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Abstract

A sender who has disclosable information with probability less than one may partially conceal bad news by choosing to withhold information and pooling with uninformed types. The success of this strategy depends on receivers' beliefs about the probability that the sender has disclosable news. In a dynamic context, informed senders try to cultivate a reputation for reticence either by concealing good news along with the bad, or by concealing some good news and disclosing some bad news. A reputation for reticence is valuable because it makes receivers less skeptical of past or future non-disclosures. The model provides insight into the choice by firms such as Google not to disclose quarterly earnings guidance to analysts, as well as Tony Blair's reticence over his son's vaccine record during the MMR scare in the UK.

1 Introduction

When does it make sense to tell the truth, but not the whole truth? Managers must avoid making objectively false statements to investors, as these could later lead to large lawsuits or prison time. However, telling the truth does not necessarily require telling the whole truth. Managers may be able to withhold information or delay its release in order to "manage" earnings and manipulate their firm's share price. Similar features are present in communication between voters and a politician who must decide how much to reveal about past indiscretions, as well as in communication between buyers and a seller who must decide how much to reveal about product quality.

The seminal "unraveling" result is that when announcements are verifiable, communication is fully revealing (Grossman and Hart 1980, Grossman 1981, Milgrom 1981, Okuno-Fujiwara, Postlewaite and Suzumura 1990). This is because, in equilibrium, receivers infer the worst whenever a sender withholds information, leading senders to reveal everything but the very worst. This result seems to fit some communication very well. For instance, during his first presidential campaign, President George W. Bush said that he had not used illegal drugs at any time since 1974, when he was 28 years old (CNN 1999). A reasonable person would infer that President Bush used illegal drugs in 1973 and earlier.

In other cases, however, it seems unlikely that unraveling is occurring. For instance, when Google announced in its IPO prospectus that it would not provide earnings guidance (Brin and Page 2004), investors did not appear to infer the worst. On the contrary, Google's share offering was widely considered a success. Researchers have found voluntary disclosure to be incomplete for food nutrition labeling (Mathios 2000), restaurant hygiene scores (Jin and Leslie 2003), and HMO quality (Jin 2005). For an example from the domain of politics, consider the fact that, during a United Kingdom (UK) health scare about an alleged link between the MMR (measles-mumps-rubella) vaccine and autism, former UK Prime Minister Blair refused to say whether or not his son Leo had received the MMR vaccine (Westscott 2001, BBC 2001b). Naively applying the unraveling result leads to the inference that Leo did not have the vaccine, perhaps because there is a UK government cover-up of a causal link to autism. However, Blair gave the public a reason not to make this inference, and instead to trust the epidemiological evidence for vaccine safety: Blair claimed his refusal to divulge Leo's medical history stemmed from a desire to protect his family's privacy (Westscott 2001, NHS 2006). Since the public does not know whether or not Blair faces high personal costs for revealing Leo's medical history, they cannot infer the worst about the MMR vaccine from Blair's nondisclosure.

Indeed, subsequent research enriches the seminal theory by including features of exactly this kind. Dye (1985), Jung and Kwon (1988), and Shin (1994, 2003) point out that if there is some

positive probability that a sender is unable to make a disclosure, either from prohibitively high disclosure costs or simple lack of information, then the unraveling result partially unravels. Senders can partially conceal bad news by pooling with those who are unable to disclose. The authors argue that senders will follow a sanitization strategy, revealing good news when possible but concealing all bad news.

Unfortunately, this static sanitization result does not fully explain the behavior of Google, Blair, or other senders who face repeated disclosure choices. For instance, while the sanitization strategy describes selective disclosure of good news, Google announced that it would not provide any earnings guidance. Moreover, senders' self-described reasons for concealing information are often inherently dynamic, based on the idea that concealing one piece of information today can make it easier to conceal another tomorrow.

This paper therefore seeks to address two primary questions: First, in a dynamic setting, are senders motivated to establish a precedent for nondisclosure, or a reputation for reticence? Second, how do such reputational incentives affect equilibrium information disclosure? I show that the desire to create a credible excuse for future nondisclosure, such as a believable claim about privacy concerns, makes a reputation for reticence valuable. This value motivates withholding even good news, and unravels the unraveling result still further.

For example, Blair's nondisclosure may not only tell us something about Leo's vaccination history, but may also tell us something about Blair's value of privacy. The fact that he withheld private family information when it could have been politically expedient may send a strong signal that Blair highly values his children's privacy. Thus, it may be that Blair declined to disclose Leo's vaccination history simply because he wanted to develop a precedent for keeping family information private. Such a precedent helps protect his ability to decline to answer future questions about his family. This, in fact, was part of Blair's motivation according to his own statement released on December 22, 2001 (BBC 2001a):

> The reason we have refused to say whether Leo has had the MMR vaccine is because we never have commented on the medical health or treatment of our children. The advice to parents to have the MMR jab is one of scores of pieces of advice or campaigns the government supports in matters ranging from underage sex to teenage alcohol abuse... Once we comment on one, it is hard to see how we can justify not commenting on them all.

Similarly, firm management might prefer suppressing current good news, so as to help prevent future nondisclosures from standing out. There is plenty of anecdotal evidence that managers

conceal good news for this reason; take for instance firms such as Google that have chosen not to issue any earnings guidance. Moreover, Graham, Harvey and Rajgopal (2005) find in a survey of 401 financial executives that:

> The most common reason that executives limit voluntary disclosure is related to setting a precedent. More than two-thirds of the survey participants... agree or strongly agree that a constraint on current disclosure is the desire to avoid setting a disclosure precedent that is difficult to maintain in the future.

Furthermore, several of the 20 CFOs the authors interviewed

> state that they would not make an earnings forecast or start making voluntary disclosures of non-financial leading indicators for fear of starting a practice that they might later want to abandon. One CFO likened this process to 'getting on a treadmill' that you can not get off. The market then expects the company to maintain the newly initiated disclosures every quarter, regardless of whether the news is good or bad.

Whether in politics or finance, these explanations for hiding information are inherently dynamic, and hence motivate this paper's analysis. I develop a model using Jung and Kwon's (1988) one-shot verifiable-disclosure game as a starting point. In the one-shot game, a manager learns disclosable information about the value of her firm with probability θ and must choose whether to disclose this to the market. My innovation incorporates two new elements: uncertainty by investors surrounding the manager's type θ, and repeated interaction between the investors and the firm.

I characterize equilibrium disclosure under two alternate assumptions about the level of discretion in disclosure. Initially, I assume that senders may delay disclosure by at most one period (A1). Later I allow senders to delay disclosure indefinitely (A2). Since public companies cannot suppress results indefinitely, A1 may be most appropriate for understanding firm disclosures to investors. On the other hand, A2 is relevant to senders like Blair who can conceal Leo's medical records as long as he wishes.

Given at most one-period delay (A1), I show that reputational concerns cause all senders to conceal some good news in all equilibria, and in some cases senders may initially hide all information. Hiding information initially softens the market's reaction towards future nondisclosure. This matches Graham et al.'s (2005) findings well. I also find equilibria in which senders actually disclose bad news initially to signal their future reticence. This may explain the common advice to get bad news out early and the frequency with which firms do so - such early revelations may help persuade the market that future nondisclosures do not hide more bad news. (Skinner (1994)

finds that firms preempt bad quarterly earnings reports about 25% of the time, but other earnings reports less than 10% of the time.) These equilibria are supported by the intuitive criterion, yet intuitively appealing equilibria in which all bad news is concealed always exist.

Allowing indefinite delay of disclosure (A2) introduces an important new element: reputational concerns become backward-looking as well as forward-looking. A sender may conceal good news today not only to protect the credibility of a future nondisclosure but also that of a past nondisclosure.[1] Moreover, if a sender discloses good news today, prior non-disclosures will be treated with greater skepticism, and hence the sender may choose to simultaneously reveal previously hidden information. Hence information is frequently bottled up and then comes out all at once or not at all.

The following section describes related papers not discussed elsewhere in the text. Section 3 describes the model, Sections 4 and 5 characterize equilibrium disclosure under assumptions A1 and A2 (with additional details in Appendix A), and Section 6 concludes. All proofs are in Appendix B.

2   Related Literature

There is a large body of related literature concerning discretionary verifiable disclosure, for which Verrecchia (2001), Healy and Palepu (2001), and Dranove and Jin (2009) provide excellent surveys. There are also several especially relevant papers that investigate situations in which a sender distorts his or her communication choices to try to convey objectiveness and hence improve credibility of future communication (Sobel 1985, Benabou and Laroque 1992, Morris 2001, Avery and Meyer 2003, Dziuda 2007). In these models, decision maker uncertainty about sender bias means that credibility arises from developing a reputation for being unbiased. In contrast, in this paper all senders are equally biased and sender reputation concerns the likelihood of receiving disclosable news, which affects the credibility of nondisclosure.

In repeated cheap talk settings, Sobel (1985) and Benabou and Laroque (1992) assume that unbiased senders have no incentive to be dishonest, and examine the trade-off biased senders face between developing credibility through honesty, and lying to cash in on their reputations. Morris (2001) endogenizes cheap talk of both biased and unbiased senders and finds that reputational incentives to appear objective lead even unbiased senders to distort information. If advisors may

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[1]It is intriguing to note that Blair specifically cites previous nondisclosure as a reason for not talking about Leo (see previous quote), whereas Graham et al. (2005) attribute only forward looking incentives for nondisclosure to CFOs. Although only anecdotal, this difference exactly matches the predicted effect of a change in the level of sender discretion between A2 and A1.

be either objective, or biased against a politically correct policy, an objective advisor may give overly politically correct advice to maintain future credibility. In a similar vein, Avery and Meyer (2003) show that a reference letter writer biased in favor of his or her own candidates may be overly harsh early on and not recommend candidates who would be desirable hires from the employer's perspective. Dziuda (2007) analyzes a static verifiable-disclosure game in which a sender observes multiple signals and has a bias (left, right, or honest) that is unknown to the receiver. Biased senders reveal all good signals, but rather than sanitize their reports completely, they also reveal some bad signals in order to pool with the honest sender.

Other sender-receiver games with reputational effects focus on accuracy rather than objectivity. For instance, in a cheap-talk setting, Gentzkow and Shapiro (2006) demonstrate that otherwise neutral media companies will bias news reports towards the prior beliefs of their customers to develop a reputation for accuracy. Prendergast (1993) shows that optimal incentives for collecting accurate information explain the presence of "yes men" in organizations. In both papers, as well as other related works (e.g. Ottaviani and Sørensen 2006a, 2006b), an expert's incentive to make reports conform to a receiver's prior leads to the loss of valuable information. Prat (2005) shows that such information loss can sometimes be mitigated by delegating a decision to the expert and committing to observe only the consequences of the decision, not the choice itself. Reputational concerns for accuracy can also lead experts to distort reports in the opposite direction: away from a receiver's prior (e.g. Prendergast and Stole (1996), Levy (2004), and Ottaviani and Sørensen (2006b)).

Teoh and Hwang's (1991) related paper takes a distinctly different approach. They show that with the right signal structure[2] in a two-period model, a firm may initially hide a good signal and disclose a bad signal to credibly signal a favorable (but unverifiable) component of firm value. Unlike this paper or those discussed immediately above, in Teoh and Hwang (1991) the distortion of disclosure does not enhance credibility of communication. As a result, second-period disclosure choices are independent of those in the first period. Thus hiding good news does not set a precedent for nondisclosure. Instead, unraveling always applies in the second period.

The most relevant work outside the literatures on disclosure and sender-receiver games is the segment of the repeated games literature that examines repeated interaction between a single long-lived player with private information about his or her type and a series of short-lived players. Chapters 15 and 17 of Mailath and Samuelson's (2006) book provide an excellent reference. Assume

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[2]The result requires that a future verifiable binary signal of firm value is more likely to be good for a high-type firm than a low-type firm, that firm value is higher for a high-type firm than a low-type firm independent of the verifiable signal, and that firm value has increasing differences in the unverifiable firm type and the verifiable signal.

that a long-lived player in an infinitely repeated game may be strategic and arbitrarily patient, or one of a variety of commitment types. A typical result is that, with a rich enough set of commitment types, the strategic type will profit as much from short-run player uncertainty about her type as she could from commitment power without that uncertainty. Such a result would have little relevance in an infinitely repeated version of my model, however, because commitment power has no value given common knowledge of a sender's type. (A receiver who knows the sender's strategy will always correctly interpret the sender's disclosures on average, regardless of the particular strategy in use.) Moreover, I do not assume that uncertainty revolves around whether the sender is a strategic type or a commitment type. In my model both sender types are strategic, but they differ in their likelihood of receiving disclosable information. (The exception is in Section 5 where I focus on a special case with only one strategic type.)

3 Model Description

I will first describe a reduced form sender-receiver game, and then outline specific examples captured by the model. Afterwards, I adopt the terminology of the final example concerning communication between a firm and investors.

Players: Game players are a sender (firm) and a receiver (investors).

Information Structure: In each of two periods $t \in \{1, 2\}$, nature chooses an outcome x_t that has mean μ_t and is independently distributed across the bounded support $[A_t, B_t]$ with cumulative distribution F_t. The distribution F_t is continuous, strictly increasing, and common knowledge. In each period, with independent probability θ, the sender privately receives a disclosable, verifiable, and fully informative signal $s_t = x_t$. Alternatively, with probability $(1 - \theta)$, the sender receives no disclosable information $(s_t = \phi)$.

While the sender knows the probability θ with which signals are disclosable, the receiver is uncertain. In particular, prior to period one, nature chooses θ to be H with probability $q \in (0, 1)$, or to be L with probability $(1 - q)$, where L is strictly less than H. The sender privately learns her value of θ, which is constant across periods, but cannot directly and credibly disclose this value to the receiver.

Communication: After receiving signal s_t in period t, the sender makes a report $r_t \in \{s_t, \phi\}$ to the receiver, and may update previous reports concerning earlier signals. Based upon these reports and other publicly available information (I_t), the receiver updates his expectation of x_1 and x_2.

The sender must give a truthful report due to the threat of severe penalty, but may strategically avoid telling the whole truth by not reporting any information. Thus, a sender with no disclosable

information has no choice but to report nothing ($r_t = \phi$), while a sender with a disclosable signal may either reveal the true outcome ($r_t = x_t$), or strategically conceal it ($r_t = \phi$).

Payoffs: In each period, the receiver plays a static best response which is a function of his expectations of outcomes x_1 and x_2. The sender's reduced form payoff is given by equation (1).

$$\Pi = E\left[x_1 | I_1\right] + \delta E\left[x_1 + x_2 | I_2\right] \tag{1}$$

Feasible Delay: Finally, I make two different assumptions about how long the sender can conceal information.

