Capital (Mis)allocation and Incentive Misalignment

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Abstract

This paper studies the impact of managerial incentives on the allocation of capital. We provide empirical evidence that short-termist incentives cause capital misallocation within firms, using a within-firm estimator and a US accounting reform as an exogenous shock to managers' incentives. Managers shift investments towards more short-lived assets, effectively reducing the durability of firms' capital stocks. We then build a model of firm investments with incentive frictions that we calibrate to the US economy. Our outcomes imply that the pass-through from incentives to investments is large: more short-termist incentives raise wedges between the marginal products of capital goods, causing declines in output and real wages.

Keywords: Corporate investment, Firm dynamics, Capital reallocation, Short-term incentives
JEL: E22, G31, D24, D25, L23

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1 Introduction

Economists have long claimed that management is key in explaining the large and persistent differences in productivity levels across businesses (Syverson 2011, Bloom and Van Reenen 2007). In this paper, we study one specific channel how managers shape firm performance by investigating within-firm misallocation of capital caused by distorted managerial incentives.

While many durable investment goods have a life span of several years, typical CEO compensation schemes of public US firms feature much shorter vesting periods of the different CEO pay components.[1] When the private marginal products of capital goods that decision-makers in firms face do not match the social marginal products of capital, this can lead to capital misallocation within firms. The mismatch between the horizon of managers' incentives and the durability of firms' assets suggests that there is a risk that managers opt for investment policies that are substantially biased towards more short-term investment goods as these have a shorter time to pay off. Consequently, economic output would be larger if capital expenditures were reallocated away from the capital goods with a shorter life span towards more durable capital goods. Furthermore, when managers systematically face short-termist incentives and do not invest sufficiently into long-term assets, this can be impedimental for aggregate growth.

We approach this topic in two ways. First, we provide empirical evidence on the existence of such a within-firm misallocation channel caused by short-termist incentives. Second, we develop a dynamic model of firm investments with incentive frictions that rationalizes our empirical results and that we calibrate to the US economy to quantify the economic impact of this misallocation channel.

In the first part of the paper, we provide reduced-form empirical evidence by exploiting the introduction of the FAS 123 accounting reform in the US as a quasi-natural experiment. This change in accounting rules effectively raised the opportunity costs of more durable executive compensation, causing a shorter horizon of managerial incentives in treated firms. We exploit this reform and combine it with a within-firm estimator that identifies variation across investment goods that differ in their life span to show that more short-term incentives cause capital misallocation inside businesses. To empirically study the changing investment composition inside firms, we use data on the population of stock-listed firms in the US. Listed firms disclose investment expenditures across different asset categories such that we can exploit variation in durability across asset groups to distinguish between short- and long-term investments, similar to Garicano and Steinwender

[1] Gopalan et al. (2014) find an average duration of CEO pay of about 1.5 years, computed as the weighted average of the vesting periods of the different components of executive pay including salary, bonus, stocks and options. Following on that, a duration of 1.5 years would correspond to a depreciation rate of 66.7% which by far exceeds the estimates of capital depreciation rates from the literature (see e.g., Nadiri and Prucha 1996).

(2016) or Fromenteau et al. (2019). Combining these data on firm investments in land, buildings, machinery, transport equipment, R&D, computer equipment and advertising with information on compensation practices allows us to measure how incentives affect the capital allocation within firms.

The main identification challenge in this empirical exercise is that both, compensation practices and investment policies are endogenous firm choices. We address the endogeneity of compensation packages by studying firms around the revision of accounting rule FAS 123 in the year 2005. This revision – effective for US public companies after 2005 – abolished an accounting advantage of option-based employee compensation and thereby raised the relative costs of equity-linked compensation to the benefit of monetary bonuses (see Hayes et al. 2012). The accounting reform prohibited companies to expense option compensation to employees at its intrinsic value such that firms were obliged to expense option compensation at fair value after the revision took effect. Additionally, the Financial Accounting Standards Board (FASB) allowed firms to accelerate unvested options to fully vest prior to the compliance date, further increasing short-term incentives. We document that firms which offered option-based compensation to their management prior to the reform and thus were subject to treatment, shifted compensation towards less durable compensation parts such as higher salaries or bonuses after the accounting reform compared to other firms.[2] This shift in the compensation structure of CEOs reduced the durability of CEO compensation as measured by Gopalan et al. (2014).

We find that the reform-induced increase in short-term managerial incentives caused a wedge in investment expenditures. Firms that were subject to more short-term managerial incentives shifted investment expenditures towards assets with a shorter life span compared to other firms. Our within-firm estimator – comparing investment expenditures across categories for treated and untreated firms around the introduction of the accounting reform – allows us to estimate a statistically and economically significant effect of incentives on investment policies. Moreover, we document that the observed changes in investment policies tilt capital stocks towards more short-term capital and increase firm-specific depreciation rates. Compared to untreated firms, treated firms invest 6% more into capital goods with a 10 percentage points higher depreciation rate. This shift towards more short-term assets is reflected in a 1.58 percentage-point increase of firm-specific depreciation rates causing substantial refinancing costs related to this decrease in the durability of capital stocks.

We then develop a model of firm investments that we quantify to evaluate the impact of short-termist incentive distortions on within-firm misallocation and economic outcomes. Our model

[2]This is consistent with Hayes et al. (2012) who document such a shift of compensation around the introduction of FAS 123R in a setting that is not based on difference-in-differences variation but on overall pay variation over time.

builds on the neoclassical model of dynamic firm investments, similar to the models in Bond and Van Reenen (2007), Cooper and Haltiwanger (2006), Hsieh and Klenow (2009) or Bloom (2009), and we extend it in two dimensions. First, we introduce a decision-maker that faces monetary incentives from a compensation package that is composed of a fixed salary, a bonus component based on current profits and a share of total equity similar to Nikolov and Whited (2014). The larger is the equity share of firm value that accrues to the decision-maker, the closer her incentives are aligned with value maximization.[3] Second, we introduce two types of capital that differ in their durability, measured by different depreciation rates, in the spirit of Aghion et al. (2010) or Rampini (2019). Both types of capital are subject to convex capital adjustment costs and firms combine capital and labor to produce output. We show analytically that such a compensation package based on bonuses and equity induces investment short-termism as the decision-makers' optimization problem mirrors quasi-hyperbolic preferences (i.e. quasi-geometric discounting) which implies time inconsistency. These time inconsistencies in our model are driven by a too strong focus on current profits induced by the combination of bonus payments and equity ownership.[4]

We use our model to quantify the economic effects of managerial incentives on capital misallocation within firms and carry out an evaluation of FAS 123R in this regard. 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 and then simulate the effects of an unexpected, persistent shock to decision-makers' incentive structure that resembles the empirical variation around the accounting reform. 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 (see Krusell and Smith 2003 and Maliar and Maliar 2005, 2016). As suggested by Maliar and Maliar (2016), we adapt the method of endogenous gridpoints (Carroll 2006) to solve for dynamic firm behavior. Using this method, we are able to compute the implied effects of the reform on various firm-level variables and compare them to a counterfactual scenario without a change in managerial incentives. Even though the accounting reform had a moderate effect on managerial compensation structures (managers' long-term incentives fell on average by 3%), we find that the pass-through from changes in incentives to changes in investment behavior is substantial. Our quantification shows that firms respond to the reform with a short-run cut in investments consistent with the empirical findings by Ladika and Sautner (2019) who report a reform-induced investment cut in the years after the implementation of FAS 123R. Importantly, this investment

[3]We do not derive the form of optimal contracts but instead approximate contracts that we observe in the data and that may or may not be optimal. This approach allows us to identify the effects of changing contract features on firms' investment policies.

[4]Time inconsistencies from hyperbolic discounting have been studied in the context of consumption-saving problems (see e.g. Laibson 1997). Furthermore, the corporate finance literature has also suggested that myopic decision-making can lead to suboptimal equilibria (see e.g. Stein 2003).

cut is asymmetric across capital goods and the drop in long-term investments is substantially larger which tilts the within-firm allocation of capital toward short-term capital goods. These model-implied investment responses are quantitatively similar to their empirical counterparts and cause a substantial rise in within-firm capital misallocation – the average difference in the rates of return across capital goods increases by 3.7 basis points. This within-firm shift in the capital mix away from the social optimum increases short-run profits but lowers long-run profits by 0.2% on average. In a general-equilibrium extension, we find that this change in incentives lowered real wages by 0.2%.

Policy-makers, 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 relates to other papers studying the origins of short-term behavior and its consequences for corporate decisions and the aggregate economy. We contribute to that literature by identifying a specific microeconomic channel – short-termist incentive distortions – causing misallocation of capital inside firms leading to aggregate output losses. Our paper most closely relates to Terry (2017), who shows that short-termist managerial pressures from investors can lower investment and aggregate growth. On the theoretical side, models by Bénabou and Tirole (2016) and Garicano and Rayo (2016) formulate managerial short-termism as an intertemporal version of a multitasking model in which agents must choose between projects that maximize short-term objectives versus projects that maximize long-run objectives. 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. We rely on these ideas in our investment model by letting decision-makers solve an intertemporal optimization problem with the choice between two types of capital with different durabilities.

