Capital (Mis)allocation, Incentives and Productivity

Jan Schymik* Matthias Meier‡

Alexander Schramm¶ Alexander Schwemmer§

February 2023

Abstract

This paper argues that managerial incentives can cause within-firm capital misallocation. We document empirically that managers reallocate capital towards less durable investment projects when their financial incentives become more short-term oriented. To quantify this channel of within-firm misallocation for the US economy, we build a model of firm investments under agency frictions, in which capital misallocation within firms arises from short-termist incentives. Shifts from equity ownership to bonus payments increase managers' focus on current cash flows, leading to underinvestment in low-depreciation assets. This increases wedges in the rates of return across assets within firms, lowering average productivity.

Keywords: Investment, Capital misallocation, Firm dynamics, Short-term incentives

JEL: E22, G31, D24, D25, L23

We are grateful to Christoph Boehm, Lukas Buchheim, Jan Eeckhout, Andreas Engert, Carola Frydman, Simon Gilchrist, Michael Reiter, Dominik Sachs, Raffaella Sadun, Stephen Terry, Elu von Thadden, Thomas Winberry, seminar or conference audiences at Mannheim, LMU Munich, ifo Institute, EEA-ESEM 2021, Society of Economic Dynamics Annual Meeting 2021, VfS Committee for Organizational Economics, VfS Annual Meeting Cologne 2020, CRC TR 224, GEABA Vallendar 2019 and SIOE Virtual Conference 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.

* University of Mannheim, jan.schymik@uni-mannheim.de; ‡ University of Mannheim, m.meier@uni-mannheim.de; ¶ LMU Munich, alexander.schramm@econ.lmu.de; § LMU Munich, alexander.schwemmer@econ.lmu.de.

1 Introduction

The performance pay of managers includes a mix of cash bonuses linked to annual profits and equity-based compensation. While cash bonuses incentivize short-term profit maximization, equity-based compensation better aligns the manager's incentives with maximizing the value of the firm. A key managerial decision is which investment projects to invest in. A manager with short-term incentives may allocate relatively more funds to investment projects with fast but relatively short-lived returns (e.g., computer equipment or advertising) rather than long-lived projects (e.g., production facilities). In this paper, we quantify the impact of the managerial pay structure on investment and its implications for firms and the economy.

Our paper makes two contributions to the literature. First, we provide novel empirical evidence on the effects of the managerial pay structure. Firms exposed to an accounting reform that changed managerial pay toward cash bonuses (i) invested relatively more in investment projects with high depreciation rates, (ii) their weighted average depreciation rate increased, (iii) their self-reported discount rates increased, and (iv) their productivity decreased. Second, we develop a quantitative model to rationalize the evidence and study its implications. Through the lense of the model, a short-termist change in the managerial pay structure distorts the allocation of capital toward more short-lived investment projects which raises capital misallocation within the firm and thereby lowers firm productivity. In the long run, gross investment rates are higher as the new allocation of capital contains more high-depreciation capital.

Our empirical analysis levers a quasi-natural experiment which provides a shift in managerial pay that is unrelated to economic fundamentals and incentive contracting problems within firms. The 2005 FAS-123 reform of accounting rules in the US raised the costs of equity-based compensation.[1] Firms responded to the reform by providing less performance pay via equity-based compensation and more via cash bonuses (Hayes et al. 2012). To assess whether the change in pay structure changed firm investment, we use balance sheet data for listed US firms from Compustat and combine it with FactSet data. The latter data allow us to distinguish seven investment categories which

[1]Prior to the reform, equity options had an accounting advantage as firms were allowed to expense equity-linked compensation at its intrinsic value (Hayes et al. 2012). The reform abolished this accounting advantage which raised the costs of equity options which constitute a large fraction of equity-based compensation (Frydman and Jenter 2010).

differ in their depreciation rates.[2]

Our main empirical finding is that managers exposed to the reform invest less in projects with low depreciation rates and relatively more in high-depreciation projects. The estimated effect is statistically significant, robust in various dimensions, and quantitatively meaningful. Managers exposed to the reform invest between 5 and 10% more in investment goods with a 10 percentage point higher depreciation rate compared to non-exposed managers. This shift towards short-term investment projects is reflected in a 1 percentage-point increase of firm-specific weighted average depreciation rates. Consistent with more short-term incentives, managers exposed to the reform announce a significant and 0.4 percentage point higher discount rate in earning calls (using data from Gormsen and Huber, 2022). Importantly, exposed firms face a significant decline in productivity, consistent with the shift across investment types raising capital misallocation within the firm.

To rationalize the empirical findings and to study the implications of managerial pay for firms and the economy, we develop and calibrate a model which extends the standard dynamic model of firm investment in two dimensions. First, we introduce a manager who faces monetary incentives from a compensation package that includes a cash bonus on current profits and equity compensation, similar to Nikolov and Whited (2014). Second, we introduce two types of capital that differ in their depreciation rates, similar to Aghion et al. (2010) and Rampini (2019). Managers hire labor and invest in low-depreciation and high-depreciation capital to produce output. In the model, the larger is the equity share of firm value that accrues to the manager, the better her incentives align with value maximization.

We show that if the compensation package includes a cash bonus, the rational manager's problem mirrors an optimization problem under quasi-hyperbolic preferences. This implies time inconsistency and leads to investment short-termism which favors the high-depreciation capital good. From a computational point of view, our model shares many similarities with models of quasi-hyperbolic discounting, including the numerical challenges in solving them with Euler-equation-based methods (Krusell and Smith 2003, Maliar and Maliar 2005, 2016). As suggested by Maliar and Maliar (2016), we solve the model via the method of endogenous gridpoints (Carroll 2006).

[2]Notably, we consider firm investment in land, buildings, machinery, transport equipment, R&D, computer equipment, and advertising. The associated depreciation rates are in descending order (Garicano and Steinwender 2016; Fromenteau et al. 2019).

We calibrate the model to match specific firm- and sector-level moments for the US economy in a simulated sample of firms prior to the reform. We then simulate the effects of an unexpected, persistent exogenous change in the managerial pay structure that resembles the FAS 123R reform. Around the reform, managers experienced reductions in equity compensation and increases in bonus payments. This observed change in the managerial pay structure raises our model-based measure of time inconsistency by 3% on average. We compute the effects of the reform on various firm-level variables. Our quantification shows that firms respond to such a change in the managerial pay structure with a short-run drop in total investments. Importantly, this decline in investment is asymmetric across types of capital goods: investment in low-depreciation capital declines more, so that the intra-firm allocation of capital shifts to high-depreciation capital goods. This leads to within-firm misallocation of capital, as measured by the difference between the rates of return on long- and short term investment projects, which increases by 3.7 basis points on average. Initially, productivity rises because firms can save on capital expenditures when they run down their capital stocks. In the long run, productivity declines as the capital mix shifts away from the social optimum towards high-depreciation capital. We show in a general-equilibrium extension that this shift causes a decline in real wages by 0.2%.

Policy-makers, business executives and investors have often warned about the dangers of boosting short-term profits at the cost of long-term value (see e.g. Dimon and Buffet 2018 or Barton 2011). This paper links the literature on macroeconomic impacts of capital misallocation and the corporate finance literature on managerial incentives and therefore relates to other papers studying short-term behavior and its consequences for the aggregate economy. We contribute to that literature by identifying a specific microeconomic channel – short-termist managerial incentive distortions – causing misallocation of capital inside firms leading to aggregate output losses. Our paper is most closely related to Terry (2022), who also studies the macroeconomic implications of managerial short-termism. In his paper, short-termism is caused by firms' incentives for managers to ignore positive R&D externalities in an endogenous-growth model. We focus instead on distortions caused by inefficient intra-firm allocation of capital between high- and low-depreciation investment projects due to the financial incentives faced by managers. In addition, we use the FAS 123R reform to provide empirical evidence for our economic mechanism.

On the theoretical side, our model borrows from Bénabou and Tirole (2016) and Garicano and Rayo (2016) by formulating managerial short-termism as an intertemporal version of a multitasking problem in which agents must choose between projects that maximize short-term goals versus projects that maximize long-term goals. In contrast to these papers, we introduce this idea into a dynamic model of firm investment. Similar to our model, Aghion et al. (2010) study an investment model with two types of capital to analyze the role of credit constraints on the composition of investment.

Empirically, Edmans et al. (2017a,b) and Ladika and Sautner (2019) find that short-term incentives proxied by vesting equity are associated with a decline in total capital expenditures. Our estimated effects of incentive distortions relate to Ladika and Sautner (2019) or Glover and Levine (2015) who also study the FAS 123R reform. Asker et al. (2014) show that private firms, whose management is presumably less prone to short-termism, have substantially higher capital expenditures and are more responsive to investment opportunities. While these studies consider aggregate capital expenditures, our focus is on capital (mis)allocation caused by incentive distortions. Since our estimates are based on within-firm variation across investment categories, we are also able to effectively account for idiosyncratic demand or technology shocks which are absorbed by firm-year fixed effects. These adjustments via within-firm capital (mis)allocation across capital goods also contribute to the literature that discusses and quantifies causes of factor misallocation (see, 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).

The remainder of the paper is structured as follows. In the following Section, we present empirical evidence on the relation between managerial ownership and investment. Section 3 presents our model and quantification. Finally, Section 4 concludes.

2 Empirical Evidence

This section provides empirical evidence how shifts in short-termist managerial incentives distort investment decisions and affect the allocation of capital within firms. We first document that reductions in the fraction of equity that managers own in the firm are associated with shifts to lower long-term investment shares. Since managerial incentives are chosen endogenously, we then provide similar evidence using the revision of FAS 123 in the US as a quasi-natural experiment.

2.1 Data

Measuring the Durability of Firm Investments: Our sample combines annual data on firm investments with executive remuneration data. We focus on the sample of publicly traded US firms from 2002 to 2007 and consider seven broad investment categories which differ along their durability. Following the approach suggested by Garicano and Steinwender (2016) and Fromenteau et al. (2019) we consider investments in the following seven categories: land, buildings, machinery, transport equipment, R&D, computer equipment and advertising and assign category-specific depreciation rates listed in Table 1. We directly obtain annual expenses on R&D and advertising from Compustat North America. Data on the remaining categories of Property, Plant & Equipment are provided by Factset. We use a perpetual inventory method to transform stock variables into annual gross investment. Negative investments and missing values are excluded from the analysis.[3] We keep only active firms in the sample and exclude utilities, financial and public sector firms in our baseline estimations as it is standard in the literature (see e.g. Clementi and Palazzo 2019, Ottonello and Winberry 2018).

Table 1: Assigned Depreciation Rates

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

Notes: Assigned category-specific depreciation rates following Garicano and Steinwender (2016) and Fromenteau et al. (2019).

Measuring Managerial Incentives and Equity Ownership: ExecuComp serves as our primary data source for executive compensation. Since CEOs arguably have the largest impact on the investment decisions of firms, we concentrate on the remuneration of CEOs. To measure a CEO's equity ownership share (η^e), we rely on data on the manager's firm-related wealth provided by

[3] We show that our results are also valid if we treat negative investment as true negatives or if we set them to zero.

Table 2: Selected Summary Statistics

Variable	Mean	Std. Dev.	Min	p25	p50	p75	Max	Obs	Sample
Firm-Investment Data									
Land	35.94	211.54	0.00	0.11	2.00	10.01	3,929.20	2,080	2002 - 2007
Buildings	120.23	531.43	0.00	3.86	15.82	60.60	10,978.46	2,965	2002 - 2007
Machines	468.29	2284.84	0.03	20.51	81.29	297.76	78,706.20	2,941	2002 - 2007
Transport	163.35	687.75	0.00	0.50	2.34	21.13	7,587.88	389	2002 - 2007
Research	288.42	966.98	0.00	3.20	29.91	132.70	12,183.00	2,694	2002 - 2007
Computer	102.00	388.51	0.19	10.21	21.72	77.30	7,800.70	597	2002 - 2007
Advertising	265.35	659.28	0.00	8.50	42.56	178.20	7,937.00	1,827	2002 - 2007
Compensation Data									
Equity Share	0.028	0.05	0.000	0.005	0.011	0.026	0.23	3,684	2002 - 2007
Option Dummy	0.797	0.40	0	1	1	1	1	725	2004

Notes: Investment expenditures are denoted in millions USD. Equity ownership shares are the CEO's firm-related wealth divided by the total market capitalization of the firm. Option Dummy takes 1 if any unexercised options are outstanding, zero otherwise.

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. we define the managerial ownership share in firm i during year t as

$$\eta^e_{it} = \frac{\text{Firm-related Wealth}_{it}}{\text{Market Capitalization}_{it}}.$$

To construct a proxy for treatment eligibility in our quasi-natural experiment, we consider the current CEO in the year before the reform of FAS 123 in 2004 and construct a dummy indicating if the executive has unexercised stock options outstanding (*option dummy*). We then merge the CEO data with the investments panel. To motivate our empirical strategy, we additionally make use of another data source of executive compensation, which is BoardEx. BoardEx offers a more detailed listing on the individual components and time-structure of manager remuneration than ExecuComp, which comes at the costs of having less matches with our investment sample.

Table 2 lists selected summary statistics. Our comprised sample entails about 700 firms. Most of firms' resources are on average spent on machinery, R&D and advertising, whereas a smaller proportion goes into land and IT investment. Overall, each investment category seems to play a substantial non-negligible role for the investment policy of a firm. The last two rows of Table 2 summarize the firms' compensation policies in 2004. On average, 80% of CEOs have unexercised outstanding stock options. Thus, awarding stock options is a widely and strongly used method in

CEO compensation.

2.2 A First Look: Managerial Ownership and Investment

We begin with a first look at the association between investment and managerial equity ownership. We estimate the following empirical specification, where the outcome $\textit{invest}_{ict}$ denotes a measure of investments by firm i in investment category c at time t:

$$\textit{invest}_{ict} = \beta_1 \quad \eta^e_{it} + \beta_2 \quad \eta^e_{it} \quad \delta_c + \lambda_{ci} + \lambda_{t/i} + \varepsilon_{ict}. \tag{1}$$

Our sample includes firms' expenditures on seven investment categories c: advertising, computer equipment, R&D, transportation equipment, machinery equipment, buildings and land. We transform investment expenditures using the inverse hyperbolic sine function in our baseline estimations.[4] This has the advantage that we include zero investments in our estimations while we get $\text{arsinh}\,(I_{ict}) \;\; ! \;\; \ln 2 + \ln I_{ict}$ for large investment expenditures such that the interpretation is almost identical to a log regression.[5] The term δ_c reflects the depreciation for each investment category c. Following the approach used by Garicano and Steinwender (2016) and Fromenteau et al. (2019), we either ordinally rank asset categories according to their time to payoff or we directly use the category-specific depreciation rate to distinguish between more long- and more short-term investments. All regressions include fixed effects for category-firm combinations to account for firm-specific differences in production functions and a full set of year or firm-year fixed effects. Table 3 presents our results. Columns 1 to 3 use the ordinal ranking of asset categories as a measure of how short-term each investment category is and column 4 directly uses depreciation rates. Our parameter of interest is β_2 on the interaction between managerial equity ownership and the depreciation of investments δ_c. It captures distortions in the relative composition of firm investments created by shifts in equity ownership. The coefficient of interest β_2 turns out negative throughout all specifications which suggests that reductions in managerial ownership are associated with relatively more investment in short-term asset categories.

[4] $invest_{ict} = \text{arsinh}\,(I_{ict}) = \ln\left(I_{ict} + \sqrt{I_{ict}^2 + 1}\right)$.

[5] In Table A.6, we demonstrate that our empirical findings do not hinge on the inverse hyperbolic sine transformation but are robust to using investment rates, log(investments) or log(1 + investments).

Alternatively, we can directly interact our measure of managerial ownership with dummies for each investment category. We plot the coefficient estimates for each asset category in Figure A.1 in Appendix A.3. Consistent with the results from Table 3, the null hypothesis of equal investment elasticities across categories can be rejected at the 5%-level and it is noticeable that investments into more durable projects, such as land or buildings, tend to be associated more elastically with managerial equity ownership than investments in less durable projects, such as computer equipment or advertising.

Table 3: Equity Ownership and the Durability of Investments

	Investments			
	(1)	(2)	(3)	(4)
Measure of Depreciation:		*Ordering*		*Dep. Rate*
Equity Share	-0.651*	0.635		-0.200
	(0.368)	(0.614)		(0.428)
Equity Share Depr		-0.355***	-0.254*	-2.500*
		(0.123)	(0.132)	(1.280)
Investment-Firm FE				
Year FE				
Firm-Year FE				
Observations	29,330	29,330	28,611	29,330
No. Firms	672	672	649	672
Sample Period	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014

Notes: The Table reports the results on the relationship between managerial equity ownership and investment decisions. *Equity Ownership* is the CEO's ownership share. *Depr* is the measure of depreciation, following an ordinal scale in columns 2 and 3, and expressed in absolute depreciation rates in column 4. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

2.3 Evidence from a Reform of Executive Compensation

In a next step, we exploit the revision of accounting statement FAS 123 as a quasi-natural experiment to study the relationship between managerial incentives and investment policies.

