The Dynamics of Concealment

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Abstract

CEOs likely possess more information about firm prospects than outside investors. If managers strategically conceal such information, the accuracy of firm valuations may decline. To quantify this channel, we develop and solve a dynamic model of corporate disclosure with a plausible link between a manager’s future reputation and their disclosure policy today. We estimate our structural model using a comprehensive sample of management earnings forecasts released by large public companies in the US between 2004 and 2014. Our estimated model matches untargeted patterns in the dynamics of firm earnings and analyst forecasts around disclosure events, with managers publicly forecasting earnings only in unusually profitable years relative to market expectations. Using our framework, we infer that managers conceal information strategically 26% of the time, leading to a sizable information loss of 6% relative to a setting where managers never hide bad news from investors. The lost accuracy in firm valuations can be substantial, running anywhere from around $20 million to $100 million for a typical large public firm in our sample. Overall, the presence of strategic information concealment by managers appears to materially reduce the precision of market valuations.

Keywords: voluntary disclosure; structural estimation; reputations; persuasion
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1 Introduction

Where does news about future cash flows come from? In the US, public firms release their financial statements each quarter, but accounting earnings are limited to a large extent to past and current transactions which are largely anticipated by investors (Ball and Brown 1968). In this paper, we investigate a supplementary channel used by corporations to transmit forward-looking information. Firms often supplement their financial statements with voluntary forecasts about future earnings. Empirically, these forecasts contain most of the price-relevant news released in recurrent reporting events. For example, Beyer, Cohen, Lys, and Walther (2010) document that management forecasts explain a large portion of a firm’s quarterly return variance, about 16%, which is more than analyst forecasts, earnings announcements, and regulatory filings added together.

We develop a dynamic theory of voluntary management forecasts. Managers can choose to withhold information when news is unfavorable, delaying its arrival and exploiting information asymmetries between management and investors. We ask multiple questions. How much more information do managers possess that investors do not have, and what portion of this information is concealed? Also, to what extent does strategic withholding cause deviations between market prices and fundamentals, and what increases in price efficiency could we expect if strategic withholding could be eliminated?

An obvious challenge for research in this area is that withheld information cannot be directly observed. We therefore exploit our structural model, inferring the precision of manager information and the extent to which they strategically withhold information from the observed pattern of manager disclosure in equilibrium. We build dynamics and reputational concerns into our analysis because managers self-report that reputations are a critical determinant of forecasting choices (Graham, Harvey, and Rajgopal 2005). Our quantified model delivers intuitive measures of the amount of strategic withholding and the resulting loss in investor information.

Our theory fits stylized facts about the empirical distribution of forecasts and earnings. While unravelling theory predicts that all firms should make a forecast (Viscusi 1978; Grossman and Hart 1980; Milgrom 1981), we observe a fairly low propensity to forecast. Even for the S&P500 index, that is, large firms with active investor relations, a forecast is made only between one third and one half of the time. We also observe a significant stickiness in propensities to disclose, which, empirically, is poorly explained by observed firm characteristics. Third, managers appear to select periods in which information is more favorable to make a forecast, and strategically withhold information (Kothari, Shu, and Wysocki 2009). Markets react unfavorably to firms that stop giving forecasts, and such decisions usually precede declines in actual earnings.

We rationalize these facts as an optimal strategic disclosure policy with persistent information endowment. We enrich the model of Dye (1985) and Jung and Kwon (1988), a static model in which a manager may not be endowed with information and maximizes the current price. To make this model amenable to an empirical analysis, we make this model fully dynamic, adding to it insights from recent disclosure theory: (a) the manager is forward looking and considers the effect of a disclosure on future prices (Guttman, Kremer, and Skrzypacz 2014; Marinovic, Skrzypacz, and Varas 2015; Beyer and Dye 2012); (b) managers’ information endowment is serially correlated, and markets update
their beliefs as a function of realized earnings (Einhorn and Ziv 2008); and (c) a public
news process, e.g. analyst consensus forecasts, affects the propensity to disclose (Acharya,
Demarzo, and Kremer 2011).

The model implies a threshold level of internal news about profitability below which
an informed manager chooses to conceal information from the market. This threshold
is time varying and depends on the market assessment of the current probability that
the manager is informed, which is itself a function of the entire past history of forecasts.
A forward-looking manager benefits from maintaining a reputation to be uninformed
because the market penalizes non-disclosure less when strategic withholding is perceived
to be unlikely. By making a forecast, the manager reveals their information endowment in
the current period, and, thus, a higher likelihood that they will be informed in future. The
loss of reputation that follows in our model generates an endogenous cost of disclosure,
especially after long periods without a forecast. Consistent with (Graham, Harvey, and
Rajgopal 2005), managers are reluctant to initiate a forecast because doing so would
create a precedent that would increase pressure to make forecasts in future. Therefore,
after long periods without forecasts, the firm will be less likely to disclose and more likely
to reveal only the most favorable information to the public.

Our approach provides a quantitative assessment of a channel through which manda-
tory disclosure affects the provision of voluntary disclosure. In a simpler static version
of our model, a public signal such as realized earnings would not affect the probability
of disclosure because disclosure strategies are solely a function of current market beliefs.
In our full dynamic model, by contrast, realized earnings help discipline forecasting be-
behavior. Realized earnings inform investors about the private information observed by
the manager and reduce a manager’s ability to build an uninformed reputation. When
observing low realized earnings, the market knows that the manager was more likely to
be informed and will carry this information into the future. The greater the information
contained in earnings, the less likely it is that the manager will be able to maintain a
reputation which, in turn, reduces incentives to withhold information.

We estimate our structural model by using a comprehensive dataset of annual realized
earnings, management forecasts, and analyst consensus forecasts provided by I/B/E/S.
Our sample is a panel of around 1,000 US public firms spanning 2004–2014 for a total
of around 8,000 firm-fiscal years. We estimate the volatility of fundamental earnings and
the precision of information contained in analyst forecasts by directly matching some key
moments of observed earnings and consensus forecasts. We also estimate the likelihood
that a manager is informed, together with the persistence of manager information, by
requiring in a straightforward generalized method of moments (GMM) procedure that the
model closely reproduce the likelihood of manager disclosure, the persistence of disclosure
policies, and the observed magnitude of manager forecast errors.

We then subject our estimated model to a stringent test, computing the dynamic
paths of analyst consensus forecasts and realized earnings around disclosure dates in the
data. This exercise reveals that managers choose to publicly disclose earnings projec-
tions only during very particular episodes with a spell of unusually high earnings. Both
quantitatively and qualitatively, our model matches these untargeted dynamic patterns,
offering some confidence that our theory adequately captures the equilibrium pattern of
Our results indicate that managers possess more information than investors about 84% of the time and strategically conceal this information about in one-fourth of cases. We also calculate that relative to a counterfactual in which managers report all their information, strategic withholding increases the root mean squared error (RMSE) of investor earnings expectations, and hence market valuations, by 6% relative to an environment without strategic withholding. A back of the envelope calculation suggests that managers’ strategic withholding of information may distort firm valuations by anywhere from around $20 million to $100 million for a typical firm in our sample. The sheer size of these figures validates policymaker and academic concerns with manager concealment and suggests that disclosure policies and incentives are critical for determining price efficiency in public markets.

We build on a substantial body of previous theoretical work on disclosure. Our dynamic model is a part of what Milgrom (1981) defines as persuasion theory, namely, a class of sender–receiver problems in which the sender’s preference depends only on the receiver’s posterior belief. For the most part, the early disclosure literature is static (Jovanovic 1982; Verrecchia 1983; Dye 1985; Shin 1994; Shavell 1994). Persuasion theory has only been recently extended to a dynamic context because most single-period disclosure models no longer fit this definition of persuasion when they are repeated.

Three recent examples of two-period disclosure models serve to best illustrate this point. Acharya, Demarzo, and Kremer (2011) develop a model in which the manager can delay a disclosure after the release of public news. In this model, the value of delay is a function of the manager’s expectation about the public news, which depends on the information privately observed by the manager. Beyer and Dye (2012) consider a model in which some managers may be forthcoming and disclose all of their information. Managers know their propensity to be forthcoming in the next period, which implies that their type affects their payoff from withholding. Guttman, Kremer, and Skrzypacz (2014) examine a model in which more information may be received at some later date. A manager choosing to delay can anticipate the information received at a later date: managers with a low signal know it is more likely that they will be willing to withhold later. The traditional methods of persuasion theory fail to apply or, at least, are significantly changed for repeated versions of these models.

One approach has been shown to preserve the basic structure of persuasion with some dynamic aspects. Einhorn and Ziv (2008) and Marinovic (2012) are models in which the market updates dynamically to new information, but the manager is myopic and maximizes only current short-term stock prices. The stock price is the sole channel through which future periods affect current actions. In Einhorn and Ziv (2008), the stock price includes the discounted value of expected disclosures in the future. In Marinovic (2012), the stock price is equal to the value implied by all past disclosures. After observing a current disclosure, the market reassesses the propensity to be truthful and reprices the entire sequence of past disclosures.

Our model shares its focus with a recent literature applying structural models to analyze strategic financial communication. Bertomeu, Ma, and Marinovic (2016) is the paper closest to ours and estimates the Dye (1985) model under the assumption that
the manager, when informed, maximizes current stock prices. This paper generalizes
the approach to a manager with forward-looking motives and adds an exogenous public
news process, analysts’ forecasts, to the estimation procedure. Two other recent stud-
ies empirically evaluate strategic behavior in information dissemination. Manela (2014)
structurally estimates the diffusion and value of information to strategic traders in a ra-
tional expectations market, and finds that information profits are hump-shaped in the
diffusion of public information. Their focus lies on the diffusion process after the informa-
tion event, while we focus on the strategic initial release of information. Jin, Luca, and
Martin (2015) evaluate the formation of expectations when faced with non-disclosure
in an experimental setting and find that expectations often understate the true information
following non-disclosure.

Several other studies focus on incentives to manipulate the earnings process rather
than selectively withhold forecasts. Beyer, Guttman, and Marinovic (2014) structurally
estimate a dynamic model of costly earnings misreporting, in which the manager’s equity
incentives are not known to the market (Fischer and Verrecchia 2000; Frankel and Kartik
2014). Terry (2016) studies a model in which manager earnings misreporting choices
interact with real manipulation of long-term investments. Zakolyukina (2014) examines
a model in which managers trade off higher stock prices in the present versus a greater
probability of prosecution in the future when making manipulation or deception choices.

2 Theoretical model

2.1 Assumptions

This section extends the model in Dye (1985) to a dynamic setting in which the man-
ger has forward-looking motives and public information flows interact with management
disclosure choices. There is a single firm and a large number of risk-neutral investors,
referred to as the market. Time is discrete and indexed by \( t = \{1, 2, ..., \infty\} \). Following
Acharya, Demarzo, and Kremer (2011), Benmelech, Kandel, and Veronesi (2010), and
Beyer (2012), we assume that the manager maximizes the present value of the firm’s
future stock prices. That is, the manager’s expected utility in period \( t \) is

\[
U_t = \mathbb{E}\left( \sum_{n=t}^{\infty} \beta^{n-t} P_n | I_t \right),
\]

where \( \beta \in (0, 1) \) is the manager’s discount factor, \( P_n \) is the market price of the firm, and
\( I_t \) is the manager’s information set. We discuss this specification of manager preferences
further below.

In each period there are three dates. First, the market observes signal \( c_t \) of the
firm’s earnings \( e_t \). We refer to \( c_t \) as the consensus forecast, but we can think of \( c_t \) more
generally as comprising all the public information available to investors prior to the firm’s
disclosure. Second, with some probability, the manager observes a private signal \( s_t \) of the
firm’s future earnings and chooses whether to disclose this signal or not. Based on the
manager’s disclosure choice, the market sets the stock price \( P_t \) as the expected present

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value of the firm’s future earnings. Finally, firm’s earnings $e_t$ are realized and publicly observed. Figure 1 summarizes the timeline.

