Information Distortion, R&D, and Growth

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Information vs Investment

Managers continually report information while investing
Under high pressure from options compensation and elsewhere to manipulate reported profits in order to exploit asymmetric information

Misreporting profits vs messing with investment
If both forms of manipulation are costly at the margin, will engage in both activities, linking investment choices to the cost of misreporting.

After crises and scandals, a crackdown on misreporting occurred
Sarbanes-Oxley & Dodd Frank tightened regulation of information financial reporting considerably, with a stated goal of improving investor welfare.

Our question in this paper
Given manager incentives, is there a quantitatively meaningful tradeoff between the quality of reported information and the efficiency of investment?

What We Do in This Paper

#1 Provide some context on manipulation
Discussion of profit manipulation via accruals or intangible investment in practice plus an overview of US policy shifts

#2 Build a dynamic model of investment & distortion
PE firm growth via R&D, firm-level profitability shocks, intermittent manipulation detection, manager option compensation, rational pricing with asymmetric info

#3 Exploit data on restatements to estimate the model
Approach: SMM from data on restatements, exec comp, R&D
Result: Satisfactory fit, match to untargeted R&D dynamics

#4 Quantify the information-investment tradeoff
Managers bias profits + R&D jointly to distort short-term profits. Eliminating bias increases R&D vol. by 10%, reduces value by 0.5%.

Literature Why We Care

Roadmap

Some context for profit manipulation

A model of information vs investment

Exploiting restatements to estimate the model

The quantitative tradeoff of information vs investment

What are Earnings, and How Can They Be Manipulated?

Earnings, profits, or net income, are a short-term measure meant to be more informative than cash flows. The basic idea is

$$\text{Earnings} \approx \text{Sales} - \text{Expenses} - \text{Investment}$$

Timing and accruals manipulation
Accounting matches the timing of outflows and inflows. Discretion over the time of recognition for sales or expenses through "accruals" arises.

Manipulation of long-term investment
Tangible investment is depreciated (think "$Y - WL - \delta K$"), but R&D and intangible investments are expensed (think "$Y - WL - I$"). Long-term investment cuts lead directly to higher profits today.

SEC regulation, investigations, and penalties
The SEC regulates disclosure by public firms in the US according to "generally accepted accounting principles" (GAAP) and can impose penalties.

Some Practical Examples from SEC Investigations

Cardinal Health, Inc (pharmaceutical distributor, 2007 detection)

- "The Commission's complaint alleges that, from September 2000 through March 2004, Cardinal engaged in this conduct in order to present a false picture of its operating results to the financial community and the investing public..."
- Premature recognition of $133 million in invoices to inflate sales, overestimation of inventory, penalties of around $36 million

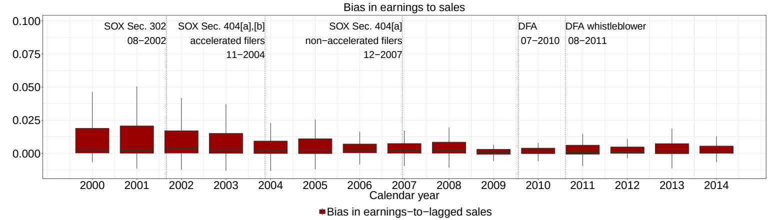
Aspen Technology, Inc (software manufacturer, 2007 detection)

- "The SEC's order finds that Aspen's former senior management, motivated by a desire to boost revenues and meet securities analyst earnings expectations, was directly involved in negotiating and improperly recognizing revenue on transactions..."
- Premature recognition of 19 contracts which were not yet signed, no penalties

Point Blank Solutions, Inc (body armor manufacturer, 2011 detection)

- "The company overstated inventory values, failed to include appropriate charges for obsolete inventory, and falsified journal entries."
- Inflated profits and fradulent expense reports, criminal charges filed

US Disclosure Regulation Has Become Increasingly Strict



Sarbanes-Oxley Act (SOX, 2002)
After the dot-com crash and some famous scandals, SOX introduced changes such as direct manager certification of financial statements and internal control mechanisms, increased SEC enforcement power, etc...