Assumption A1 (Short Delay): *The sender can delay disclosure of information by at most one period. Regardless of the disclosures made in period one, the receiver learns the value of x_1 in period two. (Note, in this case payoffs reduce to $\Pi = E\left[x_1 | I_1\right] + \delta E\left[x_2 | I_2\right]$.)*

Assumption A2 (Indefinite Delay): *The sender can delay disclosure of information indefinitely. The receiver does not learn the value of x_1 in period two unless it is disclosed by the sender.*

I consider assumption A1 in Section 4, and the alternate assumption A2 for the special case in which $L = 0$ in Section 5. The analysis is qualitatively different under A2 because the sender's period-two report may cause the receiver to revise his beliefs about x_1. Assumption A2 corresponds to the MMR example in which the public may never learn whether Leo Blair was vaccinated. In contrast, assumption A1 corresponds to a firm's choice of whether or not to issue earnings guidance, since regardless of the guidance choice, earnings will be announced in the upcoming quarterly report. Similarly, Google may choose whether or not to disclose the planned launch of a new service such as Gmail, but cannot help making it public when actually launching the service.

A critical assumption of the model is that the sender receives verifiable and disclosable information with probability θ, but with probability $(1 - \theta)$ receives no disclosable information. The literature offers two interpretations for this assumption. First, the sender could simply be uninformed some of the time. Second, the sender might always receive verifiable information, but in some cases its disclosure could be prohibitively costly. The examples below illustrate both interpretations.

3.1 Examples

3.1.1 Seller Communicating with Buyers

A natural example is that in which the sender is a seller who auctions an asset with common value x_t in each of two periods. With probability θ, the seller learns the value of the asset, but with probability $(1 - \theta)$ the seller is uninformed. The receiver represents a collection of competitive

bidders who will bid in each auction until the asset sells for its expected value given publicly available information. The value of the first asset becomes publicly known before the second auction. Thus the seller earns revenues of $E[x_1|r_1] + \delta E[x_2|r_1, r_2, x_1]$, which corresponds to equation (1) given assumption $A1$. (Given $A1$, the sender cannot influence $E[x_1|I_2] = x_1$, so it does not affect the sender's optimal strategy.)

3.1.2 Tony Blair Communicating with his Constituents

In the MMR example, x_1 may be interpreted as a measure of vaccine safety, such as an indicator for Leo having had the jab.[3] This may not be disclosable because it concerns a particularly sensitive subject (family medical records) for which Tony Blair's direct value of privacy may override political concerns. Equation (1) captures the idea that Blair's payoff is increasing in public confidence about vaccine safety in both periods, as well as in public confidence about some other issue x_2 raised by the press in a future period.[4] Here A2 is the appropriate assumption, since the public will not find out about Leo's medical history unless Blair discloses the information. As a result, Blair must continue to manage public expectations about vaccine safety when responding to future questions about other issues. For instance, if Blair disclosed information about Leo's Polio vaccination today, the public would likely view Blair's nondisclosure about Leo's MMR vaccine with increased skepticism.

3.1.3 Firm Management Communicating with Investors

Let the underlying value of a firm be the sum of the two outcomes: $V = x_1 + x_2$. Assume that firm management maximizes the value of the firm to existing shareholders, some small fraction $(1 - \delta) > 0$ of whom must sell in each of periods 1 and 2 for liquidity reasons. These liquidity sales will take place at the prevailing share price S_t, which will equal the market's expectation of firm value, given existing public information $E[x_1 + x_2|I_t]$. Then, in a third period, an outside buyer acquires the firm and pays shareholders the true value of the firm, as discovered through due diligence. The firm's objective function is therefore given by equation (2).

$$\Pi = (1 - \delta) S_1 + \delta (1 - \delta) S_2 + \delta^2 V \tag{2}$$

On the one hand, with probability $(1 - \theta)$, information possessed by the firm about outcome x_t

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[3]Strictly speaking this doesn't fit the model, since I assume x_t are continuous random variables. However, the basic features of the model are still present with binary random variables.

[4]In this example, the linearity of payoffs in equation (2) is somewhat restrictive, but as discussed in Section 4.3, this assumption can be relaxed.

will be *proprietary* in the sense that its disclosure would not only be informative about firm value and influence share prices, but also adversely affect underlying firm value if disclosed. When the number of liquidity trades $(1 - \delta)$ is small, the firm's primary objective is to maximize the firm's true value V. Hence, the firm will avoid disclosing such proprietary information.

On the other hand, with probability θ, information possessed by the firm about outcome x_t will be *nonproprietary*, in the sense that its disclosure would not affect underlying firm value, and merely influence short run share prices.[5] The firm will disclose or withhold such nonproprietary information in order to maximize the discounted sum of share prices: $\hat{\Pi} = (S_1 + \delta S_2)$, which matches equation (1) for $\delta \in (0, 1)$ up to the constant $E[x_2|I_1] = \mu_2$.[6] Either assumption A1 or A2 may be appropriate, depending on whether x_1 becomes public knowledge in the interim between periods 1 and 2.

I will use the language of this example (firm and market for players, and proprietary or nonproprietary information for signal type) throughout the rest of the paper.

4 Equilibrium with short disclosure delay (A1)

4.1 Second-period disclosure

When information disclosure can be delayed by at most one period, the firm's objective function reduces to equation (3) since the firm cannot influence $E[x_1|I_2]$.

$$\hat{\Pi} = E[x_1|r_1] + \delta E[x_2|r_1, r_2, x_1] \tag{3}$$

A Perfect Bayesian Equilibrium can be characterized by starting with the second-period continuation game. In this case, the second-period continuation game and its unique equilibrium coincide with Jung and Kwon's (1988) one-type static model. In Jung and Kwon's (1988) model, there is only one type of firm $\bar{\theta}$, one period, and one outcome x with distribution F and mean μ.

The unique equilibrium is for the firm to *sanitize* by disclosing the outcome x if it is nonproprietary and exceeds a unique threshold $\bar{x}^S$ equal to the market's expectation following nondisclosure: $E[x|r = \phi]$. Outcomes below this point are "**bad news**" and concealed, since they lower market expectations relative to nondisclosure. Outcomes above this point are "**good news**" and are dis-

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closed, since they raise market expectations.[7] The threshold $\bar{x}^S\left(\bar{\theta}, F\right)$ is a function of the likelihood of nonproprietary information $\bar{\theta}$, and the distribution of outcomes F, defined implicitly by equation (4) (Jung and Kwon 1988, equation 7):

$$\bar{x}^S = E\left[\left.x\right| r = \phi\right] = \frac{\left(1 - \bar{\theta}\right)\mu + \bar{\theta}F\left[\bar{x}^S\right]E[x|\, x \le \bar{x}^S]}{\left(1 - \bar{\theta}\right) + \bar{\theta}F\left(\bar{x}^S\right)}. \tag{4}$$

In the second-period continuation game of my model, both types L and H also sanitize by disclosing only nonproprietary good news. I incorporate uncertainty about the manager's type θ by working with the market's second-period updated beliefs $q' = \Pr\left(\left.\theta = H\right| r_1, x_1\right)$ and $\bar{\theta}' = q'H + (1 - q')L$ given both the first-period disclosure r_1, and the exogenous revelation of x_1. The threshold for disclosing x_2 (the market's expectation of x_2 following its nondisclosure) is then given by $\bar{x}_2 = \bar{x}^S(\bar{\theta}', F_2)$, and the firm's expected second-period payoff Π_2 is:

$$\Pi_2\left(\theta, \bar{x}_2\right) = \left((1 - \theta) + \theta F_2\left[\bar{x}_2\right]\right)\bar{x}_2 + \theta\left(1 - F_2\left[\bar{x}_2\right]\right)E\left[x_2|x_2 > \bar{x}_2\right]. \tag{5}$$

Proposition 1 *The market's expectation of x_2 following its nondisclosure, and the firm's expected second-period payoff, are both decreasing in the market's expectation $\bar{\theta}'$.[8] The firm's expected second-period payoff has increasing differences in θ and $\bar{\theta}'$.*

Proposition 1 shows that firms value a reputation for primarily receiving proprietary signals (low $\bar{\theta}'$): investors will treat nondisclosure with less skepticism if they expect the firm's signal to be proprietary much of the time. Moreover, Proposition 1 shows that low-types have a greater incentive to improve their reputation than do high-types. This endogenous single-crossing property causes separating behavior in the first period, and leads standard refinements to select equilibria in which bad news is disclosed in the first period[9] (Proposition 4). It arises because the benefit of improved reputation, improved credibility for the "proprietary" excuse following nondisclosure, is only realized ex-post if a firm actually reports nothing about x_2. A given improvement in

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[7]I define good and bad news relative to market expectations conditional on nondisclosure. An alternative convention, often useful for interpreting empirical work, defines good and bad news relative to lagged expectations (in this context the unconditional expectation μ). Under this interpretation, nondisclosure itself is bad news since $E\left[x|r = \phi\right] < \mu$. Several studies confirm that nondisclosure is bad news relative to prior expectations. For instance, Chen, Matsumoto and Rajgopal (2007) find that stock prices fall upon announcement of earnings guidance cessation.

[8]*The firm's second-period expected payoff is increasing in the firm's true probability θ of receiving nonproprietary news, since the firm is only able to report good news when its information is nonproprietary. If $\bar{\theta}' = \theta$ then second-period expected payoff $\Pi_2 = \mu_2$. Market uncertainty about firm type allows $\bar{\theta}'$ to differ from θ, Π_2 to differ from μ_2, and hence first period strategies to differ from the static case.*

[9]This is related to counter signaling, which arises due to differences in the distribution of exogenous "extra information" across types (Feltovich, Harbaugh and To 2002).

reputation will therefore benefit low-type firms more than high-type firms, since low-types have a greater probability of receiving proprietary signals, and therefore of disclosing nothing.

4.2 First-period disclosure

First-period firm strategy is described by a pair of functions $\{\sigma_L(x_1), \sigma_H(x_1)\}$ that give the probability of first-period disclosure of outcome x_1, conditional on the news being nonproprietary. When concealing the first-period outcome until period two, the firm receives immediate payoff $\bar{x}_1$, which is equal to the market's expectation $E[x_1|r_1 = \phi]$:

$$\bar{x}_1 = \frac{\mu_1 - E[x_1(qH\sigma_H(x_1) + (1-q)L\sigma_L(x_1))]}{1 - E[qH\sigma_H(x_1) + (1-q)L\sigma_L(x_1)]}. \tag{6}$$

Note that the value $\bar{x}_1$ is the dividing threshold between good news $(x > \bar{x})$ and bad news $(x < \bar{x})$. In the first period, the firm has to consider more than the impact of good or bad news on the current share price; it must also take into account its reputation in the following period. Proposition 2 highlights differences from the static sanitization equilibrium which arise from this additional consideration.

Proposition 2 *In all equilibria: (1) both types of firms will always conceal at least some nonproprietary good news, and (2) the market gives greater credibility to first-period nondisclosure than in the static sanitization equilibrium: $\bar{x}_1 > \bar{x}_1^S \equiv \bar{x}^S(\bar{\theta}, F_1)$.*

The original unraveling result is that firms follow a sanitization strategy and reveal only good news. Moreover, the adverse inference following nondisclosure is so severe that in comparison all news is good news, and hence all news is disclosed. Papers by Jung and Kwon (1988), Shin (1994, 2003) and others show that while firms will still sanitize and only disclose good news, a positive probability of non-disclosable proprietary information tempers the market's adverse inference following nondisclosure. Hence the unraveling result is partially unraveled – some news is now bad news relative to nondisclosure, and is concealed.

Proposition 2 shows that in a dynamic context market uncertainty about the likelihood of nonproprietary news further unravels the unraveling result in two ways. First, the market's adverse inference following nondisclosure is moderated further. Second, firms no longer sanitize, and instead always conceal some good news. This is because pooling with firms who have non-disclosable proprietary news reduces market skepticism about future nondisclosure. While both these effects correspond to reduced disclosure, reputational incentives can also lead to disclosure of bad news, which never occurs in the static model. As Propositions 3 and 4 will show, while there always exist

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equilibria with full concealment of bad news, standard refinements select equilibria in which bad news is disclosed.

4.2.1 Monotonic Equilibria

In order to further characterize equilibrium disclosure, I examine two classes of equilibria separately. First, I will focus on equilibria in which market beliefs about the firm's type θ are monotonically increasing in the level of first-period disclosure. While these equilibria are plausible, some standard equilibrium refinements rule out monotonic equilibria. Hence, Section 4.2.2 analyzes non-monotonic equilibria.

Monotonic Equilibria: *Beliefs are monotonic if the market's belief that the firm is the high-type that frequently receives nonproprietary news is weakly higher given first-period disclosure than first-period nondisclosure. An equilibrium is monotonic if beliefs are monotonic.*

Given monotonic beliefs,[10] there is always a weak reputational benefit of nondisclosure. Thus, it is always optimal for both types to conceal bad news. For good outcomes, the reputational benefit of concealment varies with the market's beliefs about the firm's disclosure policy. The reputational benefit for concealing a good outcome x_1 is higher when the market expects the low-type to conceal x_1 than when the market expects the low-type to reveal x_1. As a result, for a range of good outcomes, market beliefs about the low-type's disclosure policy are self-fulfilling, and hence there are multiple monotonic equilibria with varying amounts of disclosure of good news in the first period.[11]

All monotonic equilibria lie somewhere between two extremes: the minimum and maximum monotonic-disclosure equilibria. Figure 1 depicts the qualitative features of these equilibria. (See Proposition 6 and Solutions 1-2 in Appendix A for a precise characterization.) In each, the low-type discloses only above a threshold. When the low-type uses the highest possible threshold (minimum disclosure), the high-type discloses strictly more news, gradually switching from full concealment to full disclosure over a range of outcomes that the low-type conceals.[12] When the low-type uses the lowest possible threshold (maximum disclosure) the equilibrium market expectation $\bar{x}_1$ is smaller.

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[10]Monotonic off-equilibrium beliefs are supported by small trembles as long as a low-type is not too much more likely to make an accidental disclosure than a high-type.

[11]In contrast, the market's beliefs about the high-type's disclosure policy are not self-reinforcing. If the market expects the high-type to conceal outcome x_1, then the incentive to do so is lower than otherwise. As a result, while multiplicity arises from variation in the low-type's strategy, given a particular strategy for the low-type, that for the high-type is pinned down.

[12]The high-type does not use a threshold strategy, because increased disclosure by the high type makes disclosure less attractive.

In fact, $\bar{x}_1$ is at its minimum across all monotonic equilibria because the least amount of good news is pooled with undisclosed news, and hence the market's adverse inference following nondisclosure is most severe. Moreover, for some parameters the high-type may jump to full disclosure at the same threshold as the low-type as shown in Figure 1.