**Figure 1. Timeline**

<table>
<thead>
<tr>
<th>$t=1$</th>
<th>$t=2$</th>
<th>$t=3$</th>
</tr>
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<tbody>
<tr>
<td>The consensus $c_t$ is publicly released.</td>
<td>The manager privately observes $s_t$ and chooses $d_t$.</td>
<td>Earnings $e_t$ are released.</td>
</tr>
<tr>
<td>The price $P_t$ is set.</td>
<td></td>
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Following Dye (1985), we assume that the manager’s information endowment $\theta_t \in \{0, 1\}$ is random, where the manager observes signal $s_t$ when $\theta_t = 1$. As in Einhorn and Ziv (2007), we model the manager’s information endowment $\theta_t$ as a hidden Markov chain with a transition matrix:

$$\Pi = \begin{bmatrix} 1 - \lambda_1 & \lambda_1 \\ \lambda_0 & 1 - \lambda_0 \end{bmatrix},$$

where $\lambda_0 \equiv P(\theta_{t+1} = 0 | \theta_t = 1) \in (0, 1)$ denotes the probability of transitioning from the informed to the uninformed state, and $\lambda_1 \equiv P(\theta_{t+1} = 1 | \theta_t = 0) \in (0, 1)$ denotes the probability of transitioning from the uninformed to the informed state. The information endowment is persistent if becoming uninformed is less likely than remaining uninformed, or $\lambda_0 < 1 - \lambda_1$. We will sometimes parametrize the process $\theta_t$ by using the long-run probability of being uninformed given by $\bar{p} \equiv \frac{\lambda_0}{\lambda_0 + \lambda_1}$ as well as the “persistence” of information endowments $r \equiv 1 - \frac{1}{2} \frac{\lambda_0}{\bar{p}}$. At any time $t$, we denote the market’s belief before disclosure that the manager is uninformed by $p_t$.

We model the firm’s earnings as an AR(1) process (see Ohlson 1995; Gerakos and Kovrijnykh 2013). We assume that the process of earnings, consensus, and manager signal jointly satisfies

$$e_t = \rho e_{t-1} + u_t$$
$$c_t = e_t + n_t$$
$$s_t = e_t + v_t,$$

where each coordinate of $\varepsilon_t = (u_t, n_t, v_t)$ is iid and normally distributed. The assumption that $\varepsilon_t$ is iid is not essential to our analysis but simplifies the exposition without significantly compromising the model’s realism. At this point, it is useful to pause and elaborate on some of the more critical assumptions embedded in our framework.

1This representation implicitly assumes that empirical measures of consensus and the forecasts correspond to the actual signal received, not the posterior expectation. Empirically, we find that there are predictable deviations between actual analyst and manager forecasts and earnings, and this is also detected by Chen and Jiang (2006) in the case of individual analysts. However, it is also possible to estimate the model by parameterizing the process in terms of posterior expectations.
Manager preferences. The manager maximizes the present value of stock prices at the firm. For our purposes the crucial assumption is that a manager cares at least somewhat about short-term movements in the stock price, so that by withholding information strategically they may benefit from the short-term changes in market prices. Our assumption of preferences written in terms of the market price is instrumental to most disclosure studies (Hagerty and Fishman 1989; Acharya, Demarzo, and Kremer 2011; Guttmann, Kremer, and Skrzypacz 2014) and is also widely used in research involving signaling in capital markets, see, e.g., Miller and Rock (1985) and Brandenburger and Polak (1996) or Edmans, Heinle, and Huang (2016). Such preferences could in principle arise from some underlying possibility of takeover of the company by outsiders (Stein, 1989), from managerial myopia, or from the prospect of manager departure from the company with a positive probability (Zakolyukina, 2014). These preferences may also capture incentives arising from empirically realistic stock-based compensation. For example, Edmans, Goncalves-Pinto, Wang, and Xu (2014) show that CEOs strategically release news in months in which their equity vests to boost the stock price and stock liquidity. Furthermore, in our framework the manager does not care exclusively about the current stock price, as in static models, but also about future stock prices. This concern for future prices is natural because compensation contracts typically specify long-term incentives that are linked to future stock prices (Core and Larcker 2002).

Information endowment. Following Einhorn and Ziv (2008), we model the manager’s information endowment as a hidden Markov chain. This process represents more broadly the possibility that in some years managers do not observe a precise signal of future earnings. A key maintained assumption in this literature is that a manager cannot make a forecast when uninformed, that is, the manager must provide some evidence or justification for the forecast (Dye 1985; Shin 2003). In practice, for example, forecasts are accompanied by explanations during earnings conference calls. Furthermore, forecasts relate to observed earnings, which limits the ability of managers to issue arbitrary forecasts. Large deviations of earnings from forecasts can also trigger shareholder lawsuits, during which the manager may have to show the private information used to make the forecast (Dye 2013; Caskey 2014). Other models of communication may accommodate misreporting, but we have chosen not to include misreporting conditional upon disclosure in the model because empirically, we do not see (i) large differences between average forecasts and average realized earnings in contrast to models in which forecasts are manipulated (Einhorn and Ziv 2012; Heinle and Verrecchia 2015) nor (b) large differences in the informational content of favorable versus unfavorable forecasts in contrast to models in which information is partially unverifiable (Morgan and Stocken 2003; Marinovic 2013).

Public information. Empirical evidence suggests that public information, particularly bad news, triggers an unusually high number of voluntary disclosures. Acharya, Demarzo, and Kremer (2011) refer to this phenomenon as disclosure clustering. In a voluntary disclosure context, two main sources of public information interact with the firm’s voluntary disclosures: mandatory financial reports, such as earnings announcements, and information released by external parties, notably financial analysts. The former is partic-
ularly important because it allows the market to update perceptions regarding whether managers who withheld information in the past did it for strategic reasons. The latter source is also important because it sets market expectations prior to the voluntary disclosure choice.

Reputation concerns. Disclosure behavior may be affected by reputation concerns. For example, Beyer and Dye (2012) argue that managers may improve their reputation for being forthcoming by disclosing the firm’s prospects often. By doing so, managers can improve their ability to hide information in bad times by softening the market reaction to non-disclosure. On the other hand, Grubb (2011) shows that managers may refrain from disclosing positive information if doing so allows to generate a reputation for reticence that reduces the impact non-disclosing information in bad times. In our setting, when the information endowment is persistent, the manager experiences reputation concerns similar to the one in Grubb (2011). The manager seeks to build a reputation for being uninformed to inflate the market’s perception that the manager will be uninformed in the future. This incentive captures, in a reduced form, the notion that managers wish to avoid setting a precedent of high disclosure frequency.

Endogenous timing. We ignore the possibility that managers have discretion over the timing of their disclosures. Although managers can choose whether or not to disclose, they may not delay disclosure to a future period. By contrast, control over the timing of disclosure is implicit or explicit in two other multi-period disclosure models. In Shin (2003), managers can disclose the cumulative number of favorable events realized in past periods, but sanitization equilibria in a binomial tree for the news process imply that they never delay disclosing favorable news. In Guttman, Kremer, and Skrzypacz (2014), the information received by the manager is continuous, and some moderate news is strategically delayed in anticipation of receiving better news in the future. To mitigate concerns about the endogeneity of disclosure timing, we focus on news whose horizon is restricted by the release of actual earnings. Further, for the vast majority of our sample, forecasts are made at one point in time, i.e. the earnings announcement date.

Litigation risk. Ever since the work of Skinner (1997), the role of litigation risk as a determinant of a firm’s disclosure incentives has been hotly debated. Skinner (1997) conjectures that firms use disclosures to preempt litigation by advancing the release of bad news early, whereas others studies conjecture that voluntary disclosures trigger litigation, especially if the subsequent earnings realization is too disappointing relative to forecasts (Francis, Philbrick, and Schipper 1994). Modeling litigation risk in depth is far beyond the scope of our paper, but we hope that understanding the amount of strategic withholding in management forecasts may help future work relate it to lawsuits.

2.2 Equilibrium

Some notation is in order. Let $z_t = (c_{t-1}, c_t)$ be the public information available at the beginning of period $t$ and $z^t = \{z_0, \ldots, z_t\}$ the public history up to time $t$. We
consider Markov perfect equilibria (MPE). In MPE, the payoff relevant public information is given by \((p_t, z_t)\), and the payoff relevant information of the manager is \((\theta_t, z_t, s_t)\). From this point onwards, unless needed for clarity, we omit the time \(t\) subscript and refer to future periods using the \('t\) notation.

For any public state \((p, z)\) let \(D(p, z) \equiv \{ s \in \mathbb{R} | d(p, z, s) = 1 \}\) be the manager’s disclosure set when the manager disclosure strategy is \(d(p, z, \_)\) and \(D^c(p, z)\) its complement. Let \(P^D(z, s)\) and \(P^{ND}(p, z)\) be the market price conditional upon disclosure and non-disclosure, respectively. We require prices to be consistent with Bayes’ rule and the manager’s disclosure strategy:

\[
P^D(z, s) = \frac{\mathbb{E}(e'|z, s)}{1 - \beta \rho}, \quad (1)
\]

\[
P^{ND}(p, z) = \frac{1}{1 - \beta \rho} \frac{p \mathbb{E}(e'|z) + (1 - p) \mathbb{E}(e'|I_{D^c(p, z)}|z)}{p + (1 - p) \mathbb{E}(1_{D^c(p, z)}|z)}. \quad (2)
\]

This price function assumes that prices are given by the expected present value of the firm’s economic earnings, depending upon the AR(1) persistence parameter \(\rho\) and the manager discount factor \(\beta\). The market reassesses the probability that the manager was informed in the current period on the basis of earnings realization \(e'\). Conditional on non-disclosure and earnings realization \(e'\), the updated probability that the manager will be uninformed in the next period is given by

\[
p' = \varphi(p, z, e') \equiv \frac{p(1 - \lambda_1) + (1 - p) \lambda_0 \mathbb{E}(1_{D^c(p, z)}|e')}{p + (1 - p) \mathbb{E}(1_{D^c(p, z)}|e')} \quad (3)
\]

When the manager withholds their signal, they retain an informational advantage about the firm’s fundamentals and their expected information endowment. Specifically, investors do not know whether the manager strategically withheld unfavorable information or was uninformed. By contrast, if the manager discloses their signal, the market learns that the manager was informed and updates the probability that the manager will be uninformed in the future to the probability \(\lambda_0\).

We can now define the manager’s optimization problem, when informed, as

\[
V^D_1(p, z, s) = P^D(s, z) + \beta E \left[ (1 - \lambda_0) V_1(\lambda_0, z', s') + \lambda_0 V_0(\lambda_0, z') | z, s \right] \quad (4)
\]

\[
V^{ND}_1(p, z, s) = P^{ND}(p, z) + \beta E \left[ (1 - \lambda_0) V_1(p', z', s') + \lambda_0 V_0(p', z') | z, s \right] \quad (5)
\]

\[
V_1(p, z, s) = \max_{d \in \{0, 1\}} \left[ d V^D_1(p, z, s) + (1 - d) V^{ND}_1(p, z, s) \right] \quad (6)
\]

\[
V_0(p, z) = P^{ND}(p, z) + \beta E \left[ \lambda_1 V_1(p', z', s') + (1 - \lambda_1) V_0(p', z') | z \right], \quad (7)
\]

where \(V^{ND}_1(p, z, s)\) (resp., \(V^D_1(p, z, s)\)) is the value function for an informed manager conditional on withholding (resp., disclosing), \(V_1(p, z, s)\) is the informed manager’s value function prior to making a disclosure choice, and \(V_0(p, z)\) is the value function of an uninformed manager.