2.3.1 Institutional Background: Changes in Accounting Rules for Equity Payments

We exploit an unexpected and unprecedented change in accounting practices for US firms caused by the revision of FASB Statement No. 123 (FAS 123R). In December 2004, the Financial Accounting Standard Board (FASB) revised this practice that establishes standards to account for transactions in which an entity exchanges its equity instruments for goods or services. The revision then became effective for companies with their first full reporting period beginning after June 15, 2005.

The principal motivation for revising this accounting rule was to remove an accounting advantage that affected the issuance of equity-based employee compensation leading to potential misrepresentation of economic transactions. Before the reform, companies were allowed to expense equity-based compensation to employees at its intrinsic value, i.e. the difference between the stock price on the granting date and the strike price. This had the consequence that equity-linked compensation could often be granted without causing according accounting expenses. For example, options with a strike price equal to current stock prices had no intrinsic value and therefore did not show up as an expense. After introduction of the reform, firms were obliged to expense option compensation at fair value which effectively abolished this accounting advantage of equity-based compensation. Other stated reasons for this revision were to simplify US Generally Accepted Accounting Principles (GAAP) and to make them more comparable with international accounting rules by moving towards fair-value accounting.

The change in accounting treatment provided a more accurate representation of a company's financial performance by accounting for the cost of employee incentive compensation. However, this reform also shifted the incentives of CEOs and other executives towards a more short-term horizon.

First, firms that previously offered equity-based compensation faced pressure to substitute towards other forms of incentive compensation such as paying cash bonuses on profits. As profits are inherently more short-term than equity value, incentivizing managers with cash bonuses is inherently more short-term. While firms also had the opportunity to substitute compensation towards restricted stocks and the average value of restricted stocks increased after the reform (see also Hayes et al. 2012), this increase was not more pronounced within firms that compensated their CEOs with options before the change in accounting rules.

Second, as part of the reform, the FASB also allowed firms to accelerate unvested options to fully vest prior to the original compliance date in order to swiftly move towards a fair-value accounting for equity compensation. This policy change particularly incentivized firms to accelerate the vesting of slightly in- as well as out-of-money options, which gave rise to an additional source of short-term managerial incentives caused by the reform (see Ladika and Sautner 2019 and Edmans et al. 2017b).

In a difference-in-differences setting, we show that firms that previously offered equity-based compensation, substituted away from equity and equity-linked compensation, did not significantly increase the grants of restricted stocks, and reduced the duration of executive pay compared to other firms (see Appendix A.3).

2.3.2 Identification of Within-Firm Distortions in Capital Allocation

To identify the effects of managerial incentives on investment decisions, we compare the investment behavior of firms that were most affected by the reform to the investment behavior of less affected firms during the time span around the revision of FAS 123 in 2005. We consider all firms whose CEOs had outstanding options in the pre-reform year 2004 as the set of treated firms. We consider these firms as affected for two reasons. First, the costs of equity-linked compensation effectively increased for firms that compensated managers with options before FAS 123R while firms that did not choose to offer options before 2005 did not necessarily face any additional costs. Second, firms that compensated managers with options before FAS 123R were allowed to let these options vest earlier, effectively reducing the duration of executive compensation while non-option-paying firms remained unaffected.

We estimate the following within-firm triple-differences specification:

$$\textit{invest}_{ict} = \beta_1 \quad \textit{Shock}_t \quad X_{i,2004} \quad \delta_c + \beta_2 \quad X_{i,2004} \quad \delta_c + \lambda_{it} + \lambda_{c/i} + \varepsilon_{ict}. \tag{2}$$

The parameter of interest is β_1 which identifies a distortion in the relative composition of firm investments created by a shift in incentives due to the payment reform. This parameter is the coefficient of the triple interaction $\textit{Shock}_t \quad X_{i,2004} \quad \delta_c$, where $\textit{Shock}_t$ is a time-specific dummy variable that equals one for years succeeding the reform (i.e. for $t > 2005$) and zero otherwise. Furthermore,

$X_{i,2004}$ is our firm-specific treatment indicator, which measures whether firms granted options to its CEO before the reform.

Importantly, if the revision of FAS 123 induces treated firms to adjust their investment composition towards short-term assets, the coefficient of interest β_1 is expected to be positive. By exploiting the change in incentives triggered by this reform as a quasi-natural experiment, we aim to capture a causal and economically meaningful effect of incentives on within-firm capital (mis)allocation.

The vector λ_{it} contains fixed effects at the firm-year level. These firm-year fixed effects absorb unobserved time-varying firm-specific factors that can affect investment decisions. Notably, these include demand shocks or technology shocks as long as they do not affect short- and long-term investments differently. Hence, our identification is based on within-firm variation across investment categories for a given time period. The vector $\lambda_{c/i}$ contains fixed effects for either investment categories c or for category-firm fixed effects ci to account for differences in firms' production functions. In our baseline specifications, we restrict our sample period to the years around the implementation of FAS 123R. Either we consider a smaller time frame from 2002 to 2007 or a more extended time frame from 2000 to 2014.

2.3.3 Main Results

Investment Behavior: Table 4 presents our main results of estimating Equation (2), showing the effects of the reform on firm investments. The binary treatment divides our sample into two groups: the treatment group of firms with management affected by the reform and the control group with management less affected by the reform. Besides that, our specifications control for ex-ante differences in investment between firms with different compensation practices by interacting the measure of long-term incentives with the measure of depreciation. Standard errors are all clustered at the firm-level following Abadie et al. (2017).

In the upper panel, we use depreciation rates as a measure of asset depreciation. We are interested in the coefficient outlined in the first row which is the coefficient of the composite interaction term combining the FAS 123R dummy, the treatment indicator and the depreciation measure. We infer that our coefficient of interest is positive and significant at the 1%-level in column 1 when we consider a long sample period around the reform between 2000 and 2014 and include fixed effects for firm-years and each investment category. When we include fixed effects at the category-firm level in column 2 to control for idiosyncratic differences in production technologies across firms, the coefficient of interest becomes smaller in magnitude yet remains significant at the 1%-level and positive. In columns 3 and 4 we then replicate these specifications with a more narrow sample window around the reform between 2002 and 2007. Our estimates still suggest a significant shift of investments towards short-term assets within treated firms after the reform took place. In column 5, we go back to the longer sample and additionally include the interaction between a time trend and the treatment indicator as an attempt to account for potential pre-trends. We still estimate a statistically-significant positive investment wedge when including this additional interaction term. Quantitatively, the coefficient estimate implies that treated firms shift about 5 to 10% more investment to a category with a 10 percentage point higher depreciation rate compared to control-group firms. In the lower panel, we repeat the same regressions with the difference that we now assign the simple order of categories as the measure of depreciation, ranging from 1 (for land) to 7 (for advertising). Again, we estimate a positive coefficient of interest which is significant at the 5%- or 1%-level. Overall, these results suggest that the reform-induced incentive shifts caused a relative shift in investments towards high-depreciation investment projects.

We also regress investment expenditures on the interaction between annual dummies, depreciation rates and the treatment dummy to see how the effects evolve over time. Figure 1 plots the coefficient estimates for each triple interaction and shows that there is a distinct and permanent jump in the investment wedge in the years around the reform. Overall, we can strongly reject the null hypothesis that the average pre-FAS-123R coefficient equals the post-FAS-123R averages at the 1%-level.

Durability of Capital Stocks: Since we considered gross investments as dependent variable so far, the observed relative increase in short-term investments could be partly absorbed by the faster depreciation of these investments, such that a reallocation towards a shorter-lived capital stock within the firm does not take place in the end. To explicitly test for the effects on capital reallocation, we construct category-specific capital stocks and include them as an alternative dependent variable in our baseline regressions. Physical capital stocks are directly obtained from Factset and intangible capital stocks are determined based on a perpetual inventory method. The results from Table 5 demonstrate that the introduction of FAS 123R led indeed to substantial reallocation of capital within firms. On average, option-paying firms increased the stock of a capital category with a 10 percentage point higher depreciation rate by about 2 to 12% compared to non-option-paying firms.

In this context, we also provide evidence that the firm-specific depreciation rate of treated firms went up by the adoption of FAS 123R. We construct depreciation rates for each firm-year based on the relative size of each firm's category-specific capital stocks.[6] We then use these firm-specific depreciation rates as outcome variable and run firm-level difference-in-differences regressions. The results in the upper panel of Table 6 confirm a reduction in the durability of the capital stock in treated firms. Quantitatively, the depreciation rate on the average capital stock of option-paying firms increased by roughly 1 percentage point compared to the control group. Besides the real distortions that firms suffer from output losses due to suboptimal factor composition, this observed decrease in the durability of the capital stock requires affected firms to refinance their capital stocks earlier. We quantify this additional cost burden by calculating the additional financing costs required to match the level of the pre-FAS-123R capital stock. Assuming a 3% refinancing rate, we obtain additional costs of USD 8.05 per USD 1,000 invested for affected firms.[7]

Corporate Discount Rates: Next, we assess how the reform-induced change in incentives affects how managers discount future cash flows. We study firms' discount rates and perceived cost of capital, as an alternative to looking at investment expenditures, using data from Gormsen and Huber (2022). The dataset measures firms' discount rates and perceived cost of capital using text transcripts of corporate conference calls. On these calls, managers often announce their discount rates and perceived cost of capital to make investment decisions more transparent to shareholders. Perceived costs of capital are a firm's internal estimate of a weighted average of costs of debt and equity, the discount rate then is the rate at which the management evaluates future cash flows. In the bottom panel of Table 6, we regress these announced discount rates on the perceived cost of capital, the capital stock and the interaction term combining the FAS 123R dummy and the treatment indicator. The coefficient of the interaction term thus identifies how the accounting reform affected

[6] Figure A.2 in Appendix A.3 plots fluctuations of the average depreciation rate for treated and untreated firms over time. The difference between those two groups of firms starts to increase around 2005.

[7] See Appendix A.2 for details on the calculations.

the wedge between discount rates and capital costs.[8] We find that the change in incentives due to the reform had strong effects on managers' discount rates. Compared to untreated firms, managers of treated firms discounted future cash flows by approximately 0.4 percentage points significantly more.

Total Factor Productivity: In Table 7, we study the impact of the reform on total factor productivity. We compute revenue TFP as residuals from regressing log sales on log employment and log assets as a proxy for the firm-level capital stock, including a full set of 2-digit SIC industry fixed effects. The estimates in columns 1 and 2 use the longer sample period between 2000 and 2014 and suggest that treated firms experience a TFPR reduction of approximately 7 to 8% which is significant at the 5%-level. This TFPR reduction is smaller (about 5%) when considering the tighter sample period between 2002 and 2007.[9]

2.3.4 Alternative Channels and Robustness Checks

Firm Size and Other Ex-ante Differences: In Table A.2, we compare firms by treatment status. Treated firms are larger, less intense in intangible investments, have a lower liquidity, lower equity volatility and pay more to their CEOs in terms of current compensation. By explicitly controlling for these ex-ante differences in Tables A.3 and A.4, we illustrate that the change in investment behavior was particularly caused by differences in managerial incentives and not by those potentially confounding factors. We run regressions where we allow for two groups of interaction terms, one including the treatment variable $X_{i,2004}$ and the other including a potential confounder. The results in Table A.3 show that ex-ante differences in firm size are not driving our results. The triple interaction terms with firm size hardly explain any variation in the data and are insignificant for either proxy of firm size. We can further see that the coefficient magnitude of our original interaction term of interest remains similar. The original point estimate of 0.462 (Table 4, column 4) changes slightly to 0.473 when considering employment, to 0.503 when considering assets and to 0.489 when considering the capital stock with similar levels of significance. In Table A.4, we show

[8]Gormsen and Huber (2022) document that this wedge has substantially increased on average over the last decades while costs of capital have declined.

[9]This is consistent with the calibrated model results as firms can increase TFPR in the short term by cutting investments in the short run and thereby reducing capital costs.

Table 4: Incentives and the Durability of Investments

	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:			*Ordering*		
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)
Investment FE					
Investment-Firm FE					
Firm-Year FE					
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 results on the relationship between managerial incentives and investment decisions. *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. *Depr* is the measure of depreciation, expressed in absolute depreciation rates in the upper panel and following an ordinal scale in the lower panel. Column 5 additionally includes a treatment-specific linear trend: Trend Option Depr. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table 5: Incentives and Capital Stocks

	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:			*Ordering*		
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)
Investment FE					
Investment-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 results on the relationship between managerial incentives and capital stocks. *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. *Depr* is the measure of depreciation, expressed in absolute depreciation rates in the upper panel and following an ordinal scale in the lower panel. Column 5 additionally includes a treatment-specific linear trend: Trend Option Depr. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table 6: Incentives, Capital Stock Depreciation and Corporate Discount Rates

	(1)	(2)	(3)
	Average Depreciation Rate		
FAS123 Option	0.0120*	0.00931*	0.0158*
	(0.00619)	(0.00537)	(0.00869)
Cost of Capital	-0.0101***	-0.00871**	-0.00883**
	(0.00258)	(0.00401)	(0.00401)
Capital Stock	-0.0365***	-0.0385***	-0.0385***
	(0.00474)	(0.00686)	(0.00686)
Observations	9,304	3,757	3,757
No. Firms	695	679	679
	Corporate Discount Rate		
FAS123 Option	0.362*	0.445***	0.564**
	(0.187)	(0.158)	(0.234)
Cost of Capital	0.790***	0.328**	0.328**
	(0.0698)	(0.131)	(0.131)
Capital Stock	0.00656	0.0254	0.0257
	(0.0765)	(0.104)	(0.104)
Observations	5,972	2,321	2,321
No. Firms	546	478	478
Year FE			
Firm FE			
Trend			
Sample Time	2000 - 2014	2002 - 2007	2002 - 2007

Notes: The Table reports results on the relationship between managerial incentives, depreciation rates and discount rates. In the upper panel, we use the firms' average depreciation rates weighted by capital stocks in the individual categories as the dependent variable. For each firm i with depreciation-specific capital stocks C in year t, the capital-stock-weighted depreciation rate δ_{it} equals $\sum_{c=1}^{C} \delta_c \, \frac{cap-stock_{itc}}{\sum_{c=1}^{C} cap-stock_{itc}}$. In the lower panel, the outcome is the firms' self-reported corporate discount rates from Gormsen and Huber (2022). *Option* is a dummy that indicates if any unexercised options are outstanding in 2004. *FAS123* takes 0 for each year until 2005, 1 afterwards. Standard errors (reported in parentheses) are clustered at the firm-level. All columns control for the level of capital stocks (in logs) and the costs of capital, columns 1 and 3 additionally include *Trend Option*. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table 7: Incentives and Total Factor Productivity

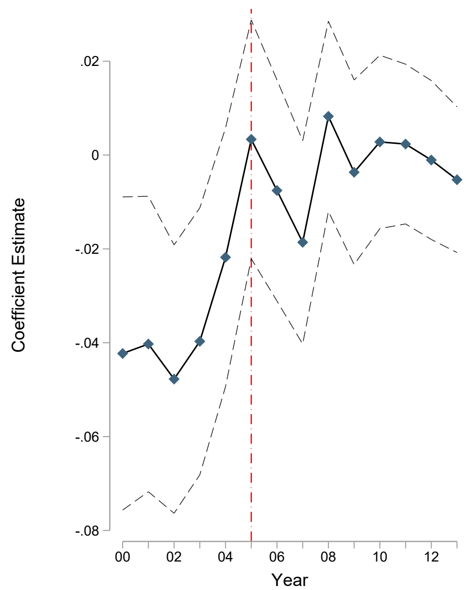
		TFPR	
	(1)	(2)	(3)
FAS123 Option	-0.0804**	-0.0711**	-0.0489**
	(0.0333)	(0.0360)	(0.0234)
Year FE			
Firm FE			
Trend			
Observations	9,926	9926	3,977
No. Firms	699	699	695
Sample Time	2000 - 2014	2000 - 2014	2002 - 2007

Notes: The Table reports the results on the relationship between managerial incentives and productivity. We use the firms' TFPR as the dependent variable. We compute TFPR as regression residuals from regressing log sales on log employment and log assets and 2-digit SIC industry fixed effects. *Option* is a dummy that indicates if any unexercised options are outstanding in 2004. *FAS123* takes 0 for each year until 2005, 1 afterwards. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

that the effect of incentives on investment also remains robust after accounting for other ex-ante differences in firm characteristics. Here, we again include two groups of interaction terms, one including the treatment variable $X_{i,2004}$ and the other including an ex-ante firm characteristic that appeared to be significantly different for treated and untreated firms ex ante (share of intangible investments, liquidity ratio, equity volatility and current CEO pay). Adding these controls leaves the interaction of interest largely unaffected.

Career Concerns and CEO Turnover: It might be possible that career concerns also matter for investment decisions and interfere with financial incentives. We would then wrongly attribute changes in the investment mix to changes in the compensation scheme whenever a new CEO enters the firm or whenever a CEO is replaced. We show in Table A.5 that our results are not driven by CEO turnover. Focusing on a subsample that includes only firms with a unique CEO, we are able to rule out that channel. Results in Table A.5 indicate that the effect is more pronounced when we exclude firms where a CEO turnover occurred. The coefficient of interest almost doubles in size and is estimated with higher precision.

