Capital (Mis)allocation, Incentives and Productivity

Jan Schymik ⓡ Matthias Meier ⓡ Alexander Schramm ⓡ Alexander Schwemmer

January 2025

Abstract

This paper studies how managerial pay shapes the allocation of capital within firms. We leverage quasi-experimental variation in the composition of managerial pay between cash bonuses and equity compensation. We find that a relative increase in cash bonuses leads firms to reallocate capital toward less durable investment projects. To rationalize the empirical evidence, we develop a quantitative model with agency frictions. In the model, a relative increase in cash bonuses strengthens managerial short-termism, which shifts the investment composition toward less durable projects. The observed change in managerial pay exacerbates within-firm capital misallocation and leads to a sizeable contraction in output.

Keywords: Investment, Firms, Managerial Pay, Capital Misallocation.

JEL: D25, E22, E32, G31.

We are grateful to Christoph Boehm, Lukas Buchheim, Jan Eeckhout, Andreas Engert, Carola Frydman, Simon Gilchrist, Ingo Isphording, Michael Reiter, Dominik Sachs, Raffaella Sadun, Stephen Terry, Elu von Thadden, Thomas Winberry, audiences at various seminars and conferences for helpful conversations and comments. We thank Kilian Huber and Niels Gormsen for sharing their data on corporate discount rates. Jan Schymik thanks Harvard Business School for its hospitality where parts of the paper were written. Support from the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) through CRC TR 224 (Projects B06 and C05) is gratefully acknowledged. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Federal Ministry of Finance of Germany.
Jan Schymik (University of Mannheim): jan.schymik@uni-mannheim.de. Matthias Meier (University of Mannheim): m.meier@uni-mannheim.de. Alexander Schramm (Munich Re Group): aschramm@munichre.de. Alexander Schwemmer (Federal Ministry of Finance of Germany): alexander.schwemmer@bmf.bund.de.

1 Introduction

Capital misallocation lowers productivity. In contrast to between-firm misallocation, little is known about the sources and implications of within-firm misallocation. We study how managerial pay shapes the (mis)allocation of capital within firms. Managers with short-term incentives are more inclined to invest in short-lived projects (e.g., computer equipment) rather than long-lived projects (e.g., production facilities), which may lead to within-firm capital misallocation. We show that such short-termism arises from the composition of managerial pay, which generally includes cash bonuses—depending on current profits—and equity-based compensation. While cash bonuses incentivize short-term profit maximization, equity-based compensation better aligns managerial incentives with maximizing long-term firm value.

Our paper makes two contributions to the literature. First, we provide novel empirical evidence showing that firms reallocate capital toward less durable investment projects when managerial pay shifts toward cash bonuses relative to equity compensation. Second, we develop a quantitative model with agency frictions, which rationalizes the evidence and allows us to quantify the implications of a change in managerial pay for the allocation of capital within firms and the economy.

Our empirical analysis levers a quasi-natural experiment, which provides a shift in the composition of managerial pay that is unrelated to economic fundamentals and incentive contracting problems within firms. In particular, we exploit the 2005 FAS 123R reform of accounting rules in the U.S., which raised the costs of equity-based compensation. In response to the reform, firms lowered equity-based compensation relative to cash bonuses (Hayes et al. 2012). To assess whether the change in pay changed the composition of firm investment, we use balance sheet data for listed U.S. firms from Compustat and data from FactSet, which allow us to distinguish seven investment categories that differ in their depreciation rates.

The main empirical finding of this paper is that firms affected by the reform reduced investment in projects with low depreciation rates relative to high-depreciation projects. The estimated effect is statistically significant, robust in various dimensions, and quantitatively meaningful. For managers exposed to the reform, equity-based compensation falls on average by 23–36% relative to cash bonuses. Exposed managers invest 5–10% more in investment projects with a 10 percentage point higher depreciation rate relative to non-exposed managers. This shift towards short-term investment projects translates into a one percentage point higher weighted average capital depreciation rate. Consistent with managerial pay changing managerial incentives, we find that the discount rate which managers use to evaluate new investment opportunities increases by 0.4 percentage points.

We then develop and quantify a structural model that rationalizes the empirical findings and allows us to study the implications of managerial pay on capital misallocation. Our model extends a standard dynamic model of firm investment in two dimensions. First, we introduce two types of capital that differ in their depreciation rates. Second, we introduce a manager who receives a compensation package that includes a cash bonus depending on current profits and equity compensation, similar to Nikolov and Whited (2014). The manager's incentives are better aligned with firm value maximization the more equity is provided to the manager. The presence of any cash bonus implies that managerial incentives are not fully aligned with firm value maximization. Formally, we show that the rational manager's optimization problem mirrors an optimization problem under quasi-hyperbolic discounting. The present bias, or short-termism, raises the relative attractiveness of investment in the high-depreciation capital good and depends positively on the relative size of the cash bonus.[1]

We calibrate the model to match firm-level and sectoral moments of the U.S. economy prior to the accounting reform. We then simulate the effects of an unexpected exogenous change in the managerial pay structure that matches the change around the FAS 123R accounting reform. The change in managerial pay raises present bias. The present bias factor, by which managers discount future profits, falls from 0.92 to 0.89 on average, with 1.00 corresponding

[1] Our model poses similar numerical challenges as solving models of quasi-hyperbolic discounting (Krusell and Smith 2003, Maliar and Maliar 2005, 2016). Following Maliar and Maliar (2016), we solve the model using the method of endogenous gridpoints (Carroll 2006).

to no present bias. In response, the investment rate drops by 20% in the short-run but features little long-run change. In contrast, output falls by little in the short run but converges to a 3% decline in the long run. Beneath the surface, the investment decline is highly asymmetric across the two types of capital goods, with investment in low-depreciation capital goods declining relatively more. The shift in the investment composition raises within-firm capital misallocation. We show that misallocation contributes 20% to the decline in output, with the remainder reflecting higher markups. In general equilibrium, conservatively assuming fixed labor supply, the long-run decline in aggregate output is still 1%, and likewise, the real wage falls by 1%.

This paper relates to a growing literature that studies the effects of short-termism.[2] Our paper is most closely related to Terry (2023), who studies the implications of managerial short-termism on R&D and growth. Instead, we study how managerial short-termism affects the allocation of capital across capital goods with different depreciation rates and provide novel empirical evidence and a quantitative analysis. While Terry (2023) emphasizes the impact of short-termism on productivity through R&D externalities, our study demonstrates that short-termism affects productivity through capital misallocation within firms. Our paper is thereby also related to a large literature studying factor misallocation between firms (e.g., Hsieh and Klenow 2009, Alder 2016, Kehrig and Vincent 2019, Midrigan and Xu 2014, David and Venkateswaran 2019, Peters 2020, Meier and Reinelt forthcoming).

Our model setup builds on Bénabou and Tirole (2016) and Garicano and Rayo (2016). We formalize managerial short-termism as a multitasking problem in which agents choose between short-term projects and long-term projects. We embed this idea into a dynamic model of firm investment. Our model further relates to Aghion et al. (2010), which studies an investment model with two types of capital in the presence of credit constraints, but without considering managerial short-termism.

[2]Policy-makers, business executives and investors have often warned about the dangers of boosting short-term profits at the cost of long-term value (e.g., Dimon and Buffet 2018 or Barton 2011).

Our empirical results build on Edmans et al. (2022, 2017) and Ladika and Sautner (2019) who show that managers with less equity-based compensation lower total investment. In addition, Asker et al. (2014) argue that private firms, whose management is presumably less prone to short-termism, have substantially higher capital expenditures and are more responsive to investment opportunities. Our contribution to the literature is to show that not only the level of investment but also the composition of investment across depreciation rates depends on managerial incentives.

Finally, our paper contributes to a literature studying within-firm misallocation (e.g., Giroud 2013, Kehrig and Vincent 2019, Giroud and Mueller 2019, Doerr et al. 2025). These papers study the allocation of capital across multiple plants within firms. In contrast, we study the allocation of capital across types of capital within firms absent multi-plant dynamics.

2 Empirical Evidence

In this section, we provide evidence on the implications of managerial pay for the allocation of capital within firms. Our empirical analysis leverages an accounting reform that provides a quasi-natural experiment which shifts managerial pay toward cash bonuses. We find that firms exposed to the reform: (i) invested relatively more in investment projects with high depreciation rates, (ii) their weighted average capital depreciation rate increased, and (iii) their self-reported discount rates increased.

2.1 Accounting Reform

Since the composition of managerial pay across cash bonuses and equity-based compensation is endogenous to observable and unobservable firm characteristics, we exploit an accounting reform that is unrelated to firm characteristics and provides a shift of managerial pay toward cash bonuses. The reform is the revision of Financial Accounting Standard Board (FASB)

Statement No. 123 (shortly: FAS 123R), which constituted an unexpected and unprecedented change of accounting practices for U.S. firms.

In December 2004, the FASB revised the standards to account for transactions in which an entity exchanges its equity or related instruments for goods or services. The reform became effective for companies with their first full reporting period beginning after June 15, 2005. Before the reform, companies were allowed to expense equity-based compensation such as stock options or long-term incentive plans to employees at their intrinsic value. The pre-reform accounting standard implied low accounting expenses of equity-based compensation.[3] In contrast, FAS 123R obliges firms to expense equity-based compensation at fair value, effectively abolishing the accounting advantage.[4] The principal motivation behind the reform was to correct the accounting misrepresentation of the economic expenses incurred by managerial pay. Other reasons for the revision were to simplify U.S. Generally Accepted Accounting Principles (GAAP) and to make them more comparable with international accounting rules. Importantly, the reform provides us with quasi-exogenous variation in the composition of managerial pay.

2.2 Data

Our empirical analysis uses data on executive compensation from ExecuComp as well as balance sheet data for listed U.S. firms from Compustat and FactSet. We focus on a period around the accounting reform from 2000 through 2014. Table 1 provides summary statistics for the main variables used in our empirical analysis.

We use ExecuComp data to construct a measure of firm exposure to the accounting reform, $\text{Option}_{i,2004}$, which is a dummy variable that equals one for firms with unexercised CEO equity options outstanding in 2004 and zero else. Across the 725 firms in our sample, 80% of

[3]The intrinsic value of an option is the difference between the firm's stock price on the date the equity option is granted and the strike price. Equity options with a strike price equal to the stock price have no intrinsic value and, therefore, generate no accounting expenses under the pre-reform accounting standard.

[4]Fair value accounts for the option value of a higher future stock price.

Table 1: Selected Summary Statistics

Variable	Mean	Std. Dev.	p10	p25	p50	p75	p90	Obs.
Compensation								
Option Dummy	0.797	0.402	0	1	1	1	1	725
Total Compensation	5.33	9.44	0.81	1.59	3.34	6.31	11.23	10,498
Non-Curr. Compensation	4.20	9.07	0.12	0.82	2.34	5.12	9.37	10,498
Investment								
Land	33.82	461.50	0.00	0.07	1.53	8.47	34.82	4,966
Buildings	100.97	404.21	0.90	3.34	13.45	52.49	193.62	7,335
Machines	438.52	2,046.36	6.02	20.56	75.32	272.57	909.52	7,300
Transport	141.79	590.74	0.06	0.37	2.35	21.49	260.14	938
Research	279.38	900.53	0.00	3.16	29.56	130.58	522.10	6,764
Computer	101.04	300.98	3.85	9.81	24.03	80.25	199.37	1,979
Advertising	240.92	607.38	1.34	6.21	38.07	164.46	619.67	4,625
Other								
Depreciation Rate	15.35	10.01	7.04	10.42	12.69	18.09	25.44	10,532
Corporate Discount Rate	14.61	2.41	11.89	12.96	14.36	15.98	17.71	6,199

Notes: Option Dummy equals one for firms with unexercised CEO equity options outstanding in 2004 and zero else. Non-current and total compensation and all investment expenditures are denoted in million USD of year 2000 capital prices. Depreciation and discount rates are denoted in percent. The table presents summary statistics for Option Dummy across firms in 2004 and for all other variables across firms and years from 2000 through 2014.

CEOs had unexercised equity options in the pre-reform year.[5] To capture variation in CEO compensation across firms and years, we analyze the composition of total compensation between current (cash bonus) compensation and non-current compensation of CEOs in our sample. The average CEO receives annual compensation of $5.3million (measured in year 2000 prices) of which $4.2 million is non-current compensation and the remainder are cash bonuses.

The main focus of our empirical analysis is the investment composition of firms. Combining data from Compustat and FactSet allows us to analyze firm-level investment across seven different investment categories: land, buildings, machinery, transport equipment, R&D, computer equipment, and advertising. We obtain annual expenses on R&D and advertising from Compustat. Data on the remaining investment categories are obtained from Factset.[6] Ta-

[5]Our sample includes all firms in the sample that are covered in Compustat and ExecuComp, and classified as active in Compustat. We exclude firms that never report any investment between 2000 and 2014, firms that enter the sample after 2004 or exit before 2006, and firms in the utilities, financial, and public sectors.

[6]We use a perpetual inventory method to transform stock variables into annual gross investment for the

Table 2: Investment Categories and Depreciation Rates

Category	*Land*	*Buildings*	*Machines*	*Transport*	*R&D*	*Computer*	*Advertising*
Depreciation	0%	3%	12%	16%	20%	30%	60%

Notes: The depreciation rates are based on the literature survey in Garicano and Steinwender (2016).

ble 1 shows that investments in machinery, R&D, and advertising tend to be the largest, whereas investments into land and IT are typically smaller.[7] A fundamental dimension in which the investment categories differ is their depreciation rate. Table 2 provides estimates of investment category-specific depreciation rates based on the literature survey in Garicano and Steinwender (2016). The capital-weighted average depreciation rate in our sample is 15%, and 8% when excluding intangible capital, i.e., R&D and advertising. Finally, we use data on corporate discount rates from Gormsen and Huber (2023), measured as the minimum required return on new investments announced in firms' earning calls.

2.3 Main Empirical Results

This section provides the main empirical results. We estimate the change in managerial pay, the composition of investment, the depreciation rate, and the discount rate for firms exposed to the reform relative to non-exposed firms in the years around the accounting reform.

Managerial Pay: We first examine the effects of the accounting reform on the composition of managerial pay. We find that cash bonuses increased relative to total compensation for exposed firms around the reform. The findings are in line with the reform raising the relative cost of equity-based compensation.

tangible investment categories.

