Insider trading and the voluntary disclosure of information by firms

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Abstract

We examine the voluntary disclosure policy of a firm where the manager has private information and opportunities to trade on it. The equilibrium disclosure policy ranges from full disclosure to partial disclosure to nondisclosure depending on whether the manager’s pay–performance sensitivity is high, medium or low, respectively. In the partial disclosure equilibrium, good news is more likely to be disclosed early than bad news and insiders are more likely to sell than buy shares, two results for which there is ample empirical support. The likelihood and amount of voluntary disclosure increases with the manager’s pay–performance sensitivity, firm quality, and the number of insiders privy to the information and decreases with market liquidity. Stringent enforcement of insider trading regulations induces more disclosure by firms whereas the short sales prohibition on insiders induces less disclosure. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

It is generally accepted that corporate managers have access to private information which they can and do use to trade profitably in their firms' securities.¹ In this paper, we examine the question: how much of this private information about their firms will managers voluntarily disclose in light of the potentially large profits they can make if they withhold disclosure?

The issue of voluntary disclosure has attracted the attention of researchers in accounting, economics and finance. A seminal result in this area, due to Grossman (1981) and Milgrom (1981), is that in a market with rational expectations and costless disclosure, firms will voluntarily disclose all information. Intuitively, the market knows that firms want to disclose good news and withhold bad news and so it will rationally interpret nondisclosure as bad news (“no news is bad news”). Therefore, the market will drive down the stock prices of nondisclosing firms precipitously till they disclose their information. In effect, the market suspects the worst of nondisclosing firms, causing their stock prices to drop to the lowest possible level, so that even the firm with the least favorable information has no incentive to withhold it. However, this full disclosure result is inconsistent with the prevalence of government-mandated disclosure requirements on firms and with the widely-held belief that managers do exercise discretion in disclosure.

Verrecchia (1983) shows that the full disclosure argument unravels when disclosure is costly.² He considers a model where firms incur a fixed, exogenous disclosure cost and shows that, in equilibrium, they will disclose only when their news is sufficiently good, for only then is it worth their while to incur the disclosure cost. In this model, nondisclosure does not necessarily imply that the firm has bad news; rather, it could imply that the firm has good news, but the news is not good enough to incur the disclosure cost. However, the available empirical evidence is not consistent with all of the model’s predictions. For example, the model predicts that, in an industry in which all firms are potential recipients of information, disclosure by one firm should lead to a stock price decline for nondisclosing firms since only firms with relatively good news disclose their information. But Lev and Penman (1990) find no stock price reaction for nondisclosing firms and Foster (1981) and Clinch and Sinclair (1987) find that stock prices of nondisclosing firms actually increase. Additionally, we see that firms sometimes withhold good news even when there is no obvious disclosure cost, contrary to this model’s predictions. For example, Texas Gulf

¹ Jaffe (1974) and Seyhun (1986) are just two examples of the many studies that show evidence of abnormal trading profits to corporate insiders.
² For example, firms with proprietary information may find disclosure costly because it can hurt their competitive positions in their industries.
Sulphur discovered one of the largest strikes of copper and zinc in Canada in November 1963 and did not disclose this information until April 1964. Similarly, the Wall Street Journal (November 22, 1989) reports that Texas Instruments did not disclose its ownership of a Japanese patent even though analysts estimated that it would bring in about US $700 million in annual revenues.

In this paper, we present a model with costly disclosure where the disclosure cost is variable and endogenously derived. An advantage of our model is that not only does it have implications similar to the Verrecchia model, it also has implications consistent with the anomalous empirical findings discussed above. We consider the disclosure decision faced by a manager whose compensation is increasing in the firm’s stock price and who has private information and opportunities to trade on this information. If the manager discloses his information, he surrenders his information advantage over the market and foregoes trading profits – this is the cost of disclosure in our model. When the manager receives bad news, he has no incentive to disclose it because by doing so he is assured of receiving the minimum compensation and zero trading profits. But his incentives are more complicated when he receives good news. Disclosure gives him a larger compensation (due to a higher current stock price) but no trading profits. Nondisclosure allows him to make trading profits; but his compensation is smaller since the rational market is uncertain of his news and will set a lower stock price, even while incorporating the information conveyed by the order flow. The manager’s choice of disclosing or not disclosing good news involves a trade-off between the larger compensation with disclosure and the larger profits with nondisclosure. We show that the unique equilibrium to the disclosure/trading game is one of the following:

1. **Full disclosure** – the manager discloses good and bad news.
2. **Nondisclosure** – the manager does not disclose good or bad news.
3. **Partial disclosure** – the manager does not disclose bad news and he may or may not disclose good news.

The full disclosure (nondisclosure) equilibrium will exist when the sensitivity of the manager’s compensation to the stock price (pay–performance sensitivity) is high (low). The partial disclosure equilibrium will exist for intermediate values of the pay–performance sensitivity. Intuitively, the manager’s disclosure decision rests on his trade-offs when he receives good news. If his pay–performance sensitivity is high, then the additional compensation he receives from disclosing good news is greater than his trading profits with nondisclosure and so he will disclose good news. Therefore, a market with rational expectations will interpret nondisclosure as indicative of bad news and so the manager will have no incentive to withhold bad news either, resulting in full disclosure. On the other hand, if the manager’s pay–performance sensitivity is low, the additional compensation from disclosure is smaller than the trading profits from nondisclosure. So the manager will not disclose good news and since he never has an incentive to disclose bad news, the nondisclosure equilibrium will exist.
For intermediate values of the pay–performance parameter, the manager will follow a mixed strategy of disclosing or not disclosing good news with some probabilities and never disclosing bad news.

Our model predicts that firms are more likely to disclose good news than bad news in the partial disclosure equilibrium, a result similar to Verrecchia (1983). This is consistent with the empirical evidence in Givoly and Palmon (1982) and Patell and Wolfson (1982) who find that managers release good news promptly and delay disclosure of bad news. Since insiders are less likely to disclose bad news than good news and more likely to trade on it instead, another implication of our model is that insiders are more likely to sell than buy shares. This result is consistent with the studies of insider trading data by Elliot et al. (1984), Seyhun (1986) and others who find that sellers outnumber buyers. Our model can also explain the previously-mentioned anomalous empirical evidence because the possible existence of the nondisclosure and partial disclosure equilibria in our model implies that firms will sometimes not disclose even good news and that stock prices of nondisclosing firms will not necessarily decline.3 Our model also has other as yet untested predictions relating the amount and likelihood of disclosure to firm quality, market liquidity, and the pay–performance parameter.

Our model implies that stricter enforcement of insider trading laws and/or larger penalties for violating these laws will move managers towards full disclosure because expected insider trading profits will decline. Since stock prices are more efficient under full disclosure, insider trading regulations improve market efficiency in our model. This result runs counter to a standard argument made by critics of these regulations like Manne (1966) who argue that these regulations reduce market efficiency by hindering informed traders from trading and driving prices in the right direction. Our result complements Fishman and Hagerty (1992) who show that banning insider trading can improve market efficiency by encouraging information acquisition by outsiders, and it adds to the debate on the desirability of such regulations.4 While enforcement of insider trading regulations induces more disclosure in our model, we show that the short sales prohibition on insiders induces less disclosure and, therefore, reduces market efficiency.

It is useful to distinguish our model from two recent papers that have also examined the relationship between disclosure and insider trading. Bushman and Indjejikian (1995) show that a manager trying to increase his trading

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3 In the Texas Gulf Sulphur case mentioned earlier, the opportunity to make insider trading profits by buying undervalued stock was indeed the motivation for nondisclosure of good news. The civil suit brought against the insiders led to the landmark disclose-or-abstain insider trading law.

4 A partial list of recent papers that have tackled this issue from different perspectives includes Ausubel (1990), Fischer (1992) and Leland (1992).
profits may actually choose to disclose some of his information because by
doing so, he discourages information acquisition and trading by other com-
peting informed traders. Baiman and Verrecchia (1996) derive the optimal
amount of disclosure by trading off shareholder concerns about liquidity and
managerial shirking. In their model, disclosure reduces insider trading by the
manager and this improves shareholder liquidity while worsening shareholder–
manager agency problems. While both papers address important issues relating
to disclosure and insider trading, they suffer from a common problem: they
assume that the amount of disclosure is independent of the manager’s signal. 5
In contrast, our model explicitly allows the manager to choose different levels
of disclosure for good and bad news. As we will see, this generalization rewards
us with many new theoretical and empirical insights by allowing us to examine
the partial disclosure equilibrium described above. Another distinctive feature
of our model is its focus on regulatory issues such as the enforcement of insider
trading laws and the short sales prohibition.

The rest of the paper is organized as follows. Section 2 describes the basic
model. Section 3 derives the equilibrium, analyzes its properties and presents its
empirical implications. Section 4 examines the impact of three extensions to the
basic model: multiple insiders, the short sales prohibition, and the possibility of
making false disclosures. Section 5 presents our conclusions.

2. The basic model

Consider a firm run by a risk-neutral manager. The manager receives
private information about the firm’s future value and decides whether to
disclose it or not. The firm’s shares trade in a market where the price is set
based on rational expectations about the firm’s value given the manager’s
strategy. The following events take place discretely over five dates. At
$t = 1$, the manager privately observes an informative signal about the future value of
the firm. The market knows that the manager has received a signal though it
is unaware of its contents. 6 At $t = 2$, the manager either discloses his signal

5 They make this assumption for reasons of tractability. Both use the Kyle (1985) trading model
which requires normally distributed random variables. They characterize disclosure as the precision
(inverse of variance) of the signal being disclosed. They cannot allow the precision of disclosure to
depend on the signal level because doing so will cause key variables to become non-normal and
make their models unsolvable.

