What does the market know?*

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Abstract

I measure how much information market participants have about (1) firm fundamentals and (2) managers' misreporting incentives, and the effects of the market's information on earnings quality and price efficiency. The market knows 81.9% of fundamental and 57.3% of misreporting incentives information related to current earnings reports before managers issue their current earnings reports. A 1% increase in the market's fundamental information will increase earnings quality by 1.29% and price efficiency by 1.70%. A 1% increase in the market's misreporting incentives information will decrease earnings quality by 0.38% and increase price efficiency by 0.17%. Reported earnings differ from true earnings by 91.7% of the standard deviation of true earnings. An average firm is mispriced by $0.35 billion due to information asymmetry.

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1 Introduction

Bias in financial reporting is a key problem for investors who make trading decisions and regulators who assess the state of companies in the economy. Financial misreporting is the product of two ingredients: managers' superior information about firm performance – *fundamental* information asymmetry – and managers' incentives to bias reported numbers – *misreporting incentives* information asymmetry. Lower fundamental information asymmetry implies lower reporting bias because investors rely less on the manager's report; lower misreporting incentives information asymmetry implies higher bias because price reaction to the report increases (Fischer and Stocken (2004), Kim (2021)). It is thus crucial to distinguish the two types of information asymmetry and their relative effects.

Both information asymmetries are (partially) resolved when investors acquire information from sources other than financial reports, e.g., analyst reports, mass media, or financial filings of peer firms. This paper uses structural estimation to quantify how much information from these other sources market participants have about firm fundamentals and managers' misreporting incentives. I further estimate how the market's information endowment affects earnings quality and price efficiency.

I choose the structural technique for four reasons. First, many information events, such as disclosure regulations or changes in media coverage, likely change both types of information in the market's hands. If a researcher did a reduced-form study, it would be challenging to find a setting where one type varies and another remains constant and thus isolate the effect of one information type. Second, researchers can only observe outcomes (price reaction and managerial report) of an unobserved interplay between the two informational components. Third, structural estimation allows me to quantify the magnitudes of effects of the two information types on accounting quality and price efficiency. The reduced-form approach is imprecise when the relationship between a dependent variable (i.e., earnings quality or price efficiency) and an independent variable (i.e., amount of information) is non-linear theoretically. Finally, endowed with parameter estimates, one can conduct counterfactual analyses and answer questions that could not be answered without costly policy implementation.

I start with a stylized but easy-to-follow model. A manager of a firm is compensated based on the firm's stock price. The manager releases an annual report about firm book value, defined as the sum of current and all past earnings, and may bias the report at a cost[1]. Firm earnings and the manager's misreporting incentives

[1] I follow the setup in Beyer et al. (2019), where the manager makes a report about book value rather than earnings, to allow for an inter-temporal manipulation trade-off that the manager faces. For instance, if she heavily overstates firm book value today,

are persistent processes with annual innovations. The manager knows whole realizations of earnings and misreporting incentives innovations. Investors, before they receive the manager's report, already know a fraction of these innovations[2] from any sources except the manager's report. I further allow investors to learn some information about next-year earnings and incentive innovations concurrently with the current-year earnings report[3].

In equilibrium, the manager's report is increasing in her misreporting incentives multiplied by the market's reaction to the report (earnings response coefficient, ERC). ERC is decreasing in the market's fundamental information known before the report and increasing in the misreporting incentives information known before the report. Earnings quality – negative deviation of the manager's earnings report from the firm's true earnings – increases in the market's fundamental and decreases in the market's misreporting incentives information. Price efficiency – negative deviation of the firm price from the firm's price absent information asymmetry, – increases in both types of information.

I estimate the model for 6,965 public firms in the United States from 1992 to 2020, using three time series: reported earnings, firm prices, and analyst forecasts. I use the General Method of Moments, which minimizes the distance between data moments and model moments[4] with optimal weighting matrix.

The results indicate that the market knows 81.9% of fundamental and 57.3% of misreporting incentives information related to the current earnings report before the manager issues the current earnings report. 70.8% of this fundamental and 46.8% of this misreporting incentives information is learned concurrently with the manager's previous earnings report. The standard deviation of innovation in firm earnings is \$236,361,366 for an average firm in my sample. The standard deviation of innovation in misreporting incentives is \$357,082,366. Reported earnings differ from true earnings by 91.7% of the standard deviation of true earnings. An average firm is mispriced by \$346,837,672 due to information asymmetry.

I conduct several counterfactual analyses. First, given the current levels of the market's information endowment, a 1% increase in the market's fundamental (misreporting incentives) information known before the earnings report will lead to a 1.290% increase (0.383% decrease) in earnings quality. A 1% increase in

she will have little room for overstatement (and boosting firm price) going forward. On the other hand, if the manager reports too conservatively and understates book value today, it will be harder for him to report a high number in the future.

[2]The information structure resembles the one in Fischer and Stocken (2004).

[3]An example would be earnings calls or analyst reports concurrent with earnings announcements. This information comes out at the same time as the report, but is orthogonal to the report itself.

[4]The procedure targets eight moments: the variances of one- and two-year changes in annual reports, the variance of changes in forecasts, the covariance of one-year changes in annual reports with changes in forecasts and changes in prices, the covariance of changes in forecasts and changes in prices, the earnings response coefficient, and the residual variance of the regression of price change on earnings surprise.

fundamental (misreporting incentives) information will improve price efficiency by 1.700% (0.166%).

Second, both earnings quality and price efficiency are extremely sensitive to large changes in the market's fundamental information: a 10% increase (decrease) in fundamental information leads to a 16.02% increase (11.09% decrease) in earnings quality and a 20.07% increase (15.15% decrease) in price efficiency. Price efficiency is more sensitive to fundamental variance than earnings quality. Earnings quality is more sensitive than price efficiency to changes in the market's misreporting incentives information and misreporting incentives variance.

I apply the developed technique to measure how much information about misreporting incentives the market has learned after the compensation disclosure regulation in 2006[5]. The introduction of the Compensation Disclosure and Analysis (CD&A) section in firms' proxy statements was primarily aimed at providing investors with detailed information on executive compensation structure. I show that, as a result of this regulation, the amount of misreporting incentives information in the market's hands increased by more than 1.5 times, leading to a 52.66% decrease in earnings quality and an 8.49% increase in price efficiency.

Finally, I estimate model parameters separately for firms that do and do not hold conference calls on the day they announce earnings. The market's fundamental information is high for both types of firms, 85.2% for firms with and 79.8% for firms without earnings calls. However, when this information is learned differs substantially. For firms with earnings calls, 80.7% of fundamental information about the next reported earnings is learned concurrently with the prior-year earnings report. For firms without earnings calls, this number is only 64.5%, suggesting that the market obtains a lot of fundamental information from sources non-concurrent with earnings reports. More interestingly, the market's knowledge of misreporting incentives differs dramatically for firms with and without earnings calls. For the former, the market knows 77.6% of misreporting incentives, 76.3% of that is learned concurrently with the prior-year earnings report (i.e., during earnings calls). For the latter, the market knows only 27.7% of misreporting incentives and learns nothing on the day of the prior-year report.

This study could be of interest to regulators. I provide quantitative estimates for the effects of changes in the market's information on earnings quality and price efficiency. The two information components – fundamental and misreporting incentives – have different effects both in terms of signs and magnitudes. In addition, the structural estimation technique can be used to measure the two types of information provided by regulations ex post.

[5] See https://www.sec.gov/rules/final/2006/33-8732a.pdf.

I aim to contribute to three streams of research. Following Ball and Brown (1968) and Beaver (1968)'s discovery that earnings announcements have informational value for the market, researchers try to measure the amount of information contained in accounting numbers. Ball and Shivakumar (2008) measure it as R^2 of the regression of firms' annual returns on quarterly announcements' short event-window returns. Their estimates – quarterly earnings accounting for 6 to 9% of information – are smaller than my estimates for annual earnings announcements. One possible reason is that the structural estimation approach is more precise and allows to disentangle the two information types, which would not be possible with a simple regression model. Another reason might be the time frame. As Ball and Shivakumar (2008) note, the information content of earnings announcements increases in recent years in their sample – 2004 and 2006. My results suggest that this trend continued. More importantly, this paper is the first structural approach to measure informational content not only of accounting numbers but of all other information sources used by market participants. I further distinguish information coming from earnings numbers and other sources concurrent with earnings announcements.

The broad literature is concerned with ways to estimate the quality of information disclosed by firms from regulators' and the market's perspectives (e.g., Sloan and Sloan (1996), Dechow and Dichev (2002), Gerakos and Kovrijnykh (2013), Nikolaev (2014), Beyer et al. (2019)). Earlier studies associate abnormal accruals with a higher measurement error of firm earnings (Dechow and Dichev (2002), Xie (2013)), and later studies impose specific structures on accruals (Nikolaev (2014)). Other researchers use reversals and second-order auto-correlation in the earnings process to detect earnings management (Gerakos and Kovrijnykh (2013)). More recent studies employ structural estimation (e.g., Zakolyukina (2018), Beyer et al. (2019), Bertomeu et al. (2019), Bertomeu et al. (2019)). Zakolyukina (2018) estimates the probability of misreporting detection and its effect on misstated earnings. Bertomeu et al. (2019) analyze a scenario with managers' uncertain information endowment. A closely related paper is Beyer et al. (2019), which quantifies overall fundamental uncertainty and the degree of fundamental information asymmetry between the manager and the market. I add by providing a way to distinguish and quantify two types of information asymmetry that differentially affect earnings quality and price efficiency.