Dodd Frank Act (DFA, 2010)
After the financial crisis, DFA introduced some more moderate changes such as more whistleblower protections

Explicitly stated goal of improving information on behalf of investors
"The overarching goals of the Act [SOX] are far-reaching and include restoring investor confidence and assuring the integrity of our markets..." (SEC Chair Donaldson, 2003)

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Here's the Model in Words

Piece 1: Real firm-level model of R&D and growth

- Firms face persistent, stationary fundamental shocks
- R&D drives growth through endogenous intangible quality
- Stationary in growth rates or ratios but not levels

Piece 2: Accounting and information

- Profits reflect real side + nonfundamental noise + intentional bias
- Investors rationally price firms with less information than managers
- Any nonzero bias is discovered with some probability each period

Piece 3: Manager incentives and decisions

- Managers are compensated with equity as well as options
- Suffer personal costs if bias is detected
- Determine all investment and bias choices

PE model with no labor, fixed interest rates, but rational pricing is a key fixed point imposing substantial discipline.

Firm-Level Fundamentals

A model with an infinitely lived firm in discrete time

Sales Y depend on shock ν_y and quality Q

$$\log \nu_y' = \rho \log \nu_y + \eta_y', \quad \eta_y' \sim N(0, \sigma_y^2)$$

$$Y = \nu_y Q$$

Endogenous quality Q grows via R&D W

$$\Delta Q' = Q' - Q = \xi W^{\gamma} Q^{1-\gamma}$$

Dividends or free cash flows

$$D = Y - p_w W$$

Profits and Information

Profits Π deviate from fundamentals for two reasons

$$\Pi = Y - p_w W + \nu_\pi Q + (B - B_{-1})$$

Reason 1: noise ν_π in profits hits firms each period

$$\nu_\pi Q, \quad \nu_\pi \sim N(0, \sigma_\pi^2)$$

Reason 2: intentional shifts in bias B

$$B - B_{-1}$$

Rational price P for the firm based on investor information $\mathcal{I}$

$$P(\mathcal{I}) = \mathbb{E}\left(\frac{1}{1+r} V_F' | \mathcal{I}\right), \quad \Pi \in \mathcal{I}$$

Manager Incentives in the Model

Infinitely lived risk-neutral managers choose R&D and manipulation

Exogenous equity and options compensation

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

Random detection of any bias $B \neq 0$ occurs with fixed probability

$$\mathbb{P}(\text{Detection}|B \neq 0) = \lambda$$

If misreporting is discovered, managers face nonpecuniary costs

$$MC(B,Q) = \left[\kappa_f + \kappa_q \left(\frac{B}{Q}\right)^2\right] Q$$

Firm & Manager Value

Manager optimization determines firm policies and value V_M

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

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

Fundamental firm value V_F is implied

$$V_F(\nu_y, \nu_\pi, P_{-1}, B_{-1}, Q) =$$

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

Nested value maximization

If no options compensation or costs of misreporting, then managers will choose value-maximizing investment

Scaling and Solving the Model

The model is nonstationary. We exploit homogeneity by rescaling all growing quantities by the endogenous quality Q, yielding lowercase variables.

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

Implement rational pricing using a polynomial rule with $\mathcal{I} = \Pi$

$$\hat{P}(\Pi) \approx \mathbb{E}\left(\frac{1}{1+r} V_F' | \Pi\right)$$

Numerically solve the model with an iterative approach, akin to Krusell-Smith solution approach

1. Guess pricing rule coefficients
2. Solve for manager policies using discretization + policy iteration
3. Compute firm value implied by manager policies
4. Update pricing rule using the model's ergodic distribution

When the pricing rule converges, the model is solved

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We Use Three Sources of Data on US Public Firms

Audit Analytics data on restatements, bias

Focus on revenue restatements in the data related to SEC bulletin No. 101, considered serious by practitioners

Equilar data on executive compensation

Essentially the universe of US public firms, far broader than Execucomp

Compustat data on investment, free cash flow

Standard data on income statements and balance sheets for US firms

Our resulting panel dataset

Spans post-SOX pre-DFA period 2002-2009, with around 5K firms for about 25K firm-years. Includes earnings, free cash flow, intangible investment (SG&A or R&D), and restatements with bias amounts.

