Information Distortion, R&D, and Growth

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Abstract

Does firms' opportunistic information disclosure affect investment in R&D? To answer this question, we estimate a dynamic model that incorporates a trade-off between R&D investment and accruals manipulation. This trade-off arises because both are effective tools for distorting observable earnings. Distortion incentives stem from the combination of incomplete investor information and short-term manager compensation incentives based on the stock price. These incentives alone hurt shareholder value by 13%. With these incentives in place, regulations preventing information distortion further distort real investment, whose volatility rises by 10%. This excess volatility lowers firm value by 0.5%.

PRELIMINARY DRAFT
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1. Introduction

Shareholders rely on firm managers to carry out two distinct tasks: making long-term investment choices for the firm and disclosing information about firm performance. However, managers' incentives may not be set to perform these two tasks as efficiently as possible. We consider and quantify an important trade-off between the incentives of managers to disclose accurate information and make efficient investment choices. We focus our analysis on the arena of earnings misreporting, which is a natural laboratory to examine this question, as data on earnings announcements, realizations, and restatements are widely available. Specifically, we ask whether mangers' manipulation of information disclosure spills over to affect their real investment decisions. This general notion is grounded in the survey evidence in Graham, Harvey, and Rajgopal (2005) that managers rely on both misreporting and investment distortions to manipulate earnings. Thus, reduced flexibility in misreporting can result in managers' reliance on investment distortions that destroy firm value. This trade-off has important policy implications. For example, disclosure regulations such as the Sarbanes-Oxley Act (SOX) are sometimes criticized for forcing firms to substitute accrual-based with real earnings management (Cohen, Dey, and Lys 2008). Quantifying the extent of this substitution is clearly of interest to policymakers and corporate boards.

To understand this question, we develop and estimate a dynamic model of earnings reporting and real R&D investment, in which managers have incentives to manipulate both R&D and information about earnings, but in which managers also face costs of manipulation if they get caught. We find that the model exhibits a quantitatively important and empirically relevant trade-off between investment volatility and accumulated information manipulation. To arrive at this conclusion, we estimate the model parameters, finding that the model matches a wide array of data moments related to both real investment outcomes and accounting restatements. We also find that managers in the baseline estimated model choose reporting bias equal to around 2% of sales, conditional upon restatement.

When we counterfactually make information manipulation so costly that zero accruals-based manipulation is optimal, managers also optimally manipulate earnings more via adjustments to R&D. Growth in R&D becomes approximately 10% more volatile, and firm value drops by approximately half a percent. We also quantify the slope of this trade-off between earnings manipulation and investment volatility. We find that a one percentage point reduction in bias can be achieved only through an increase in the volatility of investment of approximately half a percentage point.

An understanding of the intuition behind these results requires some fleshing out of the model, which captures a fundamental trade-off between investment efficiency and information disclosure. This trade-off arises because of conflicting managerial incentives. On the one hand, risk-neutral managers have long-term incentives that are aligned with shareholder incentives and that are delivered by stock compensation. On the other hand, this alignment is incomplete, as managers also have short-term incentives to manipulate information to boost the firm's stock price, where these incentives stem from options compensation. However, these short-term incentives are tempered by the probability that the manager gets caught and receives punishment.

With this compensation structure in place, managers then choose both long-term investment and short-term earnings manipulation to maximize their utility over an infinite horizon. They face a stochastic, decreasing returns production function that transforms R&D into sales, with the stochastic portion of this technology exhibiting persistence. They also face an exogenous transitory shock to earnings, which is non-fundamental in the sense that it has no effect on actual cash flows, while at the same time affecting observable earnings. Earnings manipulation feeds into stock prices because investors rationally price the firm using an information set that is more restricted than the managers'. Therefore, managers manipulate reported earnings and opportunistically cut and overinvest in R&D at suboptimal times. The result is less accurate information provision to the public and capital misallocation that produces an efficiency loss in real terms.

The optimal response of a manager to incentives depends crucially on the joint outcome of the fundamental and nonfundamental shock. First, suppose the manager is unlucky today with a negative transitory earnings shock. In this case, if fundamentals are also bad, their options compensation is with high probability out of the money, so neither severe cuts to investment nor upward bias in earnings would lead to a positive options payout. Thus, they report downwardly biased earnings, while at the same time increasing R&D spending. The first action lowers the strike price for future options compensation, and the second raises the likelihood that the future stock price will be high. In contrast, when faced with positive fundamental and nonfundamental shocks, managers' options compensation is very likely in the money. They therefore reverse these two forms of manipulation, relative to the case of low shocks, in order to receive compensation from their options by boosting the current stock price. Of course, in the absence of options compensation, the manager would ignore any transitory earnings volatility and simply respond to the persistent fundamental shock.

These results would have been hard to obtain in a reduced form setting. Although managers can be caught misstating earnings, which results in earnings restatements, manipulation or biases in reported earnings are not observed in most cases. Moreover, the mechanisms whereby earnings manipulation spills over into real outcomes are also unobservable. Questions that are couched in terms of unobservables are prime candidates for structural estimation. For example, Zakolyukina (forthcoming) also takes a structural approach to the analysis of manipulation.

These results are also of broad interest. Given the long literature in macroeconomics linking endogenous growth of the economy as a whole to sustained R&D investments at the firm level, distortions to long-term or intangible investments through earnings pressure may have broad consequences, as emphasized recently by Terry (2015). Moreover, the link between intangible investment and earnings manipulation seems intuitive, as intangible investments like R&D and advertising are expensed rather than capitalized and subsequently depreciated. Therefore, these investments provide an immediate impact on current-period earnings figures, so they are a natural tool for manipulation.

Our project links to two distinct literatures. First, managers in our model engage in what accounting researchers commonly refer to as accruals manipulation, which occurs through earnings misreporting, and real manipulation, which occurs through opportunistic changes to long-term investment. By focusing on distortions of investment decisions and on manipulation that results in earnings restatements, this paper contributes to the empirical literatures on both accrual-based and real earnings management.

Empirical patterns consistent with accruals and real manipulation have been documented in reduced-form studies in accounting for decades. This literature traditionally measures both accrual-based and real earnings management using residuals from linear regressions. For example, Jones (1991), Dechow, Sloan, and Sweeney (1995), and Kothari, Leone, and Wasley (2005) measure accrual-based earnings management via discretionary accruals models, which are regressions of total accruals on variables correlated with theoretical normal accruals. Similarly, discretionary R&D expenditures are residuals of regressions with R&D as a dependent variable (e.g., Roychowdhury 2006; Cohen et al. 2008; Zang 2011). Using these measures, the literature has documented substitution between accrual-based and real earnings management (e.g., Cohen et al. 2008; Cohen and Zarowin 2010; Zang 2011).

We advance this literature by substituting an economic model for statistical models of manipulation and R&D. The advantage of this approach is twofold. We can make specific quantitative predictions, and our explicit modeling framework allows us to understand the economics behind our empirical results in a transparent manner. In doing so, we address the call in Leuz and Wysocki (2016) for more research on the real effects of disclosure regulation and its aggregate impact on the economy.[1]

Second, we contribute to the large literature in finance and macroeconomics that studies distortions to real investment decisions. Here, our contribution is a demonstration that distortions caused by earnings pressures and information manipulation constitute a distinct

[1] As we model explicit incentives for manipulation, our paper also touches on the theoretical and empirical literature on moral hazard problems that can arise from performance measure manipulation. See, for example, Lambert (2001), Margiotta and Miller (2000), Armstrong, Jagolinzer, and Larcker (2010), Gayle and Miller (2015), Li (2016), Gayle, Li, and Miller (2016), and Glover and Levine (forthcoming).

and quantitatively important friction alongside long-studied forces such as financial frictions, adjustment costs, or agency frictions, as in Cooper and Haltiwanger (2006), Hennessy and Whited (2007), and Nikolov and Whited (2014). We enter this picture by using transparent structural estimation to determine the quantitative relevance of the trade-off between information revelation and investment efficiency.

Our model builds on several features of models in this literature. For example, firms in the model are subject to *exogenous* shocks to their productivity or profitability as in Hopenhayn (1992). Simultaneously, managers choose intangible investment that leads to innovation and *endogenous* growth from new ideas. At its core, the model features growth at the micro level that shares the same source—innovation—as models of macro-level endogenous growth (Romer 1990; Aghion and Howitt 1992). Because idiosyncratic shocks differentiate firms and drive their innovation decisions, the firm-level environment bears some similarity to the Schumpeterian model of Klette and Kortum (2004), although lumpy innovation arrivals and entry/exit dynamics are absent.

The remainder of the paper is organized as follows. Section 2 develops our model and analyzes optimal policies. Section 3 describes our data and provides summary statistics. Section 4 outlines our estimation strategy. Section 5 presents estimation results and our counterfactuals. Section 6 concludes.

2. Model

Time is discrete and the horizon is infinite. A unit mass of infinitely lived firms, each of which is run by a manager who receives both equity and options compensation. He chooses investment in R&D, as well as potential earnings misreporting to maximize his own utility. He faces a decreasing returns technology that is subject to persistent profitability shocks and noise in the earnings process.

2.1 Firms and Fundamentals

The firm's revenue net of flexible inputs, Y, is the product of endogenous quality, Q, and exogenous productivity, ν_y, which follows an $AR(1)$ process in logs:

$$\log \nu_y' = \rho_y \log \nu_y + \eta_y', \quad \eta_y' \sim N(0, \sigma_y^2). \tag{1}$$

Here, a prime indicates a variable in the subsequent period, and $|\rho_y| < 1$. The manager can choose expenditures in intangible capital or R&D, denoted as W, which drives growth in endogenous productivity Q according to:

$$Q' - Q = \Delta Q' = \xi W^{\gamma} Q^{1-\gamma}, \quad 0 < \gamma < 1. \tag{2}$$

The parameter ξ represents a multiplicative productivity shifting parameter. This production technology exhibits decreasing returns, given by γ, and it implies that the growth rate in endogenous productivity is identically given by:

$$g \equiv \frac{\Delta Q'}{Q} = \xi \left(\frac{W}{Q} \right)^{\gamma}.$$

Distributions to shareholders, D, are given by output minus R&D:

$$D \equiv Y - p_w W, \tag{3}$$

in which p_w is the price of R&D relative to output. Because we have no depreciated capital expenditures in the model, from an accounting perspective, $Y - p_w W$ can be thought of as intrinsic earnings that ultimately convert to shareholder cash flows.