[7]Some categories of firm-level investment are frequently missing, thus the difference in the number of observations across investment categories. Our empirical analysis considers all category-firm-year observations as long as we observe at least two investment categories per firm-year.

Formally, we estimate difference-in-differences regressions of the type

$$y_{it} = \beta_1 \left(\text{FAS123}_t \times \text{Option}_{i,2004}\right) + \beta_2 \times \Delta_{it} + \lambda_i + \lambda_t + \varepsilon_{it}, \tag{1}$$

where y_{it} is a variable related to managerial pay in firm i in year t. On the right-hand side, FAS123_t is a step dummy that equals one for years succeeding the reform ($t > 2005$) and zero otherwise, $\text{Option}_{i,2004}$ is the option dummy introduced in Section 2.2, Δ_{it} is a vector of control variables, and λ_i and λ_t denote firm and year fixed effects. The key coefficient of interest is β_1. It captures the relative change of y_{it} after the accounting reform for firms with outstanding CEO equity options in the pre-reform year relative to firms without outstanding CEO equity options in the pre-reform year.

We consider a specification of (1) with y_{it} defined as the log of non-current CEO compensation and Δ_{it} defined as the log of total CEO compensation. The first two columns of Table 3 show the associated estimates of β_1, respectively for a long and a short time window around the reform year. In the third column, we additionally control for a linear trend that may differ between exposed and non-exposed firms (t $\times$ $\text{Option}_{i,2004}$). Standard errors, clustered at the firm-level following Abadie et al. (2023), are in parentheses. For all specifications, we find that exposed firms significantly reduced non-current compensation by more than 30% relative to total compensation and in comparison to non-exposed firms.[8]

Investment: The focus of our empirical analysis is whether managerial pay shapes the composition of firm investment. The central empirical finding of our paper is that exposed firms changed their investment toward investment projects with high depreciation rates.

We use investment data at the firm-year-investment category level allowing us to control for

[8]We further do not find a significant increase in grants of restricted stock to executives in exposed firms compared to non-exposed firms. While the overall level of restricted stock grants did increase after FAS 123R (see Hayes et al. 2012), this increase does not significantly differ between exposed and non-exposed firms.

Table 3: Managerial Compensation

	Non-Current Compensation		
	(1)	(2)	(3)
FAS123 × Option	-0.363	-0.342	-0.231
	(0.092)	(0.114)	(0.121)
Total Compensation	1.629	1.718	1.629
	(0.055)	(0.106)	(0.055)
Year FE	×	×	×
Firm FE	×	×	×
Time Trend			×
Observations	9,806	3,912	9,806
No. Firms	699	695	699
Sample Period	2000 - 2014	2002 - 2007	2000 - 2014

Notes: The table reports estimates of equation (1). *Option* is a dummy that indicates if any unexercised options are outstanding in 2004. *FAS123* takes value 0 for all years until 2005 and value 1 afterwards. *Non-current compensation* is log equity-linked compensation and *Total Compensation* is log total compensation of the CEO. Columns (1) and (2) vary in sample period, while column (3) additionally controls for a linear time trend interacted with the option dummy. Standard errors (in parentheses) are clustered at the firm-level.

a rich set of fixed effects. Formally, we estimate triple-differences regressions of the type

$$\begin{aligned} invest_{ict} =& \beta_1 \left(\text{FAS123}_t \times \text{Option}_{i,2004} \times \delta_c\right) + \beta_2 \left(\text{FAS123}_t \times \delta_c\right) \\ &+ \beta_3 \left(\text{Option}_{i,2004} \times \delta_c\right) + \lambda_{it} + \lambda_{c(i)} + \varepsilon_{ict}, \end{aligned} \tag{2}$$

where $invest_{ict}$ denotes investment by firm i in investment category c in year t. On the right-hand side, FAS123_t and $\text{Option}_{i,2004}$ are defined as below equation (1), and δ_c denotes the depreciation rate of investment category c presented in Table 2. The regression further includes firm-year fixed effects, λ_{it}, which absorb unobserved firm-specific time variation in demand or supply factors that affect investment decisions. Hence, our identification strategy is based on within-firm variation across investment categories in a given year. Finally, $\lambda_{c(i)}$ contains either investment category fixed effects λ_c or category-firm fixed effects λ_{ci}. Including fixed effects λ_{ci} allows us to absorb differences in the investment rate across investment categories (and firms) that are constant over time, which may, for example, control for category-specific capital intensities.[9]

The coefficient of interest is β_1. It captures the relative change of investment in high-depreciation capital goods after the accounting reform for firms with outstanding CEO equity options in the pre-reform year. If the reform induces exposed firms to adjust their investment composition towards short-term investment projects, β_1 will be positive. Our baseline measure of investment is the inverse hyperbolic sine of investment expenditures.[10]

Table 4 presents the main empirical result of the paper. It shows the estimated coefficients of equation (2) for different measures of category-specific capital depreciation, different fixed effects, and sample periods. The key takeaway is that the estimate of β_1 is positive and statistically significant at the 5% level across a variety of specifications. In the upper panel of the table, we define δ_c as the depreciation rate in Table 2. In the lower panel, δ_c is the ordinal rank of the depreciation rate ranging from 1 (for land) to 7 (for advertising). The ordinal rank partly addresses concerns about the estimates of the depreciation rates in Table 2. Between columns (1) and (2), we replace the investment-category fixed effect δ_c by a category-firm fixed effect δ_{ci}. The first two columns are based on a wide sample around the reform. While a wide sample helps to capture relative differences in investment that build up slowly, it creates the risk of contamination from unrelated, other developments. We therefore repeat the analysis for a short sample around the reform in columns (3) and (4). Finally, we address the concern of potential pre-trends by controlling for the interaction between a linear time trend, the option dummy, and the depreciation measure in column (5). Across specifications (in both panels), the estimates of β_1 are positive and significant. Quantitatively,

[9] Including a fixed effect λ_{ci} absorbs the regressor ($\text{Option}_{i,2004} \times \delta_c$).

[10] Formally, $invest_{ict} = \text{arsinh}\,(I_{ict}) = \ln\left(I_{ict} + \sqrt{I_{ict}^2 + 1}\right)$, where I_{ict} denotes investment expenditures in million USD as in Table 1. The transformation has the advantage that we include zero investments in our estimations while we get $\text{arsinh}\,(I_{ict}) \to \ln 2 + \ln I_{ict}$ for large investment expenditures such that the interpretation is almost identical to a log regression. To address concerns about the inverse hyperbolic sine transformation in Mullahy and Norton (2024), we also consider the alternative investment measures I_{ict}/K_{ict} and $\log(I_{ict})$. Our results are robust to these alternative investment measures, see Section 2.4.

Table 4: Investment Composition

	Investments				
	(1)	(2)	(3)	(4)	(5)
Measure of Depreciation:			*Depreciation Rate*		
FAS123 × Option × Depr	0.999	0.668	0.721	0.462	0.805
	(0.247)	(0.216)	(0.233)	(0.186)	(0.254)
FAS123 × Depr	-0.766	-0.344	-0.673	-0.421	-0.766
	(0.209)	(0.197)	(0.199)	(0.166)	(0.209)
Option × Depr	-0.303		-0.387		-54.03
	(0.344)		(0.355)		(39.71)
Measure of Depreciation:			*Ordinal Rank*		
FAS123 × Option × Depr	0.0920	0.0560	0.0693	0.0423	0.0625
	(0.0254)	(0.0208)	(0.0253)	(0.0197)	(0.0266)
FAS123 × Depr	-0.0571	-0.0130	-0.0620	-0.0360	-0.0570
	(0.0222)	(0.0189)	(0.0224)	(0.0176)	(0.0222)
Option × Depr	-0.0596		-0.0688		-8.214
	(0.0349)		(0.0346)		(4.172)
Category FE	×		×		×
Category-Firm FE		×		×	
Firm-Year FE	×	×	×	×	×
Time Trend					×
Observations	32,947	32,875	13,097	12,941	32,947
No. Firms	681	677	666	661	681
Sample Period	2000 - 2014	2000 - 2014	2002 - 2007	2002 - 2007	2000 - 2014

Notes: The table reports estimates of equation (2). *Option* is a dummy that indicates if any unexercised options are outstanding in 2004. *FAS123* takes value 0 for all years until 2005 and value 1 afterward. *Depr* is a measure of depreciation: the rate of depreciation in the upper panel and the ordinal depreciation rank in the lower panel. Columns (1)–(4) vary in sample period and fixed effects. Column (5) controls for a linear time trend interacted with the interaction of the option dummy and the measure of depreciation. Standard errors (in parentheses) are clustered at the firm level.

the coefficient estimates in the upper panel mean that exposed firms increase by 5–10% their investment in capital categories with a 10 percentage point higher depreciation rate relative to non-exposed firms.

As a plausibility analysis, we next provide year- and category-specific estimates in Figure 1. The estimates broadly reconfirm the finding in Table 4. We estimate the year-specific differences in the relative investment in high-depreciation projects between exposed firms and non-exposed firms using the regression

$$invest_{ict} = \sum_j \mathbb{1}\{j = t\} \left[\beta_{1,j} \left(\text{Option}_{i,2004} \times \delta_c \right) + \beta_{2,j} \delta_c \right] + \lambda_{it} + \lambda_{ci} + \varepsilon_{ict}, \tag{3}$$

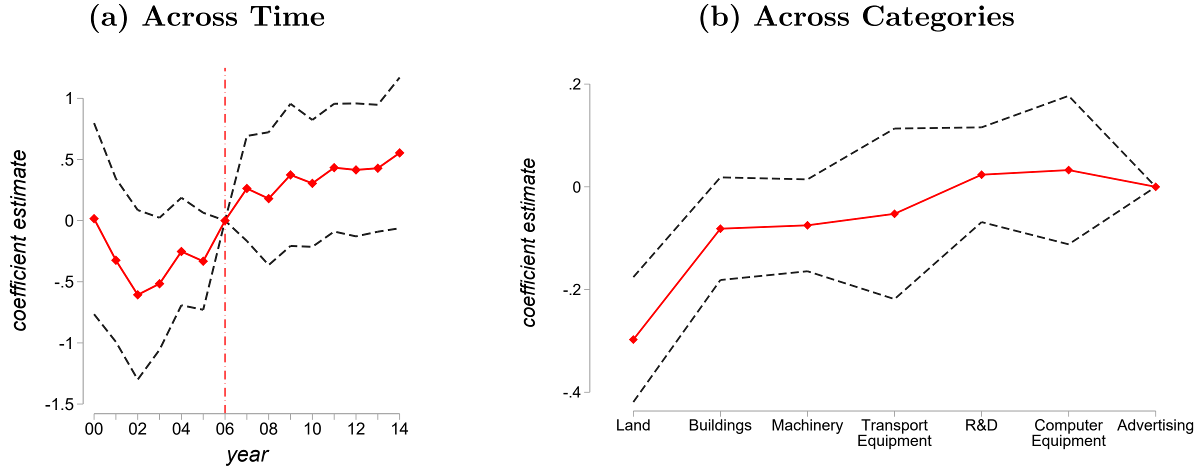
where $\mathbb{1}\{\cdot\}$ denotes an indicator function. Panel (a) of Figure 1 shows the estimates of $\beta_{1,t}$ together with 95% confidence bands. Maybe not surprisingly, the year-specific estimates of $\beta_{1,t}$ are less precisely estimated than the corresponding pooled estimates in Table 4. However, the figure broadly confirms our main finding: firms exposed to the reform shifted their investment composition toward high-depreciation projects. We find a shift in the investment composition that slowly builds up in the years following the reform. We can reject the null hypothesis that post-FAS-123R coefficients equal their pre-FAS-123R counterparts at the 1%-level. The $\beta_{1,t}$ estimates further reveal a non-significant trend in the pre-reform period. The null hypothesis that $\beta_{1,2002} + \beta_{1,2003} = \beta_{1,2004} + \beta_{1,2005}$ has a p-value of 0.22, meaning what may appear as a pre-trend in the point estimates is highly insignificant.

We further estimate the category-specific differences in the investment between exposed firms and non-exposed firms using the regression

$$invest_{ict} = \sum_j \mathbb{1}\{j = c\} \left[\beta_{1,j} \left(\text{FAS123}_t \times \text{Option}_{i,2004} \right) \right] + \lambda_{it} + \lambda_{ci} + \varepsilon_{ict}. \tag{4}$$

Panel (b) of Figure 1 shows that firms with outstanding options reduced investment more in low-depreciation categories such as land, causing a reallocation of capital towards more

Figure 1: Investment Composition across Time and Categories



Notes: Panel (a) shows point estimates of $\beta_{1,t}$ (solid line) in equation (3). The measure of depreciation is the rate of depreciation. Panel (b) shows point estimates of $\beta_{1,c}$ (solid line) in equation (4). Standard errors are clustered at the firm level and the dashed lines show 95% confidence intervals. The regressors associated with $\beta_{1,2006}$ and $\beta_{1,\text{advertising}}$ are absorbed by fixed effects.

high-depreciation categories such as transportation and computer equipment. The coefficient on advertising investment is absorbed by the fixed effects. The null hypothesis of coefficient equality across categories can be rejected at the 1%-level ($p < 0.001$).

Depreciation Rate: We next estimate the change in the depreciation rate for exposed firms following the reform. In line with the evidence on the investment composition, we find that the depreciation rates of exposed firms increased following the reform.

We re-use equation (1) but with the firm-level weighted average depreciation rate as left-hand side variable and specifying the control vector (Δ_{it}) to include firm-year-specific total capital and costs of capital.[11] The upper panel of Table 5 shows our estimates for three different specifications that differ in the sample and whether we control for pre-trends. Across all specifications, we find that the depreciation rate increased for exposed firms. All estimates are significant at the 10% level. Quantitatively, the depreciation rate increased by about 1

[11] We use perceived costs of capital from Gormsen and Huber (2023), which are a firm's internal estimates of weighted average costs of debt and equity.