Bertomeu et al. (2019) provide the first estimate of investors' uncertainty about managers' reporting objectives. Their model is also characterized by an interplay between fundamental and reporting objectives uncertainties. While Bertomeu et al. (2019) focus on investors' uncertainty related to earnings announcements, I concentrate on quantifying the market's ex ante information from other sources.

Finally, I complement literature that uses plausibly exogenous shocks to identify the effects of various regulations on accounting quality and price informativeness (e.g., Ferri et al. (2018)). Existing papers have already identified the direction, and I add by quantifying relative contributions of two types of information – fundamental and misreporting incentives – to the changes in accounting quality and mispricing.

The rest of the paper is organized as follows. Section 2 describes the theoretical model, and section 3 the data and the estimation procedure. Section 4 provides counterfactual analyses; section 5 describes time-series and cross-sectional analyses. Section 6 concludes.

2 Model

2.1 Setup

In what follows, I denote by $\tilde{x}$ random variables, and by x their realizations.

A firm is ruled by a manager. Firm annual earnings have the following structure:

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

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

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

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 can obtain information about current earnings from any sources other than the manager's report: mass media articles, financial analysts, macroeconomic data, etc. q_v represents the fraction of total fundamental information that the market would have in absence of the manager's report.

I further allow some fundamental information to arrive concurrently with the manager's report:

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

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

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

where $0 < q_v^0 < 1$. $\varepsilon^0_{1,t}$ is fundamental information that arrives together with the manager's report (e.g., in a form of the managerial forecast of the next year earnings); $\varepsilon^1_{1,t}$ is fundamental information that arrives on other days.

The earnings is modelled as sum of the current and three prior year shocks for two reasons. First, it preserves important properties of earnings such as persistence and mean-reversion (Gerakos and Kovrijnykh (2013)). Second, when the earnings process is truncated, the managerial report in equilibrium is a finite sum of innovations. This feature is necessary to test how shocks to model parameters will affect the manager's behavior and market outcomes.

I assume that the firm pays no dividends and define the firm book value as cumulative sum of all prior earnings:

$$\theta_t = \sum_{k=0}^{k=t} \varepsilon_k \tag{7}$$

Every year, the manager makes a report (potentially biased), r_t, about firm book value and is compensated based on the firm's stock price, p_t, net of personal cost for misreporting. Her utility at time t is

$$U_t = m_t p_t - \frac{(r_t - \theta_t)^2}{2}, \tag{8}$$

where m_t is the sensitivity of managerial compensation to firm price, or misreporting incentives.

Misreporting incentives are realized every year and described by the following process:

$$\tilde{m}_t = \tilde{m}_{1,t} + \tilde{m}_{2,t}, \tag{9}$$

$$\tilde{m}_{1,t} = \tilde{\xi}_{1,t} + \tilde{\xi}_{1,t-1} + \tilde{\xi}_{1,t-2}, \quad \tilde{\xi}_{1,t} \sim N(0, q_\xi \sigma_\xi^2), \tag{10}$$

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

where $0 < q_\xi < 1$. Similarly to earnings, the manager knows both $m_{1,t}$ and $m_{2,t}$, and the market only $m_{1,t}$. q_ξ represents the share of total misreporting incentives information that the market would know if it did not observe managerial reports. I allow part of misreporting incentives information to arrive concurrently with the manager's report:

$$\tilde{m}_{1,t} = \tilde{m}^0_{1,t} + \tilde{m}^1_{1,t}, \tag{12}$$

$$\tilde{m}^0_{1,t} = \tilde{\xi}^0_{1,t} + \tilde{\xi}^0_{1,t-1} + \tilde{\xi}^0_{1,t-2}, \quad \tilde{\xi}^0_{1,t} \sim N(0, q_\xi q^0_\xi \sigma_\xi^2), \tag{13}$$

$$\tilde{m}^1_{1,t} = \tilde{\xi}^1_{1,t} + \tilde{\xi}^1_{1,t-1} + \tilde{\xi}^1_{1,t-2}, \quad \tilde{\xi}^1_{1,t} \sim N(0, q_\xi (1-q^0_\xi)\sigma_\xi^2). \tag{14}$$

where $0 < q_{\xi}^{0} < 1$. $m_{1,t}^{0}$ is misreporting incentives information that arrives together with the manager's report (e.g., in a form of the managerial forecast of the next year earnings); $m_{1,t}^{1}$ is misreporting incentives information that arrives on other days.

The market prices the firm risk-neutrally at the expectation of its book value and sum of all future earnings:

$$p_t = E\left[\tilde{\theta}_t + \sum_{k=t+1}^{k=\infty} \tilde{\varepsilon}_k | I_t^{market}\right], \tag{15}$$

where $I_t^{market} = \{r_0, r_1, ..., r_t; \varepsilon_{1,0}, \varepsilon_{1,1}, ..., \varepsilon_{1,t}; m_{1,0}, m_{1,1}, ..., m_{1,t}\}$ is all the information available to the market at time t. It includes histories of all managerial reports and all fundamental and misreporting incentives information independently observed by the market.

In this setting, the manager faces a dynamic trade-off: on the one hand, he may have incentives to temporarily increase or decrease firm price. On the other hand, if she heavily overstates firm book value today ($r_t > \theta_t$), she will have little room for overstatement (and boosting firm price) going forward. If the manager reports too conservatively and understates book value today ($r_t < \theta_t$), it will be harder for him to report a high number in the future. The manager's problem at time t is

$$max_{r_t} \quad E\left[\sum_{k=t}^{k=\infty} \delta^{k-t} (\tilde{m}_k p_k - \frac{(r_k - \tilde{\theta}_k)^2}{2}) | I_t^{manager}\right], \tag{16}$$

where $I_t^{market} = \{\varepsilon_0, \varepsilon_1, ..., \varepsilon_t; m_0, m_1, ..., m_t\}$ is all the information available to the manager at time t, including histories of all earnings and misreporting incentives.

The final element that I define is market expectations of annual earnings, or changes in the managerial report (since the report is about book value). At the time t, the market expects the change in the annual report to be

$$ME_t = E\left[\tilde{r}_t - r_{t-1} | I_t^{market}\right]. \tag{17}$$

2.2 Equilibrium

2.2.1 Strategies in Equilibrium

I conjecture the following steady-state equilibrium strategies:

- The manager's report about firm book value:

$$r_t = r_0 + r_\theta \theta_t + \sum_{k=0}^{k=t} r_{m_1^0,k} m_{1,t-k}^0 + \sum_{k=0}^{k=t} r_{m_1^1,k} m_{1,t-k}^1 + \sum_{k=0}^{k=t} r_{m_2,k} m_{2,t-k};$$

- Firm price:

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

- Market expectations:

$$ME_t = ME_0 + \sum_{j=0}^{j=t} a_j^t r_j + \sum_{j=0}^{j=t} b_j^{0,t} \varepsilon_{1,j}^0 + \sum_{j=0}^{j=t} b_j^{1,t} \varepsilon_{1,j}^1 + \sum_{j=0}^{j=t} c_j^{0,t} m_{1,j}^0 + \sum_{j=0}^{j=t} c_j^{1,t} m_{1,j}^1.$$

α_j^t is price-t response to the 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, $\gamma_j^{0,t}$ 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.

The lemma below describes the optimal report of the manager.

Proposition 1 *In equilibrium, the manager's report is*

$$\begin{aligned} r_t &= \theta_t + \alpha_t^t m_t + \sum_{k=1}^{\infty} \delta^k \alpha_t^{t+k} E_t[m_{t+k}] \\ &= \theta_t + \alpha_t^t(\xi_t + \xi_{t-1} + \xi_{t-2}) + \delta \alpha_t^{t+1}(\xi_t + \xi_{t-1}) + \delta^2 \alpha_t^{t+2} \xi_t. \end{aligned} \tag{18}$$

Manager's optimal report is a sum of firm true book value (θ_t) and a bias ($\alpha_t^t m_t + \sum_{k=1}^{\infty} \delta^k \alpha_t^{t+k} E_t[m_{t+k}]$). The bias is greater if the current and future price reactions to the report are greater and if the sensitivity of the manager's compensation to firm price is greater. The bias is smaller for a more impatient manager, who has a low discount rate, δ.

Prices and market expectations in steady-state are updated two times during a year: (1) based on the manager's report and the information on firm earnings and the manager's misreporting incentives that comes out together with the report, and (2) based on the information on firm earnings and the manager's misreporting incentives obtained on other days. Since these two steps are independent from the market's point of view, I can analyze them sequentially. The lemmas below describe price changes after the issuance of the managerial report and the receipt of concurrent information, and after the receipt of information on other days.

I denote by $p_t^{pre-report}$ and $p_t^{post-report}$ firm prices before and after the manager's report, respectively.