2.2 Reporting and Manipulation

In each period, the firm must report its earnings, Π, to investors. We allow for observed earnings to deviate from intrinsic earnings, $Y - p_w W$, in two ways. First, we specify an accounting shock, ν_π that drives non-fundamental exogenous variation in earnings Π, with

$$\nu_\pi \sim N(0, \sigma_\pi^2). \tag{4}$$

This shock has no actual cash flow consequences and simply reflects deficiencies in accounting standards related to accurate estimation of intrinsic cash flows. Below, we refer to the shock, ν_π, as a non-fundamental shock or profit shock.

Next, the manager can manipulate earnings by introducing bias into the book value of the firm. In particular, the manager enters the current period with an inherited bias in book value given by B_{-1}. He then chooses a new level of bias, B, to obtain a net distortion, $B - B_{-1}$, to reported earnings. These two extra components of earnings imply that

$$\Pi \equiv Y - p_w W + \nu_\pi Q + B - B_{-1}. \tag{5}$$

If the new choice of bias, B, is nonzero, then the manager faces a constant probability, λ, of discovery, at which point he must pay a private cost of

$$MC(B, Q) = \left[\kappa_f + \kappa_q \left(\frac{B}{Q}\right)^2\right] Q, \quad \kappa_f, \kappa_q \geq 0. \tag{6}$$

In principle, such costs could arise either outside the firm from investor pressures or litigation risk or inside the firm through a sophisticated manager compensation contract. In addition, such costs could represent real disruptions and resource losses for the firm itself (e.g., litigation risk) or purely non-pecuniary internal costs for the manager (e.g., career or reputational concerns). In our counterfactuals below, we want to isolate the effects of these costs on managerial actions, and we want to avoid a purely mechanical impact of the costs themselves on the implied changes in firm value. Therefore, we conservatively assume that all of the smoothing and misreporting incentives reflected in (6) are purely non-pecuniary and internal to the manager. Finally, we assume that upon discovery and after payment of the private cost, $MC(B, Q)$, bias is unwound and reflected in the current value of the firm.

2.3 Managers' Incentives

Managers are risk neutral, and their compensation contracts have two components. The first is a fixed fraction, $\theta_d > 0$, of the outstanding equity of the firm. As such, the manager receives the same fraction, θ_d, of the distributions to shareholders. The second component is option compensation, where the manager is granted θ_o options, where $\theta_o > 0$ and also expressed as a fraction of total equity. We assume that each period the option grant is refreshed so that the strike price is always last period's stock price, denoted as P_{-1}. Thus, each period the manager receives a cash flow of D_M, which is given by:

$$D_M \equiv \theta_d D + \theta_o \max\{P - P_{-1}, 0\}, \tag{7}$$

where P is the current ex-dividend stock price. The stock price is rationally determined based on an information set discussed below. This compensation framework directly follows the structure of Glover and Levine (forthcoming), although we omit fixed compensation because the manager's risk neutrality renders such compensation irrelevant for the manager's choice of policies. In contrast, the two components of compensation that we model have important implications for the manager's actions. The stock component aligns the managers' incentives with those of long-term shareholders, while the options component gives the manager an incentive to boost the current period share price above last period's price.

We motivate this compensation scheme in large part by the survey of CEO compensation by Frydman and Jenter (2010), which documents that most CEO compensation packages contain salary, bonuses, payouts from long-term incentives plans, and restricted option and stock grants. Because the manager is risk-neutral, the fixed cash component is irrelevant for manipulation and investment decisions, so we omit the salary components.

As in Nikolov and Whited (2014) and Glover and Levine (forthcoming), we remain silent on the optimality of this compensation structure. Instead, we model actual contracts, as our goal is to quantify empirically the trade-off between information and investment in the face of incentives that are widely observed but that do not necessarily induce behavior that maximizes shareholder value. This strategy is sensible given the evidence in Dittmann and Maug (2007) that standard principal-agent models cannot rationalize observed executive compensation contracts. Alternatively, another reasonable view of this compensation policy is that it is a reduced-form description of a contracting outcome that allows for equilibrium self-interested behavior on the part of the agent, as in Zhu (2013).

2.4 Investor Pricing

If investors and managers have identical information sets, then manipulation is of no value to the manager because investors can see through this behavior. One of our central goals is to examine a trade-off between R&D efficiency and the accuracy of investor pricing of a firm relative to underlying true firm value. To this end, we assume that the price $P(\mathcal{I})$ of the firm in the market is a rational pricing function based on some information set, $\mathcal{I}$ for risk-neutral investors, which at a minimum includes observable firm earnings, Π. Because outsider investors make a rational inference based on their information set, to prevent full unravelling of manipulation we assume the investor information set does not include the full state vector. Accordingly, the pricing function represents investors' conditional expectation of the discounted stream of distributions to investors, and is given by:

$$P(\mathcal{I}) \equiv \mathbb{E}\left(\frac{1}{1+r}V_F' \mid \mathcal{I}\right), \tag{8}$$

where V_F is fundamental value of the firm.

2.5 Managers' Dynamic Optimization

We now describe the manager's dynamic optimization problem. He faces a state vector at any time of $(\nu_y, \nu_\pi, P_{-1}, B_{-1}, Q)$, and he discounts cash flows at a rate r. He optimally chooses R&D, W, and new gross bias, B. Given that the manager wants to maximize the expected discounted value of his compensation, the manager's private value function is given by V_M, as follows:

$$V_M(\nu_y, \nu_\pi, P_{-1}, B_{-1}, Q) = \max_{W,B} \left\{ \begin{array}{c} \mathbb{I}(B=0)\left(D_M + \frac{1}{1+r}\mathbb{E}V_M(\nu_y', \nu_\pi', P, 0, Q')\right) \\ + \\ \mathbb{I}(B \neq 0)(1-\lambda)\left(D_M + \frac{1}{1+r}\mathbb{E}V_M(\nu_y', \nu_\pi', P, B, Q')\right) \\ + \\ \mathbb{I}(B \neq 0)\lambda\left(D_M|_{B=0} - MC(B,Q) + \frac{1}{1+r}\mathbb{E}V_M(\nu_y', \nu_\pi', P|_{B=0}, 0, Q')\right), \end{array} \right\} \tag{9}$$

subject to the constraints and definitions given in (1)–(7). The first line in curly brackets in (9) is the value to the manager if he chooses not to manipulate. The second line represents the case in which he chooses to manipulate but does not get caught. The third line represents the case in which he does get caught.

While (9) gives lifetime managerial utility, it does not represent the fundamental value of the firm, which we denote as V_F, and which is simply the expected present value of distributions to shareholders. On the basis of the manager's privately optimal policies B^* and

W^*, the fundamental value of the firm V_F is thus given by

$$V_F(\nu_y, \nu_\pi, P_{-1}, B_{-1}, Q) = \left\{ \begin{array}{c} \mathbb{I}(B^* = 0) \left(D^* + \frac{1}{1+r} \mathbb{E} V_F(\nu_y', \nu_\pi', P, 0, Q') \right) \\ + \\ \mathbb{I}(B^* \neq 0)(1-\lambda) \left(D^* + \frac{1}{1+r} \mathbb{E} V_F(\nu_y', \nu_\pi', P, B^*, Q') \right) \\ + \\ \mathbb{I}(B^* \neq 0)\lambda \left(D^* + \frac{1}{1+r} \mathbb{E} V_F(\nu_y', \nu_\pi', P|_{B=0}, 0, Q') \right), \end{array} \right\}, \quad (10)$$

in which D^* is given by (3), evaluated at the policies B^* and W^*. We note that in the absence of options compensation, the manager has no incentive to manipulate, so managerial utility, (9), equals fundamental firm value (10).

Next, to reduce the state space of the model, we normalize output, R&D, and distributions by endogenous productivity Q as follows:

$$y \equiv \frac{Y}{Q} = \nu_y, \quad d \equiv \frac{D}{Q} = y - p_w w, \quad w \equiv \frac{W}{Q}, \quad g = \xi w^\gamma.$$

Earnings also naturally scale linearly with Q, so scaled earnings are given by:

$$\pi \equiv \frac{\Pi}{Q} = y - p_w w + \nu_\pi + b - b_{-1}, \quad b \equiv \frac{B}{Q}, \quad b_{-1} \equiv \frac{B_{-1}}{Q}.$$

Similarly, normalized by endogenous productivity, Q, manager incentives are given by

$$d_m \equiv \frac{D_M}{Q} = \theta_d d + \theta_o \max\left\{p - p_{-1}, 0\right\}, \quad p \equiv \frac{P}{Q}, \quad p_{-1} \equiv \frac{P_{-1}}{Q}.$$

The manager's value function (9) is homogenous in Q, so we can write

$$V_M(\nu_y, \nu_\pi, P_{-1}, B_{-1}, Q) = Q v_m(\nu_y, \nu_\pi, p_{-1}, b_{-1}),$$

where the normalized manager value function is given by

$$
v_m(\nu_y, \nu_\pi, p_{-1}, b_{-1}) = \max_{w,b} \left\{ \begin{array}{c} \mathbb{I}(b=0)\left(d_m + \dfrac{1+g(w)}{1+r}\mathbb{E}v_m(\nu_y', \nu_\pi', \frac{p}{1+g(w)}, 0)\right) \\ + \\ \mathbb{I}(b \neq 0)(1-\lambda)\left(d_m + \dfrac{1+g(w)}{1+r}\mathbb{E}v_m(\nu_y', \nu_\pi', \frac{p}{1+g(w)}, \frac{b}{1+g(w)})\right) \\ + \\ \mathbb{I}(b \neq 0)\lambda\left(d_m|_{b=0} - mc(b) + \dfrac{1+g(w)}{1+r}\mathbb{E}v_m(\nu_y', \nu_\pi', \frac{p}{1+g(w)}|_{b=0}, 0)\right) \end{array} \right\} \tag{11}
$$

subject to the following constraints and processes:

$$
\begin{aligned}
y &= \nu_y, \quad \log \nu_y = \rho_y \log \nu_{y,-1} + \eta_y, \quad \eta_y \sim N(0, \sigma_y^2) \\
d &= y - p_w w \\
\nu_\pi &\sim N(0, \sigma_\pi^2) \\
\pi &= y - p_w w + \nu_\pi + b - b_{-1} \\
d_m &= \theta_d d + \theta_o \max\{p - p_{-1}, 0\} \\
mc(b) &= MC(B/Q, 1) \\
g(w) &= \xi w^\gamma \\
p &= \mathbb{E}\left(v_f | \mathcal{I}\right).
\end{aligned}
$$

The definition of scaled manager value v_m given by (11) implicitly contains, through the pricing function, an equivalent scaled concept for fundamental firm value $v_f \equiv \frac{V_F}{Q}$, which is given by

$$v_f(\nu_y,\nu_\pi,p_{-1},b_{-1}) = \left\{ \begin{array}{c} \mathbb{I}(b=0)\left(d+\dfrac{1+g(w)}{1+r}\mathbb{E}v_f(\nu_y',\nu_\pi',\tfrac{p}{1+g(w)},0)\right) \\ + \\ \mathbb{I}(b\neq 0)(1-\lambda)\left(d+\dfrac{1+g(w)}{1+r}\mathbb{E}v_f(\nu_y',\nu_\pi',\tfrac{p}{1+g(w)},\tfrac{b}{1+g(w)})\right) \\ + \\ \mathbb{I}(b\neq 0)\lambda\left(d+\dfrac{1+g(w)}{1+r}\mathbb{E}v_f(\nu_y',\nu_\pi',\tfrac{p}{1+g(w)}|_{b=0},0)\right) \end{array} \right\}. \quad (12)$$

Here, the fundamental firm value function is evaluated at the optimal policies b, w derived from the manager dynamic optimization, and the transitions and constraints are identical to the v_m definition.