Figure 1: Incentives and the Durability of Investments over Time



Notes: The Figure plots time-specific coefficients when investments are regressed on the interaction between an option dummy with year dummies and durability ranks. Firm-category and year fixed effects are included, standard errors are clustered at firm-level. Dashed lines illustrate 95% confidence intervals. The null hypothesis of coefficient equality before versus after the reform can be rejected at the 1%-level ($p = 0.001$).

Alternative Measurement of Investments: We provide evidence that our results do not depend on a specific transformation of the investment variable $invest_{ict}$ in Table A.6. As an alternative to applying the inverse hyperbolic sine transformation to investment expenditures, we run regressions using the investment share, the logarithm of investments or the log of 1 plus investments as outcomes. In columns 7 and 8, we treat missing investment information as 0s. All those transformations of the outcome variable reveal similar results.

Stock options, Short-term Perspective and US GAAP: An alternative mechanism that might be a threat to our identification is embedded around the argument that a reduction of equity options might not increase but reduce short-term incentives. If the accounting reform causes firms to substitute towards restricted stock and previous options have short vesting dates, incentives might actually become more long-term. Then, managers of treated firms might be less inclined to manipulate short-term earnings and therefore invest more into intangibles since investments into intangibles are directly expensed under US GAAP rules and happen to be more short-term on average.

We address this concern on several fronts. Firstly, our evidence in Table A.1 of the Appendix suggests that incentives indeed became more short-term in treated firms relative to untreated firms. Managers in treated firms experienced a significant reduction in non-current compensation compared to managers of untreated firms around the reform. Meanwhile, there was no significant increase in grants of restricted stock to executives in treated compared to untreated firms even though there was an overall increase in restricted stock grants with the implementation of FAS 123R (see Hayes et al. 2012). Additionally, the duration of executive pay slightly decreased compared to untreated firms. Furthermore, our analysis in Table 6 shows that the change in incentives increased discount rates. Lastly, Table A.7 demonstrates that the reallocation of investments also happens within tangibles and intangibles and does not only occur between tangible and intangible investment categories and is also robust to the exclusion of expenditures on R&D.

3 Quantifying the Impact of Incentives on Within-Firm Capital Misallocation

We now present a model of firm investments that serves two purposes. First, it rationalizes the empirical evidence how shifts in managerial incentives away from equity and towards bonus payments affect investments. Second, a calibrated version of the model helps understanding the implications of the observed mechanism. Our starting point is a standard neoclassical dynamic investment model where firms combine capital and labor to produce output. We extend this model in the following ways. First, we assume that decisions are made by a risk-neutral manager who maximizes the present value of her compensation package. This distorts investment decisions away from those predicted by a standard neoclassical model where the manager acts to maximize the value of equity and thus makes decisions that are completely congruent to shareholder interests. Similar to Nikolov and Whited (2014), we consider compensation packages that are composed of a fixed salary, a bonus based on current profits and a share of managerial firm ownership. The larger is the equity share of firm value that accrues to the manager, the more managerial and shareholder incentives are aligned. Second, we introduce two types of capital that differ in their durability in the spirit of Aghion et al. (2010) or Rampini (2019), measured by their depreciation rates.

3.1 Baseline Model

Production: Consider a firm that uses labor inputs N_t and a set of two capital inputs $\mathbf{K}_t = [K_{lt}, K_{st}]$. Importantly, we assume that the two capital goods differ in their depreciation rates $\delta_l < \delta_s$ such that capital inputs K_{lt} are more durable than capital inputs K_{st}. The firm uses these inputs to produce output Q_t according to a simple Cobb-Douglas production function

$$Q_t = \widetilde{Z} F(\mathbf{K}_t, N_t) = \widetilde{Z} \left(K_{lt}^{\nu} K_{st}^{1-\nu} \right)^{\alpha} N_t^{1-\alpha}, \tag{3}$$

where $\widetilde{Z}$ measures the firm's productivity. The firm faces isoelastic demand with elasticity ε:

$$Q_t = B P_t^{-\varepsilon}, \tag{4}$$

where B is a demand shifter. Combining the production function with the demand curve yields the following revenue production function:

$$R_t = P_t Q_t = Z^{1-a-b} \left(K_{lt}^{\nu} K_{st}^{1-\nu} \right)^{a} N_t^{b}, \tag{5}$$

where we substitute $Z^{1-a-b} \equiv B^{1/\varepsilon} \widetilde{Z}^{1-1/\varepsilon}$ such that Z captures the firm's overall business conditions. We define the terms $a \equiv \alpha(1 - 1/\varepsilon)$ and $b \equiv (1 - \alpha)(1 - 1/\varepsilon)$ for tractability.

Furthermore, each type of capital is subject to quadratic adjustment costs.[10] That is, using a current capital mix of $\mathbf{K}_t$ and acquiring a future capital mix of $\mathbf{K}_{t+1}$ gives total capital-related costs of

$$C_t^K = \sum_{j \in l,s} \left[\gamma \left(\frac{K_{jt+1}}{K_{jt}} - 1 \right)^2 K_{jt} + q_j \left(K_{jt+1} - (1 - \delta_j) K_{jt} \right) \right], \tag{6}$$

with q_j as the unit price of capital good j. Since we will perform partial-equilibrium analyses in

[10]Empirical adjustment costs are likely neither quadratic nor fully symmetric across different types of capital. In the calibrated version of our model, we have also examined versions with partially irreversible investment and different adjustment cost parameters γ for different capital goods. These variations do not affect our calibration results in a qualitatively meaningful way. Two additional dimensions excluded from the analysis that are potentially important are *i.* to what extent different capital goods can serve as collateral for loans and *ii.* to what extent capital goods can be rented without actually appearing on the firm's balance sheet.

what follows, we treat aggregate variables as constant and also set $q_l = q_s = 1$. Furthermore, we abstract from uncertainty regarding $\widetilde{Z}$ and B. The variable factor labor only causes variable costs of wN_t such that overall profits from the operations of the firm in period t are given by

$$\Pi_t = R_t \quad C_t^K \quad wN_t. \tag{7}$$

Agency Frictions and Incentive Contracts: In this model, we focus on firms with owner-manager separation. As in Nikolov and Whited (2014), we do not derive the form of optimal compensation contracts but instead approximate contracts that we actually observe in the data without making a statement about their optimality.[11] This approach allows us to identify the effects of changing contractual features on firms' investment policies, the allocation of capital and economic activity. Specifically, we assume that the total remuneration for a manager Γ_t is the sum of a fixed salary w_t^f, a bonus b_t that is some proportional share of current profits $b_t = \eta^b \Pi_t$ and equity grants E_t^m proportional to total equity E_t, such that $E_t^m = \eta^e E_t$:

$$\Gamma_t = w_t^f + b_t + E_t^m. \tag{8}$$

This particular structure of remuneration packages highlights the core mechanism at hand: a part of the remuneration depends on current (short-term) profits, while another part is linked to long-term firm value. To keep the model tractable, we follow Glover and Levine (2015) in assuming that contracts only last for one period and that the manager does not start out with any pre-existing holdings of equity.[12] For future reference, it is opportune to denote managers of the firm by the period t that they are in charge of steering the firm.

Assuming a complete financial market in the background, the market value of equity E_t is given by the discounted stream of expected future cash flows. After taking into account salaries and bonuses for management, the total amount available for dividend payments in each period is given

[11] See Murphy (1999) for an empirical survey on CEO compensation packages.

[12] Considering multi-period contracts between managers and owners quickly complicates matters a lot and requires a substantial amount of further structural assumptions. These include *i.* managers' preference relation regarding payoffs at different points in time, *ii.* managers' ex-ante exposure to the firm's performance via preexisting holdings of equity, *iii.* a process linking managers' probability of staying with the firm to firm performance and *iv.* uncertainty about future remuneration packages. All these assumptions on their own would have important consequences regarding the overall term-structure of the managers' decision problem.

by $(1-\eta^b)\Pi_t - w_t^f$. Furthermore, we let capital markets anticipate that similar remuneration schemes may exist in the future. Hence, if the manager in charge during period $t+1$ is also expected to be awarded a share η^e of equity, shareholders in period t anticipate that the share of future total market capitalization they hold shrinks by a factor of $1-\eta^e$, leading to share dilution.[13] With complete markets and rational expectations, equity then is valued as

$$E_t = (1-\eta^b)\Pi_t - w_t^f + \frac{1}{1+r}\mathsf{E}_t\left\{(1-\eta^e)E_{t+1}\right\}, \tag{9}$$

where r is the relevant market interest rate. After recursive substitution, this becomes

$$E_t = (1-\eta^b)\left[\Pi_t + \sum_{\tau=1}^{\infty}\left(\frac{1-\eta^e}{1+r}\right)^{\tau}\mathsf{E}_t\left\{\Pi_{t+\tau}\right\}\right] - \sum_{\tau=0}^{\infty}\left(\frac{1-\eta^e}{1+r}\right)^{\tau}\mathsf{E}_t\left\{w_{t+\tau}^f\right\}. \tag{10}$$

Using (10), we can rewrite the value of the manager's remuneration package as

$$\Gamma_t = w_t^f - \eta^e\sum_{\tau=0}^{\infty}\theta^{\tau}\mathsf{E}_t\left\{w_{t+\tau}^f\right\} + \varphi\left[\Pi_t + \beta\sum_{\tau=1}^{\infty}\theta^{\tau}\mathsf{E}_t\left\{\Pi_{t+\tau}\right\}\right], \tag{11}$$

where we define

$$\varphi \equiv \eta^b + \eta^e(1-\eta^b), \quad \beta \equiv \frac{\eta^e(1-\eta^b)}{\eta^b + \eta^e(1-\eta^b)}, \quad \theta \equiv \frac{1-\eta^e}{1+r}. \tag{12}$$

The term $w_t^f - \eta^e\sum_{\tau=0}^{\infty}\theta^{\tau}\mathsf{E}_t\left\{w_{t+\tau}^f\right\}$ captures the manager's fixed wage and the wage payments of her successors which is exogenous to the decision problem such that we may ignore it in the following.

Decision-Making: Notably, the payout profile represented in (11) resembles the preferences that a risk-neutral agent with quasi-hyperbolic time preferences for profits would have. In other words, incentivizing managers with a combination of both, bonuses on current profits and equity payouts induces decision-making that is present biased. To derive a manager's decision problem, we express the manager's optimization problem in recursive form. Formally,the manager in t chooses an action

[13] The fact that equity-based compensation can lead to share dilution is a well known fact in finance (see, e.g., Asquith and Mullins 1986, Huson et al. 2001, Core et al. 2002). In the model context, this implies that managers' overall share in market capitalization would converge to 100% eventually if they were to remain employed infinitely by the firm. This aspect counteracts discounting and could lead to non-trivial time preferences.

$a_t = (\mathbf{K}_{t+1}, N_t)$ depending on the history of previous managers' decisions $\mathcal{H}_t = (a_s | s < t)$. Denote by s_τ a strategy of manager τ. The decision problem of the manager in t follows as

$$
\begin{aligned}
&\max_{a_t} \Gamma_t \\
s.t.\ &(5), (6), (7), \\
&\text{given } \mathcal{H}_t, \\
&\text{given beliefs regarding } s_\tau, \tau > t.
\end{aligned} \tag{13}
$$

Generally, this type of problem has an extremely large strategy space and a multitude of equilibria can occur. Although a thorough examination of the strategy space of such a game may seem interesting, we focus on symmetric, smooth Markov-perfect equilibria, where the state of the game is entirely described by a_{t-1}, in line with most macroeconomic models.

While demand for the freely adjustable factor labor equates marginal labor costs and the marginal revenue product of labor[14], it is not possible to analytically solve for the policy functions regarding the two capital goods in the presence of capital adjustment costs. We can implicitly characterize a time-invariant policy function, assuming that the policy functions of all managers just depend on the current capital goods and on expectations that future managers will behave in the same way. We denote this function as $\mathcal{K}(\mathbf{K}) = (\mathcal{K}_l(\mathbf{K}), \mathcal{K}_s(\mathbf{K}))$. Here, $\mathcal{K}_j(\mathbf{K})$ is the policy function for capital good $j \in \{l, s\}$. I.e., in period t a manager whose firm starts with capital stocks $\mathbf{K}_t = (K_{lt}, K_{st})$ chooses $K_{j,t+1} = \mathcal{K}_j(\mathbf{K}_t)$. The function $\mathcal{K}(\cdot)$ is then the solution to the manager's first-order conditions. Hence, with a slight abuse of notation, in period t, the policy function will be the solution $\mathbf{K}_{t+1}$ of the following self-referencing characterization for j:[15]

$$
0 = \frac{\partial \Pi_t}{\partial K_{j,t+1}} + \beta\theta \frac{\partial \Pi_{t+1}}{\partial K_{j,t+1}} + \theta(1-\beta) \sum_{k=l,s} \frac{\partial \mathcal{K}_k(\mathbf{K}_{t+1})}{\partial K_j} \frac{\partial V(\mathcal{K}(\mathbf{K}_{t+1}))}{\partial K_k}. \tag{14}
$$

Here, the term $V(\cdot) := [\Pi_t + \theta V(\mathcal{K}(\mathbf{K}_t))]|_{\mathbf{K}_t}$ represents a recursive continuation value, conditional on the current choice of capital inputs. This capital-specific Euler equation (14) takes into account

[14] $N_t = \left(\frac{b Z^{1-a-b} \left(K_{lt}^{\nu} K_{st}^{1-\nu}\right)^a}{w} \right)^{\frac{1}{1-b}}$

[15] The derivation of the optimality condition (14) is relegated to Appendix B.1.

the strategic dependence of future behavior on current decisions. The first two elements are fairly standard: the first element incorporates the current costs of investment (including the unit prices of capital goods and the marginal adjustment costs), the second term represents the marginal returns in the next period, discounted by $\beta\theta$, adjusted for depreciation. The final term is a peculiarity of our model and other models with quasi-hyperbolic time preferences. This term captures the marginal effect on equity via changes in future investment behavior. Both, the unknown gradients of the capital policy functions $\frac{\partial \mathcal{K}_k(\mathbf{K}_{t+1})}{\partial K_j}$ for $j, k \in \{l, s\}$ as well as the unknown gradient of the continuation-value function $V(\cdot)$ are relevant to evaluate the effects of future investment on equity value. Whenever managers are compensated with a combination of bonuses and equity (which implies that $\beta \neq 1$), this last term does not cancel out such that this cannot be solved analytically and requires to be approximated numerically within the calibration exercise.

Discussion: The direct effects of managerial incentives on corporate investments modeled in this paper are captured by the terms β and θ introduced by the compensation package. The investment policy of a decision-maker that maximizes the long-term firm value corresponds to terms $\beta = 1$ and $\theta = \frac{1}{1+r}$. Intuitively, the term $\beta < 1$ induces the manager to behave as if she was solving some quasi-hyperbolic optimization problem. This behavior arises from the fact that the compensation structure in (8) causes a short-term bias for the manager since current profits are rewarded by both, equity ownership and bonus payments. Increasing the bonus share η^b and lowering the equity share η^e decreases β and increases her bias towards optimizing current profits. Furthermore, the term $\theta < 1$ incorporates a dilution factor arising from the manager taking into account that her equity ownership will be diluted by future managers that will also be incentivized with equity. With equity-based remuneration, share dilution affects long-term investors' holdings of the firm's stock. This implies that for any $\eta^e > 0$, future income streams are more strongly discounted than purely at the market interest rate since $\theta < \frac{1}{1+r}$.

While our model allows for fairly rich dynamics on investment patterns and firms' capital stocks, we abstract from other factors that typically vary over time and affect investment decisions. One of these abstractions is risk-aversion. While it is difficult to measure the extent of an individual manager's risk-aversion, a risk-averse decision-maker could likely 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 and the behavior associated with it. While this simplifies our quantitative analysis, Hayes et al. (2012) provide empirical evidence that the change in convexity induced by the reform of FAS 123 had little impact on CEOs' risk-taking behavior.[16] Another aspect that we abstract from in the baseline quantification is the consideration of general-equilibrium effects. Since factor prices could adjust in general equilibrium, this would explicitly allow for feed-back effects into other decision-makers' investment decisions even though their incentives might have remained unchanged. As a robustness check, we study a general-equilibrium extension of the model that takes these price-effects into account. This general-equilibrium extension comes at the cost that we have to abstract from aggregate dynamics such that we only compare steady-state equilibria.

3.2 Model Quantification

With the help of our model, we aim to quantify the effects of a shift in incentives on the capital allocation of firms and its associated economic outcomes. We calibrate the model to match certain features of public US companies and industry characteristics before the introduction of FAS 123R. We then assume an unexpected shock to β that is consistent with what we observe in the data around the reform.[17] Industry-specific information is obtained from the US files of the EU KLEMS database for 2003–2005, for firm-level remuneration data we rely on Execucomp and Coles et al. (2006).[18]

Calibrating Incentive Contracts: We consider a sample of 1,000 firms that draw a pre- and a post-FAS-123R value for β that match the observed distributions of β in the years 2005 and 2007 from a discretized distribution taking observed transition probabilities into account. The calculation of the structural parameter β follows Equation (12) and is determined by the bonus share η^b and the equity share η^e. For the construction of η^b, we scale the sum of bonuses and non-equity incentive compensation by firm sales. The equity share is constructed by scaling managers' equity-linked

[16]Related to that, Bebchuk and Fried (2010) discuss how equity-based compensation packages can be designed to achieve strong ties to long-term results.