Proposition 2 *In steady-state, the change in firm price after the issuance of managerial report and learning* $\varepsilon_{1,t+1}^0$ *and* $m_{1,t+1}^0$ *is*

$$p_t^{post-report} - p_t^{pre-report} = E[\tilde{\theta}_t | I_t^{market}] - E[\tilde{\theta}_t | I_t^{market} \setminus \{r_t\}] \tag{19}$$

$$= \alpha_0 (r_t - E[\tilde{r}_t | I_t^{market} \setminus \{r_t\}]) + 3\nu_{1,t+1}^0, \tag{20}$$

where α_0*, the solution to the equation* $\alpha_0 = \frac{3(1-q_\nu)\sigma_\nu^2}{3\sigma_\nu^2(1-q_\nu)+\sigma_\xi^2(1-q_\xi)\alpha_0^2((1+\delta+\delta^2)^2+\delta^4+\delta^2+1)}$*, is current price's response to the managers' report.*

The price change is a function of "report surprise", $(r_t - E[\tilde{r}_t | I_t^{market} \setminus \{r_t\}])$, and the new fundamental information, ν_{t+1}^0. In appendix A.2 I prove that current post-report price's, one-year-ahead, and two-year-ahead post-report prices' responses to the current report are equal to each other and equal to α_0. From the manager's perspective, however, these responses are not equal because of discounting.

The second round of price updating happens when the market obtains information on firm earnings and the manager's misreporting incentives on other days. Thus, I can denote price change in this round as the difference between prices right before the next report, $p_t^{pre-report}$, and right after the most recent report, $p_t^{post-report}$.

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

$$p_{t+1}^{pre-report} - p_t^{post-report} = 3\nu_{1,t+1}^1. \tag{21}$$

The change in prices outside the issuance of the managerial report only depends on new fundamental information received by the market ($\nu_{1,t+1}^1$). The new known shock to firm earnings is multiplied by 3 because, according to earnings process (2), this shock persists in current earnings and earnings one and two years ahead.

The two following lemmas describe changes in the market's expectations after the manager's report is issued and concurrent information is received by the market, and after information is received on other days. I denote by $ME_t^{pre-report}$ and $ME_t^{post-report}$ market expectations before and after the managerial report, respectively.

Proposition 4 *In a steady-state, the change in market expectations of change in the managerial report after the issuance of the managerial report and learning* $\varepsilon^0_{1,t+1}$ *and* $m^0_{1,t+1}$ *is*

$$ME_t^{post-report} - ME_t^{pre-report} = \nu_{1,t} + \nu_{1,t-1} + \nu^0_{1,t+1} \tag{22}$$

$$+E[\tilde{\varepsilon}_{2,t+1}|I_t^{market}] - E[\tilde{\varepsilon}_{2,t}|I_t^{market} \setminus \{r_t\}] \tag{23}$$

$$+\left(\alpha_0(\xi^0_{1,t+1} - \xi_{1,t-2}) + \alpha_0\delta(\xi^0_{1,t+1} - \xi_{1,t-1}) + \alpha_0\delta^2(\xi^0_{1,t+1} - \xi_{1,t})\right) \tag{24}$$

$$+\left(\alpha_0 \sum_{k=1}^{k=\infty} \delta^{k-1} E[\tilde{m}_{2,t+k}|I_t^{market}] - \alpha_0 \sum_{k=0}^{k=\infty} \delta^k E[\tilde{m}_{2,t+k}|I_t^{market} \setminus \{r_t\}]\right) \tag{25}$$

$$-r_t + r_{t-1} \tag{26}$$

Change in the market expectations of the next report after the issue of a current report are driven by two forces: first, the expectations before the report are of this report, but after the report, they are of the next report; second, the market learns new information about firm fundamentals and the manager's misreporting incentives from the current report and from other sources concurrent with the report. Line (20) in the Proposition 4 above denotes the expectation of $t+1$ earnings that will be reported in the next report, based on the information that the market observes from other sources. Line (21) denotes the expectation of the unobserved part of $t+1$ earnings based on the manager's report minus the expectation of the unobserved part of t earnings based on the previous report. Lines (22) and (23) are the expected bias at time $t+1$ minus the expected bias at time t. Line (22) is based on the information observed by the market concurrent with the report and on other days, and line (23) is an update in belief about unobserved information based on the manager's report.

Proposition 5 *In steady-state, the change in market expectations of change in the managerial report after the market learns* $\varepsilon^1_{1,t+1}$ *and* $m^1_{1,t+1}$ *is*

$$ME_{t+1}^{pre-report} - ME_t^{post-report} = \nu^1_{1,t+1} + \alpha_0(1+\delta+\delta^2)\xi^1_{1,t+1}. \tag{27}$$

When the market learns $\varepsilon^1_{1,t+1}$ and $m^1_{1,t+1}$, market expectations are a sum of new information about firm earnings, $\nu^1_{1,t+1}$, and new information about reporting bias based on the new information about misreporting incentives, $\xi^1_{1,t+1}$.

2.2.2 Earnings Quality in Equilibrium

I define earnings quality as the negative ratio of expected error in the manager's earnings report to the standard deviation of earnings, which is in equilibrium:

$$EQ_t = \frac{-\sqrt{E[(\varepsilon_t - (r_t - r_{t-1}))^2]}}{\sqrt{Var[\varepsilon_t]}} = \frac{-\sqrt{\sigma_\xi^2 \alpha_0^2 2(1+\delta+2\delta^2+\delta^3+\delta^4)}}{\sqrt{3\sigma_v^2}} \tag{28}$$

The measure of earnings quality is affected by the market's shares of information from other sources – q_v and q_ξ – through the current and two future prices' responses to the manager's report, α_0. The lemmas below describe how the price's response and earnings quality change with q_v and q_ξ. As the market's fundamental information increases, prices' reaction to the manager's report decreases, implying a smaller reward for a manager per unit of misreported book value. This leads to higher earnings quality. The relation is opposite for the market's misreporting incentives information: it increases prices' reaction to the manager's report and the reward per unit of misreported book value. As a result, earnings quality is lower.

Proposition 6 *In equilibrium, current price's, one-year-ahead price's, and two-year-ahead price's responses to the current managerial report, α_0, decrease (increase) in the market's share of fundamental (misreporting incentives) information, q_v (q_ξ).*

Lemma 1 *In equilibrium, earnings quality, EQ_t increases (decreases) in the market's share of fundamental (misreporting incentives) information, q_v (q_ξ).*

2.2.3 Price Efficiency in Equilibrium

Price efficiency is the negative deviation of firm price from its value if the market knew all the information that the manager knows:

$$PE_t = -\sqrt{E[(p_t - TrueExpectedValue)^2]} = -\sqrt{E\left[\left(E\left[\tilde{\theta}_t + \sum_{k=t+1}^{k=\infty} \tilde{\varepsilon}_k | I_t^{market}\right] - E\left[\tilde{\theta}_t + \sum_{k=t+1}^{k=\infty} \tilde{\varepsilon}_k | I_t^{manager}\right]\right)^2\right]}$$
$$= -\sqrt{(1-q_\xi)\sigma_\xi^2 \alpha_0^2 (2\delta^3+4\delta^2+4\delta+3) + 5(1-q_v)\sigma_v^2} \tag{29}$$

The lemma below describes how price efficiency evolves when the market learns more about firm fundamentals (q_v increases) and about the manager's misreporting incentives (q_ξ increases). In contrast to accounting quality, price efficiency improves with both types of information in the market's hands. This result implies that, as the market knows more about managerial misreporting incentives, even though from an external observer's perspective the manager's report contains more noise, from the market's perspective, the report becomes more informative because the market can unravel a greater share of the manager's manipulation.

Lemma 2 *In equilibrium, price efficiency, PE_t, increases in the market's share of fundamental, q_ν, and misreporting incentives, q_ξ, information.*

2.3 Theoretical Moments

In this section, I describe the theoretical moments from the model that I use to estimate model primitives: total variances of innovations in firm earnings (σ_ν^2) and the manager's misreporting incentives (σ_ξ^2), total shares of information about them (q_ν and q_ξ, respectively) that are available to the market via different sources, and shares of this information that the market obtains concurrently with the manager's report (q_ν^0 and q_ξ^0).

The model's primary goal is to describe the dynamics of annual managerial reports about firm book value, market expectations, co-movement of the manager's report and market expectations with a firm price, and firm price response to the manager's report. I choose the following eight moments for estimation:

1. Variance of one-year change in the annual managerial report:

$$Var[r_t - r_{t-1}] = 3\sigma_\nu^2 + \alpha_0^2\sigma_\xi^2((1+\delta+\delta^2)^2 + \delta^4 + \delta^2 + 1) \quad (30)$$

2. Variance of two-year change in annual managerial report:

$$Var[r_t - r_{t-2}] = 10\sigma_\nu^2 + \alpha_0^2\sigma_\xi^2((1+\delta+\delta^2)^2 + 2(1+\delta)^2 + (\delta+\delta^2)^2 + 1) \quad (31)$$

3. Variance of change in market expectations from after the previous report to before the current report:

$$Var[ME_{t+1}^{pre-report} - ME_t^{post-report}] = q_\nu(1-q_\nu^0)\sigma_\nu^2 + q_\xi(1-q_\xi^0)\alpha_0^2\sigma_\xi^2(1+\delta+\delta^2)^2 \quad (32)$$

4. Covariance of change in prices from after the previous report to before the current report with one-year

change in annual managerial report:

$$Cov[p_{t+1}^{pre-report} - p_t^{post-report}, r_{t+1} - r_t] = 3q_\nu(1 - q_\nu^0)\sigma_\nu^2 \tag{33}$$

5. Covariance of change in prices from after the previous report to before the current report with change in market expectations from after the previous report to before the current report:

$$Cov[p_{t+1}^{pre-report} - p_t^{post-report}, ME_{t+1}^{pre-report} - ME_t^{post-report}] = 3q_\nu(1 - q_\nu^0)\sigma_\nu^2 \tag{34}$$

6. Covariance of change in market expectations from after the previous report to before the current report with one-year change in annual managerial report:

$$Cov[ME_{t+1}^{pre-report} - ME_t^{post-report}, r_{t+1} - r_t] = q_\nu(1 - q_\nu^0)\sigma_\nu^2 + q_\xi(1 - q_\xi^0)\alpha_0^2\sigma_\xi^2(1 + \delta + \delta^2)^2 \tag{35}$$

7. Earnings response coefficient:

$$E[(p_t^{post-report} - p_t^{pre-report}) - \alpha_0(r_t - r_{t-1} - ME_t^{pre-report})] = 0 \tag{36}$$

8. Residuals variance of the regression of price change around the report, $(p_t^{post-report} - p_t^{pre-report})$ on the earnings surprise, $(r_t - r_{t-1} - ME_t^{pre-report})$:

$$Var[(p_t^{post-report} - p_t^{pre-report}) - \alpha_0(r_t - r_{t-1} - ME_t^{pre-report})] = 9q_\nu q_\nu^0\sigma_\nu^2 \tag{37}$$

α_0 is a function of σ_ν^2, q_ν, σ_ξ^2, and q_ξ.