Table 5: Incentives, Capital Stock Depreciation and Corporate Discount Rates

	(1)	(2)	(3)
	Weighted Average Depreciation Rate		
FAS123 × Option	1.383	0.931	1.196
	(0.529)	(0.537)	(0.619)
Observations	9,304	3,757	9,304
No. Firms	695	679	695
	Corporate Discount Rate		
FAS123 × Option	0.136	0.445	0.362
	(0.148)	(0.158)	(0.187)
Observations	5,972	2,321	5,972
No. Firms	546	478	546
Year FE	×	×	×
Firm FE	×	×	×
Trend			×
Sample Period	2000 - 2014	2002 - 2007	2000 - 2014

Notes: The table reports estimates of equation (1) with the left-hand side being the firms' weighted average depreciation rate (upper panel) and the firms' corporate discount rates from Gormsen and Huber (2023) (lower panel). Otherwise, the table is analogous to Table 3. Standard errors (in parentheses) are clustered at the firm level.

percentage point for exposed firms relative to other firms.

We have constructed the weighted average depreciation rate assuming time-invariant depreciation rates (Table 2). Hence, the findings for the weighted average depreciation rate reflect changes in the composition of the capital stock across categories, which changes the weights. We have also directly estimated the change in capital stock across categories. We use equation (2) with category-specific capital stocks (in logs) as left-hand side variable. Table A.1 provides the estimates. We find that the accounting reform led to substantial reallocation of capital within firms. On average, exposed firms increased the stock of a capital category with a 10 percentage point higher depreciation rate by 2–12% compared to non-exposed firms.

Corporate Discount Rate: A possible mechanism behind the above evidence is that the reform-induced change in managerial pay toward cash bonuses provides more short-term incentives to managers. In response, firm managers allocate investment toward more short-lived projects. We provide empirical evidence that is consistent with the change in managerial pay increasing managerial short-termism.[12] We find that the corporate discount rates of exposed firms increase relative to other firms.

We use equation (1) but with the corporate discount rate as left-hand side variable and specifying the control vector (Δ_{it}) to include firm-year-specific total capital and costs of capital. The lower panel of Table 5 shows our estimates for three different specifications that differ in the sample and whether we control for pre-trends. Across all specifications, we find that the discount rate increased for exposed firms. The estimates are significant at the 5% level for the last two columns. Quantitatively, the discount rate increased by 0.14–0.45 percentage points for exposed firms relative to other firms.

2.4 Sensitivity Analysis

Ex-ante Differences: In Table A.2, we compare firms by exposure status in the pre-reform year. Firms exposed to the reform are larger, invest relatively less in intangibles, have a lower share of liquid assets, have lower equity volatility, and their CEOs receive higher current compensation. To address the concern that these ex-ante differences may drive our main result, we repeat the analysis controlling for these ex-ante differences (adding further triple interaction terms in equation 2). We find that neither controlling for size differences (Table A.3) nor controlling for the other ex-ante differences listed above (Table A.4) strongly change our finding in Table 4. It thus appears unlikely that our main finding is driven by ex-ante differences between exposed and non-exposed firms.

[12] We formally study the link between pay and incentives in the structural model in Section 3.

CEO Turnover: A possible concern is that the compensation scheme may differ for CEOs who are newly appointed or close to losing their job, which may also affect the CEOs' investment incentives. To address this concern we focus on the subsample of firms without CEO turnover during the sample period. Compared to Table 4, the estimates for this subsample are larger and more significant, see Table A.5.

Alternative Measurement of Investments: In Table A.6, we consider alternatives to defining category-specific investment $invest_{ict}$ as the inverse hyperbolic sine transformation of investment expenditures. We find that our results in Table 4 are robust for a range of alternative investment measures.

Intangibles: Under U.S. GAAP rules, expenses for R&D and advertisement are fully deducted from profits in the period of the expense. On the flip side, intangibles have a less direct impact on balance sheets than tangibles.[13] The accounting practice is particularly striking for R&D given its role for long-term growth. We address the potential concern that the accounting treatment of R&D investment biases our estimates, we repeat our analysis when excluding R&D expenditures, see the first three columns of Table A.7. Compared to Table 4, the β_1 estimates are highly similar in magnitude and significance. Additionally, we consider investment variation within tangible and intangible categories in the last three columns of Table A.7 by including an additional interaction $\text{FAS123}_t \times \text{Option}_{i,2004} \times \text{intangible}_c$. The estimates are broadly similar to the estimate in Table 4.

2.5 Evidence Beyond the Accounting Reform

The final part of our empirical analysis goes beyond the accounting reform. Instead of exploiting changes in equity-based compensation due to the accounting reform, we exploit differences in the managerial equity ownership share across firms and years. We find a

[13] Only externally acquired intangible assets appear on the balance sheet.

Table 6: Equity Ownership and the Durability of Investments

	Investments			
	(1)	(2)	(3)	(4)
Measure of Depreciation:	*Depreciation Rate*		*Ordinal Rank*	
Equity Share × Depr	-0.355	-0.254	-2.500	-1.461
	(0.123)	(0.132)	(1.280)	(1.318)
Equity Share	0.635		-0.200	
	(0.614)		(0.428)	
Category-Firm FE	×	×	×	×
Year FE	×		×	
Firm-Year FE		×		×
Observations	29,330	28,611	29,330	28,611
No. Firms	672	649	672	649
Sample Period	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014

Notes: The table reports estimates of equation (5). *Equity Share* is the CEO's ownership share. *Depr* is a measure of depreciation: the rate of depreciation in columns (1)-(2) and the ordinal depreciation rank in (3)-(4). Standard errors (in parentheses) are clustered at the firm-level.

negative correlation between managerial equity ownership and the share of investment in high-deprecation capital goods. The broader scope of this exercise comes at the expense of stronger assumptions needed to interpret our estimates causally.

We define the managerial ownership share η_{it}^{e} for firm i and year t as the ratio of the CEO's firm-related wealth over the market capitalization of the firm.[14] We obtain data on CEOs' firm-related wealth from Coles et al. (2006) who use Compustat ExecuComp data to construct a measure of managers' equity ownership (as in Core and Guay 2002). We estimate the following empirical specification:

$$invest_{ict} = \beta_1 \left(\eta_{it}^{e} \times \delta_c\right) + \beta_2\ \eta_{it}^{e} + \lambda_{ci} + \lambda_{t(i)} + \varepsilon_{ict}. \quad (5)$$

Our parameter of interest is β_1, which captures the relative change of investment in high-depreciation capital goods for firms with higher managerial ownership.

[14]The managerial ownership share is central in the theory we develop in Section 3.

Table 6 presents our findings. The estimates of β_1 are negative in all specifications, which suggests that reductions in managerial equity ownership are associated with relatively more investment in short-term investment categories. Alternatively, we interact our measure of managerial ownership with dummies for each investment category. Consistent with Table 6, we find that investments in more durable projects, such as land or buildings, depend more strongly on managerial equity ownership compared to investments in less durable projects, such as computer equipment or advertising, see Figure A.1.

3 Model

The previous section established empirically that a shift toward short-term managerial compensation leads to relatively more investment in high-depreciation capital goods, a higher weighted average depreciation rate, and a higher discount rate. In this section, we develop a model to rationalize the empirical evidence and to understand its implications for firms and the economy. In the model, firms produce using two types of capital goods that differ in their depreciation rate. Investment decisions are made by a risk-neutral manager who maximizes the present value of her compensation package, which includes a cash bonus based on current profits, and equity compensation.

Technology and Profits: Consider a firm that uses labor N_t and a set of two capital inputs $\mathbf{K}_t = [K_{lt}, K_{st}]$, a long-lived and a short-lived capital good with the associated depreciation rates given by $0 < \delta_l < \delta_s < 1$. The firm produces output Q_t according to the Cobb-Douglas production technology

$$Q_t = ZF(\mathbf{K}_t, N_t) = Z\left(K_{lt}^{\nu} K_{st}^{1-\nu}\right)^{\alpha} N_t^{1-\alpha}, \tag{6}$$

where Z denotes firm productivity. The firm faces isoelastic demand, $Q_t = BP_t^{-\varepsilon}$, where B is a demand shifter and ε the demand elasticity. Accordingly, the firm's revenues are

$$R_t = P_t Q_t = X^{1-a-b} \left(K_{lt}^{\nu} K_{st}^{1-\nu} \right)^a N_t^b, \tag{7}$$

where $X^{1-a-b} = B^{1/\varepsilon} Z^{1-1/\varepsilon}$ captures the firm's overall business conditions, $a = \alpha(1 - 1/\varepsilon)$, and $b = (1 - \alpha)(1 - 1/\varepsilon)$. Capital follows the law of motion

$$K_{jt+1} = (1 - \delta_j) K_{jt} + I_{jt}, \quad j \in \{l, h\}, \tag{8}$$

where I_{jt} denotes gross investment for capital type j. Capital is subject to one-period time to build and a convex adjustment friction. Total capital expenses are given by

$$C_t^K = \sum_{j \in \{l,s\}} \left[(K_{jt+1} - (1 - \delta_j) K_{jt}) + \gamma \left(\frac{K_{jt+1}}{K_{jt}} - 1 \right)^2 K_{jt} \right]. \tag{9}$$

Labor adjustment is frictionless and we denote the wage rate by w. Accounting for optimal labor demand, profits are given by[15]

$$\Pi_t = \max_{N_t} \left\{ R_t - w N_t \right\} - C_t^K. \tag{10}$$

Managerial Pay: The decision-maker in the firm is a manager. The manager's compensation consists of a fixed salary w_t^f that is independent of firm performance, a cash bonus that is a share $\eta^b \in [0, 1)$ of (current) profits Π_t, and equity compensation that is a share $\eta^e \in (0, 1)$ of the market value of equity E_t. Total managerial compensation is

$$\Gamma_t = w_t^f + \eta^b \Pi_t + \eta^e E_t. \tag{11}$$

[15]Profit-maximizing labor demand satisfies: $N_t = \left(b X^{1-a-b} \left(K_{lt}^{\nu} K_{st}^{1-\nu} \right)^a w^{-1} \right)^{\frac{1}{1-b}}$.

The key feature of managerial compensation is that it may depend partly on current profits and partly on (long-term) firm value. As in Nikolov and Whited (2014), we do not derive the optimal contract but instead model the compensation contracts that we observe in the data. This approach allows us to identify the effects of changing contractual features on firms' investment policies, and on real economic activity. To keep the model tractable, we follow Glover and Levine (2015) in assuming that contracts last for one period and that the manager does not hold shares in the firm at the beginning of the period.[16]

The market value of equity E_t depends on the discounted stream of expected dividends. Taking into account the fixed salary and the cash bonus of the manager, the dividend in period t is given by $(1-\eta^b)\Pi_t - w_t^f$. In addition, the manager receives equity compensation. Under complete financial markets and rational expectations, the market value of equity E_t is recursively defined by

$$E_t = (1-\eta^b)\Pi_t - w_t^f + \frac{1}{1+r}\mathbb{E}_t\Big\{(1-\eta^e)E_{t+1}\Big\}, \tag{12}$$

where r is the risk-free interest rate. Note that equity compensation leads to share dilution.[17] Using (12), we can rewrite the value of the manager's compensation package in (11) as

$$\Gamma_t = w_t^f - \eta^e \sum_{\tau=0}^{\infty} \theta^\tau \mathbb{E}_t\Big\{w_{t+\tau}^f\Big\} + \varphi\left[\Pi_t + \beta \sum_{\tau=1}^{\infty} \theta^\tau \mathbb{E}_t\Big\{\Pi_{t+\tau}\Big\}\right], \tag{13}$$

where

$$\varphi = \eta^b + \eta^e(1-\eta^b), \quad \beta = \frac{\eta^e(1-\eta^b)}{\eta^b+\eta^e(1-\eta^b)}, \quad \theta = \frac{1-\eta^e}{1+r}. \tag{14}$$

Because the term $w_t^f - \eta^e \sum_{\tau=0}^{\infty} \theta^\tau \mathbb{E}_t\big\{w_{t+\tau}^f\big\}$ is exogenous to the manager's decisions we will

[16]Considering multi-period contracts between managers and owners complicates the model and its solution and may necessitate further structural assumptions, e.g.: managers' preferences regarding payoffs at different points in time, managers' ex-ante exposure to the firm's performance via pre-existing holdings of equity, a process linking managers' probability of staying with the firm to firm performance, and uncertainty about future remuneration packages.

[17]Shareholders in period t anticipate that the share of future total market capitalization they hold shrinks by a factor of $1-\eta^e$. The effect of equity-based compensation on share dilution is a well-known fact in finance (see, e.g., Asquith and Mullins 1986, Huson et al. 2001, Core et al. 2002).

ignore it in the following and focus on the last term in (13).

The payout profile in (13) is akin to the preferences of a risk-neutral agent with quasi-hyperbolic discounting preferences over the stream of profits Π_t (see Laibson 1997). The implicit preferences feature present bias if $\beta < 1$. A necessary condition for present bias is a strictly positive cash bonus share η^b of current profits. Increasing η^b, or lowering the equity share η^e conditional on $\eta^b > 0$, both reduce β and thus increase the present bias towards current profits. Furthermore, θ incorporates the equity dilution factor $(1-\eta^e)$, which results in stronger discounting of future profits. Stronger discounting arises because the present manager's equity compensation is diluted by the equity compensation of future managers.[18]

Investment Problem: The manager decides how much to invest in each type of capital and how much labor to hire. Taking as given optimal labor demand, the manager in period t chooses $\mathbf{K}_{t+1}$ depending on the history of previous managers' decisions $\mathcal{H}_t = \{\mathbf{K}_s | s \leq t\}$. Denote by s_τ a strategy of manager τ. The decision problem of the manager in t is

$$\max_{\mathbf{K}_{t+1}} \Gamma_t \quad \text{s.t.} \quad (13), (10), (9), (7), \tag{15}$$

$$\text{given } \mathcal{H}_t, \text{ and beliefs regarding } s_\tau \text{ for } \tau > t.$$

In general, this type of problem has an extremely large strategy space and a multitude of equilibria can occur. We focus on symmetric, smooth Markov-perfect equilibria, for which the state of the game is described by $\mathbf{K}_t$.