Estimating the Model via SMM

We estimate 10 parameters

Name	Explanation	Name	Explanation
ξ	Growth level	κ_q	Manipulation quad. cost
γ	Growth elasticity	κ_f	Manipulation fixed cost
ρ_y	Fundamental pers.	p_w	R&D relative price
σ_y^2	Fundamental vol.	λ	Detection rate
σ_π^2	Profit noise vol.	p_s	Cash flow reshuffling

In addition, we externally fix the values of θ_d, θ_o, and r.

We target 17 moments

Name	Explanation
$\mathbb{E}\Delta_3 Y$	Mean three-year weighted sales growth rate
$\mathbb{E}\frac{W}{Y}$	Mean ratio of R&D to sales
$\mathbb{E}I_d$	Probability of detection
$\mathbb{E}I_r$	Probability of restatement
$\mathbb{E}\left(\left\lvert\frac{B}{Y}\right\rvert \lvert I_r\right)$	Mean bias to sales ratio upon I_r
$Cov(\Delta\Pi, \Delta D, \Delta W)$	Cov. of profits, cash flows, R&D growth
$Cov(\Delta\Pi, \Delta D, \Delta W \lvert I_r)$	Cov. of profits, cash flows, R&D growth upon I_r

Identification SMM Details

Our Model's Fit

	Data	Model
Mean three-year weighted sales growth rate	0.1621	0.1067
Mean ratio of R&D to sales	0.3398	0.3049
Mean bias to sales ratio, given restatement	0.0137	0.0088
Probability of detection	0.0141	0.0182
Probability of restatement	0.0317	0.0239
Variance of dividend growth	1.3594	1.0984
Covariance of dividend and earnings growth	0.2903	0.8272
Covariance of dividend and R&D growth	-0.0107	-0.0230
Variance of earnings growth	1.1709	1.4193
Covariance of earnings and R&D growth	-0.0104	-0.0282
Variance of R&D growth	0.0596	0.0074
Variance of dividend growth, given restatement	1.5416	0.6695
Covariance of dividend and earnings growth, given restatement	0.4304	0.6837
Covariance of dividend and R&D growth, given restatement	-0.0183	-0.1074
Variance of earnings growth,given restatement	1.4306	0.8171
Covariance of earnings and R&D growth, given restatement	-0.0282	-0.1263
Variance of R&D growth, given restatement	0.0743	0.0332

Our Estimated Parameters

Parameter	Estimate	SE
ξ multiplicative productivity shifter	0.0673	(0.0027)
γ curvature of the innovation production function	0.3782	(0.0148)
p_w price of R&D relative to output	2.1972	(0.1456)
ρ_y serial correlation of the persistent productivity shock	0.4938	(0.0202)
σ_y volatility of the persistent productivity shock	0.2861	(0.0242)
σ_π volatility of the i.i.d. shock to earnings	0.1824	(0.0067)
κ_q quadratic cost of manipulation	21.3018	(1.9424)
κ_f fixed cost of manipulation	0.001	(0.0006)
λ probability of manipulation detection	0.1478	(0.0261)
p_s probability of intertemporal earnings reshuffling	0.0207	(0.0057)

Based on Equilar averages, we also fix $\theta_d = 4.9\%$, $\theta_o = 1.1\%$. We choose $r = 6\%$ to reflect a realistic firm discount rate.