3 Estimation

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

3.1 Data

For changes in annual reports of firm book value, or reported earnings, I use actuals from the I/B/E/S database. For firm prices, I use market values from the CRSP database. For pre-report prices, I take market values one day before earnings release dates; for post-report prices, I take market values one day after earnings release dates. As a proxy for market expectations, I use analyst earnings forecasts from the I/B/E/S database. For pre-report expectations, I take the last analyst forecast before the earnings release; for post-report expectations, I take the first analyst forecast after the earnings release. I multiply variables from I/B/E/S by the number of common shares outstanding on the corresponding date to obtain all the variables on the firm-level. In addition, I divide all the variables by firm book value at the date a firm first appears in my sample. This normalization allows me to control for firm size as one of the drivers of firm-level volatility of earnings innovations.

The final sample contains 6,965 public firms in the United States with fiscal years from 1992 to 2020; 35,165 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 in my sample. A lot of firms (more than a third of the sample) do not have data on their NAICS codes. Manufacturing industry consists the largest share – 22.36%, followed by finance and insurance – 14.06%. The third is information – 4.85%.

Table 1: Sample selection procedure

Sample reduction reason	**Sample size**
Initial sample, containing all the variables needed from I/B/E/S and CRSP	68,240
Firms with non-missing book value in Compustat	65,643
Firms with positive book value	64,237
Firms with market-to-book ratio less than 30	63,191
Truncate sample at 0.1% for all variables + manually remove price outliers	44,126
Firms with non-missing two-year lags of reports	35,165

Summary statistics for the main time-series are provided in Table 3. Reported earnings and changes in market value around the report and outside the report are positive on average. Reported earnings are on average less than the last analyst's forecast. The change in analyst forecasts from the last to the first forecast is negative on average. This pattern is consistent with common 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 date moves closer to the report date. Such

Table 2: Percent of firms in NAICS sectors in the sample

NAICS	% of total sample
Agriculture, Forestry, Fishing and Hunting	0.16
Mining	3.05
Utilities	2.24
Construction	0.78
Manufacturing	22.36
Wholesale Trade	1.25
Retail Trade	2.90
Transportation and Warehousing	2.35
Information	4.85
Finance and Insurance	14.06
Real Estate Rental and Leasing	2.78
Professional, Scientific, and Technical Services	3.75
Management of Companies and Enterprises	1.35
Administrative and Support and Waste Management and Remediation Services	1.19
Educational Services	0.38
Health Care and Social Assistance	1.02
Arts, Entertainment, and Recreation	0.47
Accommodation and Food Services	1.19
Other Services (except Public Administration)	0.25
Missing NAICS	33.62

bias is explained by purely behavioral motives or by analysts' desire to curry favor coupled with forecasting difficulty. Because I de-mean all my variables for estimation, the existence of the walk-down does not bias my results.

Table 3: Summary statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
$r_t - r_{t-1}$	35,165	0.169	0.433	−6.500	0.027	0.268	11.609
$ME_t^{pre-report} - ME_{t-1}^{post-report}$	35,165	−0.024	0.169	−4.854	−0.041	0.016	4.402
$p_t^{pre-report} - p_{t-1}^{post-report}$	35,165	0.275	0.839	−1.431	−0.257	0.746	2.549
$p_t^{post-report} - p_t^{pre-report}$	35,165	0.010	0.399	−4.193	−0.070	0.084	4.500
$r_t - r_{t-1} - ME_t^{pre-report}$	35,165	−0.001	0.089	−3.131	−0.006	0.009	2.329

In addition, the standard deviation of price changes between the two reports is about 2 (5) times higher than the variance of changes in reports (analyst forecasts), consistent with the return volatility puzzle (Mehra and Prescott (1985)). Since my model's main goals do not include a precise description of return variance, I do not target variance of price changes in my estimation.

3.2 Estimation Procedure

I use the Generalized Method of Moments (GMM) to estimate the model (Hansen (1982)). The method looks for the values of theoretical model parameters (σ_ν^2, q_ν, q_ν^0, σ_ξ^2, q_ξ, and q_ξ^0 in my case) that minimize the distance between theoretical moments (right-hand sides of equations (30)-(37) in my case) and empirical moments (left-hand sides of the same equations). The distance is measured as a quadratic form of differences between theoretical and empirical moments with a pre-specified weighting matrix.

I start with an identity weight matrix and then use the estimates to compute the optimal weight matrix. The procedure is repeated until the process converges: the model parameters that minimize the distance do not change with new iterations.

To estimate the model, I need to choose a certain level of the manager's discount rate, δ, because this parameter is difficult to identify from the data (Magnac and Thesmar (2002)). I follow Zakolyukina (2018) and set a discount rate of 0.9.

3.3 Results

In this section, I present and discuss estimation results and how well the model does its job of matching the targeted variances and covariances of reports, prices, and analyst forecasts.

Table 4 presents the estimated parameters. The total variance of innovation in firm earnings is 0.029, implying that, for a representative firm in my sample[6], the standard deviation of innovation to annual earnings is \$236,361,366. The market knows 81.9% of this innovation from sources other than the manager's report, and 70.8% of this information (or 58.0% of total information) is learned concurrently with the manager's report.

Total variance of innovation in the manager's misreporting incentives is 0.065, which in dollar terms means the standard deviation of misreporting incentives innovation – an increase in the manager's compensation per \$1 increase in firm price – is \$357,082,366. The market knows 57.3% of this innovation from other sources, and 46.8% of this information (or 26.8% of total information) is learned concurrently with the manager's report.

[6]The average book value at a date a firm first appears in my sample is \$1,398,539,000.

Table 4: Estimated model primitives

Parameter estimate	
Fundamental variance, σ_v^2	0.029 (0.002)
Market's total share of fundamental information, q_v	0.819 (0.053)
Market's share of fundamental information received concurrently with the manager's report, q_v^0	0.708 (0.012)
Incentives variance, σ_ξ^2	0.065 (0.019)
Market's total share of incentives information, q_ξ	0.573 (0.202)
Market's total share of incentives information received concurrently with the manager's report, q_ξ^0	0.468 (0.236)

Note: Standard errors are in parentheses. The parameters are estimated assuming a discount rate of $\delta = 0.9$.

The table 5 below presents values of the empirical and theoretical moments at estimated parameters. Moments #3, #5-#8 are closely matched. Differences between theoretical and empirical moments #1-#2 and #4 are higher.

Table 5: Empirical and theoretical moments

#	Moments	Empirical	Theoretical	t-value of difference
1	**Variance of one-year change in annual reports**	0.18773	0.15766	-3.80
2	**Variance of two-year change in annual reports**	0.49233	0.42127	-4.10
3	**Variance of change in market expectations between two reports**	0.02843	0.02325	-2.82
4	**Covariance of change in prices with one-year change in annual reports**	0.05573	0.02051	-14.02
5	**Covariance of change in prices with change in market expectations**	0.01701	0.02051	3.56
6	**Covariance of change in market expectations with one-year change in annual reports**	0.01799	0.02325	2.52
7	**Earnings response coefficient**	0.00267	0.00263	0.12

8	**Residual variance of the regression of price changes around reports on earnings surprises**	0.15861	0.14898	-2.23

Note: The theoretical moments are calculated for estimates assuming $\delta = 0.9$.

The level of earnings quality at the estimated parameters is -0.917, implying that reported earnings differ from true earnings by 91.7% of standard deviation of true earnings. Price efficiency equals -0.248, implying that, on average, the price is $346,837,672 different from its value in absence of information asymmetry.

4 Counterfactual Analyses

In this section, I quantify how the earnings quality would evolve if the overall uncertainty or the market's information endowment would change.

4.1 Small Changes in the Market's Information

I begin the analysis by computing elasticities of earnings quality and price efficiency with respect to two types of information in the market's hands. Elasticities measure the percent change in earnings quality and price efficiency if the market was given an additional 1% of fundamental (or misreporting incentives) information. Since the notion of elasticity assumes linear relation, and earnings quality and price efficiency are not linear functions of the market's information, the measures presented here are only informative for small changes in the shares of the market's information.