Scaling implies that all of our lower case variables are measured in terms of dollars per quality unit. Because quality units are unobservable, scaling implies that our model has empirical predictions for the growth rates of observable variables such as R&D expenditure, but not for the levels.

2.6 Model Solution Algorithm

The value of the firm, given by (12), requires a pricing function, given by (8), and vice versa. Therefore, to solve the model we use a nested loop, in which the outer loop, indexed by i, determines the rational pricing function, and the inner loop determines the optimal policies. First, we assume that the investors' information set $\mathcal{I}$ contains observable earnings, π. Second, we guess a linear rational pricing function of earnings, which we denote as $p^{(i)}(\pi)$. Third, given this guess, we use policy function iteration to solve (12), obtaining optimal R&D and manipulation policies, denoted as $b^{(i)}$ and $w^{(i)}$. Fourth, we construct the implied firm value function $v_f^{(i)}$ by forward iteration on equation (12) using $b^{(i)}$ and $w^{(i)}$. Fifth, we construct the implied stationary distribution $\mu^{(i)}$ induced by $b(\cdot)$, $w(\cdot)$, and the exogenous transitions in (1) and (4). Sixth, we update the pricing function, using

$$p^{(i+1)}(\pi) = \mathbb{E}_{\mu^{(i)}} \left(\frac{1 + g(w^{(i)})}{1 + r} v_f^{(i)\prime} \middle| \pi \right).$$

We then return to step two and repeat until $\|p^{(i+1)} - p^{(i)}\| < \varepsilon_P$, in ε_P is a preset tolerance.

It is restrictive to assume that earnings are the only variable in the investors' information sets. For example, knowledge of the strike price conveys additional information about the manager's manipulation decision, beyond the information contained in earnings. Below, we examine the quantitative sensitivity of our results to including extra variables in the information set.

2.7 Revenue Recognition

The model contains one further parameter that does not enter into the managerial optimization problem but that does enter into the simulation of data from the model and is important for matching simulated with actual data moments. This parameter reflects accrual accounting, which is an important feature of earnings measurement and which is designed to provide a better indication of company's performance or economic earnings than operating cash flows (FASB 1978).[2]

Accrual accounting induces a wedge between the measurements of earnings and operating cash flows, so accounting earnings do not generally correspond to cash inflows and outflows for the period. Moreover, because accruals are managers' forecasts of future cash flows, these forecasts must reconcile with realized cash flows in the future (e.g., Allen, Larson, and Sloan 2013; Nikolaev 2016). This reconciliation property implies that we can view operating cash flows as a reshuffling of accounting earnings across adjacent periods. As such, we allow for a random portion of accounting earnings to be realized as cash flows in the periods immediately

[2] According to Statement of Financial Accounting Concepts No. 1, "Information about enterprise earnings based on accrual accounting generally provides a better indication of an enterprise's present and continuing ability to generate favorable cash flows than information limited to the financial effects of cash receipts and payments."

before or immediately after the current period. Although we allow for reshuffling in only one adjacent period, this idea is similar to the mechanism underlying the accrual quality measure in Dechow and Dichev (2002), who represent accounting earnings as the sum of past, present, and future cash flows that are recognized in the current period earnings, with an allowance for estimation errors.

To implement this principle, we first define a parameter $\hat{p}_s \in (0,1)$, which represents the probability of intertemporal cash flow reshuffling. Next, we draw a set of uniform shocks, $\zeta^s_{it}, \quad \forall i, t$, where i indexes firms and t indexes time. We then initialize observed cash flows at time 1, which we denote $\tilde{d}_{i,1}$, equal to the actual cash flow simulated directly from the model, that is, $\tilde{d}_{i,1} \equiv y_{i,1} - p_w w_{i,1}$. Finally, iteratively progressing from $t = 2, ..., T-1$ for each firm i, we update the observed cash-flow series by the following rules:

$$\begin{aligned}
&\text{If } \zeta^s_{it} < 0.5, \quad \text{set} \quad \tilde{d}_{it-1} = \tilde{d}_{it-1} + 2\hat{p}_s(0.5 - \zeta^s_{it}) \text{ and } \tilde{d}_{it} = \tilde{d}_{it} - 2\hat{p}_s(0.5 - \zeta^s_{it}) \\
&\text{If } \zeta^s_{it} > 0.5, \quad \text{set} \quad \tilde{d}_{it+1} = \tilde{d}_{it+1} + 2\hat{p}_s(\zeta^s_{it} - 0.5) \text{ and } \tilde{d}_{it} = \tilde{d}_{it} - 2\hat{p}_s(\zeta^s_{it} - 0.5).
\end{aligned}$$

In words, this procedure randomly pushes forward some portion of today's cash flows into tomorrow and yesterday, given the random mistiming or reshuffling shock, ζ^s_{it}, keeping the sum of cash flows over any medium-term horizon unchanged, where here the horizon is three years.

2.8 Optimal Policies

Each period, the manager chooses how much to invest and whether to bias her earnings report. Figure 1 plots her choices as a function of the persistent fundamental shock, ν_y. The manager's decision depends upon two sometimes conflicting incentives embedded in her compensation. On the one hand, because of her equity ownership in the firm, the manager wishes to choose higher investment when the firm's fundamental conditions are more favorable, as value maximization dictates. On the other hand, because she also receives options compensation, the manager internalizes the impact of her reported profits on the value of the firm relative to the strike price embedded in her compensation. The nonlinearity of the options compensation leads the manager to choose different paths for investment and bias, depending upon whether she faces high or low short-term non-fundamental shocks, ν_π, to profits, even though a value-maximizing manager would ignore all short-term non-fundamental shocks.

The left column of Figure 1 plots investment and bias during bad times, i.e., in the face of an adverse non-fundamental shock to profits. In this case, if fundamental business conditions, ν_y, are also unfavorable, then neither severe cuts to investment nor reasonable upward bias in earnings would lead to a market price above the manager's current option strike price. Therefore, the manager chooses a high level of investment (top left panel, left side) and a negative bias (bottom left panel, left side) in her current earnings in order to reduce her reported profits. The result is a lower strike price and higher future expected value of her new options grants as a result of an "earnings bath" in the present period. However, a manager facing more favorable fundamental conditions finds manipulating her earnings downwards through bias too costly to justify and chooses zero manipulation (bottom left panel, right side). No longer seeking to artificially depress her profits today, the manager then chooses a smaller investment policy (top left panel, right side). Within each of these regions, the manager's investment policy is upward-sloped with respect to the fundamental shock, reflecting the value-maximization incentives to invest more during persistently good times.

The right column of Figure 1 plots investment and bias during good times, i.e., in the face of a positive non-fundamental shock to profits. If fundamental business conditions, ν_y, are also highly favorable, then with high likelihood the manager's options compensation will be in the money. Therefore, the manager places a high value on profits today relative to future profits. The result is upward bias of reported income (bottom right panel, right side) and opportunistic cuts to investment (top right panel, right side). For firms with less favorable fundamental conditions, the upward bias in profits required to inflate their options compensation is too large to justify given the fixed cost of manipulation. Therefore, the manager chooses zero bias (bottom right panel, left side) and no longer opportunistically cuts her investment (top right panel, left side). Within each of these regions, the manager's equity compensation causes her to choose investment that increases with the fundamental shock, but once again the options compensation and non-fundamental shocks induce substantial variation in the level of investment and bias.

Another interesting feature of the model is path dependence whereby a manager's past choices affect her current behavior. This path dependence is embedded in the strike price of her options compensation and the lagged or accumulated bias in earnings on the balance sheet. To illustrate this feature of the model, in Figure 2, we plot average investment and current bias as a function of the strike price and lagged bias. The left two panels plot optimal policies as a function of the strike price. Here, we see that for a manager with higher past earnings performance and hence with a higher strike price, her options lie out of the money with higher probability. Therefore, she prefers to manipulate reported earnings downward to increase the expected value of her newly granted options. The result is a choice of higher investment (top left panel) and downward reporting bias (bottom left panel).

The right two panels plot optimal policies as a function of bias. Here, we find a similarly intuitive result, as a manager with more accumulated bias on her balance sheet faces higher punishment if discovered for any current bias she chooses to introduce. A high-bias manager has less flexibility to manipulate her earnings or the value of their options compensation upwards today. Naturally, a manager with less flexibility today chooses to maximize future options compensation instead by unravelling bias and increasing investment today (right column). The result is lower profits today, a lower strike price on current options grants, and a favorable shift in the value of the manager's future compensation. Because neither the lagged performance of the firm nor the accumulated bias on a firm's balance sheet reflects fundamental conditions at the firm, the reaction of investment to these factors drives a further wedge between a manager's investment choices and the choices that maximize value.

3. Data

3.1 Sources

The data come from several sources. The financial data are from Compustat, and the data on executive compensation are from Equilar, which collects data on executive compensation from annual proxy filings (DEF 14A). Its coverage is more than double the coverage of Compustat ExecuComp, whose universe is the S&P 1500. In contrast, Equilar covers virtually all public companies. The data on restatements are from Audit Analytics, where we use restatements that correct accounting errors as a measure of detected misstatements.

Data availability from the intersection of these three sources means that our sample spans fifteen years from 2000 to 2014 and includes firms incorporated in the United States and listed on the NYSE, Amex, or NASDAQ. For firms included into the sample, we require positive total assets and sales, as well as non-negative R&D and SG&A expenses and known accelerated filer status, which we use in robustness tests. We further consider two samples of firms. The first sample excludes firms with all R&D expenses missing or equal to zero (R&D sample); and the second sample excludes firms with all SG&A expenses being missing or equal to zero (SG&A sample). These restrictions retain firms for which the discretionary investment into R&D or SG&A decisions are relevant. Table 1 provides the variable definitions.

Although manipulation is chosen optimally by the manager in the model, not all restatements observed in the data correct intentional manipulation. As such, classifying restatements as intentional incurs some unavoidable discretion, and the choice of any particular definition of an intentional restatement reflects a trade-off between the number of restatements and the likelihood that these restatements correct intentional misstatements.