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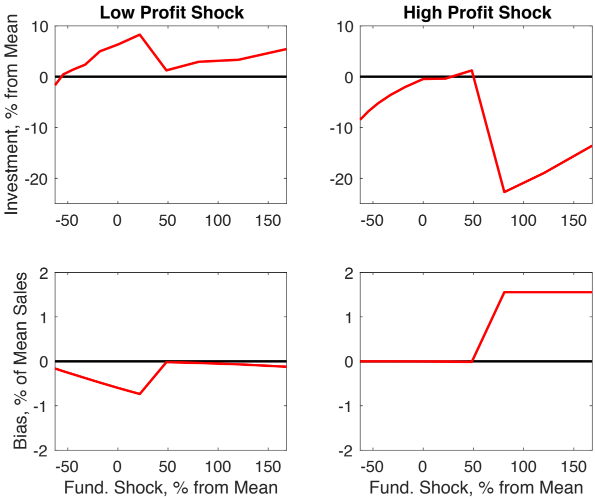
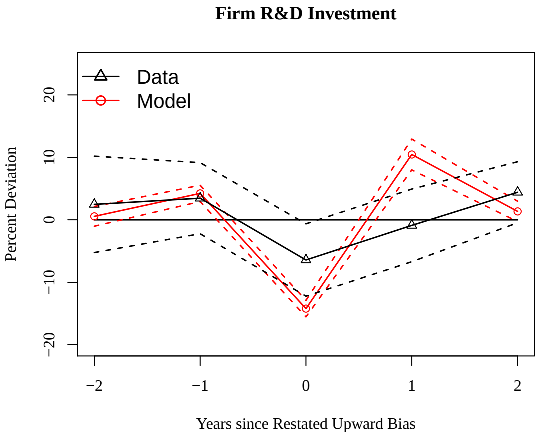
Mean R&D and Bias Choices



R&D Dynamics: Model and Data



Plot the coefficients from the panel regression

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

Counterfactual Experiments

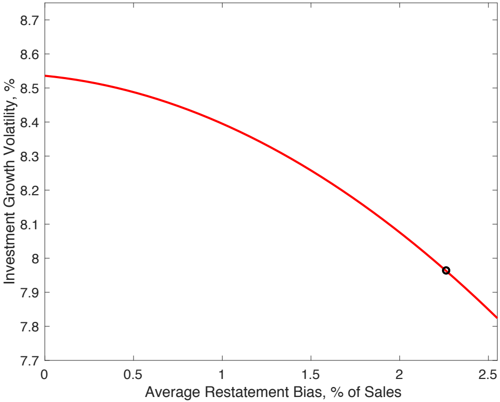
We first ask two questions

- What would happen if misreporting was eliminated?
- What if managers were value maximizing with no options compensation?

Starting from baseline estimates, we examine the change in bias, investment volatility, and value in each case in the model stationary distribution.

Percent	Baseline (Estimated)	No Bias ($\kappa_q = \kappa_f = \infty$)	Value Maximizing ($\theta_o = 0$)
Mean bias to sales ratio	2.26	0.00	0.00
Std dev. of R&D growth	7.96	8.53	2.06
Mean ΔV_F	-	-0.45	13.45

Information vs Investment



- In a less extreme experiment, vary misreporting costs κ_q over a range of parameterizations.
- At estimated parameterization (circled), 1% bias reduction costs about 0.5% increased R&D growth volatility

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Backup Slides

Our Estimation Approach

Standard SMM objective

- Vector of model parameters θ
- Vector of simulated model moments $m(\theta)$ and data moments $m(X)$
- Minimize weighted deviations of model and data moments

$$\hat{\theta} = \arg\min_{\theta} \left(m(\theta) - m(X)\right)' W \left(m(\theta) - m(X)\right)$$

Implementation

We use an estimate of the efficient weighting matrix $W = Cov(m(X))^{-1}$, and we minimize the objective use particle swarm optimization. The standard errors follow the usual SMM formulas.

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How Does Identification Work?

This is a joint and not one-to-one mapping, but some moments are particularly influential for some parameters.