Optimal Capital Policy: The optimal capital policy has no closed-form solution (unless $\gamma = 0$, see below). However, we can implicitly characterize how present bias affects the capital policy function. We denote this function by $\mathcal{K}(\mathbf{K}) = [\mathcal{K}_l(\mathbf{K}), \mathcal{K}_s(\mathbf{K})]$, where $\mathcal{K}_j(\mathbf{K})$

[18] Note that we have restricted the parameter space to rule out three peculiar cases: $\eta^b = 1$, $\eta^e = 0$, and $\eta^e = 1$. In these cases, either $\beta = 0$ or $\theta = 0$, meaning the manager's compensation does not depend on future profits. Given the assumption of one-period time to build, the firm's capital stock will then converge toward zero, because each successive manager will find it optimal to sell capital.

is the policy function for capital good $j \in \{l, s\}$. In period t, the manager of a firm with a predetermined capital stock $\mathbf{K}_t$ chooses $K_{j,t+1} = \mathcal{K}_j(\mathbf{K}_t)$. The function $\mathcal{K}(\cdot)$ is the solution to the manager's first-order conditions associated with (15). With a slight abuse of notation, the policy function is the solution $\mathbf{K}_{t+1}$ of the following self-referencing characterization:[19]

$$0 = \frac{\partial \Pi_t}{\partial K_{j,t+1}} + \beta\theta \frac{\partial \Pi_{t+1}}{\partial K_{j,t+1}} + (\beta - 1)\theta \sum_{k=l,s} \frac{\partial \mathcal{K}_k(\mathbf{K}_{t+1})}{\partial K_{j,t+1}} \frac{\partial \Pi_{t+1}}{\partial K_{k,t+2}}. \tag{16}$$

The capital-specific Euler equation (16) takes into account the strategic dependence of future behavior on current decisions. The first two terms are standard and incorporate the costs of investment and the marginal returns. The final term is a peculiarity of models with quasi-hyperbolic discounting. It captures the marginal effect of changes in today's investment on future investment behavior, which feeds back into today's equity and thus today's decisions. The unknown gradients of the capital policy functions $\frac{\partial \mathcal{K}_k(\mathbf{K}_{t+1})}{\partial K_{j,t+1}}$ for $j, k \in \{l, s\}$ determine the effects of future investment on today's equity. Whenever managers are compensated with a combination of cash bonuses and equity (i.e., $\beta \neq 1$), the last term does not cancel out, rendering the the optimal capital policy analytically non-tractable.

A Tractable Special Case: The optimal capital policy has a closed-form solution in the special case $\gamma = 0$. Absent capital adjustment costs, the capital choice of the manager in t does not depend on the predetermined period t capital stock, chosen by the manager in $t-1$. The gradient of the policy function is zero: $\frac{\partial \mathcal{K}_k(\mathbf{K}_t)}{\partial K_{j,t}} = 0$ for $j \in \{l, s\}$. We can therefore simplify the optimality condition (16) as

$$1 = \beta\theta \left[\frac{\partial R_t}{\partial K_{jt}} + (1 - \delta_j) \right], \tag{17}$$

which permits analytically solving the optimal capital policy. We can characterize how present bias affects the allocation of capital within the firm. The ratio of long-lived capital

[19] The derivation of the optimality condition (16) is relegated to Appendix B.1.

to short-lived capital chosen by the manager is given by

$$\frac{K_{lt}}{K_{st}} = \frac{\nu}{1-\nu}\frac{(\beta\theta)^{-1} - 1 + \delta_s}{(\beta\theta)^{-1} - 1 + \delta_l}, \tag{18}$$

where the second fraction is the present-biased manager's 'user cost' of short-lived capital over long-term capital. A decrease in β unambiguously lowers the ratio of long-lived capital relative to short-lived capital. In other words, a change in managerial compensation that lowers β changes the relative allocation of the firm's capital stock toward short-lived capital. Another effect of a decline in β is that firms scale down capital leading to higher markup.

Discussion: The model described in this section is a partial equilibrium model. This model will be the basis of our quantitative analysis. We therefore abstract from the general equilibrium (GE) spillovers between firms. GE price responses imply that the reform also affects those firms whose managerial compensation structure is not directly affected by the reform. Importantly, we analyze a general equilibrium (GE) extension of the model at the end of Section 4. Our model allows for rich investment dynamics, but it abstracts from other potential factors that affect investment. One of these potential factors is managerial risk aversion. While difficult to measure, a manager with high risk aversion may have an even stronger preference to tilt the within-firm capital allocation further towards short-term assets as these assets expose the decision-maker to less uncertainty in the future. We also neglect the role of convexity in compensation schemes. In our defense, Hayes et al. (2012) provide empirical evidence that the change in convexity induced by FAS 123R had little impact on CEOs' risk-taking behavior.

4 Quantitative Analysis

We use our model to quantify the effects of a shift in managerial pay on the capital allocation of firms and real economic activity. The calibrated model rationalizes the empirical evidence and predicts a sizeable output drop that partly reflects exacerbated within-firm capital misallocation.

4.1 Solution Method

The decision problem of the manager features present bias and resembles a quasi-hyperbolic discounting problem. Solving our model involves similar challenges as those documented in previous neoclassical growth models with quasi-geometric discounting (e.g., Krusell and Smith 2003, Maliar and Maliar 2016). As the optimal capital policy does not have a closed-form solution in general, we solve the model numerically. Since Euler-equation methods are likely to fail (cf. Maliar and Maliar 2016), we solve the model using a version of the endogenous gridpoint method first introduced by Carroll (2006). This method works similarly to backward induction: for a fixed number of possible future stocks of both types of capital, we use the managers' optimality conditions to obtain current capital stocks.

4.2 Calibration

A period in the model is a year. We calibrate the model to match the change in managerial compensation in the years around the accounting reform for a simulated sample of firms. Model parameters not directly related to managerial compensation are calibrated to match salient features of the data before the reform.

Calibrating Incentive Contracts: Table 7 provides summary statistics for three key parameters that describe managerial incentive contracts. We document the empirical distribution of the equity share (η^e), the cash bonus shares (η^b), and the present bias (β) in the year before and after the accounting reform, respectively. We compute η^b as the sum of bonuses and non-equity incentive compensation divided by firm sales. The equity share η^e is computed as the manager's equity-linked firm wealth divided by the firm's market capital-

Table 7: Summary Statistics on Incentive Contracts

Variable	Mean	Std. Dev.	p25	p50	p75	Obs
Bonus Share η^b						
2005	0.00034	0.00060	0.00004	0.00014	0.00036	7,786
2007	0.00046	0.00200	0.00005	0.00015	0.00041	8,534
Equity Share η^e						
2005	0.0097	0.0254	0.0009	0.0024	0.0067	7,786
2007	0.0063	0.0168	0.0006	0.0016	0.0045	8,534
Present Bias β						
2005	0.918	0.078	0.874	0.943	0.982	7,786
2007	0.890	0.087	0.803	0.910	0.968	8,534

Notes: The table reports summary statistics on the bonus shares η^b, the equity shares η^e and the associated values of β before and after the FAS 123R reform (2005 and 2007) constructed based on Execucomp, Compustat, Coles et al. (2006), Core and Guay (2002), and equation (14), see Appendix C.1 for details.

ization, see Appendix C.1 for details. We compute β following equation (14). Between 2005 and 2007, the sample mean of β falls by 3 percentage points from 0.918 to 0.890, driven by both lower η^e and higher η^b.

We simulate a sample of 2,400 firms.[20] Each firm is endowed with a pre-reform value of β and a post-reform value of β. The β values are random draws from the empirical joint distribution of pre- and post-reform β. In particular, we discretize the distribution of β into 10 equally-sized bins ranging from 0.75 to 1.0 and compute the distribution across bins in 2005 and the transition probabilities across bins between 2005 and 2007. Figure C.1 shows the shift in the distribution of β (across bins) between 2005 and 2007. For 70% of the firms β remains the same, while it changes for 30% of firms, mostly downward. Thus, the incentive structure of managers shifted towards stronger present bias around the reform. In addition, firms draw a value of η^e from a discretized beta distribution that approximates the empirical distribution of η^e.[21]

[20] We choose a relatively large number of simulated firms in order to represent well heterogeneity across industries and to keep sampling noise small.

[21] The change in η^e between 2005 and 2007 documented in Table 7 also implies a change in $\theta = \frac{1-\eta^e}{1+r}$. However, the change is of secondary quantitative importance. While β drops by 0.03, θ increases by only 0.003. To keep our quantitative exercise transparent, we let θ remain constant over time.

Other Parameters: The remaining parameters of the model are the two depreciation rates (δ_l, δ_s), parameters describing production technology (α, ν), and parameters describing demand and wages (ε, B, w). In order to capture heterogeneity across sectors, we randomly assign firms to sectors, using as probability weights the number of firms per sector in the U.S. based on the OECD Structural Statistics of Industry and Services database. We consider the 13 sectors listed in Table 8. We calibrate the depreciation rates to sector-specific weighted average depreciation rates when grouping capital goods into the long-lived category (buildings and structures) and the short-lived category (various types of equipment). For the remaining parameters, we target sector-specific revenues R, the share of long-lived capital $\frac{K_l}{K_l+K_s}$, the ratio of long-lived capital over revenues $\frac{K_l}{R}$, the ratio of labor costs over revenues $\frac{wN}{R}$, and the wage w. We abstract from incentive distortions when calibrating these sector-specific production and demand parameters using the steady-state conditions of the model, see Appendix C.2 for details. Table 8 shows the calibrated sector-level model parameters.[22]

A firm's overall business condition X is the composite of a sector-wide demand condition B and productivity Z according to $X = B^{\frac{1}{\varepsilon}} Z^{\frac{\varepsilon-1}{\varepsilon}}$. We allow for permanent productivity differences across firms, and draw Z from a log-normal distribution with mean zero and a standard deviation of 0.52 matching the corresponding estimate in İmrohoroğlu and Şelale Tüzel (2014). We set the quadratic adjustment-cost parameter $\gamma = 0.9$, which matches a half-life of capital adjustment between three and four years. Finally, we set the interest rate r to 2.98%.

Non-Targeted Moments: A key test of our calibrated model is whether it can replicate the (non-targeted) empirical evidence in Table 4 of Section 2. We run the regression in equation (2) on our simulated sample of firms. To replicate a model analog to $\text{Option}_{i,2004}$ in the empirical analysis, we first create a dummy variable which is one for firms that experienced a reduction in β and zero else. To mimic the fact that $\text{Option}_{i,2004}$ does not perfectly predict

[22]In line with the data, our calibration assumes β to be identically distributed across sectors. We cannot reject the null hypothesis of equal average *beta* across sectors at p=0.89 for 2005 and p=0.57 for 2006.

Table 8: Industry-Level Parameters

Code	Industry Name	Industry Weight (in %)	Value Added (in Mio. USD, 2010 prices)	Capital Stock (in Mio. USD, 2010 prices)	Share of Long-Term Capital Stock	Depreciation Rates		Production Function Parameters		Wage Rate (in Thd. USD, 2010 prices)	Demand Elasticity	Demand Shifter (in Thd. USD, 2010 prices)
						δ_l	δ_s	ν	α	w	ε	B
A	Agriculture, forestry and fishing	2.0	138,161	462,506	0.58	0.02	0.13	0.30	0.55	28.4	2.4	17,426
B	Mining and quarrying	0.3	260,953	1,481,196	0.93	0.02	0.14	0.79	0.58	113.5	2.3	184,719
C	Total manufacturing	7.9	1,726,301	2,794,956	0.47	0.03	0.11	0.27	0.24	57.4	3.4	22,978,000
D, E	Electricity, gas and water supply	0.5	288,219	1,665,872	0.79	0.02	0.10	0.59	0.55	58.1	3.3	628,381
F	Construction	12.6	748,735	228,765	0.32	0.03	0.16	0.13	0.07	51.5	2.9	3,633,884
G	Wholesale and retail trade	22.3	1,777,411	1,367,003	0.71	0.03	0.15	0.45	0.12	48.6	2.6	976,920
H	Transportation and storage	3.1	472,378	1,051,537	0.60	0.03	0.14	0.35	0.25	57.5	10.1	$34{,}204 \times 10^{12}$
I	Accommodation and food service activities	7.9	414,118	466,458	0.78	0.03	0.14	0.56	0.13	28.9	3.5	5,043,535
J	Information and communication	0.4	698,043	1,374,041	0.71	0.04	0.13	0.52	0.29	66.9	2.9	27,135,000
K	Financial and insurance activities	5.0	930,028	925,047	0.62	0.04	0.18	0.35	0.18	76.2	3.0	13,328,000
M, N	Other business services	17.8	1,343,732	1,056,987	0.50	0.04	0.15	0.28	0.13	81.3	4.0	563,140,000
Q	Healthcare	9.0	929,544	940,826	0.76	0.03	0.15	0.51	0.10	48.7	11.8	$792{,}530 \times 10^{15}$
R, S	Arts, entertainment and recreation	11.2	510,096	743,230	0.85	0.05	0.15	0.71	0.17	40.8	4.7	350,250,000

Notes: Industry weights are based on the number of enterprises across sectors from the OECD Structural Statistics of Industry and Services database for the year 2005. All other industry-level information is based on US 2003–2005 files from EU KLEMS data. Depreciation rate δ_s displays the depreciation rate of the short-term capital stock, which is given by the capital stock-weighted depreciation rates of telecommunication equipment (N11322G), computer hardware (N11321G), transport (N1131G) and other machinery equipment and weapons (N11OG). Accordingly, depreciation rate δ_l is the industry-specific long-term depreciation rate, given by the depreciation rate for other buildings and structures (N11OG).

reductions in β in the data, we add classical measurement error to the model dummy variable.[23] The dependent variable is the inverse hyperbolic sine of investment as in the empirical regression.[24]

Table 9 reports the estimates of equation (2) in our simulated sample of firms. Across specifications, the estimates coincide in sign. The estimates are also fairly close in magnitude compared to their empirical counterparts in Table 4. For example, for the specification in column (1), our key coefficient of interest, the first row, is estimated at 0.865 in simulated data compared to 0.999 in real data. In an additional exercise, we revisit the empirical regressions (on real data) when replacing the option dummy by the firm-specific β. Appendix Table C.2 shows that reductions in β are associated with a shift of investments towards more short-lived capital goods. Moreover, we use $\text{FAS123}_t \times \text{Option}_{i,2004}$ as an instrument for decreases in β allowing us to confirm that the reform-induced shift in incentives caused a more short-term investment behavior.

4.3 Quantitative Results

In the calibrated model, the shift in managerial compensation toward cash bonuses leads to managerial short-termism. Profits rise in the short term but subsequently fall below the initial level. Managers lower total investment, in particular investment in long-term capital. The investment response lowers output, partly because of exacerbated capital misallocation within firms. Finally, we study the effects of managerial compensation in general equilibrium.