Consider next the market posterior expectation evaluated at alternative information sets. With a slight abuse in notation, let \(F(e'|I)\) and \(F(s|I)\) denote the cumulative
distributions of $e'$ and $s$ conditional on $I$, respectively. To compute the equilibrium, we need the following distributions: $F(e'|z)$, $F(e'|z,s)$, $F(s|z)$, and $F(s|e')$. For any random variable $x$, let $\tau_x \equiv 1/\sigma_x^2$ be the precision; then, by Bayes’ rule, the beliefs are given by

$$
e'|z \sim N\left(\frac{\tau_u \rho e + \tau_n c}{\tau_u + \tau_n}, \frac{1}{\tau_u + \tau_n}\right)$$

$$e'|z,s \sim N\left(\frac{\tau_u \rho e + \tau_n c + \tau_s s}{\tau_u + \tau_n + \tau_s}, \frac{1}{\tau_u + \tau_n + \tau_s}\right)$$

$$s|z \sim N\left(\frac{\tau_u \rho e + \tau_n c}{\tau_u + \tau_n + \tau_s}, \frac{1}{\tau_u + \tau_n + \tau_s}\right)$$

$$s|e' \sim N\left(e', \frac{1}{\tau_s}\right).$$

We can now formally define an equilibrium.

**Definition 1.** An MPE is a tuple $\langle P^D, P^{ND}, d, \varphi, V_0, V_1^D, V_1^{ND} \rangle$, such that

1. The market price is

$$P = \begin{cases} 
P^{ND}(p, z) & \text{if } d(p, z, s) = 0 \\
P^D(z, s) & \text{if } d(p, z, s) = 1, 
\end{cases}$$

where $P^D$ and $P^{ND}$ are given by (1) and (2).

2. The disclosure strategy $d(p, z, s) \in \{0, 1\}$ is

$$d(p, z, s) = \arg \max_{d \in \{0, 1\}} \left[ dV_1^D(p, z, s) + (1 - d)V_1^{ND}(p, z, s) \right],$$

if the manager is informed and is $d(p, z, s) = 0$ if the manager is uninformed.

3. The evolution of market beliefs is

$$p' = \begin{cases} 
\varphi(p, z, e') & \text{if } d(p, z, s) = 0 \\
\lambda_0 & \text{if } d(p, z, s) = 1, 
\end{cases}$$

where $\varphi(p, z, e')$ is given by (3).

4. The value function of the informed manager solves

$$V_1(p, z, s) = \max \left\{ V_1^D(z, s), V_1^{ND}(p, z, s) \right\},$$

where

$$V_1^D(z, s) = P^D(s, z) + \beta E\left[ (1 - \lambda_0)V_1(\lambda_0, z', s') + \lambda_0 V_0(\lambda_0, z') | z, s \right]$$

$$V_1^{ND}(p, z, s) = P^{ND}(p, z) + \beta E\left[ (1 - \lambda_0)V_1(p', z', s') + \lambda_0 V_0(p', z') | z, s \right].$$

5. The value function of the uninformed manager solves

$$V_0(p, z) = P^{ND}(p, z) + \beta E\left[ \lambda_1 V_1(p', z', s') + (1 - \lambda_1)V_0(p', z') | z \right].$$
2.3 Model Characterization and Numerical Intuition

In this section, we provide intuition for the main economic tradeoffs that drive the equilibrium. Consider the manager’s disclosure and withholding incentives. Withholding information carries two benefits from the manager’s standpoint. First, by hiding bad news the manager delays the decline in stock price because the market is uncertain about the true cause of a non-disclosure. Because the manager benefits from higher short-term stock prices, such a delay is attractive. Second, the manager further influences the market’s perception about their future information endowment. By pretending to be uninformed, the manager can increase the perceived probability that they will be uninformed in the future. This, in turn, mitigates the price penalty triggered by non-disclosure and increases the option value from continuing to withholding information. Withholding information thus entails a reputational benefit.

Naturally, when the information endowment is iid, namely, \( \lambda_0 = 1 - \lambda_1 \), the reputation benefit of withholding is absent. In this case, market beliefs are constant and independent of the manager’s disclosure choices. For this reason, the manager’s disclosure strategy collapses to that of a static or “myopic” model. We provide this result as a benchmark, which follows directly from Jung and Kwon (1988) in the case of normally distributed random variables.

Proposition 2. When the information endowment is iid, i.e., \( \lambda_0 = 1 - \lambda_1 \), there is a unique equilibrium where in each period the manager uses myopic threshold \( \tau \), defined as

\[
-\frac{\bar{p}}{1 - \bar{p}} \tau = \int_{-\infty}^{\tau} \Phi(x)dx,
\]

where \( \bar{p} \equiv \frac{\lambda_0}{\lambda_0 + \lambda_1} \) and \( \Phi(\cdot) \) is the c.d.f. of the standard normal. In each period, the manager discloses his signal \( s_t \) if i) \( \theta_t = 1 \) and ii) \( s_t \geq E[s_t|z_t] + \tau \sqrt{\text{Var}(s_t|z_t)} \).

Notice that, in this model, unravelling to a full disclosure equilibrium does not occur because the informed manager withholding bad news pools with uninformed managers withholding non-strategically. The threshold \( \tau \) is independent of all parameters of the model, except \( \bar{p} \). This means that, in the static case, the frequency of disclosure is independent of most firm characteristics, including the precision of the manager’s signal \( \tau_s \), the precision of consensus signal \( \tau_c \), and the volatility of firm fundamentals, \( \sigma_u \). Hence, these characteristics of the information environment must affect disclosure behavior via dynamic channels.

The comparative statics of the model cannot be easily recovered analytically, but Figure 2 reports the probability of withholding as a function of market beliefs for several levels of persistence in the manager’s information endowment from numerical solution of the model. The model with iid information endowment coincides with the static or myopic solution (dotted curve), and the other lines represent equilibria in which the persistence is set to higher levels. As the information endowment becomes more persistent, the reputational benefit of withholding increases, and, therefore, the manager becomes more likely to withhold for any given market belief. Furthermore, for all levels

\(^2\)We describe the numerical solution of the model in more detail in the appendix.
of persistence, Figure 2 reveals that managers are more likely to withhold information strategically when the market belief $p$ is high, since the market penalty for non-disclosure becomes less severe.

![Figure 2. Effect of information persistence ($r$) on disclosure choices](image)

Note: The figure plots the likelihood of strategic withholding, i.e. the probability of non-disclosure $d = 0$ given an informed manager with $\theta = 1$, conditional upon a pre-existing level of market belief $p$ that the manager is uninformed. The results were numerically computed from the stationary distribution of the model with various levels of persistence $r = 1 - \frac{\lambda_0 + \lambda_1}{2}$, fixing the amount of earnings risk, manager information, and consensus precision at the round values of $\sigma_u = \sigma_v = \sigma_n = 1$.

We next consider the structure of the manager’s payoffs after a disclosure, obtaining a simple formula linking manager value in the case of disclosure to the implied market price.

**Proposition 3.** In any equilibrium, $V_1^D(p, z, s) = \frac{P_D(z, s)}{1-\rho\beta}$.

The manager’s payoff conditional on disclosure is linear in both public information $z$ and the manager’s private signal $s$. On the surface, this property seems to ignore the option value of withholding information in future periods: the disclosing manager’s payoff is the same as if the manager had committed to full disclosure forever. However, the market is fully price-protected against future private information, so the price is calibrated such that the option value of future withholding is always zero in expectation. Upon disclosure, the manager’s and market’s information sets coincide so that there are no further channels for the manager to affect expected prices.
The manager’s payoff given non-disclosure also increases in the value of their signal \( s \) because a higher \( s \) has a positive expected reputation effect. Since higher values of \( s \) are correlated with higher realizations of earnings \( e \), the market is more likely to give the manager the benefit of the doubt given non-disclosure. However, the payoff given non-disclosure is non-linear in \( s \). The existence of a threshold equilibrium is therefore not guaranteed. Indeed, when the information endowment is persistent and the manager signal is very precise, there is no threshold equilibrium in our game. We show this result in a special case of the model with no public signal \( z \) and iid earnings.

**Proposition 4.** Assume (i) the information endowment is persistent, \( \lambda_0 < 1 - \lambda_1 \), (ii) there is no public signal \( z \) (\( \text{Var}(n_t) \to \infty \)), (iii) the manager is almost perfectly informed (\( \text{Var}(v_t) \to 0 \)), and (iv) the earnings process \( e_t \) is iid. Then, there is no equilibrium, such that for any current market belief \( p \), the manager adopts a threshold equilibrium, defined as disclosing if \( s > k_p \) and withholding if \( s < k_p \).

The classic threshold structure characterizing the equilibrium in the static game is not assured in our dynamic setting. The reasoning behind Proposition 4 follows the reasoning in Grubb (2011), who shows that equilibrium disclosure strategies are mixed in a dynamic model with reputation concerns. In our setting, we can understand why a threshold equilibrium can not exist, by assuming that the firm does use a threshold equilibrium and considering two informed managers, A and B, whose signals lie slightly below and slightly above the threshold, respectively. Manager A must prefer to withhold; hence, the net effect of withholding on the current price and on the reputation must be zero or positive. Now, suppose that manager B deviates to withhold information, as well. This will cause almost the same current price effect; however, the reputational effect is different. After earnings are revealed, the market will attribute the above-threshold earnings to an uninformed manager with probability one because this is the updated belief on the equilibrium path. Hence, manager B benefits more from withholding than manager A does.

The key to this argument is that reputations in our model are endogenous and depend on market expectations. The reputational effects are stronger near a disclosure threshold because this is where the market learns the most from realized earnings, and the same effects are also stronger for managers with more favorable information because the market makes more favorable reputational updates after positive earnings are reported. Fortunately, some amount of noise in realized earnings can preserve the existence of threshold equilibria. To address this potential issue, we solve the model without assuming threshold equilibrium, and computationally verify whether each type is choosing to disclose optimally. For levels of noise in earnings consistent with our empirical sample, we find that the optimal policy is a threshold equilibrium.

Below, we elaborate on the mechanisms at play in the dynamic model by considering how economic primitives affect the solution of the model. Managers’ disclosure choices are affected by several aspects of the information environment. First, disclosure choices depend on the extent to which the manager cares about the current price. A higher subjective discount rate or manager patience parameter \( \beta \) is equivalent to an increase in the manager’s reputation concern. Following our discussion above, this could be motivated as a reduction in takeover pressure or the likelihood of manager departure from the firm.
Market-Perceived Probability of Uninformed Manager ($p$)

**Figure 3. Effect of CEO patience ($\beta$) on disclosure choices**

Note: The figure plots the likelihood of strategic withholding, i.e. the probability of non-disclosure $d = 0$ given an informed manager with $\theta = 1$, conditional upon a pre-existing level of market belief $p$ that the manager is uninformed. The results in solid lines were numerically computed from the stationary distribution of the model with various levels of manager patience $\beta$ fixing the amount of earnings risk, manager information, and consensus precision at the round values of $\sigma_u = \sigma_v = \sigma_n = 1$ and setting the long-run probability of information and the persistence of information to $\bar{p} = 0.5$ and $r = 0.9$, respectively. The myopic model (dotted line) features disclosure policies equivalent to a model with an iid information endowment and independent of the level of manager patience $\beta$.

The effect of changes in $\bar{p}$ is intuitive: the higher the probability that the manager is informed, the more skeptical is the market about the firm value when the manager does not disclose, which, in turn, prompts more disclosure in the short term. Figure 3 plots the level of strategic withholding in the model as a function of market beliefs for several values of manager patience. As shown in Figure 3, a more patient manager tends to withhold information more often to affect market perceptions about $\theta$, thus foregoing a short-term price benefit to gain disclosure flexibility in the future. In the limit, an infinitely patient manager would wait for the realization of all uncertainties via public news and earnings realizations. This suggests that a model ignoring the importance of reputations will tend to attribute non-disclosures as indicative that the manager is uninformed, biasing downwards the probability of strategic withholding.