Elasticities of earnings quality with respect to the market's share of fundamental and misreporting incentives information are 1.290 and -0.383, respectively, implying that if the market's share of fundamental, q_v (misreporting incentives, q_ξ), information from other sources increased by 1%, the deviation of the manager's earnings report from the true earnings would increase by 1.290% (decrease by 0.383%). At current levels of total uncertainty and the market's information endowment, earnings quality is more sensitive to small changes in fundamental information than it is to small changes in misreporting incentives information.

Elasticities of price efficiency with respect to the market's fundamental and misreporting incentives information endowment are 1.700 and 0.166. If the market was given 1% more fundamental (misreporting incentives) information, price efficiency would increase by 1.700% (0.166%). Price efficiency is more than 10 times more sensitive to small changes in fundamental information than to changes in misreporting incentives information.

Figures 1-2 demonstrate ERCs (from the manager's perspective), earnings quality, and price efficiency at the estimated parameters as functions of the market's fundamental (q_v) and misreporting incentives (q_ξ) information. The points on the graphs of earnings quality and price efficiency denote the current position on the curve – levels of earnings quality and price efficiency at current shares of the market's information. The slope of price efficiency at current level of the market's fundamental information endowment (Figure 1(c)) is higher than the slope of earnings quality (Figure 1(b)). The opposite is true for the market's misreporting incentives information (Figure 2(b) and (c)).

4.2 Large Changes in the Market's Information

Next, I analyze how earnings quality and price efficiency would respond to larger changes in overall uncertainty about firm earnings (σ_v^2) and the manager's misreporting incentives (σ_ξ^2) and in the market's shares of fundamental (q_v) and misreporting incentives (q_ξ) information.

Table 6 summarizes the results for earnings quality, and Table 7 for price efficiency. Both earnings quality and price efficiency are most sensitive to changes in the market's fundamental information: a 10% increase (decrease) in q_v leads to a 16.02% increase (11.09% decrease) in earnings quality and a 20.07% increase (15.15% decrease) in price efficiency. Price efficiency is more sensitive to overall fundamental variance than earnings quality. A change in the market's misreporting incentives information would affect earnings quality stronger than price efficiency.

Imagine a regulator is considering a policy that reduces the amount of information that the market has about managers' misreporting incentives. Assume that the regulator weighs price efficiency and earnings quality equally. A percentage increase in earnings quality will outweigh a loss in price efficiency; the policy should be adopted. A policy that increases the market's fundamental information, in contrast, is beneficial from the perspective of both earnings quality and price efficiency.

Table 6: The effects of changes in total uncertainty and the market's information on earnings quality

Parameter	**Earnings Quality**

	Current level	10% increase in parameter	10% decrease in parameter
Fundamental variance, σ_v^2	-0.917	-0.898 (2.03% increase)	-0.937 (2.28% decrease)
Market's share of fundamental information, q_v	-0.917	-0.770 (16.02% increase)	-1.018 (11.09% decrease)
Misreporting incentives variance, σ_ξ^2	-0.917	-0.935 (2.06% decrease)	-0.896 (2.25% increase)
Market's share of misreporting incentives information, q_ξ	-0.917	-0.955 (4.17% decrease)	-0.884 (3.54% increase)

Table 7: The effects of changes in total uncertainty

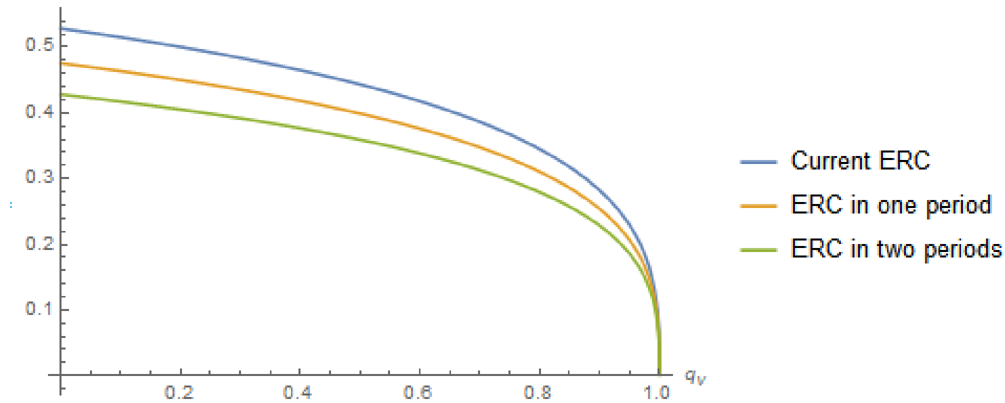
and the market's information on price efficiency

Parameter	**Price Efficiency**		
	Current level	10% increase in parameter	10% decrease in parameter
Fundamental variance, σ_v^2	-0.248	-0.257 (3.65% decrease)	-0.238 (3.88% increase)
Market's share of fundamental information, q_v	-0.248	-0.198 (20.07% increase)	-0.285 (15.15% decrease)
Incentives variance, σ_ξ^2	-0.248	-0.250 (1.19% decrease)	-0.244 (1.29% increase)
Market's share of incentives information, q_ξ	-0.248	-0.243 (1.76% increase)	-0.251 (1.58% decrease)

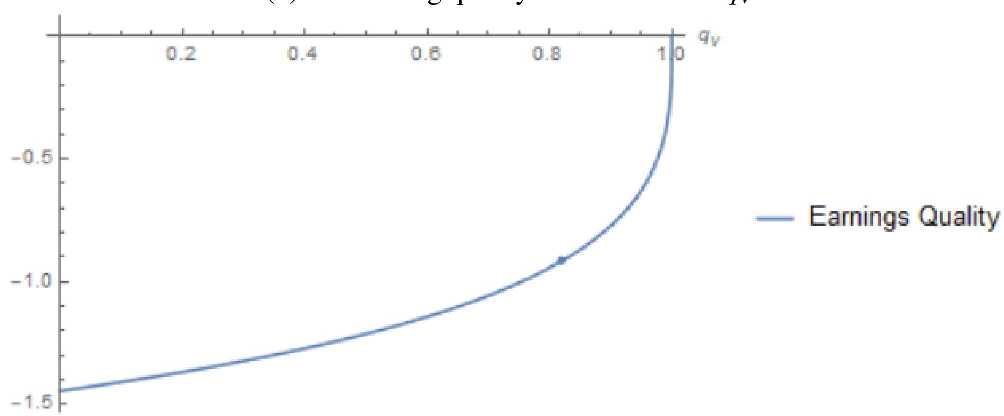
5 Time-series and cross-sectional analysis

In the first part of this section, I investigate how a regulatory shock – compensation disclosure regulation of 2006 (Ferri et al. (2018)) – affected misreporting incentives information in the market's hands, earnings quality, and price efficiency. In the second part, I analyze cross-sectional differences in firms' information environment and estimate the market's information endowment for firms that do and do not hold conference calls concurrently with their earnings announcements.

(a) ERC from the manager's perspective as functions of q_v



(b) Accounting quality as a function of q_v



(c) Price efficiency as a function of q_v

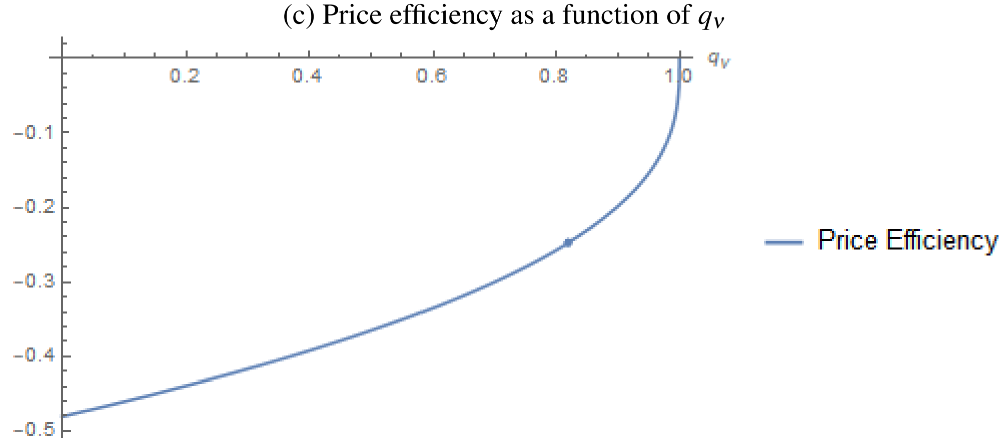
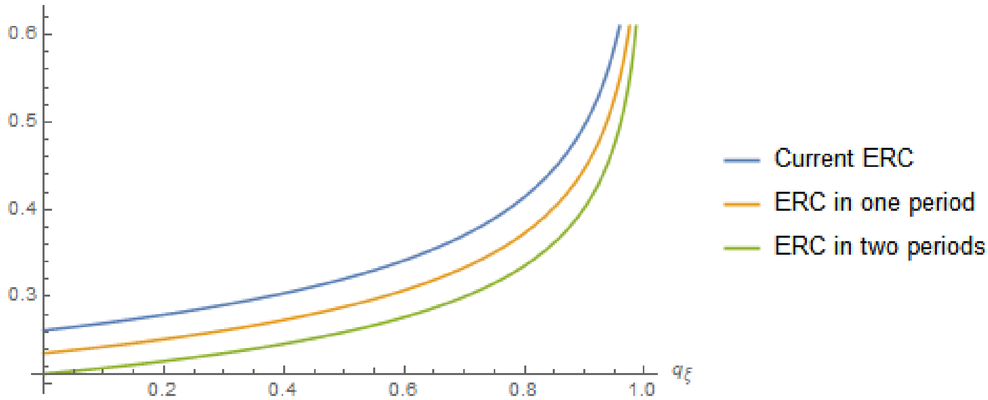
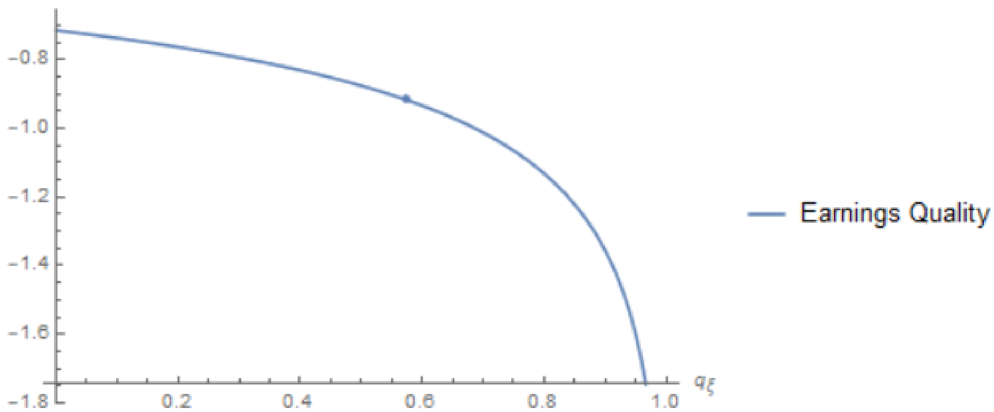


