What Does the Market Know?*

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Abstract

Investors' information about different aspects of financial reporting – firms' fundamentals and managers' incentives to misreport these fundamentals – unambiguously affects earnings quality (Fischer and Stocken (2004)), making proper measurement of these types of information important for researchers and policymakers. Potential managerial incentives and investors' multiple information sources are not easily observable to researchers. I develop a structural approach that uses earnings reports, firms' prices, and analyst forecasts to measure how much information about firms' fundamentals and their managers' misreporting incentives investors know. I estimate the amount of information an average U.S. investor has, earnings informativeness, and the magnitude of the trade-off between earnings quality and price efficiency. I also apply the technique to complement prior reduced-form studies. In particular, I study the extent to which expanded compensation disclosures increased investors' information about managers' incentives and the extent to which early reporting firms' earnings reports spill over and subsume the information conveyed by late reporting firms.

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Introduction

Earnings is one of the most widely studied and focal summary accounting statistics, and accordingly, much attention has been paid to market responses to earnings and the quality of earnings (i.e., how well earnings reflect an underlying fundamental or true earnings). Earnings, however, is not the only component in the investor information set. Investors obtain information from various sources, and the market response to, and the quality of, earnings rests on the nature of that information. When investors have more information about the firm's earnings – fundamental information – prior to the manager's earnings report (e.g., information from analyst forecasts of earnings), the report offers them less incremental information. Thus, investors react less to the manager's earnings report; that is, the earnings response coefficient (ERC) decreases. Because the ERC decreases, the firm's manager benefits less from misreporting and misreports less, increasing earnings quality.[1] In contrast, when investors have more information about the manager's incentives to misreport – incentives information – they can better adjust reported earnings for misreporting, increasing the ERC. The manager benefits more from misreporting, misreports more, and earnings quality deteriorates. Given that the nature of the other information determines market responses to reported earnings and the quality of those earnings, assessing the general nature of that other information is important for policymakers and researchers. In this study, I aim to estimate the amounts of investors' information, from sources other than earnings, about firm fundamentals and managers' misreporting incentives.

Assessing the nature of other information poses significant challenges because many sources of information are hard for researchers and regulators to observe and parse. For example, managers' incentives, especially if nonmonetary, may not be fully captured by reported compensation structures. In addition, while some sources of investors' information are observable and measurable (e.g., downloads from the SEC's Electronic Data Gathering, Analysis, and Retrieval (EDGAR) system), some may be hidden. Finally, a single source also can contain information about both firm fundamentals and manager reporting incentives (e.g., managerial compensation affects firm fundamentals by influencing managers' real decisions in addition to influencing the managers' reporting activities). I resolve this issue using a structural estimation approach to measure investors' fundamental and incentives information. The approach uses observed financial market outcomes – earnings reports, firms' prices, and analyst forecasts – to measure the amount of each type of investor information, fundamental versus incentive, and their effects on earnings quality.

[1] Earnings quality in this paper is defined as the fraction of information in earnings reports driven by firms' fundamental or true earnings.

I build a dynamic earnings management model based on the work of Fischer and Stocken (2004) that features a manager who runs a company and issues (potentially biased) annual earnings reports to investors. The manager is concerned with the firm's stock price and has full information about firm fundamentals – the actual value of the earnings – and the misreporting incentives – the extent to which the manager cares about the price. In contrast to the manager, investors know only part of the fundamental and misreporting incentives information known by the manager.

To identify investors' unobserved information, I rely on three series in the data: reported earnings, prices, and analyst forecasts. Firms' prices, representing investors' beliefs about intrinsic values of firms, reveal the amount of fundamental information investors have. Analyst forecasts, which aim to predict the upcoming earnings reports (Mikhail et al. (1999), Hilary and Hsu (2013)), help identify both the market's information about the fundamental earnings and about the bias that the manager will add to those earnings when reporting, which is a function of the manager's incentives. To account for the fact that a lot of non-earnings information (e.g., concurrent analyst forecasts or managerial guidance) is bundled with earnings releases, I separately estimate how much information investors learn on earnings report days and on other days during the year. Short-window changes in firms' prices and analyst forecasts that are not explained by earnings identify the amount of information the market learns from sources other than earnings on the report day. Prices' and analyst forecasts' movement during a year excluding the report day, in turn, identify how much information the market learns on other days.

The estimates of the structural model suggest that, while firm earnings are volatile, investors anticipate a high portion of earnings before the report's release. For a typical firm, the standard deviation of an annual shock to earnings equals about 20.4% of the firm's lagged book value, and the market can anticipate around 85.5% of this shock using information sources other than the manager's earnings reports. Investors appear to know a lot about firm earnings, and only about a fifth of this knowledge is acquired when prior earnings are released, suggesting that sources other than managerial guidance or concurrent analyst reports matter for market learning about fundamentals. In contrast to fundamentals, managers' misreporting incentives are more volatile and investors know only a low portion of these incentives. For a manager at a representative firm, the standard deviation of an annual shock to the extent to which the manager's utility increases in response to a unit increase in the firm's price is about 49.2% of the firm's lagged book value, and the market can anticipate only around 35.6% of this shock.

Parameter estimates allow me to evaluate key statistics of interest: earnings quality and price efficiency.

For earnings quality, on average, only about 33.02% of variation in annual earnings reports is driven by the variation in firms' fundamentals. The remaining 66.98% of reports' variation is noise due to the bias added by the manager. These numbers support the evidence that corporate CFOs believe that roughly 50% of companies' earnings quality is due to innate factors and the other 50% due to managers' reporting choices (Dichev et al. (2013)). I further find that the standard deviation of reporting noise is large – about 50.2% of lagged book value. This estimate complements prior work which finds that, on average, misreporting appears low (e.g., Gerakos and Kovrijnykh (2013), Zakolyukina (2018)): while average manager biases earnings report a little, there is considerable cross-sectional variation in the size of biases across firms.

In addition to providing measurable insight into earnings quality, I consider how price efficiency is impacted by the information asymmetry between managers and investors. I find that the standard deviation of the difference between intrinsic and actual prices is as large as 49.2% of lagged book value. Similarly to misreporting, mispricing appears to vary substantially across firms, making variation important for understanding the full picture of price efficiency.

To evaluate the roles of different forces in the model and their effects on earnings quality and price efficiency, I conduct several counterfactual analyses. First, when considering the marginal effects of investors' information, I find that both earnings quality and price efficiency are most sensitive to the amount of fundamental information investors have: earnings quality (price efficiency) is about 11 (9) times more sensitive to investors' fundamental information than to investors' incentives information. Second, the analyses highlight the trade-off between earnings quality and price efficiency faced by an information regulator. A 1% increase in investors' incentives information decreases earnings quality by 0.14% yet increases price efficiency by 0.3%. In an extreme scenario when investors know almost all of the managers' incentives, earnings quality drops by as much as 95.3% but price efficiency increases by about 67.1%. Third, earnings quality and price efficiency are not substantially sensitive to investors' and managers' discount rates: large changes in either discount factor alter earnings quality and price efficiency by less than 10%.

Finally, I demonstrate how my technique can be employed to complement prior reduced-form studies. First, I study the effect on investors' information of the enhanced compensation disclosures after the introduction of the compensation disclosure and analysis (CD&A) section in companies' proxy statements. Research (e.g., Ferri et al. (2018)) has documented an increase in the ERC for firms subject to the regulation. It remains less clear, however, which forces drive this change. On the one hand, the CD&A in 2007 could have provided investors with more information on managerial incentives, increasing the ERC. At the same time, the financial crisis in the post-2007 period may have made investors less certain about firm fundamentals, also increasing the ERC. These forces are difficult to disentangle using a standard reduced-form approach. To evaluate their magnitudes, I structurally estimate my model on pre- and post-CD&A data. I find support for both forces: the amount of investors' information about managerial incentives increased by about 43 percentage points in the period after the CD&A, and the amount of investors' information about firms' fundamentals decreased by about 20 percentage points, suggesting that the increase in the ERC cannot be attributed solely to the regulation. This finding highlights the importance of considering changes in the entire system when evaluating the outcomes of information-related policies.

Second, I expand upon the antecedent literature on spillovers of information from firms reporting early in the earnings report cycle to those reporting late in the cycle (e.g., Ramnath (2002), Savor and Wilson (2016), Hann et al. (2019), Ogneva et al. (2021)). Research has found that early reporters get substantial market reactions on their reporting days because they convey information not only about themselves but also about the economy. Following that logic, late reporters should see lower market reactions on their reporting days because investors have more information about their fundamentals from early reporters' reports. However, the lower market reaction to late reporters' reports can also be due to investors being more uncertain about late reporters' misreporting incentives (Trueman (1990)). To disentangle the two explanations, I estimate the structural model separately for firms reporting early and those reporting late in the earnings report cycle. I find, first, that fundamental information spillover does not add new fundamental information for late reporters' investors but rather redistributes where this information comes from: late reporters' investors know a similar total amount of fundamental information but learn more of it from sources nonconcurrent with earnings reports. (Presumably these sources are early reporters' reports.) Second, late reporters' incentives are indeed substantially more opaque to investors. Because high incentives uncertainty implies a lower ERC, the earnings quality of late reporters is higher than that of early reporters. At the same time, the prices of late reporters are less efficient than of early reporters.

The rest of the paper is organized as follows. Section 1 reviews relevant literature in the area and clarifies how this paper contributes. Section 2 introduces model setup and equilibrium, defines earnings quality and price efficiency and discusses identification strategy. Section 3 describes the data and reports main estimation results. Section 4 conducts counterfactual analyses. Section 5 shows two applications of the structural model to complement reduced-form evidence. Section 6 concludes.

1 Relation to prior literature

This study expands upon multiple streams of literature in accounting. The first literature aims to define and measure earnings quality and the amount of earnings manipulation. Early papers in this space used accruals or abnormal changes in earnings to identify instances of manipulation (e.g., Jones (1991), Dechow et al. (1995), Sloan (1996), Burgstahler and Dichev (1997), Dechow and Dichev (2002)), or treated persistent earnings as high quality (e.g., Revsine et al. (2001), Penman (2012)). Dechow et al. (2010) provide an extensive review of various measures of earnings quality. More recent studies use theory-based or structural approaches to uncover the magnitudes of earnings manipulations and the fraction of manipulating firms (e.g., Gerakos and Kovrijnykh (2013), Zakolyukina (2018), Liang et al. (2018), Beyer et al. (2019), Bertomeu et al. (2019), Bird et al. (2019), Bertomeu et al. (2021), Cheynel et al. (2024)). Liang et al. (2018) propose and structurally estimate a model of misreporting where the manager's trustworthiness is unknown to investors. Gerakos and Kovrijnykh (2013) develop a way to measure misreporting which relies on the assumption that managers bias earnings to mask shocks to their firms' performance. Zakolyukina (2018) estimates a dynamic model of misstatements to evaluate the amount of misreporting that is left undetected. Bertomeu et al. (2021) estimate the cost of earnings management and associated earnings manipulation. A concurrent study by Bertomeu et al. (2019) aims to estimate investors' uncertainty about managers' stock-price-driven misreporting incentives; they use a static modeling framework and a different identification strategy. Below I discuss in detail how my paper relates to this large literature.

A study in the structural literature that is closest to mine is Beyer et al. (2019). This study uses a dynamic earnings management model where a stock-price-motivated manager can bias reported book value and suffers a cost of manipulation in current and prior periods. Beyer et al. (2019) do not have stock-price-based misreporting incentives but instead include reporting noise directly into the manager's cost function. Similarly to my paper, Beyer et al. (2019) focus on the noise in earnings introduced by managers' biasing behavior. Despite different structures, our estimates of reporting noise are close. In the specification with persistent reporting noise (which is closer to my model where reporting noise is persistent because managerial incentives are persistent), Beyer et al. (2019) find that the ratio of the variance of reporting noise to the variance of true earnings shocks is 15.8% (40.1%, 125.2%) for small (medium, large) firms. My corresponding estimate is 101%. A potential reason for the slight differences in the two studies' estimates is that, in my paper, I allow investors to have some information about managerial incentives and thus about the bias in earnings. Beyer et al. (2019) assume investors do not know anything about the manager's cost of misreporting and thus about the bias. As shown by Fischer and Stocken (2004), when investors have some information about the bias, managers manipulate earnings more, increasing reporting noise. If I disallow investors' knowledge about managerial incentives in my model, the estimated magnitude of noise reduces to 90.01% and becomes even closer to Beyer et al. (2019).

Studies that focus on estimating average reporting bias conclude that, on average, misreporting is low: Zakolyukina (2018) estimates that on average, bias in firms' earnings is about 0.17% of lagged total assets; Gerakos and Kovrijnykh (2013) find a 0.70% median absolute misreporting in earnings; Bertomeu et al. (2021) evaluate the average magnitude of earnings management is about 0.006 of the beginning-of-the-year book value. My focus is not on the bias itself but on the noise in earnings introduced by managers' biasing behavior.[2] Nevertheless, I complement findings in prior studies on average bias by estimating the variance of this bias. I find that the standard deviation of reporting bias is about 50.2% of firms' lagged book value or 7.43% of lagged total assets.[3] This finding highlights that, while the magnitude of average misreporting is important, considering variation in misreporting is necessary for understanding the full picture. Even though on average misreporting appears low, firms vary a lot in the extent of their misreporting: for some firms, misreporting may be substantial. This result echoes Cheynel et al. (2024) who find that extreme misstatement cases are of very high magnitudes.

Similarly to misreporting, my study complements prior findings about price inefficiency due to earnings manipulation. Zakolyukina (2018) calculates that companies' prices are inflated due to misreporting by about 2.02% (0.77%) for misreporting (all) firms; Bertomeu et al. (2019) find that, in a parametric (semi-parametric) model, reporting noise causes a reduction in firm value by 0.2% (0.1%) of lagged total assets. I estimate that the standard deviation of mispricing is about 49.2% of the firms' lagged book value or 7.28% of lagged total assets.[4] Like misreporting, the extent to which companies' values deviate from their intrinsic values due to manipulation varies considerably.

Overall, the structural approach has been proven useful in studying disclosure decisions. Researchers

[2]The average misreporting can be estimated in my model if I bring in the data on, for example, restatements (like Zakolyukina (2018)). With the current setup, the average level of misreporting cannot be identified because the optimal report only contains a linear combination of mean earnings shocks and mean incentives shocks known by the manager. The data on firm prices, analyst forecasts, and earnings reports are insufficient to separate mean earnings shocks from mean incentives shocks. Beyer et al. (2019) note a similar feature of their setup.

[3]The average lagged book value of a company in my sample is $2.687 billion, and the average lagged total assets are $18.154 billion. $\frac{0.502\times2.687}{18.154}\approx 0.0743$.

[4]The average lagged book value of a company in my sample is $2.687 billion, and the average lagged total assets are $18.154 billion. $\frac{0.492\times2.687}{18.154}\approx 0.0728$.

have used structural estimation to evaluate unobserved determinants of disclosure and manipulation, including investor learning (Zhou (2021)), disclosure frictions (Cheynel and Liu-Watts (2020), Bertomeu et al. (2020)), investment efficiency-information trade-off (Terry et al. (2022)), audit practices (Cheynel and Zhou (2023)), and reputation building (Bertomeu et al. (2022)). I add to these studies by estimating investor uncertainty about managers' reporting objectives as a determinant of financial misreporting.

The second large stream of literature studies investors' uncertainty about managerial incentives and the implications for financial misreporting (e.g., Ferri et al. (2018), Bertomeu et al. (2019), Kim (2024)). Ferri et al. (2018) use the staggered adoption of the CD&A section in companies' proxy statements, and Kim (2024) uses investors' searches for compensation-related disclosures to identify how investor uncertainty about managerial incentives affects financial reporting bias. The advantage of my approach is that I can disentangle information about fundamental and misreporting incentives and the respective effects on misreporting, even if investors simultaneously learn both types of information.

Finally, my paper contributes to extensive literature studying other sources of information about firms' earnings and fundamentals in general. These sources include managerial guidance (e.g., Lu and Skinner (2020)), analyst reports (e.g., Francis et al. (2002), Lobo et al. (2017)), peers' disclosures (e.g., Arif and De George (2020)), macroeconomic news (e.g., Carabias (2018)), bank loans (e.g., Best and Zhang (1993)), tender offers (e.g., Dann et al. (1991)), and, more recently, social networks (e.g., Bartov et al. (2018)) and general internet searches (e.g., Drake et al. (2012)). While each of these studies analyzes one or a few sources of information, the total amount of information investors obtain from other sources has not been measured. Simply adding up findings of studies of individual sources may not capture the total amount of investors' information because some sources may be unobservable to researchers and others may be duplicates. My study fills this void and estimates the aggregate amount of the market's fundamental and incentives information. A relevant recent study by Smith (2023) uses a structural model to measure how much investors know about fundamentals from external sources and the effectiveness of earnings in accelerating arrival of information investors would have learned elsewhere after an earnings announcement. Smith (2023) studies the precise timing of information arrival and the extent to which earnings carries forward this information; my paper's focus is investors' uncertainty about managerial incentives and the resulting earnings manipulation.

2 Model

This section discusses the model and equilibrium and presents theoretical moments that are used to estimate model parameters. In what follows, I denote random variables by the ˜ sign and their realizations without the sign.

2.1 Setup

The model is a dynamic version of an earnings management model where the company manager's incentives are uncertain, as in Fischer and Stocken (2004). A manager with a long tenure at the company cares about its price and periodically reports earnings to investors. The report does not have to be truthful: the manager can bias it at a cost. The manager has more information than investors about both earnings and misreporting incentives – the extent to which the manager cares about the firm's price.

The firm's earnings in year t have two parts, one observed by both the manager and the market and another privately observed by the manager. Earnings, $\tilde{\varepsilon}$, are characterized by the following process:

$$\tilde{\varepsilon}_t = \tilde{\varepsilon}_{1,t} + \tilde{\varepsilon}_{2,t}, \tag{1}$$

$$\tilde{\varepsilon}_{1,t} = \tilde{v}_{1,t} + \tilde{v}_{1,t-1} + \tilde{v}_{1,t-2}, \quad \tilde{v}_{1,t} \sim N(0, q_v \sigma_v^2), \tag{2}$$

$$\tilde{\varepsilon}_{2,t} = \tilde{v}_{2,t} + \tilde{v}_{2,t-1} + \tilde{v}_{2,t-2}, \quad \tilde{v}_{2,t} \sim N(0, (1-q_v)\sigma_v^2), \tag{3}$$

where $0 < q_v < 1$. The manager observes both parts, $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$, and the market only observes $\varepsilon_{1,t}$. The market learns $\varepsilon_{1,t}$ from sources other than the manager's report. The parameter q_v represents the fraction of total fundamental information that the market knows.

I model firm earnings as a sum of the current and two prior-year shocks to preserve important time-series properties of earnings while keeping the model tractable. The time series process for earnings in (2) and (3) ensures earnings persist and mean-revert (Gerakos and Kovrijnykh (2013)). Two prior-year shocks imply that, to evaluate current earnings, investors mostly rely on information about earnings from the last two years. This number of relevant past earnings is consistent with prior studies (e.g., Albrecht et al. (1977)), which find that autocorrelation coefficients for earnings reports cross-sectionally vary between about 0.4 and 0.8. In addition, when earnings are a sum of a finite number of shocks rather than an AR(1) process, the manager's report in equilibrium is also a finite sum of shocks, allowing for a closed-form solution of the model.

The market learns its part of current earnings in two periods. A fraction is learned concurrently with the previous earnings report (e.g., from concurrent analyst reports), and another fraction is learned at other times during the year leading up to the earnings report. Formally, $\varepsilon_{1,t}$ has two parts:

$$\tilde{\varepsilon}_{1,t} = \tilde{\varepsilon}^0_{1,t} + \tilde{\varepsilon}^1_{1,t}, \tag{4}$$

$$\tilde{\varepsilon}^0_{1,t} = \tilde{v}^0_{1,t} + \tilde{v}^0_{1,t-1} + \tilde{v}^0_{1,t-2}, \quad \tilde{v}^0_{1,t} \sim N(0, q_v q^0_v \sigma^2_v), \tag{5}$$

$$\tilde{\varepsilon}^1_{1,t} = \tilde{v}^1_{1,t} + \tilde{v}^1_{1,t-1} + \tilde{v}^1_{1,t-2}, \quad \tilde{v}^1_{1,t} \sim N(0, q_v(1-q^0_v)\sigma^2_v), \tag{6}$$

where $0 < q^0_v < 1$. $\varepsilon^0_{1,t}$ is the fraction of the market's fundamental information contained in the time-t report that arrives concurrently with the previous (time-$(t-1)$) earnings report. $\varepsilon^1_{1,t}$ is the fraction of the market's fundamental information in the time-t report that arrives on other days during the year leading up to the time-t earnings report. The fraction of investors' earnings information that is learned concurrently with the previous report is captured by q^0_v. The timing of information arrival is shown in figure 1.

The firm's manager cares about stock price, so that a unit increase in the price at time t provides an extra m_t units of utility. Misreporting incentives m_t not only capture the manager's compensation but can include nonmonetary benefits, such as reputation or happiness from running a successful company. The incentives can be positive or negative. Misreporting incentives evolve and are described by the following process:

$$\tilde{m}_t = \tilde{m}_{1,t} + \tilde{m}_{2,t}, \tag{7}$$

$$\tilde{m}_{1,t} = \tilde{\xi}_{1,t} + \tilde{\xi}_{1,t-1} + \tilde{\xi}_{1,t-2}, \quad \tilde{\xi}_{1,t} \sim N(0, q_\xi \sigma^2_\xi), \tag{8}$$

$$\tilde{m}_{2,t} = \tilde{\xi}_{2,t} + \tilde{\xi}_{2,t-1} + \tilde{\xi}_{2,t-2}, \quad \tilde{\xi}_{2,t} \sim N(0, (1-q_\xi)\sigma^2_\xi), \tag{9}$$

where $0 < q_\xi < 1$. Like earnings, the manager knows both components of her incentives, $m_{1,t}$ and $m_{2,t}$, and the market knows only a part of them, $m_{1,t}$. The parameter q_ξ represents the share of misreporting incentives information that the market has.