We adopt a conservative approach by considering restatements of revenue recognition errors from Audit Analtytics data. Restatements are included in these data only if they are related to errors. For instance, Audit Analytics includes SEC Staff Accounting Bulletin (SAB) No. 101 restatements on revenue recognition only if they are related to errors in SAB 101 implementation, and Audit Analytics manually excludes retrospective revisions related to the application of new accounting principles. These types of restatements elicit the largest negative market reaction relative to other types of errors (e.g., Palmrose, Richardson, and Scholz 2004; Scholz 2008). Moreover, the closely related model of intentional manipulation in Zakolyukina (forthcoming) has more power to explain these types of errors relative to other types of errors such as expense recognition errors. At the same time, having a market reaction to a restatement disclosure as the only criterion for restatement severity could be considered restrictive. Firms vary in the amount and the sequence of information they release about a misstatement, with the extent of disclosure not being uniform across companies (Karpoff, Koester, Lee, and Martin forthcoming). This group of restatements provides 501 distinct restating firms.

For all restatements, we require that misstatements have a nonzero net income effect over restated period. This requirement is important because in the estimation, we set the bias in book value, B, equal to the cumulative impact of a restatement on net income. Because the patterns in descriptive statistics are similar for the R&D and SG&A samples, the discussion below focuses on the SG&A sample.

3.2 Subsample construction

Our sample period covers two significant regulatory changes in disclosure regulation: the Sarbanes-Oxley Act (SOX) and the Dodd-Frank Act (DFA). SOX constituted major disclosure regulation. Section 302 requires CEOs and CFOs to certify financial statements and establishes CEOs and CFOs as having direct responsibility for the accuracy of financial reports and internal controls over financial reporting. Section 404[a] requires management certification of internal controls over financial reporting. The first year of Section 404[a] compliance for smaller companies was 2007. Section 404[b] requires auditors to attest to the management's assessment of internal controls. U.S. accelerated filers had to implement Section 404[b] after November 15, 2004. DFA exempted U.S. non-accelerated filers from Section 404[b] compliance entirely

While DFA has fewer direct implications for disclosure than SOX, it nonetheless includes significant whistleblower protection. This program requires the SEC to pay an award to eligible whistleblowers, strengthens anti-retaliation protection, and allows a whistleblower to report misconduct directly to the SEC without first reporting through internal compliance.

This legislation and concurrent events have changed the expected cost of manipulation, both in terms of detection probability and penalty. Accordingly, there are three distinct regimes that can affect the misstatement cost parameters: the pre-SOX period ending in August, 2002; the post-DFA period starting in July, 2010; and the period between SOX and DFA (SOX-DFA).

We use this subsample heterogeneity as follows. First, we estimate our model on the subsample with the longest time span, the SOX-DFA period. Next, to understand whether these pieces of disclosure regulation affect manipulation, we assume that we obtain consistent estimates of the innovation production parameters and then use data from the other subsamples to reestimate the parameters related to manipulation.

3.3 Summary statistics

Figure 3 plots the incidence of restatements and the corresponding rate of restated annual periods by year. These two quantities are not identical because when a restatement occurs, financial statements from several previous years are often corrected at the same time. The incidence of restatements increases dramatically right after the passage of SOX and peaks after the SOX Section 404 implementation of internal control disclosures in 2004 (Whalen, Usvyatsky, and Tanona 2016). Incidence steadily declines thereafter. This pattern is consistent with detection probability increasing in the post-SOX period. Because of the backward-looking nature of restatements, the rate of restated annual periods also declines over time.

Figure 4 plots the ratio of the bias in earnings to sales as a function of time. Because the cost of manipulation increases over this time period, the magnitude of earnings misstatements naturally declines over time.

Panel A of Table 2 provides descriptive statistics for restatements. Among restating firms, the mean (median) bias in book value is \$36 (\$2.4) million or 3.4% (0.7%) of total assets. The corresponding bias in earnings is \$11.6 (\$1.17) million or 2.9% (0.4%) of sales.

Panel B of Table 2 provides descriptive statistics for the two forms of compensation that we model. In line with the evidence in Frydman and Jenter (2010), the mean (median) CEO holds 4.2% (0.65%) of all outstanding stock, and his options compensation constitutes 0.81% (0.39%) of stock.

Panel C of Table 2 provides descriptive statistics for the variables used in estimation, as well as other firm characteristics. Recall that many of our moments are growth rates, which we compute as differences relative to the absolute value of an average following Davis and Haltiwanger (1992) and Terry (2015). For instance, the one-year growth in x_t is computed as

$$\Delta x = \begin{cases} 0, x_t = 0 \text{ and } x_{t-1} = 0, \\ 2\frac{x_t - x_{t-1}}{|x_t| + |x_{t-1}|}.\text{otherwise} \end{cases} \tag{13}$$

These growth rates have the advantage of being bounded within $[-2; 2]$. This restriction is important because often variables shift from zero to nonzero values, so, for example, the shift from zero to positive R&D investment results in a finite rather than a missing value.

The median one-year growth in cash flows is 4.4%, the one-year growth in earnings is 5.3%, the one year growth in SG&A is 9.3%, and the three-year growth in sales is 25.7%. Because this last figure is quite large, and because it likely reflects not only greenfield growth but also mergers, entry, and exit, we use a sales weighted growth rate in our estimation. Finally, the firms in our sample are identical in size to a generic Compustat sample. The mean firm assets are \$2.51 billion in our sample, while the mean assets of all firms in Compustat over the same period is \$2.52 billion.

4. Estimation

Two of the model parameters, θ_d and θ_o, can be estimated directly from our Equilar data. Following Nikolov and Whited (2014) and Glover and Levine (forthcoming), we set the equity share, θ_d, equal to the fraction of manager-owned shares to total shares outstanding. Similarly, we set the managers' option share, θ_o, equal to the fraction of manager-owned unexercised options to total shares outstanding. Another of the model parameters, the discount rate, r, we set to 6%. This figure represents a premium over the 3.84% average ten-year Treasury bond over our sample period, and it is generally consistent with evidence that managers set discount rates higher than one would predict using a standard model (Graham and Harvey 2001).

We estimate the model parameters using a simulated minimum distance estimator, where we need to simulate because of the presence of the earnings reshuffling shock, ζ_{it}^s. The mechanics of the estimation are straightforward and by now familiar (Bazdresch, Kahn, and Whited forthcoming). For a given set of parameters, we solve the model and use the solution to generate simulated data, which is ten times the size of our data set (Michaelides and Ng 2000). Next, we calculate a set of statistics, which are either moments or functions of moments. Based on the distance between model-generated statistics and their empirical counterparts, the values of the structural parameters are updated. To gauge this distance, we use the inverse covariance matrix of the empirical moments. To minimize the econometric objective function, we use a particle swarm algorithm as in Terry (2015).

4.1 Identification

We have 10 model parameters to estimate: ξ, the innovation productivity shifter; p_w, the relative price of intangible investment; γ, the elasticity of innovation to investment; ρ_y and σ_y, the persistence and volatility of the fundamental shock; σ_π, the volatility of the non-fundamental shock to profits; κ_f and κ_q, the fixed and quadratic costs of manipulation, conditional upon discovery; λ, the probability of manipulation discovery; and $\hat{p}_s$, the intensity of reshuffling.

To identify these parameters, we use 17 moments. Three are directly related to manipulation and detection. The first is the mean absolute ratio of manipulation to sales, conditional upon restatement, $\mathbb{E}\left[|b/y|\,|I_r\right]$. The second is the probability of detection, $\mathbb{P}(I_d)$, in which the dummy variable, I_d, indicates the actual discovery of manipulation in a period, rather than the restatement of manipulation in that period. If manipulation is detected in a period, restatement happens in that period, but not necessarily vice-versa. The third is the probability of restatement, $\mathbb{P}(I_r)$, in which the dummy variable, I_r, indicates revision of data, rather than the detection of manipulation.

The next two moments are means. First, we use mean ratio of intangible investment to sales, given by $\mathbb{E}(w/y)$. Second, we use the sales-weighted three-year growth rate of sales, given by $\mathbb{E}_y\Delta_3 y$, which we compute using sample averages to evaluate $\mathbb{E}_y\left(y_{i,t-3}\Delta_3 y_{i,t}\right)/\mathbb{E}_y\left(y_{i,t-3}\right)$, where $\Delta_3 y_{i,t} = 2(y_{i,t} - y_{i,t-3})/(y_{i,t} + y_{i,t-3})$

The next three moments are variances. The first of these is the variance of observed dividend growth, given by $\text{cov}(\Delta d, \Delta d)$, where $\Delta d = 2(d - d_{-1})/(d + d_{-1})$. The next two variances are those of the growth rates of reported earnings, π, and intangible investment, w, which are defined similarly. The next three moments are covariances, in particular, the three possible covariances between Δd, $\Delta\pi$, and Δw. The final six moments are these three variances and three covariances, each conditional upon restatement.

While each of these moments is related to nearly all of the parameters in the model, some moments have strong monotonic relationships to certain parameters and are thus particularly useful for identifying those parameters. To ascertain the strength of these relationships, we perform a battery of comparative statics exercises, which we then use to justify our moment choices.

We start with ξ, which shifts the innovation production function and thus maps strongly and positively into the mean growth rate, $\mathbb{E}_y\Delta_3 y$, and the size of intangible investment,

$\mathbb{E}(w/y)$. Next, we consider the price of intangible investment, p_w. Because this parameter determines the costliness of intangible investment in terms of the numeraire output, it also maps positively into the mean growth rate $\mathbb{E}_y\Delta_3 y$ and the size of intangible investment $\mathbb{E}(w/y)$. Although both parameters map to the same moments, because the relative strength of these mappings is not identical across the two parameters, these moments are still informative.

The third important technological parameter is γ, which governs the returns to intangible investment in the innovation equation. Intuitively, when this parameter is higher, intangible investment responds more strongly to shocks, so a high level for γ results in high covariances between intangible investment and indicators of fundamentals, in particular, dividends and earnings, both unconditionally and conditional on restatement. Naturally, if investment is more responsive, it also has a higher variance, so γ also affects this latter moment.

Next, we consider the persistence of the fundamental shock, ρ_y. This parameter affects many different moments. For example, it maps negatively into the volatility of all growth rates in the model because higher persistence drives lower volatility in the growth rate of fundamentals. This negative relation holds for all of the growth rate volatility moments under restatement as well. A separate, less mechanical effect is also at work. Because higher fundamental persistence makes today's fundamental shock more informative for tomorrow, the covariance of the output shock and investment increases. This effect leads to a higher covariance between dividend and investment growth. Because accruals manipulation allows the manager to choose a more fundamentals-aligned investment level without sacrificing earnings, this last effect is more pronounced with restatements than without.