6 We assume away the possibility of the manager not receiving any information. See Jung and
Kwon (1988) for an analysis of how managers will disclose only good news and withhold bad news
when the market is not certain that they have any private information. Therefore, our assumption
that the manager always receives some information makes the case for partial disclosure and
nondisclosure even tougher to prove by ruling out the situation studied by Jung and Kwon (1988).
or withholds it till the final date $t = 5$. \footnote{The manager’s choice between disclosure and nondisclosure in the single period ($t = 2$) of our model is equivalent to his more realistic choice between prompt and delayed disclosure. Therefore, we can interpret our results on disclosure and nondisclosure as applying to prompt and delayed disclosure in the real world.} At $t = 3$, the market sets the stock price based on the manager’s disclosure decision. The market makes rational inferences about the manager’s signal taking into account the manager’s disclosure and trading strategies. At $t = 4$, the manager will trade if he previously withheld his signal, or, do nothing if he previously disclosed his signal because he no longer has an information advantage over the market. At a later, possibly distant, date $t = 5$, the manager’s private signal becomes publicly known if he has not previously disclosed it. The manager can only make truthful disclosures in the basic model though we allow him to make false disclosures later in Section 4.

Denote the per share future value of the firm’s stock, net of the manager’s compensation, by the random variable $\tilde{v}$, whose unconditional expectation is $v_0$, i.e., $E(\tilde{v}) = v_0$. The manager can receive either one of two signals about $\tilde{v}$: a low signal $S = L$ (bad news) or a high signal $S = H$ (good news) with probabilities $p_L$ and $1 - p_L$, respectively. The conditional expectations are $E(\tilde{v} \mid S = L) = v_0 - \epsilon_L$ and $E(\tilde{v} \mid S = H) = v_0 + \epsilon_H$. By definition, the unconditional mean equals the conditional means multiplied by the appropriate probabilities:

$$v_0 = p_L(v_0 - \epsilon_L) + (1 - p_L)(v_0 + \epsilon_H) \Rightarrow p_L\epsilon_L = (1 - p_L)\epsilon_H. \tag{1}$$

The manager’s compensation is assumed to be \textit{linearly increasing} in the stock price. It is easy to justify the assumption that compensation is increasing in the stock price because this will align the interests of the manager and the shareholders. The linearity assumption is made for reasons of tractability though we believe that the main results of the model will hold even with nonlinear contracts. \footnote{Holmstrom and Milgrom (1987) present a model where the optimal contract is linear. Baiman and Verrecchia (1996) and Bebchuk and Fershtman (1994) are two examples of the many papers which make this assumption.} Since our model has a bid price ($B$) and an ask price ($A$) for the stock, we assume that the compensation is linear in their mean and is given by $\alpha((A + B)/2)$. The exogenous parameter $\alpha > 0$ is the manager’s pay–performance sensitivity and it represents the sensitivity of all components of the manager’s compensation, like salary, bonus and stock options, to the stock price.

The manager’s disclosure strategy is given by the 2-tuple $\{d_L, d_H\}$, where $d_L$ and $d_H$ are the probabilities of the manager disclosing, and $1 - d_L$ and $1 - d_H$ are the probabilities of his withholding, if his signals are $S = L$ and $S = H$, respectively. By allowing mixed withholding strategies, we are able to analyze a
richer menu of disclosure policies. If the manager was restricted to pure disclosure strategies, then he would choose only between full disclosure (disclosing both signals) and nondisclosure (disclosing neither signal). Partial disclosure would be equivalent to full disclosure because if the manager always disclosed one signal and never disclosed the other, the market would rationally interpret nondisclosure as the other signal and the manager would be indifferent between disclosing or withholding that signal. But mixed strategies allow us to consider partial disclosure in addition to full disclosure and nondisclosure for reasons shown below.9

The manager’s actual disclosure is denoted by \( D \). When the manager discloses his signal \((D = L \text{ or } H)\), the market’s inference problem is trivial. But when the manager does not disclose his signal \((D = \phi)\), the market makes inferences about the manager’s signal using Bayes’ rule:

\[
\Pr(S = L \mid D = \phi) = \frac{\Pr(S = L) \Pr(D = \phi \mid S = L)}{\Pr(S = L) \Pr(D = \phi \mid S = L) + \Pr(S = H) \Pr(D = \phi \mid S = H)} = \frac{p_L(1 - d_L)}{p_L(1 - d_L) + (1 - p_L)(1 - d_H)},
\]

on substituting for the different probabilities. Similarly, we can show that

\[
\Pr(S = H \mid D = \phi) = \frac{(1 - p_L)(1 - d_H)}{p_L(1 - d_L) + (1 - p_L)(1 - d_H)}.
\]

If the manager always discloses good news, i.e., \( d_H = 1 \), then nondisclosure is fully revealing as bad news because \( \Pr(S = L \mid D = \phi) = 1 \). This explains why partial disclosure and full disclosure are equivalent with pure strategies and it is the motivation for our use of mixed strategies. Furthermore, if the manager chooses the nondisclosure strategy of \( d_L = d_H = 0 \), we can see that nondisclosure is uninformative because \( \Pr(S = L \mid D = \phi) = p_L \) and \( \Pr(S = H \mid D = \phi) = 1 - p_L \).

Finally, we describe the features of the market in which trading takes place. The manager is the only informed trader in the market. There are \( N \) liquidity traders who trade for reasons that are exogenous to the model. Each liquidity trader is equally likely to buy or sell shares. The liquidity traders are an essential modeling device because they camouflage the manager’s trade. The manager and liquidity traders submit buy and sell orders (on date 4) for a fixed

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9 Partial disclosure is possible with pure strategies only if there are more than two private signals. But we prefer a binomial signal structure and use mixed strategies to arrive at partial disclosure policies in equilibrium.
number of shares $Q$ each, to a single, risk-neutral, competitive market maker. The market maker sets the bid ($B_D$) and ask ($A_D$) prices so as to make zero expected profits taking into account the manager’s disclosure and trading strategies. While our trading environment is similar to most market microstructure models, our pricing protocol follows Admati and Pfleiderer (1989) in that the market maker posts a single bid (ask) price at which he executes all incoming sell (buy) orders.

3. The equilibrium

The equilibrium in our model is defined as the manager’s disclosure strategy $\{d^*_L, d^*_H\}$, his trading strategy, and the prices $A_D$ and $B_D$ which satisfy the following conditions:
1. The manager’s equilibrium disclosure and trading strategies are such that given the equilibrium prices $A_D$ and $B_D$, he has no incentive to defect to any other strategy.
2. The equilibrium prices $A_D$ and $B_D$ are set so as to make zero expected profits for the market maker conditional on disclosure $D$, taking the manager’s equilibrium disclosure and trading strategies as given.

In order to characterize the equilibrium we proceed as follows. First, we calculate the prices $A_D$ and $B_D$ for any conjectured equilibrium disclosure strategy $\{d_L, d_H\}$ in Section 3.1. We then proceed to calculate the equilibrium disclosure strategy $\{d^*_L, d^*_H\}$ in Section 3.2.

3.1. The trading prices

When the manager discloses his signal on date 2, the date 3 bid and ask prices will adjust to the full information levels. Therefore, we have

$$B_L = A_L = v_0 - \epsilon_L,$$
$$B_H = A_H = v_0 + \epsilon_H.$$  \hspace{1cm} (4)

When the manager does not disclose his signal on date 2, he will trade on it. Obviously, he will buy $Q$ shares when his signal is $S = H$ and sell $Q$ shares when his signal is $S = L$. The following proposition gives the market maker’s bid and ask prices given this trading strategy.

Lemma 1. When $D = \phi$, the market maker sets the following zero-profit bid and ask prices based on rational inferences of the manager’s signal and trading strategy:
\[ B_\phi = v_0 - \frac{p_L[(N + 2)(1 - d_L) - N(1 - d_H)]}{p_L(N + 2)(1 - d_L) + N(1 - p_L)(1 - d_H)} \epsilon_L, \]
\[ A_\phi = v_0 + \frac{(1 - p_L)[(N + 2)(1 - d_H) - N(1 - d_L)]}{Np_L(1 - d_L) + (N + 2)(1 - p_L)(1 - d_H)} \epsilon_H. \]

**Proof.** See Appendix A.

The market maker sets a spread between the bid and ask prices so that he can recoup his losses to the better-informed manager by profiting at the expense of the liquidity traders. We can calculate the bid-ask spread \( \Delta = A_\phi - B_\phi \) by substituting from Eqs. (6) and (7):

\[ \Delta = \{4p_L\epsilon_L(N + 1)(1 - d_L)(1 - d_H)\} / \{[Np_L(1 - d_L) + (N + 2)(1 - p_L) \times (1 - d_H)] \times [p_L(N + 2)(1 - d_L) + N(1 - p_L)(1 - d_H)]\} \geq 0. \]

Using Eqs. (6) and (7), we can easily show that \( B_\phi - (v_0 - \epsilon_L) \geq 0 \) and \( (v_0 + \epsilon_H) - A_\phi \geq 0 \). Given these inequalities and the nonnegative bid-ask spread above, we can infer that

\[ v_0 - \epsilon_L \leq B_\phi \leq A_\phi \leq v_0 + \epsilon_H. \]

### 3.2. The equilibrium disclosure strategy

The trading prices \( \{A_D, B_D; D \in (L, H, \phi)\} \) in Eqs. (4)–(7) were calculated for a given strategy \( \{d_L, d_H\} \). Now, we calculate the equilibrium disclosure strategy \( \{d_{L}^*, d_{H}^*\} \) taking these prices as given. By definition, this equilibrium disclosure strategy is such that the manager has no incentive to defect to any other strategy. Therefore, the equilibrium mixing probabilities \( \{d_{L}^*, d_{H}^*\} \) are calculated, as usual, so that the manager is indifferent between disclosing and not disclosing his signal and thus he has no incentive to defect from this equilibrium.