Managerial Pay and Profits: Figure 2 shows the change in β caused by the shift in managerial pay. The average present bias β across firms is constant initially. The exogenous

[23] In 32% of the empirical observations, either $\text{Option}_{i,2004} = 1$ and β_i does not fall, or $\text{Option}_{i,2004} = 0$ and β_i falls. We construct $\text{Option}_{i,2004}$ in the model as the dummy variable for reductions in β when re-coding the dummy from zero to one, or from one to zero, for randomly selected 32% of firms. Appendix Table C.1 shows the results when not introducing measurement error, which naturally leads to larger coefficient estimates.

[24] Due to the scale variance of this transformation, we scale investment in the calibrated sample to match the sample mean of investment in the data in order to ensure comparability of the estimates.

Table 9: Simulated Firms - Regression Results

	Investments				
	(1)	(2)	(3)	(4)	(5)
Measure of Depreciation:	*Depreciation Rate*				
FAS123 × β Reduced × Depr	0.865	0.865	1.785	1.785	3.541
	(0.153)	(0.153)	(0.254)	(0.254)	(0.325)
FAS123 × Depr	0.598	0.598	1.042	1.042	0.598
	(0.0795)	(0.0795)	(0.122)	(0.122)	(0.0795)
β Reduced × Depr	0.948		1.556		2.018
	(0.247)		(0.287)		(0.292)
Category FE	×		×		×
Category-Firm FE		×		×	
Firm-Year FE	×	×	×	×	×
Trend					×
Years around reform	15	15	6	6	15

Notes: This Table reports the results on the relationship between managerial incentives and investment decisions based on the panel of simulated firms. *β Reduced* is defined as dummy variable which indicates if a firm experiences a reduction in its firm-specific β. *FAS123* is a dummy variable indicating the post-shock period. Empirical specifications in columns 1 to 5 resemble those in Table 4. The treatment-specific linear trend in column 5 is Trend × *β Reduced* × Depr. Standard errors (reported in parentheses) are clustered at the firm-level.

shift in managerial pay permanently lowers β by almost three percentage points on average, matching the pre- and post-reform level of β in the data (Table 7). Consistent with a lower β, i.e., stronger present bias, firm profits initially increase. However, starting seven years after the shift in managerial pay, profits fall below the level prevaling before the shift and subsequently remain permanently suppressed. The increase in present bias due to a lower β hence raises short-term profits at the expense of long-term profits.

Investment and Capital: We next study the change of managerial behavior underlying the response of profits. The key managerial decision is how much to invest, respectively, in short-lived and long-lived capital. Panel (a) of Figure 3 shows the change in the investment-capital ratio caused by the shift in managerial pay. Increased present bias reduces the man-

Figure 2: Present Bias and Profits

(a) Present Bias

(b) Profits

Notes: The figure shows the evolution of the average present bias β and profits Π_t across firms, the latter in % deviation from the pre-shock level.

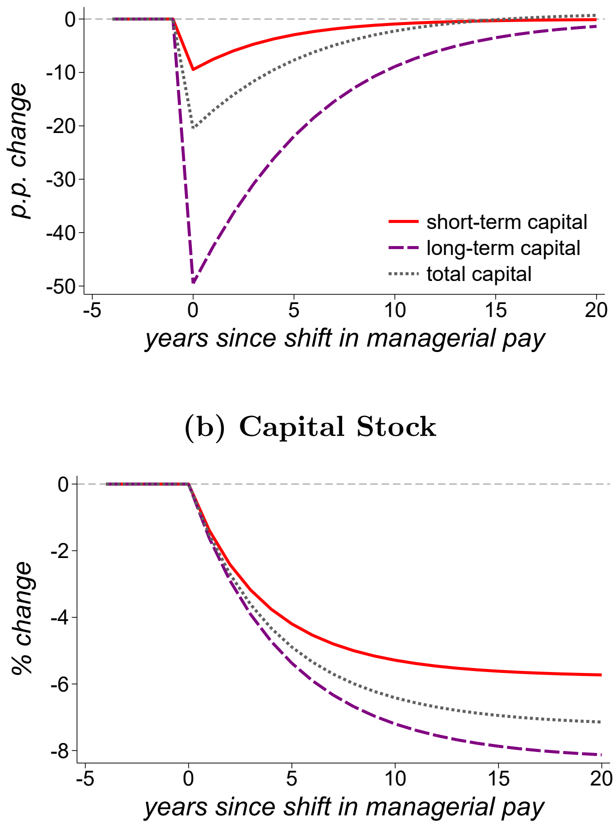
agers' incentive for any investment. In response, the ratio of total investment over total capital falls 20 percentage points on average in the first year and slowly recovers subsequently. Consistent with our empirical findings in Table 4, the response in investments is asymmetric across capital goods. While the investment ratio of short-term capital initially falls 9 percentage points, the investment ratio of long-term capital plummets 49 percentage points. The shift in managerial pay hence causes a sizeable contraction and reallocation of investment.

Panel (b) shows the change in capital stocks. Consistent with lower investment rates and sluggish capital adjustment, we observe a decline in the firms' capital stock that builds up

Figure 3: Investment and Capital

(a) Investment-Capital Ratio

(b) Capital Stock



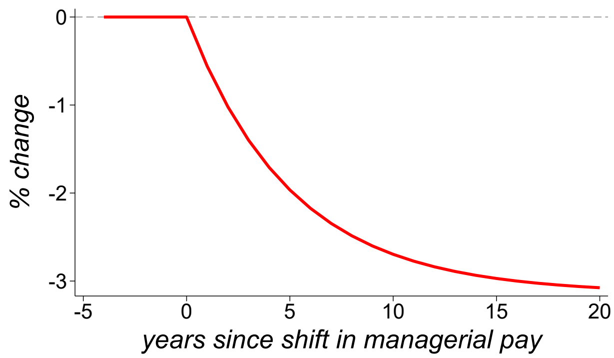
Notes: The figure shows the evolution of the investment-capital ratios and capital stocks. The investment-ratio is defined as I_{jt}/K_{jt} for short-term capital ($j = s$) and long-term capital ($j = l$), and as $(I_{st}+I_{lt})/(K_{st}+K_{lt})$ for total capital. For all investment ratios we show average percentage point deviation from the pre-shift level. For all capital stocks we show average percent deviation from the pre-shift level.

slowly. In the long run, the average stock of long-lived capital is 8% below the initial level, short-lived capital is 6% lower and the sum of short-lived and long-lived capital about 7% lower.[25] The patterns of investment and capital are important to understand the response of profits in Figure 2. In the short term, managers lower investment (especially in long-lived capital) to raise profits, but in the long term, a lower capital stock depresses profits.

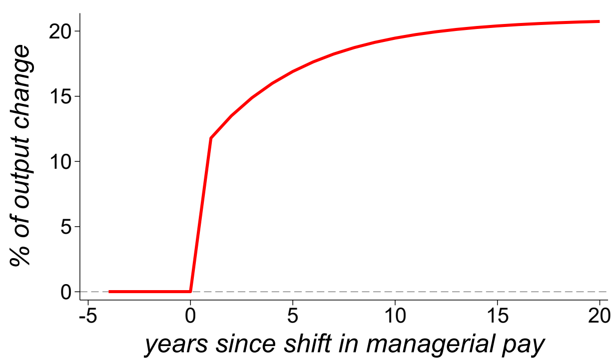
[25]The permanent shift in the capital composition toward short-lived capital explains why the total investment-capital ratio converges to a level slightly above the initial level. Maintaining a constant capital stock in the new steady state requires higher investment to offset higher depreciation.

Figure 4: Output and Capital Misallocation

(a) Output



(b) Misallocation



Notes: The figure depicts the dynamic adjustment of output Q_t, in percent and indexed to pre-shock values and the contribution of misallocation to the output decline in percent.

Output and Capital Misallocation: Finally, we analyze the effects of the shift in managerial pay on output and capital misallocation. Panel (a) of Figure 4 shows the drop in output. The response of output resembles the sluggish response of capital. The initial response is small. In the long term, however, average output drops by 3%. We consider it worthwhile to stress that the size of the output decline is sizeable given what may seem to be small changes in the managerial pay structure in Table 7.

The output response partly reflects an increase in within-firm capital misallocation. Conceptually, we decompose the change in output into a markup change and a change in marginal costs that captures the productivity effects of within-firm capital misallocation:

$$\Delta \log Q_t = -\underbrace{\varepsilon \Delta \log \mu_t}_{Markup} - \underbrace{\varepsilon \Delta \log MC_t}_{Misallocation}. \tag{19}$$

The decomposition follows from isoelastic demand and constant returns to scale technology.[26] Given isoelastic demand, if the manager scales down production, the markup rises. Capital misallocation increases if the mix of short-term and long-term capital becomes more suboptimal, leading to higher marginal costs.

Panel (b) of Figure 4 shows the contribution of misallocation to the output decline over time. While most of the output decline reflects higher markups, higher capital misallocation is quantitatively relevant. In the first year after the shift in managerial pay, it explains 12% of the output. In the long term, capital misallocation explains 20% of the output drop.

General Equilibrium: We finally analyze the effects of changes in managerial pay in general equilibrium. We have shown that the simulated change in managerial pay lowers capital demand, and thus lowers labor demand. In general equilibrium, we may expect the contraction in factor demand to be dampened by the adjustment of factor prices.

We analyze the same sample of firms as before but complement the model of the firm with a demand structure, households, and market clearing. The firms produce variety goods which are combined into a sector-specific CES bundle. The sector-specific bundles are combined into an aggregate Cobb-Douglas final good. We assume that capital adjustment costs are labor costs and that households' labor supply is fixed. This assumption renders our general equilibrium results rather conservative. Labor is an important factor in production and keeping aggregate labor fixed limits the aggregate contraction in real economic activity after the simulated change in managerial pay. We use the final good as numéraire and normalize the aggregate price index to unity. The remaining equilibrium price is the wage rate. Formal

[26] Marginal costs can be computed as $MC_t = C_t/Q_t$, where C_t denotes total costs evaluated with efficient user costs of capital. The markup is $\mu_t = P_t/MC_t = R_t/C_t$.

Table 10: General-Equilibrium Effects

Variable	Change (%)	Variable	Change (%)
Output	-1.06	Real wage	-1.06
Long-term investment	-5.50	Short-term investment	-4.35
Long-term capital stock	-5.44	Short-term capital stock	-4.34
Total investment	-4.69	Total capital stock	-5.05

Notes: The table shows the percentage change of aggregate variables between the stationary equilibrium before and after the change in managerial pay.

details on the general equilibrium model are provided in Appendix B.2.[27]

Table 10 presents the aggregate effects of the simulated change in managerial pay in the new stationary equilibrium relative to the stationary equilibrium before the change. Output contracts by about 1%, about one third of the long-term output decline in partial equilibrium (Figure 4). The real wage contracts by the same magnitude, as may be expected given the Cobb-Douglas production technology. The contractions of short-term and long-term capital differ by relatively little from the long-term response in partial equilibrium. Long-term capital falls 5.4% in general equilibrium relative to 8% in partial equilibrium. For short-term capital, the contraction is 4.3% in general equilibrium relative to 6% in partial equilibrium. Hence, the general equilibrium increase in the real wage does relative little to dampen the capital response to the change in managerial pay. Relatedly, the dampened output response in general equilibrium mostly reflects fixed labor supply.

[27]For comparability with the partial equilibrium results, we calibrate fixed household labor supply to correspond to aggregate labor demand in the partial equilibrium steady state before the reform. This means differences between partial and general equilibrium after the change in managerial pay solely reflect an adjustment in the real wage to clear the labor market.

5 Conclusion

In this paper, we analyze how managerial pay affects the allocation of capital. We provide empirical evidence showing that firms systematically shift investment expenditures towards less durable assets in response to a shift in managerial pay towards more short-term incentives. To quantify the impact of managerial present bias on capital (mis)allocation and output, we calibrate a model of heterogeneous firms that are subject to agency frictions since there is a separation between ownership and control and managers are incentivized with equity-bonus contracts. Our results indicate that changes in incentives away from motivating managers to maximize long-term firm values cause substantial economic distortions. Firms cut their investments into long-term assets and within-firm capital misallocation increases due to a mismatch in decision-makers' private marginal products of capital and social marginal products of capital, causing a decline in economic activity in the long-run. We conclude that corporate decision-makers' incentives are crucial for economic policy-making as managers respond very sensitively to changes in their incentives, which in turn affects economic outcomes.

References

Abadie, Alberto, Susan Athey, Guido W. Imbens, and Jeffrey Wooldridge. When Should You Adjust Standard Errors for Clustering? *Quarterly Journal of Economics*, 138(1):1–35, 2023.

Aghion, Philippe, George-Marios Angeletos, Abhijit Banerjee, and Kalina Manova. Volatility and Growth: Credit Constraints and the Composition of Investment. *Journal of Monetary Economics*, 57(3):246–265, 2010.

Alder, Simeon D. In the Wrong Hands: Complementarities, Resource Allocation, and TFP. *American Economic Journal: Macroeconomics*, 8(1):199–241, 2016.

Asker, John, Allan Collard-Wexler, and Jan De Loecker. Dynamic Inputs and Resource (Mis)Allocation. *Journal of Political Economy*, 122(5):1013–1063, 2014.

Asquith, Paul and David W. Mullins. Equity Issues and Offering Dilution. *Journal of Financial Economics*, 15(1):61–89, 1986.

Barton, Dominic. Capitalism for the Long Term. *Harvard Business Review*, 2011.

Bénabou, Roland and Jean Tirole. Bonus Culture: Competitive Pay, Screening, and Multitasking. *Journal of Political Economy*, 124(2):305–370, 2016.

Carroll, Christopher D. The Method of Endogenous Gridpoints for Solving Dynamic Stochastic Optimization Problems. *Economics Letters*, 91(3):312–320, 2006.

Coles, Jeffrey L., Naveen D. Daniel, and Lalitha Naveen. Managerial Incentives and Risk-Taking. *Journal of Financial Economics*, 79(2):431–468, 2006.

Core, John and Wayne Guay. Estimating the Value of Employee Stock Option Portfolios and Their Sensitivities to Price and Volatility. *Journal of Accounting Research*, 40(3):613–630, 2002.

Core, John E., Wayne R. Guay, and S. P. Kothari. The Economic Dilution of Employee Stock Options: Diluted EPS for Valuation and Financial Reporting. *The Accounting Review*, 77(3):627–652, 2002.