Again like earnings, the market learns its part of managerial incentives in two periods. Some fraction is learned concurrently with the previous earnings report (e.g., because previous-year earnings may be a target to beat next year), and another fraction is learned at other times during the year leading up to the earnings report. Formally, $m_{1,t}$ has two parts:

$$\tilde{m}_{1,t} = \tilde{m}^0_{1,t} + \tilde{m}^1_{1,t}, \tag{10}$$

$$\tilde{m}^0_{1,t} = \tilde{\xi}^0_{1,t} + \tilde{\xi}^0_{1,t-1} + \tilde{\xi}^0_{1,t-2}, \quad \tilde{\xi}^0_{1,t} \sim N(0, q_\xi q^0_\xi \sigma^2_\xi), \tag{11}$$

$$\tilde{m}^1_{1,t} = \tilde{\xi}^1_{1,t} + \tilde{\xi}^1_{1,t-1} + \tilde{\xi}^1_{1,t-2}, \quad \tilde{\xi}^1_{1,t} \sim N(0, q_\xi (1 - q^0_\xi) \sigma^2_\xi). \tag{12}$$

where $0 < q^0_\xi < 1$. $m^0_{1,t}$ is the fraction of the market's incentives information related to the time-t report that arrives concurrently with the previous (time-$(t-1)$) earnings report. $m^1_{1,t}$ is the fraction of the market's incentives information related to the time-t report that arrives on other days during the year leading up to the time-t earnings report.

Every year, the manager releases a (potentially biased) report, e_t, about the firm's earnings and is compensated based on the firm's stock price, p_t, net of personal cost of misreporting. The misreporting cost is a function of the bias in the current period's earnings and all other biases in prior periods' earnings. This cost function captures the increasing likelihood of being caught and penalized when as misreporting accumulates. Second, the cost of prior years' misreporting naturally introduces the reversal of accruals (which can happen at any point) because, to exaggerate current earnings, the manager must bias the report by an additional amount to compensate for the reversal rate and thus bears a higher misreporting cost. The manager's utility at time t is

$$U_t = m_t p_t - \frac{\left(\sum_{k=0}^{t} (e_k - \varepsilon_k)\right)^2}{2}, \text{[5]} \tag{13}$$

where m_t is the manager's misreporting incentives.[6]

The manager faces a dynamic trade-off: if the misreporting incentive is positive ($m_t > 0$), on the one hand, by overstating earnings today, the manager increases firm price and thus increases her utility. On the other hand, if the manager overstates firm earnings today ($e_t > \varepsilon_t$), she will have less room for overstatement (and boosting firm price) going forward. If the manager understates earnings today ($e_t < \varepsilon_t$), it will be

[5] Other studies considered accounting system errors as another source of investors' uncertainty related to financial misreporting (e.g., Beyer et al. (2019)). The accounting system error can be incorporated in my model by changing the manager's misreporting cost to $\frac{\left(\sum_{k=0}^{t} (e_k - \varepsilon_k - \eta_k)\right)^2}{2}$, where η_k is the error introduced by the accounting system. Adding this feature to the model complicates it without helping my main focus – uncovering investors' uncertainty about managers' misreporting incentives, m_t. Since accounting error noise has been explored in detail elsewhere (Beyer et al. (2019)), I leave the investigation of jointly misreporting incentives and accounting error uncertainty for future research.

[6] The manager bears one unit of cost for the misreporting of size $\frac{\left(\sum_{k=0}^{t} (e_k - \varepsilon_k)\right)^2}{2}$. This implies that m_t is the manager's benefit of misreporting relative to the one unit of misreporting cost. Alternatively, the cost of misreporting can be modelled as $c\frac{\left(\sum_{k=0}^{t} (e_k - \varepsilon_k)\right)^2}{2}$ and the manager's misreporting incentives can be modelled as $M_t = cm_t$.

costlier to report a higher number in the future. The manager's problem at time t is

$$\max_{e_t} \quad E\left[\sum_{k=t}^{k=\infty} \delta_M^{k-t}\left(\tilde{m}_k p_k - \frac{\left(\sum_{\tau=0}^{k}(e_\tau - \varepsilon_\tau)\right)^2}{2}\right)|I_t^{\text{manager}}\right], \tag{14}$$

where $0 < \delta_M < 1$ is the manager's discount factor and $I_t^{\text{manager}} = \{\varepsilon_0, \varepsilon_1, ..., \varepsilon_t;\ m_0, m_1, ..., m_t\}$ is all the information available to the manager at time t, which is simply all realizations of earnings and misreporting incentives.

The market prices the firm risk-neutrally at the expectation of its current and discounted future earnings:

$$p_t = E\left[\sum_{k=t}^{\infty} \delta_I^{k-t} \tilde{\varepsilon}_k | I_t^{\text{market}}\right], \tag{15}$$

where $0 < \delta_I < 1$ is investors' discount factor and $I_t^{\text{market}} = \{e_0, e_1, ..., e_t; \varepsilon_{1,0}, \varepsilon_{1,1}, ..., \varepsilon_{1,t}; m_{1,0}, m_{1,1}, ..., m_{1,t}\}$ is all the information available to the market at time t. This information includes the history of managerial reports and fundamental and misreporting incentives information observed by the market.

The final element that I define is the market's expectation of the manager's next earnings report:

$$ME_\tau = E\left[\tilde{e}_t | I_\tau^{\text{market}}\right], \tag{16}$$

where $\tau \in \{t-1, t\}$ denotes the period when the expectation is formed. For example, $ME_{t-1}^{\text{post-report}} = E\left[\tilde{e}_t | I_{t-1}^{\text{market}}\right]$ is the market's expectation of the manager's report at time t, formed at time $t-1$ right **after the manager's report $\mathbf{e_{t-1}}$** is released (hence the "post-report"). $ME_t^{\text{pre-report}} = E\left[\tilde{e}_t | I_t^{\text{market}} \setminus \{e_t\}\right]$ is the market's expectation of the manager's report at time t, formed at time t right **before the manager's report $\mathbf{e_t}$** is released (hence the "pre-report"). Since the market's information evolves, the information used to form the expectation of the same report may differ at different times. In the example, $I_{t-1}^{\text{market}} = \{e_0, e_1, ..., e_{t-1}; \varepsilon_{1,0}, \varepsilon_{1,1}, ..., \varepsilon_{1,t-1}, \varepsilon_{1,t}^0; m_{1,0}, m_{1,1}, ..., m_{1,t-1}, m_{1,t}^0\}$ includes all the reports, including the report at time $(t-1)$, $\{e_0, e_1, ..., e_{t-1}\}$, investors' fundamental information about earnings up to time $(t-1)$ and about time-t earnings learned concurrently with time-$(t-1)$ report, $\{\varepsilon_{1,0}, \varepsilon_{1,1}, ..., \varepsilon_{1,t-1}, \varepsilon_{1,t}^0\}$, and investors' incentives information up to time $(t-1)$ and time-t learned concurrently with time-$(t-1)$ report, $\{m_{1,0}, m_{1,1}, ..., m_{1,t-1}, m_{1,t}^0\}$. To compare, $I_t^{\text{market}} \setminus \{e_t\} = \{e_0, e_1, ..., e_{t-1}; \varepsilon_{1,0}, \varepsilon_{1,1}, ..., \varepsilon_{1,t-1}, \varepsilon_{1,t}; m_{1,0}, m_{1,1}, ..., m_{1,t-1}, m_{1,t}\}$ in addition includes fundamental and incentives information learned during the year leading up to the time-t report, $\varepsilon_{1,t}^{1}$ and $m_{1,t}^{1}$ ($\varepsilon_{1,t} = \varepsilon_{1,t}^{0} + \varepsilon_{1,t}^{1}$; $m_{1,t} = m_{1,t}^{0} + m_{1,t}^{1}$). The timing of formation of the firm's prices and the market's expectations are illustrated in Figure 2.

Importantly, ME_{τ} is the market's expectation of the report that the manager will release at time t, $\tilde{e}_t$, not the firm's true earnings. The market's expectation thus is the expectation of the sum of the firm's true earnings and the bias added by the manager. Such a formulation of the market's expectation is consistent with the goal of financial analysts to correctly forecast the report (Mikhail et al. (1999), Hilary and Hsu (2013)), not the unbiased earnings. Modeling the market's expectation this way allows me to glean the market's information about the manager's misreporting incentives. The expectation of the report is the expectation of the sum of true earnings and the bias that the manager adds. The bias, in turn, is a function of the manager's incentives. Coupling market expectations with firm prices, which represent solely beliefs about firm earnings, I can disentangle investors' expectations of the reporting bias and thus of misreporting incentives.

2.2 Analysis in equilibrium

This section presents the model's equilibrium and discusses earnings quality and price efficiency in equilibrium.

2.2.1 Earnings reports, and evolution of prices and market's expectations

I focus on equilibria with the following steady-state relations:

- The firm's price is a linear function, with time-invariant coefficients, of the manager's reports and the market's fundamental and misreporting incentives information:[7]

$$p_t = p_0 + \sum_{j=0}^{j=t} \alpha_j^t e_j + \sum_{j=0}^{j=t} \beta_j^{0,t} \varepsilon_{1,j}^{0} + \sum_{j=0}^{j=t} \beta_j^{1,t} \varepsilon_{1,j}^{1} + \sum_{j=0}^{j=t} \gamma_j^{0,t} m_{1,j}^{0} + \sum_{j=0}^{j=t} \gamma_j^{1,t} m_{1,j}^{1}; \tag{17}$$

- The manager's earnings report is a linear function, with time-invariant coefficients, of the firm's cur-

[7] A formulation where the firm's price is a linear function of its earnings is consistent with the Ohlson (1995) equity valuation framework. Under the assumption that earnings that stay at the firm earn an equity rate of return, the firm's dividend policy is irrelevant, and I can assume that all earnings are paid out as dividends. The price formula in 15 can be re-written as the sum of the firm's past earnings (book value) and current earnings (Feltham and Ohlson (1995)).

rent true earnings and the manager's misreporting incentives:[8]

$$e_t = e_{const} + e_\varepsilon \varepsilon_t + \sum_{k=0}^{k=t} e_{m_1^0,k} m_{1,t-k}^0 + \sum_{k=0}^{k=t} e_{m_1^1,k} m_{1,t-k}^1 + \sum_{k=0}^{k=t} e_{m_2,k} m_{2,t-k}. \tag{18}$$

- The market's expectation of the manager's earnings report is a linear function, with time-invariant coefficients, of prior reports, and the market's fundamental and misreporting incentives information:

$$ME_t = ME_{const} + \sum_{j=0}^{j=t} a_j^t e_j + \sum_{j=0}^{j=t} b_j^{0,t} \varepsilon_{1,j}^0 + \sum_{j=0}^{j=t} b_j^{1,t} \varepsilon_{1,j}^1 + \sum_{j=0}^{j=t} c_j^{0,t} m_{1,j}^0 + \sum_{j=0}^{j=t} c_j^{1,t} m_{1,j}^1, \tag{19}$$

where the constant p_0 is the firm's price at some initial time 0, α_j^t is the price-t response to the time-j managerial report; $\beta_j^{0,t}$ and $\beta_j^{1,t}$ are price-t responses to the fundamental information learned at the time of the manager's report and on other days, respectively; and $\gamma_j^{0,t}$ and $\gamma_j^{1,t}$ are price-t responses to the misreporting incentives information learned at the time of the manager's report and on other days, respectively. The term e_{const} is a constant; e_ε is the weight the manager puts on the firm's true earnings in her report; $e_{m_1^0,k}$, $e_{m_1^1,k}$, and $e_{m_2,k}$ are the weights the manager puts on the m_1^0, m_1^1, and m_2 components, respectively, of her price-related compensation given at time $t-k$. The term ME_{const} is a constant; a_j^t is the response of the market expectation at time t to the time-j managerial report; $b_j^{0,t}$ and $b_j^{1,t}$ are the responses of the market expectation at time t to the fundamental information learned at the time of the manager's report and on other days, respectively; $c_j^{0,t}$ and $c_j^{1,t}$ are the responses of the market expectation at time t to the misreporting incentives information learned at the time of the manager's report and on other days, respectively. There exists a unique equilibrium of this type.

The firm's price and the market's expectations rely on multiple sources of information. First, the market uses information from sources other than the manager's report. Second, the market uses the manager's earnings reports to form beliefs about unobservable parts of earnings and of the manager's incentives. Investors use not only the most recent but all the past earnings reports. Since shocks to true earnings and misreporting incentives persist for two years, at least two past earnings reports are useful for gleaning shocks to true earnings and misreporting incentives in the current year. In addition, since all earnings reports are noisy signals of true earnings and misreporting incentives and the noise across earnings reports is correlated due

[8] Studies (Guttman et al. (2006)) have found that, in the earnings management setting with uncertain managerial incentives, multiple equilibria, including non-linear, can exist and some of them are not fully revealing of where the manager's report can be perfectly mapped into true earnings but have partial pooling where managers in the middle earnings region issue the same report. I choose to focus on smooth, linear equilibria, as this formulation is less challenging to estimate.

to persistence in misreporting incentives, earnings reports beyond the past two periods help predict the noise in the past two earnings and thus help back out information from the current earnings report.

The proposition below describes the optimal earnings report chosen by the manager.

Proposition 1 *In a steady-state, the manager's earnings report is*

$$e_t = \varepsilon_t + (\alpha_0 + \delta_M \alpha_1 + \delta_M^2 \alpha_2)\xi_t - \alpha_0 \xi_{t-3} - \delta_M \alpha_1 \xi_{t-2} - \delta_M^2 \alpha_2 \xi_{t-1}, \tag{20}$$

where α_0, α_1, and α_2 are the current, one-year-ahead, and two-year-ahead prices' responses to the manager's earnings report, defined in the appendix.

The manager's optimal report is the sum of the firm's true earnings (ε_t), the bias added to the current earnings $\left((\alpha_0 + \delta_M \alpha_1 + \delta_M^2 \alpha_2)\xi_t\right)$ net of the bias in the prior earnings report $\left(\alpha_0 \xi_{t-3} + \delta_M \alpha_1 \xi_{t-2} + \delta_M^2 \alpha_2 \xi_{t-1}\right)$. This behavior represents the common notion that a bias in the report must reverse in the future. In equilibrium, the manager chooses to (at least partially) undo the bias she added to the report last year. If the product of her misreporting incentives and market response to the report is higher this year than last, the manager overstates current earnings but also must reverse last year's bias.

To understand how the market learning from the manager's report and other information sources is reflected in prices, I analyze the firm's price at different times of the year: right before the time-t report is issued, right afterward, and right before the time-$(t+1)$ earnings report is issued. I denote with $p_t^{\text{pre-report}}$ the firm's price right before the earnings report e_t is issued and with $p_t^{\text{post-report}}$ the firm's price right afterward. I_t^{market} denotes the market's information at time t, which includes the time-t earnings report e_t and information concurrent with the time-t earnings report, $\varepsilon_{1,t+1}^0$ and $m_{1,t+1}^0$; $I_t^{\text{market}} \setminus \{e_t\}$ denotes the market's information excluding the time-t earnings report e_t and information concurrent with the time-t earnings report. Before the earnings report at time t, the market price is

$$p_t^{\text{pre-report}} = E\left[\sum_{k=t}^{\infty} \delta_I^{k-t} \varepsilon_{1,k} | I_t^{\text{market}} \setminus \{e_t\}\right] + E\left[\sum_{k=t}^{\infty} \delta_I^{k-t} \varepsilon_{2,k} | I_t^{\text{market}} \setminus \{e_t\}\right] \tag{21}$$

$$= \varepsilon_{1,t} + \left(\delta_I (\nu_{1,t} + \nu_{1,t-1}) + \delta_I^2 \nu_{1,t}\right) + E\left[\sum_{k=t}^{\infty} \delta_I^{k-t} \varepsilon_{2,k} | I_t^{\text{market}} \setminus \{e_t\}\right] \tag{22}$$

The first summand ($\varepsilon_{1,t}$) represents the part of the current earnings that investors learned perfectly from other information sources, and the second summand $\left(\delta_I (\nu_{1,t} + \nu_{1,t-1}) + \delta_I^2 \nu_{1,t}\right)$ represents investors' expectation of the first part of future earnings, given their information from other sources. Since the two parts of earnings, ε_1 and ε_2, are independent and investors perfectly know the history of the first part, ε_1, investors do not rely on the manager's report to build their expectations about the first part of future earnings, $E\left[\sum_{k=t+1}^{\infty} \delta_I^{k-t} \varepsilon_{1,k} | I_t^{\text{market}} \setminus \{e_t\}\right]$, but rather rely on their historical knowledge. The third summand represents investors' belief about the second part of current and future earnings. Because investors do not observe the second part of earnings, the only source of information about it is the manager's earnings reports.

When the time-t earnings report e_t is issued, two types of information arrive. First, the earnings report itself, e_t, provides investors with information about the current earnings, which include shocks that will persist in periods $t+1$ and $t+2$. Second, concurrent information sources (e.g., earnings calls) reveal partial information about the first part of the next period's earnings, $\nu_{1,t+1}^0$. The firm's price right after the time-t earnings report e_t is issued is

$$p_t^{\text{post-report}} = E\left[\sum_{k=t}^{\infty} \delta_I^{k-t} \varepsilon_{1,k} | I_t^{\text{market}}\right] + E\left[\sum_{k=t}^{\infty} \delta_I^{k-t} \varepsilon_{2,k} | I_t^{\text{market}}\right] \tag{23}$$

$$= \varepsilon_{1,t} + \left(\delta_I \left(\nu_{1,t+1}^0 + \nu_{1,t} + \nu_{1,t-1}\right) + \delta_I^2 \left(\nu_{1,t+1}^0 + \nu_{1,t}\right) + \delta_I^3 \nu_{1,t+1}^0\right) + E\left[\sum_{k=t}^{\infty} \delta_I^{k-t} \varepsilon_{2,k} | I_t^{\text{market}}\right] \tag{24}$$

This price differs from the price right before the earnings report, $p_t^{\text{pre-report}}$, in two ways. First, the expectation of the first part of the next two period's earnings is updated – investors add $\left(\delta_I \nu_{1,t+1}^0 + \delta_I^2 \nu_{1,t+1}^0 + \delta_I^3 \nu_{1,t+1}^0\right)$. Second, the investors' information set now includes the current earnings report e_t. The price change around a time-t earnings announcement is formalized in the following proposition.

Proposition 2 *In a steady state, the change in firm price after the issuance of the manager's report is*

$$p_t^{\textit{post-report}} - p_t^{\textit{pre-report}} = \left(\delta_I + \delta_I^2 + \delta_I^3\right) \nu_{1,t+1}^0 + \alpha_0 \left(e_t - E[\tilde{e}_t | I_t^{\textit{market}} \setminus \{e_t\}]\right), \tag{25}$$

where α_0 is the earnings response coefficient, derived in the appendix.

The price is updated the second time when the market learns information from other sources throughout the following year. The price of the firm right before the time-$(t+1)$ earnings report e_{t+1} is issued is

$$p_{t+1}^{\text{pre-report}} = E\left[\sum_{k=t+1}^{\infty} \delta_I^{k-(t+1)} \varepsilon_{1,k} | I_{t+1}^{\text{market}} \setminus \{e_{t+1}\}\right] + E\left[\sum_{k=t+1}^{\infty} \delta_I^{k-(t+1)} \varepsilon_{2,k} | I_{t+1}^{\text{market}} \setminus \{e_{t+1}\}\right] \tag{26}$$

$$= \varepsilon_{1,t+1} + \left(\delta_I \left(\nu_{1,t+1} + \nu_{1,t}\right) + \delta_I^2 \nu_{1,t+1}\right) + E\left[\sum_{k=t+1}^{\infty} \delta_I^{k-(t+1)} \varepsilon_{2,k} | I_{t+1}^{\text{market}} \setminus \{e_{t+1}\}\right] \tag{27}$$

The price changes from right after the time-t report to right before the time-$(t+1)$ report in two ways. First, investors learn new information about earnings and misreporting incentives ($\varepsilon_{1,t+1}^1$ and $m_{1,t+1}^1$). Second, one year passes, and investors discount their expectations of time-$(t+1)$ cash flows less heavily.[9]

Proposition 3 *In a steady-state, the change in firm price after the market learns $\varepsilon_{1,t+1}^1$ and $m_{1,t+1}^1$ is*

$$p_{t+1}^{\text{pre-report}} - p_t^{\text{post-report}} = \left(1 + \delta_I + \delta_I^2\right)\left(\nu_{1,t+1}^0 + \nu_{1,t+1}^1\right) - \left(\delta_I + \delta_I^2 + \delta_I^3\right)\nu_{1,t+1}^0$$
$$+ (\alpha_1 - \alpha_0) \times \left(e_t - E[\tilde{e}_t | I_{t+1}^{\text{market}} \setminus \{e_t\}]\right) \tag{28}$$

Next I discuss how the market's expectation of the closest earnings report evolves. The market's expectation of the time-t earnings report right before the time-t report is issued is:

$$ME_t^{\text{pre-report}} = E\left[\tilde{e}_t | I_t^{\text{market}} \setminus \{e_t\}\right] = \tag{29}$$

$$\varepsilon_{1,t} + E_t\left[\varepsilon_{2,t} | I_t^{\text{market}} \setminus \{e_t\}\right] \tag{30}$$

$$+ \left(\alpha_0 + \delta_M \alpha_1 + \delta_M^2 \alpha_2\right) \xi_{1,t} - \alpha_0 \xi_{1,t-3} - \delta_M \alpha_1 \xi_{1,t-2} - \delta_M^2 \alpha_2 \xi_{1,t-1} \tag{31}$$

$$-\alpha_0 E_t\left[\xi_{2,t-3} | I_t^{\text{market}} \setminus \{e_t\}\right] - \delta_M \alpha_1 E_t\left[\xi_{2,t-2} | I_t^{\text{market}} \setminus \{e_t\}\right] - \delta_M^2 \alpha_2 E_t\left[\xi_{2,t-1} | I_t^{\text{market}} \setminus \{e_t\}\right] \tag{32}$$

Recall that the market's expectation of the earnings report is the sum of the market's expectation of the firm's true earnings and the market's expectation of the bias added by the manager. For the first part – the market's expectation of true earnings – resembles the pre-report price, and there are two components: the one learned perfectly from other sources ($\varepsilon_{1,t}$) and the one known imperfectly from the history of prior reports $\left(E_t\left[\varepsilon_{2,t} | I_t^{\text{market}} \setminus \{e_t\}\right]\right)$. The second part – the market's expectation of the bias in the earnings report – which is a function of misreporting incentives, has a similar structure. Investors know one component of

[9] The second change does not occur for price changes around an earnings announcement, $p_t^{\text{post-report}} - p_t^{\text{pre-report}}$, because I assume that investors do not discount cash flows that are expected to arrive within less than 2 days.

incentives (31) from other sources and use the history of reports to form beliefs about the second component (32).