Suppose the manager receives the \( S = L \) signal. If he discloses it, he will only get his compensation \( \alpha(A_L + B_L)/2 = \alpha(v_0 - \epsilon_L) \). If he withholds the signal, his payoff will be the sum of his compensation \( \alpha(A_\phi + B_\phi)/2 \) and his insider trading profits from selling \( Q \) shares, \( Q(B_\phi - v_0 + \epsilon_L) \). In equilibrium, \( d_{L}^* \) is such that he is indifferent between the two pure strategies of disclosing and withholding, i.e., \( d_{L}^* \) satisfies

\[ \alpha(v_0 - \epsilon_L) = \alpha \left( \frac{A_\phi + B_\phi}{2} \right) + Q(B_\phi - v_0 + \epsilon_L). \]

Similarly, when the manager receives the \( S = H \), his payoff from disclosing it is \( \alpha(A_H + B_H)/2 = \alpha(v_0 + \epsilon_H) \) and his payoff from withholding it is the sum of his
compensation, \( x(A_\phi + B_\phi)/2 \), and his trading profits from buying \( Q \) shares, \( Q(v_0 + \epsilon_H - A_\phi) \). In equilibrium, \( d_H^* \) satisfies

\[
x(v_0 + \epsilon_H) = x\left(\frac{A_\phi + B_\phi}{2}\right) + Q(v_0 + \epsilon_H - A_\phi).
\] (10)

We know from Eq. (8) that \( (A_\phi + B_\phi)/2 \geq v_0 - \epsilon_L \) and \( B_\phi \geq v_0 - \epsilon_L \). Therefore, the right-hand side of Eq. (9) is never less than its left-hand side. In other words, when the manager receives the \( S = L \) signal, he is always better off withholding rather than disclosing it. Therefore, the equilibrium disclosure probability is \( d_L^* = 0 \). Intuitively, the manager has no incentive to disclose bad news in our model because disclosure ensures him the minimum compensation and zero trading profits. But when the manager receives the \( S = H \) signal, his incentives are different. From Eq. (10), we can see that disclosure gives him a compensation of \( x(v_0 + \epsilon_H) \), which is greater than his compensation from withholding, \( x(A_\phi + B_\phi)/2 \), by Eq. (8). But withholding allows him to make trading profits of \( Q(v_0 + \epsilon_H - A_\phi) \). Therefore, the manager’s choice of \( d_H^* \) involves a trade-off between greater compensation with disclosure and greater profits with nondisclosure.

If \( d_H^* = 1 \), the manager always discloses good news and the full disclosure equilibrium prevails because nondisclosure is unambiguously indicative of bad news. \(^{10}\) If \( d_L^* = 0 \), the manager withholds both good news and bad news and the nondisclosure equilibrium prevails. Lastly, if \( 0 < d_H^* < 1 \), the manager sometimes discloses good news and at other times withholds it, but he never discloses bad news. We call this the partial disclosure equilibrium. The following proposition characterizes \( \{d_L^*, d_H^*\} \) and presents the conditions under which these three equilibria exist.

**Proposition 1.** There exists a unique equilibrium disclosure strategy \( \{d_L^*, d_H^*\} \) which is:

1. **The full disclosure equilibrium** if \( x \geq Q \), where \( d_L^* = 0 \) (or 1) and \( d_H^* = 1 \).

2. **The nondisclosure equilibrium** if

\[
0 < x \leq Q\left[\frac{N(N + 2p_L)}{N(N + 2) + 2(1 - p_L)}\right],
\]

where \( d_L^* = d_H^* = 0 \).
3. **The partial disclosure equilibrium** if

\[
Q\left[\frac{N(N + 2p_L)}{N(N + 2) + 2(1 - p_L)}\right] < x < Q,
\]

\(^{10}\) We can confirm that when \( d_H^* = 1 \), substitution of this value in Eqs. (6) and (7) gives us \( B_\phi = A_\phi = v_0 - \epsilon_L \). Therefore, bad news is revealed even though \( d_L^* = 0 \).
where \( d_L^* = 0 \) and
\[
d_H^* = \frac{2\alpha(1 - p_L)(N + 1) - N(N + 2p_L)(Q - \alpha)}{2\alpha(1 - p_L)(N + 1) - N^2(1 - p_L)(Q - \alpha)}.
\]

**Proof.** See Appendix A.

The intuition for these results is quite straightforward. When the manager’s pay–performance sensitivity, \( \alpha \), is large, the manager will disclose the \( S = H \) signal in order to obtain the large compensation, resulting in the full disclosure equilibrium. Conversely, when \( \alpha \) is small, the additional compensation obtained from disclosing the \( S = H \) signal is not large and the manager is better off not disclosing it and making trading profits, resulting in the nondisclosure equilibrium. For intermediate values of \( \alpha \), the manager is indifferent between disclosing and withholding the \( S = H \) signal and he follows a mixed strategy, resulting in the partial disclosure equilibrium.

Just like Verrecchia (1983), our model predicts that good news is more likely to be disclosed earlier than bad news for intermediate \( \alpha \) firms since \( d_H^* > d_L^* \). But our model is also consistent with the anomalous evidence that firms may not always disclose good news and that nondisclosure need not always lead to a stock price decline. Specifically, for low and intermediate \( \alpha \) firms, we find \( d_H^* < 1 \), implying that firms do not always disclose good news. This implies that nondisclosure need not lead to a stock price decline and the actual market reaction to nondisclosure can be positive, negative or zero depending on the market’s prior beliefs (\( p_L \)). The following corollary gives us the comparative static properties of the disclosure equilibrium in Proposition 1.

**Corollary 1.** The nondisclosure equilibrium becomes more likely and the amount of disclosure in the partial disclosure equilibrium decreases, when: (i) \( \alpha \) decreases; (ii) \( p_L \) increases; (iii) \( N \) increases.

**Proof.** See Appendix A.

The results in this corollary have an appealing intuition. When \( \alpha \) decreases, the additional compensation from disclosure of good news becomes less valuable and this leads to more nondisclosure. When \( p_L \) increases, the market believes that good news is less likely to occur. So, if the manager does receive good news, his information advantage over the market and therefore, his potential insider trading profit increases as \( p_L \) increases. This reduces his incentive to disclose and leads to more nondisclosure. A similar situation occurs when \( N \) increases. Since the market maker breaks even in our model, the manager makes trading profits at the expense of the liquidity traders. When the number
of liquidity traders increases, so does the potential trading profit for the manager and this leads to more nondisclosure.

We can now examine the effect that enforcement of insider trading laws will have on the disclosure equilibrium. Suppose that a regulatory agency like the Securities and Exchange Commission (SEC) conducts an investigation to uncover insider trading in the market. Further suppose that because of the costs involved in investigating and building a legal case against the manager, because of its limited resources, and because of the ambiguities in the law, the SEC cannot convict every nondisclosing manager even though it knows that such managers are trading on inside information in our model. Specifically, assume that the SEC convicts a nondisclosing manager with probability \( l \). In accordance with the Insider Trading Sanctions Act (ITSA) of 1984, if the manager is convicted, his trading profits are confiscated \textit{ex post} and he pays punitive penalties that can be up to three times his profits. Suppose these penalties, which can also include include nonmonetary costs like loss of reputation, are \( F \) times his trading profits. Then, the manager’s expected net insider trading profits when \( S = H \) are

\[
(v_0 + \epsilon_H - A_\phi)Q - \mu[(v_0 + \epsilon_H - A_\phi)Q + F(v_0 + \epsilon_H - A_\phi)Q] = Q[1 - \mu(1 + F)](v_0 + \epsilon_H - A_\phi).
\]

Therefore, we see that enforcement of insider trading laws reduces the manager’s trading profit because \( Q \) is reduced to \( Q(1 - \mu - \mu F) \). This reduction in \( Q \) is greater when SEC enforcement is more stringent (larger \( l \)) and when insider trading penalties are increased (larger \( F \)). We can see from Proposition 1 that a reduction in \( Q \) makes the full disclosure equilibrium more likely (since \( \alpha \) is more likely to lie in the full disclosure range) and increases the amount of disclosure in the partial disclosure equilibrium, since

\[
\frac{\partial d^*_\mu}{\partial Q} = -\frac{2\alpha Np_\ell(1 - p_\ell)(N + 1)(N + 2)}{[2\alpha(1 - p_\ell)(N + 1) - N^2(1 - p_\ell)(Q - \alpha)]^{3/2}} < 0.
\]

This leads naturally to the following corollary.