Figure 1: ERC, accounting quality, and price efficiency as functions of the market's fundamental information

(a) ERC from the manager's perspective as functions of q_ξ



(b) Accounting quality as a function of q_ξ



(c) Price efficiency as a function of q_ξ

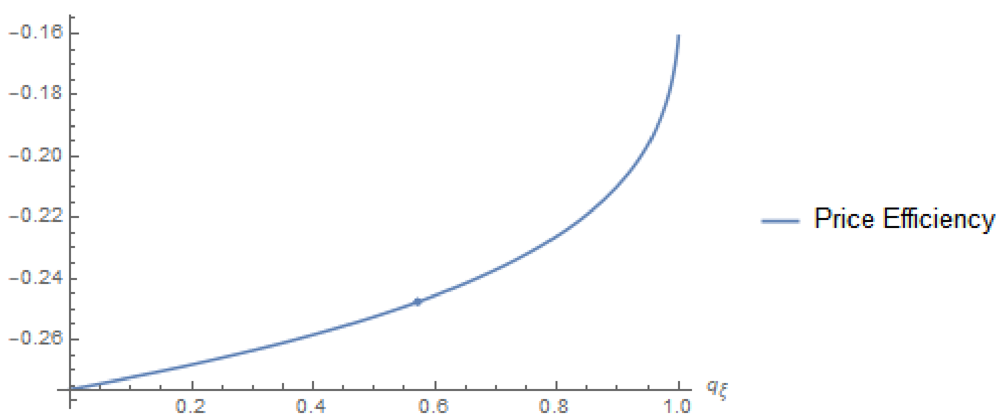


Figure 2: ERC, accounting quality, and price efficiency as functions of the market's misreporting incentives information

5.1 Compensation Disclosure Regulation of 2006

This section focuses on the revision of rules for executive compensation disclosures that were proposed by the Securities and Exchange Commission (SEC) in January 2006. The primary goal of the regulation was to provide investors with more information on managerial compensation and its sensitivity to company performance. The revisions were released by the SEC in August 2006 and effective for firms with the fiscal-year ends on or after December 15, 2006.

I divide my sample into two groups: before and after the compensation disclosure regulation. The "before regulation" period is fiscal-year end before the SEC proposal date, January 26, 2006. Since information on misreporting incentives in my model is a sum of current and two prior period innovations, meaning that three years after an external shock to a parameter are needed for a new steady-state to stabilize, the "after regulation" period is fiscal-year end after December 15, 2009.

To analyze how the share of the information that the market knows about managerial misreporting incentives, q_ξ in my model, changed following the introduction of new rules, I keep all parameters except q_ξ at their estimated levels (Table 4) and estimate the model separately on subsamples before and after the regulation.

Table 8 reports the results. The estimates suggest that the share of total information about managerial misreporting incentives in the market's hands increased by more than 1.5 times, from 38.8% to 69.7%, as a result of the SEC's revision of compensation disclosure rules of 2006. Earnings quality decreased by 52.66%, from -0.826 to -1.261; price efficiency, in contrast, increased by 8.49%, from -0.259 to -0.237. The percentage loss in earnings quality outweighed the gain in price efficiency.

Table 8: Estimated q_ξ before and after the executive compensation disclosure regulation of 2006

Parameter estimate	**Before regulation**	**After regulation**
Market's share of incentives information, q_ξ	0.388 (0.028)	0.697 (0.036)

Note: Standard errors are in parentheses. The parameters are estimated assuming a discount rate of $\delta = 0.9$.

5.2 Firms that do and do not hold earnings calls

The market's information endowment and the fraction of information arriving concurrently with earnings reports might substantially differ for firms that do and do not hold earnings calls on the days when they report earnings. I divide my sample into two parts: companies with and without earnings calls.

I take dates of earnings calls from Compustat – Capital IQ database. Because the database only contains events starting from 2008, I drop all observations before January, 2008. In the remaining sample, there are 9,445 firms with and 7,392 firms without earnings calls.

Firms that choose to hold and not to hold earnings call may differ on various dimensions. That is why I estimate the full set of parameters for the two subsamples.

Table 9 presents the results. Firms with earnings calls are more volatile: both fundamental and misreporting incentive variances are higher for this set of firms. The market knows more information about firms with earnings calls. The market's share of fundamental information for them is 85.2% and 79.8% for firms without earnings calls. Interestingly, the difference in misreporting incentives information is huge: the market knows 77.6% of misreporting incentives information for firms with earnings calls and only 27.7% for firms without. The result can be explained by the fact that most of the misreporting incentives information (76.3%) for firms with earnings calls arrives concurrently with the earnings report. Investors may infer the manager's misreporting incentives from forecasts that the manager provides during earnings calls, from the manager's non-verbal expressions, or from concurrent analyst forecasts that include expected bias in the next report.

Table 9: Estimated model primitives for firms that do and do not hold earnings calls

Parameter estimate	**Hold EC**	**Do not hold EC**
Fundamental variance, σ_v^2	0.041 (0.005)	0.022 (0.004)
Market's total share of fundamental information, q_v	0.852 (0.100)	0.798 (0.139)
Market's share of fundamental information received concurrently with the manager's report, q_v^0	0.807 (0.018)	0.645 (0.029)

Incentives variance, σ_ξ^2	0.122 (0.019)	0.064 (0.029)
Market's total share of incentives information, q_ξ	0.776 (0.211)	0.277 (0.819)
Market's total share of incentives information received concurrently with the manager's report, q_ξ^0	0.763 (0.088)	0.000 (4.547)

Note: Standard errors are in parentheses. The parameters are estimated assuming a discount rate of $\delta = 0.9$.

6 Conclusion

This paper provides a structural estimation technique to measure the amounts of two types of information – fundamental and misreporting incentives information – that market participants have before the manager issues annual earnings report. I further quantify the effects of the market's information endowment on earnings quality and price efficiency, and current levels of misreporting and mispricing due to information asymmetry.

The estimates suggest that the market knows a lot of fundamental and misreporting incentives information that the manager knows – 81.9% and 70.8%, respectively. Fundamental information has higher effects on earnings quality and price efficiency than misreporting incentives information. Counterfactual analyses consider different scenarios about changes in market's information and overall uncertainty.

The study could be of interest to regulators who are concerned with informational reforms to improve earnings quality and/or price efficiency. In particular, I show that an increase in the market's misreporting incentives information will dramatically decrease earnings quality, but only slightly improve price efficiency.

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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:

$$max_{r_T} \quad m_T p_T - \frac{(r_T - \theta_T)^2}{2} \tag{A38}$$

$$= m_T(p_0 + \sum_{j=0}^{j=T-1} \alpha_j^t r_j + \sum_{j=0}^{j=T-1} \beta_j^{0,t} \varepsilon_{1,j}^0 + \sum_{j=0}^{j=T-1} \beta_j^{1,t} \varepsilon_{1,j}^1 + \sum_{j=0}^{j=T-1} \gamma_j^{0,t} m_{1,j}^0 + \sum_{j=0}^{j=T-1} \gamma_j^{1,t} m_{1,j}^1) - \frac{(r_T - \theta_T)^2}{2} \tag{A39}$$

The optimal report is:

$$r_T^* = \theta_T + m_T \alpha_T^T \tag{A40}$$

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

$$max_{r_{T-1}} \quad m_{T-1}p_{T-1} - \frac{(r_{T-1}-\theta_{T-1})^2}{2} + \delta E_{T-1}[U_T] \tag{A41}$$

$$= m_{T-1}p_{T-1} - \frac{(m_T\alpha_T^T)^2}{2} + \delta E_{T-1}[U_T] \tag{A42}$$