When the time-t earnings report is issued, the market uses it to update its beliefs and also learns information about fundamentals ($\varepsilon^0_{1,t+1}$) and misreporting incentives ($m^0_{1,t+1}$) related to the next time-$(t+1)$ report from concurrent sources. The next proposition describes the market's expectation of the time-$(t+1)$ earnings report right after the time-t earnings report, e_t.

Proposition 4 *In a steady-state, the market's expectation of the manager's earnings report e_{t+1} after the issuance of the manager's report e_t is*

$$ME_t^{\text{post-report}} = E\left[\tilde{e}_{t+1}|I_t^{market}\right] =$$

$$\nu^0_{1,t+1} + \nu_{1,t} + \nu_{1,t-1} \quad (33)$$

$$+\left(\alpha_0 + \delta_M\alpha_1 + \delta_M^2\alpha_2\right)\xi^0_{1,t+1} - \alpha_0\xi_{1,t-2} - \delta_M\alpha_1\xi_{1,t-1} - \delta_M^2\alpha_2\xi_{1,t} \quad (34)$$

$$+\beta_0 \times \left(e_t - E[\tilde{e}_t|I_t^{market} \setminus \{e_t\}]\right) + \beta_1 \times \left(e_{t-1} - E[\tilde{e}_{t-1}|I_{t-1}^{market} \setminus \{e_{t-1}\}]\right) + \beta_2 \times \left(e_{t-2} - E[\tilde{e}_{t-2}|I_{t-2}^{market} \setminus \{e_{t-2}\}]\right) \quad (35)$$

$$+g\left(e_{t-3}, e_{t-4}, ...e_0\right) \quad (36)$$

where β_0, β_1, and β_2 are the regression coefficients of the market's expectations of the time-$(t+1)$ earnings report on the surprise in the time-t earnings report, defined in the appendix. The function $g\left(e_{t-3}, e_{t-4}, ...e_0\right)$ is a linear function of the past earnings reports $e_{t-3}, e_{t-4}, ...e_0$.

Line (33) is the first the part of time-$(t+1)$ true earnings. After the day the time-t report was issued, the market learned new fundamental information – $\varepsilon^0_{1,t+1}$ (and thus $\nu^0_{1,t+1}$). Line (34) is part of the bias the manager will add to the time-$(t+1)$ report that the market knows about. Again, after the day the time-t report was issued, the market learned new incentives information – $m^0_{1,t+1}$ (and thus $\xi^0_{1,t+1}$). Finally, the market learns information about unobserved components of time-$(t+1)$ earnings and the manager's time-$(t+1)$ incentives from the time-t earnings report (line (35)).

During the rest of the year leading up to the time-$(t+1)$ report e_{t+1}, investors learn information about fundamentals, $\varepsilon^1_{1,t+1}$, and misreporting incentives, $m^1_{1,t+1}$ from external sources. This new information makes the market change its expectation of the time-$(t+1)$ earnings report.

Proposition 5 *In a steady-state, the change in the market's expectation of the manager's next earnings* *report e_{t+1} during the year is*

$$ME_{t+1}^{\textit{pre-report}} - ME_t^{\textit{post-report}} = E\left[\tilde{e}_{t+1} | I_{t+1}^{market} \setminus \{e_{t+1}\}\right] - E\left[\tilde{e}_{t+1} | I_t^{market}\right] = v_{1,t+1}^1 + \left(\alpha_0 + \delta_M \alpha_1 + \delta_M^2 \alpha_2\right) \xi_{1,t+1}^1 \quad (37)$$

2.2.2 Earnings Quality

I define earnings quality as the proportion of variance of earnings reports driven by the variance of the firm's true earnings:

$$EQ_t = \frac{Var[\varepsilon_t]}{Var[e_t]} = \frac{3\sigma_v^2}{3\sigma_v^2 + \left(\alpha_0 + \delta_M \alpha_1 + \delta_M^2 \alpha_2\right)^2 \sigma_\xi^2 + \alpha_0^2 \sigma_\xi^2 + \delta_M^2 \alpha_1^2 \sigma_\xi^2 + \delta_M^4 \alpha_2^2 \sigma_\xi^2} \quad (38)$$

Intuitively, earnings quality measures the amount of useful information – information about the firm's true earnings – in earnings reports. If the manager biases the report more, reporting bias will drive a larger proportion of variance of the earnings report $\left(\frac{\left(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2\right)^2\sigma_\xi^2+\alpha_0^2\sigma_\xi^2+\delta_M^2\alpha_1^2\sigma_\xi^2+\delta_M^4\alpha_2^2\sigma_\xi^2}{3\sigma_v^2+\left(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2\right)^2\sigma_\xi^2+\alpha_0^2\sigma_\xi^2+\delta_M^2\alpha_1^2\sigma_\xi^2+\delta_M^4\alpha_2^2\sigma_\xi^2} \text{ will increase}\right)$ and the firm's fundamentals will drive a smaller proportion $\left(\frac{3\sigma_v^2}{3\sigma_v^2+\left(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2\right)^2\sigma_\xi^2+\alpha_0^2\sigma_\xi^2+\delta_M^2\alpha_1^2\sigma_\xi^2+\delta_M^4\alpha_2^2\sigma_\xi^2}\right.$ will decrease); earnings quality is lower. This definition of earnings quality essentially captures the representational faithfulness and neutrality of earnings reports[10] and is consistent with the view of quality taken in prior studies (e.g., Fischer and Stocken (2004), Dichev et al. (2013)).

The amounts of the market's fundamental and misreporting incentives information – q_v and q_ξ – affect earnings quality through the price responses to the manager's report, α_0, α_1, and α_2. Figures 3 and 4 plot firm price responses to the earnings report. Following Fischer and Stocken (2004), when investors have more fundamental information (q_v increases), prices respond less to the manager's report, reducing the reward that the manager gets per unit of manipulated earnings. As a result, earnings quality improves. In contrast, when the market has more information about the manager's misreporting incentives (q_ξ increases), investors rely more on the earnings report; that is, they respond more to it. The manager's reward for misreporting increases, and earnings quality declines. Figures 5 and 6 show how earnings quality changes with the amount of fundamental and misreporting incentives information that investors have.

[10] Financial Accounting Standards Board's (FASB's) definition of representational faithfulness is "correspondence or agreement between a measure or description and the phenomenon it purports to represent" and of neutrality as the situation when "there is no bias in the selection of what is reported" (Financial Accounting Standards Board (1980)).

[Insert Figure 3 around here]

[Insert Figure 4 around here]

[Insert Figure 5 around here]

[Insert Figure 6 around here]

2.2.3 Price Efficiency

I define price efficiency as the negative variance of the difference between the firm's actual price and its intrinsic price had the market known all the information that the manager has:

$$\begin{aligned} PE_t &= -Var[p_t - \text{True Expected Value}] \\ &= -E\left[\left(E\left[\sum_{k=t+1}^{k=\infty} \delta_I^{k-t}\tilde{\varepsilon}_k | I_t^{\text{market}}\right] - E\left[+\sum_{k=t+1}^{k=\infty} \delta_I^{k-t}\tilde{\varepsilon}_k | I_t^{\text{manager}}\right]\right)^2\right] \\ &= -(1-q_v)\sigma_v^2\left(\left(\delta_I+\delta_I^2\right)^2+\delta_I^2\right)+(1-q_\xi)\sigma_\xi^2\left(\left(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2\right)^2+\left(\alpha_0+\delta_M\alpha_1\right)^2+\alpha_0^2\right) \end{aligned} \tag{39}$$

This price efficiency measure captures the amount of information asymmetry between investors and the manager about the firm's intrinsic value. If investors knew the same fundamental information as the manager ($q_v = 1$) and all the manager's incentives to manipulate information she discloses to investors ($q_\xi = 1$), the efficiency of price would be at its highest level. Such a definition is consistent with the definition of market efficiency proposed by Beaver (1981): "Market efficiency is defined ... in terms of the equality of security prices under two information configurations (i.e., with and without universal access to the information system of interest)."

In figures 7 and 8, I plot price efficiency as a function of the amounts of the market's fundamental (q_v) and misreporting incentives (q_ξ) information. In contrast to earnings quality, price efficiency increases with both types of information: the more investors know, the more efficient the price.

[Insert Figure 7 around here]

[Insert Figure 8 around here]

The fact that investors' misreporting incentives information affects earnings quality and price efficiency in opposite directions points to a potential trade-off faced by regulators. For example, a policy that requires greater disclosure of executive compensation will benefit investors because companies will trade closer to their fundamental values. At the same time, external users of financial information will suffer because the information will get noisier. The regulators' ultimate decision will be determined by their goal, that is, the extent to which they prioritize traders' needs versus the precision of reported earnings numbers.

2.2.4 The role of discount factors

Investors' response to earnings and thus earnings quality and price efficiency are sensitive to the discount rates of the manager and investors. Below I discuss how earnings quality and price efficiency vary with the extent to which investors and the manager care about the future.

Investors' discount factor affects the ERC, earnings quality, and price efficiency monotonically. When market participants care more about the future, they react more strongly to earnings information (figure 9), reducing earnings quality (figure 10). Price efficiency also shrinks as investors' discount factor increases (figure 11). When traders value future cash flows more, they put a higher weight on the expected financial performance of the firm, and the uncertainty about the fundamentals loads more in price variance.

[Insert Figure 9 around here]

[Insert Figure 10 around here]

[Insert Figure 11 around here]

The impact of the manager's discount factor is more complicated. The ERC decreases when the manager cares more about her future utility (figure 12), implying an unambiguous effect on the quality of earnings. On the one hand, when the manager values future utility more, she values the effect of her bias on future prices more and misreports more. This positive effect is offset by the decreasing ERC: as the manager is more forward-looking, investors do not react as strongly to her report, reducing the value of the bias. The two forces generate an inverse U-shaped earnings quality as a function of the manager's discount factor (figure 13). Price efficiency also changes nonmonotonically when the manager's discount factor increases (figure 14). Like the investors' discount factor, a higher manager's discount factor means the price varies more with investors' uncertainty. At the same time, this uncertainty shrinks when investors react less to the earnings. For very myopic managers, the first effect dominates, and as the manager becomes more farsighted, the second effect wins.

[Insert Figure 12 around here]

[Insert Figure 13 around here]

[Insert Figure 14 around here]

2.3 Theoretical moments and identification

In this section, I list theoretical moments and explain how they help identify model parameters: the total fundamental and misreporting incentives uncertainty, σ_v^2 and σ_ξ^2, the fractions of the information about fundamentals and misreporting incentives that the market knows, q_v and q_ξ, and the part of these fractions that investors learn from sources concurrent with earnings reports, q_v^0 and q_ξ^0. In total, I use eight theoretical moments. The first moment is a regression coefficient – earnings response coefficient. The second is the variance of earnings reports. Finally, I use covariances of earnings reports, the market's expectations of earnings reports, and firm prices with each other. I list all the moments with their mathematical expressions in the appendix.

The intuition for identification is the following. I need to disentangle, first, the manager's information from the market's information, which is a subset of the manager's; second, fundamental information from incentives information; and, third, within the market's fundamental and incentives information, information learned on earnings announcement days from information learned on other days. For the first part, for the manager's information, I use the variance of earnings reports (moment 2) since they are affected by all of the manager's information. In addition, I use the earnings response coefficient (moment 1) because it represents the amount of information in the manager's report that was unavailable to investors prior to the earnings release: if the report contains more new information, investors will react more to it. For the market's information – the part of the manager's information that investors learn from elsewhere – I use statistics that represent the evolution of price and the market's expectations of the next report (proxied by analyst forecasts) unexplained by the manager's report (moments 3-8). If prices and analyst forecasts evolve more even after controlling for the content of earnings reports, the market learns more information from sources other than the earnings reports.

For the second part, to distinguish the market's fundamental information from the market's incentives information, I rely on two assumptions. First, I assume that firm prices change only when investors update their beliefs about fundamentals but not about the manager's misreporting incentives.[11] Therefore, changes in firms' prices unexplained by the content of earnings reports (moments 3-6) represent the amount of fundamental information known by the market. The second assumption is that, when financial analysts try to predict the next earnings report, they forecast both true earnings and the bias that will be added to true earnings by the manager.[12] Since the bias increases with the manager's misreporting incentives, analyst forecasts represent a combination of the market's knowledge of fundamentals (true earnings) and the manager's incentives (bias). The evolution of analyst forecasts unexplained by earnings (moments 5-8), coupled with the knowledge of the market's fundamental information obtained from prices, helps identify the market's misreporting incentives information learned from other sources. For example, if analyst forecasts vary considerably during a year but prices do not, the market likely learned a lot of misreporting incentives information but not fundamental information.

For the third part, I exploit the timing of changes in firm prices and analyst forecasts. Residual changes in prices and analyst forecasts around earnings announcements after controlling for the content of earnings reports (moments 3, 5, and 8) represent information about fundamentals and incentives learned during the earnings announcement window from sources other than the earnings report. Changes in prices and analyst forecasts during the year excluding the earnings announcement window (moments 4, 6, and 7) indicate the amount of information investors learned on other days of the year.

Finally, I discuss one important limitation of the model that precludes the use of price variances in estimation. The model assumes that firms' prices are efficient and there is no volatility in returns due to factors not explained by the information about firm fundamentals.[13] Because price volatility may exceed fundamental volatility (LeRoy and Porter (1981), Shiller (1980)), one might worry that estimates of my model overstate the effect of the firm's reports and investors' information on prices. To avoid this upward bias, I do not use variances of firm prices as moments in the estimation. I only use covariance of price changes with earnings reports and changes in analyst forecasts. To the extent that additional noise in prices (such as discount rate variation) is uncorrelated with earnings or analyst forecasts, potential noise in prices does not affect parameter estimates.

[11]This assumption implies that the manager's price-related misreporting incentives are orthogonal to the firm's fundamental characteristics. Any correlation between the manager's incentives to manage earnings and the firm's financial performance, such as the selection of managers who are more likely to manipulate into certain kinds of companies, would violate the assumption.

[12]This assumption is consistent with the evidence that analysts try to forecast reported earnings as closely as possible because forecast precision drives their compensation and careers (Mikhail et al. (1999), Hilary and Hsu (2013)).

[13]One of these factors can be variation in discount rates. For example, Vuolteenaho (2002) finds that 33% of price variation in individual stocks is explained by discount rate variation.

3 Empirical analysis

This section describes the data I use to estimate the model, the estimation procedure, and the main results.

3.1 Data

Annual earnings reports come from IBES, balance sheet variables come from Compustat, and firm prices from CRSP. For pre-report prices, I take firms' market values one day before earnings release dates; for post-report prices, I take their market values one day after those dates. A proxy for the market's expectations is analyst earnings forecasts from IBES. For pre-report expectations, I take the last analyst forecast before an earnings release; for post-report expectations, I take the first analyst forecast after an earnings release. I multiply variables from IBES by the number of common shares outstanding on the corresponding date to obtain all the variables on the firm level. All the variables are divided by firms' three-year-lagged book values to ensure firm size does not mechanically drive firm volatility of earnings innovations. Throughout the paper, "lagged book value" implies three-year-lagged book value.

I remove firms that have missing data on one or more variables and firms with negative book value, firms with market-to-book ratio above 10, and firms with stock prices below $1. I winsorize all the variables at the 0.1% level.

The final sample contains 4,141 public firms in the United States with fiscal years from 1995 to 2019, 22,503 observations in total. Table 1 describes the sample selection procedure; table 2 presents the percent of firms in each North American Industry Classification System (NAICS) sector. More than 25% of the sample comprises manufacturers, followed by finance and insurance companies. Firms' characteristics are presented in table 3. A median company is large with a market-to-book ratio slightly above 1.5 and a healthy leverage ratio.

[Insert Table 1 around here]

[Insert Table 2 around here]

[Insert Table 3 around here]

Summary statistics for the variables used in estimation are in Table 4. Earnings surprises and changes in prices are positive on average. Analysts' forecasts generally go down during a year, consistent with the well-documented analyst forecast walk-down (e.g., Richardson et al. (2004), Bradshaw et al. (2016)): analysts tend to be more optimistic at the beginning of the forecasting period and gradually reduce their expectations as the reporting date approaches. This bias can be attributed to analysts' excessive optimism, desire to curry favor with companies' managers, or forecasting difficulty.

The standard deviation of price changes between two annual reports is about 4.6 (4.8) times greater than the standard deviation of earnings reports (analyst forecasts), consistent with the return volatility puzzle (Mehra and Prescott (1985)). Since my model is not primarily about companies' valuation, I do not aim to closely match the volatility of price changes in the data.

[Insert Table 4 around here]

3.2 Estimation Procedure

I use the Generalized Method of Moments (GMM) to estimate the model (Hansen (1982)). The method seeks the values of theoretical parameters (σ_v^2, q_v, q_v^0, σ_ξ^2, q_ξ, and q_ξ^0) that minimize the distance between theoretical moments (e.g., variance of earnings reports as a function of the theoretical parameters) and empirical moments (e.g., variance of earnings report calculated from the data). The distance is measured as a quadratic form of differences between theoretical and empirical moments with a weighting matrix. I describe the estimation procedure in the appendix.

I need to choose the discount factors of investors and the manager. For investors' discount factor, I set $\delta_I = 0.95$, which implies a discount rate of about 5%, which is close to discount rates assumed in the literature (Cooper and Ejarque (2003), Hennessy and Whited (2005), Hennessy and Whited (2007)). For the manager's discount factor, I follow Bertomeu et al. (2022) and set $\delta_M = 0.7$. Bertomeu et al. (2022) compute this discount factor using median vesting duration (Gopalan et al. (2014)).

3.3 Main Results and Model Fit

Table 5 presents the estimated parameters. The estimates suggest that, while firm earnings are volatile, investors anticipate a high portion of earnings before the report's release. For a typical firm, the standard deviation of an annual shock to earnings equals about 20.4% of the firm's lagged book value.[14] The market can anticipate around 85.5% of these fluctuations using information sources other than the manager's earnings reports. Investors learn about 22.5% of this 85.5% almost one year before the relevant earnings release

[14]This inference is calculated as $\sqrt{0.04147} \approx 0.204$.

from sources concurrent with the previous earnings report. Investors appear to know a lot about firm earnings, and only about a fifth of this knowledge is acquired when prior earnings are released, suggesting that sources other than managerial guidance or concurrent analyst reports contribute to market learning about fundamentals.

Managers' misreporting incentives are considerably more uncertain in general and more opaque to investors. For a manager at a representative firm, the standard deviation of an annual shock to the extent to what the manager's utility increases in response to a unit increase in the firm's price is about 49.2% of the company's lagged book value.[15] The market anticipates only about 35.6% of this change, a third (34.6% of 35.6%) of which is learned concurrently with the previous earnings report. The previous earnings report day is more significant for learning about reporting incentives than about fundamentals, perhaps because both company management and external analysts often disclose their expectations for next year's earnings on that day, creating a target for the manager (Matsumoto (2002)), or because prior-year earnings are often used as a benchmark to beat in the following year (Burgstahler and Dichev (1997)).

The parameter estimates allow me to evaluate levels of earnings quality and price efficiency. For earnings quality, on average, only about 33.02% of variation in annual earnings reports is driven by the variation in firms' fundamentals. The remaining 66.98% of reports' variation is due to the bias added by the manager. These numbers are reasonable, given the evidence that corporate CFOs believe that roughly 50% of companies' earnings quality is due to innate factors and the other 50% due to managers' reporting choices (Dichev et al. (2013)).[16]

I also estimate the extent of cross-sectional variation in misreporting. I find that misreporting can vary substantially from firm to firm: the standard deviation of misreporting is about 50.2% of firms' lagged book value or 7.43% of lagged total assets.[17] This result underlines the importance of considering the entire distribution of reporting bias for understanding the full picture of corporate misreporting. As Cheynel et al. (2024) find, for extreme cases of fraud, misstatement magnitudes in principle can be infinite.

The estimated level of price efficiency is -0.242, or the standard deviation of the difference between

[15] This inference is calculated as $\sqrt{0.24162} \approx 0.492$.

[16] I acknowledge that my estimate of reporting bias due to managers' stock-price-driven incentives may be exaggerated because incentives are the only source of reporting noise that I consider. My model, for example, does not account for reporting distortions by the accounting system (Beyer et al. (2019)).

[17] The average lagged book value of a company in my sample is \$2.687 billion, and the average lagged total assets are \$18.154. To estimate the standard deviation of misreporting, I evaluate the standard deviation of the reporting bias, $\sqrt{\left(\alpha_0+\delta_M\alpha_1+\delta_M^2\right)^2\sigma_\xi^2+\alpha_0^2\sigma_\xi^2+\delta_M^2\alpha_1^2\sigma_\xi^2+\delta_M^4\alpha_2^2\sigma_\xi^2}$, at the estimated parameters: $\sqrt{\left(\alpha_0+\delta_M\alpha_1+\delta_M^2\right)^2\sigma_\xi^2+\alpha_0^2\sigma_\xi^2+\delta_M^2\alpha_1^2\sigma_\xi^2+\delta_M^4\alpha_2^2\sigma_\xi^2} \approx 0.5019$. $\frac{0.502\times 2.697}{18.154} \approx 0.0743$.

firms' intrinsic prices and their actual prices is as large as about 49.2% of the firms' lagged book value or 7.28% of lagged total assets.[18] Like misreporting, the extent of mispricing due to reporting bias appears to vary a lot from firm to firm.