\textbf{Corollary 2.} \textit{The full disclosure equilibrium becomes more likely and the amount of disclosure in the partial disclosure equilibrium increases, when insider trading laws are more stringently enforced and when insider trading penalties are increased.}

Since prices are more informative when there is greater disclosure, the above corollary implies that insider trading regulations can increase the informational efficiency of stock prices by inducing more disclosure. This provides a possible justification for the enforcement of such regulations.
One of the limitations of our model is that we do not endogenize the number of shares traded by the manager. This is because the manager trades at given bid and ask prices and so his optimal trade size is unbounded. This problem is characteristic of all microstructure models like ours which are based on the Glosten and Milgrom (1985) extensive form. The competing model by Kyle (1985) allows us to endogenously derive the manager’s optimal trade quantity but it is critically dependent on the assumption of normality. This assumption is impossible to maintain in an equilibrium setting where partial disclosure is possible because such disclosure destroys the symmetricity that is central to normal distributions. Nevertheless, we expand our model in the Appendix to allow the manager to choose his trade size (to some extent) and show that the equilibrium in the basic model is not materially affected.

3.3. Empirical implications

Our model has many empirical implications some of which are consistent with the available evidence and others which are new and as yet untested. They are as follows:

1. Managers of firms with intermediate $x$ values are more likely to release good news than bad news promptly (because $d_l^u > d_l^b$ according to Proposition 1). This is consistent with the evidence presented by Givoly and Palmon (1982) and Patell and Wolfson (1982).

2. Since managers of firms with intermediate $x$ values are more likely to disclose good news than bad news, they are less likely to trade on good news than on bad news, i.e., insiders are more likely to sell than buy shares. This is consistent with the evidence presented by Elliot et al. (1984) and Seyhun (1986).

3. Firms with low and intermediate $x$ values sometimes may not disclose any news, good or bad (Proposition 1). Therefore, nondisclosure by itself can lead to stock prices going up, down or staying the same. This is consistent with the evidence presented by Foster (1981), Clinch and Sinclair (1987) and Lev and Penman (1990). But our model makes the new prediction that nondisclosure accompanied by insider selling (buying) implies bad (good) news and should lead to a stock price decline (increase). Therefore, in an industry where all firms are potential recipients of information, when one firm discloses information, the other nondisclosing firms should witness positive or negative market reactions depending upon whether the insiders in these firms have been buying or selling shares in the recent past.

4. Corollary 1 presents some new testable predictions. Firms that have higher managerial pay–performance sensitivities or that increase them over time will make more voluntary disclosures. Firms with heavily traded, liquid stocks (large $N$) and firms of lower quality or with more pessimistic analyst forecasts (higher $p_L$) will make fewer voluntary disclosures.
5. Proposition 1 and Corollary 1 imply that the full disclosure equilibrium is more likely to exist and $d_H^n$ in the partial disclosure equilibrium increases when $z$ increases. Since insider trading volume and bid–ask spreads are smaller with disclosure than without (compare Eqs. (4) and (5) to Eqs. (6) and (7), our model predicts negative relationships between insider trading volume and managerial pay–performance sensitivities and between bid–ask spreads and pay–performance sensitivities.

4. Extensions to the basic model

In this section, we will consider three extensions to the basic model discussed in the previous sections. First, we will analyze the effect of multiple insiders on the disclosure equilibrium. Then we will examine the impact of the short sales prohibition on insiders on the disclosure equilibrium. Finally, we will introduce the possibility of the manager making false disclosures and analyze the resulting disclosure equilibria.

4.1. Disclosure with multiple insiders

In the basic model, we assumed that the manager (the CEO) was the only person in the firm with access to private information and so he was the only one who could trade on that information. In reality, many middle and senior level executives other than the CEO are involved in producing information (such as that contained in an earnings report). Therefore, when the manager chooses not to disclose the information, he may not be the only inside trader. The resulting impact on his disclosure incentives will be the subject of our analysis in this section.

Suppose that there are $n$ insiders including the manager who are aware of the private signal $S \in \{L, H\}$. The manager’s disclosure policy is once again described by the mixed probabilities $\{d_L(n), d_H(n)\}$ where $d_S(n)$ is the probability (as a function of $n$) that he will disclose signal $S$ and $1 - d_S(n)$ is the probability that he will withhold the signal. When the manager discloses his signal, the market maker sets the bid and ask prices at their full information levels, resulting in zero spreads as in Eqs. (4) and (5):

$$B_L(n) = A_L(n) = v_0 - \epsilon_L,$$
$$B_H(n) = A_H(n) = v_0 + \epsilon_H.$$

When the manager withholds his signal ($D = \phi$), the market maker’s beliefs are the same as before (Eqs. (2) and (3)) and we can derive the bid and ask prices in a manner analogous to Lemma 1. The only difference is that the market maker will rationally anticipate $n$ orders from informed traders rather than the one
order in the basic model. Therefore, we just present these bid and ask prices in the following lemma (the proof is available on request):

**Lemma 2.** When \(D = \phi\), the market maker sets the following zero-profit bid and ask prices based on rational inferences of the manager’s signal and trading strategy:

\[
B_{\phi}(n) = v_0 - \frac{p_L[(N + 2n)(1 - d_L(n)) - N(1 - d_H(n))]}{p_L(N + 2n)(1 - d_L(n)) + N(1 - p_L)(1 - d_H(n))}\epsilon_L, \tag{13}
\]

\[
A_{\phi}(n) = v_0 + \frac{(1 - p_L)(N + 2n)(1 - d_H(n)) - N(1 - d_L(n))}{Np_L(1 - d_L(n)) + (N + 2n)(1 - p_L)(1 - d_H(n))}\epsilon_H. \tag{14}
\]

These bid and ask prices reduce to those in the basic model when we set \(n = 1\).

We can also easily show that \((\partial B_{\phi}(n)/\partial n) < 0\) and \((\partial A_{\phi}(n)/\partial n) > 0\). This implies that the bid–ask spread increases with \(n\) and is larger here than in the basic model. This result is intuitively sensible because the market maker faces a greater threat of informed trading now and so he sets a wider spread in order to break even.

The manager’s equilibrium disclosure policy \(\{d_L^*(n), d_H^*(n)\}\) must satisfy Eqs. (9) and (10) as before. Once again, he will choose \(d_L^*(n) = 0\) because disclosing bad news minimizes his payoff. The equilibrium disclosure policy will depend on his trade-offs in Eq. (10) when he has good news. As before, there are three possible disclosure equilibria depending on whether the manager’s pay–performance sensitivity is high, medium or low. These equilibria and the conditions for their existence are characterized in the following proposition.\(^{11}\)

**Proposition 2.** There exists a unique equilibrium disclosure strategy \(\{d_L^*(n), d_H^*(n)\}\) which is:

1. The full disclosure equilibrium if \(x \geq Q\), where \(d_L^*(n) = 0\) (or 1) and \(d_H^*(n) = 1\).
2. The nondisclosure equilibrium if \(0 < x \leq Q\), where \(d_L^*(n) = d_H^*(n) = 0\).
3. The partial disclosure equilibrium if

\[
0 < x < Q\left[\frac{N(N + 2np_L)}{N(N + 2n) + 2n^2(1 - p_L)}\right],
\]

where \(d_L^*(n) = 0\) and

\[
Q\left[\frac{N(N + 2np_L)}{N(N + 2n) + 2n^2(1 - p_L)}\right] < x < Q,
\]

where \(d_L^*(n) = 0\) and

\[^{11}\text{We skip the proof of this proposition since it is virtually identical to that of Proposition 1 except that the prices are given by Eqs. (11)–(14) rather than by Eqs. (4)–(7).}\]
We can now compare the disclosure equilibria in Propositions 1 and 2. It is easy to see that the full disclosure equilibrium and the conditions for its existence are the same in the two settings. But the conditions for the existence of the other two equilibria and the amount of disclosure in the partial disclosure equilibrium are different now. The following corollary specifies this difference.

**Corollary 3.** When \( n \) increases, the nondisclosure (partial disclosure) equilibrium is less (more) likely to exist and the amount of disclosure in the partial disclosure equilibrium increases.

**Proof.** See Appendix A.

The intuition here is that when \( n \) increases, the amount of informed trading in the market maker’s order flow increases. This allows the market maker to extract more information from the order flow and to set more accurate bid and ask prices (as evidenced by the larger bid–ask spread). Therefore, the manager makes smaller trading profits because his information advantage over the market is less and because of competition from other insiders. This weakens his incentive to withhold information and leads to more disclosure. One implication of this corollary is that managers are more likely to disclose information that is widely known within the firm (e.g., earnings) and less likely to disclose information that only they are privy to (e.g., a takeover bid on the firm).

4.2. Disclosure with a short sales prohibition on managers

Section 16(c) of the Securities Exchange Act of 1934 prohibits the insiders of firms from short-selling the firms’ stock. The law is intended to reduce the moral hazard problem for the manager by preventing him from making trading profits on actions that drive down the firm’s stock price. We now analyze the impact of this short sales ban on the disclosure equilibrium of Section 3.

Assume that, in our model the manager sells stock only through short sales. We can justify this by assuming that the manager owns only restricted stock which he is prevented from selling and so he is forced to sell short. Since the manager is prohibited from selling short, he will not be able to trade profitably on bad news. Based on this, the rational market maker will correctly infer that all incoming sell orders originate only from the uninformed liquidity

\[
d^*_n(n) = \frac{2xn(1 - p_l)(N + n) - N(N + 2np_l)(Q - x)}{2xn(1 - p_l)(N + n) - N^2(1 - p_l)(Q - x)}.\]

12 Our analysis in this section is unchanged (though messier) if the short sales prohibition only reduces, but does not eliminate, the likelihood of managerial trading on bad news.
traders. This allows him to ignore the sell-side order flow (which has no information content) when setting the bid price.