The distribution of the manager information endowment $\theta$ is also a key determinant of disclosure behavior. As noted above, it is convenient to characterize the distribution of $\theta$ with two parameters: the long-run probability of being informed $\bar{p} \equiv \frac{\lambda_0}{\lambda_0 + \lambda_1}$ and the persistence of information endowment $r \equiv 1 - \frac{\lambda_0 + \lambda_1}{2}$. The effect of changes in $\bar{p}$ is intuitive: the higher the probability that the manager is informed, the more skeptical is the market about the firm value when the manager does not disclose, which, in turn, prompts more
Figure 4. Effect of information persistence \((r)\) on beliefs \((p)\) and disclosure \((d)\).

Note: The top panel of the figure plots the mean and variance of market beliefs \(p\) that the manager is uninformed in the steady state distribution, and the bottom panel computes the average likelihood of manager disclosure in the model. Both panels vary the level of persistence of the manager’s information endowment \(r = 1 - \lambda_0 + \lambda_1/2\) along the horizontal axis. The results were numerically computed fixing the amount of earnings risk, manager information, and consensus precision at the round values of \(\sigma_u = \sigma_v = \sigma_n = 1\) and setting the long-run probability of information to \(\bar{p} = 0.5\). The manager patience parameter \(\beta\) is fixed at 0.95.

disclosure, as in the static case.

The effect of persistence \(r\) is more subtle. Recall that Figure 2 plotted the manager’s non-disclosure policy conditional upon a level of market belief \(p\) for various levels of persistence. However, persistence changes the underlying steady-state or stationary distribution of market beliefs \(p\) in the long run as well, and the realized level of disclosure on average in equilibrium depends upon both factors. We therefore plot in Figure 4, bottom panel, the steady-state disclosure probability from a numerical solution of the model. As noted in Figure 2, for a given market belief, greater persistence decreases the probability of disclosure by increasing the value of reputations. However, persistence also affects the dispersion of long-term beliefs about the friction, as shown in the top panel of Figure 4. Investors know more about the information endowment when it is more persistent, thus reducing the amount of equilibrium uncertainty about information endowment. In turn, with less uncertainty, the steady-state disclosure strategies tend to be closer to unravelling. In the limit case of a fully persistent information endowment, markets will know the information endowment almost perfectly in the long run, implying
that all informed managers, because they are known to be informed by the market, will disclose with probability one. Put differently, with sufficient persistence, reputations are not renewed and will dissipate in the long run (see also Cripps, Mailath, and Samuelson 2004). The result is non-monotonicity of disclosure as a function of persistence in the bottom panel of Figure 4.

![Figure 4. Effect of fundamental volatility ($\sigma_u$) on disclosure choices](image)

**Figure 5. Effect of fundamental volatility ($\sigma_u$) on disclosure choices**

*Note:* The figure plots the likelihood of strategic withholding, i.e. the probability of non-disclosure $d = 0$ given an informed manager with $\theta = 1$, conditional upon a pre-existing level of market belief $p$ that the manager is uninformed. The results in solid lines were numerically computed from the stationary distribution of the model with various levels of fundamental volatility $\sigma_u$ in earnings, fixing the amount of manager information and consensus precision at the round values of $\sigma_v = \sigma_n = 1$ and setting the long-run probability of information and the persistence of information to $\overline{p} = 0.5$ and $r = 0.95$, respectively. The myopic model (dotted line) features disclosure policies equivalent to a model with an iid information endowment.

Lastly, consider the effect of the variance in fundamentals $\sigma_u$. First, observe that if earnings were not observable, as in the static version of the model, the volatility of fundamentals would not affect the probability of disclosure: this variance would simply scale the manager’s payoffs without affecting the relative trade-offs. However, the presence of earnings can play a disciplining role in the manager’s disclosure behavior because it allows investors to refine their beliefs regarding whether the manager has concealed information in the past. Recall that the manager bears a current price decrease when concealing information, in anticipation of building a reputation. However, in environments with less noise in earnings, realized earnings reveal the private information known to the manager, and
thus the reputational benefit is weakened. Hence, as illustrated in Figure 5, a manager
withholds less for a given market belief when the variance of fundamentals is low.

3 Empirical analysis

3.1 Data

Our sample is from the I/B/E/S earnings announcement database for fiscal years ending
between January 1st, 2004 and December 31st, 2014. The details of the sample selec-
tion are reported in Table 1. We start the sample in 2004 because of significant changes
in US regulation in 2000 and 2002, which have altered both the incentives to disclose
information and the collection of forecasts. Since August 2000, Regulation Fair Disclo-
sure (RFD) has prohibited most private communications between managers and market
analysts. By shutting down this communication channel, RFD appears to have increased
the frequency of public managerial forecasts. Also, since July 2002, the Sarbanes-Oxley
Act (SOX) has dramatically increased internal controls and management responsibilities.
From a data-collection perspective, SOX also required conference calls to be in transcript
form, allowing for convenient identification of manager forecast disclosure.

We construct a sample of raw earnings per share (EPS). Earnings in I/B/E/S are
reported as pro-forma earnings calculated under the same accounting principles as an-
alysts’ and management forecasts. The initial sample includes 59,819 firm-years from
10,621 unique firms. We require non-missing announcement and lagged announcement
dates to create a window for management forecasts; this shrinks the sample to 53,993
firm-years from 9,420 unique firms.  

\footnote{We use raw EPS because this is the actual nominal variables being forecasted by managers and
analysts and, for the most part, is kept within a similar range across firms (Cheong and Thomas 2011).
EPS adjusted for stock splits are more problematic because they tend to be declining in magnitude over
time as firms split their shares. Price or assets are other possible scaling choices except that, in our
framework, they are endogenously related to the reported earnings process.}
<table>
<thead>
<tr>
<th>Step Description</th>
<th>Nb. of EA</th>
<th>Unique firms</th>
<th>Nb. of MF</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/B/E/S EA sample 2004-2014</td>
<td>58,819</td>
<td>10,621</td>
<td></td>
</tr>
<tr>
<td>Non-missing current or prior announcement date</td>
<td>53,993</td>
<td>9,420</td>
<td></td>
</tr>
<tr>
<td>I/B/E/S CIG sample 2004-2014</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched to I/B/E/S EA</td>
<td>53,993</td>
<td>9,420</td>
<td>52,273</td>
</tr>
<tr>
<td>After prior EA date but prior period end</td>
<td>53,993</td>
<td>9,420</td>
<td>46,329</td>
</tr>
<tr>
<td>Minimum 6 month before period end</td>
<td>53,993</td>
<td>9,420</td>
<td>23,826</td>
</tr>
<tr>
<td>Retain only earliest MF</td>
<td>53,993</td>
<td>9,420</td>
<td>10,950</td>
</tr>
<tr>
<td>Must have market expectation</td>
<td>51,563</td>
<td>8,890</td>
<td>10,922</td>
</tr>
<tr>
<td>Merged to CRSP</td>
<td>43,798</td>
<td>6,956</td>
<td>10,615</td>
</tr>
<tr>
<td>Merged to Compustat, non-missing assets</td>
<td>43,604</td>
<td>6,913</td>
<td>10,601</td>
</tr>
<tr>
<td>At least 10 EA</td>
<td>20,974</td>
<td>1,937</td>
<td>6,908</td>
</tr>
<tr>
<td>Drop firms with no MF</td>
<td>11,390</td>
<td>1,048</td>
<td>6,908</td>
</tr>
<tr>
<td>Trim 1% outliers</td>
<td>11,182</td>
<td>1,044</td>
<td>6,814</td>
</tr>
<tr>
<td>Require 3 lags of disclosure data</td>
<td>8,095</td>
<td>1,043</td>
<td>4,811</td>
</tr>
<tr>
<td><strong>Full sample</strong></td>
<td><strong>8,095</strong></td>
<td><strong>1,043</strong></td>
<td><strong>4,811</strong></td>
</tr>
</tbody>
</table>

**Note:** This table summarizes the sample selection criteria. Annual earnings announcements (EA) and management forecasts (MF) are obtained from I/B/E/S. Firms in our sample must be present in the CRSP and Compustat database using the I/B/E/S ticker, gvkey and permno matching tables from Wharton Research Data Services. Market expectation is calculated as the I/B/E/S analyst consensus in CIG (for observations with a MF), or as a researcher-created consensus from the I/B/E/S analyst forecast file (for observations without a MF); if any of these is not available, we use the inflation-corrected lagged EPS.
We obtain management forecasts from the I/B/E/S management forecast guidance (CIG) database. We merge them with the I/B/E/S earnings database by using I/B/E/S unique tickers and the forecast period end date, retaining only annual forecasts where the forecast period end date can be matched to the I/B/E/S earnings announcement sample. This selection yields a sample of 52,273 forecasts from 9,420 firms. We require a forecast to be made after the prior earnings announcement date but at least six months before the period end date, reducing the sample to 23,826 forecasts from 9,420 firms. We remove forecasts made after the fiscal year end because they are less likely to be consistent with a model of incomplete information endowment. The majority of our forecasts are made bundled with the prior earnings announcement, and between 10 and 11 months before a fiscal year end. For periods with multiple forecasts, we use the earliest forecast, which yields a sample of 10,950 forecasts from 9,420 unique firms. We calculate the raw forecast, as it was made, by multiplying the forecast in I/B/E/S, adjusted for the number of shares with the I/B/E/S adjustment factor. We recover the latter by using the ratio of raw earnings to the adjusted earnings in the I/B/E/S earnings database.\(^4\)

For each firm-year with or without a forecast, we require a measure of market expectation about realized earnings. For any firm-year with a forecast, we use the I/B/E/S CIG analyst consensus; this number is provided adjusted for stock splits by I/B/E/S, and we unadjust it by multiplying by the adjustment factor. This consensus measure reflects the consensus before a management forecast is made. For firm-years without a forecast, we calculate a consensus by using the I/B/E/S analyst file, which reports all annual forecasts made by financial analysts. The consensus is defined as the average of all analyst forecasts for the current fiscal year earnings made during the window between one and two prior earnings announcements. This implies that the consensus is always constructed from analyst forecasts made prior to the management forecast. When this information was unavailable, that is, for firms with few analysts or analysts who rarely update their forecasts, we used the EPS at the prior earnings announcement as the market expectation, following Gerakos and Gramacy (2013). We remove observations for which we are unable to form a market expectation.

Dropping all firm-years for which no market expectation could be constructed, the sample has 51,563 firm-years and 10,922 management forecasts from 8,890 firms. We obtain the price and number of outstanding shares from CRSP and the accounting fundamentals from Compustat, merge by using the WRDS link between the identifiers I/B/E/S ticker, Compustat gvkey, and CRSP permno, and then perform an additional merge by using the fiscal year end and CUSIP. After the merge, the sample shrinks to 43,604 firm-years and 10,615 management forecasts from 6,913 firms. To ensure a complete time-series for each firm, we require at least 10 earnings announcement, which may include firms with a complete time-series of 11 firm-years. The final sample includes 8,095 firm-years and 4,811 forecasts, from 1,043 firms.