[Insert Table 5 around here]

Table 6 shows values of the empirical and theoretical moments at the estimated parameters and t-values of differences between the theoretical and empirical moments. For seven out of eight moments, differences between estimated theoretical and empirical values are statistically indistinguishable from zero. The one moment that is matched poorly is the variance in the market's expectations during a year not explained by fundamental information this year. The variance in the data is considerably greater than the variance produced by the model, suggesting that analyst forecasts in reality may change for reasons other than changes in firm fundamentals or misreporting incentives.

[Insert Table 6 around here]

4 Counterfactual analyses

A structural model allows researchers to predict how financial markets would behave in different counterfactual scenarios without actually implementing these scenarios. In this section, I use this advantage of structural modeling to assess how different hypothetical changes to the economic environment may affect earnings quality and price efficiency. First, I study the sensitivities of earnings quality and price efficiency to the overall uncertainty and the market's information about firm fundamentals and managers' misreporting incentives. Next I consider large changes to the information environment. Finally, I study how managers' and investors' discount rates affect earnings quality and price efficiency.

4.1 Small changes in investors' information

To better understand model parameters' marginal effects on earnings quality and price efficiency, for every parameter governing overall uncertainty or investors' knowledge, I change the estimated value by 1% up

[18] $\sqrt{0.242} \approx 0.4919$. The average lagged book value of a company in my sample is \$2.687 billion, and the average lagged total assets are \$18.154 billion. $\frac{0.492 \times 2.687}{18.154} \approx 0.0728$.

and down while keeping other parameters fixed. I then examine the resulting changes in earnings quality and price efficiency.

Histograms of sensitivities are presented in figures 15 and 16. The analysis suggests that the factor with the largest marginal effect is the amount of fundamental information known by investors. Both earnings quality and price efficiency are most sensitive to investors' fundamental information, and this sensitivity exceeds sensitivities to other economic parameters by more than three times. A policy that reduces stock market investors' information about firm fundamentals, such as a reduction in mandatory disclosures, by about 1%, will cause about a 2.68% drop in price efficiency and about a 1.51% drop in earnings quality.

The nontrivial effects of investors' misreporting incentives information can be seen in the last bar of the histograms. When investors have more information about managers' incentives, price efficiency improves while earnings quality deteriorates. Changes in the two statistics are of comparable magnitudes, suggesting a meaningful trade-off regulators face when deciding whether to increase the amount of misreporting incentives information provided to investors.

Earnings quality and price efficiency co-move when misreporting incentives uncertainty changes but move in opposite directions when fundamental uncertainty changes. A firm's price is closer to its value under full information when investors are more confident about fundamentals or misreporting incentives. This mechanism does not work for earnings quality. As misreporting incentives uncertainty rises, the noisy term in earnings reports grows, making them less informative. In contrast, higher fundamental uncertainty increases the signal-to-noise ratio in earnings, providing users of earnings numbers with better information.

[Insert figures 15 and 16 around here.]

4.2 Large changes in investors' information

Next I consider large changes in the information environment. First, I compare two scenarios: in one, fundamental uncertainty is a considerably greater concern than misreporting incentives uncertainty – perhaps an economy with a harsher regulatory environment. In another, misreporting incentives are considerably more uncertain than firms' fundamentals. Second, I consider scenarios where investors' information is close to perfect. In one scenario, investors know almost everything about companies' fundamentals; in the other, investors almost perfectly understand managers' incentives to misreport financial information.

4.2.1 Fundamental versus misreporting incentives uncertainty

The first set of counterfactual analyses aims to illuminate the characteristics of financial markets where only one type of uncertainty is a primary concern: uncertainty about fundamentals or about misreporting incentives. In scenario 1 in table 7, I set uncertainty about managers' reporting objectives close to zero. Earnings quality in this scenario is almost perfect: almost 100% of the variation in earnings reports is due to fundamental variation; in other words, report users find the report very precise and thus useful. This result is intuitive: if the manager's misreporting incentives do not vary, the manager's bias in the report is a constant, and investors can interpret any change in the report as driven by a change in firm fundamentals. As for price efficiency, mispricing is less prominent compared to the baseline estimate when managers' reporting objectives are certain: the standard deviation of the difference between actual and intrinsic prices is about 16.23% of the lagged book value.

In the scenario 2 in table 7, I reduce fundamental uncertainty to zero. When firms' fundamentals are perfectly stable, the quality of earnings is zero. Any variation in the report is due to variation in the manager's misreporting incentives and thus in the reporting noise, rendering the report useless for understanding the firm's earnings. Price efficiency is lower than in the scenario with certain misreporting incentives: the standard deviation of mispricing is about 48.84% of the lagged book value.

4.2.2 Perfect knowledge of fundamentals vs. of misreporting incentives

Next I consider scenarios where market participants know close to all information about firms' fundamentals (scenario 3 in table 7) and managers' incentives to misreport (scenario 4 in table 7). If a social planner were to choose between giving investors more fundamental or more misreporting incentives information, she would face a trade-off. Increasing fundamental information makes earnings numbers a more precise measure of true earnings while providing more information about incentives substantially improves price efficiency yet reduces earnings quality.

Counterfactual analyses demonstrate how nuanced the regulators' problem is when designing information provision systems. When investors have perfect knowledge of firms' fundamentals, earnings quality is about 30.9%, and when investors perfectly know managers' incentives, earnings quality is as low as 1.5%. At the same time, prices are substantially more efficient when investors know managers' incentives perfectly (price inefficiency is 16.17%) than when investors know fundamentals perfectly (price inefficiency is

48.85%).

If overall fundamental and incentives uncertainty are taken as fixed characteristics of an economy, whether to provide traders with information about fundamentals or incentives depends on the regulator's objective function. A regulator who mostly cares about market participants' welfare, which can be proxied by price efficiency, providing investors with as much information as possible about both fundamentals and incentives is the best strategy. Misreporting incentives information would have a greater positive effect; thus, the regulator would prioritize incentives disclosures. In contrast, a regulator seeking to make earnings numbers most informative would prefer that investors know little about misreporting incentives but can precisely predict companies' fundamental performance.

4.3 Manager's and investors' discount rates

Next I study how changes in managers' and investors' horizons affect earnings quality and price efficiency in the economy. As discussed in Section 2.2.4, both earnings quality and price efficiency decrease when investors' discount factor increases. The effect of the manager's discount factor is more nuanced: both earnings quality and price efficiency have an inverse U-shaped relationship with the manager's discount factor.

In the baseline specification, I set the manager's discount factor at $\delta_M = 0.7$ and investors' discount factor at $\delta_I = 0.95$. In table 7, I consider three counterfactual scenarios for discount factors: investors and the manager have the same discount factor (scenario 5), investors' discount factor is smaller than the manager's and both factors are low (scenario 6), and investors' discount factor is smaller than the manager's and both factors are high (scenario 7).

[Insert table 7 around here.]

Keeping the manager's discount factor constant, lowering the discount factor of investors improves earnings quality and price efficiency, although at a small rate (scenarios 5 and 6). A large drop in investors' discount factor – from 0.95 to 0.7 (0.5) – only improves earnings quality by 2.57 (4.48) percent. Price efficiency is more sensitive to investors' discounting: a drop in the discount factor to 0.7 (0.5) implies about 5.61 (8.99) percent improvement in price efficiency.

An increase in the manager's discount factor from baseline 0.7 to counterfactual 0.99 leads to a decrease in earnings quality and price efficiency, suggesting that the current state of financial markets is located at the right-hand side of the inverse U-shaped relationship (scenario 7). Earnings quality is more sensitive to the manager's discount factor than to investors', while price efficiency is less sensitive: an increase in the manager's discount factor from 0.7 to 0.99 leads to about a 9.81 percent decrease in earnings quality and a 0.98 percent decrease in price efficiency.

5 Applications: the effect of expanded compensation disclosure and information spillovers

Researchers face challenges when evaluating the effects of disclosure policies and thus can be limited in their ability to inform regulators. Leuz and Wysocki (2016) note that the reduced-form approach relies on proper identification to provide magnitudes of policies' effects. Without magnitudes, it is difficult for policymakers to weigh regulations' benefits against their costs. Moreover, even if standard empirical methods do find a credible identification strategy, it is hard for them to measure policies' externalities or economy-wide implications. Policymakers, however, must consider the complete picture of the economy and information environment in their decisions.

This study highlights that financial market qualities regulators care about – price efficiency and earnings quality – hinge on the nature of financial market investors' information. Because different objectives can be at odds for some information-related regulations, it is important to be able to disentangle the two types of information and their effects. Structural estimation can do this by directly evaluating multiple economic parameters and how they change after regulations or vary with companies' characteristics. In this section, I demonstrate how structural estimation can be applied to measure the two types of investors' information in two settings: the introduction of the CD&A section and information spillover during an earnings cycle.

5.1 Expanded compensation disclosure and investors' information

The Securities and Exchange Commission (SEC) proposed revised rules for executive compensation disclosures in January 2006. The primary goal of the regulation was to provide investors with more information about managerial compensation and its sensitivity to company performance. Consistent with theory (Fischer and Stocken (2004)), reduced-form empirical evidence confirmed that the introduction of CD&A increased the ERC (Ferri et al. (2018)), which might have increased earnings management.

It remains less clear, however, which forces drive the change in the ERC. On the one hand, CD&A since

2007 could have provided investors with more information on managerial incentives, increasing the ERC. At the same time, the financial crisis in the post-2007 period may have made investors less certain about firm fundamentals, also increasing the ERC. The two concurrent forces are difficult to disentangle using a standard reduced-form approach. To evaluate the magnitudes of the two forces, I structurally estimate my model on the pre- and post-CD&A subsamples.

The revisions of the proxy statement guidelines were released by the SEC in August 2006 and were effective for firms with the fiscal year ending on or after December 15, 2006. To estimate the effect of the regulation, I divide my sample into two groups: before and after the regulation. The before period is the fiscal year-ends before the SEC proposal date, January 26, 2006, and the after period is the fiscal year-ends after December 15, 2009.[19]

The results, presented in table 8, support both mechanisms that could drive an increase in the ERC. First, the introduction of CD&A appears to have achieved its main goal: the fraction of misreporting incentives information known by investors has increased from 38.7% before the regulation to 81.8% afterward. Next, presumably due to the financial crisis, investors' information about firms' fundamentals decreased from 86.5% to 66.9%. The findings suggest that researchers and regulators should be cautious when attributing the increase in the ERC in the post-2009 period solely to the expanded compensation disclosure. Part of this decrease is a result of concurrent changes in another aspect of investors' information – fundamental information.

The combination of more incentives and less fundamental information substantially reduced earnings quality: in the pre-2006 period; about 32% of variation in earnings reports was driven by fundamental variation. In the post-2009 period, this number falls to 16%. For price efficiency, the increase in investors' incentives information outweighed the decrease in fundamental information, and price efficiency improved in the post-2009 period.

In addition, the estimates suggest that, in the post-2009 period, the overall variance of managers' misreporting incentives considerably decreased. This change could result from the adoption of FAS 123R,[20] after which corporations reduced the number of option grants in executive compensation packages (Hayes et al. (2012)) and thus managers' incentives became more homogenous.

[19] Since in the model every shock to firm fundamentals or misreporting incentives persists for three periods, the model needs at least three periods after a shock to converge to a new steady-state.

[20] The accounting treatment of stock options changed after the adoption of FAS 123R in 2005. For a summary of the statement, see https://www.fasb.org/page/PageContent?pageId=/reference-library/superseded-standards/summary-of-statement-no-123-revised-2004.htmlbcpath=tff.

[Insert table 8 around here.]

5.2 Information spillovers and investors' information

Empirical studies have widely documented information spillovers from companies that announce earnings earlier to their peers (e.g., Ramnath (2002), Savor and Wilson (2016), Hann et al. (2019), Ogneva et al. (2021)). Ramnath (2002) shows that financial analysts and investors can better predict the earnings of firms announcing later in the reporting cycle, and the prediction partially comes from early announcers' reports. Savor and Wilson (2016) document higher abnormal returns for early announcers. The authors posit that investors use announcers' disclosures to revise their beliefs about non-announcers, which increases covariance between early announcers' and market-wide cash flow news – early announcers' systemic risk. Following that logic, late reporters should obtain lower market reactions on their reporting days because investors have more information about their fundamentals from earlier announcers' reports. However, lower market reaction to later reports can also be due to investors being more uncertain about these reporters' misreporting incentives (Trueman (1990)). To disentangle the two explanations, I estimate the structural model separately for firms that report early and those that report late in the earnings reporting cycle.

I split my sample into early and late reporters. A company is classified as a late reporter if it reports earnings later than three-quarters of companies in a given year and as an early reporter if it reports earnings earlier than three-quarters of companies in a given year. Table 9 presents the estimation results.

[Insert table 9 around here.]

The estimated parameters for early and late reporters suggest that investors do not necessarily know more about late reporters' fundamentals but rather learn more of these firms' information from sources nonconcurrent with the manager's report. Investors know about 67.4% (63.2%) of early (late) reporters' fundamental information. At the same time, about 37.4% (65.6%) of early (late) reporters' fundamentals are learned throughout the year preceding the report. An important source of information for late reporters' investors can be early reporters' reports. Thus, the spillover does not increase the total amount of fundamental information but shifts late reporters' information sources.

Consistent with the theory by Trueman (1990), late reporters' misreporting incentives are considerably more opaque to investors: the market knows about 61.9% of early reporters' incentives and only about 16.3% of late reporters' incentives. Late reporters' incentives may be more opaque because firms that report later in the earnings cycle tend to (or are believed to) manage earnings more. Trueman (1990) offers a theory that connects companies' earnings management to their choice of disclosure timing. First, earnings management itself may result in delayed reporting, and, second, a manager who wants to manipulate may choose to observe other reports first to better understand what the market's expectations are for the earnings of her firm. Whether late firms have incentives to misreport may therefore be unclear to investors, and this uncertainty appears to outweigh the gain from learning more about fundamentals from other companies' early reports.

Because investors know less about late reporters' incentives and do not know more about their fundamentals, late reporters' ERCs are smaller, and their earnings quality is higher. Their price efficiency, however, is substantially lower than that of early reporters.

6 Conclusion

Measuring how much information investors know is valuable to researchers and regulators because investors' information has an unambiguous effect on earnings quality and price efficiency. This paper develops a structural estimation technique to measure how much information the market knows about firm fundamentals and managers' misreporting incentives and how these types of information affect accounting quality and price efficiency.

I further take advantage of the technique to study two settings where investor information plays considerable role. First, I assess the effect of introducing the compensation disclosure & analysis (CD&A) section in companies' proxy statements in 2007. The structural approach allows me to disentangle multiple concurrent events in financial markets that might have affected investors' information in post-2007. I find that, while CD&A indeed provided investors with more incentives information, investors are significantly more uncertain about firm fundamentals post-2007, presumably because of the Financial Crisis. Better information about incentives outweighed increased fundamental uncertainty, and earnings quality worsened following the CD&A.

Second, I study information spillover during the earnings reporting cycle. The common belief is that investors acquire information from early reporters' disclosures and thus anticipate more of late reporters' disclosures. I refine this prediction and show that late reporters' investors do not know more fundamental information but only learn this information from other sources (presumably early reporters' reports) than early reporters. In addition, I find that late reporters' misreporting incentives are considerably more opaque to investors. As a result, late reporters have higher earnings quality and less efficient prices than early reporters.

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Table 1: Sample selection procedure.

Sample reduction reason	Sample size
Initial sample, containing all the variables needed from I/B/E/S and CRSP	81,138
Non-missing book value in Compustat	65,183
Positive book value	62,004
Market-to-book ratio less than or equal to 10	56,900
Price above or equal to $1	56,060
Firms with non-missing lagged and lead variables	22,503

Table 2: Percent of observations in NAICS sectors in the sample.

NAICS	% of total sample
Agriculture, Forestry, Fishing and Hunting	0.15
Mining	2.64
Utilities	2.58
Construction	0.96
Manufacturing	28.42
Wholesale Trade	1.60
Retail Trade	4.21
Transportation and Warehousing	2.51
Information	4.82
Finance and Insurance	15.66
Real Estate Rental and Leasing	2.78
Professional, Scientific, and Technical Services	3.98
Management of Companies and Enterprises	1.76
Administrative and Support and Waste Management and Remediation Services	1.17
Educational Services	0.40
Health Care and Social Assistance	1.11
Arts, Entertainment, and Recreation	0.70
Accommodation and Food Services	1.20
Other Services (except Public Administration)	0.28
Missing NAICS	23.06

Table 3: Descriptive statistics. All the variables are taken from or calculated from the Compustat database. The market value is the product of the firm's price multiplied by the number of shares outstanding. The book value is the product of the book value per share multiplied by the number of shares. The market-to-book ratio is market value divided by book value. ROA is net income divided by total assets. The leverage ratio is the total amount of debt divided by stockholders' equity. The number of observations for the leverage ratio is less than for other variables because not all firms in the sample have data on debt and stockholders' equity.

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
Book value (in $ 100 mil)	22,503	31.923	122.154	1.995	5.570	16.354
Market value (in $ 100 mil)	22,503	57.523	207.649	2.991	9.309	30.204
Total assets (in $ 100 mil)	22,253	183.145	1,243.988	4.492	15.256	52.119
Market-to-book ratio	22,503	2.046	1.451	1.093	1.648	2.535
ROA	22,253	0.023	0.129	0.007	0.031	0.066
Leverage ratio	17,880	0.688	1.525	0.045	0.363	0.816

Table 4: Summary statistics for the variables used in estimation. Reported earnings and analyst forecasts are from the IBES database. Prices are from CRSP database. The detailed description of variables is given in the Appendix.

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
Reported earnings, e_t	22,503	0.174	0.550	0.051	0.127	0.226
Earnings surprise, $e_t - E[\tilde{e}_t \mid I_t^{\text{market}} \setminus \{e_t\}]$	22,503	0.0004	0.087	−0.003	0.001	0.007
Price change around earnings announcements, $p_t^{\text{post-report}} - p_t^{\text{pre-report}}$	22,503	0.002	0.447	−0.066	0.001	0.078
Price change during a year, $p_{t+1}^{\text{pre-report}} - p_t^{\text{post-report}}$	22,503	0.291	2.546	−0.242	0.123	0.615
First analyst forecast after an earnings announcement, FAF_t	22,503	0.187	0.524	0.064	0.132	0.227
Analyst forecast during a year, $LAF_{t+1} - FAF_t$	22,503	−0.013	0.196	−0.029	−0.002	0.016

Table 5: Estimated model parameters. Standard errors are in parentheses. The parameters are estimated assuming discount factors $\delta_M = 0.7$ and $\delta_I = 0.95$. The estimation procedure and calculation of standard errors are described in the Appendix. Earnings quality is calculated according to the formula (38). Price inefficiency is calculated as the square of the negative (39).

Parameter	Estimate
Fundamental variance, σ_v^2	0.041 (0.004)
Market's total share of fundamental information, q_v	0.855 (0.125)
Market's share of fundamental information received concurrently with the manager's report, q_v^0	0.225 (0.047)
Incentives variance, σ_ξ^2	0.242 (0.179)
Market's total share of incentives information, q_ξ	0.356 (0.415)
Market's total share of incentives information received concurrently with the manager's report, q_ξ^0	0.346 (0.741)
Earnings quality, fraction of earnings report variance driven by fundamental variance, %	33.02
Price **in**efficiency, standard deviation of the difference between actual and intrinsic price, % of lagged book value	49.16

Table 6: Data moments and theoretical moments at the estimated parameters. The estimated parameters are in table 5. A detailed description of how theoretical and empirical moments are calculated are in the appendix. Summary statistics for data used to calculate empirical moments are in table 4. The t-statistics compare whether empirical values of the moments at each observation are statistically different from theoretical values of the moments.

	Moment	Empirical value	Theoretical value	t-statistic [p-value]
1	Earnings response coefficient	0.00036	0.0000	0.286 [0.775]
2	Variance of earnings reports	0.30267	0.37683	1.817 [0.069]
3	Covariance of the earnings report at time $(t+1)$ with residuals of the "ERC" regression at time t	0.01541	0.02162	1.250 [0.211]
4	Covariance of the earnings report at time $(t+1)$ with residuals from regressing price change during year $(t+1)$ on earnings surprise at time t	0.06588	0.07955	0.270 [0.787]
5	Covariance of residuals of the time-t "ERC" regression with residuals from regressing market expectations of time-$(t+1)$ earnings report at time t on the time-t earnings report surprise, the time-$(t-1)$ earnings report surprise, and the time-$(t-2)$ earnings report surprise	0.01301	0.02162	1.892 [0.058]
6	Covariance of the residuals from regressing price change during year $(t+1)$ on earnings surprise at time t with changes in the market's expectations of time-$(t+1)$ earnings reports during year $(t+1)$	0.06774	0.07841	0.636 [0.525]
7	Variance of change in the market's expectation of the next earnings report during a year not explained by new fundamental information learned that year	0.75947	0.04320	-6.677 [0.000]
8	Covariance of time-$(t+1)$ earnings with residuals from regressing the market's expectation of the time-$(t+1)$ earnings report on the time-t earnings report surprise, the time-$(t-1)$ earnings report surprise, and the time-$(t-2)$ earnings report surprise not explained by new fundamental information learned during year t	0.04915	0.04662	-0.107 [0.915]

Table 7: Earnings quality and price efficiency in counterfactual scenarios. Earnings quality is calculated according to the formula (38). Price efficiency is calculated as the square of the negative (39). In the counterfactual scenario 1, σ_ξ^2 is set to 0.00001. In the counterfactual scenario 2, σ_ν^2 is set to 0.00001. In the counterfactual scenario 3, q_ν is set to 0.99999. In the counterfactual scenario 4, q_ξ is set to 0.99999.