[17]In this exercise, we do not alter θ to focus ideas purely on the effect of a relative shift in the duration structure of managers' remuneration. That is, in terms of the model we effectively consider a shock to η^b.

[18]See Table 8 for an industry overview.

firm wealth by their employing firms' market capitalization.[19] We then discretize the distribution of β into ten bins varying from 0.75 to 1.0 in steps of size 0.025. Table 9 provides the observed transition probabilities across bins, the changing distribution of β is plotted in Figure 2. The histograms illustrate the shift of compensation packages away from equity around the reform: drawing a large value for β became less likely after the reform. Moreover, the transition matrix also suggests that there is substantial path-dependency as the diagonal elements (i.e. the probabilities of remaining within a certain bin) show values between 63.6% and 90.15%. Path dependency seems to matter in particular at the outer bounds of the distribution as the probability of remaining within a bin is highest for the bottom and the top bin. Overall, the sample mean value for β falls by about 3 percent from 0.918 to 0.890. This decline in β is driven by both, a reduction in the share of equity compensation (η^e) and an increase in the average bonus share (η^b). Moreover, about 70% of the firms remain in the same bin for β, while about 19% move to a bin with a higher value for β and only 11% enter a lower β-bin. Thus, the incentive structure of managers has shifted slightly, but noticeably, in the period around the reform.

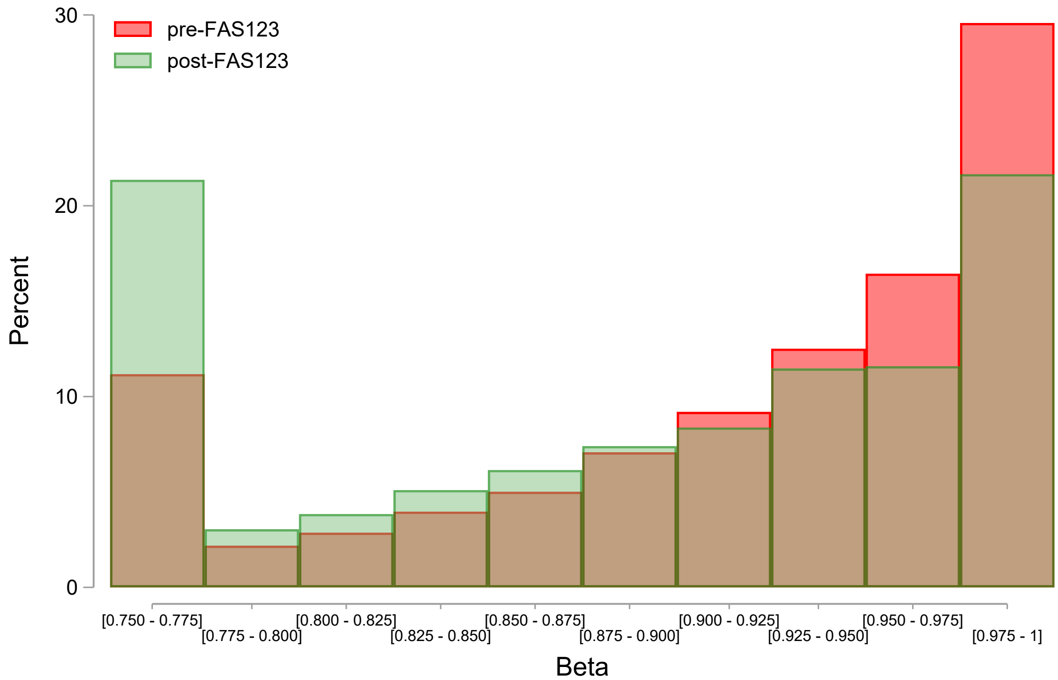
In Table A.9 of the Appendix, we link the constructed structural parameter β back to our reduced-form estimates. There, we estimate that reductions in β are indeed associated with a shift of investments towards more short-lived capital goods. Moreover, we use $\mathit{Shock}_t \quad X_{i,2004}$ as an instrument for β to confirm that the reform-induced shift in incentives caused a more short-term investment behavior.

Other Parameters: We assign each firm to a specific industry taking the size composition of industries in the US according to OECD data on the number of firms by sector into account. We assume that the measure for firms' overall business conditions Z is composed of a industry-wide demand condition $B = B^{ind}$ and a firm-specific TFP component $\tilde{Z} = Z^{firm}$ according to $Z = (B^{ind})^{\frac{1}{\varepsilon}}(Z^{firm})^{\frac{\varepsilon-1}{\varepsilon}}$. For each industry, we use value added as a proxy for revenues,[20] the total stock of both types of capital, average depreciation rates for both types of capital, the average wage paid to employees and the number of employees. For information on the industries used and the corresponding values for the variables, we refer to Table 8. Each firm is characterized by a vector of

[19] Details on the computation can be found in Appendix C.1.

[20] We could, of course, explicitly consider a production function with intermediate inputs, but this would complicate the analysis without materially affecting the mechanism studied here.

Figure 2: Changing Incentives Around FAS 123R



Notes: The Figure depicts the empirical distribution of the β parameter before (red) and after (green) FAS 123R. Distribution overlap is illustrated by the brown area. 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.

three i.i.d. random draws which determine Z^{firm}, the manager's incentive structure determined by β and the equity ownership share η^e. The wage rate and the depreciation rates for short- and long-term capital goods are directly inferred from the industry draw. We use standard values from the literature for the adjustment-cost parameter γ and the interest rate r.[21]

Next, the scale parameter B^{ind}, the factor shares a and b for capital and labor, and the long-term capital share ν have to be calibrated. Here, we calibrate the parameters $B^{ind}, \alpha, \nu, \varepsilon$ to the benchmark case $\beta = 1$ such that the values for the labor-to-output ratio $\frac{wN}{R}$, the share of long-term capital in total capital $\frac{K_l}{K_s+K_l}$, the capital-to-output ratio $\frac{K_l+K_s}{R}$ and the overall scale of operations R match those of the respective sector in the data.[22]

[21]For γ we follow Bloom (2009, Table III) and choose 4.844. The interest rate r is set to 2.98%. A detailed discussion can be found in Appendices C.2 and C.3.

[22]This approach implies that the simulated sample is not exactly representative of the empirical sample because the observed average of the firms' β is below 1. However, this is the only way of calibrating the parameters analytically. Also the relative size of the effects is not altered in a materially important way by this strategy.

The idiosyncratic scaling factor Z^{firm} is drawn from a random distribution, where we assume the logarithm of Z^{firm} to be normally distributed around a zero mean and a standard deviation of 0.52, which is what İmrohoroğlu and Şelale Tüzel (2014) find for the productivity dispersion in Compustat data.

We then solve the model for each firm individually. Since the incentive structure in the model features a present-bias ($\beta < 1$) and decision-makers face capital adjustment costs ($\gamma > 0$), our model resembles a quasi-hyperbolic discounting problem such that solving it involves similar challenges as those documented in previous papers on neoclassical growth models with quasi-geometric discounting (e.g. Krusell and Smith 2003, Maliar and Maliar 2016).[23] In particular, as the generalized Euler equation for capital does not have a specific closed-form solution, we resort to numerical methods. Since Euler-equation methods are likely to fail (cf. Maliar and Maliar 2016), we use a version of the endogenous gridpoint method first introduced by Carroll (2006). This method works similar to backward induction: for a fixed number of possible future stocks of both types of capital, one solves the managers' optimality conditions for current stocks. This procedure essentially constructs inverted policy functions from which we can back out the dynamics for each firm.

3.3 Results

Relation to the Empirical Estimates: We begin by replicating the reduced-form regressions using our simulated sample. Table 10 reports estimates based on the simulated sample of firms. In contrast to the empirical sample, these data only contain two types of capital and the treatment indicator used in the estimations is either a dummy indicating whether the firm experienced a reduction in β or the value of β in the pre-reform period. We find the magnitude of the investment distortion to be very similar compared to the empirical counterparts. When using the dummy

[23] In the case without adjustment costs ($\gamma = 0$), a simple equilibrium is straightforward: since managers' utility is modelled as linear and markets are complete, the choice of $\mathbf{K}_t$ by manager $t-1$ only acts as a level shift to current profits. Hence, manager t's marginal calculations are separate from the current state of the capital stock. As such, the manager could simply choose an arbitrary value of $\mathbf{K}_{t+1}$ irrespective of $\mathbf{K}_t$. If all managers follow such a strategy, the gradients of the policy function are zero everywhere. In anticipation of this, future behavior cancels out of the model equations and the optimality conditions (14) for each capital good $j \in \{l, s\}$ simplifies to

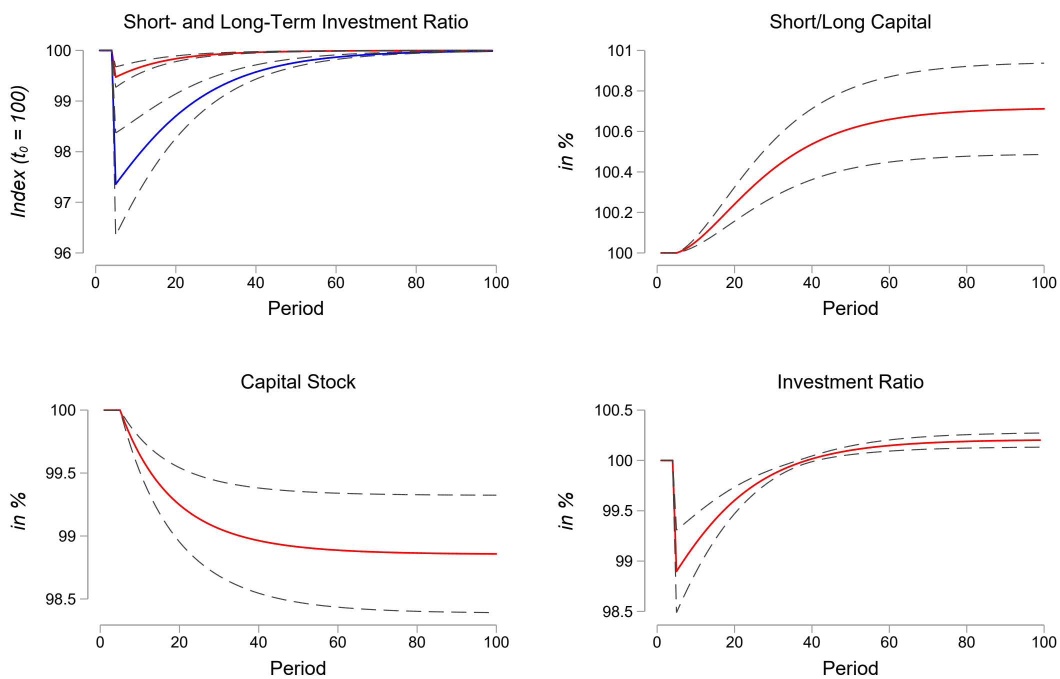
$$1 = \beta\theta \left[\frac{\partial R(K_{lt}, K_{st}, N_t,)}{\partial K_{jt}} + (1 - \delta_j) \right].$$

as treatment indicator in columns 1 and 2 of Panel A, we obtain a coefficient of 0.426 which almost equals the counterpart of 0.462 in column 4 of Table 4 based on the empirical sample. In the two subsequent columns, we consider the respective capital stocks as dependent variable. Given the close replication of the empirical estimates, we feel confirmed that our calibration approach is suitable to quantify the effects of managerial incentives on production, investment and capital misallocation.

Capital Adjustments within Firms: In a next step, we use our simulated firm panel to analyze the dynamic within-firm adjustments of capital in response to the shift in incentives. These are depicted in Figure 3. The graph at the upper left in the Figure plots investments into short- and long-term capital goods, each normalized by their respective capital stocks. Firms respond to the reform with a short-run dip in investments in both capital goods. This investment dip is consistent with empirical findings by Ladika and Sautner (2019), who report a reform-induced investment cut in the years directly after the introduction of FAS 123R. As expected, the results show that this cut in investments is highly asymmetric across both investment goods. Consistent with our empirical findings, the reform causes a distortion in investments across assets with different life span. While short-term investments are only reduced by about 0.5% on average, the drop in long-term investments appears substantially larger around 2.6%. This heterogeneous response in investments results in a shift of the within-firm capital stock towards relatively more short-term capital. This can be observed in the upper right graph of Figure 3 which depicts the share of short-term capital in percent of long-term capital goods. On average this fraction is 82.3% in t_0 and increases about 0.7 percentage points in response to the reform.

As gross investment falls in the aggregate, this leads to a reduction in firms' total capital stock by around 1.1% on average, which is illustrated in the lower left graph of the Figure. The lower right graph depicts total gross investment normalized by the total capital stock. Again, one can observe the immediate reduction in the investment ratio (by about 1.1%) directly after the reform that already became apparent in the upper graph showing investment into individual capital goods. Interestingly, the long-run steady-state level of total gross investment relative to the capital stock slightly *increases* compared to pre-reform levels. This effect is driven by the within-firm reallocation of capital. Since the capital composition shifts towards short-term capital goods and these deplete faster, the average depreciation rate of capital increases. Consequently - in relative terms - larger re-investments are necessary.

Figure 3: Capital Adjustments within Firms



Notes: The Figure depicts the dynamic adjustment process for short-term investment in red and long-term investment in blue (top-left), the capital ratio (top-right), the capital stock (bottom-left) and the total investment ratio (bottom-right). Investment ratios are normalized by their respective capital stocks. We normalize each of the responses with respect to their pre-shock values. The average adjustment is illustrated by solid lines, dashed lines depict 95% confidence intervals.

Misallocation, Output and Productivity: Next, we consider the effects of the change in incentives on misallocation, output and productivity which we illustrate in Figure 4. In order to make a statement on the economic relevance of such a relatively mild shift in the within-firm composition of capital stocks, we compute the distortion of marginal revenue products across investment categories within firms, inspired by Hsieh and Klenow (2009). Specifically, we define the marginal product gap within a firm as

$$MPG_t = |MPK_{st} - MPK_{lt}|, \quad (15)$$

where $MPK_{jt}, j \in \{l, s\}$ is the sum of the marginal revenue product of a capital good and its resale value $(1 - \delta_j)$ such that the marginal product gap MPG_t captures the wedge in the different rates of return across capital goods within firms. The graph at the upper left of Figure 4 plots this measure of within-firm misallocation of capital. It shows that the relatively moderate shift in the composition of capital stocks causes a very substantial rise in within-firm capital misallocation. Since short-term capital goods have higher depreciation rates those capital goods can adjust relatively faster which explains the spike in the marginal product gap followed by a slight reduction afterwards. This can also be seen in the change of the curvature of the relative capital stocks from convex to concave (upper right graph in Figure 3). The within-firm wedge in the rates of return across capital goods increases in the long-run by about 3.7 basis points.

We then quantify the effects of the within-firm capital misallocation channel on economic output and total factor productivity. Based on the underlying Cobb-Douglas production function (3), output falls by about 0.5% on average. Due to the homogeneity of the production function and labor being a freely adjustable production factor, the observed relative decline in output is similar to the employment change. The graph at the lower left depicts changes in total factor productivity. We define revenue total factor productivity here as

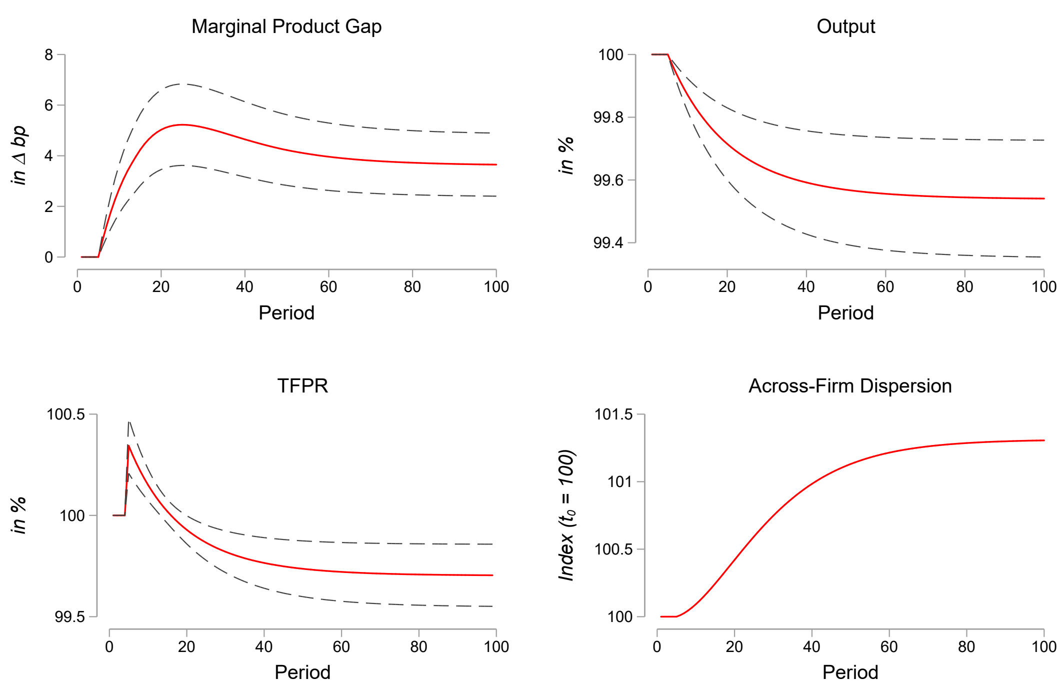
$$TFPR_t = \frac{R_t}{\left(C_{lt}^{\nu} C_{st}^{1-\nu}\right)^{\alpha} N_t^{1-\alpha}}. \tag{16}$$

A short-run spike in productivity by about 0.3% on average becomes evident. This short-run productivity spike is driven by the sudden cut in investments and the according reduction in capital costs. Productivity then declines in the long-run by about 0.2% on average as the within-firm capital mix shifts away from the social optimum. The finding that the motive to raise short-term profits at the expense of long-run macroeconomic growth matters in the aggregate is also in line with Terry (2022) who finds that short-termist incentives cost 6% of output in the long-run. Compared to this finding, the impact of the reform on output is indeed substantial, even though its direct effect on incentives has been moderate.