Unlike the persistence parameter, ρ_y, the volatility of the fundamental shock, σ_y, is a neutral volatility shifter that primarily affects observable growth rate variances, with and without restatement. Although σ_y mechanically affects covariances, these effects are small relative to the effects on volatilities.

The identification of the volatility of our nonfundamental earnings shock, σ_π, operates somewhat differently. First, mechanically, we have a strong positive link between this parameter and the variance of earnings, both unconditionally and conditional on restatement. However, the volatility of non-fundamental shocks also maps into the volatility of investment, conditional upon there being a motive for real manipulation, which in our model takes the form of high accruals-based manipulation costs. Naturally, this mapping is weaker when accruals-based manipulation is present. Next, because dividends include investment, because positive profit shocks force options to be in the money, and because there is less investment when options are in the money, higher nonfundamental shock volatility leads to lower comovement between dividends and profits. This effect is stronger when more real manipulation occurs.

Next, we consider the manipulation cost parameters, starting with the quadratic cost parameter, κ_q. This parameter determines the costliness of accruals manipulation on the intensive margin. When accruals manipulation is more costly, more manipulation occurs through investment, so the variance of investment growth increases. In addition, a higher cost reduces the covariance between investment and dividend growth, as investment becomes a tool with which to respond to non-fundamental shocks. Because non-fundamental shocks (when positive) tend to push options into the money, if κ_q is large, the model produces cuts in investment, with the result that the covariance between earnings and profits growth is negative.

Our second manipulation cost parameter, κ_f, quantifies the fixed costs of manipulation, conditional upon discovery. As such, this parameter determines the cost of accruals manipulation at the extensive margin. Mechanically, a higher fixed cost of discovery of manipulation leads to a lower probability of manipulation and hence detection of restatement, so the probability of both of these events is lower. Note, however, that the detection probabilities are also driven in large part by the random detection likelihood parameter λ, which maps more strongly into detection, $\mathbb{P}(I_d)$, and less strongly into restatement, $\mathbb{P}(I_r)$, relative to the κ_f parameter. A second effect operates through increasing returns to manipulation, which naturally arises in the presence of a fixed cost. In this case, detection does not occur unless it is highly worth it, so a high fixed cost implies a higher average bias conditional on restatement.

The probability of manipulation discovery, λ, governs the likelihood of random discovery of manipulation, which is a Poisson-style shock in the model. Mechanically, the likelihood of restatement and detection go up, but because firms internalize the likelihood of discovery in their manipulation choices, restatement values increase less. The slope of each of these mappings increases with the size of κ_f.

Our final parameter is the intensity of earnings reshuffling, $\hat{p}_s$, which governs the extent to which we randomly reshuffle some of the actual cash flows from a particular period into the preceding or following periods. Naturally, this reshuffling leads to more volatile dividend growth, and it also reduces the correlations between dividends and all other series in the model.

5. Estimation results and counterfactuals

The results from our estimation are in Table 3. In Panel A, we report the actual data moments and the model-simulated moments. In part because of our large sample size and because many of our moments, especially the means are easily estimated, all of the seventeen moment pairs are significantly different from one another. However, few are economically different, and several of these pairs match up nicely. Actual and simulated mean balance sheet bias are quite close, as are the probabilities of detection and restatement and the mean ratio of R&D to sales. None of the simulated moments take the wrong sign, and this result is important because many of our moments are covariances. Moreover, we only see four instances in which the simulated and actual moments differ by a factor of two or more. In particular, the model markedly misses both the conditional and unconditional covariances between dividend and R&D growth, given restatement, as well as the conditional and unconditional covariances between earnings and R&D growth. Overall, however, we believe the fit of the model is remarkably good, given that we have a high degree of overidentification. Accordingly, it is a useful laboratory for counterfactual policy experiments.

Next, we turn to the parameter estimates, which are reported in Panel B. These parameters divide naturally into two groups, reflecting firm fundamentals on the one hand and income reporting or manager incentives on the other hand. Turning to the first group of parameter estimates, the implied fundamentals for firms are in line with many of the extant estimates in the literature. Intangible investment, a specialized input into innovation, costs a bit more than twice as much as output with $\hat{p}_w \approx 2.25$. The persistence of productivity or profitability of $\hat{\rho} \approx 0.6$ lies comfortably within the range of the estimated persistence of productivity in all U.S. firms estimated by Winberry (2016) (≈ 0.78) or in U.S. manufacturing estimated by Castro, Clementi, and Lee (2015) (≈ 0.45). The total conditional volatility of shocks to firm profitability each year is $\sqrt{\hat{\sigma}_y^2 + \hat{\sigma}_\pi^2} \approx 0.33$, which is slightly higher than the total volatility of shocks to U.S. public firms estimated by studies that omit a role for non-fundamental shocks such as Gourio and Rudanko (2014). Finally, the estimated elasticity of innovation to intangible investments $\hat{\gamma} \approx 0.4$ lies below one, consistent with the evidence from patenting, firm growth, and R&D in papers including Acemoglu, Akcigit, Bloom, and Kerr (2013). The parameters governing reporting incentives for the manager mostly relate to manager preferences and lack a direct empirical equivalent. One exception is the probability of detection $\hat{\lambda} \approx 0.15$, which compares closely to the estimates from a similar dynamic model in Zakolyukina (forthcoming). Moreover, the mistiming of revenues is moderate at around $\hat{p}_s \approx 2\%$ per year. Overall, the parameters in Table 3 appear reasonable.

5.1 The dynamics of restatement and intangible investment

The model provides high-powered incentives to managers to shift reported profits upwards in periods when their options compensation is in the money. Managers have two tools with which they can achieve this upward manipulation, biased reporting or real investment shifts, and each tool is costly at the margin. The direct implication within the model is that managers will use both levers to manipulate their earnings upward in such periods, leading to a positive shift in bias as well as a lower level of intangible investment. But does this untargeted prediction of our model hold up empirically, both in a qualitative sense as well as quantitatively given our estimated parameters? To investigate further, we examine periods in our restatement sample in which upward bias was detected and later restated. We then run the following panel regression of R&D w_{jt} for firm j at time t on a full set of firm and time dummies, together with indicators for a restated period in which upward bias was reported.

$$\log w_{jt} = \sum_{k=-K}^{K} \beta_k \mathbb{I}(\text{Upward Bias Restated})_{jt+k} + f_j + g_t + \varepsilon_{jt}.$$

The coefficients β_k trace out the within-firm idiosyncratic variation in intangible investment at horizons k periods away from the restatement event. The black line plots the resulting dynamics of R&D in the data, and we see a quick drop in R&D of around 6.4% for the firm in periods in which upward bias is restated (see the period labelled "0" in the figure). The red line, plotting identical estimates from a simulated panel of firms in the model, also exhibits a quick decline in R&D in periods with upward-biased restatements, this time with a drop of around 14%. The model doesn't exactly match the quantitative size of the contemporaneous drop in R&D in periods with upwards bias, but the empirical and simulated magnitudes are broadly comparable. Examination of each plot also reveals that the model and data dynamics match along another untargeted dimension, the transitory nature of the associated R&D declines. In the model, R&D rebounds quickly because of the short-lived nature of opportunities for manipulation of options compensation. The transitory observed fluctuation in R&D is not an extraneous feature of the model. Instead, mismatch between the short-term variation in incentives to manipulate long-term investment, on the one hand, and more persistent variation in incentives to invest, on the other hand, drive the efficiency loss for firms in a context with real investment manipulation.

5.2 Counterfactuals

In the presence of options compensation, managers face incentives to manipulate their reported earnings using one of two available tools: real investment choices or bias in reporting. Reporting is subject to convex costs upon discovery, and large manipulation of investment leads to more costly deviations from a value maximizing benchmark. Therefore, managers in general will substitute across the two different forms of manipulation, shifting their investment only moderately while simultaneously introducing some bias in their reporting. The result, of course, is a classic trade-off. Managers facing higher cost of biased reporting will release more accurate income statements but choose less efficient, and more volatile, investment paths.

In Table 4, we quantify these trade-offs based on a series of counterfactual calculations, reporting a set of results based on the baseline estimated model, a model with no reporting bias, and a value-maximizing firm for comparison. The first column of the table reports that managers in the baseline estimated model in equilibrium choose reporting bias equal to around 2% of sales, conditional upon restatement. A manager facing infinite costs of misreporting in the second column, and choosing no bias, clearly releases more accurate income statements. However, the second row emphasizes the trade-off discussed above. Because managers without the ability to misreport their profits choose to manipulate through their investment alone, the volatility of investment growth increases by around a tenth relative to the baseline model. Distortions to the path of investment lead to a loss in the underlying or fundamental firm value, and the third row reports that eliminating bias in income statements from the estimated equilibrium would cost around half a percent of firm value on average. Of course, in an environment with no options compensation and hence value-maximizing managers, no trade-off between accuracy and firm value exists. The third column reports that such value maximizing managers would choose zero bias and much smoother investment policies, although such an equilibrium may be unfeasible to achieve in practice given other unmodeled motives for disciplining executives with options compensation.

The counterfactual cases considered in Table 4 are informative but extreme. Figure 6 plots the equilibrium trade-off between investment efficiency and bias in reporting as the cost of bias κ_q varies more moderately. As the costs of manipulation decline, average bias increases on the horizontal axis, but investment efficiency improves, as reflected in lower investment volatility on the vertical axis. Starting from the estimated model, indicated with the circular marker on the figure, a one percent reduction in bias can be achieved only through around half a percent increase in the volatility of investment. Policymakers concerned with both the accuracy of income reporting and the real efficiency of firms must take the quantitative magnitude of this trade-off, which constrains their choices, into account when designing reporting regulation.

6. Conclusion

We quantify the importance of managers' opportunistic distortion of information to the public as a force that improves the efficiency of their investment choices. This seemingly counterintuitive connection makes sense in the context of widespread observed compensation structures. On the one hand, many features of compensation contracts, such as options compensation, give managers the incentive to manipulate stock prices through earnings disclosures. On the other hand, disclosure regulation does not erase these incentives, so when managers find it costly to manipulate earnings, they substitute opportunistic cuts to investment, which can have adverse effects on shareholder value. Indeed, survey evidence suggests that managers facing pressures to report high earnings numbers appear to both misreport their earnings and distort long-term investments (Graham et al. 2005). If managers are willing to substitute between these two forms of manipulation, then reforms either to reporting regulations or executive compensation may face a crucial trade-off between the accuracy of information reported by firms and the efficiency of long-term investment (Cohen et al. 2008).