\(^4\)For a few cases in which this information was missing (for example, if the earnings are zero), we used the last available adjustment factor or, if unavailable as well, the earliest adjustment factor in the following period.
Table 2. Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>1%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>99%</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forecast characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forecast frequency</td>
<td>59%</td>
<td>49%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Management forecast</td>
<td>2.49</td>
<td>1.74</td>
<td>-2.75</td>
<td>-0.26</td>
<td>1.31</td>
<td>2.19</td>
<td>3.28</td>
<td>8.00</td>
<td>18</td>
</tr>
<tr>
<td>Forecast surprise</td>
<td>-0.07</td>
<td>0.48</td>
<td>-7.13</td>
<td>-1.41</td>
<td>-0.19</td>
<td>-0.03</td>
<td>0.07</td>
<td>1.62</td>
<td>4.50</td>
</tr>
<tr>
<td>Forecast error</td>
<td>0.04</td>
<td>0.58</td>
<td>-2.11</td>
<td>-1.21</td>
<td>-0.19</td>
<td>-0.04</td>
<td>0.14</td>
<td>2.64</td>
<td>4.15</td>
</tr>
<tr>
<td>Realized I/B/E/S earnings</td>
<td>1.99</td>
<td>1.96</td>
<td>-9.16</td>
<td>-2.12</td>
<td>0.75</td>
<td>1.70</td>
<td>2.89</td>
<td>8.25</td>
<td>16.99</td>
</tr>
<tr>
<td><strong>Firm characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of years</td>
<td>10.88</td>
<td>0.32</td>
<td>10</td>
<td>10</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Total assets</td>
<td>17,600</td>
<td>98,628</td>
<td>19</td>
<td>62</td>
<td>791</td>
<td>2,564</td>
<td>8,430</td>
<td>237,512</td>
<td>2,264,909</td>
</tr>
<tr>
<td>Market capitalization</td>
<td>8,660</td>
<td>23,572</td>
<td>9</td>
<td>58</td>
<td>680</td>
<td>2,019</td>
<td>6,396</td>
<td>135,364</td>
<td>378,823</td>
</tr>
<tr>
<td>Book to market ratio</td>
<td>.61</td>
<td>.78</td>
<td>-7.87</td>
<td>-0.19</td>
<td>0.29</td>
<td>0.48</td>
<td>0.75</td>
<td>3.30</td>
<td>23.06</td>
</tr>
</tbody>
</table>

**Note:** This table reports descriptive statistics. Forecast frequency is computed as the frequency of a management forecast over all firm-years. Management forecast (MF) is the unadjusted annual management forecast. Realized I/B/E/S earnings are the pro-forma earnings reported by I/B/E/S. Forecast surprise is the difference between the MF and the market expectation (from I/B/E/S or estimated as lagged EPS when a consensus is unavailable). Forecast error is the difference between MF and the realized I/B/E/S earnings. Firm characteristics are obtained from Compustat and measured at the lagged earnings announcement date. Market capitalization is obtained from CRSP and measured as the closing price (variable prc) multiplied by the number of shares outstanding (variable shrout) one day before the lagged earnings announcement.
Table 3. Outside Calibration of Some Earnings and Forecast Parameters

<table>
<thead>
<tr>
<th>Parameter, Role</th>
<th>Value</th>
<th>Targeted Moment</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho$, Earnings Persistence</td>
<td>0.85</td>
<td>$\text{Corr}(e_t, e_{t-1})$</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>$\sigma_u$, Earnings Volatility</td>
<td>0.45</td>
<td>$\text{St Dev}(\text{IHS}(e_t - \mathbb{E}e_t))$</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td>$\sigma_n$, Analyst Precision</td>
<td>0.68</td>
<td>$\text{St Dev}(\text{IHS}(c_t - e_t))$</td>
<td>0.59</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Note: The first two columns report the name, role, and value of each of the three parameters that are calibrated externally through a moment-matching exercise. The final three columns report the data and model values of the three targeted moments. “Corr” refers to correlation, “St Dev” refers to standard deviation, and “IHS” refers to the inverse hyperbolic sine transformation $\text{IHS}(x) = \log(x + \sqrt{1 + x^2})$. The moments are computed from I/B/E/S data on manager forecasts and realized fiscal year earnings spanning 2004–2014 for a sample of 1,043 US public firms in an unbalanced panel with 8,095 firm-year observations. In the model, moments are computed from a simulation of earnings $e_t$ and consensus $c_t$ processes for 10,000 years, discarding the first 500 years of data. The minimization of the distance between model and data moments was performed numerically via particle swarm optimization.

Table 2 reports several descriptive statistics. The overall disclosure frequency in the sample is about 60%. An average management forecast is about $2.49, and about half of the forecasts lie within $1.31 and $3.28 per share. Management forecasts tend to be greater than realized earnings, which are, on average, $1.99 per share. This appears to be consistent with some self-selection in forecasting behavior. When correcting for the market expectation, we find, however, that forecast surprises are not positive at about −7 cents. Forecast errors are small, at about 4 cents per share, on average. A typical firm in our sample has a full time series of 10 earnings announcements. The average total assets are about $18 billion, and the average market capitalization is $8.7 billion. These distributions, however, are highly right-skewed. The median firm has assets equal to $2.5 billion and $2.0 billion in market cap. The median book-to-market is 0.48, although the average of 0.61 is much greater primarily because of a few outliers.

3.2 Estimation

We fix the values of the parameters of the quantitative dynamic model in two main steps. First, we fix four of the parameters ($\beta$, $\rho$, $\sigma_u$, $\sigma_n$) externally, drawing on both comparable quantitative exercises from the literature on dynamic corporate finance as well as a moment-matching exercise for the parameters of some purely exogenous series. Second, conditional upon these parameters, we estimate each of the three remaining disclosure-related parameters ($\sigma_v$, $\lambda_0$, $\lambda_1$) through a straightforward application of GMM.

3.2.1 Outside Estimation of Earnings and Consensus Parameters

We assume a model period of one year, corresponding to the frequency of our I/B/E/S data. We set the value of the manager subjective discount rate to $\beta = \frac{1}{101}$, approximately in the middle of a range of annual discount factors commonly used in dynamic corporate
### Table 4. Targeted Moments for the GMM Estimation

<table>
<thead>
<tr>
<th>Moment</th>
<th>Data Value (Standard Error)</th>
<th>Model Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P(d_t = 1))</td>
<td>0.59 (0.0117)</td>
<td>0.63</td>
</tr>
<tr>
<td>(P(d_t = 1</td>
<td>d_{t-1} = 1))</td>
<td>0.88 (0.0054)</td>
</tr>
<tr>
<td>(P(d_t = 1</td>
<td>d_{t-2} = 1))</td>
<td>0.83 (0.0072)</td>
</tr>
<tr>
<td>(P(d_t = 1</td>
<td>d_{t-3} = 1))</td>
<td>0.78 (0.0088)</td>
</tr>
<tr>
<td>St Dev(IHS((s_t - e_t))</td>
<td>(d_t = 1))</td>
<td>0.45 (0.0122)</td>
</tr>
</tbody>
</table>

**Note:** The table reports the data values of moments computed from I/B/E/S data on manager forecasts \(s_t\) conditional upon disclosure \(d_t\) and realized fiscal year earnings \(e_t\) spanning 2004-2014 for a sample of 1,043 US public firms with 8,095 observations. \(d_t\) refers to a disclosure event in time \(t\), “St Dev” refers to standard deviation, and “IHS” refers to the inverse hyperbolic sine transformation \(IHS(x) = \log(\sqrt{1 + x^2})\). Standard errors are based on a block bootstrap procedure, resampling at the firm level. The third column of the table reports the values of the targeted moments in the estimated model.

The values \(\rho\), \(\sigma_u\), and \(\sigma_n\) govern the persistence and volatility of the fundamental earnings process, as well as the signal precision for analyst forecasts. The realized earnings process \(e_t\) and consensus forecasts \(c_t\) are directly observable in our data for all years. Both series are exogenous to the model disclosure choice, so to economize on the number of computationally costly estimated parameters, we fix the values of these parameters by matching three data moments directly.

The model assumes a homogeneous underlying driving process with \(e_t = \rho e_{t-1} + u_t\) and \(c_t = e_t + n_t\), where \(u_t \sim N(0, \sigma_u^2)\) and \(n_t \sim N(0, \sigma_n^2)\). Before taking this to the data directly, it is useful to note that the reported values within our dataset for earnings per share may vary across firms in levels and scale, as the share structure and size of firms vary in the cross section. To compute transformations that are approximately unit free, we target the autocorrelation of earnings and the dispersion of the inverse hyperbolic sine (IHS) of firm-demeaned earnings and analyst forecast errors. We calculate the corresponding value of moments within the model on the basis of the simulation of the processes for \(e_t\) and \(c_t\) over thousands of years.

Table 3 reports the values of the three calibrated parameters and the targeted moments in the model and the data. The model reproduces these targeted moments exactly, and the resulting parameter values reveal substantial persistence in fundamental earnings, as well as a large amount of noise in the analyst signal relative to underlying earnings. Although the mapping between moments and parameters here is joint and not one-to-one, the autocorrelation of earnings is informative for the value of persistence \(\rho\), and the dispersion of earnings and analyst forecast errors help pin down the values of \(\sigma_u\) and \(\sigma_n\), respectively.

---

5 See, for comparison, the dynamic firm-level investment model calibrations studied in Hennessy and Whited (2007) or in Cooper and Ejarque (2003).

6 The inverse hyperbolic sine \(IHS(x)\) is a convenient function that is approximately equal to \(\log(2x)\) for large values of \(x\) and hence is approximately unit free. The \(IHS\) function is also defined for both positive and negative values, which is convenient given the presence of losses and negative analyst forecast errors in the observed data. See MacKinnon and Magee (1990) for further information on this transformation.
3.2.2 Internal Structural Estimation of Disclosure Parameters

Armed with values for each of the other parameters in the model, we now turn to the estimation of $\sigma_v$, $\lambda_0$, and $\lambda_1$. These three parameters relate directly to the unobserved series of manager signals and information endowments in the model, and we cannot observe either of these series directly in the dataset. Instead, we turn to a GMM procedure. We minimize the sum of squared deviations between the model and data values of a selected set of moments relating to the disclosure process.

To ensure identification, moment-based structural estimation strategies rely crucially on the selection of an appropriate set of targeted moments that are informative for the underlying parameters of interest. Within our GMM estimation exercise, just as in the case of our external calibration, the mapping between parameters and moments is joint and not one-to-one. However, in the model, the disclosure rate and dynamics rely directly on parameters $\lambda_0$ and $\lambda_1$ of the manager information endowment. This dependence reflects a direct effect through the information endowment itself, as well as an indirect effect through the dynamics of the market belief $p$ surrounding the manager’s information state at any point in time. To capture this relationship, we target the unconditional probability of disclosure, as well as the probability of disclosure given prior disclosure in each of the past three years. Note that conditional upon disclosure, the dispersion of manager forecast errors depends directly on the precision of manager signal $\sigma_v$. Following the same strategy implemented for the analyst forecast errors above, we target the standard deviation of the transformed manager forecast errors in the data. Table 4 reports the values and standard errors of the five targeted moments from our sample of I/B/E/S data.

With the targeted moments from the data in Table 4 and given any candidate values for parameters $\sigma_v$, $\lambda_0$, and $\lambda_1$, we can compute comparable model moments directly from the ergodic or stationary distribution of the model after solving the model numerically. More information on the solution technique we use for the model is available in the appendix. We numerically minimize the GMM objective function, the sum of squared deviations between data and model moments, to obtain point estimates. The standard errors of the estimated parameters follow standard GMM formulas and rely upon a bootstrap procedure to calculate the empirical moment covariance matrix. Table 5 reports the parameter estimates. We estimate substantial persistence in manager information endowments with only around 4% probability of future information loss given a manager signal today ($\lambda_0$) and less than 20% chance of becoming informed for a currently uninformed manager ($\lambda_1$). We reject the iid hypothesis of static information endowments $\lambda_0 = 1 - \lambda_1$ at the 1% significance level. Indeed, our point estimate of persistence $r$ is .88. The high degree of persistence confirms the importance of forward-looking considerations.