Minimum-Disclosure Monotonic-Equilibrium

Maximum-Disclosure Monotonic-Equilibrium
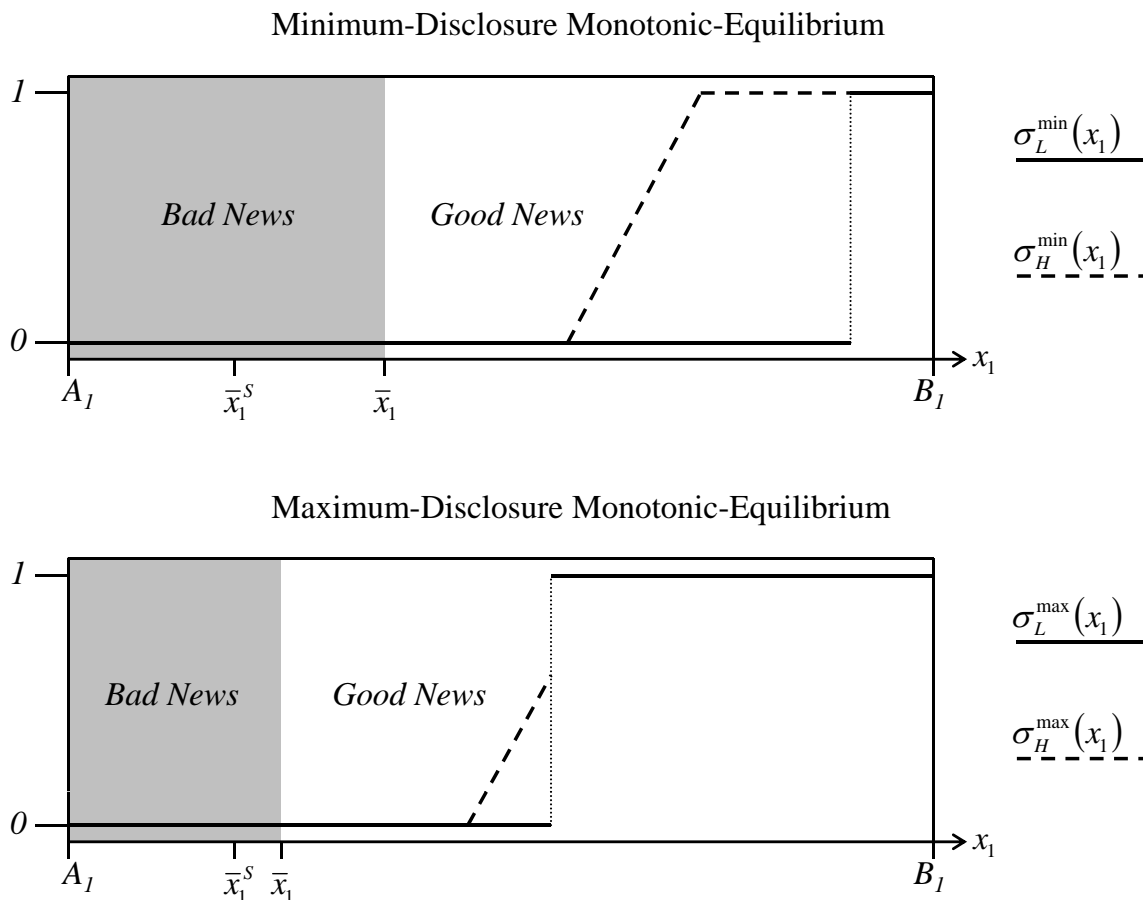
Figure 1: Hypothetical monotonic minimum and maximum disclosure equilibria. Due to the increased disclosure of good news, market expectation $\bar{x}_1$ is lower in the maximum-disclosure equilibrium.

The maximum-disclosure equilibrium involves the greatest disclosure of nonproprietary signals about x_1 in period one, among all monotonic equilibria. However, it may communicate less information about firm type θ to the market so that second-period nondisclosures are less well understood. Thus, it is ambiguous whether short run share prices track underlying firm value more closely in the maximum or the minimum-disclosure equilibrium.

Proposition 3 summarizes general properties of all monotonic equilibria.

Proposition 3 *A monotonic equilibrium always exists. In all monotonic equilibria: (1) In the first period, firms not only conceal all bad news, but also conceal some nonproprietary good news that*

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would be tempting to disclose in the short run. (2) The low-type conceals more nonproprietary news than the high-type (3) First period nondisclosure both reduces future disclosure, and makes the market more forgiving of future nondisclosure. (In this sense a first period nondisclosure sets a precedent for future nondisclosure.)

Although some good news is always concealed in equilibrium, the amount of good news concealed depends on outcome distributions and other model parameters.[13] Figure 1 depicts disclosure of very good news by both types in both minimum and maximum monotonic-disclosure equilibria. This is not a general feature, as reputational incentives may be strong enough to compel firms to conceal all first period information. Moreover, this will always be the case if there is sufficient uncertainty about the second period outcome x_2.[14]

4.2.2 Non-Monotonic Equilibria

While monotonic equilibria are plausible, standard equilibrium refinements select non-monotonic equilibria in which some bad news is disclosed. Upon receiving nonproprietary good news, the only possible way for a firm to signal low-type is to conceal the news and pool with firms who have proprietary information. Disclosing bad news can be a signal of low-type, however, if in equilibrium low-types disclose nonproprietary bad news with sufficiently higher probability than do high-types. In this case, such early revelations help persuade the market that future nondisclosures do not hide more bad news. Disclosing bad news can be a credible signal of low-type because it incurs an immediate cost, similar to earning an education in Spence (1973). Although this cost $(x_1 - \bar{x}_1)$ is the same for both low and high type firms, a low-type gains more from improving its reputation (Proposition 1), and hence strictly prefers to disclose bad news when a high-type is indifferent.

At the opposite extreme from monotonic equilibria are those in which the widest possible interval of bad news is disclosed in equilibrium. In such equilibria, the low-type discloses all bad news above a certain threshold, and the high-type uses a mixed disclosure strategy for all bad news above a strictly higher threshold. (See Condition 1 in Appendix A for a precise characterization of maximal bad-news disclosure strategies.)

Figure 2 illustrates two hypothetical equilibria with maximum bad news disclosure[15] (Satisfy-

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[13]First period disclosure decreases with δ and increases with L. The relationship between disclosure, and the outcome distributions and parameters H and q is less clear cut. See Appendix A for additional discussion of comparative statics.

[14]This is similar to Nanda and Zhang's (2006) result in a static framework that a good signal may be concealed if its value is sufficiently uninformative and its observation is strongly correlated with that of an informative signal.

[15]I mean maximum bad news disclosure in the weak sense that the widest possible interval of bad news is disclosed.

ing Condition 1 for all bad news). The first plot in the figure assumes that for good news the minimum-disclosure monotonic-equilibrium strategy is used (Appendix A, Solution 1). The second plot assumes that for good news, the maximum-disclosure monotonic-equilibrium strategy is used (Appendix A, Solution 2).

Maximum Bad-News / Minimum Good-News Disclosure-Equilibrium

Maximum Bad-News / Maximum Good-News Disclosure-Equilibrium
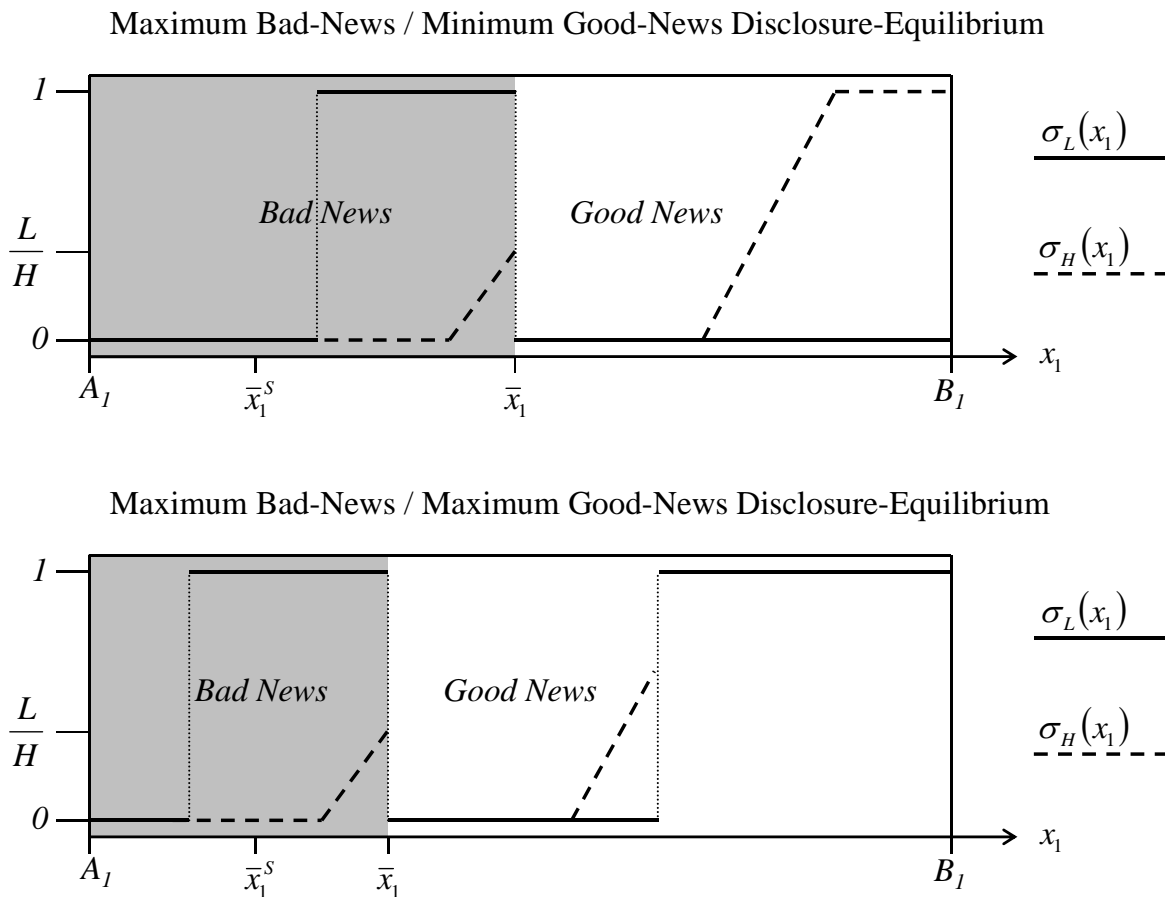
Figure 2: Non Monotonic Equilibria that satisfy D1.

As shown in Figure 2, low-types are willing to reveal worse news than high-types. Moreover, in equilibrium low-types either do not disclose a piece of bad news at all, or disclose it with higher probability than high-types, unconditional on whether it is proprietary or not, so that the disclosure is a signal of low-type. Figure 2 shows both types reveal bad news in a neighborhood below $\bar{x}_1$, which is true of any equilibrium with maximum bad news disclosure.

The Figure 2 strategies for bad news are the same in both plots relative to $\bar{x}_1$. However $\bar{x}_1$ is lower in the second plot, since firms conceal less good news. Further, relative to Figure 1, in both plots $\bar{x}_1$ is higher in the non-monotonic case, since there is greater disclosure of bad news.

This corresponds to the largest probability of bad news disclosure when the outcome x_1 is uniformly distributed.

Proposition 4 *All monotonic equilibria fail the D1 criterion (Cho and Kreps 1987, Banks and Sobel 1987, Cho and Sobel 1990), appropriately defined for this setting. For certain parameters, monotonic equilibria also fail the weaker intuitive criterion (Cho and Kreps 1987). All non-monotonic equilibria with maximal bad news disclosure (of which multiple exist) satisfy D1.*

Proposition 4 states that the D1 criterion always rules out monotonic equilibria in favor of non-monotonic equilibria, and that the weaker intuitive criterion may do so as well. Nevertheless, monotonic equilibria are very plausible, and should not be ignored.

Neither Cho and Kreps (1987) nor Banks and Sobel (1987) provide a behavioral defense for the strong D1 criterion. Cho and Kreps (1987) do provide a behavioral motivation for the intuitive criterion. The intuition is that upon receiving moderately bad news, a low-type firm could deviate from a monotonic equilibrium by disclosing the bad news and making the following speech: "By disclosing bad news I ought to convince you that I am the low-type who is infrequently able to make disclosures. If I am able to convince you, it will have been in my interest to make the disclosure. Were I the high-type who is frequently able to make disclosures, I would have no incentive to disclose this bad news, regardless of whether or not you are persuaded."

The speech that motivates the intuitive criterion certainly has an intuitive appeal, but it is a sophisticated rather than a straightforward intuition. It is plausible that an audience would not find such a speech compelling. For instance, imagine Tony Blair surprising the public by announcing that Leo was not vaccinated and, at the same time, making a speech perversely asking the public to interpret the violation of Leo's privacy as evidence that he is normally very concerned about his family's privacy. It seems plausible that, contrary to the intuitive criterion, the public would instead have reasoned that Tony Blair is more likely to be someone who normally does not value his family's privacy.

The straightforward belief that off-equilibrium revelations of bad news are mistakes equally likely to be from either type supports concealment of all bad news in any equilibrium. Such an off-equilibrium belief seems just as intuitive, if not more so, than a non-monotonic equilibrium. Moreover, while Skinner (1994) finds evidence that firms selectively disclose bad news, several other studies find evidence that firms delay bad news disclosure (e.g. Chambers and Penman (1984), Kothari, Shu and Wysocki (2009), and Sletten (2009)). As a result, attention should be given to both non-monotonic and monotonic equilibria.

4.3 Strength of Reputational Incentives

Propositions 2-3 show that reputational incentives cause all firms to hide some initial good news, and Proposition 4 points out that reputational concerns can actually lead firms to announce bad

news. What affects the strength of reputational incentives, and the corresponding size of these distortions away from static sanitization? Within the existing model, reputational incentives will be strongest when the market is very uncertain about the firm's type ex ante, and when future disclosures are important (see Appendix A).

The importance of future disclosures depends not only on the firm's discount factor δ, but upon the amount of information which arrives in the future. A reputation for reticence is most valuable when there is large uncertainty about the future realization of x_2. Thus, while shifting the distribution of x_2 upwards by a constant has no effect on disclosure, increasing the spread of x_2 can reduce first period disclosure of good news. In fact, holding all else fixed, there always exists a mean preserving spread of the second-period outcome distribution $F_2(x_2)$ such that all first-period news is concealed in all monotonic equilibria.[16]

It might also be expected that relaxing either of two assumptions, that outcomes x_1 and x_2 are independent, or that payoffs are linear in market beliefs (equation 2), would affect reputational incentives and equilibrium disclosure. Positive correlation between outcomes might arise from symmetric uncertainty about average project quality. Given assumption $A1$, it is straightforward to introduce simple forms of correlation. For example, modify the game by assuming that outcomes x_t follow an AR(1) process: $x_t = \alpha x_{t-1} + e_t$. Assume that x_0 is common knowledge at the beginning of the game and innovations e_t are independent with distributions F_t.