Scenario	Earnings quality, fraction of earnings report variance driven by fundamental variance, %	Price **in**efficiency, standard deviation of the difference between actual and intrinsic price, % of lagged book value
0. Baseline estimates, $\delta_I = 0.95$, $\delta_M = 0.7$.	33.02	49.16
1. Fundamental uncertainty is much greater than misreporting incentives uncertainty, $\sigma_\xi^2 \to 0$.	99.99	16.23
2. Misreporting incentives uncertainty is much greater than fundamental uncertainty, $\sigma_\nu^2 \to 0$.	0.00	48.84
3. Investors perfectly know fundamentals, $q_\nu \to 1$.	30.92	48.85
4. Investors perfectly know misreporting incentives, $q_\xi \to 1$.	1.53	16.17
5. Investors' discount factor is the same as the manager's, $\delta_I = \delta_M = 0.7$.	33.87	46.40
6. Investors' discount factor is smaller than the manager's, and both discount factors are low, $\delta_I = 0.5$, $\delta_M = 0.7$.	34.50	44.74
7. Investors' discount factor is smaller than the manager's, and both discount factors are high, $\delta_I = 0.95$, $\delta_M = 0.99$.	29.78	49.64

Table 8: Estimated model parameters before and after the introduction of CD&A. Standard errors are in parentheses. The "before CD&A" period is fiscal-year-ends before January 26, 2006. The "after CD&A" period is fiscal-year-ends after December 15, 2009. The parameters are estimated assuming discount factors $\delta_M = 0.7$ and $\delta_I = 0.95$. The estimation procedure and calculation of standard errors are described in the Appendix. Earnings quality is calculated according to the formula (38). Price inefficiency is calculated as the square of the negative (39).

Parameter	Before CD&A	After CD&A
Fundamental variance, σ_v^2	0.029 (0.017)	0.019 (0.003)
Market's total share of fundamental information, q_v	0.865 (0.207)	0.669 (0.394)
Market's share of fundamental information received concurrently with the manager's report, q_v^0	0.265 (0.119)	0.345 (0.209)
Incentives variance, σ_ξ^2	0.178 (0.100)	0.078 (0.047)
Market's total share of incentives information, q_ξ	0.387 (0.882)	0.818 (0.245)
Market's total share of incentives information received concurrently with the manager's report, q_ξ^0	0.225 (1.275)	0.153 (0.248)
Earnings quality, fraction of earnings report variance driven by fundamental variance, %	32.21	15.77
Price **in**efficiency, standard deviation of the difference between actual and intrinsic price, % of lagged book value	40.44	30.31

Table 9: Estimated model parameters for early and late earnings reporters. Standard errors are in parentheses. A company is classified as a late reporter if it reports earnings later than three-quarters of companies in a given year, and as an early reporter if it reports earnings earlier than three-quarters of companies in a given year. The parameters are estimated assuming discount factors $\delta_M = 0.7$ and $\delta_I = 0.95$. The estimation procedure and calculation of standard errors are described in the Appendix. Earnings quality is calculated according to the formula (38). Price inefficiency is calculated as the square of the negative (39).

Parameter	Early reporters	Late reporters
Fundamental variance, σ_v^2	0.009 (0.028)	0.025 (0.004)
Market's total share of fundamental information, q_v	0.674 (0.528)	0.632 (0.341)
Market's share of fundamental information received concurrently with the manager's report, q_v^0	0.626 (0.626)	0.344 (0.187)
Incentives variance, σ_ξ^2	0.252 (0.658)	0.119 (0.185)
Market's total share of incentives information, q_ξ	0.619 (0.779)	0.163 (0.990)
Market's total share of incentives information received concurrently with the manager's report, q_ξ^0	0.361 (0.374)	0.748 (6.362)
Earnings quality, fraction of earnings report variance driven by fundamental variance, %	9.73	28.45
Price **in**efficiency, standard deviation of the difference between actual and intrinsic price, % of lagged book value	36.61	49.62

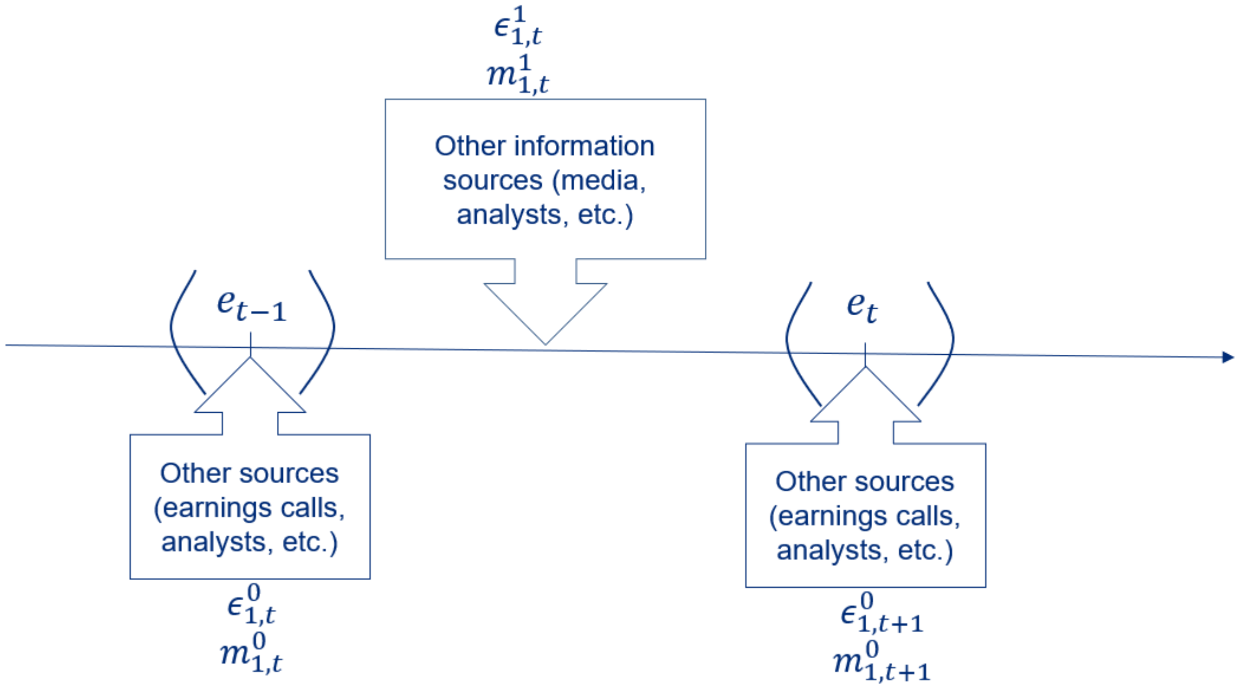

Figure 1: Timing of information arrivals to investors in the model. e_τ is an earnings report issued at time τ, ε_τ and m_τ are investors' earnings and misreporting incentives information related to the earnings report at time τ.

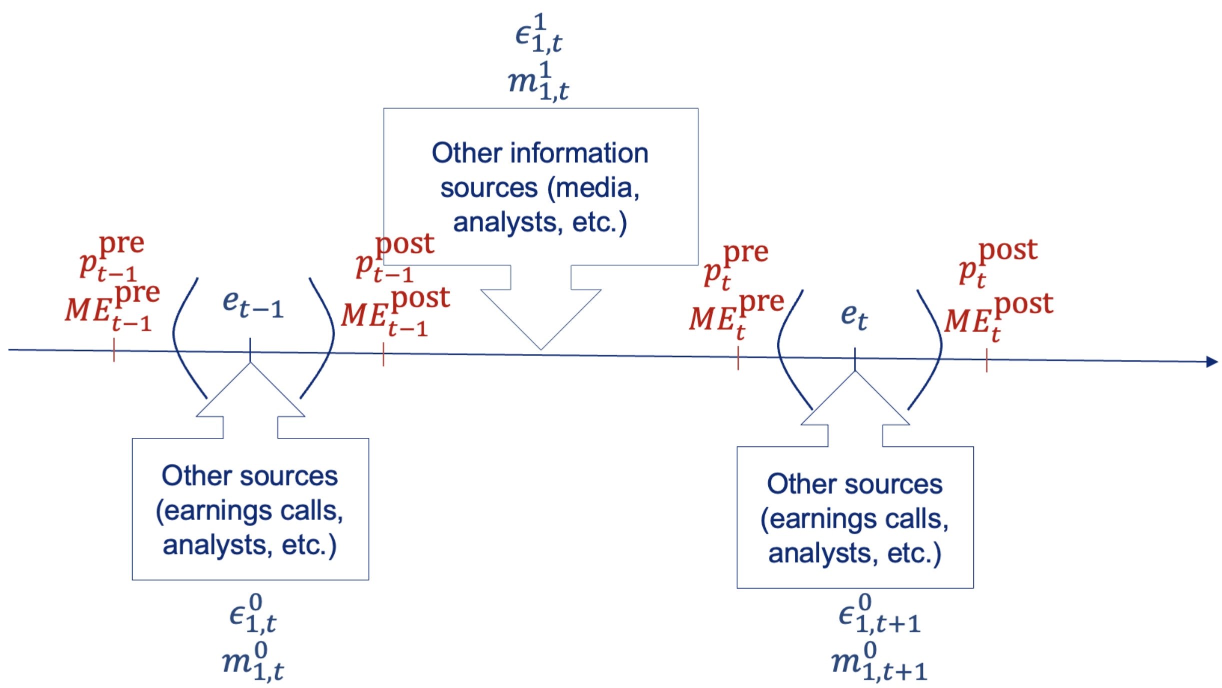

Figure 2: Timing of formation of the firm's prices and the market's expectations.

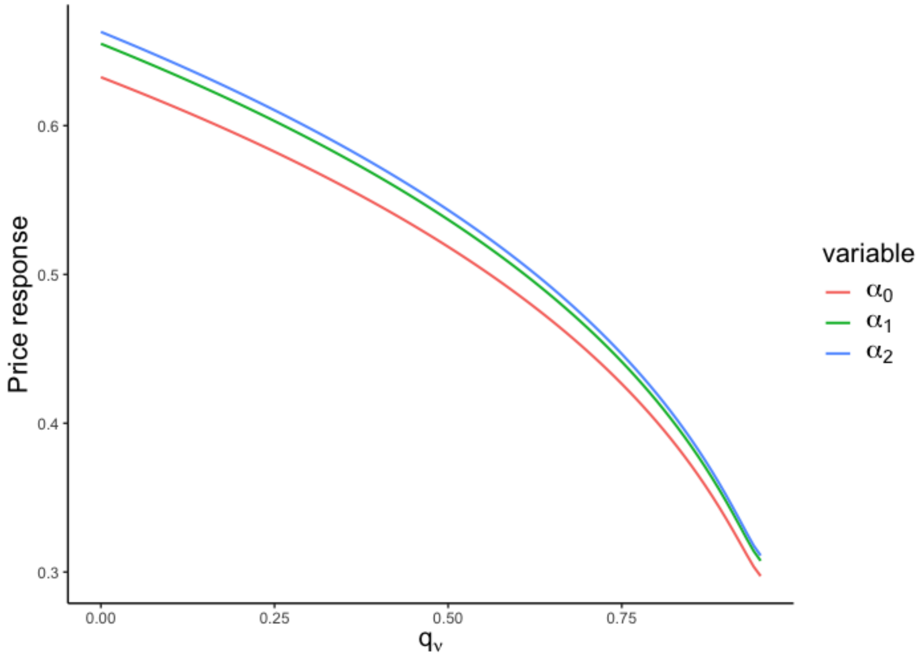

Figure 3: Price responses to the manager's report as a function of the market's fundamental information, q_ν. $\sigma_\nu^2 = 0.8$, $q_\xi = 0.6$, $\sigma_\xi^2 = 0.5$, $\delta_M = 0.9$, $\delta_I = 0.9$.

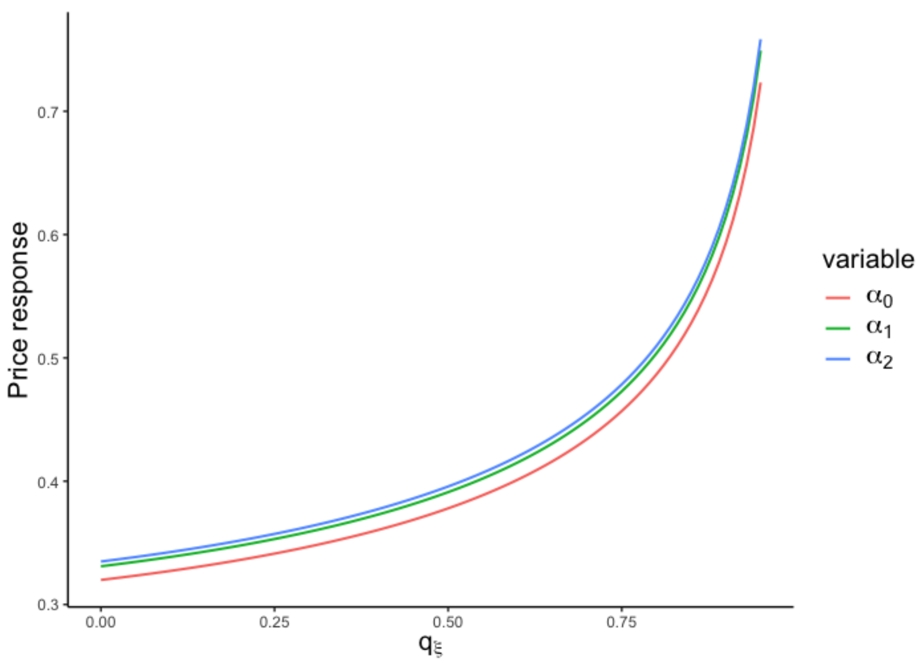

Figure 4: Price responses to the manager's report as a function of the market's misreporting incentives information, q_ξ. $q_\nu = 0.8$, $\sigma_\nu^2 = 0.08$, $\sigma_\xi^2 = 0.5$, $\delta_M = 0.9$, $\delta_I = 0.9$.

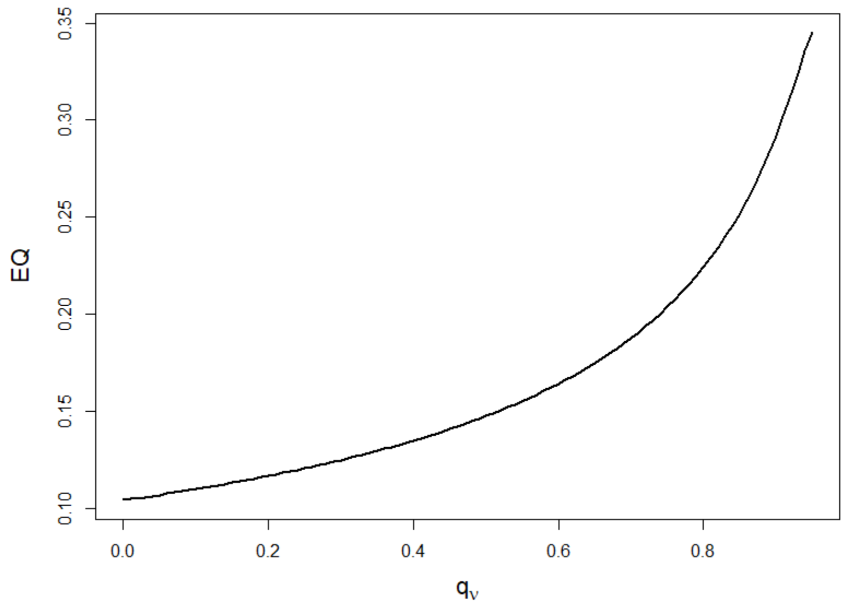

Figure 5: Earnings quality as a function of the market's fundamental information, q_ν. $\sigma_\nu^2 = 0.08$, $q_\xi = 0.6$, $\sigma_\xi^2 = 0.5$, $\delta_M = 0.9$, $\delta_I = 0.9$.

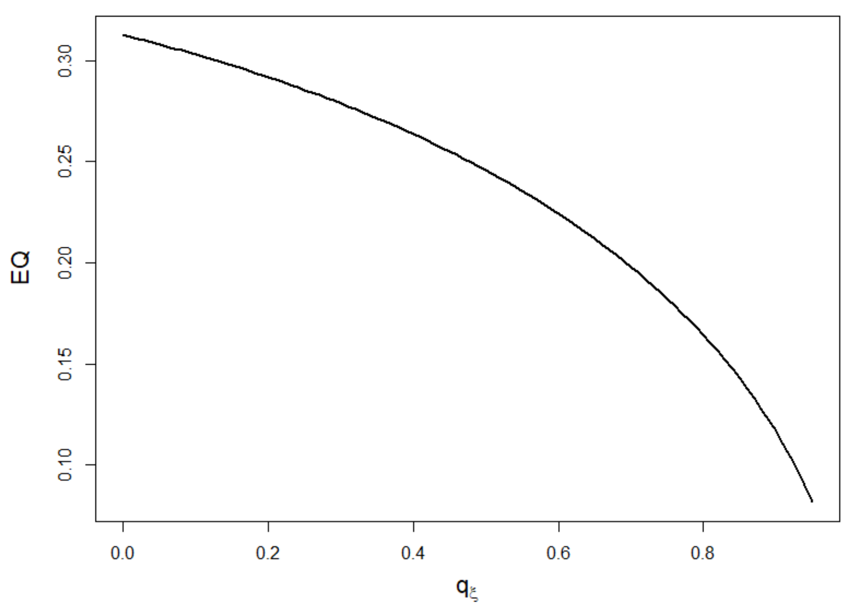

Figure 6: Earnings quality as a function of the market's misreporting incentives information, q_ξ. $q_\nu = 0.8$, $\sigma_\nu^2 = 0.08$, $\sigma_\xi^2 = 0.5$, $\delta_M = 0.9$, $\delta_I = 0.9$.

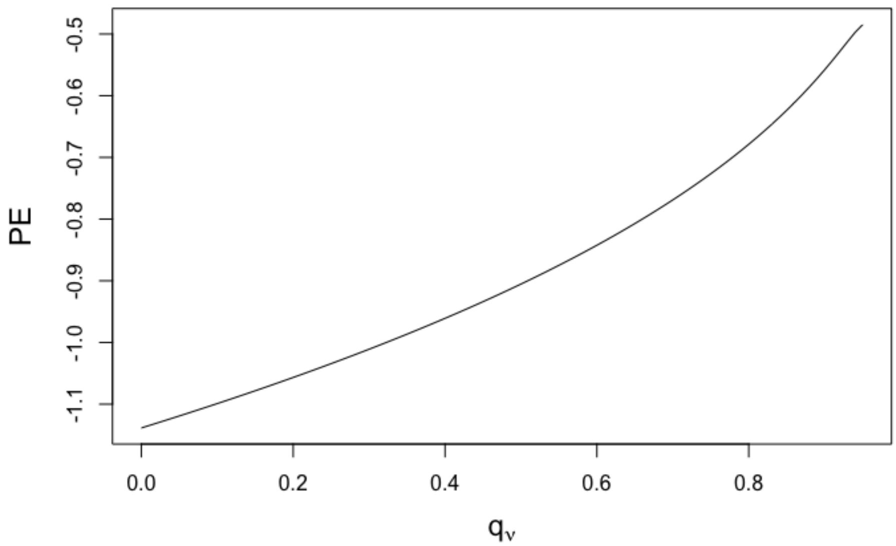

Figure 7: Price efficiency as a function of the market's fundamental information, q_ν. $\sigma_\nu^2 = 0.08$, $q_\xi = 0.6$, $\sigma_\xi^2 = 0.5$, $\delta_M = 0.9$, $\delta_I = 0.9$.

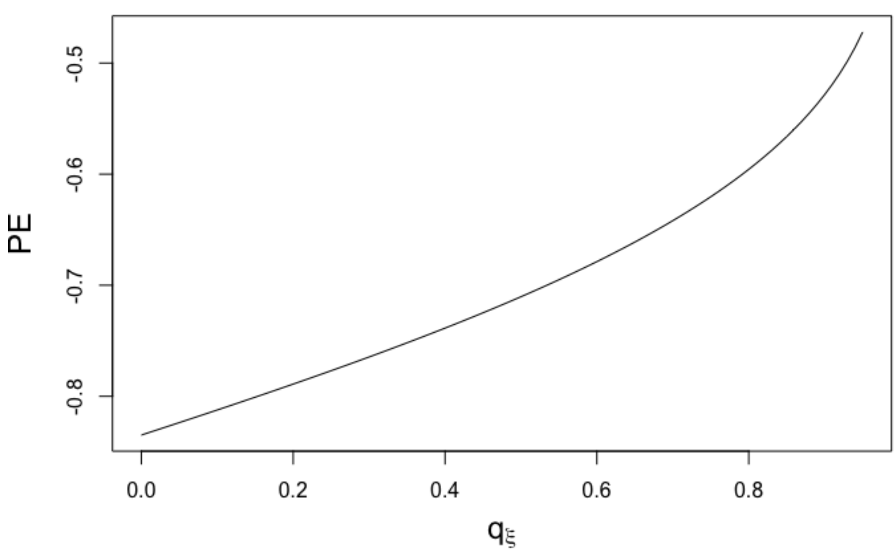

Figure 8: Price efficiency as a function of the market's misreporting incentives information, q_ξ. $q_\nu = 0.8$, $\sigma_\nu^2 = 0.08$, $\sigma_\xi^2 = 0.5$, $\delta_M = 0.9$, $\delta_I = 0.9$.

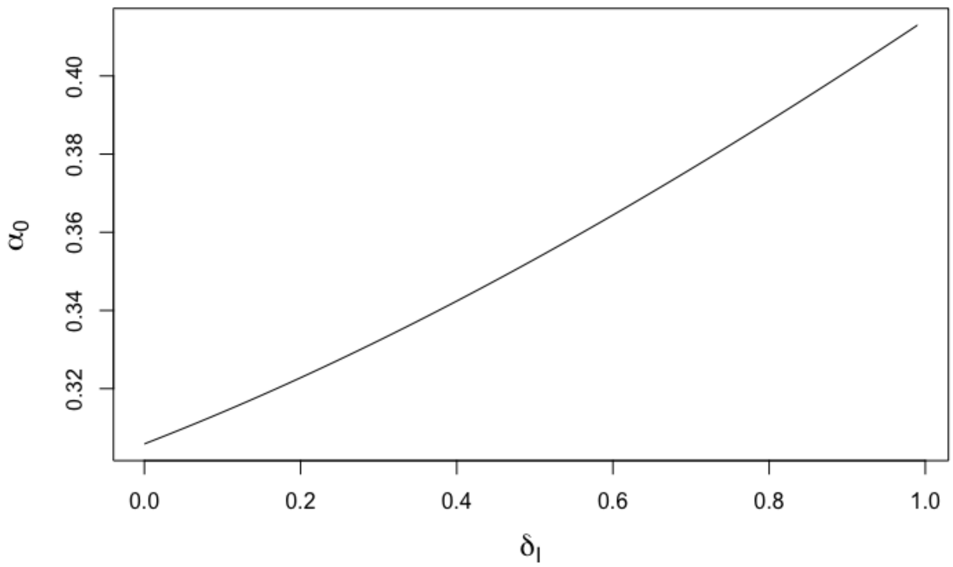

Figure 9: Earnings response coefficient as a function of investors' discount factor, δ_I. $q_\nu = 0.8, \sigma_\nu^2 = 0.08$, $q_\xi = 0.6$, $\sigma_\xi^2 = 0.5$, $\delta_M = 0.9$.