David, Joel M. and Venky Venkateswaran. The Sources of Capital Misallocation. *American Economic Review*, 109(7):2531–67, 2019.

Dimon, Jamie and Warren E. Buffet. Short-Termism Is Harming the Economy: Public Companies Should Reduce or Eliminate the Practice of Estimating Quarterly Earnings. *Wall Street Journal*, 2018.

Doerr, Sebastian, Dalia Marin, Davide Suverato, and Thierry Verdier. International Trade and the Allocation of Capital within Firms. *Journal of International Economics*, (104023), 2025.

Edmans, Alex, Vivian W. Fang, and Allen Huang. The Long-Term Consequences of Short-Term Incentives. *Journal of Accounting Research*, 60(3):1007–1046, 2022.

Edmans, Alex, Vivian W. Fang, and Katharina A. Lewellen. Equity Vesting and Investment. *Review of Financial Studies*, 30(7):2229–2271, 2017.

Garicano, Luis and Luis Rayo. Why Organizations Fail: Models and Cases. *Journal of Economic Literature*, 54(1):137–92, 2016.

Garicano, Luis and Claudia Steinwender. Survive Another Day: Using Changes in the Composition of Investments to Measure the Cost of Credit Constraints. *Review of Economics and Statistics*, 98:913–924, 2016.

Giroud, Xavier. Proximity and Investment: Evidence from plant-level data. *The Quarterly Journal of Economics*, 128(2):861–915, 2013.

Giroud, Xavier and Holger M. Mueller. Firms' Internal Networks and Local Economic Shocks. *American Economic Review*, 109(10):3617–49, 2019.

Glover, Brent and Oliver Levine. Uncertainty, Investment, and Managerial Incentives. *Journal of Monetary Economics*, 69:121–137, 2015.

Gormsen, Niels and Kilian Huber. Corporate Discount Rates. NBER Working Papers

31329, National Bureau of Economic Research, Inc, 2023.

Hayes, Rachel M., Michael Lemmon, and Mingming Qiu. Stock Options and Managerial Incentives for Risk Taking: Evidence from FAS 123R. *Journal of Financial Economics*, 105(1):174–190, 2012.

Hsieh, Chang-Tai and Peter J. Klenow. Misallocation and Manufacturing TFP in China and India. *Quarterly Journal of Economics*, 124(4):1403–1448, 2009.

Huson, Mark R., Thomas W. Scott, and Heather A. Wier. Earnings Dilution and the Explanatory Power of Earnings for Returns. *The Accounting Review*, 76(4):589–612, 2001.

İmrohoroğlu, Ayşe and Şelale Tüzel. Firm-Level Productivity, Risk, and Return. *Management Science*, 60(8):2073–2090, 2014.

Kehrig, Matthias and Nicolas Vincent. Good Dispersion, Bad Dispersion. NBER Working Papers 25923, National Bureau of Economic Research, Inc, 2019.

Krusell, Per and Anthony A. Smith. Consumption-Savings Decisions with Quasi-Geometric Discounting. *Econometrica*, 71(1):365–375, 2003.

Ladika, Tomislav and Zacharias Sautner. Managerial Short-Termism and Investment: Evidence from Accelerated Option Vesting. *Review of Finance*, 23(4):forthcoming, 2019.

Laibson, David. Golden Eggs and Hyperbolic Discounting. *Quarterly Journal of Economics*, 112(2):443–478, 1997.

Maliar, Lilia and Serguei Maliar. Solving the Neoclassical Growth Model with Quasi-Geometric Discounting: A Grid-Based Euler-Equation Method. *Computational Economics*, 26(2):163–172, 2005.

Maliar, Lilia and Serguei Maliar. Ruling Out Multiplicity of Smooth Equilibria in Dynamic Games: A Hyperbolic Discounting Example. *Dynamic Games and Applications*, 6(2):243–261, 2016.

Meier, Matthias and Timo Reinelt. Monetary policy, markup dispersion, and aggregate TFP, forthcoming. Review of Economics and Statistics.

Midrigan, Virgiliu and Daniel Yi Xu. Finance and Misallocation: Evidence from Plant-Level Data. *American Economic Review*, 104(2):422–58, 2014.

Mullahy, John and Edward C Norton. Why Transform Y? The Pitfalls of Transformed Regressions with a Mass at Zero. *Oxford Bulletin of Economics and Statistics*, 86(2):417–447, 2024.

Nikolov, Boris and Toni M. Whited. Agency Conflicts and Cash: Estimates from a Dynamic Model. *Journal of Finance*, 69(5):1883–1921, 2014.

Peters, Michael. Heterogeneous Markups, Growth and Endogenous Misallocation. *Econometrica*, 88(5):2037–2073, 2020.

Terry, Stephen J. The Macro Impact of Short-Termism. *Econometrica*, 91(5):1881–1912, 2023.

World Bank. Real interest rate (%) - United States. 2020. Data retrieved from `https://data.worldbank.org/indicator/FR.INR.RINR?locations=US`.

A Empirical Appendix

Figure A.1: Equity Ownership and the Durability of Investments - By Category

Notes: The figure plots jointly estimated category-specific associations between investment and managerial equity ownership. Formally, it shows the estimated $\beta_{1,j}$ in

$$invest_{ict} = \sum_j \left[\mathbb{1}\{j = c\} \beta_{1,j} \eta_{it}^e \right] + \lambda_{it} + \lambda_{ci} + \varepsilon_{ict},$$

where j denotes an investment category. Advertising investment is absorbed by the fixed effects. The null hypothesis of coefficient equality across categories can be rejected at the 5%-level ($p = 0.015$).

Table A.1: Composition of Capital Stock

	Capital Stocks				
	(1)	(2)	(3)	(4)	(5)
Measure of Depreciation:	*Depreciation Rate*				
FAS123 × Option × Depr	0.790	0.513	0.477	0.220	1.166
	(0.287)	(0.226)	(0.238)	(0.170)	(0.284)
FAS123 × Depr	-1.112	-0.634	-0.504	-0.164	-1.112
	(0.265)	(0.214)	(0.220)	(0.163)	(0.265)
Option × Depr	-0.623		-0.603		103.5
	(0.349)		(0.355)		(27.17)
Measure of Depreciation:	*Ordinal Rank*				
FAS123 × Option × Depr	0.0621	0.0416	0.0384	0.0224	0.0852
	(0.0264)	(0.0193)	(0.0216)	(0.0138)	(0.0262)
FAS123 × Depr	-0.0787	-0.0387	-0.0355	-0.0109	-0.0787
	(0.0246)	(0.0182)	(0.0201)	(0.0129)	(0.0246)
Option × Depr	-0.0622		-0.0622		6.311
	(0.0337)		(0.0339)		(2.412)
Category FE	×		×		×
Category-Firm FE		×		×	
Firm-Year FE	×	×	×	×	×
Trend					×
Observations	36,765	36,694	14,640	14,532	36,765
No. Firms	690	684	670	661	690
Sample Period	2000 - 2014	2000 - 2014	2002 - 2007	2002 - 2007	2000 - 2014

Notes: The table reports estimates of equation (2) when replacing the left-hand side by capital. *Option* is a dummy that indicates if any unexercised options are outstanding in 2004. *FAS123* takes value 0 for all years until 2005 and value 1 afterward. *Depr* is a measure of depreciation: the rate of depreciation in the upper panel and the ordinal depreciation rank in the lower panel. Columns (1)–(4) vary in sample period and fixed effects. Column (5) controls for a linear time trend interacted with the interaction of the option dummy and the measure of depreciation. Standard errors (in parentheses) are clustered at the firm level.

Table A.2: Ex-Ante Differences across Firms

Variable	Option-Paying (N=553)	Non-Option-Paying (N=144)	t-test	p-value
Total Assets	8,153	7,491	0.29	0.77
Sales	7,512	7,145	0.16	0.87
Capital Stock	3,709	2,897	1.02	0.31
Employment	32.15	17.56	3.10	**<0.01**
Labor Productivity	115.4	98.9	1.44	0.15
Depreciation Rate	0.17	0.18	-1.35	0.18
Intangible Share	0.49	0.56	-2.01	**0.05**
Investment Rate	0.05	0.04	1.23	0.22
Leverage Ratio	0.20	0.19	0.19	0.85
Liquidity Ratio	0.15	0.21	-3.46	**<0.01**
Equity Volatility	0.34	0.40	-3.64	**<0.01**
Current CEO Compensation	1,929	1,538	2.05	**0.04**

Notes: A firm is classified as an option-paying firm if it has unexercised stock options to its management in 2004. We report arithmetic means across various outcomes in 2004. *Total Assets*, *Sales* and *Capital Stock* are denoted in millions USD, *Employment* is denoted in thousands. *Labor Productivity* is value added per employee in thousands USD (calculated as (SALE - COGS) / EMP). *Capital Stock* is obtained by summing up category-specific capital stocks for each firm, *Depreciation Rate* is the capital-stock weighted mean of category-specific depreciation rates for each firm. *Intangible Share* is the ratio of intangible investments (sum of advertising and R&D investments) to total investments. *Investment Rate* is capital expenditures (CAPX) relative to total assets (AT). The *Leverage Ratio* is defined as the ratio of total debt (sum of items DLC and DLTT) to total assets. The *Liquidity Ratio* equals the ratio of cash and short-term investments (CHE) to total assets. *Equity Volatility* is the annualized equity-return volatility, calculated as the standard deviation of daily stock returns multiplied by $\sqrt{252}$. Daily returns are calulated as (PRCCD $\times$ TRFD / AJEXDI) relative to the previous day. *Current CEO Compensation* is the current compensation of the CEO in thousands USD (compensation excluding equity). The last two columns show the t-test statistic for the null hypothesis that the arithmetic average is equal between option-paying and non-option-paying firms, and the associated p-value.

Table A.3: Investment Composition – Controlling for Firm Size

	Investments					
	(1)	(2)	(3)	(4)	(5)	(6)
Firm Size Measure:	*Employment*		*Assets*		*Capital Stock*	
Measure of Depreciation:	*Ordinal Rank*	*Depreciation Rate*	*Ordinal Rank*	*Depreciation Rate*	*Ordinal Rank*	*Depreciation Rate*
FAS123 × Option × Depr	0.0464	0.473	0.0477	0.503	0.0456	0.489
	(0.0201)	(0.191)	(0.0201)	(0.192)	(0.0200)	(0.190)
FAS123 × Depr	-0.0240	-0.386	0.0347	0.0674	0.00577	-0.116
	(0.0188)	(0.183)	(0.0353)	(0.342)	(0.0315)	(0.301)
FAS123 × Firm Size × Depr	-0.00685	-0.0194	-0.00984	-0.0676	-0.00655	-0.0477
	(0.00484)	(0.0460)	(0.00463)	(0.0443)	(0.00420)	(0.0395)
Category-Firm FE	×	×	×	×	×	×
Firm-Year FE	×	×	×	×	×	×
Observations	12,887	12,887	12,953	12,953	12,953	12,953
No. Firms	659	659	663	663	663	663
Sample Period	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007

Notes: The table reports estimates of equation (2) when controlling for various measures of firm size (employment, assets, capital stock) interacted with the *Option* dummy and the *FAS123* dummy. Standard errors (in parentheses) are clustered at the firm level.

Table A.4: Investment Composition – Controlling for Other Firm Differences

	Investments							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Firm Control:	*Intangible Share*		*Liquidity Ratio*		*Equity Volatility*		*Current CEO Compensation*	
Measure of Depreciation:	*Ordinal Rank*	*Depreciation Rate*	*Ordinal Rank*	*Depreciation Rate*	*Ordinal Rank*	*Depreciation Rate*	*Ordinal Rank*	*Depreciation Rate*
FAS123 × Option × Depr	0.0409	0.453	0.0392	0.398	0.0463	0.483	0.0479	0.483
	(0.0201)	(0.189)	(0.0201)	(0.188)	(0.0206)	(0.196)	(0.0209)	(0.200)
FAS123 × Depr	-0.0254	-0.324	-0.0275	-0.229	-0.0618	-0.562	0.0375	-0.163
	(0.0231)	(0.232)	(0.0207)	(0.195)	(0.0300)	(0.288)	(0.0790)	(0.748)
FAS123 × Control × Depr	-0.0192	-0.168	-0.0380	-0.849	0.0692	0.378	-0.0107	-0.0377
	(0.0265)	(0.255)	(0.0508)	(0.484)	(0.0587)	(0.548)	(0.0113)	(0.107)
Category-Firm FE	×	×	×	×	×	×	×	×
Firm-Year FE	×	×	×	×	×	×	×	×
Observations	12,933	12,933	12,953	12,953	12,953	12,953	12,902	12,902
No. Firms	661	661	663	663	663	663	661	661
Sample Period	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007				

Notes: The table reports estimates of equation (2) when controlling for various firm characteristics (intangible asset share, liquid asset ratio, equity volatility, current CEO compensation) interacted with the *Option* dummy and the *FAS123* dummy. Standard errors (in parentheses) are clustered at the firm level.

Table A.5: Investment Composition – Subsample Without CEO Turnover

	Investments				
	(1)	(2)	(3)	(4)	(5)
Measure of Depreciation:			*Depreciation Rate*		
FAS123 × Option × Depr	1.331	0.823	0.855	0.393	0.779
	(0.379)	(0.345)	(0.309)	(0.259)	(0.382)
FAS123 × Depr	-0.873	-0.515	-0.816	-0.488	-0.872
	(0.320)	(0.320)	(0.247)	(0.226)	(0.320)
Option × Depr	-1.109		-1.195		-153.1
	(0.474)		(0.481)		(60.33)
Measure of Depreciation:			*Ordinal Rank*		
FAS123 × Option × Depr	0.125	0.0714	0.0863	0.0392	0.0513
	(0.0356)	(0.0309)	(0.0331)	(0.0264)	(0.0367)
FAS123 × Depr	-0.0613	-0.0290	-0.0778	-0.0447	-0.0611
	(0.0305)	(0.0282)	(0.0280)	(0.0230)	(0.0305)
Option × Depr	-0.120		-0.128		-20.48
	(0.0528)		(0.0516)		(6.373)
Category FE	×		×		×
Category-Firm FE		×		×	
Firm-Year FE	×	×	×	×	×
Trend					×
Observations	14,810	14,779	5,919	5,851	14,810
No. Firms	292	291	286	285	292
Sample Period	2000 - 2014	2000 - 2014	2002 - 2007	2002 - 2007	2000 - 2014

Notes: The table reports estimates of equation (2) for the subsample of firms without CEO turnover, either for 2000–2014 or 2002–2007. Standard errors (in parentheses) are clustered at the firm level.