Fundamental parameters are familiar

- Covariances and variances inform shock processes ρ_y, σ_y^2, σ_π^2
- Mean ratios, growth rates, and covariances inform relative price and quality growth parameters p_w, γ, ξ

Detection and misreporting parameters are less familiar

- Mean bias magnitude informs quadratic cost κ_q
- Covariances given restatement inform fixed cost κ_f
- Detection probability informs λ
- $Cov(\Delta\Pi, \Delta D)$ informs reshuffling in free cash flows p_s

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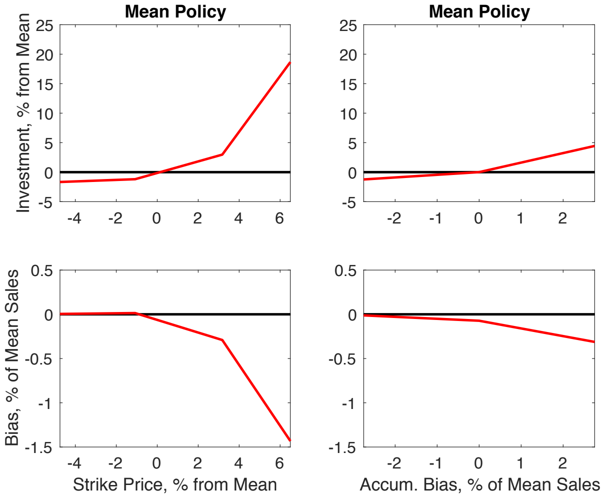
History-Dependent R&D and Bias



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Why Should We Care?

A meaningful quantitative tradeoff between info distortion and investment efficiency matters for at least two reasons.

Reason 1: An equilibrium constraint on policy
Given pervasive short-term options compensation, increasing info accuracy may lower average real efficiency

Reason 2: A new source of misallocation
Executive incentives and info regulation generate misallocation of investment, in the same manner as financial frictions, adjustment costs, taxation, etc.

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Related Strands of Literature

Quantitative investment frictions for firms and managers
Nikolov and Whited (2013), Glover (2013), Cooper and Haltiwanger (2006), Eberly, et al. (2012), Gourio and Rudanko (2013, 2014), Hennessy and Whited (2005), Taylor (2010), Strebulaev and Whited (2012), Eisfeldt and Rampini (2007, 2008)

Manipulation of profits with real activities or accruals
Dichev, et al. (2013), Marinovic, et al. (2012), Burgstahler and Chuk (2013), Zakolyukina (2013), Burgstahler and Eames (2006), Graham, et al. (2005), Hertzberg (2004), Gunny (2010), Bartov, et al. (2002), Roychowdhury (2006), Bange and De Bondt (1998), Baber, et al. (1991), Huang and Marquardt (2013), Cheng and Warfield (2005), Bartov, et al. (2002)

Endogenous growth and long-term investment
Acemoglu, et al. (2013), Eisfeldt and Papanikolaou (2013), Peters and Taylor (2014), Aghion, et al. (2010), Peters (2013), Lentz and Mortensen (2008), Barlevy (2004, 2007), Klette and Kortum (2004), Hall (2004), McGrattan and Prescott (2005, 2010, 2014), Corrado, et al. (2006, 2013), Acemoglu and Cao (2010), Kortum and Lerner (2000), Griliches (1990)

Executive compensation, short-term incentives
Stein (1989), Asker, et al. (2014), Bhojraj, et al. (2009), Larkin (2014), Oyer (1998), Liebman and Mahoney (2013), Edmans, et al. (2013), Aghion, et al. (2013), Wolfers (2014), Allan and Dechow (2013), Asch (1990), Kester (1992), Markoff (1990), Mayer (2012), Michie (2001), Dechow and Sloan (1991), Matsunaga and Park (2001), Bushee (1998), Gourio and Roys (2012), Murphy (2001), Jenter and Lewellen (2010)

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