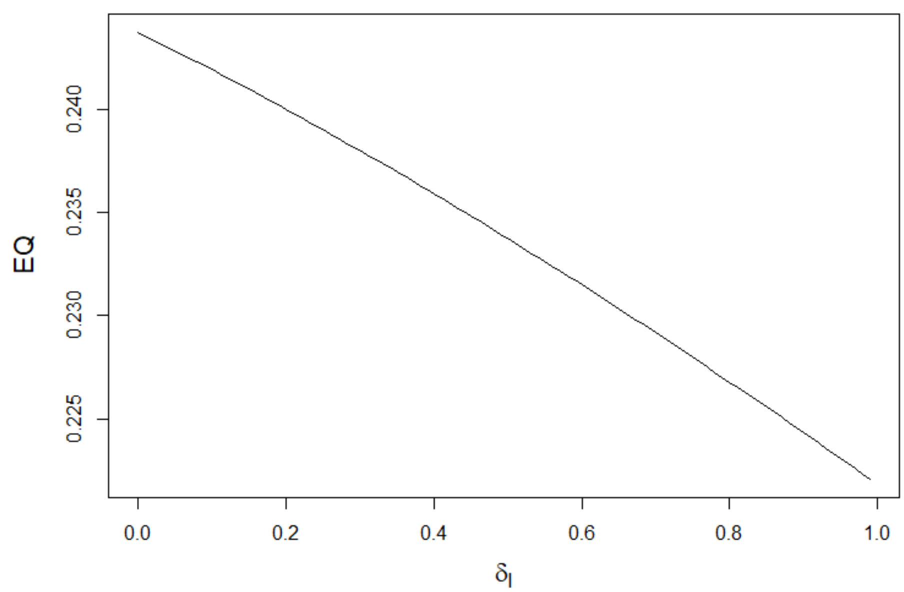

Figure 10: Earnings quality as a function of investors' discount factor, δ_I. $q_\nu = 0.8, \sigma_\nu^2 = 0.08$, $q_\xi = 0.6$, $\sigma_\xi^2 = 0.5$, $\delta_M = 0.9$.

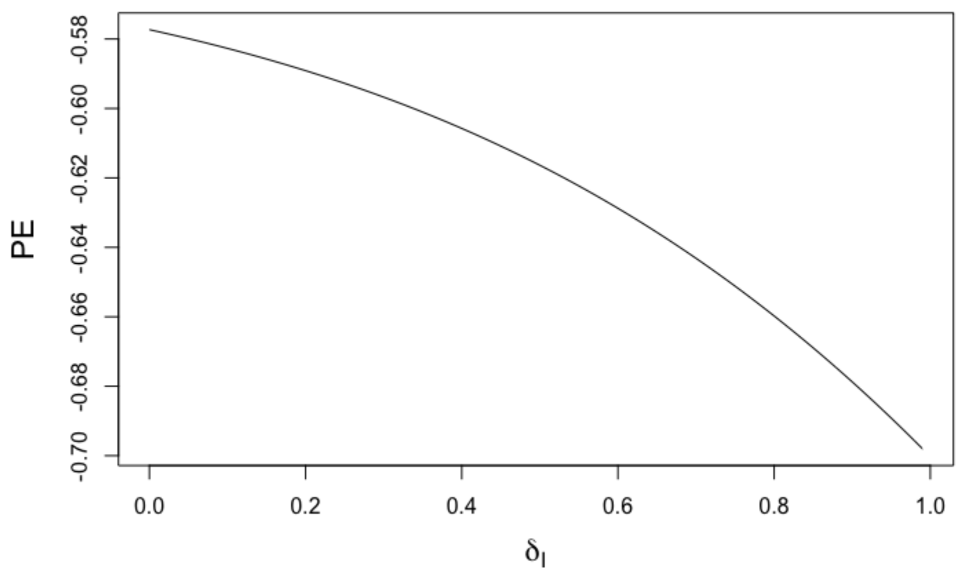

Figure 11: Price efficiency as a function of investors' discount factor, δ_I. $q_\nu = 0.8, \sigma_\nu^2 = 0.08$, $q_\xi = 0.6$, $\sigma_\xi^2 = 0.5$, $\delta_M = 0.9$.

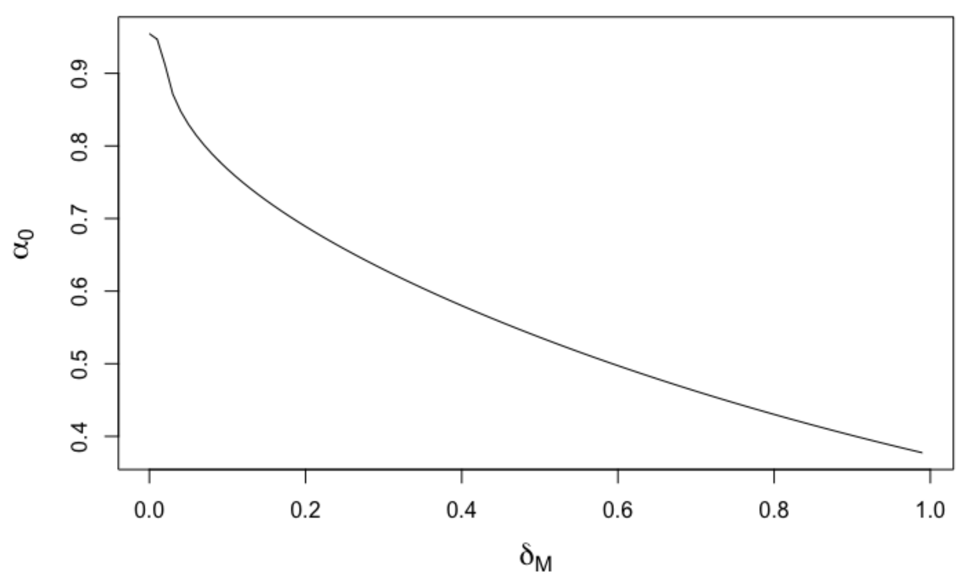

Figure 12: Earnings response coefficient as a function of the manager's discount factor, δ_M. $q_\nu = 0.8, \sigma_\nu^2 = 0.08$, $q_\xi = 0.6$, $\sigma_\xi^2 = 0.5$, $\delta_I = 0.9$.

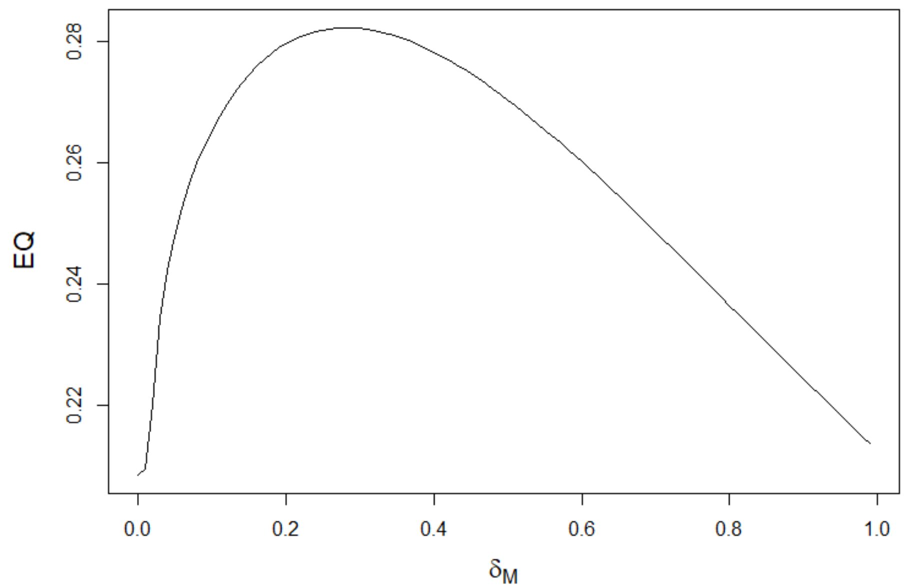

Figure 13: Earnings quality as a function of the manager's discount factor, δ_M. $q_\nu = 0.8, \sigma_\nu^2 = 0.08, q_\xi = 0.6, \sigma_\xi^2 = 0.5, \delta_I = 0.9$.

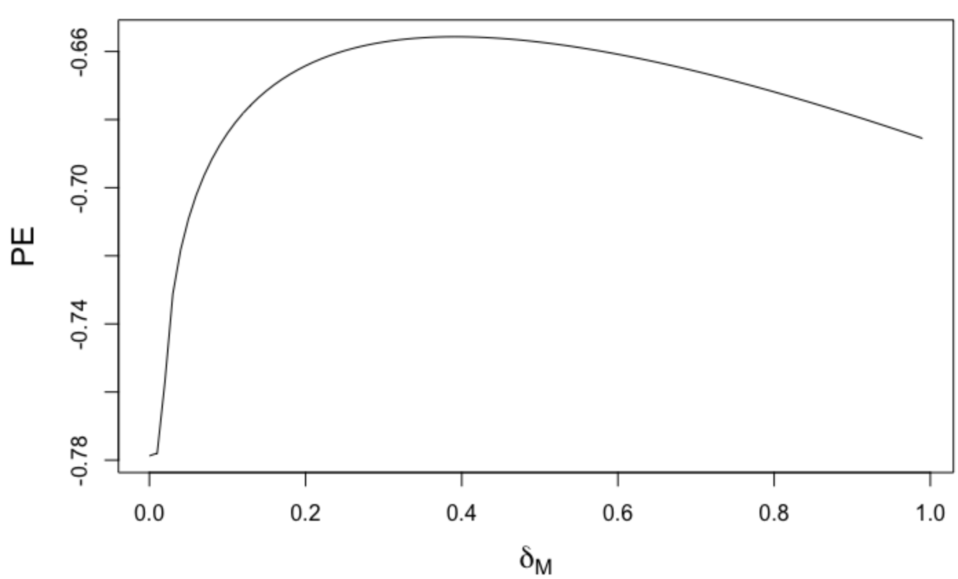

Figure 14: Price efficiency as a function of the manager's discount factor, δ_M. $q_\nu = 0.8, \sigma_\nu^2 = 0.08, q_\xi = 0.6, \sigma_\xi^2 = 0.5, \delta_I = 0.9$.

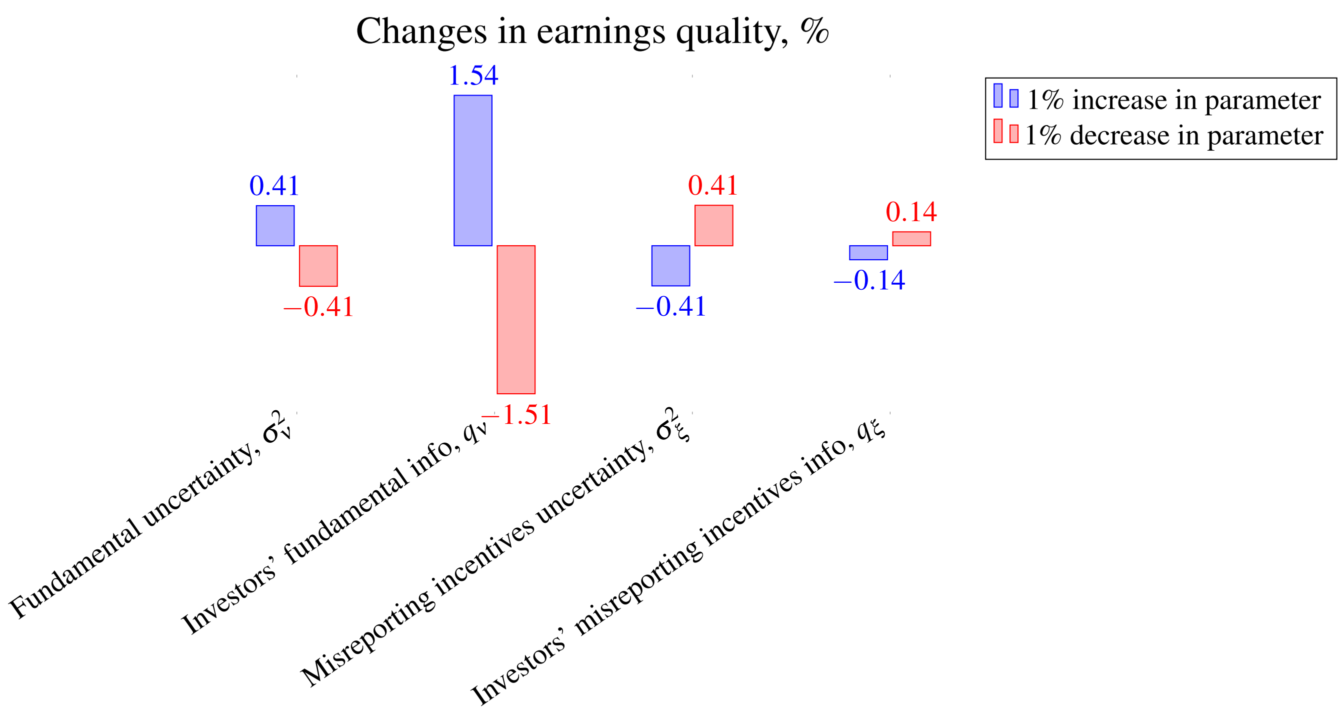

Figure 15: Sensitivity of earnings quality to model parameters. Parameter estimates and the baseline level of earnings quality are in Table 5. To compute an effect of a 1% parameter increase (decrease) on earnings quality, I increase (decrease) the value of this parameter by 1% from the estimated levels, keeping other parameters unchanged, and compute percentage change in the earnings quality relative to the baseline level. Earnings quality is calculated according to the formula (38).

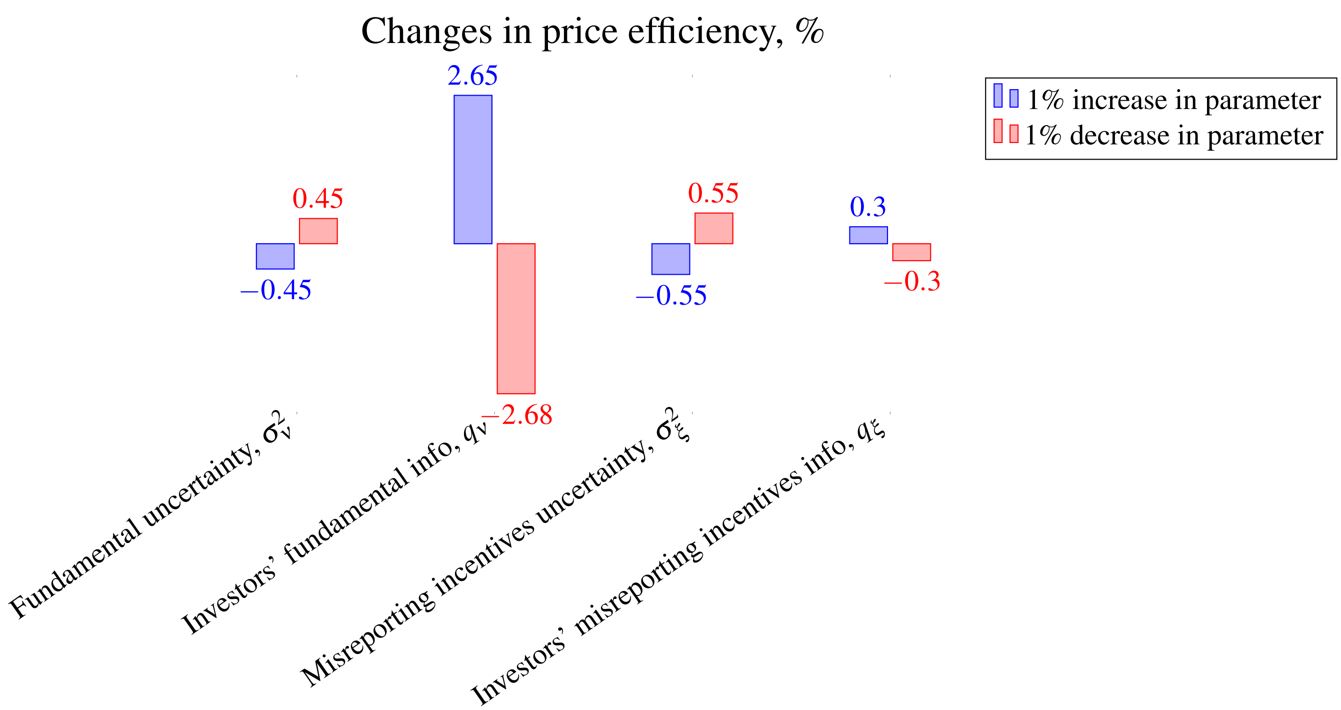

Figure 16: Sensitivity of price efficiency to model parameters. Parameter estimates and the baseline level of price efficiency are in Table 5. To compute an effect of a 1% parameter increase (decrease) on price efficiency, I increase (decrease) the value of this parameter by 1% from the estimated levels, keeping other parameters unchanged, and compute percentage change in the price efficiency relative to the baseline level. Price efficiency is calculated according to the formula (39).

Appendix

A.1 Proof of Proposition 1

Let us start with a manager who has finite tenure, that is, works at a firm with certainty up until time T. At time T, the manager's problem is:

$$\max_{r_T} \quad m_T p_T - \frac{\left(e_T - \varepsilon_T + \sum_{k=0}^{T-1}(e_k - \varepsilon_k)\right)^2}{2} \tag{A40}$$

$$= m_T(p_0 + \sum_{j=0}^{j=T} \alpha_j^T e_j + \sum_{j=0}^{j=T} \beta_j^{0,T} \varepsilon_{1,j}^0 + \sum_{j=0}^{j=T} \beta_j^{1,T} \varepsilon_{1,j}^1 + \sum_{j=0}^{j=T} \gamma_j^{0,T} m_{1,j}^0 + \sum_{j=0}^{j=T} \gamma_j^{1,T} m_{1,j}^1)$$
$$- \frac{\left(e_T - \varepsilon_T + \sum_{k=0}^{T-1}(e_k - \varepsilon_k)\right)^2}{2} \tag{A41}$$

The optimal report is:

$$e_T^* = \varepsilon_T - \sum_{k=0}^{T-1}(e_k - \varepsilon_k) + m_T \alpha_T^T \tag{A42}$$

Given the optimal choice at time T, the manager's problem at time $T-1$ is:

$$\max_{r_{T-1}} \quad m_{T-1} p_{T-1} - \frac{\left(e_{T-1} - \varepsilon_{T-1} + \sum_{k=0}^{T-2}(e_k - \varepsilon_k)\right)^2}{2} + \delta_M E_{T-1}[U_T] \tag{A43}$$

The expected utility at time T is

$$E_{T-1}[U_T] = E_{T-1}[m_T p_T + \frac{(m_T \alpha_T^T)^2}{2}] = E_{T-1}[m_T] \times$$
$$\left(p_0 + \sum_{j=0}^{j=T-1} \alpha_j^{T-1} e_j + \sum_{j=0}^{j=T-1} \beta_j^{0,T-1} \varepsilon_{1,j}^0 + \sum_{j=0}^{j=T-1} \beta_j^{1,T-1} \varepsilon_{1,j}^1 + \sum_{j=0}^{j=T-1} \gamma_j^{0,T-1} m_{1,j}^0 + \sum_{j=0}^{j=T-1} \gamma_j^{1,T-1} m_{1,j}^1\right)$$
$$+ E_{T-1}[\frac{(m_T \alpha_T^T)^2}{2}] \tag{A44}$$

The optimal report at time $T-1$ is

$$e_{T-1} = \varepsilon_{T-1} - \sum_{k=0}^{T-2}(e_k - \varepsilon_k) + m_{T-1} \alpha_{T-1}^{T-1} + \delta_M E_{T-1}[m_T] \alpha_{T-1}^T \tag{A45}$$

By induction, the manager's optimal report at time t is

$$e_t = \varepsilon_t - \sum_{k=0}^{t-1}(e_k - \varepsilon_k) + m_t\alpha_t^t + \delta_M\alpha_t^{t+1}E_t[m_{t+1}] + \delta_M^2\alpha_t^{t+2}E_t[m_{t+2}] \tag{A46}$$

Now work forwards starting from $t = 0$:

$$e_0 = \varepsilon_0 + \alpha_0^0 m_0 + \delta_M\alpha_0^1 E_0[m_1] + \delta_M^2\alpha_0^2 E_0[m_2] \tag{A47}$$

$$\begin{aligned} e_1 = \varepsilon_1 &- \left(\alpha_0^0 m_0 + \delta_M\alpha_0^1 E_0[m_1] + \delta_M^2\alpha_0^2 E_0[m_2]\right) \\ &+ \alpha_1^1 m_1 + \delta_M\alpha_1^2 E_1[m_2] + \delta_M^2\alpha_1^3 E_1[m_3] \end{aligned} \tag{A48}$$

$$\begin{aligned} e_2 = \varepsilon_2 - \left(-\left(\alpha_0^0 m_0 + \delta_M\alpha_0^1 E_0[m_1] + \delta_M^2\alpha_0^2 E_0[m_2]\right) + \alpha_1^1 m_1 + \delta_M\alpha_1^2 E_1[m_2] + \delta_M^2\alpha_1^3 E_1[m_3]\right) \\ - \left(\alpha_0^0 m_0 + \delta_M\alpha_0^1 E_0[m_1] + \delta_M^2\alpha_0^2 E_0[m_2]\right) \\ + \alpha_2^2 m_2 + \delta_M\alpha_2^3 E_2[m_3] + \delta_M^2\alpha_2^4 E_2[m_4] \\ = \varepsilon_2 - \left(\alpha_1^1 m_1 + \delta_M\alpha_1^2 E_1[m_2] + \delta_M^2\alpha_1^3 E_1[m_3]\right) \\ + \alpha_2^2 m_2 + \delta_M\alpha_2^3 E_2[m_3] + \delta_M^2\alpha_2^4 E_2[m_4] \end{aligned} \tag{A49}$$

Finally,

$$e_t = \varepsilon_t + \alpha_t^t m_t + \sum_{k=0}^{\infty}\delta_M^k\alpha_t^{t+k}E_t[m_{t+k}] - \alpha_{t-1}^{t-1}m_{t-1} - \sum_{k=0}^{\infty}\delta_M^k\alpha_{t-1}^{t+k}E_{t-1}[m_{t+k}] \tag{A50}$$

In the paper, I focus on the steady-state, i.e. $T \to \infty$.