In period t, the market can infer the innovation e_t from a disclosed outcome x_t. Hence, although the firm actually chooses whether or not to disclose outcomes x_t, this is equivalent to a game in which the firm chooses whether or not to disclose innovations e_t. Since e_t are independent, and reduced form payoffs in equation (3) reduce further to $\hat{\Pi} = E[e_1 | r_1] + \delta E[e_2 | r_1, r_2, e_1]$,[17] all preceding results apply directly to the version of the game with disclosure of e_t. Disclosure is independent of α and hence of the degree of correlation between x_1 and x_2 as long as the distributions of e_t remain the same. At the same time, if x_1 and x_2 are perfectly correlated (so e_2 is a constant) then the two period disclosure game reduces to a single period disclosure game in which the standard sanitization result applies. What matters for the strength of reputational incentives in the first period is not the correlation between x_1 and x_2, but rather the amount of new information that arrives with x_2.

Returning to the case of independently distributed outcomes, the assumption of linear pay-

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[16]Let $\hat{F}_2(x_2) = F_2\left(\frac{x_2 - \mu_2}{\beta} + \mu_2\right)$ for $\beta \geq 1$. $\hat{F}_2$ is a mean preserving spread of F_2, and for β sufficiently large, reputational concerns will always outweigh the desire to disclose any good news in the first period.

[17]For the Section 3.1 example of a firm communicating with investors, the discount rate in the reduced form payoffs should be modified to $\hat{\delta} = \delta/(1 + \alpha)$ since $E[x_2 | I_1]$ is a function of e_1.

offs can also be relaxed. The primary results in Section 4 and Appendix A, including Proposi-
tions 1-4 and 6-7 are easily extended to the more general payoff function $\Pi = u_1\left(E\left[x_1|I_1\right]\right) + u_2\left(E\left[x_1|I_2\right], E\left[x_2|I_2\right]\right)$ for u_1 and u_2 strictly increasing and continuous, and u_2 additively separa-
ble. Costly improvements in reputation, achieved by concealing good news or disclosing bad news,
are similar to insurance purchases. First period payoffs decrease by a fixed amount, but improved
reputation increases the lower bound of second period payoffs. As a result, risk aversion will in-
crease reputational incentives. This will increase concealment of good news and, in non-monotonic
equilibria, increase the disclosure of bad news.

4.4 Equilibrium Informativeness

Strictly speaking, welfare analysis is beyond the scope of this paper since the reduced form model
does not specify receiver payoffs. The two examples that do fully specify player preferences (seller
communicating to buyers, and firm communicating to investors) are zero sum games, so welfare is
constant. For instance in the firm communicating to investors example, trades take place due to
liquidity reasons irrespective of disclosure. Disclosure only affects transaction prices, not trades, and
hence only the distribution of surplus between existing and new shareholders, not total surplus.
Moreover, existing shareholders always receive a fair price on average, regardless of the level of
disclosure in equilibrium.[18]

When forecasting errors cause poor decisions that result in welfare losses, then all else equal,
welfare will be increasing in the amount of information revealed in equilibrium. For instance, sup-
pose that each period t, receivers make a decision $d_t \in R$ to maximize a payoff $-\sum_{t=1}^{2}\left(x_t - d_t\right)^2$.
Receivers' optimal action is to choose $d_t = E\left[x_t \mid I_t\right]$, and expected welfare is the expected sum of
negative square errors $E[-\sum_{t=1}^{2}\left(x_t - E\left[x_t \mid I_t\right]\right)^2]$, which is one measure of equilibrium informa-
tiveness. The primary result from comparing equilibria or interventions using this or other similar
measures of equilibrium informativeness is that there is often a trade-off between information rev-
elation in periods one and two.

For instance, are minimum or maximum disclosure equilibria more informative? While the max-
imum disclosure equilibrium is more informative about x_1 in period one, it can be less informative
about θ in period one and hence less informative about x_2 in period two. This trade-off arises
because a low type's choice to conceal good news about x_1 can help the market distinguish firm
types, and better interpret period two nondisclosure. How the trade-off is resolved will depend not

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[18]Although on average firms are priced fairly by the market, this is not true conditional on firm type. On average
low-type firms are undervalued in the short run, and high-type firms are overvalued.

only on outcome distributions (F_1, F_2) and model parameters (L, H, q, δ), but also on the measure of equilibrium informativeness.

Some interventions would unambiguously increase monotonic equilibrium informativeness. The underlying reason that nonproprietary news is strategically concealed is that firms can neither credibly communicate that news is non-disclosable, nor that they are the low type with a low probability of receiving disclosable news. Interventions or institutions which solve this communication problem will unambiguously increase monotonic equilibrium informativeness. For instance, suppose that at time zero, for a small cost $c > 0$, firms could commit to disclose all future nonproprietary news and hire a third party auditor to verify their adherence to the disclosure policy. The auditor solves the communication problem by certifying nondisclosures conceal only proprietary information. In equilibrium, low-type firms would hire the auditor and disclose all nonproprietary information. High-type firms would identify themselves by not hiring the auditor, and disclose nonproprietary news above the threshold $\bar{x}^S(H, F_t)$ each period.[19] The difficulty is that it may be impossible for an outsider, whether a court or an auditor, to distinguish proprietary from nonproprietary information.

5 Equilibrium with indefinite disclosure delay (A2)

When information disclosure can be delayed indefinitely, the firm's objective function is given by equation (7). For simplicity I will focus on the special case in which the low-type never receives nonproprietary news $(L = 0)$, and hence is not a strategic player in the game.[20]

$$\hat{\Pi} = E\left[x_1 \,|\, r_1\right] + \delta E\left[x_1 + x_2 | r_1, r_1', r_2\right] \tag{7}$$

Analysis of first-period disclosure is similar to that under one-period delay, although rather than mixing, the high-type discloses nonproprietary signal x_1 if it exceeds a threshold x_H.[21] However, an analysis of second-period disclosure must account for at least two important differences. First, if x_1 is not disclosed in period one, the firm must choose again in period two whether to disclose

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[19]Hiring an auditor guarantees an expected payoff of $\mu_1 + \delta\mu_2 - c$ for any firm. Without an auditor, high types always receive an expected payoff of at least $\mu_1 + \delta\mu_2$, while low types expect strictly less if the market puts positive probability on their being a high-type. Hence for small enough c, low types hire the auditor.

[20]Assuming $L = 0$ ensures that all equilibria are monotonic because any disclosure reveals the firm to be the high-type. Allowing for L strictly greater than zero would complicate the analysis in two respects: (1) There would be greater multiplicity of equilibria, including non-monotonic equilibria with disclosure of bad news. (2) It would be possible for a low-type to signal its type by delaying the disclosure of good news by one period, and then revealing it. (This is effective if high-types with nonproprietary news disclose immediately.)

[21]The high-type does not mix because the market's beliefs about the firm's type do not vary with the outcome when it is concealed indefinitely.

x_1. Denote the firm's second-period disclosure about x_1 by $r_1' \in \{\phi, s_1\}$. Second, it is no longer necessarily in the firm's best interest to disclose nonproprietary good news about the second project. The firm may prefer to conceal nonproprietary good news about the second project to reduce skepticism about the nondisclosure of the first project outcome.

A first-period disclosure of x_1 reveals nothing about x_2, since during the first period x_2 is unknown to the firm, but it does demonstrate with certainty that the firm is a high-type. Thus, following a first-period disclosure, the second-period continuation game is identical to a static disclosure game with market belief $\bar{\theta} = H$, and the firm discloses x_2 if and only if it is good news, exceeding the static threshold $\bar{x}_2^S \equiv x^S(H, F_2)$. If nothing is disclosed in the first period, then the second-period continuation game is similar to the disclosure game analyzed by Pae (2005).[22]

Following initial nondisclosure, the firm has up to four available second-period actions, corresponding to disclosure of x_1, x_2, neither, or both, as summarized in Table 1. For a firm with

	a_0	a_1	a_2	a_3
r_1'	ϕ	x_1	ϕ	x_1
r_2	ϕ	ϕ	x_2	x_2

Table 1: Second period actions following first period non-disclosure.

two nonproprietary signals, conditional on disclosing one signal x_j, the second signal x_i will be disclosed only if it exceeds the market's expectation of x_i in absence of the additional disclosure: $E[x_i | a_j]$. I focus on equilibria in which $E[x_i | a_j]$ is independent of x_j both on and off the equilibrium path. (I discuss relaxing this assumption at the end of the section.) In such equilibria, the threshold $E[x_i | a_j]$ is equal to the static game disclosure threshold $\bar{x}_i^S \equiv x^S(H, F_i)$ given market belief $\bar{\theta} = H$. This is intuitive, because revealing one outcome reveals the firm's type and leaves the firm with the remaining objective of maximizing the market's expectation of the second outcome. When both outcomes are concealed however, the market believes the firm may be a low-type. Hence, there is a positive credibility "bonus" Δ for two nondisclosures relative to market expectations when one outcome is revealed and one is concealed:

$$\Delta \equiv E[x_1 + x_2 | a_0] - (E[x_1 | a_2] + E[x_2 | a_1]). \tag{8}$$

So, conditional on the decision to conceal one outcome x_j, the firm reveals the other outcome, x_i, only if it exceeds $\bar{x}_i^S$ by at least Δ. Thus, as described in Table 2, firms with a single nonproprietary

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[22]Pae's (2005) equilibrium characterization does not apply to my second period continuation game for two reasons. First, taking my second period continuation game in isolation, there are important differences in signal structure and other aspects of our two games. Second, I cannot solve my second period continuation game in isolation, but rather must solve for first and second period disclosure strategies simultaneously.

signal x_i disclose above the threshold $\bar{x}_i^S + \Delta$, firms with two nonproprietary signals disclose following the strategy depicted in Figure 3, and firms with two proprietary signals disclose nothing.

$$a(\phi, \phi) = a_0$$
$$a(x_i, \phi) = \begin{cases} a_0 & x_i < \bar{x}_i^S + \Delta \\ a_i & x_i \geq \bar{x}_i^S + \Delta \end{cases} \qquad a(x_1, x_2) = \begin{cases} a_0 & \text{otherwise} \\ a_1 & x_1 \geq \bar{x}_1^S + \Delta \text{ and } x_2 \leq \bar{x}_2^S \\ a_2 & x_2 \geq \bar{x}_2^S + \Delta \text{ and } x_1 \leq \bar{x}_1^S \\ a_3 & \begin{array}{l} x_1 \geq \bar{x}_1^S, \; x_2 \geq \bar{x}_2^S \\ \& \; x_1 + x_2 \geq \bar{x}_1^S + \bar{x}_2^S + \Delta \end{array} \end{cases}$$

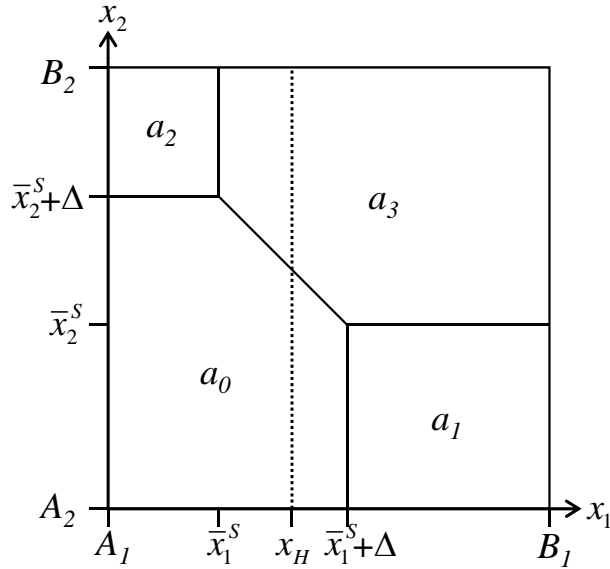Table 2: Second period strategies following $r_1 = \phi$.

Figure 3: Second period disclosure strategy, following first period non-disclosure ($r_1 = \phi$) given two nonproprietary signals $(s_1, s_2) = (x_1, x_2)$. Note that this continuation game is off the equilibrium path for $x_1 > x_H$ (to the right of the vertical dashed line) since such high values of x_1 would have been disclosed in the first period.

Since the credibility "bonus" Δ is forfeited with the announcement of either outcome, disclosures will tend to be all-or-nothing. This captures the idea that Tony Blair should have had an extra incentive to refuse to answer additional questions about his children to avoid undermining the credibility of his refusal to talk about Leo's vaccination history. Moreover, since the first-period disclosure threshold x_H falls between $\bar{x}_1^S$ and $\bar{x}_1^S + \Delta$, in equilibrium the firm may initially conceal x_1, but then reveal both x_1 and x_2 in the second period (Figure 3). Therefore undisclosed news may accumulate before being disclosed all at the same time. This suggests that had Tony Blair begun to answer other personal questions about his children, he might have disclosed Leo's vaccine record at the same time. Proposition 5 precisely summarizes the described equilibrium:

Proposition 5 *There exists a pure-strategy Perfect Bayesian Equilibrium in which: (1) In period*

one, $s_1 = x_1$ is disclosed if and only if $x_1 \geq x_H$ for some threshold $x_H \in \left[\bar{x}_1^S, \bar{x}_1^S + \Delta\right]$. (2) If x_1 is disclosed in period one, then in period two, $s_2 = x_2$ is disclosed if and only if $x_2 \geq \bar{x}_2^S$. (3) If x_1 is concealed in period one, then in period two: (i) Market expectations $E\left[x_1 | a_2\right]$ and $E\left[x_2 | a_1\right]$ are constants equal to $\bar{x}_1^S = x^S\left(H, F_1\right)$ and $\bar{x}_2^S = x^S\left(H, F_2\right)$ respectively. The difference Δ is also constant, and is positive. (ii) Firm strategy is as described in Table 2 and Figure 3, as a function of the signals s_1 and s_2, as well as x_H and Δ. (4) The constants x_H and $\Delta \geq 0$ are jointly characterized by equation (8) and equations (23-29) in Appendix B.4.

This equilibrium (or set of equilibria) is the only one in which $E\left[x_1 | a_2\right]$ and $E\left[x_2 | a_1\right]$ are constant (up to changes in the strategy at the thresholds of indifference).