7In particular, we minimize the GMM objective by using particle swarm optimization, a numerical global stochastic optimization routine. Given point estimates, we compute the covariance matrix of the targeted moments from the data $\Omega$ via a block bootstrap procedure, resampling at the firm level and accounting for within-firm serial correlation. We then compute an approximate value of the Jacobian $M$ of model moments with respect to the estimated parameters by using forward numerical differentiation from the point estimates and averaging over step sizes of 0.25%, 0.5%, and 1%. With these objects in hand, the asymptotic distribution of the estimates $\hat{\theta}$ of the underlying parameters $\theta$ is given by $\sqrt{N}(\hat{\theta} - \theta) \to N(0, \Sigma)$, where $\Sigma = (M' M)^{-1} M' \Omega M (M' M)^{-1}$ and $N$ represents the number of firms.
Table 5. GMM Parameter Estimates

<table>
<thead>
<tr>
<th>Parameter, Role</th>
<th>Estimate (Standard Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_0, \mathbb{P}(\theta_t = 0</td>
<td>\theta_{t-1} = 1)$</td>
</tr>
<tr>
<td>$\lambda_1, \mathbb{P}(\theta_t = 1</td>
<td>\theta_{t-1} = 0)$</td>
</tr>
<tr>
<td>$\sigma_v$, St Dev Manager Signal</td>
<td>0.45 (0.0178)</td>
</tr>
</tbody>
</table>

Note: Parameters estimated via GMM, targeting the five moments described in the text and implemented with a diagonal weighting matrix and numerical minimization. The standard errors are based on an empirical moment covariance matrix computed from a block bootstrap procedure, resampling at the firm level, together with a moment Jacobian computed from numerical forward differentiation averaging over step sizes of 0.25%, 0.5%, and 1%. “St Dev” refers to standard deviation.

we emphasized above. Also, the manager signal dispersion $\sigma_v \approx 0.45$ implies more precise information for managers than analysts, intuitive in this context given their location within the firm.

The final column of Table 4 reveals that the estimated model reproduces the targeted moments well. We cannot expect an exact match between data and model moments given our nonlinear model and the overidentified nature of the estimation exercise with three parameters and five targeted moments. However, the estimated model closely reproduces the unconditional disclosure probability of around 60%, the high persistence of disclosure observed in the data, and the dispersion of manager forecast errors.

3.3 Strategic Withholding and the Dynamics of Disclosure

Our estimated model serves as a quantitative laboratory within which we can conduct experiments to examine the information loss from strategic withholding. But first we subject the model to a stringent test, asking whether our structure matches the sign, magnitude, and dynamics of earnings and analyst forecasts observed around disclosure events in the data. In each case, our baseline model matches the entirely untargeted dynamics in the data, while we also show that a model without strategic withholding by managers fails along each of these dimensions.

We first trace out the dynamics of profits and consensus forecasts in the data around disclosure dates. For each outcome variable of interest $x_{j,t}$ for firm $j$ in year $t$, we estimate the following equation

$$x_{j,t} = f_j + \beta^x_s d_{j,t+s} + \varepsilon_{j,t}$$

(9)

for a range of horizons $s = -3, -2, -1, 0, 1, 2, 3$. The term $f_j$ represents a full set of firm effects, and the variable $d_{j,t+s}$ is an indicator variable equal to 1 given disclosure of management forecasts at firm $j$ in year $t+s$ and 0 otherwise. The coefficients of interest $\beta^x_s$ reflect the within-firm average deviation in the outcome $x$ observed at a distance of $s$ years from an observed disclosure of management forecasts, controlling for arbitrary permanent heterogeneity across firms. To avoid conflating disclosure dynamics with compositional changes, we estimate each regression on a panel which is balanced across horizons $s$, resulting in a dataset of around 5,000 firm-fiscal years.
Figure 6. Dynamics of Analyst Forecasts and Earnings around Disclosure

Note: The top left panel of the figure above reports the average percentage difference in analyst forecasts in year \( t + s \) from their within-firm mean given disclosure in year \( t \). The figure reports empirical OLS estimates of \( \beta_{\text{analyst}}^s \) from Equation (9), where \( x_{j,t} \) is 100 times the IHS transformation of consensus analyst forecasts for firm \( j \) in year \( t \). 95% pointwise confidence intervals based on standard errors clustered by firm are provided in the shaded band. The top right panel reports the same outcome for realized earnings. The sample of 4,996 firm-years is constructed from the baseline sample by selecting all firm-years for which at least three years of past and future disclosure behavior is observed.

Figure 6 plots the resulting estimated paths of consensus forecasts and earnings around disclosure. The figure reveals substantial selection into disclosure in the data: both analyst forecasts (in the left panel) and reported earnings (in the right panel) are around 20% higher than average at horizon 0, i.e. in those years when managers choose to disclose forecasts. Both earnings and forecasts increase persistently around disclosure dates, and earnings increase before analyst forecasts. Clearly, manager disclosure occurs during very particular periods.

To check our model’s predictions against the empirical evidence for dynamic selection into disclosure in Figure 6 we simulate a panel of firms within our baseline, estimated model to produce a dataset comparable to our empirical sample. We then re-estimate the regressions above on this simulated data. Figure 7 jointly plots the baseline simulation and data paths around disclosure.

Three key results stand out from Figure 7. First, the baseline model endogenously reproduces the basic qualitative pattern of selection into disclosure. Managers choose to disclose forecasts only in periods with above average earnings. At no point in our estimation process did we target the sign of the average difference in earnings conditional upon disclosure, but of course such a pattern naturally arises given managers’ incentives to disclose forecasts which increase, rather than decrease, the market’s perception of earnings.

Second, the baseline model reasonably captures the quantitative patterns of earnings and consensus forecasts around disclosure. Given sampling uncertainty, the path of ana-
Figure 7. Dynamics in the Baseline Model

Note: The top left panel of the figure above reports the average percentage difference in analyst forecasts in year $t + s$ from their within-firm mean given disclosure in year $t$. The figure reports OLS estimates of $\beta_{\text{analyst}}$ from Equation (9), where $x_{j,t}$ is 100 times the IHS transformation of consensus analyst forecasts for firm $j$ in year $t$. The solid line without markers is estimated from the data, while the line with circles is estimated using a simulated panel of firms from the baseline model. 95% pointwise confidence intervals based on standard errors clustered by firm are provided in the shaded band around the data estimates, while the 2.5%-ile and 97.5%-ile of the estimate from 400 independent simulations of size similar to the empirical panel are shaded around the model estimates. The top right panel reports the same outcome for realized earnings. The sample of 4,996 firm-years is constructed from the baseline sample by selecting all firm-years for which 3 at least three years of past and future disclosure behavior is observed.

Analyst forecasts in the model is indistinguishable from the data at each horizon considered here. Earnings rise more sharply conditional upon disclosure in the model than the data, but the patterns do not differ tremendously. In particular, the lower bound of model predictions yields earnings around 31% higher than average in the period of disclosure, while the upper bound in the data reveals around 25% higher earnings in the disclosure period. The reasonable overall quantitative fit seen in Figure 7 is reassuring, because our estimation did not at any point target the magnitude or the dynamic patterns of earnings and consensus forecasts around disclosure at any horizon.

Third, the baseline model endogenously reproduces the relative timing of earnings and analyst forecasts around disclosure. Figure 7 reveals that both in the data and in the model, the increase in analyst forecasts lags the increase in earnings around disclosure. Within the model, such timing reflects judicious revelation of private information by the manager during periods in which the manager perceives the firm’s prospects to be better than the market. Once again, our estimation at no point targeted any pattern in the relative timing of earnings and analyst forecast changes.

Figure 7 provides some evidence in support of our model’s performance in replicating the untargeted dynamics of selection into disclosure. However, our analysis centers on the key endogenous mechanism of strategic withholding by informed managers. One might wonder whether the simulated dynamics reported in Figure 7 reflect endogenous
Figure 8. Dynamics in the No Withholding Model

Note: The top left panel of the figure above reports the average percentage difference in analyst forecasts in year $t+s$ from their within-firm mean given disclosure in year $t$. The figure reports OLS estimates of $\beta_{\text{analyst}}$ from Equation (9), where $x_{j,t}$ is 100 times the IHS transformation of consensus analyst forecasts for firm $j$ in year $t$. The solid line without markers is estimated from the data, while the line with circles is estimated using a simulated panel of firms from the model with no strategic withholding. 95% pointwise confidence intervals based on standard errors clustered by firm are provided in the shaded band around the data estimates, while the 2.5%-ile and 97.5%-ile of the estimate from 400 independent simulations of size similar to the empirical panel are shaded around the model estimates. The top right panel reports the same outcome for realized earnings. The sample of 4,996 firm-years is constructed from the baseline sample by selecting all firm-years for which 3 at least three years of past and future disclosure behavior is observed.

strategic non-disclosure or instead simply depend upon some other exogenous feature of our model such as the manager’s persistent information endowment or our assumed earnings process. To isolate the contribution of concealment on the part of managers, we provide Figure 8 as a point of comparison, plotting the path of consensus forecasts and earnings estimated using an otherwise identically parameterized model with no strategic withholding allowed.8 Neither analyst forecasts nor realized earnings display evidence of selection with respect to disclosure. The flat lines in Figure 8 arise because the manager’s information endowment - fully governing disclosure in the case with no withholding - is independent of the earnings process.

To summarize, our baseline estimated model of strategic withholding on the part of managers matches the sign, magnitude, and relative timing of both analyst forecasts and earnings around manager forecast disclosure dates. We targeted none of these patterns in our estimation, although they provide some re-assurance that the framework provides a useful laboratory for examining the consequences of withholding.

8To generate simulated data in the case with no strategic withholding, we simply include an extremely large fixed cost to non-disclosure in manager’s payoffs, trivially leading to an equilibrium in which managers always disclose their signal when informed. Market beliefs, and all exogenous processes, are identical to the baseline model.
3.4 Strategic Withholding and Information Loss

In the last two decades, policy makers in the US encouraged firms to disclose forward-looking information. Indeed, in 1995, US regulators enacted the *Private Securities Litigation Reform Act* which includes a *safe harbor* provision that protects managers from litigation arising from unattained projections of forward-looking information. Following a similar logic, as noted above in 2002, US regulators enacted the RFD regulation to prohibit managers from selectively disclosing information to some market participants while excluding others. Arguably, these regulations partially explain the rapid expansion of management forecasts observed in the last two decades. Regulators’ preference for more disclosure emphasizes the importance of quantifying the magnitude of firms’ strategic withholding of information.

### Table 6. Strategic Withholding in Estimated and Counterfactual Cases

<table>
<thead>
<tr>
<th>Name</th>
<th>Data</th>
<th>Baseline</th>
<th>No Withholding</th>
<th>iid Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P(d_t = 1)$</td>
<td>0.59</td>
<td>0.63</td>
<td>0.85</td>
<td>0.60</td>
</tr>
<tr>
<td>$P(d_t = 1</td>
<td>d_{t-1} = 1)$</td>
<td>0.88</td>
<td>0.81</td>
<td>0.96</td>
</tr>
<tr>
<td>$P(d_t = 1</td>
<td>d_{t-2} = 1)$</td>
<td>0.83</td>
<td>0.75</td>
<td>0.94</td>
</tr>
<tr>
<td>$P(d_t = 1</td>
<td>d_{t-3} = 1)$</td>
<td>0.78</td>
<td>0.72</td>
<td>0.92</td>
</tr>
<tr>
<td>$St Dev(IHS(s_t - e_t)</td>
<td>d_t = 1)$</td>
<td>0.45</td>
<td>0.47</td>
<td>0.52</td>
</tr>
<tr>
<td>$P(d_t = 0</td>
<td>\theta_t = 1)$</td>
<td>0.26</td>
<td>0.00</td>
<td>0.29</td>
</tr>
<tr>
<td>$P(\theta_t = 1)$</td>
<td>0.85</td>
<td>0.85</td>
<td>0.85</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The table above reports data and model moments. The data moments in the second column, computed only when observable, are drawn from I/B/E/S data on manager forecasts $s_t$ conditional upon disclosure and realized fiscal year earnings $e_t$ spanning 2004-2014 for a sample of 1,043 US public firms with 8,095 firm-fiscal year observations. The model moments in the remaining columns are numerically computed directly from the theoretical stationary distribution. The third column reports moments from the estimated baseline model. The fourth column reports moments from an otherwise identical counterfactual model with no withholding allowed. The fifth column reports moments from an otherwise identical counterfactual model with no persistence in information endowments.