The expected utility at time T is

$$E_{T-1}[U_T] = E_{T-1}[m_T]((p_0 + \sum_{j=0}^{j=T-1}\alpha_j^t r_j + \sum_{j=0}^{j=T-1}\beta_j^{0,t}\varepsilon_{1,j}^0 + \sum_{j=0}^{j=T-1}\beta_j^{1,t}\varepsilon_{1,j}^1 + \sum_{j=0}^{j=T-1}\gamma_j^{0,t}m_{1,j}^0 + \sum_{j=0}^{j=T-1}\gamma_j^{1,t}m_{1,j}^1)$$
$$+\alpha_T^T E_{T-1}[m_T]E_{T-1}[\theta_T] + \alpha_T^{T2}E_{T-1}[m_T^2]$$
$$+\beta_T^T E_{T-1}[m_T]E_{T-1}[\varepsilon_{1,T}] + \gamma_T^T E_{T-1}[m_T m_{1,T}] \tag{A43}$$

The optimal report at time $T-1$ is

$$r_{T-1} = \theta_{T-1} + m_{T-1}\alpha_{T-1}^{T-1} + \delta E_{T-1}[m_T]\alpha_{T-1}^T \tag{A44}$$

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

$$r_t = \theta_t + m_t\alpha_t^t + \sum_{k=1}^{\infty}\delta^k\alpha_t^{t+k}E_t[m_{t+k}]$$
$$= \theta_t + \alpha_t^t(\xi_t + \xi_{t-1} + \xi_{t-2}) + \delta\alpha_t^{t+1}(\xi_t + \xi_{t-1}) + \delta^2\alpha_t^{t+2}\xi_t \tag{A45}$$

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:

$$r_t = \theta_t + \alpha_0(\xi_t + \xi_{t-1} + \xi_{t-2}) + \delta\alpha_1(\xi_t + \xi_{t-1}) + \delta^2\alpha_2\xi_t \tag{A46}$$

Before the current managerial report is issued, price equation is:

$$p_t^{pre-report} = \sum_{k=0}^{k=t} \varepsilon_{1,k} + E\left[\sum_{k=t+1}^{k=\infty} \varepsilon_{1,k} | I_t^{market} \setminus \{r_t\}\right] + E\left[\sum_{k=0}^{k=t-1} \varepsilon_{2,k} | I_t^{market} \setminus \{r_t\}\right] + E\left[\varepsilon_{2,t} | I_t^{market} \setminus \{r_t\}\right] + E\left[\sum_{k=t+1}^{k=\infty} \varepsilon_{2,k} | I_t^{market} \setminus \{r_t\}\right] \quad \text{(A47)}$$

The difference between current and prior year reports, $r_t - r_{t-1} = \varepsilon_{1,t} + \varepsilon_{2,t} + Bias_t - Bias_{t-1}$, is a sum of (1) part of current period earnings that is observed by the market, (2) part of current period earnings that is not observed by the market, (3) difference in biases that is a function of the manager's incentive intensity, m_t. The difference between the reports provides market with information on $\varepsilon_{2,t}$. Following the report, the market's revised expectation of $\varepsilon_{2,t}$ is

$$E[\varepsilon_{2,t}|I_t^{market}] = E[\varepsilon_{2,t}|I_t^{market} \setminus \{r_t\}] + (r_t - E[r_t|I_t^{market} \setminus \{r_t\}]) \frac{(1-q_\nu)\sigma_\nu^2}{3(1-q_\nu)\sigma_\nu^2 + (1-q_\xi)\sigma_\xi^2((\alpha_0 + \delta\alpha_1 + \delta^2\alpha_2)^2 + \delta^4\alpha_2^2 + \delta^2\alpha_1^2 + \alpha_0^2)}, \quad \text{(A48)}$$

The expectation of $\varepsilon_{2,t} = \nu_{2,t} + \nu_{2,t-1} + \nu_{2,t-2}$ affects the market's expectations of $\varepsilon_{2,t+1}$ and $\varepsilon_{2,t+2}$ through expectations of $\nu_{2,t}$. Thus, $E[\nu_{2,t}|I_t^{market}]$ will appear in the pricing function three times. Steady-state price response coefficients can be found by solving the system of equations:

$$\alpha_0 = \frac{3(1-q_\nu)\sigma_\nu^2}{3(1-q_\nu)\sigma_\nu^2 + (1-q_\xi)\sigma_\xi^2((\alpha_0 + \delta\alpha_1 + \delta^2\alpha_2)^2 + \delta^4\alpha_2^2 + \delta^2\alpha_1^2 + \alpha_0^2)} \quad \text{(A49)}$$

$$\alpha_1 = \frac{3(1-q_\nu)\sigma_\nu^2}{3(1-q_\nu)\sigma_\nu^2 + (1-q_\xi)\sigma_\xi^2((\alpha_0 + \delta\alpha_1 + \delta^2\alpha_2)^2 + \delta^4\alpha_2^2 + \delta^2\alpha_1^2 + \alpha_0^2)} \quad \text{(A50)}$$

$$\alpha_2 = \frac{3(1-q_\nu)\sigma_\nu^2}{3(1-q_\nu)\sigma_\nu^2 + (1-q_\xi)\sigma_\xi^2((\alpha_0 + \delta\alpha_1 + \delta^2\alpha_2)^2 + \delta^4\alpha_2^2 + \delta^2\alpha_1^2 + \alpha_0^2)} \quad \text{(A51)}$$

It can be shown that $\alpha_0 = \alpha_1 = \alpha_2$.

In addition to the update about ε_2, the market observes part of fundamental information – a component of next-year earnings, $\nu_{1,t+1}^0$. Thus, change in prices around the report, $p_t^{post-report} - p_t^{pre-report}$ is

$$p_t^{post-report} - p_t^{pre-report} = (r_t - E[\tilde{r}_t|I_t^{market} \setminus \{r_t\}])\alpha_0 + 3\nu_{1,t+1}^0 \quad \text{(A52)}$$

A.3 Proof of Proposition 3

Firm price after the current report and before the market learns information about next year earnings from other sources is

$$p_t^{post-report} = \sum_{k=0}^{k=t} \varepsilon_{1,k} + E\left[\varepsilon_{1,t+1}|I_t^{market}\right] + E\left[\sum_{k=t+2}^{k=\infty} \varepsilon_{1,k}|I_t^{market}\right] + E\left[\sum_{k=0}^{k=\infty} \varepsilon_{2,k}|I_t^{market}\right] + 3\nu_{1,t+1}^0 \quad \text{(A53)}$$

$$= \sum_{k=0}^{k=t} \varepsilon_{1,k} + (\nu_{1,t-1} + \nu_{1,t}) + \nu_{1,t} + E\left[\sum_{k=0}^{k=\infty} \varepsilon_{2,k}|I_t^{market}\right] + 3\nu_{1,t+1}^0 \quad \text{(A54)}$$

After the market learns information from other sources, $\varepsilon_{1,t+1} = \nu_{1,t+1} + \nu_{1,t} + \nu_{1,t-1}$, it updates its expectation on $\nu_{1,t+1}$ from 0 to its realized value. The price becomes

$$p_{t+1}^{pre-report} = \sum_{k=0}^{k=t} \varepsilon_{1,k} + (\nu_{1,t-1} + \nu_{1,t} + \nu_{1,t+1}) + (\nu_{1,t} + \nu_{1,t+1}) + \nu_{1,t+1} + E\left[\sum_{k=0}^{k=\infty} \varepsilon_{2,k}|I_t^{market}\right] \quad \text{(A55)}$$

The change in price is, therefore:

$$p_{t+1}^{pre-report} - p_t^{post-report} = 3\nu_{1,t+1}^1 \quad \text{(A56)}$$

A.4 Proof of Proposition 4

Change in market expectations of the next report after the issue of a current report are driven by two forces: first, the expectations before the report are of this report, but after the report, they are of the next report; second, the market learns new information about firm fundamentals and the manager's incentive intensity from the current report and from other sources concurrent with the report. Before current report comes out, market expectations of the current report are:

$$ME_t^{pre-report} = \sum_{k=0}^{k=t} \varepsilon_{1,k} + E\left[\sum_{k=t+1}^{k=\infty} \varepsilon_{1,k}|I_t^{market} \setminus \{r_t\}\right] + E\left[\sum_{k=1}^{k=\infty} \varepsilon_{2,k}|I_t^{market} \setminus \{r_t\}\right] - r_{t-1}$$
$$+\alpha_0((\xi_{1,t} + \xi_{1,t-1} + \xi_{1,t-2} + E[m_{2,t}|I_t^{market} \setminus \{r_t\}])$$
$$+\delta(\xi_{1,t} + \xi_{1,t-1} + E[m_{2,t+1}|I_t^{market} \setminus \{r_t\}]) + \delta^2(\xi_{1,t} + E[m_{2,t+2}|I_t^{market} \setminus \{r_t\}])) \quad \text{(A57)}$$

After the report is issued, the market (1) updates its beliefs about unobserved information (ε_2 and m_2), (2) incorporates newly observed information ($\nu_{1,t+1}^0$ and $\xi_{1,t+1}^0$), (3) forms new expectations about the next report.

$$ME_t^{post-report} = \sum_{k=0}^{k=t} \varepsilon_{1,k} + E\left[\sum_{k=t+1}^{k=\infty} \varepsilon_{1,k}|I_t^{market}\right] + E\left[\sum_{k=1}^{k=\infty} \varepsilon_{2,k}|I_t^{market}\right] - r_t$$
$$+\alpha_0((\xi_{1,t+1}^0 + \xi_{1,t} + \xi_{1,t-1} + E[m_{2,t+1}|I_t^{market} \setminus \{r_t\}]) +$$
$$\delta(\xi_{1,t+1}^0 + \xi_{1,t} + E[m_{2,t+2}|I_t^{market} \setminus \{r_t\}]) + \delta^2(\xi_{1,t+1}^0 + E[m_{2,t+3}|I_t^{market} \setminus \{r_t\}])) \tag{A58}$$