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 short-termism in the context of the FAS 123R accounting reform. Asker et al. (2014) provide evidence 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, Midrigan and Xu 2014, David and Venkateswaran 2019 or Peters 2018).

The remainder of the paper is structured as follows. In the following Section, we present empirical evidence on the effect of incentive distortions on capital (mis)allocation. Section 3 quantifies these effects based on our model of firm investments. Finally, Section 4 concludes.

2 Empirical Evidence on Incentives and Capital Allocation

This section provides empirical evidence how changes in managers' financial incentives distort investment decisions and affect the allocation of capital within firms. Since financial incentives are chosen endogenously, our identification strategy exploits the revision of the FAS 123 accounting standard in the US and we study how reform-induced changes in incentives distorted the investment behavior of publicly traded firms.

2.1 Data

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.[5] We further 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).

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 the current CEO in the year before the reform (2004) and construct the following three proxies for treatment eligibility: a dummy indicating if the executive was awarded any stock option (*option dummy*), the share of an executive's stock option awards in his total current compensation (*option per TDC*) and his position in the respective distribution (measured in quintiles). We then merge

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

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.[6]

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. The relatively high standard deviation and the large heterogeneity in expenditures per category do not only reflect differences in the investment pattern across firms but also imply lumpiness on the firm level as it is well documented in the literature (see e.g. Doms and Dunne 1998). 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, 74% of CEOs were awarded stock options and about a third of total CEO compensation falls to option grants. Thus, awarding stock options is a widely and strongly used method in CEO compensation.

2.2 Empirical Strategy

This Section outlines our empirical strategy. We describe how the revision of FAS 123 changed managerial incentives towards the short term. In our main analysis, we then examine how this reform-induced increase in short-term incentives affected the investment behavior around the reform.

2.2.1 Reform of FAS 123: Changes in Accounting Rules for Equity Payments

To study the causal effect of short-term incentives on the allocation of capital, 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 reason 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 compensation to employees at its intrinsic value, i.e. the difference between the stock price on

[6]See Appendix A.1 for a comprehensive and detailed description of the variables used in the empirical analysis.

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 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.

There are two channels how FAS 123R has shortened the horizon of incentives for option-paying firms. First, as the costs of equity compensation increase, firms might want to substitute towards other forms of incentive compensation such as paying bonuses on profits. As profits are inherently more short-term than equity value, this distorts incentives towards the presence. 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).

2.2.2 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 affected by the reform to the investment behavior of unaffected firms during the time span around the revision of FAS 123 in 2005. We consider all firms that compensated their CEOs with 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 where $invest_{ict}$ denotes a measure of investments by firm i in investment category c at time t:

$$invest_{ict} = \beta_1 \times FAS123R_t \times X_{i,2004} \times \delta_c + \beta_2 \times X_{i,2004} \times \delta_c + \lambda_{it} + \lambda_{c/t} + \varepsilon_{ict}. \tag{1}$$

Our sample includes firms' expenditures on seven investment categories c: advertising, computer equipment, R&D, transportation equipment, machinery equipment, buildings and land. 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 accounting reform. This parameter is the coefficient of the triple interaction $FAS123R_t \times X_{i,2004} \times \delta_c$, where $FAS123R_t$ 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 – depending on specification – measures whether firms granted options to its CEO (baseline specification) or measures the total amount of options granted, both during the pre-reform year 2004. 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.

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 $\lambda_{c/t}$ contains fixed effects for either investment categories c or for category-year fixed effects ct. 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.

Since investments are lumpy in their nature, we transform investment expenditures using the inverse hyperbolic sine function $invest_{ict} = \operatorname{arsinh}(I_{ict}) = \ln\left(I_{ict} + \sqrt{I_{ict}^2 + 1}\right)$ in our baseline estimations. This has the advantage that we include zero investments in our estimations while we get for large investment expenditures $\operatorname{arsinh}(I_{ict}) \to \ln 2 + \ln I_{ict}$ such that the interpretation is almost identical to a log regression. Alternatively, we also estimate (1) with logarithmic transformations or consider the Box-Cox transformation instead of using the inverse hyperbolic sine function.

2.2.3 The Effects of the FAS 123 Reform on Incentives

We begin our empirical analysis by illustrating that the reform indeed induced a shift of the compensation structure towards more short-term compensation for treated firms based on a difference-in-differences estimation. As documented by Hayes et al. (2012), the structure of CEO compensation changed substantially around the adoption of FAS 123R. For example, firms reduced the value of equity-linked compensation after the revision and increased bonus compensation at the same time. As described in the previous Subsection, we split our sample into a treatment and a control group where the former includes all firms that have granted stock options in the pre-reform year and the latter comprises all the remaining firms, respectively.[7] After having merged remuneration data provided by BoardEx with our firm-investment panel, we calculate for each firm a manager-specific measure of bonus payments by scaling the amount of bonus paid with total compensation. For the equity share we divide all equity linked compensation by total compensation. In addition, to better capture the term structure of compensation schemes and therefore to give a more nuanced view of how FAS 123R created short-term incentives for option-paying firms, we also construct a measure of manager compensation duration in the spirit of Gopalan et al. (2014), which explicitly accounts for the payout horizon of each compensation component separately.[8]

Our empirical results in Table 3 reveal that the reform led to a shift in the CEO compensation structure for our treated sample firms. Compared to non-option-paying firms, we find that treated firms reduced equity-based compensation by about 13 percentage points after the reform was introduced. Furthermore, these firms raised bonus compensation by about 6 percentage points.[9] We argue that this shift of compensation away from equity-linked compensation towards other parts of incentive compensation has contributed to a rise in short-term managerial incentives as bonuses are not tied to underlying long-term equity prices but rather to more current profits. This view is further supported when we focus directly on the duration of compensation packages in Table 4. The estimates suggest that the CEOs of treated firms experienced an average reduction in their compensation duration due to the FAS 123 reform by almost 2 months compared to CEOs of untreated firms. Furthermore, CEOs with more durable compensation structures prior to the reform experience larger cuts in compensation duration post reform.

2.3 Main Results

Tables 5 to 7 present our main results of estimating Equation (1), showing the effects of the reform on firm investments. Table 5 outlines the results of the regression analysis when we use

[7]This difference-in-differences approach is where we deviate from Hayes et al. (2012) who study the average effect of FAS 123R on compensation components using panel regressions. Given that our identification strategy outlined in Section 2.2.2 is based on differences in investment practices across firms, which differ by their exposure to the reform, we are interested in the differential adjustment in the firms' compensation structure in response to the reform.

[8]That is, duration d of firm i at time t is calculated as $d_{it} = \frac{(bonus_{it}+salary_{it})\cdot 0+\sum_{j=1}^{N}(Restr.stock_{ijt}+options_{ijt})\cdot\tau_j}{(salary_{it}+bonus_{it})+\sum_{j=1}^{N}(Restr.stock_{ijt}+options_{ijt})}$ where τ_j is the vesting period of equity-based component j.

[9]Hayes et al. (2012) find an average increase in the bonus share of around 3% around the reform.

the option dummy as treatment variable $X_{i,2004}$. This binary treatment divides our sample into two groups: the treatment group of firms with management affected by the reform and the control group whose management should be 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 depreciation. Moreover, we include firm-year fixed effects as well as either category or category-year fixed effects. It should be noted that the interaction term of the FAS 123R dummy and the depreciation rate is absorbed by these category-year fixed effects. Standard errors are clustered at the firm-level following Abadie et al. (2017).

In the first two columns, we use a simple ordering of categories as a measure of depreciation which follows the ordering of depreciation rates and ranges from 1 (land) to 7 (advertising). 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 can infer that our coefficient of interest is positive and significant at the 5%-level in column 1 when we use the ordinal ranking as a measure of asset depreciation. When we include fixed effects at the category-year level in column 2 to control for aggregate trends in certain investment categories, the coefficient of interest hardly changes. In columns 3 to 6 we then assign depreciation rates as a measure of asset depreciation. Again, we estimate a positive coefficient of interest which is significant at the 5%- or 1%-level.[10] This suggests that reform-induced shifts in incentives cause a relative shift in investments towards more short-term assets. Quantitatively, the coefficient suggests that treated firms shift about 6% more investment to a category with a 10 percentage point higher depreciation rate compared to non-option-paying firms (columns 3 and 4). This result remains robust for an extended time period around the reform between 2000 and 2014 (column 5) or when we include firms from the utility, financial and public administration sectors into the sample (column 6).