In the equilibrium characterized by Proposition 5, the market expectations following partial disclosure, $E\left[x_1 | a_2\right]$ and $E\left[x_2 | a_1\right]$, are constants independent of the disclosed outcome, even if the revelation is off the equilibrium path. By selecting alternate off-equilibrium beliefs for these two expectations, alternate equilibria may be supported in which partial-disclosure actions a_1 and a_2 are taken less frequently, in favor of either no-disclosure or full-disclosure actions a_0 and a_3. In such alternative equilibria the tendency towards all-or-nothing disclosure would be more pronounced, however I find them less plausible than that described by Proposition 5. I conjecture that there are no equilibria in which $E\left[x_i | a_j\right]$ vary on the equilibrium path.[23]

6 Discussion

In many situations, there is positive probability that disclosure is prohibited for exogenous reasons. This may be due to a lack of information, a value of keeping competitors in the dark, or other direct disclosure costs. Jung and Kwon (1988) and Shin (1994, 2003) show that in this case the unraveling result partially unravels, and senders' may strategically conceal bad news. This paper shows that the credibility with which such nondisclosure is received depends on the likelihood receivers attach to exogenous causes of nondisclosure. Thus, when there is uncertainty about senders' exogenous reticence, senders have an incentive to develop a reputation for reticence.

The model is analyzed under two assumptions, the first of which allows for one-period disclosure delay (A1), and the second of which allows for indefinitely delayed disclosure (A2). In both cases, firms may withhold good news about an initial project in order to protect their credibility in future

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[23]This is not obvious. The expectation $E\left[x_2 | r_1 = x_1, r_2 = \phi\right]$ is constant because the choice $r_1 = x_1$ is made without private information about x_2, so it can only be informative about θ, not x_2. When $r_1 = \phi$ but $r_1' = x_1$, the decision to reveal x_1 in period two is conditional on both x_1 and new information about x_2. Hence, the particular value of x_1 revealed could be informative about x_2.

nondisclosures. Moreover, the increased credibility achieved by concealing good news initially leads to reduced future disclosure.

Under A1, the model is analyzed with two strategic types, and there exist equilibria in which bad news is sometimes revealed to signal that the firm receives nonproprietary information infrequently. This may explain the frequency with which firms release bad news early (Skinner 1994). Such early revelations may help persuade the market that future nondisclosures do not hide more bad news. These equilibria are supported by the intuitive criterion, yet intuitively appealing monotonic equilibria in which all bad news is concealed always exist.

Under A2, senders may withhold good news about a second project in order to protect the credibility of a prior nondisclosure. Thus, the desire to improve the credibility of both future and past nondisclosures may motivate the withholding of good news. In all cases, firms are more likely to choose nondisclosure when the good news is only moderately better than market expectations, and more likely to disclose when good news is exceptionally better than market expectations. Nevertheless, in some situations, firms that receive nonproprietary information infrequently may initially conceal all news, however exceptional it may be.

The model may apply to communication in several settings, such as communication between politicians and their constituents, or communication between sellers and their customers. An application highlighted in this paper is that of a firm making disclosures to investors. Since public companies cannot suppress results indefinitely, assumption A1 is likely to be most appropriate in this setting. In this case, the results closely match the views expressed by surveyed financial executives (Graham et al. 2005) that they limit voluntary disclosures to avoid setting a precedent for future disclosures.

Reputational incentives rely on underlying uncertainty. Thus, suppression of good news is most likely in the model when management's possible types L and H are very different, and there is uncertainty about the true type. Uncertainty around θ might be present for companies with short reporting histories, such as those that have recently been formed by merger or become public, or for companies that have recently changed, for instance by hiring a new chief financial officer or acquiring a new division. Thus, it should not be surprising that Google made its choice not to issue earnings guidance at its IPO, or that Houston, Lev and Tucker (2008) find cessation of earnings guidance is associated with a change in top management.

A   Equilibrium Characterization Given A1

The importance of firm reputation follows from the firm's second-period expected payoff Π_2 (equation 5). The firm's second-period payoff is increasing in the threshold $\bar{x}_2$ (equation 9) and therefore decreasing in investors' expectation $\bar{\theta}'$, since by the implicit function theorem $\bar{x}_2$ is decreasing in $\bar{\theta}'$ (equation 10 and Jung and Kwon's (1988) Proposition 2).

$$\frac{d\Pi_2}{d\bar{x}_2} = 1 - \theta\left(1 - F_2\left(\bar{x}_2\right)\right) > 0 \tag{9}$$

$$\frac{d\bar{x}_2}{d\bar{\theta}'} = -\frac{\left(F_2\left(\bar{x}_2\right)\bar{x}_2 + \left(1 - F_2\left(\bar{x}_2\right)\right) E\left[x_2 | x_2 > \bar{x}_2\right]\right) - \bar{x}_2}{1 - \bar{\theta}'\left(1 - F_2\left[\bar{x}_2\right]\right)} < 0 \tag{10}$$

Moreover, reputation is most important for the low-type, due to the endogenous single crossing property:

$$\frac{d^2\Pi_2}{d\theta d\bar{\theta}'} = -\frac{d\bar{x}_2}{d\bar{\theta}'}\left(1 - F_2\left(\bar{x}_2\right)\right) > 0. \tag{11}$$

The market's posterior belief $q' = \Pr\left(\theta = H | r_1, x_1\right)$ about the firm's type captures the impact of disclosure on reputation. On the equilibrium path, Bayes' rule pins down posterior beliefs following a first-period choice to reveal (q_r) or to conceal (q_c) as a function of the outcome x_1 and the equilibrium firm strategy (equations 12 and 13). These posterior beliefs correspond to second-period disclosure thresholds $\bar{x}_c\left(x_1\right)$ and $\bar{x}_r\left(x_1\right)$ via equation (4).

$$q_r\left(x_1\right) = q\frac{H\sigma_H\left(x_1\right)}{qH\sigma_H\left(x_1\right) + \left(1 - q\right) L\sigma_L\left(x_1\right)} \tag{12}$$

$$q_c\left(x_1\right) = q\frac{1 - H\sigma_H\left(x_1\right)}{1 - \left(qH\sigma_H\left(x_1\right) + \left(1 - q\right) L\sigma_L\left(x_1\right)\right)} \tag{13}$$

For a strategy to be optimal, it must satisfy the incentive compatibility conditions in equations (14-15), where $\Pi_2\left(\theta, q'\right)$ denotes expected second-period payoffs given true type θ and updated market belief q'. The left hand side of these incentive constraints measures the immediate impact of revealing outcome x_1, while the right hand side captures the second-period reputational ramifications of concealing x_1.

$$\text{Disclosure IC: } x_1 - \bar{x}_1 \geq \delta\left\{\Pi_2\left(\theta, q_c\left(x_1\right)\right) - \Pi_2\left(\theta, q_r\left(x_1\right)\right)\right\} \quad \forall\theta, x_1 \text{ s.t. } \sigma_\theta\left(x_1\right) > 0 \tag{14}$$

$$\text{Concealment IC: } x_1 - \bar{x}_1 \leq \delta\left\{\Pi_2\left(\theta, q_c\left(x_1\right)\right) - \Pi_2\left(\theta, q_r\left(x_1\right)\right)\right\} \quad \forall\theta, x_1 \text{ s.t. } \sigma_\theta\left(x_1\right) < 1 \tag{15}$$

Good news yields an immediate disclosure benefit, but will be concealed if there is a sufficiently strong reputational cost of disclosure. Since the low-type L values reputational improvements

strictly more than the high-type (Proposition 1 and equation 11), whenever the high-type is willing to conceal good news, the low-type must strictly prefer nondisclosure (equation 16). Similarly, firms will only reveal bad news to improve firm reputation. Hence, if the high-type is willing to reveal bad news, then the low-type will strictly prefer to do so (equation 17).

$$\forall x_1 \quad > \quad \bar{x}_1 : \sigma_H(x_1) < 1 \rightarrow \sigma_L(x_1) = 0 \tag{16}$$

$$\forall x_1 \quad < \quad \bar{x}_1 : \sigma_H(x_1) > 0 \rightarrow \sigma_L(x_1) = 1 \tag{17}$$

A.1 Monotonic Equilibria

Define $R_\theta(\sigma_L, \sigma_H)$ as the second-period reputational benefit to type θ for concealing any outcome that the market believes is disclosed with probabilities (σ_L, σ_H), assuming off-equilibrium belief $q^r = 1$ for $\sigma = (0,0)$. This is the right hand side of the IC constraints (14-15),[24] which depends on the firm's disclosure policy through q^r and q^c given by Bayes' rule (equations 12-13).

$$R_\theta(\sigma_L, \sigma_H) \equiv \delta \underset{(\text{assuming } q^r(0,0)=1)}{\{\Pi_2(\theta, q_c(\sigma_L, \sigma_H)) - \Pi_2(\theta, q_r(\sigma_L, \sigma_H))\}}$$

Note that $R_\theta(\sigma_L, \sigma_H)$ is strictly decreasing in σ_L and $R_\theta(\sigma_L, \sigma_H)$ is strictly increasing in σ_H. As a result, multiple equilibria arise from variation in the low-type's strategy, but given a particular strategy for the low-type, that for the high-type is pinned down. All monotonic equilibria lie somewhere between two extremes: the minimum and maximum monotonic-disclosure equilibria. In the former the low-type discloses only above the threshold $\bar{x}_1 + R_L(0,1)$, while in the latter the low-type begins disclosing at the lower threshold $\bar{x}_1 + R_L(1,1)$.

If the market expects both types to disclose outcome x_1 whenever it is nonproprietary, then the reputational benefit to the low-type for concealing x_1 is $R_L(1,1)$. This is the smallest premium above the market's expectation $\bar{x}_1$ at which the low-type can disclose news in equilibrium. However if the market expects the high-type and only the high-type to disclose x_1, then the reputational benefit to the low-type for concealing x_1 is larger: $R_L(0,1) > R_L(1,1)$. This is the largest premium above $\bar{x}_1$ at which the low-type can conceal news in equilibrium. For good outcomes that exceed $\bar{x}_1$ by an amount between these two premia, either full disclosure, complete concealment, or mixing by the low-type can be consistent with equilibrium.

Any outcome disclosed by the low-type in equilibrium must also be disclosed by the high-type (equation 16). For outcomes concealed by the low-type, the high-type gradually switches from full

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[24]For any x_1 at which $(\sigma_L(x_1), \sigma_H(x_1)) = (\sigma_L, \sigma_H)$.

concealment to full disclosure over the range $[\bar{x}_1 + R_H(0,0), \bar{x}_1 + R_H(0,1)]$, mixing so as to be indifferent between revealing and concealing outcomes: $x_1 = \bar{x}_1 + R_H(0, \sigma_H)$. In the minimum-disclosure equilibrium, the single crossing property guarantees that the high-type begins complete disclosure of outcomes before the low-type ($R_L(0,1) > R_H(0,1)$ by equation 11). However, the ranking between $R_L(1,1)$ and either $R_H(0,1)$ or $R_H(0,0)$ will vary depending on model parameters q, L, and H, and distributions F_1 and F_2. If the low-type's maximum-disclosure threshold $\bar{x}_1 + R_L(1,1)$ is below $\bar{x}_1 + R_H(0,1)$, as in Figure 1, the high-type will jump to full disclosure with the low-type at $\bar{x}_1 + R_L(1,1)$ in the maximum disclosure equilibrium.

Proposition 6 and Solutions 1-2 give a precise characterization of both minimum and maximum monotonic-disclosure equilibria.

Proposition 6 *Solutions 1 and 2 respectively characterize the monotonic equilibria with minimum and maximum disclosure in the first period among all monotonic equilibria. Both equilibria exist and are unique. Minimum-disclosure equilibrium thresholds can be strictly ranked: $R_H(0,0) < R_H(0,1) < R_L(0,1)$, but the ranking of maximum disclosure equilibrium thresholds depends on parameters. In the minimum (maximum) disclosure monotonic-equilibrium, market expectation $\bar{x}_1$ is at a maximum (minimum) across all monotonic equilibria.*

Solution 1 *Minimum-disclosure monotonic equilibrium:*

(1) <u>Describe equilibrium strategies as a function of the market expectation</u> $\bar{x}_1$:

$$
\hat{\sigma}_H(x_1) = \begin{cases} 0 & , \ x_1 \leq \bar{x}_1 + R_H(0,0) \\ z : x_1 = \bar{x}_1 + R_H(0,z) & otherwise \\ 1 & , \ x_1 \geq \bar{x}_1 + R_H(0,1) \end{cases}
$$

$$
\sigma_L^{\min}(x_1) = \begin{cases} 0 & , \ x_1 \leq \bar{x}_1 + R_L(0,1) \\ 1 & , \ x_1 > \bar{x}_1 + R_L(0,1) \end{cases} \ ; \ \ \sigma_H^{\min}(x_1) = \hat{\sigma}_H(x_1)
$$

(2) <u>Determine equilibrium market expectation</u> $\bar{x}_1$: Step (1) defines firm strategy $\{\sigma_L^{\min}(x_1),$ $\sigma_H^{\min}(x_1)\}$ as a function of $\bar{x}_1$. Equation (6) gives $\bar{x}_1$ as a function of firm strategy. Select the <u>maximum</u> fixed point $\bar{x}_1$ that is self-consistent. This market expectation $\bar{x}_1$ and the associated strategy form the minimum-disclosure equilibrium. (The market's beliefs are given by Bayes' rule on the equilibrium path, while the market's belief is $q' = 1$ off the equilibrium-path.)

Solution 2 *Maximum-disclosure monotonic equilibrium:*

$$\sigma_L^{\max}(x_1) = \begin{cases} 0 & , \ x_1 < \bar{x}_1 + R_L(1,1) \\ 1 & , \ x_1 \geq \bar{x}_1 + R_L(1,1) \end{cases} ; \ \sigma_H^{\max}(x_1) = \begin{cases} \hat{\sigma}_H(x_1) & , \ \sigma_L^{\max}(x_1) = 0 \\ 1 & , \ \sigma_L^{\max}(x_1) > 0 \end{cases}$$

Select the <u>minimum</u> fixed point $\bar{x}_1$ that is self-consistent with $\sigma^{\max}(x_1)$ and equation (6).

A.1.1 Comparative Statics

The level of disclosure in both minimum and maximum disclosure equilibria depends on outcome distributions and other model parameters. Concealing first period good news is motivated by a concern for the future, and hence more good news can be concealed in equilibrium for higher δ. The reputational incentives to conceal good news rely on market uncertainty about the firm's type. When there is no uncertainty, because $L = H$ or $q = 1$, first period disclosure conforms to the static sanitization strategy. The same is true in the maximum disclosure equilibrium for $q = 0$, but not for the minimum disclosure equilibrium, which supports concealment of good news with the off-equilibrium belief $q_r = 1$ even for $q = 0$. As a result, disclosure in the maximum-disclosure equilibrium is minimized for intermediate $q \in (0, 1)$, but disclosure is increasing monotonically in q in the minimum-disclosure equilibrium.