Change in the market's expectations is

$$ME_t^{post-report} - ME_t^{pre-report} = \nu_{1,t} + \nu_{1,t-1} + \nu_{1,t+1}^0 \tag{A59}$$
$$+E[\tilde{\varepsilon}_{2,t+1}|I_t^{market}] - E[\tilde{\varepsilon}_{2,t}|I_t^{market} \setminus \{r_t\}] \tag{A60}$$
$$+\left(\alpha_0(\xi_{1,t+1}^0 - \xi_{1,t-2}) + \alpha_0\delta(\xi_{1,t+1}^0 - \xi_{1,t-1}) + \alpha_0\delta^2(\xi_{1,t+1}^0 - \xi_{1,t})\right) \tag{A61}$$
$$+\left(\alpha_0 \sum_{k=1}^{k=\infty} \delta^{k-1} E[\tilde{m}_{2,t+k}|I_t^{market}] - \alpha_0 \sum_{k=0}^{k=\infty} \delta^k E[\tilde{m}_{2,t+k}|I_t^{market} \setminus \{r_t\}]\right) \tag{A62}$$
$$-r_t + r_{t-1} \tag{A63}$$

A.5 Proof of Proposition 5

$$ME_t^{post-report} = \sum_{k=0}^{k=t} \varepsilon_{1,k} + E\left[\sum_{k=t+1}^{k=\infty} \varepsilon_{1,k}|I_t^{market}\right] + E\left[\sum_{k=1}^{k=\infty} \varepsilon_{2,k}|I_t^{market}\right] - r_t$$
$$+\alpha_0((\xi_{1,t+1}^0 + \xi_{1,t} + \xi_{1,t-1} + E[m_{2,t+1}|I_t^{market} \setminus \{r_t\}]) +$$
$$\delta(\xi_{1,t+1}^0 + \xi_{1,t} + E[m_{2,t+2}|I_t^{market} \setminus \{r_t\}]) + \delta^2(\xi_{1,t+1}^0 + E[m_{2,t+3}|I_t^{market} \setminus \{r_t\}])) \tag{A64}$$

When the market learns $\nu_{1,t+1}^1$ and $\xi_{1,t+1}^1$ from other sources, it updates its expectation of $\xi_{1,t+1}$ from $\xi_{1,t+1}^0$ to $\xi_{1,t+1}^0 + \xi_{1,t+1}^1$. Pre-next report market expectations are:

$$ME_{t+1}^{pre-report} = \sum_{k=0}^{k=t} \varepsilon_{1,k} + \nu_{1,t+1} + \nu_{1,t} + \nu_{1,t-1} + E\left[\sum_{k=1}^{k=\infty} \varepsilon_{2,k}|I_t^{market}\right] - r_t$$
$$+\alpha_0((\xi_{1,t+1} + \xi_{1,t} + \xi_{1,t-1} + E[m_{2,t}|I_t^{market} \setminus \{r_t\}]) +$$
$$\delta(\xi_{1,t+1} + \xi_{1,t} + E[+m_{2,t+1}|I_t^{market} \setminus \{r_t\}]) + \delta^2(\xi_{1,t+1} + E[m_{2,t+2}|I_t^{market} \setminus \{r_t\}])) \tag{A65}$$

Change in market expectations is

$$ME_{t+1}^{pre-report} - ME_{t}^{post-report} = \nu_{1,t+1}^{1} + \alpha_0(1+\delta+\delta^2)\xi_{1,t+1}^{1} \tag{A66}$$

A.6 Proof of Proposition 6

Recall that α_0 is a solution to

$$\alpha_0 - \frac{3(1-q_\nu)\sigma_\nu^2}{3\sigma_\nu^2(1-q_\nu)+\sigma_\xi^2(1-q_\xi)\alpha_0^2((1+\delta+\delta^2)^2+\delta^4+\delta^2+1)} \equiv f(\alpha_0, q_\nu, q_\xi) = 0 \tag{A67}$$

From implicit function theorem, $\frac{\partial \alpha_0}{\partial q_\nu} = -\frac{\frac{\partial f}{\partial q_\nu}}{\frac{\partial f}{\partial \alpha_0}}$ and $\frac{\partial \alpha_0}{\partial q_\xi} = -\frac{\frac{\partial f}{\partial q_\xi}}{\frac{\partial f}{\partial \alpha_0}}$.

$$\frac{\partial f}{\partial \alpha_0} = 1 + \frac{3(1-q_\nu)\sigma_\nu^2(1-q_\xi)\sigma_\xi^2(((1+\delta+\delta^2)^2+\delta^4+\delta^2+1))}{(3\sigma_\nu^2(1-q_\nu)+\sigma_\xi^2(1-q_\xi)\alpha_0^2((1+\delta+\delta^2)^2+\delta^4+\delta^2+1))^2} > 0 \tag{A68}$$

$$\frac{\partial f}{\partial q_\nu} = -\frac{3\sigma_\nu^2(3\sigma_\nu^2(1-q_\nu)+\sigma_\xi^2(1-q_\xi)\alpha_0^2((1+\delta+\delta^2)^2+\delta^4+\delta^2+1))+3\sigma_\nu^2 3(1-q_\nu)\sigma_\nu^2}{(3\sigma_\nu^2(1-q_\nu)+\sigma_\xi^2(1-q_\xi)\alpha_0^2((1+\delta+\delta^2)^2+\delta^4+\delta^2+1))^2} > 0 \tag{A69}$$

$$\frac{\partial f}{\partial q_\xi} = \frac{-3(1-q_\nu)\sigma_\nu^2\sigma_{\alpha 0}^{22}((1+\delta+\delta^2)^2+\delta^4+\delta^2+1)}{(3\sigma_\nu^2(1-q_\nu)+\sigma_\xi^2(1-q_\xi)\alpha_0^2((1+\delta+\delta^2)^2+\delta^4+\delta^2+1))^2} < 0 \tag{A70}$$

Thus, $\frac{\partial \alpha_0}{\partial q_\nu} < 0$ and $\frac{\partial \alpha_0}{\partial q_\xi} > 0$.

A.7 Proof of Lemma 1

Earnings quality is

$$EQ_t = \frac{-\sqrt{\sigma_\xi^2\alpha_0^2 2(1+\delta+2\delta^2+\delta^3+\delta^4)}}{\sqrt{3\sigma_\nu^2}} \tag{A71}$$

$\frac{\partial EQ}{\partial q_\nu} = \frac{\partial EQ}{\partial \alpha_0}\frac{\partial \alpha_0}{\partial q_\nu}$, $\frac{\partial EQ}{\partial q_\xi} = \frac{\partial EQ}{\partial \alpha_0}\frac{\partial \alpha_0}{\partial q_\xi}$.

$$\frac{\partial EQ}{\partial \alpha_0} = \frac{-\sqrt{\sigma_\xi^2 2(1+\delta+2\delta^2+\delta^3+\delta^4)}}{\sqrt{3\sigma_\nu^2}} < 0 \tag{A72}$$

Given Lemma 6, $\frac{\partial EQ}{\partial q_\nu} > 0$ and $\frac{\partial EQ}{\partial q_\xi} < 0$.

A.8 Proof of Lemma 2

$$PE_t = -\sqrt{(1-q_\xi)\sigma_\xi^2\alpha_0^2(2\delta^3+4\delta^2+4\delta+3)+5(1-q_\nu)\sigma_\nu^2} \tag{A73}$$

$$\begin{aligned}\frac{\partial AQ}{\partial q_\nu} &= -\frac{1}{\sqrt{(1-q_\xi)\sigma_\xi^2\alpha_0^2(2\delta^3+4\delta^2+4\delta+3)+5(1-q_\nu)\sigma_\nu^2}} \\ &\times\left((1-q_\xi)\sigma_\xi^2(2\delta^3+4\delta^2+4\delta+3)2\alpha_0\frac{\partial\alpha_0}{\partial q_\nu}-5\sigma_\nu^2\right)\end{aligned} \tag{A74}$$

$$\begin{aligned}\frac{\partial AQ}{\partial q_\xi} &= -\frac{1}{\sqrt{(1-q_\xi)\sigma_\xi^2\alpha_0^2(2\delta^3+4\delta^2+4\delta+3)+5(1-q_\nu)\sigma_\nu^2}} \\ &\times\left(-\sigma_\xi^2\alpha_0^2(2\delta^3+4\delta^2+4\delta+3)+(1-q_\xi)\sigma_\xi^2(2\delta^3+4\delta^2+4\delta+3)2\alpha_0\frac{\partial\alpha_0}{\partial q_\xi}\right)\end{aligned} \tag{A75}$$

(A61) is positive for all $\alpha > 0$, (A62) is positive iff

$$|\sigma_\xi^2\alpha_0^2(2\delta^3+4\delta^2+4\delta+3)| > |(1-q_\xi)\sigma_\xi^2(2\delta^3+4\delta^2+4\delta+3)2\alpha_0\frac{\partial\alpha_0}{\partial q_\xi}|, \tag{A76}$$

which is true for all $0 < q_\nu < 1$, $0 < q_\xi < 1$, $\sigma_\nu^2 > 0$, $\sigma_\xi^2 > 0$, $0 < \delta < 1$.