Next, we use the option share in total compensation as continuous treatment variable $X_{i,2004}$ in Table 6. Also with the continuous treatment, results suggest that more affected firms shift more investment towards short-lived categories after the accounting reform. Furthermore, we group firms into quintile spells based on their respective position in the option share distribution and run bin regressions to capture non-linear effects within $X_{i,2004}$. Results are reported in Table 7. Again, our coefficient of interest is positive and significant throughout all specifications. The average investment wedge, measured as shift to a ten percentage points higher depreciation rate investment category, equals 1.8% for two adjacent quintiles in our most stringent specification (column 4). This result remains robust for different time horizons and sample sizes (column 5 and 6). To provide evidence that the sign of the average effect is not driven by skewness or

[10] Results also remain robust to including fixed-effects at the firm-category level.

outliers of a specific quintile, we also estimate the impact of FAS 123R on the investment mix for each quintile separately by interacting the FAS 123R dummy and the depreciation rate measure with a set of five dummy variables (one for each quintile of $X_{i,2004}$). The left graph in Figure 1 plots these five coefficients and illustrates that the distortion towards more short-lived investment categories increases monotonically across quintiles. We can also reject the null hypothesis that the coefficient estimate for the first and the fifth quintile are similar at the 5%-significance-level. Overall, by exploiting the accounting reform, we are able to document that exogenous increases in short-termist incentives induce more short-termist oriented investment decisions.

As a next step, we are going to study if the common trend assumption is likely fulfilled in our empirical setting. If option-paying and non-option-paying firms experience different time trends in their investments even without the accounting reform, we would wrongly attribute the observed investment wedge to the exogenous accounting reform. To rule this out, we regress investment expenditures on the interaction between annual dummies, depreciation rates and the option dummy. The right graph in 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 year after the reform. Until 2005 the coefficient of the investment wedge is relatively constant and close to zero which suggests that investment patterns did not systematically differ across treatment and control firms. After 2005 the coefficients then unambiguously shift into positive terrain, remaining at that positive level until the end of our sample. The slight fluctuations between 2007 and 2010 are likely to be driven by turmoils around the Global Financial Crisis. 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.

Since we considered gross investments as dependent variable so far, the observed relative increase in short-term investments could principally 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 logarithmized 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 8 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 ten percentage point higher depreciation rate by 5.2% compared to non-option-paying firms.

Related to that, we further provide evidence that the firm-specific depreciation rate of treated firms went up by the introduction of FAS 123R. To assess this, we construct a depreciation rate for each firm-year based on the relative size of each firm's category-specific capital stocks. Figure

2 plots the mean depreciation rate for option-paying firms, non-option-paying firms as well as their difference. While depreciation rates move in parallel until 2004, depreciation rates of option-paying firms fall less than those of non-option-paying firms do, leading to a non-trivial difference between those two groups of firms. Comparing the pre- with the post-FAS-123R depreciation rates suggests that the difference in depreciation rates increased by about 2 percentage points. We then use these firm-year-specific depreciation rates as the dependent variable and run firm-level difference-in-differences regressions. The results in Table 9 reveal a substantial cut in the durability of the capital stock for treated firms. Quantitatively, the depreciation rate on the average capital stock of option-paying firms increased by 1.58 percentage points compared to the control group. Ceteris paribus, this decrease in the durability of the capital stock imposes substantial costs on the affected firms. Besides the risk that these firms might suffer from productivity losses due to suboptimal factor composition, firms would have to spend more to retain the same level of capital stock as before the reform.[11] We quantify these extra cost burdens by calculating the additional financing costs required to match the level of the pre-FAS-123R capital stock. Materialized in additional interest payments, we obtain an amount of USD 15.29 per USD 1,000 invested for the affected firms.[12]

In Table A.10 of the Appendix, we also report empirical evidence on the misallocation effect of incentives based on a model-derived measure of short-term incentives as an alternative to the reduced-form estimates presented here.

2.4 Alternative Channels and Robustness Checks

Firm Size and Other Ex-ante Differences: In Table A.2, we compare treated and untreated firms. Treated firms are larger in terms of assets, employment and capital stock, their equity is less volatile and they also pay more to their CEOs (in terms of current compensation). We illustrate that the change in investment behavior was particularly caused by differences in managerial incentives and not by those potentially confounding factors. In principle, larger firms might invest in a different way than their smaller counterparts. In case there is an event in 2006 which affects the investment policy of large firms only, we would run into an omitted variable problem and fail to identify the true relationship between managerial incentives and investment decisions. Equivalently, higher uncertainty – proxied by equity volatility – could incentivize firms to invest more short-term. By explicitly controlling for these confounding factors in Tables A.3 and A.4, we are able to rule out these additional channels. We run regressions where we allow for two groups of

[11] Given that FAS 123R affects investment decisions via distorted managerial incentives and has no direct impact on the production side of the firm, we argue here that this shift exacerbated effective factor usage.

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

interaction terms, one including the treatment variable $X_{i,2004}$ and the other including a potential confounding factor. As proxies for firm size, we use the log of employment, assets or the value of capital stock in Table A.3. The results in Table A.3 show that the described additional channel via differences in firm size is not present. 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 0.595 (Table 5, column 4) falls slightly to 0.564 when considering employment, to 0.586 when considering assets and to 0.584 when considering the capital stock with similar levels of significance. In Table A.4, we show that our effects also remain significantly positive after accounting for ex-ante differences in equity volatility or current CEO pay. Controlling for equity volatility suggests that firms that face more uncertainty also shifted investments towards more short-term assets while the triple interaction with the level of current CEO pay turns out to be insignificant.

Pre-Trends: In order to evaluate if pre-trends are a concern for our analysis, we conduct a placebo test based on the assumption that the reform was implemented in earlier years. In Table A.5, we estimate the investment distortions if the reform was implemented in 2002, 2003, 2004 or 2006 instead of in 2005. We do this by shifting the treatment variable $X_{i,t}$, the FAS 123R dummy and the sample window. We do not expect these estimates to be significantly different from zero if our baseline estimates identify investment distortions that are specifically caused by FAS 123R. Indeed, the coefficients that identify the investment distortions are insignificant in the placebo treatments.

CEO Turnover: In general, it might be possible that investment decisions are CEO-specific and that incentives related to career concerns also matter. 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.6 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. The results in Table A.6 indicate that the effect is even more pronounced when we exclude firms where CEO turnover occurred. The coefficient of interest almost doubles in size and is estimated with higher precision.

Measurement of Investments: We provide additional empirical evidence that our results do not depend on a specific transformation of the explained investment variable $invest_{ict}$. Instead of applying the inverse hyperbolic sine function to investment expenditures, we run regressions using a log and a Box-Cox transformation in Table A.7 that reveals similar results. We also run robustness checks where we either include negative investments in the analysis or set them to zero. The results remain qualitatively the same, the effect becomes even stronger when we include negative investments (see Table A.8).

R&D Investment and Intangibles: If investments into structures cannot be directly compared with investments into intangibles, this could be an identification threat. In our baseline analysis, we classify intangible investments such as R&D or advertising as rather short-term. While this is internally consistent with neoclassical models of firm investment or calculated average depreciation rates (see Li and Hall 2020), this view is at odds with endogenous growth models where R&D creates ideas which are cumulative. Moreover, intangibles can be subject to different capitalization rules than structures under US GAAP rules. We address these concerns in Table A.9. In the upper panel of the Table, we omit R&D expenditures. Excluding R&D expenditures slightly increases the magnitude of our estimated coefficient of interest. In the lower panel of the Table, we explicitly control for differences between tangible and intangible investments by adding interactions between a dummy for intangible categories (R&D and advertising), $FAS123R_t$ and $X_{i,2004}$. Controlling for intangible categories also increases the coefficient of interest.

3 Quantitative Analysis

We now present a model of firm investments that rationalizes how the shift in compensation structure towards more bonus payments and away from equity ownership affects investments. 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 total equity. 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. Both types of capital are subject to convex capital adjustment costs.

3.1 Model

Production: Consider a firm that uses a set of two capital inputs $\mathbf{K}_t = [K_{lt}, K_{st}]$ and labor inputs N_t. 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

$$Q_t = \widetilde{Z}F(\mathbf{K}_t, N_t) = \widetilde{Z}\left(K_{lt}^{\nu}K_{st}^{1-\nu}\right)^{\alpha} N_t^{1-\alpha}, \tag{2}$$

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

$$Q_t = BP_t^{-\varepsilon}, \tag{3}$$

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

$$R_t = P_t Q_t = Z^{1-a-b}\left(K_{lt}^{\nu}K_{st}^{1-\nu}\right)^{a} N_t^{b}, \tag{4}$$

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:[13]

$$\frac{\gamma}{2}\left(\frac{K_{jt+1}}{K_{jt}} - 1\right)^2 K_{jt}, \quad j \in \{l, s\}.$$

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

$$C_t^K = \sum_{j \in l,s}\left[\gamma\left(\frac{K_{jt+1}}{K_{jt}} - 1\right)^2 K_{jt} + q_j\left(K_{jt+1} - (1-\delta_j)K_{jt}\right)\right], \tag{5}$$

with q_j as the unit price of capital good j.

Since we will perform partial-equilibrium analyses in what follows, we treat aggregate variables as

[13]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.