Disclosure by both types in both minimum and maximum disclosure equilibria is increasing in L for three reasons. First, as L increases more news is disclosable, and hence more news is disclosed holding strategies fixed. Second, conditional on receiving disclosable good news, second period reputational benefits for concealing it are muted because (a) the two types L and H are less different (reducing R_L and R_H) and (b) the low-type expects to conceal second period news less often (reducing R_L). Thus the interval of good news above $\bar{x}_1$ that is concealed shrinks. Third, the increased disclosure of good news due to the first two effects makes concealed news less credible, so that $\bar{x}_1$ decreases. The analysis for changes in H is the same, except that increasing H increases the difference between types, which increases the value of a good reputation conditional on concealing information in the second period. (This does not mean that R_H is increasing in H, however, as increasing H also reduces the likelihood that the high type will need to conceal second period news.) As a result, disclosure may increase or decrease with H.

Without loss of generality, let $x_t = \mu_t + \sigma_t \varepsilon_t$ for independent mean zero random variables ε_t, and constants μ_t. Shifting distributions of x_1 or x_2 up or down by a constant by varying μ_t has no effect on disclosure and can simply be considered a normalization. Scaling up the uncertainty about x_2 by increasing σ_2 reduces disclosure, and is equivalent to increasing δ. Scaling up uncertainty about x_1 by increasing σ_1 has the opposite effect. Other shifts in the distributions of x_1 and x_2

have more ambiguous effects on disclosure.

A.2 Non-Monotonic Equilibria

Condition 1 *Given market expectation $\bar{x}_1$, bad news disclosure strategies are:*

$$\sigma_L^{bad}(x_1) = \begin{cases} 0 & , \ x_1 < \bar{x}_1 + R_L(1,0) \\ 1 & , \ x_1 \in (\bar{x}_1 + R_L(1,0), \bar{x}_1) \end{cases}$$

$$\sigma_H^{bad}(x_1) = \begin{cases} 0 & , \ x_1 \leq \bar{x}_1 + R_H(1,0) \\ z : x_1 = \bar{x}_1 + R_H(1,z) & , \ x_1 \in (\bar{x}_1 + R_H(1,0), \bar{x}_1) \end{cases}$$

Remark 1 *The disclosure of the widest possible interval of bad news is obtained by any equilibrium for which Condition 1 is satisfied for all $x_1 < \bar{x}_1$. Given a uniform distribution of x_1, and threshold $\bar{x}_1 + R_L(1,0)$ not less than A_1, this also corresponds to the greatest probability of bad news disclosure.*

Proposition 7 *Define R_{D1} to be the reputational benefit to the low-type for concealing an outcome neither type reveals ($\sigma = (0,0)$) given the off-equilibrium belief $q^r = 0$. (Recall $R_\theta(0,0)$ is calculated assuming off-equilibrium belief $q^r = 1$.)*

$$R_{D1} \equiv \delta \{\Pi_2(L,q) - \Pi_2(L,0)\} < 0$$

An equilibrium satisfies the D1 criterion (Cho and Kreps 1987, Banks and Sobel 1987, Cho and Sobel 1990), appropriately defined for this setting, if and only if Condition 1 is met in the range $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1)$. An equilibrium satisfies the weaker intuitive criterion (Cho and Kreps 1987) if and only if Condition 1 is met in the range $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1 + R_H(1,0))$. Multiple Perfect Bayesian Equilibria that meet Condition 1 for $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1)$ exist.

Proposition 4 is an immediate corollary of Proposition 7: The D1 criterion always rules out monotonic equilibria in favor of non-monotonic equilibria. Monotonic equilibria are also ruled out by the weaker intuitive criterion given parameters for which $R_{D1} < R_H(1,0)$.[25]

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[25]Cho and Kreps's (1987) intuitive criterion and Banks and Sobel's (1987) divine equilibrium require only that negative off-equilibrium disclosures be seen as no more likely to be from the high-type than the low-type ($q_r \leq q$) when the high-type could also benefit for some inference. Thus, they would not rule out concealment of bad news in the range $x_1 \in (\bar{x}_1 + \max\{R_{D1}, R_H(1,0)\}, \bar{x}_1)$, but they would still require disclosure of bad news by the low type in the range $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1 + R_H(1,0))$. Therefore monotonic equilibria are not ruled out when $R_{D1} > R_H(1,0)$.

B Proofs

B.1 Proof of Proposition 1

Follows from Appendix A, equations (9-11).

B.2 Proof of Proposition 2

Part (1): At any good outcome $x_1 > \bar{x}_1$ for which at least one type discloses with strictly positive probability, beliefs are pinned down by Bayes' rule and equation (16) applies. Together these imply: $q_c(x_1) \leq q < q\frac{H}{\theta} \leq q_r(x_1)$. Hence there is a *strict* reputational benefit of delayed disclosure for each type of at least $\gamma \equiv \delta\{\Pi_2(H,q) - \Pi_2(H, q\frac{H}{\theta})\} > 0$. Thus for any $x_1 \in (\bar{x}_1, \bar{x}_1 + \gamma)$, good news must always be suppressed by both types.

Part (2): The sanitization strategy of only disclosing good news is the strategy that minimizes the consistent market expectation $\bar{x}_1$ over all possible disclosure strategies (equation 6). This follows since either concealing good news or revealing bad news raises the average of the pool of undisclosed information. By assumption, the outcome distribution has full support. Together with part (1) of the proposition, this implies that good news is concealed with positive probability in all equilibria. Hence $\bar{x}_1 > \bar{x}_1^S$ in all equilibria.

B.3 Proof of Propositions 3-4

Proposition 3: See Proposition 6 in Appendix A and discussion in the text. Proposition 4: Follows from Proposition 7 and Condition 1 in Appendix A which characterize the set of equilibria that pass the D1 and Intuitive criteria.

B.4 Proof of Proposition 5

Given first-period nondisclosure, let second-period market expectations be denoted by: (i) $\bar{y} \equiv E[x_1 + x_2 | a_0]$, (ii) $\bar{x}'_1 \equiv E[x_1 | a_2]$, and (iii) $\bar{x}_2 \equiv E[x_2 | a_1]$. Let a candidate second-period strategy be described by Table 3. (This matches that in Table 2 if $\bar{x}'_1 = \bar{x}_1^S$ and $\bar{x}_2 = \bar{x}_2^S$.) Finally, define $\sigma_i(s_1, s_2)$ to be the probability of taking second-period action a_i conditional on receiving signals (s_1, s_2) and first-period report $r_1 = \phi$.

B.4.1 First, I prove a Lemma.

Lemma 1 *Given $\bar{x}'_1$ and $\bar{x}_2$ are constant, a threshold strategy in period one, and the second-period strategy described in Table 3: (1) $E[x_2 | a_0] \geq \bar{x}_2^S = x^S(H, F_2)$, and (2) $E[x_1 | a_0] \geq \hat{x}_1^S$, where $\hat{x}_1^S$*

$$a\left(\phi,\phi\right)=a_0$$
$$a\left(x_i,\phi\right)=\begin{cases} a_0 & x_i < \bar{x}_i + \Delta \\ a_i & x_i \geq \bar{x}_i + \Delta \end{cases}$$
$$a\left(x_1,x_2\right)=\begin{cases} a_0 & \text{otherwise} \\ a_1 & x_1 \geq \bar{x}_1' + \Delta \text{ and } x_2 \leq \bar{x}_2 \\ a_2 & x_2 \geq \bar{x}_2 + \Delta \text{ and } x_1 \leq \bar{x}_1' \\ a_3 & \begin{array}{l} x_1 \geq \bar{x}_1', \ x_2 \geq \bar{x}_2 \\ \& \ x_1 + x_2 \geq \bar{x}_1' + \bar{x}_2 + \Delta \end{array} \end{cases}$$

Table 3: Second period strategies following $r_1 = \phi$.

is characterized by equation (18).

$$\hat{x}_1^S = \frac{(1-H)\mu_1 + HF_1\left[\min\left\{\hat{x}_1^S, x_H\right\}\right] E\left[x_1 \middle| x_1 \leq \min\left\{\hat{x}_1^S, x_H\right\}\right]}{(1-H) + HF_1\left[\min\left\{\hat{x}_1^S, x_H\right\}\right]} \tag{18}$$

Proof. (1) Under the proposed strategy, action a_0 is taken in period two under a subset of two separate events: $(E1)$ $\theta = L$ and $(E2)$ $\theta = H$ and $s_1 \in \{\phi\} \cup \{x_1 : x_1 \leq \min\{\bar{x}_1' + \Delta, x_H\}\}$. As a result, $E\left[x_2 \middle| a_0\right]$ is the weighted average of two quantities, given below in equations (19-20),[26] each of which is weakly greater than $\bar{x}_2^S$:

$$E\left[x_2 \middle| a_0, E1\right] = \mu_2 \geq \bar{x}_2^S \tag{19}$$

$$E\left[x_2 \middle| a_0, E2\right] = \frac{(1-H)\mu_2 + HE_{x_2}\left[x_2\sigma_0\left(x_2 \middle| E2\right)\right]}{(1-H) + HE_{x_2}\left[\sigma_0\left(x_2 \middle| E2\right)\right]} \geq \bar{x}_2^S \tag{20}$$

$$\sigma_0\left(x_2 \middle| E2\right) \equiv E_{s_1}\left[\sigma_0\left(s_1, x_2\right) \middle| x_2, E2\right]$$

Given event $E2$, $s_2 = \phi$ occurs with probability $(1-H)$. In this case, action a_0 is taken with certainty, which leads to the term $(1-H)\mu_2$ in equation 20. On the other hand, s_2 equals x_2 with probability H, and in this case, action a_0 will be taken with probability $\sigma_0\left(x_2 \middle| E2\right)$ as specified by the proposed strategy. The resulting expression is weakly greater than $\bar{x}_2^S = x^S\left(H, F_2\right)$, since it takes the same form as $E\left[x \middle| r = \phi, \bar{\theta} = H, \sigma\right]$ in a one variable static game. By Proposition 2, $x^S\left(\bar{\theta}, F\right)$ is the minimum attained by $E\left[x \middle| r = \phi, \bar{\theta}, \sigma\right]$ over all possible strategies σ.

(2) Under the proposed strategy, action a_0 is taken in period two under a subset of two separate events: $(E1)$ $\theta = L$ and $(E3)$ $\theta = H$ and $s_2 \in \{\phi\} \cup \{x_2 : x_2 \leq \bar{x}_2 + \Delta\}$. As a result, $E\left[x_1 \middle| a_0\right]$ is the weighted average of two quantities, given below in equations (21-22), each of which is weakly greater than $\hat{x}_1^S$:

$$E\left[x_1 \middle| a_0, E1\right] = \mu_1 \geq \hat{x}_1^S \tag{21}$$

$$E\left[x_1 \middle| a_0, E3\right] = \frac{(1-H)\mu_1 + HF_1\left(x_H\right) E_{x_1}\left[x_1\sigma_0\left(x_1 \middle| E3\right) \middle| x_1 \leq x_H\right]}{(1-H) + HF_1\left(x_H\right) E_{x_1}\left[\sigma_0\left(x_1 \middle| E3\right) \middle| x_1 \leq x_H\right]} \geq \hat{x}_1^S \tag{22}$$

---

[26]Implicitly, σ_0 depends on $\bar{x}_1$, $\bar{x}_2$, and Δ.

$$\sigma_0\left(x_1|\,E3\right)=E_{s_2}\left[\sigma_0\left(x_1,s_2\right)|\,x_1,E3\right]$$

The argument here is similar to that for $E\left[x_2|\,a_0\right]$. The comparison $\mu_1\geq\hat{x}_1^S$ follows directly from inspection of equation (18), which characterizes $\hat{x}_1^S$. The expression for $E\left[x_1|\,a_0,E3\right]$ is not symmetric to $E\left[x_2|\,a_0,E2\right]$ due to the first-period threshold strategy. Nevertheless, it is still minimized by the strategy of concealing x_1 ($\sigma_0=1$) if and only if $x_1\leq E\left[x_1|\,a_0,E3\right]$. For this strategy, the expression reduces to that for $\hat{x}_1^S$ in equation (18). Hence it must be that for any $\sigma_0\left(x_1|\,E3\right)$, $E\left[x_1|\,a_0,E3\right]\geq\hat{x}_1^S$. ∎

B.4.2 Now I prove the proposition.

Proof. (1) <u>Period 2 strategy following initial disclosure:</u> If the firm discloses x_1 in period one, it reveals itself to be type H. In the following period, further disclosures about x_1 are irrelevant, and disclosure of x_2 is identical to that in a 1 variable 1 period game where the market belief is $\bar{\theta}=H$. Hence $s_2=x_2$ is disclosed if and only if $x_2\geq\bar{x}_2^S=x^S\left(H,F_2\right)$. Further, second-period payoffs are μ_2 on average, since in this case the market has correct beliefs about the firm's type. Expected payoffs from revealing x_1 initially are then:

$$\pi\left(r_1=x_1\right)=\left(1+\delta\right)\left(x_1+\mu_2\right)$$

(2) <u>Period 2 strategy following initial concealment:</u> The second-period strategy described in Table 3 is optimal following $r_1=\phi$ if $\bar{x}_i$ is a constant (independent of x_j) for $i\in\{1,2\}$ and $\Delta\geq0$. (It is uniquely optimal up to variations at points of indifference, which are measure zero). This follows simply by comparing the payoffs from each action given in Table 4.

a	a_0	a_1	a_2	a_3
Π_2	$\bar{x}_1'+\bar{x}_2+\Delta$	$x_1+\bar{x}_2$	$\bar{x}_1'+x_2$	x_1+x_2

Table 4: Second Period Payoffs Following r1=phi

First consider $a\left(x_1,\phi\right)$, referring to the payoffs in the table above. The payoff from a_1 is better than that from a_0 if and only if $x_1\geq\left(\bar{x}_1'+\Delta\right)$. ($a\left(\phi,x_2\right)$ is symmetric). Second, consider $a\left(x_1,x_2\right)$. For a_1 to be chosen, it must still be the case that $a_1\succ a_0$, but it must now also be the case that $a_1\succ a_3$ and $a_1\succ a_2$. These require not only that $x_1\geq\left(\bar{x}_1'+\Delta\right)$ but also that $\bar{x}_2\geq x_2$ and that $x_1+\bar{x}_2\geq\bar{x}_1'+x_2$. The last requirement is redundant to the first two, for $\Delta\geq0$. For a_2 to be chosen, the requirements are symmetric. For a_3 to be chosen, it must be better than a_1 and a_2, and therefore $x_2\geq\bar{x}_2$ and $x_1\geq\bar{x}$ are required. Moreover, a_3 must be better than a_0, which is the case when $\left(x_1+x_2\right)\geq\left(\bar{x}_1'+\bar{x}_2+\Delta\right)$.