Finally, we use our model to analyze the effects of the reform on misallocation across firms. Since the FAS 123 reform only affects incentives and investment choices of some managers while other firms remain unaffected, the change in accounting rules is likely to raise misallocation across firms.

In the graph at the lower right, we plot the cross-firm dispersion in the capital mix of short- relative to long-term capital by normalizing the standard deviation of the capital ratio across firms with the initial standard deviation before the reform. It is evident that the cross-firm dispersion in the capital ratio increases by about 1.3% after the reform, speaking to the fact that firms become more heterogeneous in terms of their factor endowment. Given that FAS 123R has no direct effect on the marginal productivity of capital goods, such a reallocation of capital across firms should not have been taken place from a social-planner point of view. We therefore interpret this increase in firm heterogeneity with respect to capital endowment as indirect evidence for more cross-firm capital misallocation as firms are more unevenly endowed with short- and long-term capital after the reform.

Figure 4: Misallocation, Output and Productivity



Notes: The Figure depicts the dynamic adjustment process for the within-firm gap in marginal revenue products of capital goods (top-left), output (top-right), revenue TFP (bottom-left) and the across-firm dispersion (s.d.) of the capital ratio (bottom-right). We normalize each of the responses with respect to their pre-shock values. The average adjustment is illustrated by solid lines, dashed lines depict 95% confidence intervals.

Robustness to General-Equilibrium Effects: We next study to what extent the previous results are robust once we account for general-equilibrium effects. When the reform increases firms' demand for short-term capital goods, some parts of the within-firm misallocation of capital could be mitigated by increases in factor prices. Furthermore, when firms produce at higher marginal costs due to a sub-optimal capital mix, final-good prices might increase leading to lower welfare. At the same time, demand shifts away from short-termist firms because consumers can substitute towards cheaper goods. To study these effects, we use the same sample of firms as before but endogenize factor markets and demand for final goods. In this (pseudo-)general-equilibrium extension, goods produced by the firms within each sector are combined into a CES bundle. The various sectoral bundles are then combined into an aggregate Cobb-Douglas final good. Regarding factor markets, we assume that all costs related to gross investments are created from using labor and we impose factor-market clearing by equating aggregate labor demand with a fixed labor endowment. The demand shifter B^{ind} now becomes an endogenous equilibrium object and we use labor as the numéraire such that the wage rate is normalized to 1 and homogeneous across sectors. Compared to the partial-equilibrium analyses, the disadvantage of this approach is that we can only compare implied aggregate steady states before and after the reform and thus neglect dynamic adjustments around the reform. Details on the treatment of the general-equilibrium effects can be found in Appendix B.2.[24]

As before, firms differ along the following dimensions: each firm is assigned to one out of 13 sectors, which determines most model parameters and the CES basket into which the firm's output is included. Additionally, each firm draws an idiosyncratic TFP, as well as their own β, η^e and η^b, where we use the same transition of firm-specific βs as in the partial-equilibrium setting before.

In Table 11, we present the counterfactual effects of our simulated reform on a set of aggregate variables. In each case, the presented numbers are relative changes compared to the steady-state value before the reform. Remember that the shock on managerial incentives induced by FAS 123R has been rather moderate with an average decline in β by roughly 2.8 percentage points (about 1 percentage point if we consider the discretized distribution of β). In the previous partial-equilibrium exercise, this shock was associated with a substantial gap in the marginal products of capital caus-

[24]In this extension, we abstract from firm entry and exit and still assume managers' remuneration packages as exogenously given. As such, we denote this extension a pseudo-general-equilibrium framework.

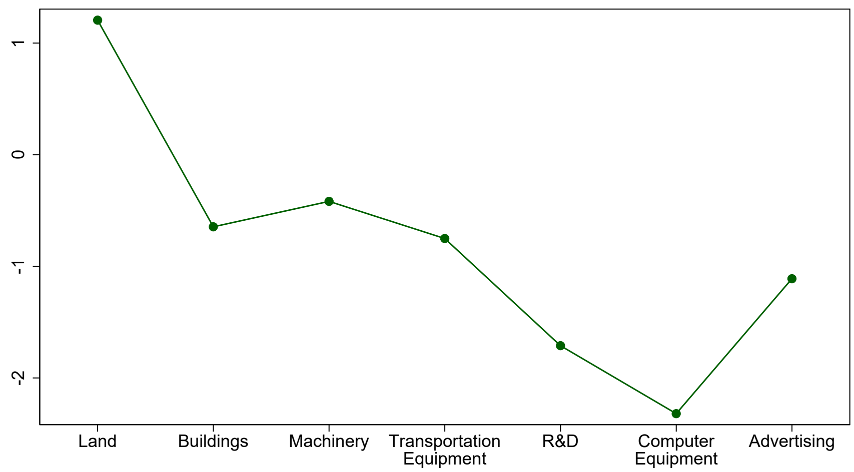
ing a drop in output, capital stocks and a relative shift in investment from long-term to short-term capital goods. These findings carry through to our general-equilibrium analysis here, albeit the effects are quantitatively smaller due to the counteracting general-equilibrium adjustments. Aggregate output drops by about 8 basis points. If we compare the change in aggregate capital stocks, we see that the general-equilibrium change is about one third smaller than the partial-equilibrium change: while the capital stock falls by 0.81% in general equilibrium, it falls by 1.1% in partial equilibrium. Furthermore, the reduction of total investments is somewhat smaller (-0.59%) than the drop in the overall capital stock as firms need to reinvest more frequently due to the shift in the capital mix away from more durable capital goods. This shift can also be observed in the larger decline in long-term investments compared to the decline in short-term investments. Lastly, the general-equilibrium exercise allows us to determine the effects of the reform on the aggregate price level of the final good and hence on the real wage and thus welfare in the economy. Here, we observe an increase in the price level of about 17 basis points, which translates to an equally-sized decline in the real wage caused by the reform.

4 Conclusion

In this paper, we studied how managerial incentives affect the allocation of capital. We provided empirical evidence showing that firms systematically shift investment expenditures towards less durable assets in response to a shift towards more short-term incentives from equity towards bonuses that lower managerial firm ownership. To quantify the impact of such incentive distortions on capital (mis)allocation, we then calibrated a dynamic model of firm investments in which managers determine investment policies and face typical incentive contracts.

Our results indicate that changes in incentives away from motivating managers to maximize long-term firm values can cause substantial economic distortions. Firms cut their investments into long-term assets and within-firm capital misallocation increased due to a mismatch in decision-makers' private marginal products of capital and social marginal products of capital, causing a fall in output, capital stocks, productivity and real wages. We conclude that corporate decision-makers' incentives are crucial for economic policy-making as managers respond very sensitively to changes in their incentives which affects economic outcomes.

Figure 5: Incentives and the Durability of Investments - By Category



Notes: The Figure plots jointly estimated category-specific coefficients when investments are regressed on the interaction between an option dummy with a FAS123R-dummy and category dummies. The null hypothesis of coefficient equality across categories can be rejected at the 1%-level ($p < 0.001$).

Table 8: Industry-Level Variables

Code	Industry Description	Probability Weight (in %)	Value Added (in Mio USD)	Wage Bill (in Mio USD)	Employment (in Thd)	Wages (in Thd USD)	Depr Rates s	Depr Rates l	Capital Stock (in Mio USD)	$\frac{K_l}{K_s+K_l}$ (in %)
A	Agriculture, forestry and fishing	1.972	138,161	36,249	1,278	28.4	0.13	0.02	462,506	58.02
B	Mining and quarrying	0.332	260,953	62,677	552	113.5	0.14	0.02	1,481,196	92.88
C	Total manufacturing	7.883	1,726,301	930,930	16,226	57.4	0.11	0.03	2,794,956	47.38
D, E	Electricity, gas and water supply	0.563	288,219	90,943	1,566	58.1	0.10	0.02	1,665,872	78.54
F	Construction	12.575	748,735	458,619	8,903	51.5	0.16	0.03	228,765	31.76
G	Wholesale and retail trade	22.269	1,777,411	961,865	19,776	48.6	0.15	0.03	1,367,003	71.11
H	Transportation and storage	3.054	472,378	317,617	5,525	57.5	0.14	0.03	1,051,537	60.11
I	Accommodation and food service activities	7.907	414,118	256,740	8,885	28.9	0.14	0.03	466,458	78.35
J	Information and communication	0.397	698,043	325,449	4,865	66.9	0.13	0.04	1,374,041	70.97
K	Financial and insurance activities	5.023	930,028	505,515	6,637	76.2	0.18	0.04	925,047	61.75
M, N	Other business services	17.840	1,343,732	874,366	10,753	81.3	0.15	0.04	1,056,987	50.14
Q	Healthcare	9.033	929,544	767,055	15,756	48.7	0.15	0.03	940,826	76.25
R, S	Arts, entertainment and recreation	11.153	510,096	332,260	8,142	40.8	0.15	0.05	743,230	84.53

Notes: Industry-specific probability weights are based on the number of enterprises across sectors from the OECD Structural Statistics of Industry and Services database for the year 2005. Other industry-level information is based on U.S. 2003–2005 files from EU KLEMS data. Wage bill is obtained by multiplying the number of people employed times the wage. Depr rate 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, depr rate l is the industry-specific long-term depreciation rate, that is directly provided by EU KLEMS (depreciation rate for other buildings and structures, N11OG). The last column displays the share of long-term capital in total capital.

Table 9: Transition Matrix β Before and After FAS 123R

		β post-FAS-123 in 2007									
		I 0.75-0.775	II 0.775-0.8	III 0.8-0.825	IV 0.825-0.85	V 0.85-0.875	VI 0.875-0.9	VII 0.9-0.925	VIII 0.925-0.95	IX 0.95-0.975	X 0.975-1
β pre-FAS-123 in 2005	I 0.75-0.775	**90.15**	1.01	1.55	0.97	1.35	1.21	0.53	0.58	0.19	2.46
	II 0.775-0.8	13.46	**67.01**	1.92	2.56	1.92	2.88	2.56	1.92	0.96	4.81
	III 0.8-0.825	10.59	1.81	**69.00**	3.10	3.36	2.07	2.07	3.62	1.55	2.84
	IV 0.825-0.85	7.04	1.85	3.70	**66.67**	3.89	4.44	3.70	3.15	1.30	4.26
	V 0.85-0.875	6.98	1.67	2.12	2.73	**67.69**	4.25	5.61	4.10	1.21	3.64
	VI 0.875-0.9	5.29	1.53	2.82	2.23	4.35	**65.92**	6.11	5.64	2.35	3.76
	VII 0.9-0.925	3.39	1.45	1.36	3.19	3.10	4.94	**63.6**	7.74	6.00	5.23
	VIII 0.925-0.95	3.19	0.94	1.38	2.25	2.39	3.41	5.66	**66.06**	7.76	6.96
	IX 0.95-0.975	1.80	0.50	0.87	1.49	1.61	3.10	4.34	9.06	**65.32**	11.91
	X 0.975-0.1	2.29	0.45	0.58	0.81	1.16	1.81	1.42	3.42	6.93	**81.13**

Notes: The Table reports transition probabilities for FAS-123R-induced changes in β. We group betas into ten bins each ranging 2.25 percentage points. Data is left-censored at 0.75, which applies to 14.39% of the observations. Row i displays for a β grouped in bin i the probabilities of being in bins 1-10 after the reform. Therefore, rows sum up to 100%. Diagonal entries indicate the probabilities for β being unchanged after the reform.

Table 10: Simulated Firms - Regression Results

	Investment		*Capital Stock*	
	(1)	(2)	(3)	(4)
Panel A:				
FAS123 Beta Reduced Depr	0.426***	0.426***	0.400***	0.400***
	(0.0231)	(0.0231)	(0.0199)	(0.0199)
Beta Reduced Depr	0.651	0.651	0.0341	0.0341
	(0.594)	(0.594)	(0.540)	(0.540)
FAS123 Depr	-0.0327***		-0.0380***	
	(0.00375)		(0.00458)	
Panel B:				
FAS123 Beta Pre Depr	0.716***	0.716***	0.744***	0.744***
	(0.0918)	(0.0918)	(0.0993)	(0.0993)
Beta Pre Depr	-7.420**	-7.420**	-8.018***	-8.018***
	(3.093)	(3.094)	(2.878)	(2.879)
FAS123 Depr	-0.605***		-0.641***	
	(0.0831)		(0.0917)	
Investment FE				
Investment-Year FE				
Firm-Year FE				
Observations	4,000	4,000	4,000	4,000
No. Firms	1,000	1,000	1,000	1,000

Notes: This Table reports the results on the relationship between managerial incentives and investment decisions for our simulated panel of 1,000 firms. We collapse the data into a pre- and post-reform era, where *FAS123* is a dummy variable indicating the latter period. *Beta Reduced* is defined as dummy variable which indicates if a firm experiences an actual reduction in its firm-specific β. Accordingly, *Beta Pre* is the firm-specific β in the pre-reform period. *Depr* is the measure of depreciation for the two capital goods, which is 3.28 percent for long-term capital and 14.48 percent for short-term capital. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table 11: General-Equilibrium Effects: Aggregate Results from Counterfactual Reform

Variable	Change (%)	Variable	Change (%)
Output	-0.08	Price level	0.17
Long-term investment	-0.88	Short-term investment	-0.46
Long-term capital stock	-0.97	Short-term capital stock	-0.51
Overall investment	-0.59	Overall capital stock	-0.81

Notes: The Table shows the effects of the simulated reform on a set of aggregate variables. For each variable, the effect is measured as the percentage change of the steady-state value after the reform relative to the steady-state value before the reform.

References

Abadie, Alberto, Susan Athey, Guido W. Imbens, and Jeffrey Wooldridge. When Should You Adjust Standard Errors for Clustering? NBER Working Papers 24003, National Bureau of Economic Research, Inc, 2017.

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.

Bebchuk, Lucian and Jesse Fried. Paying for Long-Term Performance. *University of Pennsylvania Law Review*, 158:1915–1960, 2010.

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

Bloom, Nicholas. The Impact of Uncertainty Shocks. *Econometrica*, 77(3):623–685, 2009.

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

Clementi, Gian Luca and Berardino Palazzo. Investment and The Cross-Section of Equity Returns. *Journal of Finance*, 74(1):281–321, 2019.

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.

Edmans, Alex, Vivian W. Fang, and Allen Huang. The Long-Term Consequences of Short-Term Incentives. CEPR Discussion Papers 12305, C.E.P.R. Discussion Papers, 2017a.

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

Fromenteau, Philippe, Jan Tscheke, and Jan Schymik. Foreign Competition and the Durability of US Firm Investments. *RAND Journal of Economics*, 50(3):532–567, 2019.

Frydman, Carola and Dirk Jenter. CEO Compensation. *Annual Review of Financial Economics*, 2(1):75–102, 2010.

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.

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

Gopalan, Radhakrishnan, Todd Milbourn, Fenghua Song, and Anjan V. Thakor. Duration of Executive Compensation. *Journal of Finance*, 69(6):2777–2817, 2014.

Gormsen, Niels and Kilian Huber. Corporate Discount Rates. University of Chicago, mimeo, 2022.

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.

Khan, Aubhik and Julia K. Thomas. Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity. *Journal of Political Economy*, 121(6):1055–1107, 2013.

Krusell, Per and Anthony A. Smith. Income and Wealth Heterogeneity in the Macroeconomy. *Journal of Political Economy*, 106(5):867–896, 1998.

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.

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.

Murphy, Kevin. Executive compensation. In **Ashenfelter, O. and D. Card**, editors, *Handbook of Labor Economics*, volume 3, Part B, chapter 38, pages 2485–2563. Elsevier, 1 edition, 1999.

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

Ottonello, Pablo and Thomas Winberry. Financial Heterogeneity and the Investment Channel of Monetary Policy. NBER Working Papers 24221, National Bureau of Economic Research, Inc, 2018.

