geq \tilde{Y}$, the price is

$$P(\tilde{Y} \leq x) = \mu - h^{-1}\alpha(x).$$

The difference between the initial price and the price with disclosure then follows immediately as shown below.

$$P(\tilde{Y} = y) - P^{Initial} = \left(\Pr[\tilde{Y} \geq x]\left(\mu + (y - \mu)\frac{s}{h+s} - c\right) + \Pr[\tilde{Y} \leq x](\mu - h^{-1}\alpha(x))\right) - (\mu - \Pr[\tilde{Y} \geq x]c) = \Pr[\tilde{Y} \geq x](y - \mu)\frac{s}{h+s} - \Pr[\tilde{Y} \leq x]h^{-1}\alpha(x).$$

This shows that, with a single firm, the expected price reaction from a confirmatory earnings forecast, $\tilde{Y} = \mu$, will be negative. However, with correlated information, the price reaction with confirmatory reports may be positive due to the influence of competing disclosures.

References

Admati, A. R., and P. Pfleiderer. 2000. Forcing firms to talk: Financial disclosure regulation and externalities. *Review of Financial Studies* 13 (3): 479–519.

Baginski, S. J. 1987. Intraindustry information transfers associated with management forecasts of earnings. *Journal of Accounting Research* 25 (2): 196–216.

Boot, A., and A. V. Thakor. 2001. The many faces of information disclosure. *Review of Financial Studies* 14 (3): 1021–57.

Brown, N. C., L. A. Gordon, and R. R. Werner. 2009. Herd behavior in voluntary disclosure decisions: An examination of capital expenditure forecasts. Working paper, University of Southern California.

Clement, M., R. M. Frankel, and J. Miller. 2003. The association of confirming management earnings forecasts with earnings uncertainty and stock returns. *Journal of Accounting Research* 41 (4): 653–79.

Darrough, M. N. 1993. Disclosure policy and competition: Cournot vs Bertrand. *The Accounting Review* 68 (3): 534–61.

Darrough, M. N., and N. M. Stoughton. 1990. Financial disclosure policy in an entry game. *Journal of Accounting and Economics* 12 (2): 219–43.

Dutta, S., and B. Trueman. 2002. The interpretation of information and corporate disclosure strategies. *Review of Accounting Studies* 7 (1): 75–96.

Dye, R. 1985. Disclosure of nonproprietary information. *Journal of Accounting Research* 23 (1): 123–45.

Dye, R. 1990. Mandatory versus voluntary disclosures: The case of financial and real externalities. *The Accounting Review* 65 (1): 1–24.

Dye, R., and S. Sridhar. 1995. Industry-wide disclosure dynamics. *Journal of Accounting Research* 33 (1): 157–74.

Einhorn, E. 2005. The nature of the interaction between mandatory and voluntary disclosures. *Journal of Accounting Research* 43 (4): 593–621.

Gigler, F. 1994. Self-enforcing voluntary disclosures. *Journal of Accounting Research* 32 (2): 224–40.

Gul, G., and R. Lundholm. 1995. Endogenous timing and the clustering of agents' decisions. *The Journal of Political Economy* 103 (5): 1039–67.

Jung, W. O., and Y. K. Kwon. 1988. Disclosure when the market is unsure of information endowment of managers. *Journal of Accounting Research* 26 (1): 146–53.

Kirschenheiter, M. T. 1997. Information quality and correlated signals. *Journal of Accounting Research* 35 (1): 43–59.

Levine, C. B., and M. J. Smith. 2003. Ex post voluntary disclosure strategies for insiders. *Contemporary Accounting Research* 20 (1): 719–46.

Maletta, M. J., and Y. Zhang. 2011. Investor reactions to contrasts between the earnings preannouncements of peer firms. *Contemporary Accounting Research* 29 (2): 361–81.

Myerson, R. 1981. Optimal auction design. *Mathematics of Operations Research* 6 (1): 58–73.

Sletten, E. 2011. The effect of stock price on discretionary disclosure. *Review of Accounting Studies* (forthcoming).

Verrecchia, R. 1983. Discretionary disclosure. *Journal of Accounting and Economics* 5 (3): 179–94.

Verrecchia, R. 1990. Information quality and discretionary disclosures. *Journal of Accounting and Economics* 12 (4): 365–80.

Wagenhofer, A. 1990. Voluntary disclosure with a strategic opponent. *Journal of Accounting and Economics* 12 (4): 341–63.