The estimates in Table 6 show that on average, managers are informed 85% of the time, but conditional on being informed, they withhold information strategically 26% of the time. The unconditional probability of withholding is roughly 85%*26%=22%. The amount of withholding implied by an alternative model with iid information endowment, but otherwise identical parameterization, is 29%. The greater probability of withholding implied by the iid model speaks to the importance of the dispersion effect discussed in Section 2.3. The empirically high level of persistence ($r = .88$) explains the relatively low frequency of strategic withholding.

We can also use our estimates to assess the information loss associated with the manager’s strategic withholding. We compute the RMSE of market expectations and contrast it with the accuracy arising in an otherwise identical model where managers exogenously do not conceal information strategically. We simulate a panel of 1,000 firms and 5,000 years. The results from the simulation are reported in Table 7. If managers did not strategically withhold information, the RMSE of market predictions would be...
Table 7. Strategic Withholding and Information Loss

| Model                | RMSE($E(e_t | I_t^{Market})$) | St. Dev Earnings $e_t$ |
|----------------------|-------------------------------|------------------------|
| Baseline Model       | 0.357                         | 0.894                  |
| No Withholding Model | 0.335                         | 0.894                  |

Note: In the first row, the Baseline Model results are obtained by simulating a panel of 1,000 firms for 5,000 periods on the basis of the estimated annual parameters. In the second row, the No Withholding results are obtained from simulating a similar dataset within a model environment in which managers exogenously disclose their signal whenever informed but face an otherwise identical set of model parameters. In the second column, the RMSE values are computed by comparing realized firm earnings to market perceptions given realized disclosure policies in each firm year, and the third column reports the standard deviation of realized earnings for scale comparison.

around 6% lower than in the estimated baseline (note that 0.335/0.357 - 1 ≈ -6%). Since market prices in this framework are a simple constant multiple of predicted earnings, it immediately follows that market prices would be around 6% more accurate without strategically withheld information on the part of managers.

We can perform a back of the envelope calculation to convert to the raw magnitudes of pricing error in dollar terms. In the baseline estimated model with concealment, the RMSE or the standard size of the prediction error in earnings by the market is equal to $\frac{0.357}{0.894} \approx 40\%$ of the standard deviation of earnings. It follows in our model that the standard deviation of firm valuation inaccuracy is also 40% of the standard deviation of market value. In our empirical sample, the average coefficient of variation of firm value within a firm - the ratio of the standard deviation of a firm’s valuation to its mean level - is equal to 45%. Therefore, the ratio of the standard deviation of market valuation inaccuracy to mean firm value in the equilibrium with manager concealment is $40\% \times 45\% \approx 18\%$. Because Table 2 reports that the median (mean) firm in our sample of large US public firms has a market capitalization of $2.0$ billion ($8.7$ billion), our results suggest that in a typical year firm valuations in the equilibrium with concealment may contain errors in the range of $(18\%)(2000) \approx 360$ million to $(18\%)(8700) \approx 1566$ million. Similar calculations in the case with no withholding suggest that without concealment firm valuation errors would have a standard deviation of $(16.7\%)(2000) \approx 334$ million to $(16.7\%)(8700) \approx 1453$ million.

Therefore, our estimates suggest that because managers choose to strategically conceal information from the market, firm valuations may be less accurate by anywhere from 360 - 334 = $26$ million to 1566-1453 = $113$ million in a typical year. Given magnitudes of this scale, strategic withholding of information by managers clearly leads to a substantial information loss. We conclude that the high interest in managers’ strategic disclosure incentives from both academics and policymakers appears to be justified.

Our empirical and theoretical analysis focuses on strategic concealment of earnings or firm fundamentals, rather than firm stock returns. However, in Section A.2 in the appendix we also outline a simple method for constructing a simulated panel of realized stock returns. Qualitatively, we find that the presence of strategic concealment leads to higher volatility in non-disclosure periods. A full quantitative investigation of the asset pricing implications of our model would require a substantially richer environment and lies
outside the scope of the paper. However, our result suggests that strategic withholding by managers can contribute to the well known empirical finding of more volatility in stock returns during downturns, i.e. in times with bad news.⁹

4 Conclusion

This paper develops a plausible model of voluntary disclosure in which managers have forward-looking motives and their disclosure choices interact with both analysts' consensus forecasts and mandatory earnings announcements. Building on Dye (1985), we assume that markets are uncertain about managers' information endowment. We show that small levels of persistence in the information endowment can fuel reputation concerns, capable of generating significant disclosure stickiness. This result accords with the notion originally advanced by the survey of Graham, Harvey, and Rajgopal (2005) that managers' reluctance to disclose is driven by the fear of setting a disclosure precedent that might expose the stock price to negative market reactions during non-disclosure periods.

The persistence of information endowments has a subtle effect on disclosure policy. On one hand, persistence boosts managers' reputation concerns: by manipulating disclosure choices managers may attempt to influence market perceptions regarding their information endowment. By withholding information and thus pretending to be uninformed, a manager can increase the option value of withholding information in the future. The presence of this reputation effect makes managers more reluctant to disclose information. Persistence also has another effect, running in the opposite direction. Higher persistence leads, in the long run, to greater dispersion in the distribution of market beliefs about the manager's information endowment. On average, this belief dispersion causes a stronger unraveling pressure that induces extra disclosure. In some cases, the belief dispersion effect dominates the reputation effect. Overall, high persistence is consistent with very expansive disclosure policies.

We estimate our model using data on the disclosure patterns of thousands of US public firms over the period 2004-2014. The estimated model qualitatively and quantitatively reproduces the untargeted dynamic patterns of earnings and analyst forecasts around disclosure events in the data. Our structural estimates suggest that conditional on being informed, managers withhold information 26% of the time. This concealment of information causes a substantial information loss in market prices, amounting to a 6% higher RMSE of market earnings inferences relative to a setting in which managers do not withhold information strategically. Based on these magnitudes, and the size of typical firms in our sample, strategic withholding of information may cause many anywhere from around $20 million to $100 million of lost precision in market valuations.

We view the size of the information loss we estimate due to manager concealment of information to be large. Overall, our results serve as a justification for continued high interest in manager disclosure policies by both academic researchers and policymakers.

⁹See, for example, the findings of Campbell and Cochrane (1999) or Bloom, Floetotto, Jaimovich, Saporta Eksten, and Terry (2014).
References


BERTOMEU, J., P. MA, AND I. MARINOVIC (2016): “How often do managers withhold information?,” Available at SSRN.


A Appendix

Proof. [Proof of Proposition 2] This result comes from noting that when $\lambda_0 = 1 - \lambda_1$, we get

$$V^D(p, z, s) - V^{ ND}(z, s) = P^D(p, z, s) - P^{ ND}(p, z).$$

which means that the manager maximizes his myopic price gain when choosing whether or not to disclose. \qed

Proof. [Proof of Proposition 3] By assumption, the value function can be expressed as

$$V^D_1(p, z, s) = P^D(z, s) \frac{1}{1-\beta^3},$$

where the last equality follows the law of iterated expectations and AR(1) property of earnings. \qed

Proof. [Proof of Proposition 4] For expositional purposes, we normalize the unconditional mean of $e$ to zero because it plays no role in the proof, and we drop the dependence on $z$.

(1) Suppose that there is an equilibrium, such that information is withheld (case a) or disclosed (case b) for all $s$ conditional on some belief $p \in (0, 1)$,

$$V^{ ND}_1(p, s) = P^{ ND}(p) + \beta E[\lambda_0 V^0_0(p') + (1 - \lambda_0) V^1_1(p', s') | s],$$

where $p' = p(1 - \lambda_1) + (1 - p) \lambda_0$ (case a) or $p' = 1 - \lambda_1$ (case b) so that $V^{ ND}_1(p, s)$ does not depend on $s$. On the other hand, from Proposition 3, $V^D_1(p, s)$ is unbounded in $s$, implying that the manager would prefer to disclose for $s$ large enough (case a) or withhold for $s$ small enough (case b), which is a contradiction.

(2) Suppose that there is an equilibrium, such that the manager adopts a threshold strategy $k_p$ for any $p$, i.e., discloses if $s > k_p$ and withholds if $s < k_p$. We know from (1) that $k_p$ is finite. Then,

$$V^{ ND}_1(p, s) = P^{ ND}(p) + \beta E[\lambda_0 V^0_0(p') + (1 - \lambda_0) V^1_1(p', s') | s],$$

where $p' = p(1 - \lambda_1) + (1 - p) \lambda_0$ if $s < k_p$ and $p' = 1 - \lambda_1$ if $s > k_p$.

(2.a) Suppose that

$$E[\lambda_0 V^0_0(p(1 - \lambda_1) + (1 - p) \lambda_0) + (1 - \lambda_0) V^1_1(p(1 - \lambda_1) + (1 - p) \lambda_0, s')] =
E[\lambda_0 V^0_0(1 - \lambda_1) + (1 - \lambda_0) V^1_1(1 - \lambda_1, s')] = 0,$$

where the last equality follows from Proposition 2. It follows that $E[\lambda_0 V^0_0(p') + (1 - \lambda_0) V^1_1(p')] = 0$ for any belief $p'$ that may occur on the equilibrium path, and $k_p$ must be the static threshold in Proposition 2. Then, $V^0_0(p') = P^{ ND}(p')$, which is increasing in $p'$, and $V^1_1(p', s)$ is not a function of $p'$ from Proposition 3, which is a contradiction to (11).

(2.b) Suppose that
A.1 Solving the Model

The computational strategy we use is policy iteration. The steps are as follows:

1. Discretize the state space.

2. On the s-th iteration of the solution algorithm, guess a disclosure policy \( d^{(s)}(p, e_{-1}, c, s) \).

   (a) Assume that market beliefs and manager actions are governed by \( d^{(s)} \), and iterate forward on the system of Bellman equations above until the implied \( V_1^{(s)} \), \( V_0^{(s)} \) converge to some tolerance.

   (b) Compute the stationary distribution \( \mu_1^{(s)}(p, e_{-1}, c, s) \) and \( \mu_0^{(s)}(p, e_{-1}, c) \) of the model given \( d^{(s)} \), as well as the exogenous distributions in the model. This involves repeatedly pushing forward weight on a histogram given the policies and exogenous transitions until the distributions stabilize to within some tolerance.

   (c) Compute a new policy \( d^{(s+1)}(p, e_{-1}, c, s) \), simply given by

   \[
   \arg \max_d \left( dV_1^{D(s)} + (1 - d)V_1^{ND(s)} \right).
   \]

   (d) Then, compute an error measure given by the mean absolute difference between \( d^{(s+1)} \) and \( d^{(s)} \), weighted by the ergodic distributions \( \mu_1^{(s)} \) and \( \mu_0^{(s)} \). This error

\[
E[\lambda_0 V_0(p(1 - \lambda_1) + (1 - p)\lambda_0 + (1 - \lambda_0)V_1(p(1 - \lambda_1) + (1 - p)\lambda_0, s')) <
\]

\[
E[\lambda_0 V_0(1 - \lambda_1) + (1 - \lambda_0)V_1(1 - \lambda_1, s')] = 0,
\]

so that \( E[\lambda_0 V_0(p') + (1 - \lambda_0)V_1(p', s')] < 0 \) for any \( p' \) on the equilibrium path. Because \( E[V_1(p', s')] \geq V_0(p') \) for any \( p' \), it must hold that

\[
E[p'V_0(p') + (1 - p')V_1(p', s')] \leq E[\lambda_0 V_0(p') + (1 - \lambda_0)V_1(p', s')] < 0,
\]

for any \( p' \) on the equilibrium path. The left-hand side of this inequality is equal to the unconditional mean of \( e \) from the law of iterated expectations, which is a contradiction.