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

$$\Pi_t = R_t - C_t^K - wN_t. \tag{6}$$

Compensation and Incentives: 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.[14] 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 the following remuneration structure for the manager: total remuneration 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 $E_t^m = \eta_e E_t$:

$$\Gamma_t = w_t^f + b_t + E_t^m. \tag{7}$$

This particular structure of remuneration packages highlights the core mechanism at hand: a part of remuneration depends on current (short-term) profits, while another part is linked to long-term 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.[15] 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 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.[16]

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

[15] 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.

[16] The fact that equity-based compensation can lead to share dilution is a well known fact in finance (see, e.g.,

With complete markets and rational expectations, equity then is valued as

$$E_t = (1-\eta_b)\Pi_t - w_t^f + \frac{1}{1+r}\mathbb{E}_t\left\{(1-\eta_e)E_{t+1}\right\}, \tag{8}$$

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

$$E_t = (1-\eta_b)\left[\Pi_t + \sum_{\tau=1}^{\infty}\left(\frac{1-\eta_e}{1+r}\right)^{\tau}\mathbb{E}_t\left\{\Pi_{t+\tau}\right\}\right] - \sum_{\tau=0}^{\infty}\left(\frac{1-\eta_e}{1+r}\right)^{\tau}\mathbb{E}_t\left\{w_{t+\tau}^f\right\}. \tag{9}$$

Using (9), we can rewrite the value of the manager's remuneration package as

$$\Gamma_t = w_t^f - \eta_e\sum_{\tau=0}^{\infty}\theta^{\tau}\mathbb{E}_t\left\{w_{t+\tau}^f\right\} + \varphi\left[\Pi_t + \beta\sum_{\tau=1}^{\infty}\theta^{\tau}\mathbb{E}_t\left\{\Pi_{t+\tau}\right\}\right], \tag{10}$$

where we define

$$\varphi := \eta_b + \eta_e(1-\eta_b), \tag{11}$$

$$\beta := \frac{\eta_e(1-\eta_b)}{\eta_b + \eta_e(1-\eta_b)}, \tag{12}$$

$$\theta := \frac{1-\eta_e}{1+r}. \tag{13}$$

The term $w_t^f - \eta_e\sum_{\tau=0}^{\infty}\theta^{\tau}\mathbb{E}_t\left\{w_{t+\tau}^f\right\}$ captures the manager's fixed wage and the wage payments of her successors. This term is exogenous to the manager's decision problem such that we may ignore it in the following. This simplifies the model further such that we can consider managers' remuneration packages given by

$$\Gamma_t = \varphi\left[\Pi_t + \beta\sum_{\tau=1}^{\infty}\theta^{\tau}\mathbb{E}_t\left\{\Pi_{t+\tau}\right\}\right]. \tag{14}$$

Decision-Making: As the remuneration package is represented in (14) an interesting property becomes apparent. The payout profile 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. Furthermore, managers' optimization problem in period t_0 inherently depends on the expected behavior of their successors in future periods and the behavior of a

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.

current manager directly affects the feasible set of outcomes of its immediate successor. Essentially, different generations of managers play a dynamic game with one another: each manager chooses a factor mix $(\mathbf{K}_{t+1}, N_t)$ to maximize her own remuneration taking into account previous managers' decisions and expectations regarding future behavior. We focus on Markov-perfect equilibria with stationary, smooth strategies, where each manager's decision only depends on her inherited capital stock.

Deriving the demand for the freely adjustable factor labor is straightforward and yields

$$N_t = \left(\frac{bZ^{1-a-b} \left(K_{lt}^{\nu} K_{st}^{1-\nu} \right)^a}{w} \right)^{\frac{1}{1-b}}. \tag{15}$$

Equation (15) gives a standard labor demand relation equating marginal costs and the marginal revenue product of labor.

In the presence of capital adjustment costs, it is not possible to analytically solve for the policy functions regarding the capital goods. However, 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:[17]

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

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 (16) takes into account 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 costs of adjusting the respective capital stocks), 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

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

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 (7) 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, it still is a fairly stylized simulation since we abstract from other factors that typically vary over time and affect investment decisions as well. One of these abstractions is risk-aversion. While being 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 risk. In that sense, the results that we obtain from the counterfactual analysis of the calibrated model could be seen as some lower bound of reform-induced capital misallocation. Furthermore, we 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 reform-induced change in convexity had little impact on CEOs' risk-taking behavior.[18] 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

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

that takes price effects into account. This general-equilibrium extension, however, comes at the cost that we have to abstract from aggregate dynamics such that we only compare steady-state equilibria.

3.2 Model Quantification

Equipped with our model, we aim to quantify the effects of short-termist incentives on the capital allocation of firms and economic outcomes. In order to do that, we calibrate the model to match certain features of public US companies and industry characteristics before the introduction of FAS 123R. We then assume there is an unexpected shock to β in a way consistent with what we observe in the data around the reform.[19] 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).[20]

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 firm wealth by their employing firms' market capitalization.[21] We then discretize the distribution of β into ten bins varying from 0.75 to 1.0 in steps of size 0.025. Table 11 provides the observed transition probabilities across bins, the changing distribution of β is plotted in Figure 3. 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 2.8 percentage points 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, 69.4% of firms remain in the same bin for β, while 19.7% move to a bin with a higher

[19] 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.

[20] See Table 10 for an industry overview and Appendix C for a detailed description on the construction of firm-specific compensation packages.

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

value for β and 10.9% 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.10 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 $FAS123R_t \times X_{i,2004}$ 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 of our random sample 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 firm's overall business conditions Z is composed of a industry-wide demand condition $B = B^{ind}$ and a firm-specific TFP $\tilde{Z} = Z^{firm}$ according to

$$Z = (B^{ind})^{\frac{1}{\varepsilon}} (Z^{firm})^{\frac{\varepsilon-1}{\varepsilon}}.$$

For each industry, we use the values for value added as a proxy for the revenue of the firm,[22] 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 10. Each firm is characterized by a vector of 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.[23]

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 adopt the following approach and calibrate these values to the benchmark case $\beta = 1$.[24] Then, the steady-state version of the Euler equation (16) can be simplified to

$$1 = \theta \left(MPK_j + 1 - \delta_j \right), \quad j = l, s, \tag{17}$$

[22] 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.

[23] 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 Section C.2 in the Appendix.

[24] 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.

where the marginal products of capital are given by

$$MPK_l = a\nu Z^{1-a-b} K_l^{a\nu-1} K_s^{a(1-\nu)} N^b \tag{18}$$

$$MPK_s = a(1-\nu) Z^{1-a-b} K_l^{a\nu} K_s^{a(1-\nu)-1} N^b. \tag{19}$$

The steady-state version of (15) is given by

$$wN = bZ^{1-a-b} K_l^{a\nu} K_s^{a(1-\nu)} N^b. \tag{20}$$

Conditions (17)–(20), together with the revenue function (4) can be used to pin down four parameters: the revenue-productivity shifter Z, the capital share α, the share of durable capital goods in total capital ν and the demand elasticity ε. For the calibration, we use the average firm in an industry with $Z^{firm} = 1$. Using this, we can reformulate the steady-state conditions (17)–(20) as well as Equation (4) in the following way:

$$\begin{aligned}
R &= \left(B^{ind}\right)^{1-a-b} K_l^{a\nu} K_s^{a(1-\nu)} N^b \\
1 &= \theta \left(a\nu \frac{R}{K_l} + 1 - \delta_l \right) \\
1 &= \theta \left(a(1-\nu) \frac{R}{K_s} + 1 - \delta_s \right) \\
b &= \frac{wN}{R}.
\end{aligned}$$

We then calibrate the parameters $B^{ind}, \alpha, \nu, \varepsilon$ 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.[25]

The individual scaling factor Z^{firm} is drawn from an idiosyncratic 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).[26] In particular, as the general-

[25]Note, that we use a sector's value added as a proxy for R. Also, remember: $a \equiv \alpha(1-1/\varepsilon)$ and $b \equiv (1-\alpha)(1-1/\varepsilon)$.

[26]In the case without adjustment costs ($\gamma = 0$), a simple equilibrium is straightforward: since managers' utility

ized 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 based on our simulated data. Table 12 reports estimates using the simulated sample of firms. Note that in contrast to the empirical sample, these data only contain two distinct types of capital. Furthermore, the treatment indicators used in the estimations here is either a dummy indicating whether the firm experienced a reduction in β or the continuous value of β in the pre-reform period. Even though we did not target the coefficient estimates in the parameterized version of the model, we find the magnitude of the reform-induced investment distortion to be very similar compared to the empirical counterparts. When using the dummy as treatment indicator in columns 1 and 2 of Panel A, we obtain a coefficient of 0.426 which almost equals the counterpart based on the empirical sample (0.595 in columns 3 and 4 of Table 5). In the two subsequent columns of Panel A, we consider the respective capital stocks as dependent variable and thereby replicate the reduced-form regressions from Table 8 (columns 3 and 4). The coefficients of interest from both regressions are of similar magnitude here as as well. In columns 1 and 2 of Panel B, we then use the continuous treatment variable and again find coefficients of similar size compared to the empirical counterparts given in Table 6 (columns 3 and 4). Given this relatively close replication of the empirical estimates, we feel confirmed that our calibration approach is suitable to quantify the effects of the accounting reform on production, investment and capital misallocation. As already mentioned in the previous Subsection, we also report evidence showing that empirical variation in β is associated with within-firm capital misallocation. Results are presented in Table A.10 of the Appendix.