Let the manager’s disclosure policy be denoted by \( \{d^\text{ns}_L, d^\text{ns}_H\} \), where the superscript \( \text{ns} \) indicates that no short sales are allowed. When the manager discloses his signal, the market maker will set full information bid and ask prices as shown in Eqs. (4) and (5). When the manager withholds his signal \( (D = \phi) \), the bid and ask prices are given by the following lemma.

**Lemma 3.** When \( D = \phi \), the market maker sets the following zero-profit bid and ask prices based on rational inferences of the manager’s signal and trading strategy:

\[
B^\text{ns}_\phi = v_0 - \frac{p_L (d^\text{ns}_H - d^\text{ns}_L)}{p_L (1 - d^\text{ns}_L) + (1 - p_L) (1 - d^\text{ns}_H)} \epsilon_L,
\]

\[
A^\text{ns}_\phi = v_0 + \frac{(1 - p_L) [(N + 2) (1 - d^\text{ns}_H) - N (1 - d^\text{ns}_L)]}{N p_L (1 - d^\text{ns}_L) + (N + 2) (1 - p_L) (1 - d^\text{ns}_H)} \epsilon_H.
\]

**Proof.** See Appendix A.

Given the same disclosure probabilities with and without short sales, we can easily show that \( B^\text{ns}_\phi > B_\phi \) in Eq. (6). The reason is that when short sales are prohibited, the manager cannot trade on bad news and therefore, the market maker is unable to incorporate bad news into the bid price through the sell order flow. This leads to the inflated bad news price we see in Eq. (15), a fact that has interesting implications for the manager’s disclosure incentives.

Even though the manager cannot trade on bad news, he will never disclose bad news \( (d^\text{ns}_L = 0) \) because doing so will assure him of the minimum compensation. As before, he will set \( d^\text{ns}_H \) in accordance with Eq. (10). Once again, the equilibrium will range from full disclosure to partial disclosure to non-disclosure depending on the size of \( \alpha \). These three possible equilibria and the conditions for their existence are characterized in Proposition 3 below.\(^\text{13}\)

**Proposition 3.** There exists a unique equilibrium disclosure strategy \( \{d^\text{ns}_L, d^\text{ns}_H\} \) which is:

1. The full disclosure equilibrium if \( \alpha \geq Q \), where \( d^\text{ns}_L = 0 \) (or 1) and \( d^\text{ns}_H = 1 \).
2. The nondisclosure equilibrium if

\[
0 < \alpha \leq Q \left[ \frac{N}{N + 1 - p_L} \right],
\]

\(^\text{13}\) The proof of this proposition is identical to that of Proposition 1 except that the bid and ask prices are now given by Eqs. (15) and (16) instead of Eqs. (6) and (7).
where \( d_L^{ns} = d_H^{ns} = 0 \).

3. The partial disclosure equilibrium if

\[
Q \left[ \frac{N}{N + 1 - p_L} \right] < x < Q,
\]

where \( d_L^{ns} = 0 \) and

\[
d_H^{ns} = \frac{x(1 - p_L) - N(Q - x)}{x(1 - p_L) - N(1 - p_L)(Q - x)}.\]

On comparing Propositions 1 and 3, we see that the disclosure equilibria are different with and without short sales. We can easily show that the range of \( x \) values for which the nondisclosure equilibrium exists in Proposition 3 is larger than the corresponding range in Proposition 1. We can also show after some tedious algebra that the above \( d_H^{ns} < d_H^* \) in Proposition 1. These two differences together imply that when short selling by insiders is banned, the nondisclosure (partial disclosure) equilibrium is more (less) likely to exist and the amount of disclosure in the partial disclosure equilibrium is reduced. The intuition for this finding is as follows. We saw earlier that a ban on short sales inflates the bid price when \( D = \phi \) since bad news is not incorporated in the order flow. The inflated bid price increases the manager’s compensation, \( x(A^\phi^{ns} + B^\phi^{ns})/2 \), under nondisclosure. Since the manager in our model discloses good news only to capture the resulting higher compensation, increasing the manager’s compensation under nondisclosure reduces his incentives to disclose good news voluntarily, i.e., the short sales ban leads to reduced disclosure. A related implication is that the short sales ban reduces market efficiency by reducing the amount of voluntary disclosure by managers.

4.3. Disclosure when managers can lie

Our analysis so far has given the manager a choice between disclosing his information truthfully or not at all. Now we will consider his disclosure incentives when he is allowed to make false disclosures. In order to reduce the multiplicity of possible disclosure equilibria, we will simplify the analysis by assuming that the manager makes either a truthful disclosure or a false one.\(^{14}\)

Let us denote the manager’s disclosure policy by \( \{d_L, d_H\} \), where \( d_S \) is now the probability that the manager will disclose his signal \( S \in \{L, H\} \) truthfully and \( 1 - d_S \) the probability that he will make a false disclosure (disclose good news when he receives bad news and vice versa). Therefore, the manager’s disclosure \( D \in \{L, H\} \) will not fully reveal his private information (in contrast

\(^{14}\) We can confirm that the main results of our analysis are unchanged if we allow managers the third choice of making no disclosure.
to the basic model). We will assume that the manager incurs a fixed, personal cost $C$ whenever he makes a false disclosure. This is a reasonable assumption because managers who lie face the increased risk of regulatory penalties, shareholder lawsuits and loss of reputation. Given the manager’s disclosure policy above, we derive the market maker’s bid and ask prices in the following lemma.

**Lemma 4.** The market maker sets the following zero-profit bid and ask prices, $B_D$ and $A_D$, based on rational inferences of the manager’s disclosure $D$ and his trading strategy:

$$B_L = v_0 - \frac{p_L [d_L (N + 2) - N (1 - d_H)]}{p_L d_L (N + 2) + N (1 - p_L) (1 - d_H)} \varepsilon_L,$$

$$A_L = v_0 + \frac{(1 - p_L) [(N + 2) (1 - d_H) - N d_L]}{N p_L d_L + (N + 2) (1 - p_L) (1 - d_H)} \varepsilon_H,$$

$$B_H = v_0 - \frac{p_L [(N + 2) (1 - d_L) - N d_H]}{p_L (N + 2) (1 - d_L) + N d_H (1 - p_L)} \varepsilon_L,$$

$$A_H = v_0 + \frac{(1 - p_L) [d_H (N + 2) - N (1 - d_L)]}{N p_L (1 - d_L) + d_H (N + 2) (1 - p_L)} \varepsilon_H.$$

**Proof.** See Appendix A.

As usual, the manager will choose his equilibrium disclosure probabilities $\{d^*_L, d^*_H\}$ so that he is indifferent between lying and telling the truth. With each signal, the manager faces a trade-off between disclosing truthfully to avoid the cost $C$ and lying to obtain greater trading profits and even a higher compensation. When his signal is $S = L$, his payoff from disclosing truthfully ($D = L$) is the sum of his compensation and trading profits, $\alpha (A_L + B_L) / 2 + Q (B_L - v_0 + \varepsilon_L)$. But if he falsely discloses $D = H$, his payoff will be the sum of his compensation and trading profits less the cost of lying, $\alpha (A_H + B_H) / 2 + Q (B_H - v_0 + \varepsilon_L) - C$. The manager will choose $d^*_L$ in order to satisfy

$$\alpha \frac{(A_L + B_L)}{2} + Q (B_L - v_0 + \varepsilon_L)$$

$$= \alpha \frac{(A_H + B_H)}{2} + Q (B_H - v_0 + \varepsilon_L) - C.$$  

**Similarly,** the manager will choose $d^*_H$ to satisfy

$$\alpha \frac{(A_H + B_H)}{2} + Q (v_0 + \varepsilon_H - A_H)$$

$$= \alpha \frac{(A_L + B_L)}{2} + Q (v_0 + \varepsilon_H - A_L) - C.$$  

**Proof.** See Appendix A.
Since the probabilities $d_L$ and $d_H$ can each take on one of three possible values (0, 1, or some value in between), there are nine possible candidate equilibria. In order to prune this list, we will focus our attention only on those equilibria where disclosure is relevant. Disclosure is irrelevant to the market when it sets the same bid and ask prices regardless of whether the manager discloses good news or bad news, i.e., when $A_H = A_L$ and $B_H = B_L$. We see from Eqs. (17)–(20) that

$$A_H - A_L = \frac{N_p L \epsilon_L (N + 2)(d_L + d_H - 1)}{[N_p L (1 - d_L) + d_H (N + 2)(1 - p_L)] [N_p L d_L + (N + 2)(1 - p_L)(1 - d_H)]]}$$  \hspace{1cm} (23)$$

$$B_H - B_L = \frac{N_p L \epsilon_L (N + 2)(d_L + d_H - 1)}{[p_L (N + 2)(1 - d_L) + N d_H (1 - p_L)] [p_L d_L (N + 2) + N (1 - p_L)(1 - d_H)]]}.$$  \hspace{1cm} (24)$$

Therefore, the manager’s disclosure will be irrelevant when $d_L + d_H = 1$. Since we are interested only in those equilibria where disclosure is relevant, we require that $d_L + d_H \neq 1$. This rules out two of the nine candidate equilibria: $\{d_L = 0; d_H = 1\}$ and $\{d_L = 1; d_H = 0\}$.