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

Rampini, Adriano A. Financing Durable Assets. *American Economic Review*, 109(2):664–701, 2019.

Terry, Stephen J. The Macro Impact of Short-Termism. Technical Report, Boston University, mimeo, 2022.

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

Appendix

Contents

A Empirical Appendix

A.1 Sample Selection

Our empirical sample is pooled from the 1,664 firms covered in both, Compustat and ExecuComp over the sample period. From these, we exclude 700 firms that are either inactive or never reported any investment between the years 1995 and 2015 (neither in Compustat nor in FactSet). We then exclude 133 firms for which Compustat starts reporting financial information only after 2004 or for that coverage ends before 2006. This leaves our sample at 831 firms.

A.2 Economic Significance: Calculating the Increase in Refinancing Costs

Column 2 in Table 6 reveals that for option-paying firms the average depreciation rate increased by 0.93 percentage points compared to non-option-paying firms. Assuming that the durability of the capital stock of non-option-paying firms was not affected by FAS 123R, we map this relative change to an absolute number. We compute the average pre-FAS-123R depreciation rate for option-paying firms, which is 18.10% in 2004. This rate converts into a durability of $2,016$ days ($\frac{1}{0.1810}\quad 365$ days) for the capital stock. The FAS-123R-induced depreciation rate for option-paying firms is equal to 19.03% (18.10%+0.93%), which implies a durability for the firms' capital stock of 1,918 days. Therefore, FAS 123R decreased the durability of the capital stock by 98 days. Assuming an annual refinancing interest rate of 3%, this lower durability would be associated with an additional amount of interest payments of USD 8.05 for each USD 1,000 invested ($0.03\quad \frac{98}{365}\quad$ USD $1,000$).

A.3 Robustness and Additional Results

This Appendix presents several robustness analyses and additional results.

Changing Incentives around the Reform: Columns 1 and 2 of Table A.1 show that executive compensation of firms that offered shifted away from equity around the reform. Columns 3 and 4 show that the increase in restricted stock was small and insignificant for treated firms relative to untreated firms. Furthermore, columns 5 and 6 use the pay-duration measure suggested by Gopalan et al. (2014) as outcome. Pay duration for executives in treated firms fell by around 2 months.

Firm Size and Other Ex-ante Differences: Table A.2 compares treated and untreated firms. Table A.3 includes additional interactions with firm size, using assets, employment or capital stocks as a proxy for the size of firms. Table A.4 includes additional interactions with the intangible investment share, the liquidity ratio, equity volatility or current CEO pay as these were significantly different ex ante between treatment- and control-group firms.

CEO Turnover: Table A.5 replicates estimates focusing on a subsample that includes only firms with a unique CEO to show that results are not determined by CEO-turnover events. Results indicate that the effect is even more pronounced when we exclude firms where CEO turnover occurred.

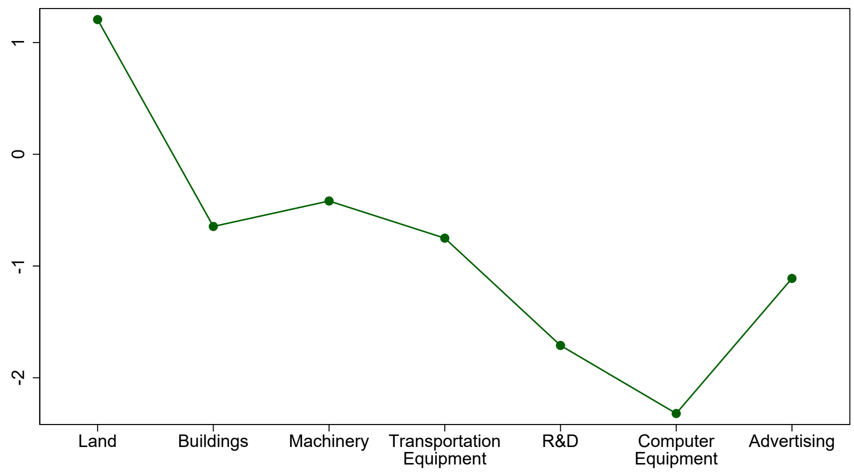
Measurement of Investments: Table A.6 shows robustness regarding the measurement of investments. It replicates our findings based on either investment rates or logarithmized investments or when missing investments are treated as 0 expenditures.

R&D Investment and Intangibles: Table A.7 shows robustness regarding the inclusion of R&D and intangibles as investment categories. It replicates results when either R&D investments are excluded or when we include interactions with a dummy that indicates intangible investment categories.

Using FAS123 as Instrument: Table A.8 shows results using the interaction between the dummy for unexercised options in 2004 and the FAS 123R timing dummy as an instrument for managerial equity ownership. The first stage coefficient confirms the expected reduction in managerial equity ownership with F-statistics of around 50 or higher. The second-stage results suggest a significant relation between lower equity ownership and a shift towards short-term investments.

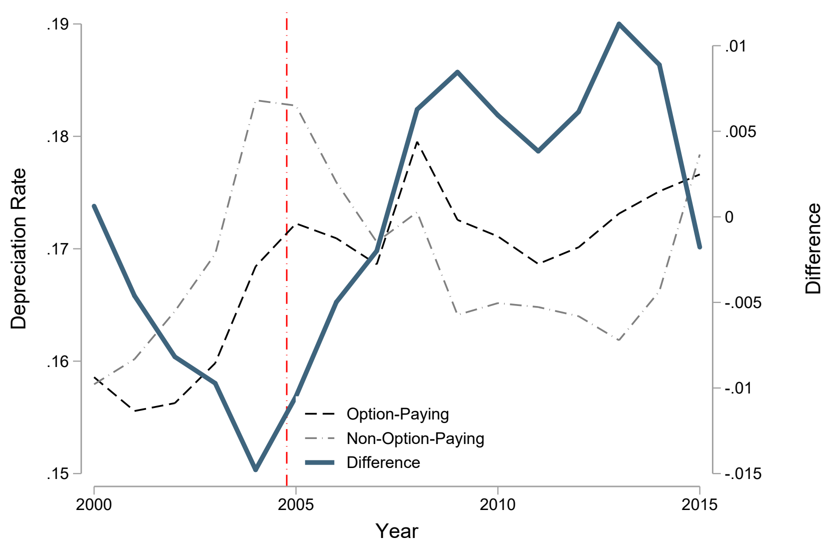
Structural Parameters: Table A.9 exploits time variation in the model-derived parameter β to study its effect on investment and firm-specific depreciation rates.

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. Fixed effects for firm-specific categories and years are included. The null hypothesis of coefficient equality across categories can be rejected at the 5%-level ($p = 0.015$).

Figure A.2: Average Firm-Specific Depreciation Rates over Time



Notes: The Figure plots the evolution of raw firm-specific mean depreciation rates for option-paying firms (black), non-option-paying firms (gray) and their difference (bold blue, right axis). Firm-specific depreciation rates are calculated as a weighted mean of category-specific depreciation rates where the weights are firms' capital stocks in the respective categories.

Table A.1: FAS 123R Accounting Reform and the Structure of Incentives

	Non-Current Compensation		Restricted Stock		Duration	
	(1)	(2)	(3)	(4)	(5)	(6)
FAS123 x Option	-0.342***	-0.363***	0.202	0.0776	-0.161*	-0.181*
	(0.114)	(0.0918)	(0.290)	(0.259)	(0.0849)	(0.0995)
Total Compensation	1.718***	1.629***	1.026***	0.905***		
	(0.106)	(0.0550)	(0.193)	(0.166)		
Year FE						
Firm FE						
Observations	3,912	9,806	3,979	9,930	3,173	6,194
No. Firms	695	699	698	699	562	567
Sample Time	2002 - 2007	2000 - 2014	2002 - 2007	2000 - 2014	2002 - 2007	2000 - 2014

Notes: The Table reports the results on the relationship between the FAS 123R reform and the structure of managerial compensation. *Option-Dummy* 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. *Non-current compensation* is the log of equity and equity-linked compensation (calculated as *TDC1 - TOTAL_CURR* in Compustat) and *Total Compensation* is the log of total compensation (*TDC1* in Compustat). *Restricted stock* is the inverse hyperbolic sine of restricted stock (*rstkgrnt* or *stock_awards_fv* in Compustat). *Duration* is the duration of executive compensation in years, computed as in Gopalan et al. (2014). Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table A.2: Summary Statistics on Treated and Untreated Firms

Variable	Option-Paying (Treated, N=553)	Non-Option-Paying (Control, 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 considered as treated if it has unexercised stock options to its management in 2004. Summary statistics correspond to 2004 values. *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 TRFD / AJEXDI) relative to the previous day. *Current CEO Compensation* is the current compensation of the CEO in thousands USD (compensation excluding equity).

Table A.3: Robustness: Incentives and the Durability of Investments - Controlling for Firm Size

	Investments					
	(1)	(2)	(3)	(4)	(5)	(6)
Firm Size Measure:	*Employment*		*Assets*		*Capital Stock*	
Measure of Depreciation:	*Ordering*	*Depreciation Rate*	*Ordering*	*Depreciation Rate*	*Ordering*	*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)
Investment-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: This Table reports the results on the relationship between managerial incentives and investment decisions. Value of total assets, capital stocks and number of employees are logarithmized and represent 2004 values. *Option-Dummy* 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. *Depr* is the measure of depreciation, following an ordinal scale in columns 1, 3 and 5, and expressed in absolute depreciation rates in columns 2, 4 and 6. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%-, and 10%-level.

Table A.4: Robustness: Incentives and the Durability of Investments - 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:	*Ordering*	*Depreciation Rate*	*Ordering*	*Depreciation Rate*	*Ordering*	*Depreciation Rate*	*Ordering*	*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)
Investment-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 Time	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007				

Notes: This Table reports the results on the relationship between managerial incentives and investment decisions. *Equity Volatility* is the annualized equity-return volatility in 2004, calculated as the standard deviation of daily stock returns multiplied by $\sqrt{252}$. *Current CEO Compensation* is the logarithmized current compensation of the CEO (compensation excluding equity) in 2004. *Option-Dummy* is a dummy that indicates if any any unexercised options are outstanding in 2004. *FAS123* takes value 0 for each year until 2005 and value 1 afterwards. *Depr* is the measure of depreciation, following an ordinal scale in columns 1 and 3 and expressed in absolute depreciation rates in columns 2 and 4. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%-, and 10%-level.

Table A.5: Robustness: Incentives and the Durability of Investments - CEO Turnover

	Investments			
	(1)	(2)	(3)	(4)
	Ordering		Depreciation Rate	
FAS123 x Option x Depr	0.0863***	0.0863***	0.855***	0.855***
	(0.0331)	(0.0331)	(0.309)	(0.309)
FAS123 x Depr	-0.0778***	-0.0778***	-0.816***	-0.816***
	(0.0280)	(0.0280)	(0.247)	(0.247)
Option x Depr	-0.128**	-0.128**	-1.195**	-1.195**
	(0.0516)	(0.0516)	(0.481)	(0.481)
Investment FE				
Investment-Firm FE				
Firm-Year FE				
Observations	5,919	5,919	5,919	5,919
No. Firms	286	286	286	286
Sample Time	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007

Notes: The Table reports the results on the relationship between managerial incentives and investment decisions. There are only firms included which have been run by the same CEO between 2002 and 2007. *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. *Depr* is the measure of depreciation, following an ordinal scale in columns 1 and 2, and expressed in absolute depreciation rates in columns 3 and 4. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table A.6: Robustness: Incentives and the Durability of Investments - Alternative Transformation of the Investment Variable

	Investments							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Transformation of Outcome:	*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)
Investment-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: This Table reports the results on the relationship between managerial incentives and investment decisions. The following transformation applies to the dependent variable y: $x/$capital stock for columns $1-2$, $y = ln(x)$ for columns $3-4$, $y = ln(x+1)$ for columns $5-6$ and missings are treated as 0s for columns $7-8$. *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. *Depr* is the measure of depreciation, following an ordinal scale in odd columns and expressed in absolute depreciation rates in even columns. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table A.7: Robustness: Incentives and the Durability of Investments - Assessing the Role of R&D and 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)
Investment FE		no				
Investment-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 Time	2000 - 2014	2000 - 2014	2002 - 2007	2000 - 2014	2000 - 2014	2002 - 2007

Notes: The Table reports the results on the relationship between managerial incentives and investment decisions. Columns 1 to 3 omit R&D investments and columns 4 - 6 additionally control for interactions between a dummy that indicates intangible investment categories (R&D and advertising), *FAS123* and *Option-Dummy*. *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. *Depr* is the measure of depreciation expressed in absolute depreciation rates. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table A.8: Equity Ownership and the Durability of Investments - 2SLS using FAS 123R

	Investments	
	(1)	(2)
Measure of Depreciation:	*Ordering*	*Dep. Rate*
Equity Share Depr	-2.840***	-18.87***
	(0.736)	(6.846)
1st Stage:		
FAS123 Option Depr	-0.0139***	-0.0144***
	(0.00168)	(0.00204)
Kleibergen-Paap F-Statistic	68.3	49.7
Investment-Firm FE		
Firm-Year FE		
Observations	28,611	28,611
No. Firms	649	649
Sample Period	2000 - 2014	2000 - 2014

Notes: The Table reports the results on the relationship between managerial equity ownership and investment decisions based on 2SLS estimates. *Equity Ownership* is the CEO's ownership share. *Depr* is the measure of depreciation, following an ordinal scale in column 1 and expressed in absolute depreciation rates in column 2. *Equity Share Depr* is instrumented with *FAS123 Option Depr*. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table A.9: Beta and the Durability of Investments/Capital Stock Depreciation

	Investments				Depr Rate
	(1)	(2)	(3)	(4)	(5)
Model	OLS		IV		OLS
			1st Stage	*2nd Stage*	
(1 β) Depr	0.281***	0.091**			
	(0.081)	(0.036)			
FAS123 Option Depr			0.046***		
			(0.004)		
(1 β)\ Depr				0.862***	
				(0.212)	
(1 β)					0.015**
					(0.006)
Investment FE					
Investment-Year FE					
Firm-Year FE					
Firm FE					
Year FE					
Observations	28,695	28,611	28,611	28,611	8,614
No. Firms	655	649	649	649	672
Sample Time	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 (12), 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 β) *Depr* with *FAS123 Option-Dummy 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. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

B Theoretical Appendix

B.1 Derivation of Managers' Optimal Behavior

Since we are interested in a symmetric equilibrium, we denote the policy function for capital as $\mathsf{K}(\mathbf{K}, \xi)$, i.e. if manager t follows this strategy profile, they will set $\mathbf{K}_{t+1} = \mathsf{K}(\mathbf{K}_t, \xi)$ when faced with a predetermined capital stock K_t. Here ξ is a simple vector collecting the parameters of the model: $\xi = (a, b, Z, \nu, \gamma, \delta_l, \delta_s, \varphi, \beta, \theta, w)$. Likewise, $\mathsf{N}(\mathbf{K}, \xi)$ denotes the policy function for N_t. Note that $\mathsf{K}(\,)$ is a vector-valued function with two outputs (one for each capital good), which in turn we denote by $\mathsf{K}_j(\mathbf{K}, \xi), j = l, s$. In particular, we denote

$$\mathbf{K}_{t+1} = \mathsf{K}(\mathbf{K}_t, \xi) := \begin{bmatrix} \mathsf{K}_l(\mathbf{K}_t, \xi) \\ \mathsf{K}_s(\mathbf{K}_t, \xi) \end{bmatrix}.$$

Under this restriction, we can represent manager t's maximization problem in a recursive way. Here, to save on notation, we drop time indices and follow a common convention in the literature: e.g., we denote by K_j the value of K_{jt} at some arbitrary point in time and by K_j' the value of $K_{j,t+1}$ for $j = l, s$. One can then use a similar approach for all other variables, in particular the current capital mix as $\mathbf{K} = [K_l\ K_s]'$ and the capital mix one period later as $\mathbf{K}'$. First, we can combine equations (7),(5) and (6) to obtain a function for the period-profits, $\Pi = \pi(\mathbf{K}, \mathbf{K}', N, \xi)$:

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

Next, the value of equity $E(\,)$ can be decomposed into current profits and a continuation value, denoted by the function $V(\mathbf{K}', \xi)$:

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

where this continuation value is given by

$$\begin{aligned} V(\mathbf{K}, \xi) &= E(\mathbf{K}, \mathsf{K}(\mathbf{K}, \xi), \mathsf{N}(\mathbf{K}, \xi), \xi) \\ &= \pi(\mathbf{K}, \mathsf{K}(\mathbf{K}, \xi), \mathsf{N}(\mathbf{K}, \xi), \xi) + \theta V(\mathsf{K}(\mathbf{K}, \xi), \xi) \end{aligned}$$

As a result, the value of the manager's remuneration is also a function of their decision according to:

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

Using these functional definitions, we can express a particular manager's optimized payoff from

(13) as

$$\Gamma^*(\mathbf{K},\xi) := \max_{(\mathbf{K}',N)} f\Gamma(\mathbf{K},\mathbf{K}',N,\xi)g \tag{B.2}$$