However, given the scale of recent reforms to firm disclosure regulations, e.g. the Sarbanes-Oxley and Dodd-Frank Acts in the United States, quantifying the extent of this trade-off seems crucial. Our vehicle for addressing this question is estimation of a dynamic model that incorporates all four ingredients necessary to generate the trade-off between misreporting and investment efficiency: a compensation structure with both short-term and long-term incentives, asymmetric information between managers and investors that allows information manipulation to work, persistent investment opportunities that enhance firm growth, and punishment for misreporting. Because the extent of misreporting, the payoffs to long-term investments, and the counterfactual response of firms to various policy and compensation regimes are difficult to measure with reduced-form exercises, our question requires estimating a dynamic model.

Our results are interesting and potentially useful for informing the debate over information disclosure regulation. Our model estimates imply that when managers are caught misreporting and forced to restate, their reporting bias equals 2% of sales. In the model, if we make the cost of misreporting high, it disappears, but then managers mistime investment so that it does not occur when investment opportunities are best. This suboptimal behavior cuts shareholder value by half a percent. Interestingly, the value loss from the existence of short-term incentives is much larger, at about 13%.

One ubiquitous drawback of our approach is the necessity of making model simplifications. For example, we only allow for one input into the production process, the firm faces no financial frictions, and the only short-term incentive comes from options compensation. We conjecture that advances in computing power will allow the specification of richer models to further our understanding of the little explored trade-offs between information manipulation, career concerns, and the efficiency of the real economy.

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Table 1: Data definitions

This table presents definitions and data sources for variables used in estimation. Compustat data codes are in parentheses.

Panel A: Firm-specific variables	
θ_d	CEOs' stock holdings (excluding options exercisable within 60 days) as a fraction of total shares outstanding. Equilar.
θ_o	CEOs' *exercisable* option holdings as a fraction of total shares outstanding. Equilar.
y	Sale revenues (SALE). Compustat.
$p_w w$	Investment. For SG&A sample, investment is XSGA; for R&D sample, investment is XRD. Compustat.
d	Free cash flow is cash from operations (OANCF) minus net capital expenditures (CAPX - SPPE). Compustat.
π	Earnings is income before extraordinary items (IB). Compustat.
Panel B: Restatement-specific variables	
I_d	The indicator variable for detection that equals 1, when a firm restates its earnings. Audit Analytics advanced restatement feed.
I_r	The indicator variable that equals 1 in the years in which retained earnings were corrected by a restatement. Audit Analytics advanced restatement feed.
b_t	The bias in book value that equals the cumulative correction of net income. Audit Analytics advanced restatement feed.

Table 2: Descriptive statistics

This table presents descriptive statistics for the variables used in estimation. The sample is based on Equilar, Audit Analytics advanced restatements, and Compustat. The sample covers the period from 2000 to 2014 at an annual frequency. Firm characteristics are based on the variables averaged by firm. Executive characteristics are based on the variables averaged by executive. Restatement characteristics are based on the variables averaged by a restating firm. Compustat data codes are in parentheses. *Earnings* is income before extraordinary items (IB). *Free cash flow* is cash from operations (OANCF) minus capital expenditures (CAPX - SPPE). *R&D* is R&D expense (XRD) with missing values set to 0. *SG&A* is SG&A expense (XSGA) with missing values set to 0. *Market value* is the product of common shares outstanding (CSHO) and fiscal-year closing price (PRCC_F). *Total assets* is assets total (AT). *Sales* is sales revenue (SALE). *Market-to-book* is the sum of market value and total assets minus book value of equity divided by total assets. *Fiscal-year return* computed using fiscal-year closing stock prices. *Ownership* is the difference between shares owned (OWN_HOLDINGS) and options exercisable within 60 days (OWN_OPT_EX_60) divided by shares outstanding at fiscal-year end (SHARES_OUT_FY). *Unexercised options, Exercisable* is vested option holdings (OPT_UNEX_EX) with missing values set to 0 divided by shares outstanding at fiscal-year end (SHARES_OUT_FY). *Bias in book value* is the cumulative change in restated net income. *Bias in earnings* is the change in restated net income. Before computing summary statistics, all variables are winsorized at the 1- and 99- percentiles.

	Obs.	Mean	SD	5%	25%	50%	75%	95%
Restatement-related variables								
Revenue recognition errors (N = 501)								
Bias in book value ($mn)	501	36.064	163.313	−3.080	0.393	2.446	11.954	115.129
Bias in book value-to-total assets	501	0.034	0.091	−0.006	0.001	0.007	0.026	0.144
Bias in earnings ($mn)	501	11.628	52.374	−2.723	0.155	1.175	4.787	37.240
Bias in earnings-to-sales	501	0.029	0.093	−0.007	0.001	0.004	0.017	0.123
Executives' equity holdings								
CEO equity holdings								
Ownership (%)	9,880	4.204	9.701	0.004	0.161	0.651	2.646	24.756
Unexercised options, Exercisable (%)	9,956	0.819	1.153	0.000	0.060	0.394	1.088	3.142

Table 2: —*Continued*

	Obs.	Mean	SD	5%	25%	50%	75%	95%
Firm characteristics								
Obs.	5,655	9.405	4.768	2.000	5.000	10.000	15.000	15.000
Market value ($bn)	5,631	2.027	5.698	0.025	0.110	0.370	1.279	8.876
Total assets ($bn)	5,655	2.511	7.094	0.023	0.126	0.460	1.617	10.896
Sales ($bn)	5,655	1.570	4.593	0.012	0.063	0.234	0.912	6.798
Market-to-book	5,631	2.009	1.412	0.954	1.112	1.496	2.291	4.941
Fiscal-year return	5,434	0.159	0.361	−0.334	0.016	0.125	0.255	0.712
Earnings-to-lagged total assets	5,645	−0.053	0.266	−0.576	−0.040	0.011	0.059	0.156
Free cash flow-to-lagged total assets	5,634	−0.030	0.221	−0.484	−0.030	0.019	0.066	0.162
R&D-to-lagged total assets	5,645	0.057	0.112	0.000	0.000	0.000	0.066	0.305
SG&A-to-lagged total assets	5,645	0.325	0.347	0.015	0.064	0.226	0.459	1.007
Earnings-to-sales	5,655	−0.919	5.113	−2.471	−0.079	0.018	0.075	0.192
Free cash flow-to-sales	5,644	−0.729	4.263	−2.156	−0.042	0.031	0.104	0.284
R&D-to-sales	5,655	0.291	1.557	0.000	0.000	0.000	0.075	0.557
SG&A-to-sales	5,655	0.620	1.734	0.042	0.144	0.285	0.460	1.528
Annual free cash flow growth	5,622	0.022	0.365	−0.589	−0.122	0.044	0.184	0.540
Annual earnings growth	5,643	0.027	0.368	−0.603	−0.115	0.053	0.182	0.544
Annual R&D growth	5,654	0.051	0.142	−0.082	0.000	0.000	0.077	0.337
Annual SG&A growth	5,654	0.129	0.173	−0.074	0.035	0.093	0.180	0.474
3-year sales growth	5,362	0.324	0.391	−0.180	0.088	0.257	0.497	1.083

Table 3: Baseline estimation results

A. Moments

	Data moments	Simulated moments	t-statistics
Mean three-year weighted sales growth rate	0.1621	0.1067	27.5362
Mean ratio of R&D to sales	0.3398	0.3049	65.1688
Expected balance sheet bias, given restatement	0.0137	0.0088	82.3521
Probability of detection	0.0141	0.0182	-16.3101
Variance of dividend growth	1.3594	1.0984	32.9072
Covariance of dividend and earnings growth	0.2903	0.8272	-74.1940
Covariance of dividend and R&D growth	-0.0107	-0.0230	10.2873
Variance of earnings growth	1.1709	1.4193	-108.0725
Covariance of earnings and R&D growth	-0.0104	-0.0282	19.9959
Variance of R&D growth	0.0596	0.0074	52.6434
Probability of restatement	0.0317	0.0239	11.6905
Variance of dividend growth, given restatement	1.5416	0.6695	15.4565
Covariance of dividend and earnings growth, given restatement	0.4304	0.6837	-5.3051
Covariance of dividend and R&D growth, given restatement	-0.0183	-0.1074	9.4243
Variance of earnings growth,given restatement	1.4306	0.8171	16.3324
Covariance of earnings and R&D growth, given restatement	-0.0282	-0.1263	11.6042
Variance of R&D growth, given restatement	0.0743	0.0332	6.0076

B. Parameter estimates

ξ	p_w	ρ_y	σ_y	σ_π	κ_q	κ_f	γ	λ	p_s
0.0673	2.1972	0.4938	0.2861	0.1824	21.3018	0.0010	0.3782	0.1478	0.0207
(0.0027)	(0.1456)	(0.0202)	(0.0242)	(0.0067)	(1.9424)	(0.0006)	(0.0148)	(0.0261)	(0.0057)

The estimation is done with simulated minimum distance, which chooses structural model parameters by matching the moments from a simulated panel of firms to the corresponding moments from the data. Panel A reports the simulated and actual moments and the clustered t-statistics for the differences between the corresponding moments. Panel B reports the estimated structural parameters, with standard errors in parentheses. ξ is a multiplicative productivity shifter. p_w is the price of R&D relative to output. ρ_y is the serial correlation of the persistent productivity shock. σ_y is the volatility of the persistent productivity shock. σ_π is the volatility of the i.i.d. shock to earnings. κ_q is the quadratic cost of manipulation. κ_f is the fixed cost of maniupulation. γ is the curvature of the innovation production function. λ is the probability of manipulation detection. p_s is the probability of intertemporal earnings reshuffling.

Table 4: Bias vs. value: counterfactual experiments

Model	Baseline (Estimated)	No Bias ($\kappa_q = \kappa_f = \infty$)	Value Maximizing ($\theta_o = 0$)
Mean Bias	2.26	0.00	0.00
Investment Volatility	7.96	8.53	2.06
Firm Value Change from Baseline	0.00	-0.45	13.45

The table reports various outcomes computed under three alternative model parameterizations. The first column reports moments from the baseline model (with estimated parameters), the second column reports moments a model with no accounting bias (identical to baseline with bias costs κ_q, κ_f set to ∞), and the third column reports moments from a value maximizing model with no options compensation (identical to baseline with options weight $\theta_o = 0$). The first row reports the mean bias relative to sales conditional upon restatement. The second row reports the standard deviation of investment growth. The third row reports the average change in fundamental firm value relative to the baseline model. All counterfactual moments are computed using the ergodic distribution of the respective models, with all units in percent.