From Eqs. (23) and (24), we can see that $A_H < A_L$ and $B_H < B_L$ when $d_L + d_H < 1$. Intuitively, when $d_L + d_H < 1$, any disclosure by the manager is more likely to be a lie than the truth because $d_L < 1 - d_H$ and $d_H < 1 - d_L$. Therefore, the market maker will interpret a disclosure of bad (good) news as more likely indicative of good (bad) news and will set higher bid and ask prices for $D = L$ than for $D = H$. Since $A_H < A_L$ and $B_H < B_L$ when $d_L + d_H < 1$, we can see from Eq. (21) that the manager who receives $S = L$ is strictly better disclosing $D = L$ than disclosing $D = H$ (because he receives larger compensation and trading profits and avoids the cost $C$). Therefore, when $d_L + d_H < 1$, the $S = L$ manager will always tell the truth and set $d_L = 1$. But this creates a contradiction since $d_L + d_H \neq 1$ when $d_L = 1$ and this implies that we cannot have $d_L + d_H < 1$ in any feasible disclosure equilibrium. This rules out another three candidate equilibria: $\{d_L = 0; d_H = 0\}; \{d_L = 0; 0 < d_H < 1\};$ and $\{0 < d_L < 1; d_H = 0\}$.

We can eliminate one more candidate equilibrium: $\{d_L = 1; 0 < d_H < 1\}$. In this equilibrium, the manager who gets $S = L$ never lies and so a $D = H$ disclosure unambiguously implies that the manager has good news, i.e., $A_H = B_H = v_0 + \epsilon_H$. As we saw earlier, the manager will choose $d_H \in (0, 1)$ in
order to satisfy Eq. (22). Substituting for $A_H = B_H = v_0 + \epsilon_H$ into Eq. (22) and rearranging terms, we get

$$C = Q(v_0 + \epsilon_H - A_L) - \alpha \left( v_0 + \epsilon_H - \frac{A_L + B_L}{2} \right). \quad (25)$$

In order for $d_L = 1$ in this equilibrium, the manager must be strictly better off disclosing truthfully than lying, i.e., the left-hand side of Eq. (21) must be greater than the right-hand side. Substituting for $A_H = B_H = v_0 + \epsilon_H$ into the resulting inequality and rearranging terms, we get

$$C > Q(v_0 + \epsilon_H - B_L) + \alpha \left( v_0 + \epsilon_H - \frac{A_L + B_L}{2} \right). \quad (26)$$

The candidate equilibrium will exist only if $C$ simultaneously satisfies Eqs. (25) and (26). We can easily check that this can never be true since we know from Eqs. (17) and (18) that $A_L > B_L$. Therefore, the above candidate equilibrium cannot exist.

We can see from the analysis so far that $d_L + d_H \neq 1$ and $d_L + d_H \neq 1$. This implies that a necessary, but not sufficient, condition for any feasible disclosure equilibrium is $d_L + d_H > 1$. In other words, the manager’s disclosure is always more likely to be true than false in any feasible equilibrium. Having eliminated six of the nine candidate equilibria, we are left with three remaining equilibria that satisfy the above necessary condition. They are:

1. Full disclosure: $\{d_L^* = 1; d_H^* = 1\}$.
2. Partial disclosure: $\{0 < d_L^* < 1; 0 < d_H^* < 1$ where $d_L^* + d_H^* < 1\}$.
3. Partial disclosure: $\{0 < d_L^* < 1; d_H^* = 1\}$.

The manager never lies in the full disclosure equilibrium though he may lie (to different degrees) in the two partial disclosure equilibria. The full disclosure equilibrium will exist when the manager’s payoff from truth-telling (the left-hand sides of Eqs. (21) and (22)) is greater than his payoff from lying (the right-hand sides of Eqs. (21) and (22)). Substituting for the bid and ask prices from Lemma 4 and setting $d_L^* = d_H^* = 1$, we get two inequalities that must be satisfied for the full disclosure equilibrium to exist: $C > (Q - \alpha)(\epsilon_L + \epsilon_H)$ and $C > (Q + \alpha)(\epsilon_L + \epsilon_H)$. The latter inequality is the binding one and it tells us that the manager will never lie in equilibrium only when the cost of lying is very large.

Obviously, the two partial disclosure equilibria listed above will exist only when $C < (Q + \alpha)(\epsilon_L + \epsilon_H)$. In the first partial disclosure equilibrium, the manager may lie with both good and bad news. We can obtain the equilibrium probabilities of truth-telling, $d_L^*$ and $d_H^*$, by solving Eqs. (21) and (22) simultaneously. Unfortunately, owing to the complexity of these equations, we are
unable to derive closed-form solutions for these equilibrium probabilities. But we can show that this equilibrium does exist for certain parameter values. For example, when \( N = 25 \), \( p_L = 0.9 \), \( \epsilon_L = 1.3 \), \( \alpha = 50 \), \( Q = 830 \), and \( C = 1000 \), we can derive \( d^*_L = 0.6122 \) and \( d^*_H = 0.6370 \).

In the second partial disclosure equilibrium, the manager never lies with good news but may lie with bad news. Since \( d^*_H = 1 \), this equilibrium will exist only if the left-hand side exceeds the right-hand side in Eq. (22). We can obtain closed-form solutions for \( d^*_L \) by solving Eq. (21) (which is quadratic in \( d^*_L \)). Once again, we can show that this equilibrium exists for certain parameter values. For example, when \( N = 100 \), \( p_L = 0.5 \), \( \epsilon_L = 1 \), \( \alpha = 30 \), \( Q = 60 \), and \( C = 100 \), we can derive \( d^*_L = 0.2105 \) and show that the inequality relating to Eq. (22) is satisfied. Unfortunately, we are unable to analytically sign the partial derivatives of \( d^*_L \) with respect to the various parameters. But our numerical calculations always show that \( d^*_L \) is increasing in \( C \) and decreasing in \( N \), \( Q \), \( p_L \) and \( \alpha \). These results are intuitively sensible. When lying becomes more costly, the manager is more likely to make truthful disclosures. When \( N \) or \( Q \) increases, the manager’s potential trading profits increase and so he has less of an incentive to disclose truthfully. Similarly, when \( p_L \) increases, the information advantage of the manager with bad news is less and so he lies more often in order to increase his payoff. Finally, the manager is more likely to lie when \( \alpha \) increases because he has a greater incentive to increase his compensation. This last result is interesting because it suggests that even though managerial contracts with high \( \alpha \) may improve their incentives, it may also encourage them to lie more often.

The above results on the different equilibria are summarized in the following proposition.

**Proposition 4.** When managers are allowed to make false disclosures, there exists a unique disclosure equilibrium which is one of the following:

1. The full disclosure equilibrium if \( C > (Q + \alpha)(\epsilon_L + \epsilon_H) \) where \( d^*_L = d^*_H = 1 \).
2. A partial disclosure equilibrium if \( C < (Q + \alpha)(\epsilon_L + \epsilon_H) \) and Eq. (21) and (22) are satisfied where \( 0 < d^*_L < 1 \); \( 0 < d^*_H < 1 \); and \( d^*_L + d^*_H > 1 \).
3. A partial disclosure equilibrium if \( C < (Q + \alpha)(\epsilon_L + \epsilon_H) \), Eq. (21) is satisfied and Eq. (22) is satisfied as an inequality where \( 0 < d^*_L < 1 \) and \( d^*_H = 1 \).

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15 We do not report this solution here because of its algebraic messiness and its resulting lack of economic intuition. It is available from the authors on request.

16 Of course, we know from scanning the business press that there is ample real-world existence that supports the existence of this equilibrium. For example, see the cover story in *Business Week*, October 5, 1998, which reports on the increasing trend among managers to inflate earnings to avoid disclosing bad news.
5. Conclusion

In this paper, we studied the incentives for managers to voluntarily disclose private information about their firms when they have opportunities to trade on it. We showed that the degree of managerial disclosure was increasing in their pay–performance sensitivity and ranged from non-disclosure to partial disclosure to full disclosure. While enforcement of insider trading laws and penalties induced managers to disclose more information and made stock prices more efficient, short sales prohibitions on insiders had the opposite effect. The presence of multiple insiders was seen to encourage more disclosure. When false disclosures were allowed, the degree of truth-telling by managers was increasing in the cost of lying. But any disclosure was always more likely to be true than false. Finally, our model generated many testable predictions, some of which are consistent with the existing evidence and others which reconcile some anomalous empirical findings. We also obtained some new predictions whose empirical validation remains the subject of future research.

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Appendix A

Proof of Lemma 1. The market maker sets the bid price $B_\phi$ at $t = 3$ so as to make zero expected profits on the incoming sell orders from the manager and the liquidity traders at $t = 4$. Similarly, he sets the ask price $A_\phi$ so as to make zero profits on the incoming buy orders from the manager and the liquidity traders.