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 (16) for each capital good $j \in \{l, s\}$ simplifies to

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

Within-Firm Adjustments: In a next step we use our simulated firm panel to analyze the dynamic within-firm adjustments in response to the reform. These are depicted in Figure 4. The upper graphs in the Figure plot investments into short- and long-term capital goods, normalized by their respective capital stocks. Firms respond to the reform with a short-run drop in investments in both capital goods. This cut in investment is consistent with empirical findings by Ladika and Sautner (2019) who report a reform-induced investment cut in the years directly following the introduction of FAS 123R. As expected, the results show that this cut in investments is asymmetric across investment goods. Our results deviate from the previous literature in this respect since our model captures heterogeneity in investment categories. Consistent with our empirical findings presented in Section 2 before, the reform causes a distortion in investments across assets with different life span. While short-term investments are 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 lower left graph of Figure 4 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.

In order to make a statement on the economic relevance of such a relatively mild shift in the within-firm capital stock composition, 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

$$MPG_t = |MPK_{st} - MPK_{lt}|, \tag{21}$$

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 lower right 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 triggered by the rather small reform-induced shift in incentives 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 (lower left graph). The within-firm wedge in the rates of return across capital goods increases in the long-run by about 3.7 basis points (lower right graph).

Firm-Level Effects: Next, we consider the firm-level effects of the reform which we illustrate in Figure 5. The upper left graph in the Figure 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 graphs 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 higher investment ratio in the long-run 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. Nevertheless, gross investment falls in the aggregate leading to a reduction in the firms' total capital stock by around 1.1% on average, which is illustrated in the upper right graph in Figure 5.

We then quantify the effects of the within-firm capital misallocation channel on economic output and profits. Based on the underlying Cobb-Douglas production function (2), economic output falls by about 0.5% on average. Due to the homogeneity of the production function, the partial-equilibrium decline in employment is similar to the output change. When considering profit changes in the graph at the lower right, a short-run spike in profits by about 0.3% on average becomes evident. This short-run profit spike is driven by the sudden cut in investments. Profits then decline in the long-run by 0.2% on average as the within-firm capital stocks and the capital mix shift 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 (2017) who finds that short-termist incentives cost 6% of output in the long-run. Compared to this finding, the impact of the FAS 123 reform on output is indeed substantial, even though its direct effect on incentives has been moderate.

Capital Misallocation across Firms: 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 Figure 6, 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 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, ceteris paribus, firms are more unevenly endowed with short- and long-term capital after the reform.

Robustness to General-Equilibrium Effects: We next study to what extent the previous partial-equilibrium 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.[27]

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 13, 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 causing 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

[27] 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.

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.

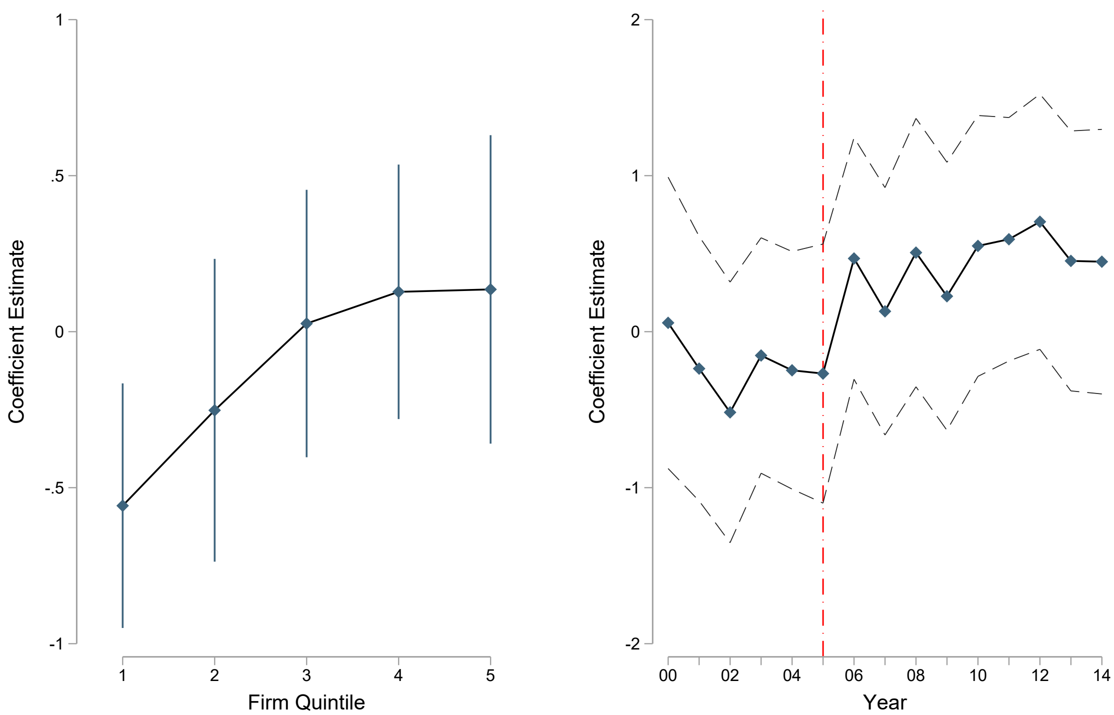
4 Conclusion

In this paper, we studied how short-termist managerial incentives affect the allocation of capital inside firms. Using the 2005 revision of the FAS 123 accounting statement as a quasi-natural experiment, we provided empirical evidence showing that affected firms systematically shifted investment expenditures towards less durable assets in response to a shift towards more short-term managerial incentives. To quantify the impact of such incentive distortions on output, investment and 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 even relatively small deviations in incentives away from long-term compensation schemes like those induced by the accounting reform 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 and real wages. The results imply that corporate decision-makers' incentives are very crucial when designing economic policies - such as the considered accounting reform - as managers react very sensitively to changes in their incentive schemes. Disregarding those aspects in policy reforms can substantially effect economic welfare.

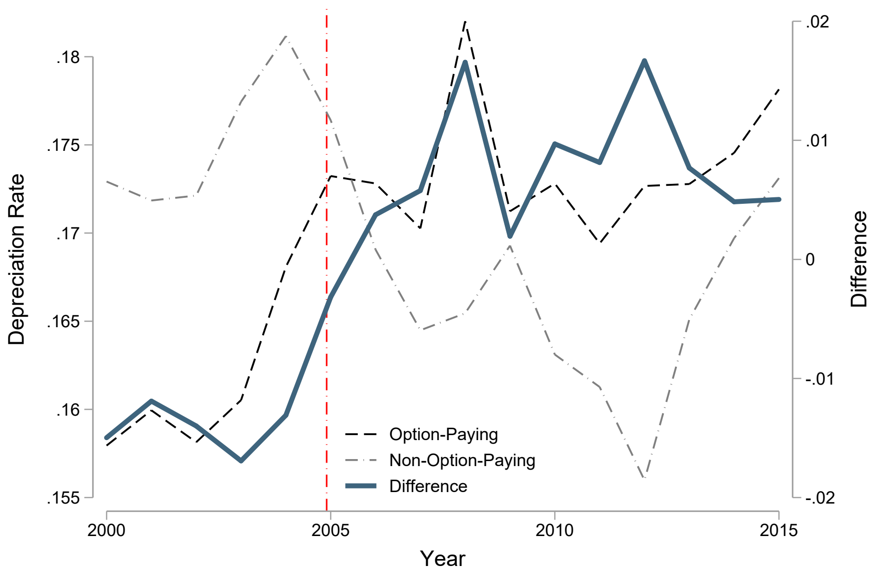
There are several future directions for this work to reduce the adverse economic effects of managerial short-termism. One direction could be to study the scope of income taxation to incentivize managers to act more long-term. Another direction of research could be to study the role of employment duration in compensation contracts to guide managerial behavior.