(3) <u>Period 1 strategy</u>: Given $\bar{x}_2 = E[x_2|a_1]$ is a constant independent x_1, the firm must use a threshold strategy in period one, disclosing $s_1 = x_1$ only if $x_1 \geq x_H$.[27] This is apparent by comparing first derivatives of expected payoffs from revealing or concealing in period one:

$$\frac{d}{dx_1}\pi(r_1 = x_1) = (1 + \delta) > 1$$

$$\frac{d}{dx_1}\pi(r_1 = \phi| x_1) = \delta \cdot \Pr(r_1' = x_1 | r_1 = \phi, x_1) < 1$$

Note that the expression for $\frac{d}{dx_1}\pi(r_1 = \phi| x_1)$ relies on $\frac{d}{dx_1}E[x_2|a_1] = 0$.

(4) $\underline{\bar{x}_2 = \bar{x}_2^S \text{ and } \bar{x}_1' = \hat{x}_1^S}$: Given $\bar{x}_i$ are constants, $\Delta \geq 0$, and the described strategy, the expression characterizing $\bar{x}_2$ is identical to that which uniquely characterizes the 1 variable 1 period static cutoff for belief $\bar{\theta} = H$ and distribution F_2:

$$E[x_2|a_1] = \bar{x}_2 = \frac{(1 - H)\mu_2 + HF_2[\bar{x}_2]E[x_2|x_2 \leq \bar{x}_2]}{(1 - H) + HF_2[\bar{x}_2]}$$

Hence $\bar{x}_2 = x^S(H, F_2) = \bar{x}_2^S$. The expressions are identical because there is $(1 - H)$ chance x_2 is not reportable, and H chance that it is. In the later case, observing a_1 informs the market that (i) $x_1 \geq (\bar{x}_1' + \Delta)$, (ii) that $x_2 \leq \bar{x}_2$ and (iii) that $x_1 + \bar{x}_2 \geq \bar{x}_1' + x_2$. The third restriction is redundant to the first two, and can be ignored since $\Delta \geq 0$. Hence the relevant information given active choice to conceal x_2 is that $x_2 \leq \bar{x}_2$, which is precisely what is known following nondisclosure in the one-variable static game.

The expression characterizing $\bar{x}_1'$ is similar, but differs due to the threshold strategy in period one:

$$E[x_1|a_2] = \bar{x}_1' = \frac{(1 - H)\mu_1 + HF_1[\min\{\bar{x}_1', x_H\}]E[x_1|x_1 \leq \min\{\bar{x}_1', x_H\}]}{(1 - H) + HF_1[\min\{\bar{x}_1', x_H\}]}$$

Although this expression differs slightly, it will still have a unique solution, and by comparison to equation (18) it is clear that it is $\bar{x}_1' = \hat{x}_1^S$.

(5) <u>Two (sets of) equations and two unknowns</u>: We already know that $\hat{x}_1^S$ and $\bar{x}_2^S$ exist and are unique (equation 18 defines $\hat{x}_1$ as a function of x_H). There are two remaining unknowns: Δ and x_H. (a) <u>Equations for Δ</u>: The expectation $E[x_1 + x_2|a_0]$ can be calculated as a function of the strategy described by $\bar{x}_1'$, $\bar{x}_2$, Δ and x_H in Table 3. This calculation is captured by the following four equations (23-26). By equation (8), this implies a value for Δ which must be consistent in

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[27]Note that I do not need to worry about influencing equilibrium selection in period 2 with first period disclosure, since following any positive disclosure in period 1, the equilibrium in period 2 is unique. The potential multiplicity only arises given concealment. However, when x_1 is concealed, its exact value cannot influence selection.

equilibrium.

$$E\left[x_1|\,a_0\right]=\frac{1}{\eta_1}\left(\begin{array}{c}\{(1-q)+q\,(1-H)\left[(1-H)+HF_2\left(\bar{x}_2+\Delta\right)\right]\}\mu_1\\+q\,(1-H)\,HF_1\left(x_H\right)E\left[x_1|\,x_1\le x_H\right]\\+qH^2F_1\left(x_H\right)\int_{A_1}^{x_H}x_1\frac{f_1(x_1)}{F_1(x_H)}F_2\left(\min\left\{\bar{x}_2+\Delta,\bar{x}_1'+\bar{x}_2+\Delta-x_1\right\}\right)dx_1\end{array}\right) \tag{23}$$

$$E\left[x_2|\,a_0\right]=\frac{1}{\eta_1}\left(\begin{array}{c}\{(1-q)+q\,(1-H)\left[(1-H)+HF_1\left(x_H\right)\right]\}\mu_1\\+q\,(1-H)\,HF_2\left(\bar{x}_2+\Delta\right)E\left[x_2|\,x_2\le\bar{x}_2+\Delta\right]\\+qH^2\int_{A_2}^{\bar{x}_2+\Delta}x_2f_2\left(x_2\right)F_1\left(\min\left\{x_H,\bar{x}_1'+\bar{x}_2+\Delta-x_2\right\}\right)dx_2\end{array}\right) \tag{24}$$

$$\eta_1\equiv(1-q)+q\,(1-H)^2+q\,(1-H)\,HF_2\left(\bar{x}_2+\Delta\right)+q\,(1-H)\,HF_1\left(x_H\right) \tag{25}$$
$$+\,qH^2F_1\left(x_H\right)\int_{A_1}^{x_H}\frac{f_1\left(x_1\right)}{F_1\left(x_H\right)}F_2\left(\min\left\{\bar{x}_2+\Delta,\bar{x}_1'+\bar{x}_2+\Delta-x_1\right\}\right)dx_1$$

$$\eta_2\equiv(1-q)+q\,(1-H)^2+q\,(1-H)\,HF_1\left(x_H\right)+q\,(1-H)\,HF_2\left(\bar{x}_2+\Delta\right) \tag{26}$$
$$+\,qH^2\int_{A_2}^{\bar{x}_2+\Delta}f_2\left(x_2\right)F_1\left(\min\left\{x_H,\bar{x}_1'+\bar{x}_2+\Delta-x_2\right\}\right)dx_2$$

(b) <u>Equations for x_H</u>: The value of $\pi\left(r_1=\phi\right)$ is calculated as follows:

$$\pi\left(r_1=\phi|\,x_1\right)=\begin{cases}\begin{array}{cc}E\left[x_1|\,r_1=\phi\right]+\delta\hat{x}_1^S+(1+\delta)\,\mu_2&x_1<\hat{x}_1^S\\+\delta\left[(1-H)+HF_2\left(\bar{x}_2^S+\Delta\right)\right]\Delta&\\\hline E\left[x_1|\,r_1=\phi\right]+\mu_2+\delta\left[(1-H)+HF_2\left(\bar{y}-x_1\right)\right]\bar{y}&\hat{x}_1^S<x_1<\hat{x}_1^S+\Delta\\+\delta H\left[1-F_2\left(\bar{y}-x_1\right)\right]\left(x_1+E\left[x_2|\,x_2\ge\bar{y}-x_1\right]\right)&\\\hline E\left[x_1|\,r_1=\phi\right]+\delta x_1+(1+\delta)\,\mu_2&x_1>\hat{x}_1^S+\Delta\end{array}\end{cases} \tag{27}$$

Given the threshold strategy, $E\left[x_1|\,r_1=\phi\right]$ is given by:

$$E\left[x_1|\,r_1=\phi\right]=\frac{\left[(1-q)+q\,(1-H)\right]\mu_1+qHF\left(x_H\right)E\left[x_1|\,x_1\le x_H\right]}{(1-q)+q\,(1-H)+qHF\left(x_H\right)} \tag{28}$$

and the threshold x_H is characterized by:

$$x_H=\frac{\pi\left(r_1=\phi|\,x_H\right)}{1+\delta}-\mu_2 \tag{29}$$

(6) <u>Existence (of a solution to the preceding system of equations)</u>: Given the proposed strategy, some starting values of $x_H\in[A_1,B_1]$ and $\Delta\in\left[0,2B_1-\left(\hat{x}_1^S+\bar{x}_2^S\right)\right]$, and the values $\bar{x}_1'=\hat{x}_1^S(x_H)$

and $\bar{x}_2 = \bar{x}_2^S$: (i) The expectation $E\left[x_1 + x_2 \middle| a_0\right]$ can be computed (equations 23-26), and from this a new value of $\Delta' = E\left[x_1 + x_2 \middle| a_0\right] - \left(\hat{x}_1^S - \bar{x}_2^S\right)$ computed. (ii) Further, given the computed value of $E\left[x_1 + x_2 \middle| a_0\right]$, $\pi\left(r_1 = \phi \middle| x_H\right)$ can be computed from equations (27) and (28), and from this a new value of $x'_H = \max\left\{A_2, \min\left\{\frac{\pi(r_1=\phi|x_H)}{(1+\delta)} - \mu_2, B_1\right\}\right\}$.

The preceding procedure describes a function mapping $\{x_H, \Delta\}$ to $\{x'_H, \Delta'\}$. The function is continuous since both $E\left[x_1 + x_2 \middle| a_0\right]$ and $\pi\left(r_1 = \phi\right)$ are continuous functions of x_H and Δ, given that F_1 and F_2 are atomless. The initial pair $\{x_H, \Delta\}$ lies within the compact set $[A_2, B_1] \times \left[0, 2B_1 - \left(\hat{x}_1^S + \bar{x}_2^S\right)\right]$. The trick is showing that the resulting pair $\{x'_H, \Delta'\}$ does so as well. It is straightforward that $\Delta' \leq (B_1 + B_2) - \left(\hat{x}_1^S + \bar{x}_2^S\right)$, since $E\left[x_1 + x_2 \middle| a_0\right] \in [A_1 + A_2, B_1 + B_2]$. It is more subtle, however, that $\Delta' \geq 0$. This follows from Lemma 1. Next $x'_H \in [A_1, B_1]$ by definition. Limiting x'_H to be inside $[A_1, B_1]$ when $\frac{\pi(r_1=\phi|x_H)}{(1+\delta)} - \mu_2$ may lie outside is okay, since all thresholds $x_H \geq B_1$ are equivalent, and all thresholds $x_H \leq A_1$ are equivalent.

Brouwer's fixed-point theorem now applies, and guarantees that there exists at least one pair $\{x_H, \Delta\}$ that form an equilibrium of the two period game when coupled with the proposed strategy, the values $\bar{x}'_1 = \hat{x}_1^S$ and $\bar{x}_2 = \bar{x}_2^S$.

(7) It is shown that $\hat{x}_1^S = \bar{x}_1^S$ and $x_H \in \left[\bar{x}_1^S, \bar{x}_1^S + \Delta\right]$: (1) Suppose that in equilibrium $x_H \geq \hat{x}_1^S$. Then x_H drops out of equation (18), and $\hat{x}_1^S = \bar{x}_1^S$. (2) If in equilibrium it is also true that $x_H > \hat{x}_1^S + \Delta$ then x_H is characterized by $E\left[x_1 \middle| r_1 = \phi\right] + \delta x_H + (1 + \delta)\mu_2 = (1 + \delta)(x_H + \mu_2)$. This implies $x_H = E\left[x_1 \middle| r_1 = \phi\right]$. This in turn implies that $x_H = \bar{x}_1^S$, which contradicts $x_H > \hat{x}_1^S + \Delta \geq \hat{x}_1^S = \bar{x}_1^S$. Therefore in equilibrium $x_H \leq \hat{x}_1^S + \Delta$. (3) Suppose in equilibrium that $x_H < \hat{x}_1^S$. Then $\hat{x}_1^S = E\left[x_1 \middle| r_1 = \phi\right]$. Moreover, x_H is characterized by:

$$x_H = \frac{E\left[x_1 \middle| r_1 = \phi\right] + \delta\hat{x}_1^S}{(1 + \delta)} + \frac{\delta}{1 + \delta}\left[(1 - H) + HF_2\left(\bar{x}_2^S + \Delta\right)\right]\Delta$$
$$= \hat{x}_1^S + \frac{\delta}{1 + \delta}\left[(1 - H) + HF_2\left(\bar{x}_2^S + \Delta\right)\right]\Delta \geq \hat{x}_1^S$$

This produces a contradiction. Together, (1)–(3) imply $\hat{x}_1^S = \bar{x}_1^S$ and $x_H \in \left[\bar{x}_1^S, \bar{x}_1^S + \Delta\right]$.

(8) $\underline{\Delta \geq 0}$: All equilibrium conditions developed in steps (1)-(7) were shown to be necessary conditions given $\bar{x}_i$ are constant and $\Delta \geq 0$. Moreover, if we assume $\bar{x}_i$ are constant and $\Delta < 0$, and then calculate $\bar{x}_i = E\left[x_i \middle| a_j\right]$, one immediately finds that $\bar{x}_i$ varies with x_j, a contradiction. Hence $\Delta \geq 0$ is also necessary given $\bar{x}_i$ constant. Therefore, this proposition characterizes the full set of equilibria for which $\bar{x}_i$ are constant. (Again, up to the changes in strategy at measure zero points of indifference.) ∎

B.5 Proof of Proposition 6

Proof. Existence & Uniqueness: (1) Minimum-disclosure equilibrium: Solution 1 part (1) specifies an optimal firm strategy as a function $\bar{x}_1$. Plugging this strategy into equation (6) gives a new $\bar{x}_1'$. Together, this procedure gives a mapping $\bar{x}_1'(\bar{x}_1) : [A_1, B_1] \to [A_1, B_1]$. By assumption, the support $[A_1, B_1]$ is bounded. The strategies vary continuously with $\bar{x}_1$ everywhere but at $\bar{x}_1 + R_L(0,1)$. Since F_1 is atomless, this discontinuity is smoothed out when expectations are taken in equation (6). Hence $\bar{x}_1'$ varies continuously with $\bar{x}_1$. Brouwer's fixed-point theorem therefore implies that there exists a non-empty set of fixed points $\bar{x}_1$, each of which corresponds to an equilibrium. It is simple to show that the set of fixed points will be compact.[28] Hence the maximum fixed point and the corresponding equilibrium exist and are unique.

(2) The argument is similar for the maximum-disclosure equilibrium described by Solution 2.