When $D = \phi$, the market maker’s updated beliefs about the manager’s signal are given by Eqs. (2) and (3). His expected profit from executing incoming sell orders at $B_\phi$ is given by
\[ E(\Pi_B) = \Pr(S = L \mid D = \phi)E(\Pi_B \mid S = L, D = \phi) \\
+ \Pr(S = H \mid D = \phi)E(\Pi_B \mid S = H, D = \phi). \] (A.1)

When \( S = L \), the manager is conjectured to sell \( Q \) shares and it is expected that \( N/2 \) liquidity traders will also submit sell orders of \( Q \) shares each (since the \( N \) liquidity traders are equally likely to buy or sell). Furthermore, the market maker’s expected profit on each share sold to him when \( S = L \) is \( (v_0 - \epsilon_L - B_\phi) \). Therefore, his total expected profit on sell orders when \( S = L \) is given by

\[ E(\Pi_B \mid S = L, D = \phi) = (v_0 - \epsilon_L - B_\phi)\left(\frac{N}{2} + 1\right)Q. \] (A.2)

When \( S = H \), the manager will not sell and the market maker is expected to receive sell orders of \( Q \) shares each only from the \( N/2 \) liquidity traders. His profit on each share sold when \( S = H \) is \( (v_0 + \epsilon_H - B_\phi) \). Therefore, his total expected profit on sell orders when \( S = H \) is given by

\[ E(\Pi_B \mid S = H, D = \phi) = (v_0 + \epsilon_H - B_\phi)\left(\frac{N}{2}\right)Q. \] (A.3)

Substituting Eqs. (A.2) and (A.3) into Eq. (A.1) above and also substituting for the Bayesian updated probabilities from Eqs. (2) and (3), we have

\[ E(\Pi_B) = \{p_L(1 - d_L)(v_0 - \epsilon_L - B_\phi)((N/2) + 1)Q \\
+ (1 - p_L)(1 - d_H)(v_0 + \epsilon_H - B_\phi)(N/2)Q\} \\
/\{p_L(1 - d_L) + (1 - p_L)(1 - d_H)\}. \] (A.4)

On equating \( E(\Pi_B) \) to zero and solving for \( B_\phi \), we can derive the zero-profit bid price \( B_\phi \) as in Eq. (6).

The market maker’s expected profit from executing incoming buy orders is calculated in a similar manner and is given by

\[ E(\Pi_A) = \Pr(S = L \mid D = \phi)E(\Pi_A \mid S = L, D = \phi) \\
+ \Pr(S = H \mid D = \phi)E(\Pi_A \mid S = H, D = \phi). \] (A.5)

Using similar arguments as before, we can show that

\[ E(\Pi_A \mid S = L, D = \phi) = (A_\phi - v_0 + \epsilon_L)\left(\frac{N}{2}\right)Q, \] (A.6)

\[ E(\Pi_A' \mid S = H, D = \phi) = (A_\phi - v_0 - \epsilon_H)\left(\frac{N}{2} + 1\right)Q. \] (A.7)

On substituting Eqs. (A.6) and (A.7) and the Bayesian probabilities from Eqs. (2) and (3) into Eq. (A.5) and setting \( E(\Pi_A) \) to zero, we can solve for \( A_\phi \). This gives us the zero-profit ask price \( A_\phi \) as in Eq. (7).
Proof of Proposition 1. We have already shown in the text of the paper that $d_L^* = 0$ and so we only have to calculate $d_H^*$. As we discussed earlier, the choice of $d_H^*$ involves a trade-off between the larger compensation with disclosure and the larger profits with nondisclosure. Referring to Eq. (10), we can see that the extra compensation from disclosure of good news is $z(v_0 + \epsilon_H - (A_\phi + B_\phi)/2)$. We can also infer from the same equation that the extra profit from nondisclosure of good news is $Q(v_0 + \epsilon_H - A_\phi)$. If the extra compensation from disclosure is greater than the extra profit from nondisclosure, the manager will follow the pure strategy of always disclosing good news, i.e., $d_H^* = 1$ if

$$z\left(v_0 + \epsilon_H - \frac{A_\phi + B_\phi}{2}\right) \geq Q(v_0 + \epsilon_H - A_\phi).$$

Equivalently, the manager will choose $d_H^* = 1$ if

$$z \geq Q\left(\frac{v_0 + \epsilon_H - A_\phi}{v_0 + \epsilon_H - (A_\phi + B_\phi/2)}\right).$$

(A.8)

On substituting for $B_\phi$ and $A_\phi$ from Eqs. (6) and (7) and setting $d_L = 0$ (as proved earlier) and $d_H = 1$ (since that is the case if Eq. (A.8) is satisfied), we can show that Eq. (A.8) reduces to

$$z \geq Q.$$  

(A.9)

This proves the first part of the proposition.

Similarly, we can see that the manager will follow the pure strategy of never disclosing good news if the extra profit from nondisclosure is greater than the extra compensation from disclosure, i.e., $d_H^* = 0$ if the inequality in Eq. (A.8) is reversed:

$$z \leq Q\left(\frac{v_0 + \epsilon_H - A_\phi}{v_0 + \epsilon_H - (A_\phi + B_\phi/2)}\right).$$

(A.10)

Once again, substituting for $B_\phi$ and $A_\phi$ from Eqs. (6) and (7) and setting $d_L = d_H = 0$ (since that is the case if Eq. (A.10) is satisfied), we can show that Eq. (A.10) reduces to

$$z \leq Q\left(\frac{N(N + 2p_L)}{N(N + 2) + 2(1 - p_L)}\right).$$

(A.11)

This proves the second part of the proposition.

Finally, when the extra compensation from disclosure is exactly equal to the extra profit from nondisclosure, the manager will follow a mixed strategy of disclosing with probability $d_H^*$ and withholding with probability $1 - d_H^*$, where $0 < d_H^* < 1$. The mixing probability $d_H^*$ is derived by solving Eq. (10) which is rewritten below:
\[ x \left( v_0 + \epsilon_H - \frac{A_\phi + B_\phi}{2} \right) = Q \left( v_0 + \epsilon_H - A_\phi \right). \]

On substituting for \( B_\phi \) and \( A_\phi \) from Eqs. (6) and (7) and solving for \( d_H^* \), we get

\[ d_H^* = \frac{2x(1 - p_L)(N + 1) - N(N + 2p_L)(Q - x)}{2x(1 - p_L)(N + 1) - N^2(1 - p_L)(Q - x)}. \] (A.12)

For this mixed strategy to exist, we must show that the equilibrium mixing probability lies between 0 and 1, i.e., \( 0 < d_H^* < 1 \). When \( x \) lies in the interval

\[ Q \left[ \frac{N(N + 2p_L)}{N(N + 2) + 2(1 - p_L)} \right] < x < Q \] (A.13)

we can easily show that the numerator of \( d_H^* \) in Eq. (A.12) is less than the denominator and that both are positive. This ensures that \( 0 < d_H^* < 1 \) and proves the final part of the proposition.

**Proof of Corollary 1.** We know from Proposition 1 that the nondisclosure equilibrium will exist if

\[ 0 < x \leq Q \left[ \frac{N(N + 2p_L)}{N(N + 2) + 2(1 - p_L)} \right] = x_{\text{max}}. \]

Obviously, as \( x \) decreases, it is more likely to fall in this range and the nondisclosure equilibrium is more likely to exist. We can also show by taking partial derivatives that

\[ \frac{\partial x_{\text{max}}}{\partial p_L} = \frac{2QN(N + 1)(N + 2)}{[N(N + 2) + 2(1 - p_L)]^2} > 0, \]

\[ \frac{\partial x_{\text{max}}}{\partial N} = \frac{2Q(1 - p_L)(N^2 + 2N + 2p_L)}{[N(N + 2) + 2(1 - p_L)]^2} > 0. \]

Therefore, as \( p_L \) and \( N \) increase, \( x_{\text{max}} \) increases. This increases the range of parameter values for which the nondisclosure equilibrium will exist and makes it more likely for the nondisclosure equilibrium to exist. This proves the corollary for the nondisclosure equilibrium.

For the partial disclosure equilibrium, we can show that the amount of disclosure (\( d_H^* \)) decreases when \( z \) decreases and when \( p_L \) and \( N \) increase by taking partial derivatives of \( d_H^* \) in Eq. (A.12):
It is easy to see that \( \frac{\partial d^*_H}{\partial \alpha} > 0 \). Since Eq. (A.13) tells us that \( \alpha < Q \) for the partial disclosure equilibrium to exist, we can infer that \( \frac{\partial d^*_H}{\partial N} < 0 \). Finally, we know from Eq. (A.13) that, for the partial disclosure equilibrium to exist,

\[
\alpha > Q \left[ \frac{N(N + 2p_L)}{N(N + 2) + 2(1 - p_L)} \right] > Q \left[ \frac{N(N + 2p_L)}{N(N + 2) + 2} \right].
\]

This implies that

\[
N^2(Q - \alpha) - 2\alpha(N + 1) = N^2 Q - \alpha(N^2 + 2N + 2) < -2NQp_L < 0.
\]

Therefore, we can conclude that \( \frac{\partial d^*_H}{\partial p_L} < 0 \). This proves the corollary for the partial disclosure equilibrium.

### A.1. Allowing the manager to choose his trade size

Suppose the manager and liquidity traders can trade one of \( T \) possible trade sizes \( Q_1, Q_2, \ldots, Q_T \) where we index these sizes without loss of generality such that \( Q_1 < Q_2 < \cdots < Q_T \). The market maker sets zero-profit bid and ask prices, \( B_D(Q_t) \) and \( A_D(Q_t) \), for each trade size \( Q_t \). When the manager discloses his signal, the market maker sets all the bid and ask prices to the full information levels given by Eqs. (4) and (5) and the manager’s optimal trade size is zero (as in the basic model). But his trade size choice is non-trivial when \( D = \phi \).