Figure 1: Investment Wedges by Treatment Quintiles and Years



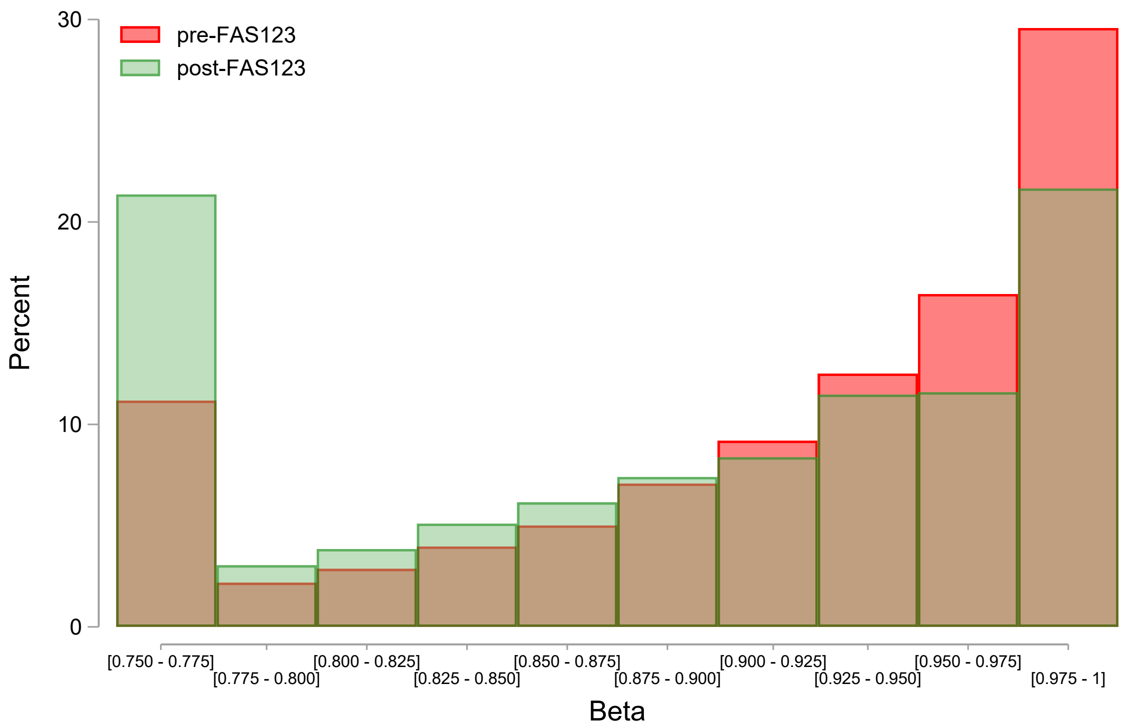
Notes: The left graph in the Figure plots jointly estimated quintile-specific coefficients when investments are regressed on the FAS 123R dummy interacted with quintile dummies and depreciation rates. Firm-year and category fixed effects are included, standard errors are clustered at firm-level. Dashed lines illustrate 95% confidence intervals. The null hypothesis of coefficient equality at the bottom and the top quintile can be rejected at the 5%-level ($p = 0.032$). The right graph in the Figure plots time-specific coefficients when investments are regressed on the interaction between an option dummy with year dummies and depreciation rates. Firm-year and category-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 ($p = 0.008$).

Figure 2: Average Firm-Specific Depreciation Rates over Time



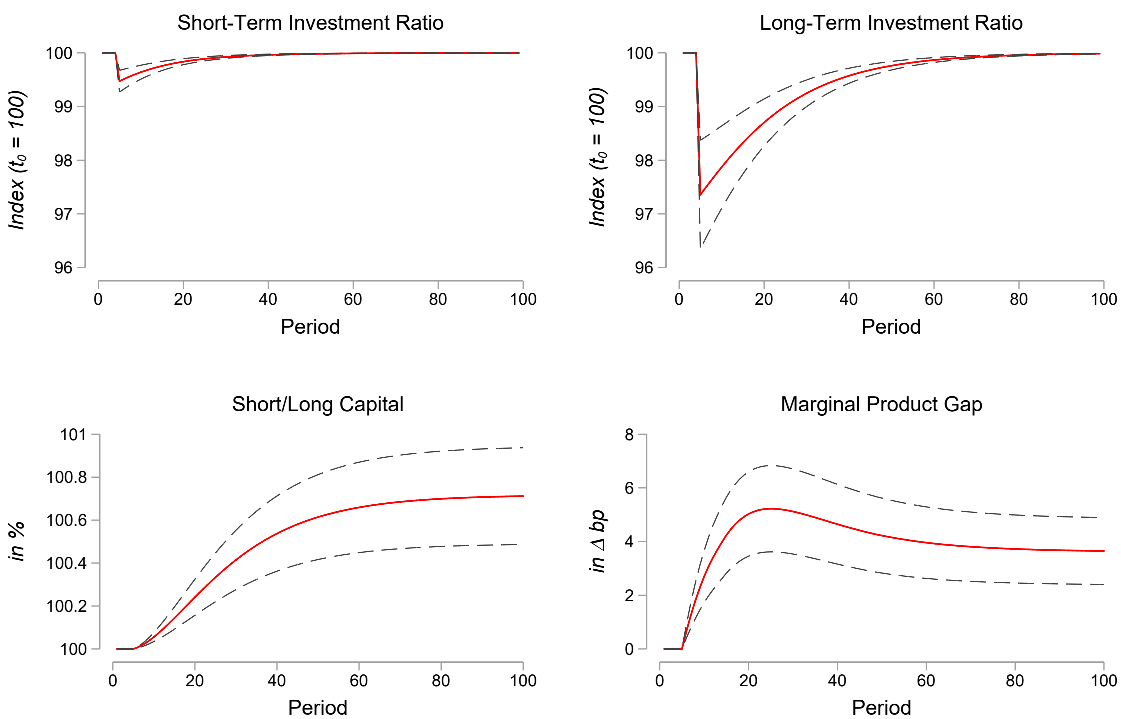
Notes: The Figure plots the evolution of firm-specific mean depreciation rates for option-paying firms (black), non-option-paying firms (gray) and their difference (bold blue, right axis). Firm-specific depreciation rates are calculated as a weighted mean of category-specific depreciation rates where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

Figure 3: Changing Incentives Around FAS 123R



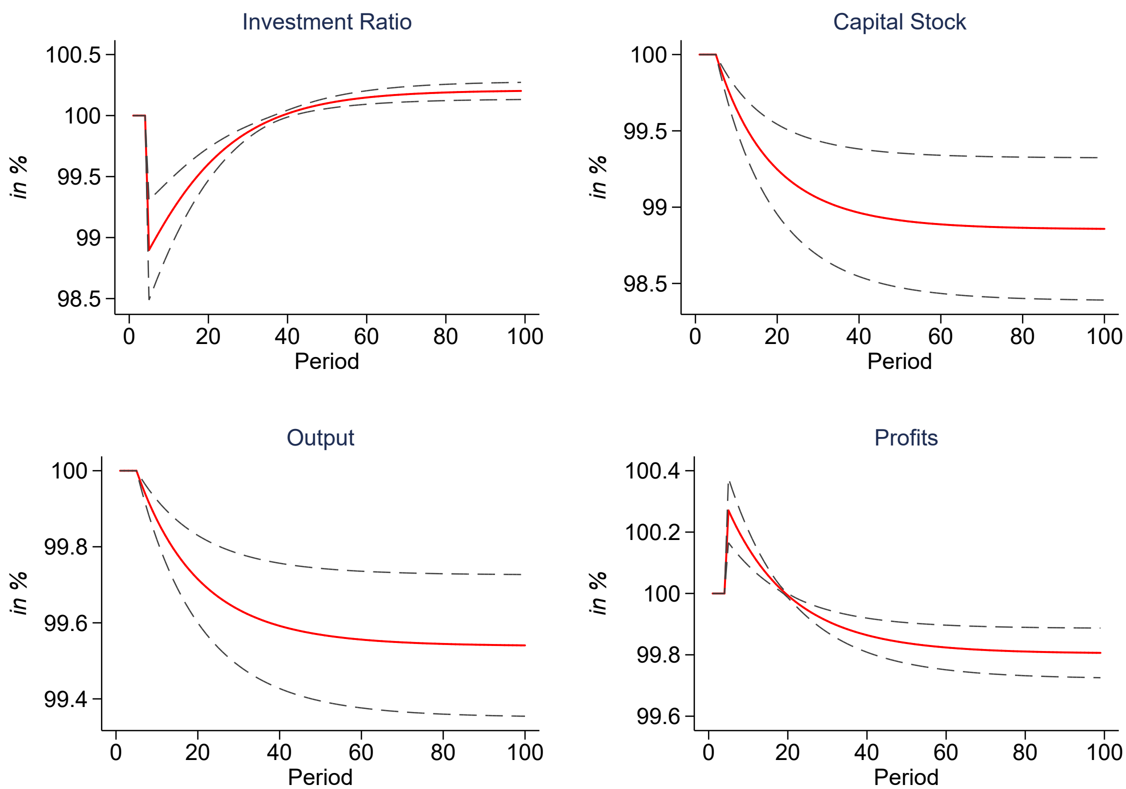
Notes: The Figure depicts the empirical distribution of the β parameter before (red) and after (green) FAS 123R. Distribution overlap is illustrated by the brown area. We group βs into ten bins each ranging 2.25 percentage points. Data is left-censored at 0.75, which applies to 14.39% of the observations.