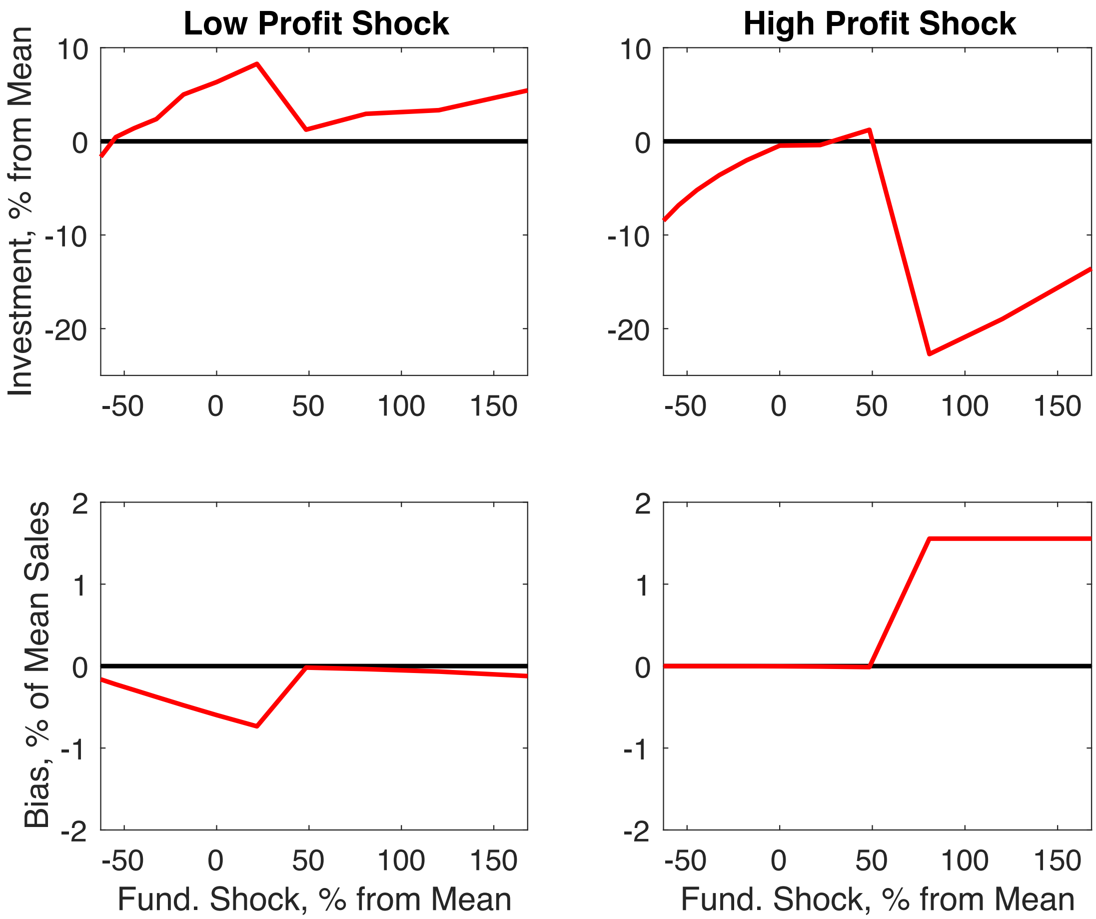


Figure 1: Investment and bias as a firm's profitability varies

Each panel of the figure plots a firm policy function - for their choice of investment or bias - in the estimated baseline model as a function of the fundamental shock v_y. The policy functions in the left column are conditioned on a low value of the profit shock $v_\pi = -0.54$, while the policy functions in the right column are conditioned on a high value of the profit shock $v_\pi = 0.54$. The top row plots a firm's investment policy in percent deviations from the mean investment policy in the model. The bottom row plots a firm's bias policy b as a percent of mean sales. The plotted policy functions are averages over the ergodic distribution of the model, conditioning upon the indicated values of the fundamental and profit shocks.

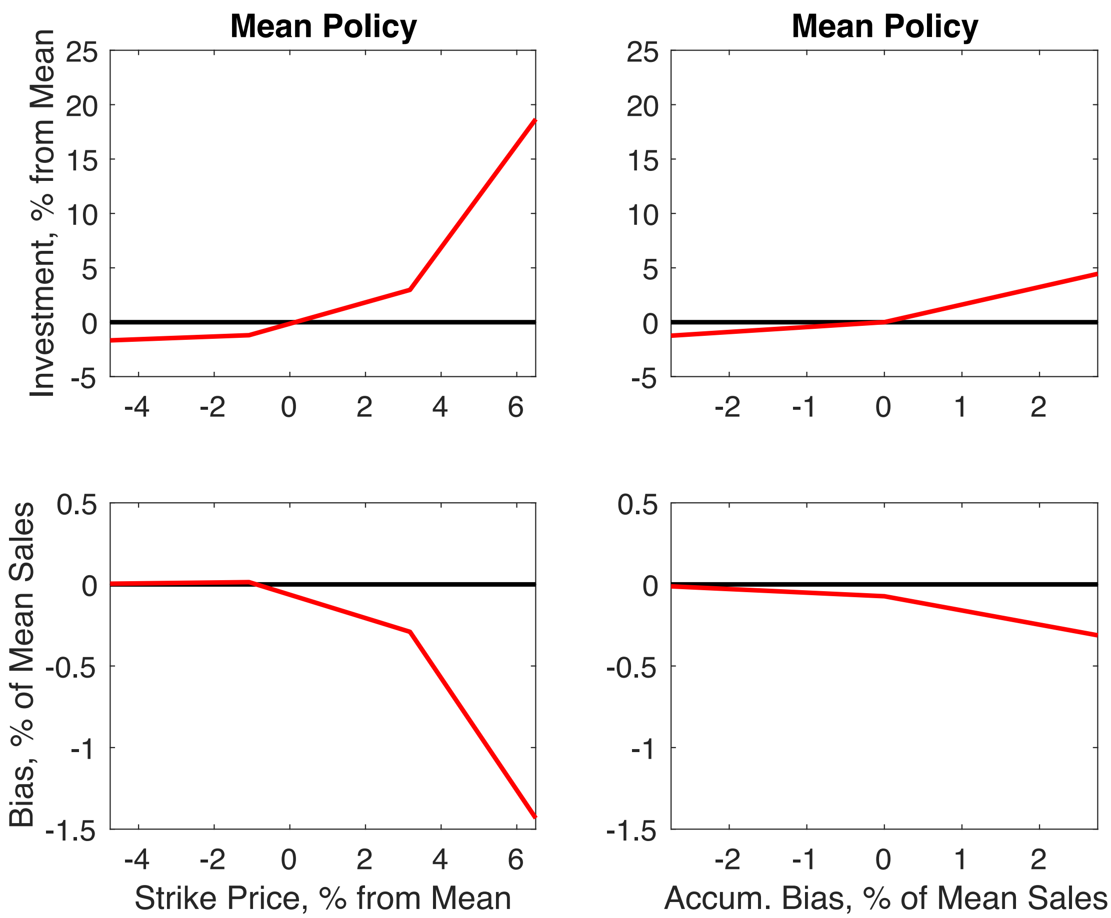


Figure 2: Investment and bias as a firm's history varies

Each panel of the figure plots a firm policy function - for their choice of investment or bias - in the estimated baseline model as a function of a state variable. The top row plots a firm's investment policy in percent deviations from the mean investment policy in the model. The bottom row plots a firm's bias policy b as a percent of mean sales. The left column plots policies as a function of the strike price of a manager's options compensation. The right column plots policies as a function of the accumulated bias on a firm's balance sheet. The plotted policy functions are averages over the ergodic distribution of the model.

Figure 3: Incidence of misreporting

This figure depicts restatement rate and restated annual financial statements by year for revenue recognition restatements.

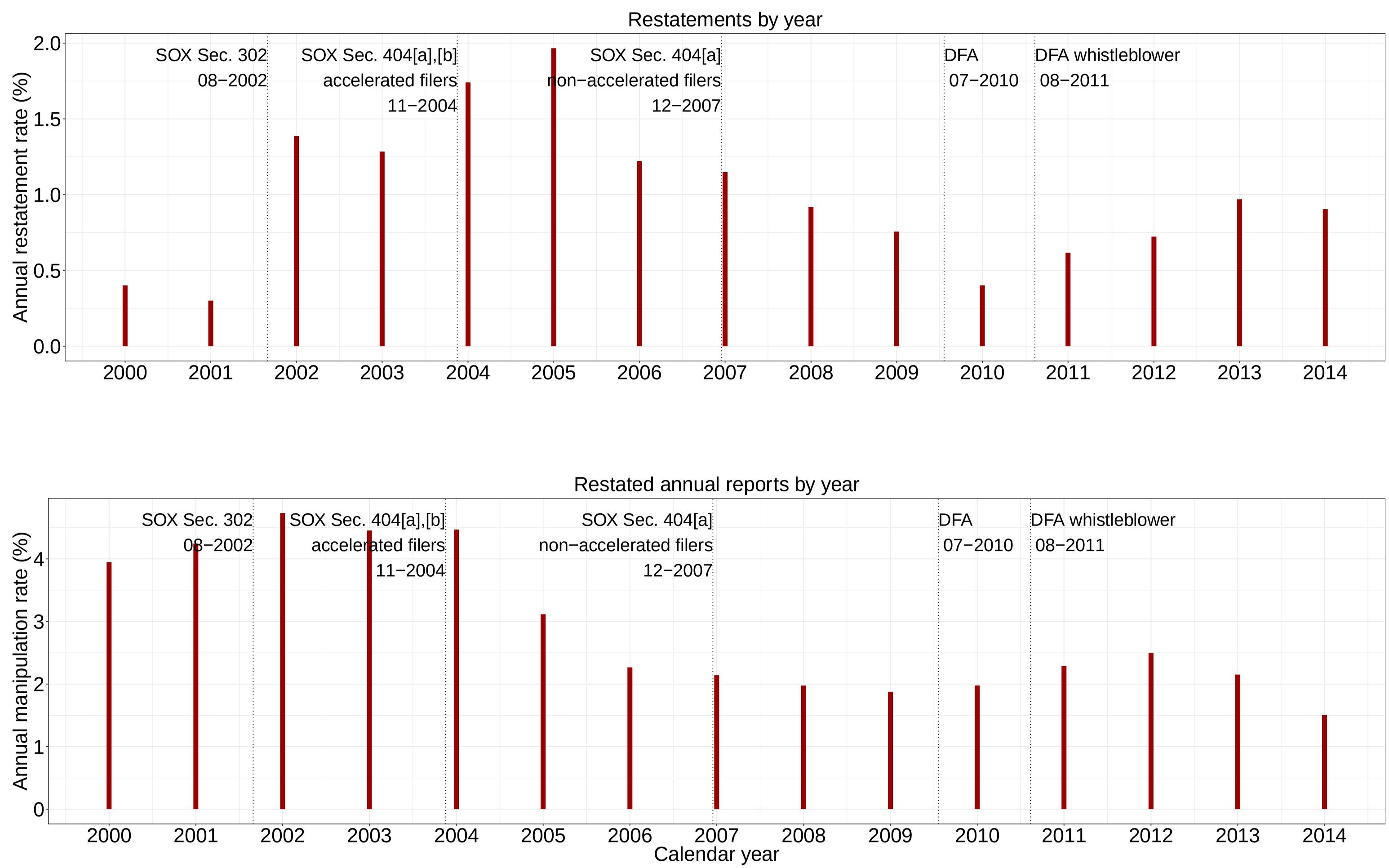
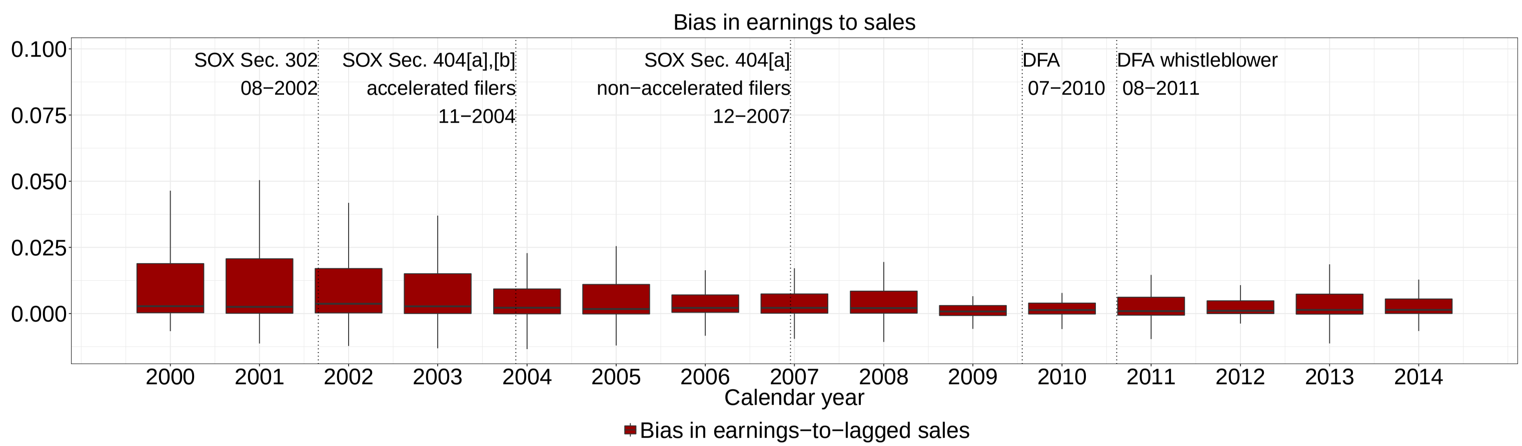