And similarly, the policy functions for the capital mix and labor are given by

$$(\mathsf{K}(\mathbf{K},\xi), \mathsf{N}(\mathbf{K},\xi)) := \arg\max_{(\mathbf{K}',N)} f\Gamma(\mathbf{K},\mathbf{K}',N,\xi)g$$

These policy function thus need to satisfy a set of optimality conditions. In particular, the policy function for labor can be derived analytically as

$$\mathsf{N}(\mathbf{K},\xi) = \left(\frac{bZ^{1-a-b}\left(K_l^{\nu}K_s^{1-\nu}\right)^a}{w}\right)^{\frac{1}{1-b}}. \tag{B.3}$$

This directly follows from the first-order condition

$$\frac{\partial}{\partial N}\Gamma(\ ) \overset{!}{=} 0 \quad , \quad \varphi\frac{\partial}{\partial N}\pi(\ ) \overset{!}{=} 0 \ , \quad \frac{\partial}{\partial N}\pi(\ ) \overset{!}{=} 0$$

whereas it is generally impossible to solve for analytical policy functions for the capital goods. At most, the following self-referencing characterization is possible:

$$\begin{aligned}\mathsf{K}_j(\mathbf{K},\xi) = \Bigg\{ K_j' \Bigg| \ 0 = \frac{\partial}{\partial K_j'}\pi(\mathbf{K},\mathbf{K}',N,\xi) + \beta\theta\frac{\partial}{\partial K_j}\pi(\mathbf{K}',\mathsf{K}(\mathbf{K}',\xi),\mathsf{N}(\mathbf{K}',\xi),\xi) \\ + \theta(1 \quad \beta)\sum_{k=l,s}\frac{\partial}{\partial K_j}\mathsf{K}_k(\mathbf{K}',\xi)\frac{\partial}{\partial K_k}V(\mathsf{K}(\mathbf{K}'),\xi)\Bigg\}\end{aligned} \tag{B.4}$$

To derive this condition, first note that the first-order condition can be stated as

$$\begin{aligned}\frac{\partial}{\partial K_j'}\Gamma(\ ) \overset{!}{=} 0 \\ , \ \varphi\left(\frac{\partial}{\partial K_j}\pi(\ ) + \beta\theta\frac{\partial}{\partial K_j}V(\ )\right) \overset{!}{=} 0\end{aligned} \tag{B.5}$$

The envelope condition defining $\frac{\partial}{\partial K_j}V(\,)$ is given by

$$\begin{aligned}\frac{\partial}{\partial K_j}V(\,) &= \frac{\partial}{\partial K_j}E(\mathbf{K}, \mathcal{K}(\mathbf{K},\xi), \mathcal{N}(\mathbf{K},\xi), \xi) + \sum_{k=l,s}\frac{\partial}{\partial K_j}\mathcal{K}_k(\mathbf{K},\xi)\frac{\partial}{\partial K'_k}E(\mathbf{K}, \mathcal{K}(\mathbf{K},\xi), \mathcal{N}(\mathbf{K},\xi), \xi) \\ &\quad + \frac{\partial}{\partial K_j}\mathcal{N}(\mathbf{K},\xi)\frac{\partial}{\partial N}E(\mathbf{K}, \mathcal{K}(\mathbf{K},\xi), \mathcal{N}(\mathbf{K},\xi), \xi) \\ &= \frac{\partial}{\partial K_j}\pi(\mathbf{K}, \mathcal{K}(\mathbf{K},\xi), \mathcal{N}(\mathbf{K},\xi), \xi) \\ &\quad + \sum_{k=l,s}\frac{\partial}{\partial K_j}\mathcal{K}_k(\mathbf{K},\xi)\left[\frac{\partial}{\partial K'_k}\pi(\mathbf{K}, \mathcal{K}(\mathbf{K},\xi), \mathcal{N}(\mathbf{K},\xi), \xi) + \theta\frac{\partial}{\partial K'_k}V(\mathcal{K}(\mathbf{K},\xi)\right] \\ &\quad + \frac{\partial}{\partial K_j}\mathcal{N}(\mathbf{K},\xi)\frac{\partial}{\partial N}\pi(\mathbf{K}, \mathcal{K}(\mathbf{K},\xi), \mathcal{N}(\mathbf{K},\xi), \xi)\end{aligned}$$

From optimal labor demand, it follows that $\frac{\partial}{\partial N}\pi(\,) = 0$ such that this simplifies to

$$\begin{aligned}\frac{\partial}{\partial K_j}V(\,) &= \frac{\partial}{\partial K_j}\pi(\mathbf{K}, \mathcal{K}(\mathbf{K},\xi), \mathcal{N}(\mathbf{K},\xi), \xi) \\ &\quad + \sum_{k=l,s}\frac{\partial}{\partial K_j}\mathcal{K}_k(\mathbf{K},\xi)\left[\frac{\partial}{\partial K'_k}\pi(\mathbf{K}, \mathcal{K}(\mathbf{K},\xi), \mathcal{N}(\mathbf{K},\xi), \xi) + \theta\frac{\partial}{\partial K'_k}V(\mathcal{K}(\mathbf{K},\xi)\right] \end{aligned} \tag{B.6}$$

Inserting equation (B.5) on the left-hand side and –iterated by one period– on the right-hand side of (B.6) gives equation (B.4).

Finally, by re-inserting time indices and suppressing functional dependencies, we can reformulate equations (B.3) and (B.4) to obtain labor demand and (14) in the main text.

B.2 Pseudo-General-Equilibrium Effects

To test the mechanism for robustness to general-equilibrium effects, we reuse the firm sample from our quantitative exercise (including the relevant parameters and β-transitions), and assume that the $\mathcal{N}_f = 1,000$ firms inhabit one single economy, divided into the $S = 13$ sectors from Table 8. Each sector is denoted by $s = 1,\ldots,S$, each firm by $f = 1,\ldots,\mathcal{N}_f$. For future reference, we define two mappings that link firms and their industries: firm f's sector is given by $s_f = 1,\ldots,S$ and the sector s is composed of a set of firms $F_s = ff = 1,\ldots,\mathcal{N}_f j s_f = s g$.

B.2.1 Demand

As before, we abstract from aggregate dynamics and we are only interested in the change of steady-state variables.[25] Also, as in the previous section, we use the notation x to represent a variable x's value in the current period and x' (x'') for the value of x one period (two periods) ahead.

[25] Solving the model with aggregate dynamics would, of course, be feasible, but it would be rather complicated (cf., e.g. Krusell and Smith, 1998) and it is not clear what this would add to the analysis at hand.

A competitive final goods firm produces a final consumption good Q from the sectoral inputs Q_s according to the Cobb-Douglas production function

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

Here, the ψ_s are calculated from Table 8 as the respective shares of value added that sector s contributes to total value added such that they satisfy $\psi_s \in (0,1)$ and $\sum_{s=1}^{S} \psi_s = 1$.

The corresponding aggregate price-level is thus given by

$$P = \prod_{s=1}^{S} \left(\frac{P_s}{\psi_s} \right)^{\psi_s}, \tag{B.7}$$

where P_s denote sectoral price levels. Following standard logic, each sector thus faces a demand curve

$$Q_s = \frac{\psi_s P Q}{P_s}. \tag{B.8}$$

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

$$Q_s = \left(\sum_{f \in F_s} Q_f^{\frac{\varepsilon_s - 1}{\varepsilon_s}} \right)^{\frac{\varepsilon_s}{\varepsilon_s - 1}}. \tag{B.9}$$

Here, the ε_s directly follow from our calibration exercise above. We assume that firms engage in monopolistic competition. The corresponding sectoral price level based on firms' prices P_f is thus

$$P_s = \left(\sum_{f \in F_s} P_f^{1-\varepsilon_s} \right)^{\frac{1}{1-\varepsilon_s}}. \tag{B.10}$$

Consequently each firm f in sector s faces the following demand:

$$Q_f = P_f^{-\varepsilon_s} P_s^{\varepsilon_s} Q_s. \tag{B.11}$$

Note how this equation compares to (4): we can now deduce that in each sector, the demand shifter is given by

$$B_s = P_s^{\varepsilon_s} Q_s.$$

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 Firm Behavior

The problem of the firm is still the same as in the partial-equilibrium setup. We only need to add the respective firm and industry subscripts to the various variables in equations (3)–(14).

For concreteness, we restate these here, dropping time indices and adding subscripts f and s: At a sectoral level, we have the following parameters:

$$a_s = \alpha_s \frac{\varepsilon_s - 1}{\varepsilon_s} \tag{B.12}$$

$$b_s = (1 - \alpha_s)\frac{\varepsilon_s - 1}{\varepsilon_s} \tag{B.13}$$

In addition, the following relations characterize each firm's behavior:

$$Q_f = \widetilde{Z}_f \left(K_{lf}^{\nu_s} K_{sf}^{1-\nu_s}\right)^{\alpha_s} N_f^{1-\alpha_s} \tag{B.14}$$

$$Q_f = B_s P_f^{-\varepsilon_s} \tag{B.15}$$

$$R_f = P_f Q_f \tag{B.16}$$

$$= Z_f^{1-a_s-b_s} \left(K_{lf}^{\nu_s} K_{sf}^{1-\nu_s}\right)^{a_s} N_f^{b_s} \tag{B.17}$$

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

$$\Pi_f = R_f - C_f^K - w_s N_f \tag{B.19}$$

$$E_f = (1-\eta_{b,f})\Pi_f + \frac{1}{1+r}\mathsf{E}\left\{(1-\eta_{e,f})E'_f\right\} \tag{B.20}$$

$$\Gamma_f = \eta_{b,f}\Pi_f + \eta_{e,f}E_f \tag{B.21}$$

$$\varphi_f := \eta_{b,f} + \eta_{e,f}(1-\eta_{b,f}), \tag{B.22}$$

$$\beta_f := \frac{\eta_{e,f}(1-\eta_{b,f})}{\eta_{b,f} + \eta_{e,f}(1-\eta_{b,f})}, \tag{B.23}$$

$$\theta_f := \frac{1-\eta_{e,f}}{1+r} \tag{B.24}$$

$$N_f = \left(\frac{b_s Z_f^{1-a_s-b_s}\left(K_{lf}^{\nu_s} K_{sf}^{1-\nu_s}\right)^{a_s}}{w_s}\right)^{\frac{1}{1-b_s}} \tag{B.25}$$

$$0 = \frac{\partial \Pi_f}{\partial K'_{jf}} + \beta_f\theta_f \frac{\partial \Pi'_f}{\partial K'_{jf}} + \theta_f(1-\beta_f)\sum_{k=l,s}\frac{\partial K''_{kf}}{\partial K'_{jf}}\frac{\partial}{\partial K''_{kf}}V_f(\mathbf{K}''_f,\xi'_s) \tag{B.26}$$

Note that now, the continuation value $V_f(\cdot)$ also depends on ξ_s, which is a vector containing the sector-wide and aggregate variables, i.e. $\xi_s = (B_s, w_s, r)$. $V_f(\cdot)$ is now given by

$$V_f(\mathbf{K}_f, \xi_s) := \Pi_f + \theta_f V_f(\mathbf{K}'_f, \xi'_s).$$

B.2.3 Factor Markets

Regarding the labor market, we deviate from the partial-equilibrium calibration before and assume a fixed homogeneous labor supply per household $\bar{N}$ which we treat as numéraire. This means the nominal wage across industries is fixed at $w_s = w = 1$ and the real wage is given by

$$w_{real} = \frac{w}{P} = \frac{1}{P}.$$

Since we assume that capital is owned by the firm and there are capital adjustment costs, we need an assumption how this investment is produced. For simplicity, we assume that capital goods are produced using only labor as an input and that the adjustment of capital goods also only requires labor as an input.[26]

I.e., the overall labor demand of firm f is given by

$$\bar{N}_f = N_f + \sum_{j \in \{l,s\}} I_{jf} + \gamma \left(\frac{K'_{jf}}{K_{jf}} \quad 1 \right)^2 K_{jf}, \tag{B.27}$$

where $I_{jf} = K'_{jf} \quad (1 \quad \delta_{js}) K_{jf}$ is the firm's gross investment in capital goods of type j.

B.2.4 Equilibrium

The economy is inhabited by a continuum of ex-ante homogeneous households (of measure 1). In every period, each household is endowed with $\bar{N} = 1$ units of labor that is inelastically offered on a competitive labor market in order to generate income w. Households are assumed to hold equity only indirectly via a competitive mutual fund. In each period, a single household ('manager') is randomly chosen to manage any given 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. We further assume time-separable, homothetic preferences with respect to consumption of a final good, as well as complete markets. This means we do not need to track the distribution of wealth and income to infer aggregate demand dynamics. On a related note, we do not impose any restrictions on how households distribute the Γ_f. In particular, it could be that managers just amass more wealth or that they use an insurance mechanism to distribute managers' income across all households.

[26]One could, of course, also assume that investment goods are produced using the final good, which would allow for input-output relationships to become important. For the sake of simplicity and comparability to the partial-equilibrium setup, we abstract from that. A side benefit is that this way, since both q_l, q_s and w are fixed, the firm is really only linked to the aggregate economy via the demand shifter B_s. This simplifies calculations a lot because the firm's operations scale one-for-one with the the demand shifter. Hence, when solving the model, each firm's problem has to be solved exactly once, and then its chosen quantities only need to be rescaled in order to guarantee market clearing in the aggregate.

For aggregate consumption C in any steady state, we thus end up with a simple relationship: all labor income $w \;\; 1$, managers' remuneration Γ_f and the remaining dividends of firms $\Pi_f \quad \Gamma_f$ (where Π_f is the operating profit of firm f) are used to fund final consumption. Hence, we have

$$C = \sum_{f=1}^{\mathcal{N}_f} [\Gamma_f + (\Pi_f \quad \Gamma_f)] + w = \sum_{f=1}^{\mathcal{N}_f} \Pi_f + w.$$

Since we treat labor as numéraire, this becomes

$$C = \sum_{f=1}^{\mathcal{N}_f} \Pi_f + 1. \tag{B.28}$$

To close the model, we impose market clearing on both, goods and labor markets which implies

$$C = \mathsf{Q} \tag{B.29}$$

$$1 = \sum_{f=1}^{\mathcal{N}_f} \bar{N}_f. \tag{B.30}$$

Limitations: Before moving on, it is important to note a few caveats in our general-equilibrium analysis. We abstract here from firm entry or exit, endogenous technological change and input-output relationships which all could certainly alter some aspects of the quantification. We also still treat the remuneration packages as exogenous. However, since we are interested in the effects of changes in remuneration packages per se, we thus consider this to be a reasonable assumption

B.2.5 Experiment

The experiment we conduct in this general-equilibrium setting is very much akin to the one reported for the partial-equilibrium case in the main text. The firms have the same parameterization as before. The only differences are that $w = 1$ for all firms and that the sectoral demand shifter is endogenous and adapts to ensure that the labor-market-clearing condition holds. Since we abstract from aggregate dynamics here (otherwise the solution algorithm would be a lot more involved), we focus on a steady-state comparison taking the observed changes due to FAS 123R as a permanent 'shock'.

B.2.6 Discussion

The quantified aggregate output drop equals 8 basis points in the general-equilibrium setting, compared to the 50 basis points in the partial-equilibrium setting. Besides differences in sectoral wages, the partial-equilibrium analyses plot means of normalized firm values which cannot be used for the aggregate adjustments in general equilibrium since here, the size differences across firms matter as well. Thus, the behavior of the normalized aggregate variables presented in Table 11 rather resembles the one of a normalized mean *across* firms in the economy. To isolate the general-equilibrium feedback, we therefore also consider a scenario, where we shock the βs but keep B^{ind} constant such that we are still in a partial-equilibrium setting but with homogeneous wages fixed at 1. If we apply this to our sample and consider the same output measure as in the partial-equilibrium setting from before, firms' output shrinks by 0.61% on average which is substantially closer to the 0.50% obtained in the partial-equilibrium analysis with sectoral wage data. In general equilibrium, this overall effect on average firm output is then mitigated in absolute terms due to factor-market competition. Here, firms' output shrinks on average by 0.29% due to the reform. In contrast, if we take size differences across firms into account, the (fictitious) average firm sees its output decrease by 0.42% in the partial-equilibrium setting, whereas the average firm in general equilibrium has an output decrease of 12 basis points. The general-equilibrium effects at the aggregate level are thus broadly in line with the behavior of the fictitious average firm that we studied in partial equilibrium. However, since consumers substitute demand away from short-termist firms, the effect on aggregate output is about one third smaller (8 versus 12 basis points) compared to the output change for the average firm.

C Parameterization and Solution Method

C.1 Remuneration Package

As we have derived in Subsection 3.1, for the purpose of our analysis we treat β as a structural parameter which is determined solely by the bonus share η^b and the equity share η^e (see Equation (12)). Both parameters can be directly inferred from the data relying on different sources which have been widely used in the literature. For η^b, we directly obtain the amount of bonus from Execucomp. Furthermore, due to 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 can be found in the *Plan-Based Awards* (*PBA*) file. This reclassification of bonuses is stressed by Hayes et al. (2012) and we follow their approach. In a next step we scale the amount of bonus with the sales of the firm (obtained from Compustat), i.e. $\eta^b = \frac{\text{Bonus+Non-eq-Targ}}{\text{Sales}}$. For the equity share 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. $\eta^e = \frac{\text{Firm-related Wealth}}{\text{Market Capitalization}}$. We winsorize each parameter $\eta_{b/e}$ at the top and bottom 1%. In a final step, we calculate β by applying Equation (12). In Table A.10, we provide summary statistics on the key parameters η^b, η^e and β for our sample.