A.2 Proof of Proposition 2

Denote by α_0, α_1 and α_2 the steady-state responses of current, one-year ahead and two-years ahead prices' to a current managerial report. Managerial report in steady-state is then:

$$e_t = \varepsilon_t + (\alpha_0 + \delta_M\alpha_1 + \delta_M^2\alpha_2)\xi_t - \alpha_0\xi_{t-3} - \delta_M\alpha_1\xi_{t-2} - \delta_M^2\alpha_2\xi_{t-1} \tag{A51}$$

Right before the report e_t is released, variance of the report from investors' perspective is

$$\begin{aligned} Var[e_t] = (1-q_\nu)\sigma_\nu^2 + Var[\nu_{2,t-1}|e_{t-1}] + Var[\nu_{2,t-2}|e_{t-1}, e_{t-2}] \\ +(1-q_\xi)\sigma_\xi^2(\alpha_0 + \delta_M\alpha_1 + \delta_M^2\alpha_2)^2 + Var[\xi_{2,t-1}|e_{t-1}]\delta_M^4\alpha_2^2 \\ +Var[\xi_{2,t-2}|e_{t-1}, e_{t-2}]\delta_M^2\alpha_1^2 + Var[\xi_{2,t-3}|e_{t-1}, e_{t-2}, e_{t-3}]\alpha_0^2 \end{aligned} \quad \text{(A52)}$$

Denote $\sigma_{\nu 1}^2 \equiv Var[\nu_{2,t-1}|e_{t-1}]$, $\sigma_{\nu 2}^2 \equiv Var[\nu_{2,t-2}|e_{t-1}, e_{t-2}]$, $\sigma_{\xi 1}^2 \equiv Var[\xi_{2,t-1}|e_{t-1}]$, $\sigma_{\xi 2}^2 \equiv Var[\xi_{2,t-2}|e_{t-1}, e_{t-2}]$, and $\sigma_{\xi 3}^2 \equiv Var[\xi_{2,t-3}|e_{t-1}, e_{t-2}, e_{t-3}]$. In this notation,

$$Var[e_t] = (1-q_\nu)\sigma_\nu^2 + \sigma_{\nu 1}^2 + \sigma_{\nu 2}^2 + (1-q_\xi)\sigma_\xi^2(\alpha_0 + \delta_M\alpha_1 + \delta_M^2\alpha_2)^2 + \sigma_{\xi 1}^2\delta_M^4\alpha_2^2 + \sigma_{\xi 2}^2\delta_M^2\alpha_1^2 + \sigma_{\xi 3}^2\alpha_0^2 \quad \text{(A53)}$$

$$cov[e_t, \nu_t] = \sigma_\nu^2(1-q_\nu) \quad \text{(A54)}$$

Therefore,

$$\begin{aligned} Var[\nu_t|e_t] = (1-q_\nu)\sigma_\nu^2 \\ -\frac{(1-q_\nu)^2\sigma_\nu^4}{(1-q_\nu)\sigma_\nu^2 + \sigma_{\nu 1}^2 + \sigma_{\nu 2}^2 + (1-q_\xi)\sigma_\xi^2(\alpha_0 + \delta_M\alpha_1 + \delta_M^2\alpha_2)^2 + \sigma_{\xi 1}^2\delta_M^4\alpha_2^2 + \sigma_{\xi 2}^2\delta_M^2\alpha_1^2 + \sigma_{\xi 3}^2\alpha_0^2} \end{aligned} \quad \text{(A55)}$$

In the steady-state, σ_{v1}^2, σ_{v2}^2, $\sigma_{\xi 1}^2$, $\sigma_{\xi 2}^2$, and $\sigma_{\xi 3}^2$ are the solution to:

$$\begin{aligned} \sigma_{v1}^2 &= (1-q_v)\sigma_v^2 \\ &- \frac{(1-q_v)^2\sigma_v^4}{(1-q_v)\sigma_v^2+\sigma_{v1}^2+\sigma_{v2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \quad \text{(A56)} \\ \sigma_{v2}^2 &= \sigma_{v1}^2 \\ &- \frac{\sigma_{v1}^4}{(1-q_v)\sigma_v^2+\sigma_{v1}^2+\sigma_{v2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \quad \text{(A57)} \\ \sigma_{\xi 1}^2 &= (1-q_\xi)\sigma_\xi^2 \\ &- \frac{(1-q_\xi)^2\sigma_\xi^4}{(1-q_v)\sigma_v^2+\sigma_{v1}^2+\sigma_{v2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \quad \text{(A58)} \\ \sigma_{\xi 2}^2 &= \sigma_{\xi 1}^2 \\ &- \frac{\sigma_{\xi 1}^4\delta_M^8\alpha_2^4}{(1-q_v)\sigma_v^2+\sigma_{v1}^2+\sigma_{v2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \quad \text{(A59)} \\ \sigma_{\xi 3}^2 &= \sigma_{\xi 2}^2 \\ &- \frac{\sigma_{\xi 2}^4\delta_M^4\alpha_1^4}{(1-q_v)\sigma_v^2+\sigma_{v1}^2+\sigma_{v2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \quad \text{(A60)} \end{aligned}$$

The change in the firm's price around the earnings report release includes updating based on the report and on the concurrent information. The concurrent information provides $v_{1,t+1}^0$, and the earnings report provides information about $v_{2,t}$, $v_{2,t-1}$, and $v_{2,t-2}$.

$$\begin{aligned} p_t^{\text{post-report}} - p_t^{\text{pre-report}} &= \left(\delta_I+\delta_I^2+\delta_I^3\right)v_{1,t+1}^0 \quad \text{(A61)} \\ &+(1+\delta_I+\delta_I^2)\left(e_t - E\left[e_t|I_t^{\text{market}}\setminus\{e_t\}\right]\right) \\ &\times \frac{(1-q_v)\sigma_v^2}{(1-q_v)\sigma_v^2+\sigma_{v1}^2+\sigma_{v2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \quad \text{(A62)} \\ &+(1+1+\delta_I)\left(e_t - E\left[e_t|I_t^{\text{market}}\setminus\{e_t\}\right]\right) \\ &\times \frac{\sigma_{v1}^2}{(1-q_v)\sigma_v^2+\sigma_{v1}^2+\sigma_{v2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \quad \text{(A63)} \\ &+3\left(e_t - E\left[e_t|I_t^{\text{market}}\setminus\{e_t\}\right]\right) \\ &\times \frac{\sigma_{v2}^2}{(1-q_v)\sigma_v^2+\sigma_{v1}^2+\sigma_{v2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2}, \quad \text{(A64)} \end{aligned}$$

where $\left(e_t - E\left[e_t|I_t^{\text{market}}\setminus\{e_t\}\right]\right)\frac{(1-q_v)\sigma_v^2}{(1-q_v)\sigma_v^2+\sigma_{v1}^2+\sigma_{v2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} = E[v_{2,t}|e_t]$,
$\left(e_t - E\left[e_t|I_t^{\text{market}}\setminus\{e_t\}\right]\right)\frac{\sigma_{v1}^2}{(1-q_v)\sigma_v^2+\sigma_{v1}^2+\sigma_{v2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} = E[v_{2,t-1}|e_t, e_{t-1}]$,

and $\left(e_t - E\left[e_t | I_t^{\text{market}} \setminus \{e_t\}\right]\right) \frac{\sigma_{\nu 2}^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} =$ $E[\nu_{2,t-2}|e_t, e_{t-1}, e_{t-2}]$. The earnings response coefficients solve

$$\alpha_0 = \frac{(1+\delta_I+\delta_I^2)(1-q_\nu)\sigma_\nu^2+(2+\delta_I)\sigma_{\nu 1}^2+3\sigma_{\nu 2}^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \quad \text{(A65)}$$

$$\alpha_1 = \frac{(2+\delta_I)(1-q_\nu)\sigma_\nu^2+3\sigma_{\nu 1}^2+3\sigma_{\nu 2}^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \quad \text{(A66)}$$

$$\alpha_2 = \frac{3\left((1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2\right)}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \quad \text{(A67)}$$

A.3 Proof of Proposition 3

Between any two earnings reports, the market only learns about ε_1^1 and m_1^1. Since ε_1 and ε_2 and m_1 and m_2 are independent, the market's beliefs about ε_2 and m_2 remain unchanged: $E[e_t|I_{t+1}^{\text{market}} \setminus \{e_t\}] = E[e_t|I_t^{\text{market}}]$.

The change in the firm price during a year between two earnings reports is

$$\begin{aligned} p_{t+1}^{\text{pre-report}} - p_t^{\text{post-report}} &= \left(\nu_{1,t+1}^1+\nu_{1,t+1}^0\right)+\left(\delta_I\nu_{1,t+1}^1+\delta_I\nu_{1,t+1}^0\right) \\ &+\left(\delta_I^2\nu_{1,t+1}^1+\delta_I^2\nu_{1,t+1}^0\right)-\left(\delta_I+\delta_I^2+\delta_I^3\right)\nu_{1,t+1}^0 \\ &+\left(e_t-E[e_t]\right)\times(\alpha_1-\alpha_0) \end{aligned} \quad \text{(A68)}$$

A.4 Proof of Proposition 4

$$\begin{aligned} &E_t[\xi_{2,t}|e_t] \\ &= \left(e_t - E\left[e_t|I_t^{\text{market}}\setminus\{e_t\}\right]\right)\times\frac{(1-q_\xi)\sigma_\xi^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \end{aligned} \quad \text{(A69)}$$

$$\begin{aligned} &E_t[\xi_{2,t-1}|e_t,e_{t-1}] \\ &= \left(e_{t-1} - E\left[e_{t-1}|I_{t-1}^{\text{market}}\setminus\{e_{t-1}\}\right]\right)\times\frac{(1-q_\xi)\sigma_\xi^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \\ &+ \left(e_t - E\left[e_t|I_t^{\text{market}}\setminus\{e_t\}\right]\right)\times\frac{\sigma_{\xi 1}^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \end{aligned} \quad \text{(A70)}$$

$$\begin{aligned} &E_t[\xi_{2,t-2}|e_t,e_{t-1},e_{t-2}] \\ &= \left(e_{t-2} - E\left[e_{t-2}|I_{t-2}^{\text{market}}\setminus\{e_{t-2}\}\right]\right)\times\frac{(1-q_\xi)\sigma_\xi^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \\ &+ \left(e_{t-1} - E\left[e_{t-1}|I_{t-1}^{\text{market}}\setminus\{e_{t-1}\}\right]\right)\times\frac{\sigma_{\xi 1}^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \\ &+ \left(e_t - E\left[e_t|I_t^{\text{market}}\setminus\{e_t\}\right]\right)\times\frac{\sigma_{\xi 2}^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu 1}^2+\sigma_{\nu 2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi 1}^2\delta_M^4\alpha_2^2+\sigma_{\xi 2}^2\delta_M^2\alpha_1^2+\sigma_{\xi 3}^2\alpha_0^2} \end{aligned} \quad \text{(A71)}$$

$$E_t[\nu_{2,t}|e_t] = \left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right) \times \frac{(1-q_\nu)\sigma_\nu^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu1}^2+\sigma_{\nu2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi1}^2\delta_M^4\alpha_2^2+\sigma_{\xi2}^2\delta_M^2\alpha_1^2+\sigma_{\xi3}^2\alpha_0^2} \tag{A72}$$

$$\begin{aligned} E_t[\nu_{2,t-1}|e_t,e_{t-1}] &= \left(e_{t-1} - E\left[e_{t-1}|I_{t-1}^{\text{market}} \setminus \{e_{t-1}\}\right]\right) \times \frac{(1-q_\nu)\sigma_\nu^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu1}^2+\sigma_{\nu2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi1}^2\delta_M^4\alpha_2^2+\sigma_{\xi2}^2\delta_M^2\alpha_1^2+\sigma_{\xi3}^2\alpha_0^2} \\ &+ \left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right) \times \frac{\sigma_{\nu1}^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu1}^2+\sigma_{\nu2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi1}^2\delta_M^4\alpha_2^2+\sigma_{\xi2}^2\delta_M^2\alpha_1^2+\sigma_{\xi3}^2\alpha_0^2} \end{aligned} \tag{A73}$$

$$ME_t^{\text{post-report}} = \nu_{1,t+1}^0 + \nu_{1,t} + \nu_{1,t-1} \tag{A74}$$

$$+(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)\xi_{1,t+1}^0 - \alpha_0\xi_{1,t-2} - \delta_M\alpha_1\xi_{1,t-1} - \delta_M^2\alpha_2\xi_{1,t} \tag{A75}$$

$$+E_t[\nu_{2,t}+\nu_{2,t-1}|e_t,e_{t-1}] \tag{A76}$$

$$E_t[(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)\xi_{2,t+1}^0 - \alpha_0\xi_{2,t-2} - \delta_M\alpha_1\xi_{2,t-1} - \delta_M^2\alpha_2\xi_{2,t}|e_t,e_{t-1},e_{t-2}] \tag{A77}$$

or

$$ME_t^{\text{post-report}} = \nu_{1,t+1}^0 + \nu_{1,t} + \nu_{1,t-1} \tag{A78}$$

$$+(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)\xi_{1,t+1}^0 - \alpha_0\xi_{1,t-2} - \delta_M\alpha_1\xi_{1,t-1} - \delta_M^2\alpha_2\xi_{1,t} \tag{A79}$$

$$+\beta_0 \times \left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right) + \beta_1 \times \left(e_{t-1} - E\left[e_{t-1}|I_{t-1}^{\text{market}} \setminus \{e_{t-1}\}\right]\right) + \beta_2 \times \left(e_{t-2} - E\left[e_{t-2}|I_{t-2}^{\text{market}} \setminus \{e_{t-2}\}\right]\right) \tag{A80}$$

where $\beta_0 = \frac{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu1}^2-\alpha_0\sigma_{\xi2}^2-\delta_M\alpha_1\sigma_{\xi1}^2-\delta_M^2\alpha_2(1-q_\xi)\sigma_\xi^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu1}^2+\sigma_{\nu2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi1}^2\delta_M^4\alpha_2^2+\sigma_{\xi2}^2\delta_M^2\alpha_1^2+\sigma_{\xi3}^2\alpha_0^2}$,
$\beta_1 = \frac{(1-q_\nu)\sigma_\nu^2-\alpha_0\sigma_{\xi1}^2-\delta_M\alpha_1(1-q_\xi)\sigma_\xi^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu1}^2+\sigma_{\nu2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi1}^2\delta_M^4\alpha_2^2+\sigma_{\xi2}^2\delta_M^2\alpha_1^2+\sigma_{\xi3}^2\alpha_0^2}$, and
$\beta_2 = \frac{-\alpha_0(1-q_\xi)\sigma_\xi^2}{(1-q_\nu)\sigma_\nu^2+\sigma_{\nu1}^2+\sigma_{\nu2}^2+(1-q_\xi)\sigma_\xi^2(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2)^2+\sigma_{\xi1}^2\delta_M^4\alpha_2^2+\sigma_{\xi2}^2\delta_M^2\alpha_1^2+\sigma_{\xi3}^2\alpha_0^2}$.

A.5 Proof of Proposition 5

Since the market's beliefs about ε_2 and m_2 remain unchanged during a year between two reports, the market's expectation of the next earnings report changes only because investors learn $\nu_{1,t+1}^1$ and $\xi_{1,t+1}^1$:

$$ME_{t+1}^{\text{pre-report}} - ME_t^{\text{post-report}} = \nu_{1,t+1}^1 + \left(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2\right)\xi_{1,t+1}^1 \tag{A81}$$

A.6 Theoretical moments

In this Appendix, I list theoretical moments and explain how they help identify model parameters: the total fundamental and misreporting incentives uncertainty, σ_ν^2 and σ_ξ^2, the fractions of fundamental and misreporting incentives information that the market knows, q_ν and q_ξ, and the part of these fractions that investors learn from sources concurrent with earnings reports, q_ν^0 and q_ξ^0. In total, I use eight theoretical moments:

1. Earnings response coefficient:

$$E\left[\left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right)\left(p_t^{\text{post-report}} - p_t^{\text{pre-report}} - \alpha_0 \times \left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right)\right)\right] = 0 \tag{A82}$$

2. Variance of earnings reports:

$$Var[e_t] = 3\sigma_\nu^2 + \left(\alpha_0 + \delta_M\alpha_1 + \delta_M^2\alpha_2\right)^2\sigma_\xi^2 + \alpha_0^2\sigma_\xi^2 + \delta_M^2\alpha_1^2\sigma_\xi^2 + \delta_M^4\alpha_2^2\sigma_\xi^2 \tag{A83}$$

3. Covariance of the earnings report at time $(t+1)$ with residuals of the "ERC" regression at time t:

$$Cov\left[e_{t+1}, p_t^{\text{post-report}} - p_t^{\text{pre-report}} - \alpha_0 \times \left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right)\right] = q_\nu q_\nu^0 \sigma_\nu^2\left(\delta_I + \delta_I^2 + \delta_I^3\right) \tag{A84}$$

4. Covariance of the earnings report at time $(t+1)$ with residuals from regressing price change during year $(t+1)$ on earnings surprise at time t:

$$\begin{aligned} Cov\left[e_{t+1}, p_{t+1}^{\text{pre-report}} - p_t^{\text{post-report}} - (\alpha_1 - \alpha_0) \times \left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right)\right] \\ = q_\nu q_\nu^0 \sigma_\nu^2(1-\delta_I^3) + q_\nu(1-q_\nu^0)\sigma_\nu^2(1+\delta_I+\delta_I^2) \end{aligned} \tag{A85}$$

5. Covariance of residuals of the time-t "ERC" regression with residuals from regressing market expectations of time-$(t+1)$ earnings report at time t on the time-t earnings report surprise, the time-$(t-1)$ earnings report surprise, and the time-$(t-2)$ earnings report surprise:

$$\begin{aligned} Cov\Big[p_t^{\text{post-report}} - p_t^{\text{pre-report}} - \alpha_0\left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right), \\ ME_t^{\text{post-report}} - \beta_0\left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right) - \beta_1\left(e_{t-1} - E\left[e_{t-1}|I_{t-1}^{\text{market}} \setminus \{e_{t-1}\}\right]\right) - \beta_2\left(e_{t-2} - E\left[e_{t-2}|I_{t-2}^{\text{market}} \setminus \{e_{t-2}\}\right]\right)\Big] \\ = q_\nu q_\nu^0 \sigma_\nu^2\left(\delta_I + \delta_I^2 + \delta_I^3\right) \end{aligned} \tag{A86}$$

6. Covariance of the residuals from regressing price change during year $(t+1)$ on earnings surprise at time t with

changes in the market's expectations of time-$(t+1)$ earnings reports during year $(t+1)$:

$$Cov\left[p_{t+1}^{\text{pre-report}} - p_t^{\text{post-report}} - (\alpha_1 - \alpha_0) \times \left(e_t - E\left[e_t | I_t^{\text{market}} \setminus \{e_t\}\right]\right), ME_{t+1}^{\text{pre-report}} - ME_t^{\text{post-report}}\right]$$
$$= q_v (1 - q_v^0) \sigma_v^2 \left(1 + \delta_I + \delta_I^2\right) \quad \text{(A87)}$$

7. Variance of change in the market's expectation of the next earnings report during a year not explained by new fundamental information learned that year:

$$Var\left[ME_{t+1}^{\text{pre-report}} - ME_t^{\text{post-report}} - \frac{1}{1+\delta_I+\delta_I^2}\left(p_{t+1}^{\text{pre-report}} - p_t^{\text{post-report}} - (\alpha_1 - \alpha_0)\left(e_t - E\left[e_t | I_t^{\text{market}} \setminus \{e_t\}\right]\right)\right.\right.$$
$$\left.\left. - \frac{1-\delta_I^3}{\delta_I + \delta_I^2 + \delta_I^3}\left(p_t^{\text{post-report}} - p_t^{\text{pre-report}} - \alpha_0\left(e_t - E\left[e_t | I_t^{\text{market}} \setminus \{e_t\}\right]\right)\right)\right)\right]$$
$$= \left(\alpha_0 + \delta_M \alpha_1 + \delta_M^2 \alpha_2\right)^2 \left(1 - q_\xi^0\right) q_\xi \sigma_\xi^2 \quad \text{(A88)}$$

8. Covariance of time-$(t+1)$ earnings with residuals from regressing the market's expectation of the time-$(t+1)$ earnings report on the time-t earnings report surprise, the time-$(t-1)$ earnings report surprise, and the time-$(t-2)$ earnings report surprise not explained by new fundamental information learned during year t:

$$Cov\left[e_{t+1}, ME_t^{\text{post-report}} - \beta_0\left(e_t - E\left[e_t | I_t^{\text{market}} \setminus \{e_t\}\right]\right) - \beta_1\left(e_{t-1} - E\left[e_{t-1} | I_{t-1}^{\text{market}} \setminus \{e_{t-1}\}\right]\right) - \beta_2\left(e_{t-2} - E\left[e_{t-2} | I_{t-2}^{\text{market}} \setminus \{e_{t-2}\}\right]\right)\right.$$
$$\left. - \frac{1}{\delta_I + \delta_I^2 + \delta_I^3}\left(p_t^{\text{post-report}} - p_t^{\text{pre-report}} - \alpha_0 \times \left(e_t - E\left[e_t | I_t^{\text{market}} \setminus \{e_t\}\right]\right) - A_t - A_{t-1}\right)\right]$$
$$= \left(\alpha_0 + \delta_M \alpha_1 + \delta_M^2 \alpha_2\right)^2 q_\xi^0 q_\xi \sigma_\xi^2 + \alpha_0^2 q_\xi \sigma_\xi^2 + \delta_M^2 \alpha_1^2 q_\xi \sigma_\xi^2 + \delta_m^4 \alpha_2^2 q_\xi \sigma_\xi^2, \quad \text{(A89)}$$

where $A_{\tau+1} = \frac{1}{1+\delta_I+\delta_I^2}\left(p_{\tau+1}^{\text{pre-report}} - p_\tau^{\text{post-report}} - (\alpha_1 - \alpha_0) \times \left(e_\tau - E\left[e_\tau | I_\tau^{\text{market}} \setminus \{e_\tau\}\right]\right) + p_\tau^{\text{post-report}} - p_\tau^{\text{pre-report}}\right.$ $\left. - \alpha_0 \times \left(e_\tau - E\left[e_\tau | I_\tau^{\text{market}} \setminus \{e_\tau\}\right]\right)\right)$.