Figure 4: Within-Firm Adjustments to FAS 123R



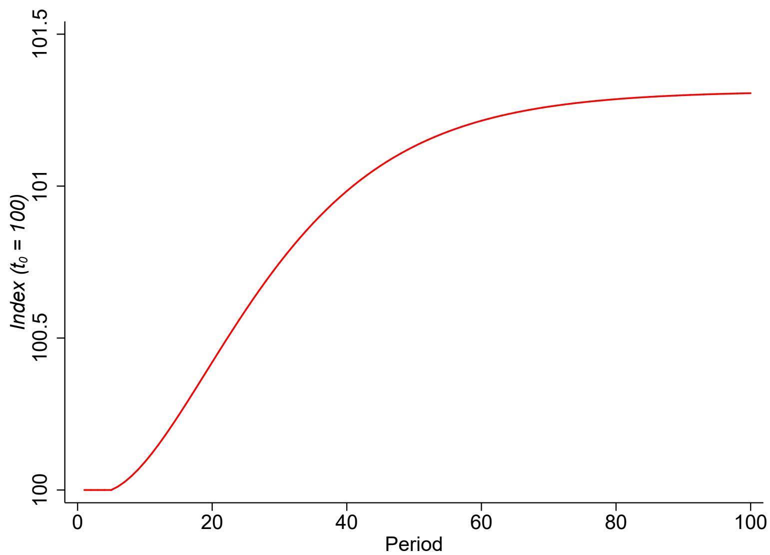
Notes: The Figure depicts the dynamic adjustment process for short-term investment (top-left), long-term investment (top-right), the capital ratio (bottom-left) and the gap in marginal products (bottom-right). Short- and long-term investment ratios are normalized by their respective capital stocks. For each firm, we normalize each of the responses with respect to their pre-FAS-123R values. The average adjustment is illustrated by the solid red line, dashed black lines depict 95% confidence intervals.

Figure 5: Aggregate Effects of FAS 123R



Notes: The Figure depicts the dynamic adjustment process for the total investment ratio (top-left), the capital stock (top-right), output (bottom-left) and profits (bottom-right). For each firm, we normalize each of the responses with respect to their pre-FAS-123R values. The average adjustment is illustrated by the solid red line, dashed black lines depict 95% confidence intervals.

Figure 6: Effects of FAS 123R on Capital Misallocation Across Firms



Notes: The Figure plots the dynamic adjustment in the cross-firm dispersion of the capital ratio. For each period, we calculate the standard deviation of the capital ratio over our firm-sample and normalize the respective value with the pre-FAS-123R standard deviation.

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).

Table 2: Selected Summary Statistics

Variable	Mean	Std. Dev.	Min	p25	p50	p75	Max	Obs	Sample
Firm-Investment Data									
Land	33.45	192.64	0.00	0.10	1.95	9.99	3,929.20	2,126	2002 - 2007
Buildings	118.60	526.41	0.00	3.77	15.46	59.81	10,978.46	3,027	2002 - 2007
Machines	461.21	2,264.74	0.03	20.09	78.71	291.36	78,706.20	2,997	2002 - 2007
Transport	143.19	622.46	0.00	0.50	2.16	19.60	7,587.88	409	2002 - 2007
Research	282.71	956.11	0.00	2.74	28.33	128.15	12,183.00	2,765	2002 - 2007
Computer	101.20	386.99	0.19	9.86	21.49	77.30	7,800.70	602	2002 - 2007
Advertising	261.27	663.45	0.00	7.95	40.95	169.00	7,937.00	1,884	2002 - 2007
Compensation Data									
Option per TDC	0.33	0.27	0.00	0.00	0.32	0.53	0.99	696	2004
Option Dummy	0.74	0.44	0	0	1	1	1	696	2004

Notes: Investment expenditures are denoted in millions USD. Option per TDC is calculated as the value of all granted options divided by total current compensation. Option Dummy takes 1 if any options are awarded, zero otherwise.

Table 3: The FAS 123R Accounting Reform and the Structure of Compensation

	Bonus Share			Equity Share		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Interaction with Pre-FAS123 Option Dummy						
FAS123 × Option-Dummy	0.0620***	0.0500***	0.0449***	-0.134***	-0.114***	-0.111***
	(0.0171)	(0.0150)	(0.0142)	(0.0224)	(0.0201)	(0.0190)
Panel B: Interaction with Pre-FAS123 Option Share						
FAS123 × Option-Share	0.155***	0.139***	0.131***	-0.267***	-0.239***	-0.237***
	(0.0237)	(0.0199)	(0.0204)	(0.0334)	(0.0290)	(0.0293)
Year FE	×	×	×	×	×	×
Firm FE	×	×	×	×	×	×
Observations	3,392	6,638	4,435	3,392	6,638	4,435
No. Firms	578	578	757	578	578	757
Sample Period	2002 - 2007	2000 - 2014	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007
Sample			incl. fin. & util.			incl. fin. & util.

Notes: The Table reports the results on the relationship between the FAS 123R reform and the structure of managerial compensation. *Option-Dummy* in Panel A is a dummy that indicates if any options are awarded in 2004. *Option-Share* in Panel B is given by the option share in total compensation in 2004. *FAS123* takes value 0 for each year until 2005 and value 1 afterwards. *Bonus Share* is the fraction of bonus payments in total compensation and *Equity Share* is the fraction of equity payments in total compensation (both obtained from BoardEx). Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table 4: The FAS 123R Accounting Reform and the Duration of Incentives

	Duration		
	(1)	(2)	(3)
Panel A: Interaction with Pre-FAS123 Option Dummy			
FAS123 × Option-Dummy	-0.156**	-0.174**	-0.104
	(0.0715)	(0.0768)	(0.0701)
Observations	3,392	6,638	4,435
No. Firms	578	578	757
Panel B: Interaction with Pre-FAS123 Duration			
FAS123 × Pre-FAS123-Duration	-0.396***	-0.341***	-0.403***
	(0.0323)	(0.0344)	(0.0378)
Observations	3,373	6,601	4,411
No. Firms	573	573	751
Panel C: Interaction with Pre-FAS123 Duration Quintile			
FAS123 × Pre-FAS123-Duration Quint.	-0.224***	-0.201***	-0.235***
	(0.0203)	(0.0204)	(0.0193)
Observations	3,373	6,601	4,411
No. Firms	573	573	751
Year FE	×	×	×
Firm FE	×	×	×
Sample Period	2002 - 2007	2000 - 2014	2002 - 2007
Sample			incl. fin. & util.

Notes: The Table reports the results on the relationship between the FAS 123R reform and the duration of managerial incentives. *Duration* is measured as in Gopalan et al. (2014). *Option-Dummy* in Panel A is a dummy that indicates if any options are awarded in 2004. *Pre-FAS123 Duration* in Panel B is given by the duration of total compensation in 2004. *Pre-FAS123 Duration Quintiles* Panel C are given by the quintile categories of the sample duration distribution in 2004. *FAS123* takes value 0 for each year until 2005 and value 1 afterwards. 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 the Durability of Investments - Option Dummy

	Investments					
	(1)	(2)	(3)	(4)	(5)	(6)
Measure of Depreciation:	*Ordering*		*Depreciation Rate*			
FAS123 × Option-Dummy × Depr	0.0478**	0.0480**	0.595**	0.595**	0.693***	0.537**
	(0.0240)	(0.0239)	(0.232)	(0.231)	(0.252)	(0.235)
Option-Dummy × Depr	0.0135	0.0132	-0.292	-0.294	-0.237	-0.454
	(0.0361)	(0.0361)	(0.355)	(0.355)	(0.356)	(0.350)
FAS123 × Depr	-0.0409**		-0.558***			
	(0.0207)		(0.200)			
Investment FE	×		×			
Investment-Year FE		×		×	×	×
Firm-Year FE	×	×	×	×	×	×
Observations	13,422	13,422	13,422	13,422	33,737	14,200
No. Firms	667	667	667	667	684	721
Sample Period	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007
Sample						incl. fin. & util.

Notes: The Table reports the results on the relationship between managerial incentives and investment decisions. *Option-Dummy* is a dummy that indicates if any options are awarded 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 to 6. 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 and the Durability of Investments - Option Share in Total Compensation

	Investments					
	(1)	(2)	(3)	(4)	(5)	(6)
Measure of Depreciation:	*Ordering*		*Depreciation Rate*			
FAS123 × Option-Share × Depr	0.0775*	0.0820**	0.711*	0.735*	0.777*	0.678*
	(0.0395)	(0.0395)	(0.391)	(0.391)	(0.417)	(0.385)
Option-Share × Depr	0.0707	0.0682	-0.580	-0.596	-0.508	-0.870
	(0.0613)	(0.0612)	(0.617)	(0.617)	(0.601)	(0.604)
FAS123 × Depr	-0.0315**		-0.353**			
	(0.0160)		(0.158)			
Investment FE	×		×			
Investment-Year FE		×		×	×	×
Firm-Year FE	×	×	×	×	×	×
Observations	13,422	13,422	13,422	13,422	33,737	14,200
No. Firms	667	667	667	667	684	721
Sample Period	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007
Sample						incl. fin. & util.