Table A.6: Investment Composition – Alternative Investment Measures

	Investments							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Investment Measure:	*Investment Rate*		*Logarithms*		*Ln(Investment+1)*		*Missings as 0s*	
FAS123 × Option × Depr	0.00542	0.0619	0.0934	1.013	0.0524	0.623	0.0404	0.430
	(0.00219)	(0.0209)	(0.0274)	(0.277)	(0.0188)	(0.196)	(0.0225)	(0.220)
FAS123 × Depr	-0.00116	-0.0149	-0.0478	-0.742	-0.00900	-0.293	0.0554	0.332
	(0.00194)	(0.0182)	(0.0255)	(0.259)	(0.0170)	(0.178)	(0.0198)	(0.193)
Category-Firm FE	×	×	×	×	×	×	×	×
Firm-Year FE	×	×	×	×	×	×	×	×
Observations	31,074	31,074	30,384	30,384	32,953	32,953	73,724	73,724
No. Firms	680	680	681	681	683	683	725	725
Sample Period	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014

Notes: The table reports estimates of equation (2) for alternative investment measures. *Depr* is the measure of depreciation, following an ordinal scale in odd columns and expressed in absolute depreciation rates in even columns. Standard errors (in parentheses) are clustered at the firm level.

Table A.7: Investment Composition – Sensitivity for Intangibles

	Investments					
	(1)	(2)	(3)	(4)	(5)	(6)
		Omitting R&D			*Controlling for Intangibles*	
FAS123 × Option × Depr	0.978	0.711	0.704	0.787	0.674	0.557
	(0.250)	(0.224)	(0.242)	(0.352)	(0.280)	(0.295)
Option × Depr	-0.363		-0.418	0.758		0.683
	(0.331)		(0.340)	(0.696)		(0.719)
FAS123 × Depr	-0.865	-0.417	-0.792	-0.754	-0.531	-0.606
	(0.215)	(0.204)	(0.211)	(0.311)	(0.258)	(0.255)
Category FE	×		×	×		×
Category-Year FE		×			×	
Firm-Year FE	×	×	×	×	×	×
Observations	25,726	25,645	10,230	32,947	32,875	13,097
No. Firms	674	669	657	681	677	666
Sample Period	2000 - 2014	2000 - 2014	2002 - 2007	2000 - 2014	2000 - 2014	2002 - 2007

Notes: The table reports estimates of equation (2) when omitting R&D investment or when controlling for the interaction between a dummy that indicates intangible investment categories (R&D and advertising) and the *Option* dummy and the *FAS123* dummy. Standard errors (in parentheses) are clustered at the firm level.

B Theoretical Appendix

B.1 Derivation of Managers' Optimal Behavior

We restrict attention to a symmetric equilibrium of the manager's decision problem. We denote the policy function for capital as $\mathcal{K}(\mathbf{K}) = [\mathcal{K}_l(\mathbf{K}), \mathcal{K}_s(\mathbf{K})]$. If manager t follows this strategy profile, she will set $\mathbf{K}_{t+1} = \mathcal{K}(\mathbf{K}_t)$ given a predetermined capital stock K_t. We next represent manager t's maximization problem recursively. We drop time indices and use $'$ to indicate subsequent periods. Period profits are given by

$$\begin{aligned}\pi(\mathbf{K}, \mathbf{K}') = &\max_N \left\{ Z^{1-a-b} \left(K_l^{\nu} K_s^{1-\nu} \right)^a N^b - wN \right\} \\ &- \sum_{j \in \{l,s\}} \left[\frac{\gamma}{2} \left(\frac{K_j'}{K_j} - 1 \right)^2 K_j + K_j' - (1-\delta_j) K_j \right].\end{aligned} \tag{B.1}$$

Next, the value of equity can be written as

$$E(\mathbf{K}, \mathbf{K}') = \pi(\mathbf{K}, \mathbf{K}') + \theta V(\mathbf{K}'),$$

where $V(\mathbf{K}')$ denotes a continuation value defined by

$$V(\mathbf{K}) = E(\mathbf{K}, \mathcal{K}(\mathbf{K})) = \pi(\mathbf{K}, \mathcal{K}(\mathbf{K})) + \theta V(\mathcal{K}(\mathbf{K})).$$

The value of the manager's remuneration is also a function of their decision according to

$$\Gamma(\mathbf{K}, \mathbf{K}') = \varphi \left(\pi(\mathbf{K}, \mathbf{K}') + \beta \theta V(\mathbf{K}') \right).$$

We can now express the manager's decision problem in (15) as:

$$\mathcal{K}(\mathbf{K}) = \arg\max_{\mathbf{K}'} \Gamma(\mathbf{K}, \mathbf{K}'). \tag{B.2}$$

The first-order condition is given by:

$$\frac{\partial \pi(\mathbf{K}, \mathbf{K}')}{\partial K_j'} + \beta \theta \frac{\partial V(\mathbf{K}')}{\partial K_j'} = 0. \tag{B.3}$$

The envelope condition is given by:

$$\frac{\partial V(\mathbf{K})}{\partial K_j} = \frac{\partial \pi(\mathbf{K}, \mathcal{K}(\mathbf{K}))}{\partial K_j} + \sum_{k=l,s} \frac{\partial \mathcal{K}_k(\mathbf{K})}{\partial K_j} \left[\frac{\partial \pi(\mathbf{K}, \mathcal{K}(\mathbf{K}))}{\partial K'_k} + \theta \frac{\partial V(\mathcal{K}(\mathbf{K}))}{\partial K'_k} \right].$$

We then use the first-order condition to rewrite the envelope condition

$$\frac{\partial V(\mathbf{K})}{\partial K_j} = \frac{\partial \pi(\mathbf{K}, \mathcal{K}(\mathbf{K}))}{\partial K_j} + \frac{\beta - 1}{\beta} \sum_{k=l,s} \frac{\partial \mathcal{K}_k(\mathbf{K})}{\partial K_j} \frac{\partial \pi(\mathbf{K}, \mathcal{K}(\mathbf{K}))}{\partial K'_k},$$

and combine it with the first-order condition to obtain

$$\frac{\partial \pi(\mathbf{K}, \mathbf{K}')}{\partial K'_j} + \beta\theta \frac{\partial \pi(\mathbf{K}', \mathcal{K}(\mathbf{K}'))}{\partial K'_j} + (\beta - 1)\theta \sum_{k=l,s} \frac{\partial \mathcal{K}_k(\mathbf{K}')}{\partial K'_j} \frac{\partial \pi(\mathbf{K}', \mathcal{K}(\mathbf{K}'))}{\partial K''_k} = 0, \qquad \text{(B.4)}$$

which is the characterization of the optimal capital policy in equation (16).

B.2 General Equilibrium

We compute the effects of changes in managerial pay in general equilibrium based on the same sample of firms used for our main quantitative results. Formally, the economy is populated by firms indexed by $f = 1, \ldots, \mathcal{N}_f$ that are allocated across sectors indexed by $s = 1, \ldots, S$. We denote firm f's sector by s_f and the sector s is composed of a set of firms $F_s = \{f = 1, \ldots, \mathcal{N}_f | s_f = s\}$. The economy is further populated by a representative household which will be specified below. We will abstract from transition dynamics and focus on stationary equilibrium, respectively before and after the change in managerial pay.

B.2.1 Aggregation and Goods Prices

Competitive final goods firms produce a final consumption good $\mathcal{Q}$ by combining sectoral inputs Q_s according to the Cobb-Douglas production function

$$\mathcal{Q} = \prod_{s=1}^{S} \mathcal{Q}_s^{\psi_s}.$$

The parameters ψ_s are calibrated to match the value added share of sector s relative to total value added based on Table 8 satisfying $\psi_s \in (0, 1)$ and $\sum_{s=1}^{S} \psi_s = 1$. The associated aggregate price-level is given by

$$\mathcal{P} = \prod_{s=1}^{S} \left(\frac{\mathcal{P}_s}{\psi_s} \right)^{\psi_s}, \tag{B.5}$$

where $\mathcal{P}_s$ denote sectoral price levels. The demand structure implies that each sector faces a demand curve given by

$$\mathcal{Q}_s = \frac{\psi_s \mathcal{P} \mathcal{Q}}{\mathcal{P}_s}. \tag{B.6}$$

The sectoral goods are a CES-aggregate of the firms' (variety) outputs Q_f according to

$$\mathcal{Q}_s = \left(\sum_{f \in F_s} Q_f^{\frac{\varepsilon_s - 1}{\varepsilon_s}} \right)^{\frac{\varepsilon_s}{\varepsilon_s - 1}}. \tag{B.7}$$

The parameters ε_s are calibrated as in Table 8. Firms engage in monopolistic competition. The associated sectoral price level based on firms' prices P_f is given by

$$\mathcal{P}_s = \left(\sum_{f \in F_s} P_f^{1-\varepsilon_s} \right)^{\frac{1}{1-\varepsilon_s}}. \tag{B.8}$$

Consequently each firm f in sector s faces the following demand

$$Q_f = P_f^{-\varepsilon_s} \mathcal{P}_s^{\varepsilon_s} \mathcal{Q}_s. \tag{B.9}$$

Hence, the sector-specific demand shifter is given by

$$B_s = \mathcal{P}_s^{\varepsilon_s} \mathcal{Q}_s. \tag{B.10}$$

This links firms on product markets while we also need to link firms' input usage K_{lf}, K_{sf} and N_f to factor markets.

B.2.2 Managers

Managers decide how much capital and labor to use in the production of firms' variety goods. The problem of the manager is fundamentally the same as to the decision problem described in in equations (6)–(16). The difference is that the demand shifters and wages reflect general equilibrium prices, taken as given by the individual manager.

For concreteness, we state the equations defining the manager problem in a stationary equilibrium:

$$Q_f = Z_f \left(K_{lf}^{\nu_s} K_{sf}^{1-\nu_s}\right)^{\alpha_s} N_f^{1-\alpha_s} \tag{B.11}$$

$$Q_f = B_s P_f^{-\varepsilon_s}, \qquad B_s = \mathcal{P}_s^{\varepsilon_s} \mathcal{Q}_s \tag{B.12}$$

$$R_f = X_f^{1-a_s-b_s} \left(K_{lf}^{\nu_s} K_{sf}^{1-\nu_s}\right)^{a_s} N_f^{b_s}, \qquad X_f^{1-a_s-b_s} = B_s^{1/\varepsilon_s} Z_f^{1-1/\varepsilon_s} \tag{B.13}$$

$$C_f^K = \sum_{j \in l,s} \left[\left(K'_{jf} - (1-\delta_{js}) K_{jf}\right) + \gamma \left(\frac{K'_{jf}}{K_{jf}} - 1 \right)^2 K_{jf} \right] \tag{B.14}$$

$$\Pi_f = R_f - w_s N_f - C_f^K, \qquad w_s = \bar{w}_s w \tag{B.15}$$

$$N_f = \left(\frac{b_s X_f^{1-a_s-b_s} \left(K_{lf}^{\nu_s} K_{sf}^{1-\nu_s}\right)^{a_s}}{w_s} \right)^{\frac{1}{1-b_s}} \tag{B.16}$$

$$0 = \frac{\partial \Pi_f}{\partial K'_{jf}} + \beta_f \theta_f \frac{\partial \Pi'_f}{\partial K'_{jf}} + (\beta - 1)\theta \sum_{k=l,s} \frac{\partial K''_{kf}}{\partial K'_{jf}} \frac{\partial \Pi'_f}{\partial K''_{kf}} \tag{B.17}$$

Note that we treat $\bar{w}_s$ as a parameter, which may reflect different (static) hiring costs across sectors, whereas w determines the equilibrium price of labor. This setup conveniently allows our general equilibrium model to nest the partial equilibrium model.

B.2.3 Households

There is a continuum of households which inelastically supply homogeneous labor aggregating to $\bar{N}$. We further assume time-separable, homothetic preferences with respect to consumption of a final good, as well as complete markets. Households are assumed to hold equity only indirectly via a competitive mutual fund. In each period, individual households are randomly chosen as managers of a random firm f, for which they receive the corresponding compensation Γ_f. We assume that managers neglect the effects that their individual decisions have on the mutual fund and – as before – we assume they do not anticipate to manage the firm in the future.

B.2.4 Factor Markets

Since capital is owned by the firm, we need an assumption how investment is produced. For simplicity, we assume investment is produced using only labor as an input. We further assume that the adjustment of capital goods also requires only labor input. Labor demand of firm f is then given by

$$\bar{N}_f = N_f + \sum_{j \in \{l,s\}} \left(K'_{jf} - (1-\delta_{js})K_{jf}\right) + \gamma \left(\frac{K'_{jf}}{K_{jf}} - 1\right)^2 K_{jf}. \tag{B.18}$$

B.2.5 Equilibrium

We let the final consumption good $\mathcal{Q}$ be the numéraire, allowing us to normalize $\mathcal{P} = 1$. The remaining equilibrium price is w, which is the real wage. Given the aggregation structure, managerial behavior, and household behavior, a general equilibrium is characterized by a real wage that clears the labor market

$$\bar{N} = \sum_{f=1}^{\mathcal{N}_f} \bar{N}_f. \tag{B.19}$$

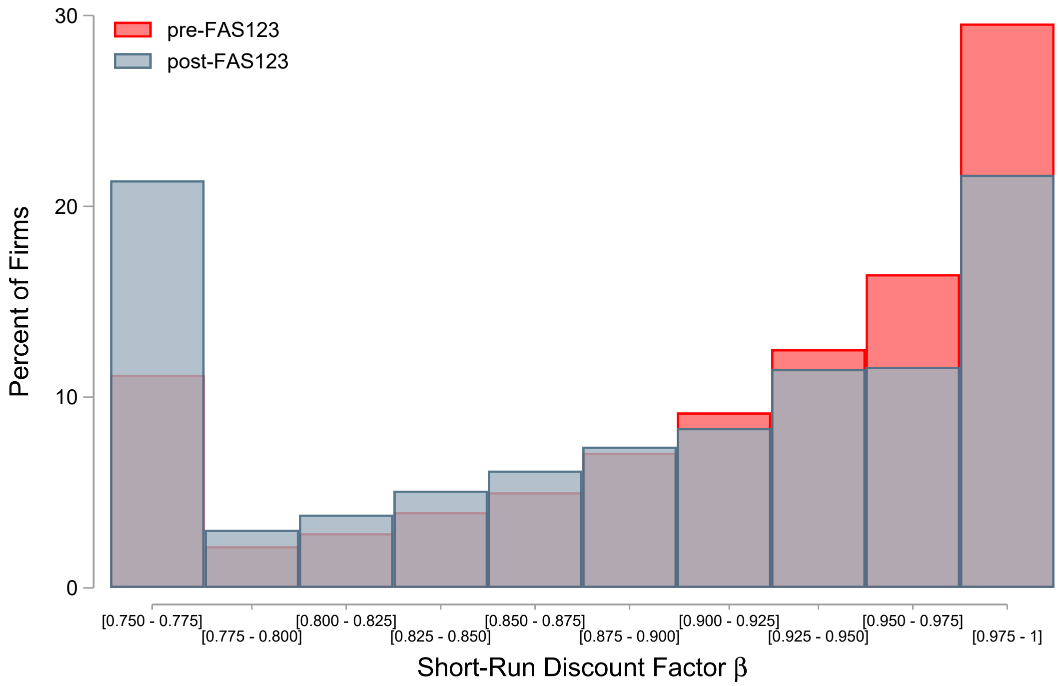
The market for the final consumption good is then cleared by Walras's law.