(2.c) Suppose that

\[
E[\lambda_0 V_0(p(1 - \lambda_1) + (1 - p)\lambda_0 + (1 - \lambda_0)V_1(p(1 - \lambda_1) + (1 - p)\lambda_0, s')) >
\]

\[
E[\lambda_0 V_0(1 - \lambda_1) + (1 - \lambda_0)V_1(1 - \lambda_1, s')] = 0.
\]

(13)

Note that \( V_1^D(s) \) is increasing and continuous in \( s \) from Proposition 3 so that we must have \( V_1^{ND}(p, k_p - a) \leq V_1^D(p_+, k_p) \leq V_1^{ND}(p, k_p + a) \) for any \( a > 0 \), where equation (13) implies that at least one inequality is strict. Assume that \( V_1^{ND}(p, k_p - a) < V_1^D(k_p) \). Then, there exists \( \epsilon > 0 \) sufficiently small, such that \( V_1^{ND}(p, k_p - a) < V_1^D(k_p - \epsilon) \), which contradicts that \( k_p \) is the disclosure threshold. The case of \( V_1^{ND}(p, k_p - a) > V_1^D(k_p) \), follows from a symmetric argument.

\[\Box\]

A.1 Solving the Model

The computational strategy we use is policy iteration. The steps are as follows:

1. Discretize the state space.

2. On the s-th iteration of the solution algorithm, guess a disclosure policy \( d^{(s)}(p, e_{-1}, c, s) \).

   (a) Assume that market beliefs and manager actions are governed by \( d^{(s)} \), and iterate forward on the system of Bellman equations above until the implied \( V_1^{(s)} \), \( V_0^{(s)} \) converge to some tolerance.

   (b) Compute the stationary distribution \( \mu_1^{(s)}(p, e_{-1}, c, s) \) and \( \mu_0^{(s)}(p, e_{-1}, c) \) of the model given \( d^{(s)} \), as well as the exogenous distributions in the model. This involves repeatedly pushing forward weight on a histogram given the policies and exogenous transitions until the distributions stabilize to within some tolerance.

   (c) Compute a new policy \( d^{(s+1)}(p, e_{-1}, c, s) \), simply given by

   \[
   \arg \max_d \left( dV_1^{D(s)} + (1 - d)V_1^{ND(s)} \right).
   \]

   (d) Then, compute an error measure given by the mean absolute difference between \( d^{(s+1)} \) and \( d^{(s)} \), weighted by the ergodic distributions \( \mu_1^{(s)} \) and \( \mu_0^{(s)} \). This error
is exactly equal to the probability of disclosure policy deviation given assumed market beliefs. When this error is sufficiently small, you have computed an equilibrium.

3. Once we have solved the model, we can compute moments as desired for input into the structural estimation routine.

We implement our solution algorithm in Fortran, discretizing driving exogenous processes for earnings, consensus forecasts, and manager signals using the method of Tauchen (1986). Broadly, our numerical approach to the resulting discrete-state dynamic programming problem follows the methods outlined in Judd (1998).

A.2 Simulating Firm Stock Returns and Analyzing Disclosure Patterns

For most of the analysis in the paper, continuing through the end of Section 3.4, our measure of market prices and firm valuations was based on the present discounted value of earnings. Given our AR(1) assumption for the exogenous firm earnings process, and a constant subjective discount rate, market value is therefore simply a constant multiple of the market’s current rational inference of firm earnings, as shown in Equations (1) and (2). However, the patterns of firm stock returns depend crucially upon the quantitative details of the dynamic of market prices. In practice, prices may reflect the present discounted value of cash flow or dividends rather than accounting earnings. So it is quantitatively appropriate to analyze a simulated measure of firm prices and stock returns which allows for the fact that cash flows and earnings may differ for firms which are growing or contracting at a fast rate. The difference between cash flows and earnings in this case depends upon the difference between firm investment and the level of depreciation of their accumulated assets, so we appeal to a canonical model of firm dynamics and investment.

In particular, we assume as in Hennessy and Whited (2007) that the output for a firm is given by

$$\begin{align*}
y = zk^\alpha, \quad \alpha \in (0,1) \tag{3}. 
\end{align*}$$

Here, $z$ is the idiosyncratic productivity. However, we assume that the investment is flexibly adjusted so that the firm chooses

$$\begin{align*}
k = i + (1 - \delta)k_{-1}, 
\end{align*}$$

where $i$ is the investment and $\delta$ is the depreciation. Given a price on new investments $p_I$, the firm solves

$$\begin{align*}
\max_k y - p_I i 
\end{align*}$$

$$\begin{align*}
k = i + (1 - \delta)k_{-1}. 
\end{align*}$$

We have optimally that

$$\begin{align*}
k = z \frac{1}{1 - \alpha} \left( \frac{\alpha}{p_I} \right)^{\frac{1}{1 - \alpha}} 
\end{align*}$$

$$\begin{align*}
y = z \frac{1}{1 - \alpha} \left( \frac{\alpha}{p_I} \right)^{\frac{\alpha}{1 - \alpha}} = \text{Revenue} 
\end{align*}$$

$$\begin{align*}
y - p_I i = (y - p_I k) + p_I (k - i) = (1 - \alpha)y + p_I (1 - \delta)k_{-1} = \text{Cash Flow} 
\end{align*}$$
\[y - p_I\delta k = (y - p_I k) + p_I(k - \delta k) = (1 - \alpha)y + p_I(1 - \delta)k = \text{Earnings}\]

As noted above, earnings may differ from cash flows because firms that are growing have higher earnings than cash flow. With the above equation rewritten,

\[\text{Earnings - Cash Flow} = p_I(1 - \delta)(k - k_{-1}) = p_I(1 - \delta)\left(\frac{\alpha}{p_I}\right)^{\frac{1}{1-\alpha}}(z^{\frac{1}{1-\alpha}} - z_{-1}^{\frac{1}{1-\alpha}}).\]

With the assumption that \(\hat{z} \equiv z^{\frac{1}{1-\alpha}}\) follows \(\hat{z} = \rho\hat{z}_{-1} + \varepsilon_t\), earnings inherit the AR(1) property of underlying productivity because they are a constant multiple of \(\hat{z}\):

\[\text{Earnings} = \hat{z}\left(\frac{\alpha}{p_I}\right)^{\frac{1}{1-\alpha}}\left[(1 - \alpha) + p_I(1 - \delta)\left(\frac{\alpha}{p_I}\right)\right].\]

Further, the difference between earnings and cash flow is given by

\[\text{Earnings - Cash Flow} = p_I(1 - \delta)\left(\frac{\alpha}{p_I}\right)^{\frac{1}{1-\alpha}}[\hat{z} - \hat{z}_{-1}].\]

We calibrate the model by assuming \(\alpha = 0.5, \delta = 0.1, p_I = 1\), which are roughly standard values (Cooper and Haltiwanger, 2006; Hennessy and Whited, 2007). Given a firm in period \(t\) with a set of values for market beliefs \(p_t\), lagged earnings \(e_{t-1}\), current analyst forecast \(c_t\), and manager signal \(s_t\) if available, we compute the average subsequent present discounted value of cash flows consistent with these values over all of our simulated dataset of firms. We set the market price today, \(P_t\), equal to this average value, imposing rational pricing. Then, we compute the return \(R_t\) over the holding period spanning the time just before an earnings announcement for \(e_t\) until just before the earnings announcement for \(e_{t+1}\) as

\[R_t = \frac{CF_t + P_{t+1}}{P_t} - 1,\]

where \(CF_t\) refers to the realized cash flows in period \(t\) and \(P_{t+1}\) to the rational market price in period \(t + 1\), computed in the same manner as \(P_t\). The text reports statistics and distributions of the net percentage returns \(100(R_t - 1)\), conditional on disclosure or non-disclosure of manager forecasts \(s_t\) in period \(t\).

**A.2.1 Strategic Witholding and Market Returns**

We use our estimated model to determine firm disclosure policies, and we compute the implied firm returns based on rational pricing of future firm cash flows. Just as in our analysis of information loss from concealment in the previous section, we simulate a dataset of 1,000 firms for 5,000 years. Returns are computed starting from the period after release of the analyst consensus forecast and the manager forecast (if disclosed) and continuing until after the earnings announcement occurs.

Figure 9 provides two histograms based on simulated stock returns from our baseline estimated model of manager concealment in periods with disclosure (left panel) and no disclosure (right panel). In each panel, the average yearly return is about \(1/(1 + 0.04) \approx\)
Figure 9. Histogram of returns in disclosure and non-disclosure periods

Note: The histograms plotted above are based on a simulation of annual percent returns from a panel of 1,000 firms over 5,000 years. The left panel plots the distribution of returns conditional on disclosure, and the right panel plots the distribution of returns conditional on non-disclosure. The solid lines in the background represent best-fit normal distributions for comparison. Market returns are based on rational pricing of the present discounted value of firm cash flows given current market beliefs about the manager’s information endowment, lagged earnings, analyst consensus forecasts, and manager forecasts when present. When simulating firm-level data, we use the estimated annual parameters in the case of the Baseline model.

4%, consistent with our assumed risk-free rate of 4%.

In the left panel, the distribution of returns conditional on disclosure is very similar to the distribution of news and is almost symmetric. Given the persistence of information endowment, in the steady state, periods with disclosure are likely to follow another period with disclosure. These are periods when forecasts tend to feature less strategic withholding and hence also smaller earnings surprises.

In the right panel, we find that the distribution of returns conditional on non-disclosure is both more volatile and skewed (we report exact values of these moments in Table 8 below). Intuitively, higher volatility of returns in periods with non-disclosure arises because pricing is less accurate in those periods. The associated surprise in future periods, and hence the associated return volatility, is larger on average. Also, because the market price conditional on non-disclosure pools firms with a range of poor manager signals about earnings today, some market prices reflect overly pessimistic inference about firm profitability. Such inferences are corrected with large positive surprises, and the result is high skewness of returns.

Our link between conditional volatility and disclosure choices is informative for several reasons. First, because managers in our structure selectively choose to conceal negative information rather than positive information, strategic withholding may help to endogenize the robust empirical finding of higher volatility or uncertainty during “bad times” for firms noted above. Second, we also provide a new quantification of a link between skewness and manager disclosure complementary to the results in Acharya, Demarzo, and Kremer (2011). Third, given the fact that non-disclosure leads to positive rather than negative skewness in our model, it’s important to observe that non-disclosure periods do not cause large market value crashes in our model, contrary to Kothari, Shu, and Wysocki (2009). We do not generate large negative returns from non-disclosure because the market prices reflect rational inference from non-disclosure before earnings are realized.
Table 8. Simulated Firm Return Statistics

<table>
<thead>
<tr>
<th></th>
<th>Baseline Model (63% Probability of Disclosure)</th>
<th>No Withholding Model (85% Probability of Disclosure)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Years</td>
<td>Non-Disclosure Years</td>
</tr>
<tr>
<td>Mean</td>
<td>3.84</td>
<td>3.84</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.90</td>
<td>1.96</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.09</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Note: All results are based on a simulation of annual percent returns from a simulated panel of 1,000 firms for 5,000 years. Market returns are based on rational pricing of the present discounted value of firm cash flows given current market beliefs about the manager’s information endowment, lagged earnings, analyst consensus forecasts, and manager forecasts when present. When simulating firm-level data, we use the estimated annual parameters in the case of the Baseline model and exogenously impose manager disclosure when informed in the No Withholding model.

In Table 8, we provide the simulated moments of returns in the sample from our Baseline model, the source of the return distributions plotted in Figure 9. We also provide moments of stock returns in a counterfactual Full Disclosure model in which disclosure is non-strategic, that is, the manager always discloses when informed. This table allows us to measure the incremental effects of strategic reporting on the distribution of reports. Note that strategic disclosure does not lead to much change in the unconditional size of stock return volatility overall. Instead, strategic disclosure does affect the timing of disclosures, as well as conditional volatilities, increasing volatility during non-disclosure periods but decreasing volatility during disclosure periods. However, given that news is revealed in earnings in each period, the total amount of fundamental news remains the same in the steady state and overall return volatility is similar in the two models. By contrast, we find that strategic disclosures creates higher return skewness unconditionally in our Baseline model relative to the Full Disclosure model. The higher unconditional skewness with concealment results entirely from higher conditional skewness during non-disclosure periods.