Figure 4: Magnitude of misreporting

This figure depicts the ratio of the bias in earnings to sales as a function of time and also as a function of the ratio of SG&A to sales for revenue recognition restatements.



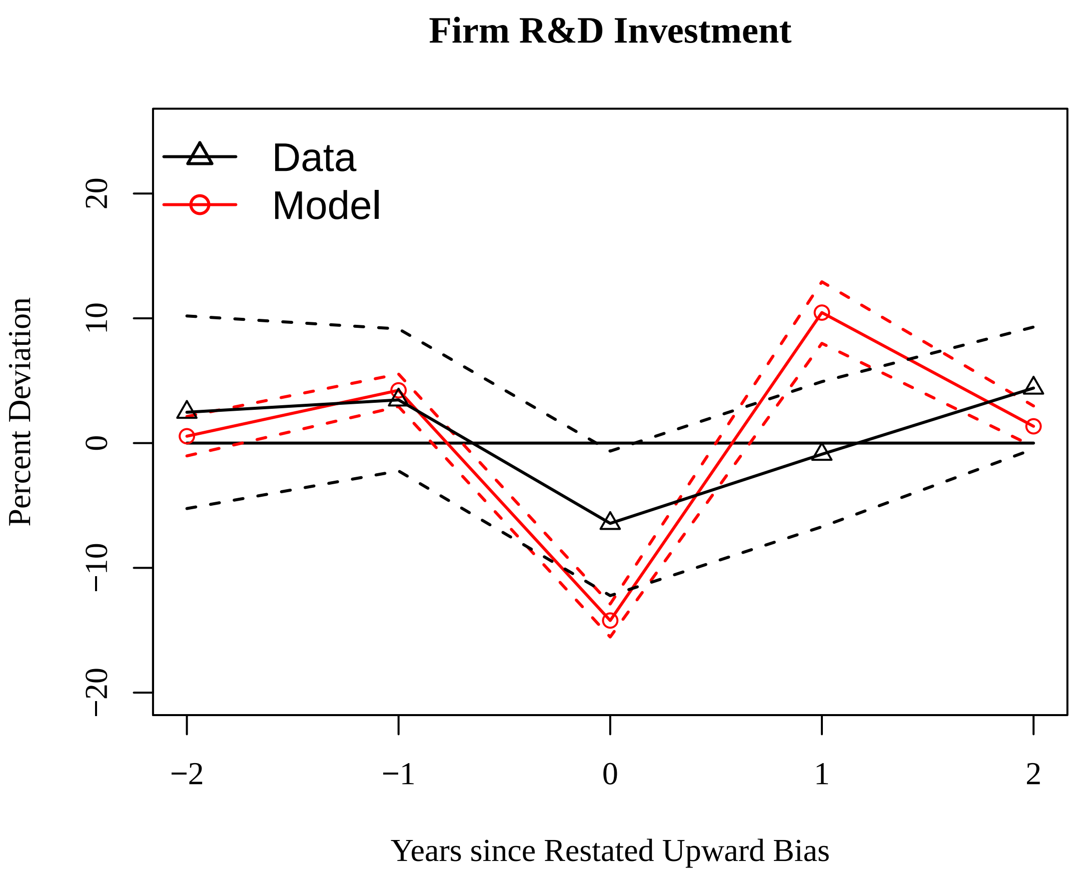


Figure 5: R&D dynamics around a restatement event

The figure plots the dynamics of R&D around restatement of profits after upward bias. In particular, each solid line in the figure plots estimated coefficients β_k, $k = -K, ..., K$ from the panel regression $\log w_{jt} = \sum_{k=-K}^{K} \beta_k \mathbb{I}(\text{Upward Bias Restated})_{jt+k} + f_j + g_t + \varepsilon_{jt}$ of log R&D w_{jt} for firm j in year t on a full set of firm and time dummies together with indicators for public restatement of an upward bias in profits for firm j at the horizon k from year t. We use $K = 2$ for the figure estimates. The black line with triangles plots estimates from the data with a sample of around 1.7K firms covering 2001-2012 with a total of around 10K firm years. The red line with circles plots estimates from a simulated sample of about 1.5K firms and a total of around 10K firm-years. The plotted associated error bands are 90% confidence intervals, clustered by firm in both the data and the model.

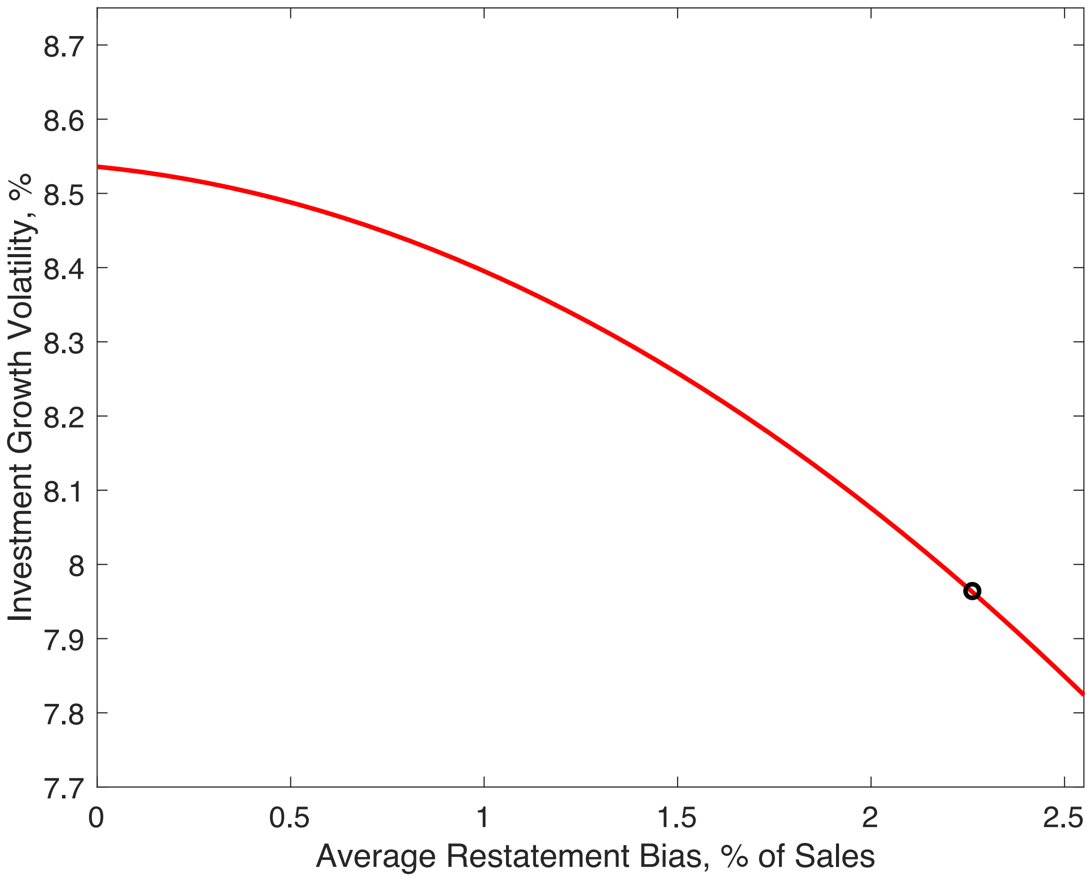


Figure 6: Tradeoffs

The figure plots the equilibrium volatility of investment growth (on the vertical axis) and average bias relative to sales in restatements (on the horizontal axis). Each point on the curve reports moments from a counterfactual experiment, starting from the baseline estimated parameterization of the model and changing only the manager's cost of bias κ_q either up or down. The curve is a polynomial interpolation of moments from a discrete set of counterfactual experiments. The infinite bias cost or no bias model lies at the intersection of the line with the vertical axis, and the baseline estimated model is represented by the circled point. At the baseline estimated model, the tangent slope or elasticity of investment volatility with respect to bias is equal to -0.45.