C Parameterization and Solution Method

C.1 Managerial Pay

As we have derived in Section 3, β is determined solely by the bonus share η^b and the equity share η^e (see Equation (14)). Both shares can be estimated directly from the data relying on data sources which have been widely used in the literature. To estimate η^b, we obtain the amount of cash bonuses from ExecuComp. To address a change in the reporting requirements for executive compensation after December 2006, we add the amount of non-equity incentive compensation to the bonus, which is available in the *Plan-Based Awards (PBA)* file in ExecuComp. This reclassification of bonuses is stressed by Hayes et al. (2012) and we follow their approach. We then divide the total amount of cash bonus payments by the sales of the firm (obtained from Compustat), i.e. $\eta^b = \frac{\text{Bonus+Non-eq-Targ}}{\text{Sales}}$. To estimate η^e, we rely on data on the manager's firm-related wealth provided by Coles et al. (2006) and Core and Guay (2002), which we divide by the total market capitalization of the respective firm (obtained from Compustat), i.e. $\eta^e = \frac{\text{Firm-related Wealth}}{\text{Market Capitalization}}$. To account for outliers, we winsorize η_b and η_e, respectively at the top and bottom 1%. Figure C.1 shows the shift in the distribution of β (across bins) between 2005 and 2007.

Figure C.1: Changes in the Short-Run Discount Factor Around FAS 123R



Notes: The figure depicts the empirical distribution of the parameter β before (red) and after (blue) the introduction of FAS 123R. We group βs into ten bins each ranging 2.25 percentage points. Data is left-censored at 0.75, which applies to 14.39% of the observations.

C.2 Other Parameters

We calibrate the sector-specific parameters δ_l, δ_s, ν, α, w, ε, and B using sector-specific moments from the U.S. files of the EU KLEMS database, averaged over the years 2003–2005 at constant prices. The moments we use are for δ_s, δ_l, R, $\frac{K_l}{K_l+K_s}$, $\frac{K_l}{R}$, $\frac{wN}{R}$, and w (approximating R by the average value added of a firm in the sector). For the calibration of the sector-specific parameters, we abstract from incentive distortions and thus consider a long-run discount factor $\theta = \frac{1}{1+r}$.[28] For r, we use the real interest rate for the United States from the year 2005, which was 2.98% according to World Bank (2020).

We combine the two FOCs of individual capital goods to get an expression that maps the moments into ν:

$$\nu = \frac{1-\theta(1-\delta_l)}{1-\theta\left[1-\delta_s-\frac{K_l}{K_l+K_s}(\delta_l-\delta_s)\right]}\frac{K_l}{K_l+K_s}.$$

[28]Hence, we neglect managerial share dilution when calibrating sector-level variables. We account for share dilution, however, when computing the investment decision of the manager.

The steady-state share of long-term capital goods in the total capital stock is larger than ν, since the term $\frac{1-\theta(1-\delta_l)}{1-\theta\left[1-\delta_s-\frac{K_l}{K_l+K_s}(\delta_l-\delta_s)\right]}$ is strictly smaller than 1. This is due to the fact that user cost of capital are higher for short-term capital such that the share of long-term capital exceeds the Cobb-Douglas production exponent ν. Given ν, we can solve the first-order condition of the long-term capital good for a as

$$a = \frac{\frac{1}{\theta} - (1-\delta_l)}{\nu} \frac{K_l}{R}.$$

Likewise, b directly follows from optimal labor demand as

$$b = \frac{wN}{R}.$$

With a and b, we obtain ε and α as

$$\varepsilon = \frac{1}{1-a-b}, \quad \alpha = \frac{a}{a+b}.$$

Finally we can determine the demand-scaling parameter B, using labor demand as well as the production function, which yields

$$B = \left(\frac{w^{\frac{b}{1-b}} R}{b^{\frac{b}{1-b}} \left(K_l^{\nu} K_s^{1-\nu}\right)^{\frac{a}{1-b}}} \right)^{\frac{1-b}{1-a-b}}.$$

C.3 Numerical Solution Method

We next describe the solution method. Using the definition of the profit function in (B.1), we first rewrite the first-order condition in (B.3) as

$$\gamma \left(\frac{K_j'}{K_j} - 1 \right) + 1 = \beta\theta \frac{\partial V}{\partial K_j'}(\mathbf{K}', \xi),$$

and solve the equation for K_j:

$$K_j = \frac{\gamma K_j'}{\gamma + \beta\theta \frac{\partial V}{\partial K_j'}(\mathbf{K}', \xi) - 1}. \tag{C.1}$$

Equation (C.1) is central for our application of the endogenous grid method. Our solution method is described by Algorithm 1 below.

Algorithm 1: EGM used to solve the model (for a given firm)

Set i_{max} as well as convergence thresholds $\bar{\epsilon}^{v}, \bar{\epsilon}^{invp} > 0$ for the continuation value and inverse policy, respectively. Set gridpoints $\tilde{\mathcal{K}}' = (\tilde{\mathbf{k}}'_g)_{g=1,\ldots,G}$, an initial guess for $\hat{V}_{0,g}$ for $g = 1, \ldots, G$, and an interpolation scheme $\rho(x, X, Y)$. Compute the interpolated values $v_0(\mathbf{K}) = \rho(\mathbf{K}, (\mathbf{k}'_g)_{g=1,\ldots,G}, (\hat{V}_{0,g})_{g=1,\ldots,G})$.

Set *continue*=true and $i = 1$. **while** *continue* **do**

- **for** g=1,...,G **do**
  - Set $\hat{\mathbf{k}}_{j,i,g} = \frac{\gamma k'_{jg}}{\gamma + \beta\theta \frac{\partial}{\partial \mathbf{K}'_j} v_{i-1}(\mathbf{k}'_g) - 1}$ for $j = l, s$.
  - Set $\tilde{v}_g = \Pi(\mathbf{k}_{i,g}, \mathbf{k}_g) + \theta \hat{V}_{i-1,g}$.
- Compute interpolant $v_i(\mathbf{K}) = \rho(\mathbf{K}, (\mathbf{k}_{i,g})_{g=1,\ldots,G}, (\tilde{v}_g)_{g=1,\ldots,G})$.
- **for** g=1,...,G **do**
  - Set $\hat{V}_{i,g} = v_i(\mathbf{K}_g)$.
  - Set $\epsilon^{v}_{ig} = \left| \frac{\hat{V}_{i,g}}{\hat{V}_{i-1,g}} - 1 \right|$.
  - Set $\epsilon^{invp}_{jig} = \left| \frac{k_{j,i,g}}{k_{j,i-1,g}} - 1 \right|$.
- **if** $\max_{g\in(1,\ldots,G)}\{\epsilon^{v}_{ig}\} < \bar{\epsilon}^{v}$ *and* $\max_{j\in(l,s),g\in(1,\ldots,G)}\{\epsilon^{invp}_{ig}\} < \bar{\epsilon}^{invp}$ **then**
  - Set *continue*=false.
- **else**
  - Set i=i+1;

Obtain policy function as $\mathcal{K}(\mathbf{K}, \xi) \approx \tilde{\mathcal{K}}(\mathbf{K}, \xi) := \rho(\mathbf{K}, (k_{i,g})_{g\in\{1,\ldots,G\}}, (\mathbf{k}_g)_{g\in\{1,\ldots,G\}})$.

Essentially, we start with a set of G gridpoints $\tilde{\mathcal{K}}' = (\tilde{\mathbf{K}}'_h)_{h=1,\ldots,G}$, which represent different outcomes of $\mathbf{K}'$, and an initial (differentiable) guess $\hat{V}_0(\cdot)$ for $V(\cdot)$. By differentiating $V(\cdot)$, we get the gradient at each point in $\tilde{\mathcal{K}}'$. Then applying the backward induction step in (C.1), we can solve for the optimal solution of the previous manager. Next, we update our guess for the continuation value function $V(\cdot)$ according to the profit function and our current guess. We then iterate on this until convergence is achieved. This algorithm is implemented as MATLAB code (tested against MATLAB R2018b and R2020a) and can be found in the replication package.

The simulated sample of firms is based on idiosyncratic parameter draws in the (K'_l, K'_s)-space. The coordinates of the gridpoints correspond to Chebyshev nodes in a range around the steady state with $\beta = 1$. To be precise, the grid ranges from factor 0.3 to 1.2 of the analytical steady state of that parameterization. As an interpolation scheme $\rho(\cdot)$ we apply Chebyshev polynomials up to degree 10 in both dimensions.[29] Since the endogenous grid method inherently involves interpolation with a changing set of interpolation bases, the domain of the chosen functions was expanded as needed to keep all points within the domain.

To specify an initial guess for the value function, we apply the following procedure. First, we analytically derive the steady state assuming $\beta = 1$. As an initial guess of the value function, we assume the model converges uniformly to that steady state within a certain number of periods. Using the resulting net present value of profits gives a reasonably accurate initial guess for the case of $\beta = 1$. However, for lower $\beta < 1$, this does not necessarily lead to convergence. For this reason, we first solved the model for the $\beta = 1$ case. Then, we use the final value function computed and use this as an initial guess to solve the model with a slightly lower value of β. Repeating this process while slowly decreasing β yields satisfactory convergence. The entire process is then repeated for all firms in the sample.

[29] We have chosen Chebyshev polynomials because they have preferable interpolation properties compared to other polynomials functions. Also, Splines were considered, but computing the gradient of a spline is computationally expensive. Experiments with cubic splines showed inferior convergence properties. We also experimented with Chebyshev polynomials with a total degree of 30. However, most coefficients with a higher degree are virtually identical to zero. In fact, higher order polynomials present a problem for the algorithm since for these higher order polynomials, the gradient quickly becomes very large in absolute terms, even if the corresponding coefficient is small; this generates additional sources of numeric error, which leads to far worse convergence properties. Given that this method ultimately generates an inverse of the policy function, we eventually have to back the real policy functions out. This final step is done using cubic splines.

C.4 Additional Quantitative Results

Table C.1: Simulated Firms - Regression Results without Introducing Noise

	Investments				
	(1)	(2)	(3)	(4)	(5)
Measure of Depreciation:	*Depreciation Rate*				
FAS123 × β Reduced × Depr	3.106	3.106	5.799	5.799	8.494
	(0.212)	(0.212)	(0.341)	(0.341)	(0.482)
FAS123 × Depr	-0.000817	-0.000817	-0.000948	-0.000948	-0.000817
	(0.000817)	(0.000817)	(0.000948)	(0.000947)	(0.000817)
β Reduced × Depr	3.308		5.156		5.463
	(0.271)		(0.328)		(0.352)
Category FE	×		×		×
Category-Firm FE		×		×	
Firm-Year FE	×	×	×	×	×
Trend					×
Years around reform	15	15	6	6	15

Notes: This Table reports the results on the relationship between managerial incentives and investment decisions based on the panel of simulated firms. β *Reduced* is defined as dummy variable which indicates if a firm experiences a reduction in its firm-specific β. *FAS123* is a dummy variable indicating the post-shock period. Empirical specifications in columns 1 to 5 resemble those in Table 4. The treatment-specific linear trend in column 5 is Trend × β *Reduced* × Depr. Standard errors (reported in parentheses) are clustered at the firm level.

Table C.2: Beta and the Durability of Investments/Capital Stock Depreciation

	Investments				Weighted Avg. Depr. Rate
	(1)	(2)	(3)	(4)	(5)
Model	OLS		IV		OLS
			1st Stage	*2nd Stage*	
$(1-\beta)\times$ Depr	0.281	0.091			
	(0.081)	(0.036)			
FAS123 $\times$ Option $\times$ Depr			0.046		
			(0.004)		
$\widehat{(1-\beta)\times}$ Depr				0.862	
				(0.212)	
$(1-\beta)$					0.015
					(0.006)
Category FE	$\times$				
Category-Year FE		$\times$	$\times$	$\times$	
Firm-Year FE	$\times$	$\times$	$\times$	$\times$	
Firm FE					$\times$
Year FE					$\times$
Observations	28,695	28,611	28,611	28,611	8,614
No. Firms	655	649	649	649	672
Sample Period	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014
Kleibergen-Paap F-Statistic			113.20		

Notes: The Table reports the results on the relationship between the model-specific incentive measure β and the durability of investments, respectively the depreciation of firms' capital stock. The calculation of β follows Equation (14), details on the computation can be found in Appendix C.1. *Depr* is the measure of depreciation, following an ordinal scale. *Option* is a dummy that indicates if any unexercised options are outstanding in 2004. *FAS123* takes value 0 for each year until 2005 and value 1 afterwards. In columns 1 and 2, we investigate the relationship between the firm-specific β and the durability of investments. In column 4, we address endogeneity concerns related to β by instrumenting $(1-\beta)\times$ *Depr* with *FAS123* $\times$ *Option-Dummy* $\times$ *Depr*. First-stage results are given in column 3. Column 5 estimates the effect of β on the capital stock depreciation by taking a firm-specific capital-stock-weighted depreciation rate as dependent variable. Standard errors (reported in parentheses) are clustered at the firm level.