Table A.10: Summary Statistics on Incentive Contracts

Variable	Mean	Std. Dev.	Min	p25	p50	p75	Max	Obs	Sample
η_b	0.0004028	0.001502	0	0.00004668	0.0001468	0.0003854	0.1242	16,320	2005 & 2007
η_e	0.007922	0.02142	0.00001916	0.0007241	0.001946	0.005445	0.1898	16,320	2005 & 2007
β	0.9033	0.0840	0.7500	0.8393	0.9281	0.9758	1	16,320	2005 & 2007

Notes: The Table reports summary statistics on the bonus share η_b, the equity share η_e and β, which is calculated by applying Equation (12).

C.2 Other Parameters

Discount Factor: Given the parameters derived above, it would be straightforward to obtain $\theta = \frac{1-\eta^e}{1+r}$. Since we draw individual η^e values for each firm, θ would vary across firms, and thus the entire calibration would differ. To avoid this, for the calibration of parameters, we assume $\theta = \frac{1}{1+r}$, i.e. we here neglect the dilution factor. In the exercise reported in the main text, we, however, include η^e.

For r, we use the real interest rate for the United States from the year 2005, which was 2.981% according to World Bank (2020). While the definition of the proper discount factor is an important ongoing discussion, in our model it seems justifiable to take the (safe, apart from inflation risk) real interest rate as a benchmark since we abstract from both, growth and risk.[27]

Production Function: We take δ_s, δ_l, R, $\frac{K_l}{K_l+K_s}$, $\frac{K_l}{R}$, $\frac{wN}{R}$, and w directly from the sectoral data.

Then, for $\beta = 1$, the steady-state conditions given in the main text can be re-arranged so as to yield direct expressions for the remaining parameters. Combining the two FOCs of individual capital goods, we get

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

[27]The choice of r merits some discussion: in the US, around the time of the reform, the real interest rate fluctuated between a high of 6.845% in 2000 and a low of 1.137% in 2011. This happened against the background of an overall downward trend since the 1980s, which was overlaid between 2005 and 2007 by contractionary monetary policy. Over the years 2000–2009 the (geometric) average real interest rate in the US was about 3.677%, but for the years 2010–2019 it has fallen to 1.996%; between 2003 and 2008 the figure was 3.309%. It's thus not entirely clear which value one should choose as a steady-state value. However, our results would not change much if we used a different value for r. For private businesses, the discount factor should take into account risk premia (related to, inter alia, idiosyncratic uncertainty and the financing structure of the firm), and thus be smaller. On the other hand, due to technological progress and the growth of the overall economy, a firm should expect the demand shifter as well as its TFP to change over time, changing the size of the firm. I.e., if we reinterpret our model's steady state as a balanced growth path with growth rate g and with the variables of the model properly detrended, the firm's discount factor would effectively be $\theta = \frac{(1-\eta^e)(1+g)}{(1+r)}$, which effectively increases the discount factor. Thus, our measure of the discount factor will most likely be either too high or too low. In fact changing θ (thus, also changing r) has a somewhat similar effect as changing β, per se.

Given ν, we can solve the first-order condition of the long-term capital good for a as

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

Likewise, b directly follows from optimal labor demand as

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

This allows us to recover ε and α from

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

Finally the scaling parameter B^{ind} can be fixed using the labor demand as well as the production function, which then yield

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

Note that our assumptions so far imply that firms within an industry have the same parameters, apart from *TFP*, θ, and the remuneration package.

C.3 Sensitivity Analysis

C.3.1 Adjustment Costs

As we have noted before, the adjustment-cost parameter γ also affects the steady state because it alters the slope of the value function and consequently also the policy functions, whenever $\beta < 1$. To study the sensitivity of our results with respect to different values of γ, we either consider a value of γ that equals half its original value ($\underline{\gamma}$) or twice its original value ($\overline{\gamma}$).

Changing γ affects both, the resulting steady-state levels of capital goods and the dynamic response to a change in β. Concerning the steady state, the effect of a change in β is muted with $\overline{\gamma}$. Both capital goods fall by roughly one fifth less in response to a given reduction in β in steady state. Alternatively, capital goods fall by approximately one fifth more in steady state with $\underline{\gamma}$. This also changes the composition of steady-state capital stocks, although only relatively mildly. For example, consider a firm that experiences a reduction in its β from 1 to some lower value. If the firm faces low adjustment costs $\underline{\gamma}$ the fall in the share of long-term capital in total capital is roughly one fourth larger compared to the case with original adjustment costs. In contrast, if the firm faces high adjustment costs $\overline{\gamma}$, the share of long-term capital is less responsive and its fall is diminished by about one fourth. Considering the dynamic impact, we also see very intuitive results. When adjustment costs are higher, firms take longer to reach the new steady state and vice versa. To sum up, higher adjustment costs make capital stocks (and their composition) more rigid, in the sense that they become less responsive to changes in β.

C.3.2 Complementarity of Capital Goods

In the main analysis, we consider a Cobb-Douglas production function which implies that the elasticity of substitution between the capital goods equals one ($\sigma_k = 1$) such that both goods are independent from each other. Here, we consider the sensitivity of our results with respect to perturbations of σ_k. A first intuition is that the closer substitutes the two capital goods are ($\sigma_k \to \infty$), the stronger the differential impact of a change in β should be. On the contrary, the more the two types of capital are complements ($\sigma_k \to 0$), the weaker a differential impact one would expect. While this intuition is correct for most perturbations of σ_k, it comes with one caveat: with perfect substitutes, we are in a knife-edge case. For a range of β values, the firm then fully invests in only one type of capital. Consequently, there will be no within-firm reallocation for certain values of β in the limit $\sigma_k \to \infty$.

In our sensitivity analysis, we consider the range $\sigma_k \in [\underline{\sigma}_k = 0.5, \overline{\sigma}_k = 2]$ and find that our results did not qualitatively change as a drop in β still induces a decline in overall investment and a relative shift between the two capital goods. With $\underline{\sigma}_k$, this effect is weakened by roughly one half which is due to long-term capital falling less and short-term capital falling more than in the Cobb-Douglas case. With $\overline{\sigma}_k$, the effect is increased by about one half.

C.4 Numerical Solution Method

To illustrate the solution method, we continue with the notation introduced in the previous section. Since the labor decision in the problem above is simply determined by the first-order condition (B.3), we can write per-period operating profits as a function of $\mathbf{K}, \mathbf{K}'$ only by defining:

$$\pi^*(\mathbf{K}, \mathbf{K}', \xi) = \max_N \{\pi(\mathbf{K}, \mathbf{K}', N, \xi)\}. \tag{B.31}$$

Importantly, this function satisfies

$$\frac{\partial}{\partial K_j'}\pi^*(\mathbf{K}, \mathbf{K}', \xi) = \frac{\partial}{\partial K_j'}\pi(\mathbf{K}, \mathbf{K}', N, \xi), \quad j = l, s.$$

The optimization problem of the manager can be re-stated in recursive form as

$$\Gamma(\mathbf{K}, \xi) = \max_{\mathbf{K}'} \{\pi^*(\mathbf{K}, \mathbf{K}', \xi) + \beta\theta V(\mathbf{K}', \xi) \tag{B.32}$$

$$\text{s.t. } V(\mathbf{K}', \xi) = \pi^*(\mathbf{K}', \mathcal{K}(\mathbf{K}', \xi), \xi) + \theta V(\mathcal{K}(\mathbf{K}', \xi), \xi)\}. \tag{B.33}$$

Here, the future policy function $K(\ )$ is defined as

$$K(\mathbf{K}, \xi) = \arg\max_{\mathbf{K}'} f \pi^*(\mathbf{K}, \mathbf{K}', \xi) + \beta\theta V(\mathbf{K}', \xi) g. \tag{B.34}$$

Note that we assume that this policy function is time-invariant which results from our focus on symmetric strategies.

Next, to keep the notation concise, define the gradient of a function $f(K, \xi)$ in terms of elements of K to be given by

$$r_{\mathbf{K}} f(\mathbf{K}, \xi) = \left[\frac{\partial f(\mathbf{K}, \xi)}{\partial K_l} \ \frac{\partial f(\mathbf{K}, \xi)}{\partial K_s} \right]'.$$

We use similar notation for functions with multiple inputs, and the index of r gives the input the gradient applies to. Then, the first-order conditions (B.5) can be stated as

$$r_{\mathbf{K}'} \pi^*(\mathbf{K}, \mathbf{K}', \xi) = \quad \beta\theta\, r_{\mathbf{K}'} V(\mathbf{K}', \xi). \tag{B.35}$$

From (B.31), we can derive

$$\begin{aligned} r_{\mathbf{K}'} \pi^*(\mathbf{K}, \mathbf{K}', \xi) &= \quad r_{\mathbf{K}'} C^K(\mathbf{K}, \mathbf{K}') \\ &= \quad \begin{bmatrix} \gamma \left(\frac{K_l'}{K_l} \quad 1 \right) + 1 \\ \gamma \left(\frac{K_s'}{K_s} \quad 1 \right) + 1 \end{bmatrix}. \end{aligned}$$

That is, in terms of any capital good, we obtain a first-order condition

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

Note that this can be readily solved for K_j:

$$K_j = \frac{K_j'}{1 + \frac{\frac{\partial V}{\partial K_j'}(\mathbf{K}', \xi) - 1}{\gamma}}. \tag{B.36}$$

Equation (B.36) is the central ingredient in the endogenous grid method we apply. This method is best described by algorithm 1 below.

Essentially, we start with a set of G gridpoints $\tilde{K}' = (\tilde{\mathbf{K}}_h')_{h=1,\dots,G}$, which represent different outcomes of $\mathbf{K}'$, and an initial (differentiable) guess $\hat{V}_0(\ )$ for $V(\ )$. By differentiating $V(\ )$, we get the gradient at each point in $\tilde{K}'$. Then applying the backward induction step in (B.36), we can solve for the optimal solution of the previous manager. Next, we update our guess for the continuation value function $V(\ )$ according to the profit function and our current guess. One then iterates on this until convergence is achieved.

We implement this algorithm as MATLAB code (tested against MATLAB R2018b and R2020a), which can be found in the replication package.

The figures in this paper are based on a sample of 1,000 firms with idiosyncratic parameter draws 30-by-30 in the (K_l', K_s')-space. The coordinates of the gridpoints correspond to Chebyshev nodes in a range around the steady state with $\beta = 1$, (which can be computed analytically). To be precise, the grid ranges from 0.3 to 1.2 of the analytical steady state of that parameterization. As an interpolation scheme $\rho(\,)$ we opt for Chebyshev polynomials up to degree 10 in either dimension.[28] 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.

Finally, to specify an initial guess for the value function, we follow the following procedure: initially, we consider with a model where β was set to 1, for which a steady state can be derived analytically. As an initial guess of the value function, we simply assumed that the model would converge uniformly to that steady state within a certain period. 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 1,000 (differently parameterized) firms in the sample.

[28]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 a computationally expensive exercise and 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.

Algorithm 1: Version of EGM used in the model solution

Set i_{max} as well as convergence thresholds $\bar{\epsilon}^v, \bar{\epsilon}^{invp} > 0$ for the continuation value and inverse policy, respectively. Pick a parameter vector ξ, a set of gridpoints $\tilde{K}' = (\tilde{\mathbf{k}}'_g)_{g=1,\dots,G}$, an initial guess for each of these points, i.e. $\hat{V}_{0,g}$ for $g = 1, \dots, G$, and an interpolation scheme $\rho(x, X, Y)$ to be used. Find interpolated values $v_0(\mathbf{K}) = \rho(\mathbf{K}, (\mathbf{k}'_g)_{g=1,\dots,G}, (\hat{V}_{0,g})_{g=1,\dots,G})$.

Set $continue$=true. set 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 $\tilde{v}_g = \Pi(\mathbf{k}_{i,g}, \mathbf{k}_g, \xi) + \theta \hat{V}_{i-1,g}$.
- Find interpolant $v_i(\mathbf{K}) = \rho(\mathbf{K}, (\mathbf{k}_{i,g})_{g=1,\dots,G}, (\tilde{v}_g)_{g=1,\dots,G})$.
- **for** g=1,...,G **do**
  - Set $\hat{V}_{i,g} = v_i(\mathbf{K}_g)$.
  - Set $\epsilon^v_{ig} = \left| \frac{\hat{V}_{i,g}}{\hat{V}_{i-1,g}} \quad 1 \right|$.
  - Set $\epsilon^{invp}_{jig} = \left| \frac{k_{j,i,g}}{k_{j,i-1,g}} \quad 1 \right|$.
- **if** $\max_{g\in(1,\dots,G)} f \epsilon^v_{ig} g < \bar{\epsilon}^v$ *and* $\max_{j\in(l,s), g\in(1,\dots,G)} f \epsilon^{invp}_{ig} g < \bar{\epsilon}^{invp}$ **then**
  - Set $continue$=false.
- **else**
  - Set i=i+1;

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

Modification in the Pseudo-General-Equilibrium Exercise: If we want to use the previous algorithm in a general-equilibrium environment, we need to take into account that each firm now also takes aggregate state variables into account. These include in our framework the two aggregate capital stocks, or more precisely their distribution across all active firms. In the related literature with heterogeneous agents or firms (e.g., Krusell and Smith 1998, Khan and Thomas 2013), the distribution of capital across agents or firms becomes an important state variable, which is an infinitely-dimensional object with infinitely many firms or agents and thus needs to be approximated. In our simulated sample, we only use a finite number of firms (1,000) but accounting for this we would still have a 2,000-dimensional state variable for capital goods alone (1,000 firms 2 capital goods). Since we are not interested in the dynamics per se, we can simplify matters a lot by only focusing on aggregate steady states.

When the economy at large is in a steady state, we can use our algorithm from before to solve for each single firm. Note that the only aggregate variable relevant for the firm's problem is the industry-level demand shifter B^{ind}. It is straightforward to show that this shifter proportionally scales the scale of the firm. To make this more precise, the policy function now depends on the demand shifter as well as on parameters ξ:

$$\mathbf{K}' = \mathsf{K}\left(\mathbf{K}, B^{ind}, \xi\right). \tag{B.37}$$

Notably, it can be shown that the policy functions scale with the demand shifter as follows:

$$\mathsf{K}(\mathbf{K}, B^{ind}, \xi) = B^{ind} \quad \mathsf{K}\left(\frac{1}{B^{ind}}\mathbf{K}, 1, \xi\right). \tag{B.38}$$

From this, we can directly infer that the steady-state capital stock of the firm directly scales with B^{ind}.

The firm affects the general equilibrium through its factor choices, its output Q_f and its price level P_f. Notably, while a firm's steady-state output Q_f is directly proportional to B^{ind} its price in steady state is fully determined by technology and the relative composition of its factor choices. We have just argued that the entire policy function is scaled up or down by B^{ind} and as a a result, B^{ind} does not affect the relative composition of its factor inputs in steady state. I.e., the steady-state price level of the firm is independent of macroeconomic outcomes. This allows us to solve for the pseudo-general-equilibrium solution in a simple way. For each firm, we can simply solve the firm's problem for an arbitrary B^{ind} and obtain the firm-level steady state. From now on, we only refer to steady-state values of all variables. We can do this exercise for our entire sample of firms, $f = 1, \ldots, 1,000$. As a result, we have a steady-state price level P_f for each firm. The resulting steady-state price level can be used to infer sectoral and aggregate price levels P_s, P using (B.10) and (B.7). From (B.8), it is possible to show that the demand shifter in any sector is then proportional to aggregate demand Q times a function purely dependent on the pricing choices of all firms. As a result, also the quantity produced by any firm, and ultimately factor choices are simply proportional to aggregate demand.

Thus, to derive general equilibrium, we simply obtain all the relevant price levels.

Using (B.8) and (B.11), we can obtain

$$Q_f = \psi_s P_f^{-\varepsilon_s} \mathsf{P}_s^{\varepsilon_s - 1} \mathsf{P} \mathsf{Q}, \tag{B.39}$$

i.e., the output of any firm and hence its factor demand is proportional to aggregate demand.

Here, since prices are fully determined by parameters and firms' incentive structure, we get

$$Q_f = p_f \mathsf{Q}, \tag{B.40}$$

where $p_f = \psi_s P_f^{-\varepsilon_s} \mathsf{P}_s^{\varepsilon_s - 1} \mathsf{P}$ does not depend on Q. From the firm's individual problem, we can derive a steady-state ratio of total labor used to output produced as $n_f = \frac{\bar{N}_f}{Q_f}$, which again is independent of Q. Total labor demand is then given by

$$\bar{N} = \sum_{f=1} \bar{N}_f = \sum_{f=1}^{\mathcal{N}_f} (n_f p_f) Q.$$

Q directly follows by imposing market clearing on the labor market. We then scale each firm accordingly, taking into account p_f and n_f.