The first result we can demonstrate is that the manager’s optimal trade size cannot be smaller than \( Q_T \). In order to prove this, assume that his optimal trade sizes with good and bad news are \( Q_i \) and \( Q_j \), respectively, where \( Q_i < Q_T \) and \( Q_j < Q_T \). So the market maker can ignore the order flow when setting bid and ask prices for quantities other than \( Q_i \) and \( Q_j \) because orders for these quantities originate only from uninformed liquidity traders. Therefore, the bid and ask prices for these trade sizes are given by

\[
B_\phi(Q_t) = A_\phi(Q_t) = \Pr(S = L | D = \phi)(v_0 - \epsilon_L) + \Pr(S = H | D = \phi)(v_0 + \epsilon_H), \quad \forall t \neq i, j.
\]
On substituting for the market maker’s updated beliefs from Eqs. (2) and (3), we get

\[ B_{\phi}(Q_t) = A_{\phi}(Q_t) = v_0 - \frac{p_L(d_H - d_L)}{p_L(1 - d_L) + (1 - p_L)(1 - d_H)} \epsilon_L, \]

\[ \forall t \neq i, j. \quad (A.17) \]

Since the manager buys \( Q_i \) shares when \( S = H \) and sells \( Q_j \) shares when \( S = L \), sell orders for \( Q_i \) shares and buy orders for \( Q_j \) shares are all liquidity trades and so \( B_{\phi}(Q_i) \) and \( A_{\phi}(Q_j) \) are also given by Eq. (A.17). But the market maker faces the threat of informed trading when he transacts buy orders for \( Q_i \) shares and sell orders for \( Q_j \) shares. Since this threat is identical to that in the basic model, he sets \( B_{\phi}(Q_i) \) and \( A_{\phi}(Q_j) \) as in Eqs. (6) and (7), respectively.

In order for \( Q_i \) and \( Q_j \) to be the optimal (equilibrium) trade sizes for the manager, he should have no incentive to defect to any other trade size. When \( S = H \) and \( D = \phi \), the manager’s payoff when he buys \( Q_i \) shares is \( \alpha P_{av} + Q_i(v_0 + \epsilon_H - A_{\phi}(Q_i)) \), where \( P_{av} \) represents the average stock price on which his compensation is based. But if the manager defects and buys \( Q_T \) shares instead, his payoff will be \( \alpha P_{av} + Q_T(v_0 + \epsilon_H - A_{\phi}(Q_T)) \). We know that \( Q_T > Q_i \) and we can show with some algebraic manipulation of Eqs. (A.17) and (7) that \( A_{\phi}(Q_T) < A_{\phi}(Q_i) \). Therefore, the manager’s payoff will be greater if he defects from buying \( Q_i \) shares to buying \( Q_T \) shares and so buying \( Q_i \) shares. Since this threat is identical to that in the basic model, he sets \( B_{\phi}(Q_i) \) and \( A_{\phi}(Q_j) \) as in Eqs. (6) and (7), respectively.

Since informed trading does not occur for trade sizes smaller than \( Q_T \), the bid and ask prices for all of these sizes are given by Eq. (A.17). When \( S = H \) and \( D = \phi \), the manager’s payoff when he buys \( Q_T \) shares is \( \alpha P_{av} + Q_T(v_0 + \epsilon_H - A_{\phi}(Q_T)) \). Since the ask prices are the same for all smaller trade sizes, his maximum defection payoff will occur if he defects to size \( Q_{T-1} \),

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at which size his payo/C128 will be $zP_{av} + QT_{T-1}(v_0 + \epsilon_H - A_\phi(QT_{T-1}))$. Obviously, $QT$ is his optimal trade size if
\[ zP_{av} + QT(v_0 + \epsilon_H - A_\phi(QT)) > zP_{av} + QT_{T-1}(v_0 + \epsilon_H - A_\phi(QT_{T-1})). \]

On substituting for $A_\phi(QT)$ and $A_\phi(QT_{T-1})$ from Eqs. (7) and (A.17), respectively, we get the necessary condition for $QT$ to be the optimal trade size when $S = H$ as
\[ \frac{QT}{QT_{T-1}} > 1 + \frac{2(1 - p_L)(1 - d_H)}{N[p_L(1 - d_L) + (1 - p_L)(1 - d_H)]}. \] (A.18)

Using similar arguments, we can derive the the necessary condition for $QT$ to be the optimal trade size when $S = L$ as
\[ \frac{QT}{QT_{T-1}} > 1 + \frac{2p_L(1 - d_L)}{N[p_L(1 - d_L) + (1 - p_L)(1 - d_H)]}. \] (A.19)

Depending on the parameter values and the equilibrium values of $d_L$ and $d_H$, one of these two conditions will be the binding constraint. But we can see that both conditions imply that a disclosure equilibrium where the manager chooses to trade $QT$ will exist only if the market has sufficient width (i.e., $QT$ is sufficiently greater than $QT_{T-1}$). 19

Once the market width conditions (A.18) and (A.19) are satisfied, we can derive the equilibrium disclosure probabilities in exactly the same manner as in the basic model since the manager’s trade-off between disclosure and nondisclosure is unchanged. The equilibrium will have the same properties as in the basic model (see Proposition 1 and Corollary 1) except that $Q$ is replaced by the optimal trade size $QT$. In other words, the disclosure equilibrium is unaffected when we allow the manager to choose his optimal trade size except that its existence requires that a new market width condition (Eq. (A.18) or Eq. (A.19)) be satisfied.

**Proof of Corollary 3.** We know from Proposition 2 that the nondisclosure (partial disclosure) equilibrium will prevail when $z \leq (>) z_{max}(n) = Q[N(N + 2np_L)/N(N + 2n) + 2n^2(1 - p_L)]$. It is easy to check that $z_{max}(n)$ is decreasing in $n$ because
\[ \frac{\partial z_{max}(n)}{\partial n} = -\frac{2QN(1 - p_L)[N(N + 2n) + 2n^2p_L]}{[N(N + 2n) + 2n^2(1 - p_L)]^2} < 0. \]

18 In this scenario, it is most reasonable to define $P_{av}$ as the average of the two most informative prices, $B_\phi(QT)$ and $A_\phi(QT)$, since the manager’s private information is partially incorporated into the $QT$-order flow.
19 Easley and O’Hara (1987) derive a similar condition for the existence of their separating equilibrium where informed traders transact only at the largest trade size.
This implies that \( x \) is less (more) likely to lie in the nondisclosure (partial disclosure) range when \( n \) increases. We can also see that \( d_{H}^{*}(n) \) is increasing in \( n \) because
\[
\frac{\partial d_{H}^{*}(n)}{\partial n} = \frac{2Np_{L}(1 - p_{L})(Q - x)[QN^{2} + 2xn(N + n)]}{[2xn(1 - p_{L})(N + n) - N^{2}(1 - p_{L})(Q - x)]^{2}} > 0
\]
since \( x < Q \) in the partial disclosure equilibrium.

**Proof of Lemma 3.** Due to the short sales ban, the manager cannot trade on bad news and so the market maker will ignore the sell order flow when setting the bid price \( B_{\phi}^{ns} \) since it originates entirely from uninformed liquidity traders. Therefore, he will set the bid price as
\[
B_{\phi}^{ns} = \Pr(S = L | D = \phi)(v_{0} - \epsilon_{L}) + \Pr(S = H | D = \phi)(v_{0} + \epsilon_{H}).
\]
On substituting for the market maker’s updated beliefs from Eqs. (2) and (3) into the above equation, we can derive \( B_{\phi}^{ns} \) as in Eq. (15). Since the manager’s trading strategy with good news is the same as before, the expression for \( A_{\phi}^{ns} \) is the same as that for \( A_{\phi} \) in Eq. (7).

**Proof of Lemma 4.** Given the manager’s disclosure policy, we know that \( \Pr(D = L | S = L) = d_{L}; \Pr(D = H | S = H) = d_{H}; \Pr(D = H | S = L) = 1 - d_{L}; \Pr(D = L | S = H) = 1 - d_{H}. \) Since the market maker’s prior probabilities are \( \Pr(S = L) = p_{L} \) and \( \Pr(S = H) = 1 - p_{L}, \) he will apply Bayes’ rule to update his beliefs conditional on the manager’s disclosure \( D \in \{L, H\}: \)
\[
\begin{align*}
\Pr(S = L | D = L) &= \frac{p_{L}d_{L}}{p_{L}d_{L} + (1 - p_{L})(1 - d_{H})}, \\
\Pr(S = H | D = L) &= \frac{(1 - p_{L})(1 - d_{H})}{p_{L}d_{L} + (1 - p_{L})(1 - d_{H})}, \\
\Pr(S = H | D = H) &= \frac{d_{H}(1 - p_{L})}{p_{L}(1 - d_{L}) + d_{H}(1 - p_{L})}, \\
\Pr(S = L | D = H) &= \frac{p_{L}(1 - d_{L})}{p_{L}(1 - d_{L}) + d_{H}(1 - p_{L})}.
\end{align*}
\]

We can use the updated beliefs above and the fact that the manager will buy (sell) when his signal is \( S = H \) \( (S = L) \) to derive the bid and ask prices in a manner analogous to Lemma 1 (see Eqs. (A.1) and (A.5)). This gives us the bid and ask prices as shown in Eqs. (17)–(20).
References