For the derivation of the moment 7, remember that

$$ME_{t+1}^{\text{pre-report}} - ME_t^{\text{post-report}} = \nu_{1,t+1}^1 + \left(\alpha_0 + \delta_M \alpha_1 + \delta_M^2 \alpha_2\right) \xi_{1,t+1}^1;$$
$$p_{t+1}^{\text{pre-report}} - p_t^{\text{post-report}} - (\alpha_1 - \alpha_0)\left(e_t - E\left[e_t | I_t^{\text{market}} \setminus \{e_t\}\right]\right) = \left(1 - \delta_I^3\right) \nu_{1,t+1}^0 + \left(1 + \delta_I + \delta_I^2\right) \nu_{1,t+1}^1;$$
$$p_t^{\text{post-report}} - p_t^{\text{pre-report}} - \alpha_0\left(e_t - E\left[e_t | I_t^{\text{market}} \setminus \{e_t\}\right]\right) = \left(\delta_I + \delta_I^2 + \delta_I^3\right) \nu_{1,t+1}^0;$$

and we can extract the term $\nu_{1,t+1}^1$:

$$p_{t+1}^{\text{pre-report}} - p_t^{\text{post-report}} - (\alpha_1 - \alpha_0)\left(e_t - E\left[e_t | I_t^{\text{market}} \setminus \{e_t\}\right]\right) - \frac{1-\delta_I^3}{\delta_I + \delta_I^2 + \delta_I^3}\left(p_t^{\text{post-report}} - p_t^{\text{pre-report}} - \alpha_0\left(e_t - E\left[e_t | I_t^{\text{market}} \setminus \{e_t\}\right]\right)\right)$$
$$= \left(1 + \delta_I + \delta_I^2\right) \nu_{1,t+1}^1.$$

To see how the moment 8 is derived, note that

$$ME_t^{\text{post-report}} - \beta_0\left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right) - \beta_1\left(e_{t-1} - E\left[e_{t-1}|I_{t-1}^{\text{market}} \setminus \{e_{t-1}\}\right]\right) - \beta_2\left(e_{t-2} - E\left[e_{t-2}|I_{t-2}^{\text{market}} \setminus \{e_{t-2}\}\right]\right)$$
$$= \nu_{1,t+1}^0 + \nu_{1,t} + \nu_{1,t-1} + \left(\alpha_0 + \delta_M\alpha_1 + \delta_M^2\alpha_2\right)\xi_{1,t+1}^0 - \alpha_0\xi_{1,t-2} - \delta_M\alpha_1\xi_{1,t-1} - \delta_M^2\alpha_2\xi_t + g\left(e_{t-3}, e_{t-4}, ..., e_0\right),$$

and also

$$p_{t+1}^{\text{pre-report}} - p_t^{\text{post-report}} - (\alpha_1 - \alpha_0)\left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right) = \left(1 + \delta_I + \delta_I^2\right)\nu_{1,t+1} - \left(\delta_I + \delta_I^2 + \delta_I^3\right)\nu_{1,t+1}^0,$$
$$p_t^{\text{post-report}} - p_t^{\text{pre-report}} - \alpha_0 \times \left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right) = \left(\delta_I + \delta_I^2 + \delta_I^3\right)\nu_{1,t+1}^0$$

Then,

$$\nu_{1,t+1} = \frac{1}{1 + \delta_I + \delta_I^2}\left(p_{t+1}^{\text{pre-report}} - p_t^{\text{post-report}} - (\alpha_1 - \alpha_0) \times \left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right)\right.$$
$$\left. + p_t^{\text{post-report}} - p_t^{\text{pre-report}} - \alpha_0 \times \left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right)\right) \equiv A_{t+1}.$$

As a result, market expectations with the following adjustment do not depend on new fundamental information learned by investors:

$$ME_t^{\text{post-report}} - \beta_0\left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right) - \beta_1\left(e_{t-1} - E\left[e_{t-1}|I_{t-1}^{\text{market}} \setminus \{e_{t-1}\}\right]\right) - \beta_2\left(e_{t-2} - E\left[e_{t-2}|I_{t-2}^{\text{market}} \setminus \{e_{t-2}\}\right]\right)$$
$$- \frac{1}{\delta_I + \delta_I^2 + \delta_I^3}\left(p_t^{\text{post-report}} - p_t^{\text{pre-report}} - \alpha_0 \times \left(e_t - E\left[e_t|I_t^{\text{market}} \setminus \{e_t\}\right]\right) - A_t - A_{t-1}\right)$$
$$= \left(\alpha_0 + \delta_M\alpha_1 + \delta_M^2\alpha_2\right)\xi_{1,t+1}^0 - \alpha_0\xi_{1,t-2} - \delta_M\alpha_1\xi_{1,t-1} - \delta_M^2\alpha_2\xi_t + g\left(e_{t-3}, e_{t-4}, ..., e_0\right).$$

A.7 Estimation procedure

The objective of the GMM procedure is to minimize the distance between the theoretical moments, which are functions of the model parameters, and empirical moments, which are calculated from the data. In other words, the goal is to find a set of parameters $\hat{\theta}$ such that

$$\hat{\theta} = \text{argmin}_{\theta\in\Theta} \quad \left(\frac{1}{N}\sum_{i=1}^{N} g(Y_i, \theta)\right)^T \hat{W}\left(\frac{1}{N}\sum_{i=1}^{N} g(Y_i, \theta)\right), \tag{A90}$$

where $\frac{1}{N}\sum_{i=1}^{N} g(Y_i, \theta) = m(d) - \hat{m}(\theta)$ is the vector of average differences between moments computed from the data $m(d)$ – a function of data d – and their counterparts computed from the model $\hat{m}(\theta)$ the model – a function of the model's parameters θ. I show how each element of this vector is calculated in table 10 below. The matrix W is the weighting matrix.

The estimation is conducted as follows. To obtain the estimate of the optimal weighting matrix $\hat{W}$, I take an arbitrary vector of the parameters $\hat{\theta}_1$, plug them into the vector $\frac{1}{N}\sum_{i=1}^{N} g(Y_i,\theta)$, and calculate the covariance matrix of this vector, $\hat{\Omega} \equiv \frac{1}{N}\sum_{i=1}^{N}[g(Y_i,\theta)][g(Y_i,\theta)]'$. I use the inverse of this covariance matrix as the weighting matrix: $\hat{W} = \hat{\Omega}^{-1}$. The algorithm searches for $\hat{\theta}_2$ that minimizes (A90). These parameter estimates $\hat{\theta}_2$ are the ultimate estimates. I use the Controlled Random Search algorithm (Price (1983), Kaelo and Ali (2006)) to search for $\hat{\theta}$ in both steps.

I calculate standard errors of the estimates using the formula for the asymptotic covariance matrix of estimates:

$$\mathbf{V} \equiv \frac{1}{N}\left[\hat{G}\hat{\Omega}^{-1}\hat{G}^{T}\right]^{-1}, \tag{A91}$$

where $\hat{G} \equiv \frac{\partial\left(\frac{1}{N}\sum_{i=1}^{N} g(Y_i,\theta)\right)}{\partial\theta}$ is the Jacobian matrix, evaluated at $\hat{\theta}_2$. The derivative of moment k with respect to parameter p, $\frac{\partial\left(\frac{1}{N}\sum_{i=1}^{N} g(Y_i,\theta)\right)_k}{\partial\theta_p}$, is calculated by increasing parameter $\hat{\theta}_p$ by 0.01% (keeping other parameters constant) and dividing the difference between the new value of the moment and the value of the moment at the $\hat{\theta}_p$, $\left(\frac{1}{N}\sum_{i=1}^{N} g(Y_i,\theta)\right)_k\left(1.0001\hat{\theta}_p\right) - \left(\frac{1}{N}\sum_{i=1}^{N} g(Y_i,\theta)\right)_k\left(\hat{\theta}_p\right)$ by 0.01% of $\hat{\theta}_p$.

The J-statistic is $J = N\left(\frac{1}{N}\sum_{i=1}^{N} g(Y_i,\theta)\right)^T \hat{\Omega}^{-1}\left(\frac{1}{N}\sum_{i=1}^{N} g(Y_i,\theta)\right)$ and follows a χ^2 distribution with the degrees of freedom equal to the number of moments in excess of the number of parameters (8-6=2 in my case) under the null hypothesis that the model does not fail to match all moments.

A.8 Calculation of differences between empirical and theoretical moments

In this Appendix, I explain how the empirical moments used to fit the model are computed. The paper uses eight moments: a regression coefficient (the ERC), the variance of earnings reports, and covariances of earnings reports, the market's expectations of earnings reports, and firm prices with each other.

The data series used in estimation are reported annual earnings and analyst forecasts of annual earnings from the IBES database, firm prices from the CRSP database, and book values (for normalization) from the Compustat database.

I start by computing aggregate reported earnings, analyst forecasts, and firm value by multiplying IBES earnings-per-share, forecasts of earnings-per-share, and prices, respectively, by the total number of shares outstanding. Next, I normalize the aggregate values by dividing them by 3-year lagged book values.

For each observation i, I have 13 columns:

1. Reported earnings, e_t^i, – earnings reported at time t.

2. 1-year-lead reported earnings, e_{t+1}^{i}, – earnings reported at time $t+1$.

3. Earnings surprise, $e_{t}^{i} - LAF_{t}^{i}$, – the difference between the reported earnings number at time t and the last analyst forecast before the earnings announcement.

4. 1-year-lagged earnings surprise, $e_{t-1}^{i} - LAF_{t-1}^{i}$, – the difference between the reported earnings number at time $(t-1)$ and the last analyst forecast before the earnings announcement.

5. 2-year-lagged earnings surprise, $e_{t-2}^{i} - LAF_{t-2}^{i}$, – the difference between the reported earnings number at time $(t-2)$ and the last analyst forecast before the earnings announcement.

6. Change in firm prices around an earnings announcement, $p_{t}^{\text{post-report}i} - p_{t}^{\text{pre-report}i}$, – firm price on the first trading day after an earnings announcement at time t minus firm price on the last trading day before the earnings announcement.

7. 1-year-lagged change in firm prices around an earnings announcement, $p_{t-1}^{\text{post-report}i} - p_{t-1}^{\text{pre-report}i}$, – firm price on the first trading day after an earnings announcement at time $(t-1)$ minus firm price on the last trading day before the earnings announcement.

8. 2-year-lagged change in firm prices around an earnings announcement, $p_{t-2}^{\text{post-report}i} - p_{t-2}^{\text{pre-report}i}$, – firm price on the first trading day after an earnings announcement at time $(t-2)$ minus firm price on the last trading day before the earnings announcement.

9. Change in firm prices during the year following an earnings announcement, $p_{t+1}^{\text{pre-report}i} - p_{t}^{\text{post-report}i}$, – firm price on the last trading day before an earnings announcement at time $t+1$ minus firm price on the first trading day after an earnings announcement at time t.

10. 1-year-lagged change in firm prices during the year following an earnings announcement, $p_{t}^{\text{pre-report}i} - p_{t-1}^{\text{post-report}i}$, – firm price on the last trading day before an earnings announcement at time t minus firm price on the first trading day after an earnings announcement at time $(t-1)$.

11. 2-year-lagged change in firm prices during the year following an earnings announcement, $p_{t-1}^{\text{pre-report}i} - p_{t-2}^{\text{post-report}i}$, – firm price on the last trading day before an earnings announcement at time $(t-1)$ minus firm price on the first trading day after an earnings announcement at time $(t-2)$.

12. First analyst forecast after an earnings announcement, FAF_t^i, – the first analyst forecast of time-$t+1$ earnings issued after the earnings report at time t.

13. Change in analyst forecasts during a year following an earnings announcement, $LAF_{t+1}^i - FAF_t^i$, – the last analyst forecast of time-$t+1$ earnings issued before the $t+1$ earnings announcement minus the first analyst forecast of time-$t+1$ earnings issued after the t earnings announcement.

In the table 10 below, I provide formulas used to calculate differences between empirical and theoretical moments. To save the space, instead of $^{\text{pre-report}}$ and $^{\text{post-report}}$ superscripts, I use $^{\text{pre}}$ and $^{\text{post}}$ superscripts.

Table 10: Formulas to calculate differences between empirical and theoretical moments

Moment	Formula for difference between empirical and theoretical moments
1. Earnings response coefficient	$\frac{1}{N}\sum_{i=1}^{N}\left(\left(p_t^{\text{post}\,i}-p_t^{\text{pre}\,i}\right)-\alpha_0\times\left(e_t^i-LAF_t^i\right)\right)$
2. Variance of earnings reports	$\frac{1}{N}\sum_{i=1}^{N}\left(e_i-\left(\frac{1}{N}\sum_{i=1}^{N}e_i\right)\right)^2-$ $\left[3\sigma_v^2+\left(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2\right)^2\sigma_\xi^2+\alpha_0^2\sigma_\xi^2+\delta_M^2\alpha_1^2\sigma_\xi^2+\delta_M^4\alpha_2^2\sigma_\xi^2\right]$
3. Covariance of the earnings report at time $(t+1)$ with residuals of the "ERC" regression at time t	$\frac{1}{N}\sum_{i=1}^{N}\left[e_{t+1}^i-\frac{1}{N}\sum_{i=1}^{N}e_{t+1}^i\right]$ $\left[\left(p_t^{\text{post}\,i}-p_t^{\text{pre}\,i}\right)-\alpha_0\times\left(e_t^i-LAF_t^i\right)-\left(\frac{1}{N}\sum_{i=1}^{N}\left(\left(p_t^{\text{post}\,i}-p_t^{\text{pre}\,i}\right)-\alpha_0\times\left(e_t^i-LAF_t^i\right)\right)\right)\right]-$ $\left[q_v q_v^0\sigma_v^2\left(\delta_I+\delta_I^2+\delta_I^3\right)\right]$
4. Covariance of the earnings report at time $(t+1)$ with residuals from regressing price change during year $(t+1)$ on earnings surprise at time t	$\frac{1}{N}\sum_{i=1}^{N}\left[e_{t+1}^i-\frac{1}{N}\sum_{i=1}^{N}e_{t+1}^i\right]$ $\left[\left(p_{t+1}^{\text{pre}\,i}-p_t^{\text{post}\,i}\right)-(\alpha_1-\alpha_0)\times\left(e_t^i-LAF_t^i\right)-\left(\frac{1}{N}\sum_{i=1}^{N}\left(\left(p_{t+1}^{\text{pre}\,i}-p_t^{\text{post}\,i}\right)-(\alpha_1-\alpha_0)\times\left(e_t^i-LAF_t^i\right)\right)\right)\right]-$ $\left[q_v q_v^0\sigma_v^2(1-\delta_I^3)+q_v(1-q_v^0)\sigma_v^2(1+\delta_I+\delta_I^2)\right]$
5. Covariance of residuals of the time-t "ERC" regression with residuals from regressing market expectations of time-$(t+1)$ earnings report at time t on the time-t earnings report surprise, the time-$(t-1)$ earnings report surprise, and the time-$(t-2)$ earnings report surprise	$\frac{1}{N}\sum_{i=1}^{N}\left[\left(p_t^{\text{post}\,i}-p_t^{\text{pre}\,i}\right)-\alpha_0\times\left(e_t^i-LAF_t^i\right)-\left(\frac{1}{N}\sum_{i=1}^{N}\left(\left(p_t^{\text{post}\,i}-p_t^{\text{pre}\,i}\right)-\alpha_0\times\left(e_t^i-LAF_t^i\right)\right)\right)\right]$ $\left[FAF_t^i-\beta_0\times\left(e_t^i-LAF_t^i\right)-\beta_1\times\left(e_{t-1}^i-LAF_{t-1}^i\right)-\beta_2\times\left(e_{t-2}^i-LAF_{t-2}^i\right)\right.$ $\left.-\left(\frac{1}{N}\sum_{i=1}^{N}\left(FAF_t^i-\beta_0\times\left(e_t^i-LAF_t^i\right)-\beta_1\times\left(e_{t-1}^i-LAF_{t-1}^i\right)-\beta_2\times\left(e_{t-2}^i-LAF_{t-2}^i\right)\right)\right)\right]-$ $\left[q_v q_v^0\sigma_v^2\left(\delta_I+\delta_I^2+\delta_I^3\right)\right]$
6. Covariance of the residuals from regressing price change during year $(t+1)$ on earnings surprise at time t with changes in the market's expectations of time-$(t+1)$ earnings reports during year $(t+1)$	$\frac{1}{N}\sum_{i=1}^{N}\left[\left(p_{t+1}^{\text{pre}\,i}-p_t^{\text{post}\,i}\right)-(\alpha_1-\alpha_0)\left(e_t^i-LAF_t^i\right)-\left(\frac{1}{N}\sum_{i=1}^{N}\left(\left(p_{t+1}^{\text{pre}\,i}-p_t^{\text{post}\,i}\right)-(\alpha_1-\alpha_0)\left(e_t^i-LAF_t^i\right)\right)\right)\right]$ $\left[LAF_{t+1}^i-FAF_t^i-\frac{1}{N}\sum_{i=1}^{N}\left(LAF_{t+1}^i-FAF_t^i\right)\right]-$ $\left[q_v(1-q_v^0)\sigma_v^2\left(1+\delta_I+\delta_I^2\right)\right]$
7. Variance of change in the market's expectation of the next earnings report during a year not explained by new fundamental information learned that year	$\frac{1}{N}\sum_{i=1}^{N}\left[\left(LAF_{t+1}^i-FAF_t^i-\frac{1}{1+\delta_I+\delta_I^2}\left(p_{t+1}^{\text{pre}^i}-p_t^{\text{post}^i}-(\alpha_1-\alpha_0)\left(e_t^i-LAF_t^i\right)-\frac{1-\delta_I^3}{\delta_I+\delta_I^2+\delta_I^3}\left(p_t^{\text{post}^i}-p_t^{\text{pre}^i}-\alpha_0\left(e_t^i-LAF_t^i\right)\right)\right)\right)-\right.$ $\left.\frac{1}{N}\sum_{i=1}^{N}\left(LAF_{t+1}^i-FAF_t^i-\frac{1}{1+\delta_I+\delta_I^2}\left(p_{t+1}^{\text{pre}^i}-p_t^{\text{post}^i}-(\alpha_1-\alpha_0)\left(e_t^i-LAF_t^i\right)-\frac{1-\delta_I^3}{\delta_I+\delta_I^2+\delta_I^3}\left(p_t^{\text{post}^i}-p_t^{\text{pre}^i}-\alpha_0\left(e_t^i-LAF_t^i\right)\right)\right)\right)\right]^2-$ $\left[\left(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2\right)^2\left(1-q_\xi^0\right)q_\xi\sigma_\xi^2\right]$
8. Covariance of time-$(t+1)$ earnings with residuals from regressing the market's expectation of the time-$(t+1)$ earnings report on the time-t earnings report surprise, the time-$(t-1)$ earnings report surprise, and the time-$(t-2)$ earnings report surprise not explained by new fundamental information learned during year t	$\frac{1}{N}\sum_{i=1}^{N}\left[e_{t+1}^i-\frac{1}{N}\sum_{i=1}^{N}e_{t+1}^i\right.$ $\left[\left(FAF_t^i-\beta_0\left(e_t^i-LAF_t^i\right)-\beta_1\left(e_{t-1}^i-LAF_{t-1}^i\right)-\beta_2\left(e_{t-2}^i-LAF_{t-2}^i\right)-\right.\right.$ $\left.\frac{1}{\delta_I+\delta_I^2+\delta_I^3}\left(p_t^{\text{post}^i}-p_t^{\text{pre}^i}-\alpha_0\times\left(e_t^i-LAF_t^i\right)-A_t-A_{t-1}\right)\right)$ $-\left(\frac{1}{N}\sum_{i=1}^{N}\left(FAF_t^i-\beta_0\left(e_t^i-LAF_t^i\right)-\beta_1\left(e_{t-1}^i-LAF_{t-1}^i\right)-\beta_2\left(e_{t-2}^i-LAF_{t-2}^i\right)-\right.\right.$ $\left.\left.\left.\frac{1}{\delta_I+\delta_I^2+\delta_I^3}\left(p_t^{\text{post}^i}-p_t^{\text{pre}^i}-\alpha_0\times\left(e_t^i-LAF_t^i\right)-A_t-A_{t-1}\right)\right)\right)\right]-$ $\left[\left(\alpha_0+\delta_M\alpha_1+\delta_M^2\alpha_2\right)^2q_\xi^0q_\xi\sigma_\xi^2+\alpha_0^2q_\xi\sigma_\xi^2+\delta_M^2\alpha_1^2q_\xi\sigma_\xi^2+\delta_m^4\alpha_2^2q_\xi\sigma_\xi^2\right],$ $A_{\tau+1}=\frac{1}{1+\delta_I+\delta_I^2}\left(p_{\tau+1}^{\text{pre}^i}-p_\tau^{\text{post}^i}-(\alpha_1-\alpha_0)\times\left(e_\tau^i-LAF_\tau^i\right)+p_\tau^{\text{post}^i}-p_\tau^{\text{pre}^i}-\alpha_0\times\left(e_\tau^i-LAF_t^i\right)\right).$