Minimum & Maximum Disclosure: (1) Minimum-disclosure equilibrium:

Solution 1 defines firm strategy $\sigma^{\min}(x_1)$ as a function of both outcome x_1 and market expectation $\bar{x}_1$. For clarity, I will now write both terms explicitly: $\sigma^{\min}(x_1, \bar{x}_1)$. Solution 1 identifies a subset of monotonic equilibria which satisfy $\sigma(x_1) = \sigma^{\min}(x_1, \bar{x}_1)$ and equation (6). I show that for any monotonic equilibrium outside this set, there is an equilibrium in the set with strictly less disclosure and weakly higher $\bar{x}_1$. Since Solution 1 selects the equilibrium with minimum-disclosure and maximum $\bar{x}_1$ from within this set, it selects equilibrium with minimum disclosure and maximum $\bar{x}_1$ among all monotonic equilibria.

Let $\bar{x}_1$ and $\sigma(x_1) \neq \sigma^{\min}(x_1, \bar{x}_1)$ form a monotonic equilibrium. For a given $\bar{x}_1$, $\sigma^{\min}(x_1, \bar{x}_1)$ describes the minimum disclosure that can be incentive compatible for each outcome x_1. Hence $\sigma(x_1) \geq \sigma^{\min}(x_1, \bar{x}_1)$ at all x_1.[29] By monotonicity, $\sigma(x_1) = (0,0)$ for all $x_1 < \bar{x}_1$. So $\sigma(x_1) \neq \sigma^{\min}(x_1, \bar{x}_1)$ implies that for some $x_1 \geq \bar{x}_1$, $\sigma(x_1) > \sigma^{\min}(x_1, \bar{x}_1)$ and everywhere else $\sigma(x_1) = \sigma^{\min}(x_1, \bar{x}_1)$. Therefore by altering the strategy from $\sigma(x_1)$ to $\sigma^{\min}(x_1, \bar{x}_1)$ the direct effect is less disclosure. The indirect effect is that the market expectation consistent with $\sigma^{\min}(x_1, \bar{x}_1)$ will be weakly greater than $\bar{x}_1$, due to more good news being concealed: $\bar{x}_1'(\sigma^{\min}(x_1, \bar{x}_1)) \geq \bar{x}_1$. This relaxes the concealment IC constraint, and makes still more concealment possible. In particular,

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[28]Each set of fixed points is compact: Take a sequence of fixed points $\{x^k\}$ that converges to x. Since $\bar{x}_1(x)$ is continuous, then $\{\bar{x}_1(x^k)\} \to \bar{x}_1(x)$. Since all x^k are fixed points, the two sequences are the same, so $\bar{x}_1(x) = x$, and x is also a fixed point. Finally, $x \in [A_1, B_1]$, because a closed set contains the limit points of all its sequences.

[29]In all equilibria, $\sigma_H(x_1) = \begin{cases} \hat{\sigma}_H(x_1, \bar{x}_1) & , \sigma_L(x_1) = 0 \\ 1 & , \sigma_L(x_1) > 0 \end{cases}$ for all $x_1 > \bar{x}_1$. No other strategy for the high-type could be incentive compatible if $\sigma_L(x_1)$ is incentive compatible. Therefore $\sigma_H(x_1) \geq \sigma_H^{\min}(x_1, \bar{x}_1)$. For $x_1 > \bar{x}_1 + R_L(0,1)$, the outcome x_1 exceeds market expectations by more than the maximum reputational benefit for concealment. Hence it must be disclosed by both types in any equilibrium: $\sigma(x_1) = \sigma^{\min}(x_1, \bar{x}_1) = (1,1)$. For $x_1 \leq \bar{x}_1 + R_L(0,1)$, clearly $\sigma_L(x_1) \geq \sigma_L^{\min}(x_1, \bar{x}_1) = 0$.

there exists $\bar{x}^* \geq \bar{x}_1$ such that $\bar{x}^*$ and $\sigma^{\min}(x_1, \bar{x}^*)$ form an equilibrium.[30] Clearly $\sigma^{\min}(x_1, \bar{x}^*) \leq \sigma^{\min}(x_1, \bar{x}_1)$ so this equilibrium has strictly less disclosure than the initial equilibrium with $\bar{x}_1$ and $\sigma(x_1)$.

(2) Maximum-disclosure equilibrium:

First note that the described maximum disclosure equilibrium has maximum disclosure among all strictly monotonic equilibria. Among weakly monotonic equilibria, the equilibrium with maximum disclosure differs only in that $\sigma = (1, L/H)$ at $x_1 = \bar{x}_1$.

Let $\bar{x}_1$ and $\sigma(x_1) \neq \sigma^{\max}(x_1, \bar{x}_1)$ form a strict monotonic equilibrium. By strict monotonicity, $\sigma(x_1) = \sigma^{\max}(x_1, \bar{x}_1) = 0$ for all $x_1 \leq \bar{x}_1$. For a given $\bar{x}_1$, $\sigma^{\max}(x_1, \bar{x}_1)$ describes the maximum disclosure that can be incentive compatible for each outcome $x_1 > \bar{x}_1$. Hence $\sigma(x_1) \leq \sigma^{\max}(x_1, \bar{x}_1)$.[31] So $\sigma(x_1) \neq \sigma^{\max}(x_1, \bar{x}_1)$ implies that for some $x_1 > \bar{x}_1$, $\sigma(x_1) < \sigma^{\max}(x_1, \bar{x}_1)$ and everywhere else $\sigma(x_1) = \sigma^{\max}(x_1, \bar{x}_1)$. Therefore by altering the strategy from $\sigma(x_1)$ to $\sigma^{\max}(x_1, \bar{x}_1)$ the direct effect is more disclosure. The indirect effect is that the market expectation consistent with $\sigma^{\max}(x_1, \bar{x}_1)$ will be weakly less than $\bar{x}_1$ ($\bar{x}_1'(\sigma^{\max}(x_1, \bar{x}_1)) \leq \bar{x}_1$), due to more good news ($x_1 > \bar{x}_1$) being disclosed. This relaxes the disclosure IC constraint, and makes still more disclosure possible. In particular, there exists $\bar{x}^* \in (\bar{x}_1^S, \bar{x}_1]$ such that $\bar{x}^*$ and $\sigma^{\max}(x_1, \bar{x}^*)$ form an equilibrium.[32] Clearly $\sigma^{\max}(x_1, \bar{x}^*) \geq \sigma^{\max}(x_1, \bar{x}_1)$ so this equilibrium has strictly more disclosure than the initial equilibrium with $\bar{x}_1$ and $\sigma(x_1)$. By a similar argument to that for the minimum-disclosure equilibrium, this is sufficient to show that Solution 2 identifies the strictly-monotonic equilibrium with maximum-disclosure and minimum $\bar{x}_1$. (For the weakly-monotonic equilibria with maximum disclosure, the argument is the same, except that at precisely $\bar{x}_1$, $\sigma = (1, L/H)$ is possible.)

(3) The inequality $R_H(0,0) < R_H(0,1) < R_L(0,1)$ follows from comparative statics results in Section 4.1 and Bayes' rule (equations 12-13). ∎

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[30] As argued earlier, $\bar{x}_1'(\sigma^{\min}(x_1, \bar{x}_1))$ is continuous in $\bar{x}_1$. Moreover $\bar{x}_1'(\sigma^{\min}(x_1, B_1)) = \mu_1 < B_1$. Coupled with $\bar{x}_1'(\sigma^{\min}(x_1, \bar{x}_1)) \geq \bar{x}_1$, this implies that there exists a $\bar{x}^* \in [\bar{x}_1, B_1)$ such that $\bar{x}_1'(\sigma^{\min}(x_1, \bar{x}^*)) = \bar{x}^*$.

[31] In all equilibria, $\sigma_H(x_1) = \begin{cases} \hat{\sigma}_H(x_1, \bar{x}_1) & , \ \sigma_L(x_1) = 0 \\ 1 & , \ \sigma_L(x_1) > 0 \end{cases}$ for all $x_1 > \bar{x}_1$. No other strategy for the high-type could be incentive compatible if $\sigma_L(x_1)$ is incentive compatible. Therefore $\sigma_L(x_1) \leq \sigma_L^{\max}(x_1, \bar{x}_1)$ implies $\sigma_H(x_1) \leq \sigma_H^{\max}(x_1, \bar{x}_1)$ for all $x_1 > \bar{x}_1$. Whenever the low-type discloses $x_1 > \bar{x}_1$ in equilibrium, her reputational benefit for concealing an outcome must be at least $R_L(1,1)$ since $\sigma_L > 0$ implies $\sigma_H = 1$ and R_L is decreasing in σ_L. Hence in any equilibria, the low-type must conceal ($\sigma_L(x_1) = \sigma_L^{\max}(x_1, \bar{x}_1) = 0$) for $x_1 \in (\bar{x}_1, \bar{x}_1 + R_L(1,1))$. For $x_1 \geq \bar{x}_1 + R_L(1,1)$, clearly $\sigma_L(x_1) \leq \sigma_L^{\max}(x_1, \bar{x}_1) = 1$.

[32] As argued earlier, $\bar{x}_1'(\sigma^{\max}(x_1, \bar{x}_1))$ is continuous in $\bar{x}_1$. Moreover, by the same logic in the proof of Proposition 2 part 2, $\bar{x}_1'(\sigma^{\max}(x_1, \bar{x}_1^S)) > \bar{x}_1^S$. Coupled with $\bar{x}_1'(\sigma^{\max}(x_1, \bar{x}_1)) \leq \bar{x}_1$, this implies that there exists a $\bar{x}^* \in (\bar{x}_1^S, \bar{x}_1]$ such that $\bar{x}_1'(\sigma^{\max}(x_1, \bar{x}^*)) = \bar{x}^*$.

B.6 Proof of Proposition 7

Proof. (1) The <u>D1 criterion and Universal Divinity both impose Condition 1 for $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1)$.</u>
(*a*) Disclosure must be on the equilibrium path for all $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1)$: Suppose instead, that there is no disclosure in equilibrium for some $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1)$. Then $q_c(x_1) = q$. The low-type would benefit by making the off-equilibrium revelation of x_1 given an off-equilibrium belief $q_r(x_1) \in [0, z]$ for some $z > 0$. Further, the low-type would benefit under a wider range of market inferences about firm type than would the high-type. These refinements suggest that in this case investors should infer that such a deviation was "infinitely more likely" to be from the low-type. The implied off-equilibrium belief $q_r(x_1) = 0$ would then make low-types want to deviate and reveal x_1.

(*b*) Given positive probability of disclosure for all $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1)$, Condition 1 must hold in that range: (*i*) Below $\bar{x}_1 + R_H(1,0)$, the high-type will never be willing to disclose bad news ($\sigma_H^b(x_1) = 0$). Therefore, for $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1 + R_H(1,0)]$, if disclosure is on the equilibrium path, it must be solely by the low-type. This implies $q_r = 0$ and $q_c \geq q$, which means the low-type strictly prefers disclosure ($\sigma_L^b(x_1) = 1$).

(*ii*) For $x_1 \in (\bar{x}_1 + \max\{R_{D1}, R_H(1,0)\}, \bar{x}_1)$, if disclosure were solely by the low-type ($\sigma_H = 0$, $\sigma_L > 0$), the low-type would strictly prefer disclosure ($\sigma_L(x_1) = 1$) since $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1)$. But $\sigma_H(x_1) = 0$ and $\sigma_L(x_1) = 1$ cannot be an equilibrium. Since $x_1 \in (\bar{x}_1 + R_H(1,0), \bar{x}_1)$, the high-type would want to deviate by disclosing x_1. Therefore, if there is positive probability of disclosure in this range, it must be by both types (σ_H, $\sigma_L > 0$). Increasing differences (equation 17) then implies $\sigma_L(x_1) = 1$.

For all bad news, the high-type cannot disclose with greater than probability $\frac{L}{H}$ ($\sigma_H \leq \frac{L}{H}$), since beyond that point $q_r > q_c$ and no one would want to disclose. Thus, the high-type must be mixing, and therefore indifferent between concealment and disclosure. This indifference is precisely the condition that uniquely specifies $\sigma_H(x_1)$ in Condition 1 for $x_1 \in (\bar{x}_1 + R_H(1,0), \bar{x}_1)$.

(2) <u>Condition 1 for $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1)$ implies both D1 criterion and Universal Divinity are met:</u> For any equilibrium meeting Condition 1 in the range $x_1 \in (\bar{x}_1 + R_{D1}, \bar{x}_1)$, the only possible off-equilibrium disclosures are of bad news below $\bar{x}_1 + R_{D1}$ or of good news. At any point x_1 for which neither firm type discloses in equilibrium, Bayes' rule dictates that $q_c(x_1) = q$. Therefore, for any such point below $\bar{x}_1 + R_{D1}$, neither firm would benefit from making an off-equilibrium disclosure, even under the most favorable off-equilibrium belief $q_r(x_1) = 0$. As a result, D1 Criterion and Universal Divinity place no restriction on off-equilibrium beliefs. For off-equilibrium revelations of good news, the D1 Criterion and Universal Divinity restrict the market inference to be $q_r = 1$, as the high-type would benefit from disclosure under a wider range of market inferences than the

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low-type. Any equilibrium with full concealment of good news at x_1 with off-equilibrium belief $q_r(x_1) < 1$, will still be an equilibrium with off-equilibrium belief $q_r(x_1) = 1$, as this only makes disclosure less profitable.

(3) <u>Existence:</u> For example, take the minimum-disclosure strategy in Solution 1 for all good news, and Condition 1 for all bad news. These specify $\sigma = \{\sigma_L(x), \sigma_H(x)\}$ as a function of $\bar{x}_1$, and equation 6 gives $\bar{x}_1$ as a function of σ. Hence Brouwer's fixed-point theorem guarantees an equilibrium exists, by the same argument as that in Proposition 6.

(4) <u>Multiplicity:</u> The argument in (3) applies for any other strategy incentive compatible with $\bar{x}_1$ and consistent second-period market beliefs that can be described as a function of $\bar{x}_1$, such that it changes continuously with $\bar{x}_1$ almost everywhere. For example, I could have chosen the maximum-disclosure strategy for good news. ∎

B.7   Proof of Remark 1

Proof. For fixed $\bar{x}_1$, Condition 1 specifies the maximum possible disclosure of bad news. For a uniform distribution, shifting $\bar{x}_1$, and therefore the range over which bad news is disclosed, does not affect the probability that bad news is disclosed. The only exception would be if $\bar{x}_1 + R_L(1, 0)$ were less than A_1, so that bad news disclosure was outside the support of outcomes. In this case, an alternate equilibrium with higher $\bar{x}_1$ could have higher probability of bad-news disclosure. ∎

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