Notes: The Table reports the results on the relationship between managerial incentives and investment decisions. *Option-Share* is given by the option share in total compensation 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 to 6. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table 7: Incentives and the Durability of Investments - Option Quintiles

	Investments					
	(1)	(2)	(3)	(4)	(5)	(6)
Measure of Depreciation:	*Ordering*		*Depreciation Rate*			
FAS123 × Option-Quintile × Depr	0.0185**	0.0193***	0.180**	0.185**	0.195**	0.168**
	(0.00718)	(0.00719)	(0.0718)	(0.0718)	(0.0781)	(0.0715)
Option-Quintile × Depr	0.0125	0.0121	-0.0926	-0.0954	-0.0772	-0.150
	(0.0112)	(0.0112)	(0.113)	(0.113)	(0.111)	(0.111)
FAS123 × Depr	-0.0604***		-0.650***			
	(0.0230)		(0.228)			
Investment FE	×		×			
Investment-Year FE		×		×	×	×
Firm-Year FE	×	×	×	×	×	×
Observations	13,422	13,422	13,422	13,422	33,737	14,200
No. Firms	667	667	667	667	684	721
Sample Period	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007
Sample						incl. fin. & util.

Notes: The Table reports the results on the relationship between managerial incentives and investment decisions. *Option-Quintile* is the quintile of the option share distribution 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 to 6. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table 8: Incentives and Capital Stocks

	Capital Stocks					
	(1)	(2)	(3)	(4)	(5)	(6)
Measure of Depreciation:	*Ordering*		*Depreciation Rate*			
FAS123 × Option-Dummy × Depr	0.0403*	0.0404*	0.513**	0.518**	0.780***	0.438*
	(0.0223)	(0.0224)	(0.224)	(0.225)	(0.288)	(0.226)
Option-Dummy × Depr	-0.0128	-0.0130	-0.472	-0.475	-0.509	-0.551
	(0.0356)	(0.0355)	(0.374)	(0.374)	(0.368)	(0.367)
FAS123 × Depr	-0.0437**		-0.572***			
	(0.0203)		(0.202)			
Investment FE	×		×			
Investment-Year FE		×		×	×	×
Firm-Year FE	×	×	×	×	×	×
Observations	12,690	12,690	12,690	12,690	31,784	13,415
No. Firms	663	663	663	663	681	710
Sample Period	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007
Sample						incl. fin. & util.

Notes: The Table reports the results on the relationship between managerial incentives and capital stocks. As dependent variable the natural logarithms of the respective capital stocks are used. Physical capital stocks are directly obtained from Factset. Intangible capital stocks (R&D and Advertising) are determined the following: Initial capital stock of category i equals $k_{i0} = \frac{Invest_{i0}}{\delta_i}$ and the subsequent values are constructed iteratively, where the capital stock of category i at time t equals $k_{it} = k_{it-1}(1 - \delta_i) + Invest_{it}$. *Option-Dummy* is a dummy that indicates if any options are awarded 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 to 6. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

Table 9: Incentives and Capital Stock Depreciation

	Average Depreciation Rate			
	(1)	(2)	(3)	(4)
FAS123 × Option-Dummy	0.0158***	0.0165***	0.0189***	0.0163***
	(0.00549)	(0.00568)	(0.00590)	(0.00584)
Option-Dummy		-0.0118		
		(0.00964)		
Year FE	×	×	×	×
Firm FE	×		×	×
Observations	4,118	4,118	10,261	4,877
No. Firms	700	700	701	831
Sample Time	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007
Sample				incl. fin. & util.

Notes: The Table reports the results on the relationship between managerial incentives and investment decisions. We use the firms' average depreciation rates weighted by capital stocks in the individual asset 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 $\sum_{c=1}^{C} \delta_c \cdot \frac{cap-stock_{itc}}{\sum_{c=1}^{C} cap-stock_{itc}}$. *Option-Dummy* takes 1 if any options are awarded in 2004, zero otherwise. *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.

Table 10: 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 11: Transition Matrix β Before and After FAS 123R

β pre-FAS-123 in 2005	*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
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 12: Simulated Firms - Regression Results

	Investment		*Capital Stock*	
	(1)	(2)	(3)	(4)
Panel A: Interaction with Pre-FAS123 Option Dummy				
FAS123 × Option-Dummy × Depr	0.426***	0.426***	0.400***	0.400***
	(0.0231)	(0.0231)	(0.0199)	(0.0199)
Option-Dummy × 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: Interaction with Pre-FAS123 Option Share				
FAS123 × Option-Share × Depr	0.716***	0.716***	0.744***	0.744***
	(0.0918)	(0.0918)	(0.0993)	(0.0993)
Option-Share × 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 1000 firms. We collapse the data into a pre- and post-reform era, where *FAS123* is a dummy variable indicating the latter period. *Option-dummy* is defined as binary variable which is 1 if a firm experience an actual reduction in its firm-specific β after the reform and 0 otherwise. Accordingly, *Option-share* is proxied by 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 13: 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.

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Internet Appendix

Contents

A Empirical Appendix

A.1 Variable Descriptions

Table A.1: Variable Descriptions and Data Sources

Variable	Description	Source
Investment Variables		
advertising_{it}	*advertising* represents the cost of advertising media (i.e., radio, television, and periodicals) and promotional expenses in millions USD; Compustat variable name: XAD	Compustat
$\text{R\&D}_{it}$	*research & development expenses* (period t) represent all direct and indirect costs related to the creation and development of new processes, techniques, applications and products with commercial possibilities in millions USD; Compustat variable name: XRD	Compustat
buildings_{it}	*buildings* (period t) - 0.97 × *buildings* (period $t-1$); *buildings* (gross property plant and equipment) represent the architectural structure used in a business such as a factory, office complex or warehouse in millions USD	FactSet
computer_{it}	*computer software & equipment* (period t) - 0.70 × *computer software & equipment* (period $t-1$); *computer software & equipment* (gross property plant and equipment) represents computer equipment and the information a computer uses to perform tasks in millions USD	FactSet
land_{it}	*land* (period t) - × *land* (period $t-1$); *land* (gross property plant and equipment) represents the real estate without buildings held for productive use, is recorded at its purchase price plus any costs related to its purchase such as lawyer's fees, escrow fees, title and recording fees in millions USD	FactSet
machines_{it}	*machinery & equipment* (period t) - 0.88 × *machinery & equipment* (period $t-1$); *machinery & equipment* (gross property plant and equipment) represent the machines and machine parts needed by the company to produce its products in millions USD	FactSet
$\text{transportation equipment}_{it}$	*transportation equipment* (period t) - 0.84 × *transportation equipment* (period $t-1$); *transportation equipment* (gross property plant and equipment) represents the cars, ships, planes or any other type of transportation equipment in millions USD	FactSet
Manager Variables		
$\text{option awards}_{2004}$	the aggregate value of stock options (expressed in thousands USD) granted to the executive during the year as valued using Standard & Poor's Black-Scholes methodology; ExecuComp variable name: *OPTION-AWARDS-BLK-VALUE*	ExecuComp
TDC_{2004}	total compensation (expressed in thousands USD) comprised of the following: Salary, Bonus, Other Annual, Total Value of Restricted Stock Granted, Total Value of Stock Options Granted (using Black-Scholes), Long-Term Incentive Payouts, and All Other Total; ExecuComp variable name: *TDC1*	ExecuComp
bonus share_t	this is the ratio between *Bonus* (i.e. an annual payment made in addition to salary) and *Total Compensation*, which is the sum of *Total Direct Compensation* and *Total Equity Linked Compensation*; *Total Direct Compensation* consists of *Salary* and *Bonus*, and *Total Equity Linked Compensation* is the sum of *Value of Shares Awarded*, *Value of LTIP Awarded* and *Estimated Value of Options Awarded*; *Value of LTIP Awarded* is the sum of all cash, equity, equity matched and Option plans received over time where the receipt of these awards is contingent on the company's performance	BoardEx
equity share_t	this is the ratio between *Total Equity Linked Compensation* (= *Value of Shares Awarded* + *Value of LTIP Awarded* + *Estimated Value of Options Awarded*) and *Total Compensation*, which is the sum of *Total Direct Compensation* and *Total Equity Linked Compensation*	BoardEx
pay duration d_{it}	duration d of firm i at time t is calculated as $d_{it} = \frac{(bonus_{it}+salary_{it})\cdot 0+\sum_{j=1}^{N}(Restr.stock_{ijt}+options_{ijt})\cdot\tau_j}{(salary_{it}+bonus_{it})+\sum_{j=1}^{N}(Restr.stock_{ijt}+options_{ijt})}$ where τ is the *vesting period* of equity-based component j; *vesting period* is obtained by taking the difference between the *vesting date*, which is the date from which options can be exercised, and the annual report date	BoardEx and Gopalan et al. (2014)
$\text{firm-related wealth}_t$	firm-specific wealth is the sum of the value of the stock and option portfolio held by the executive; the value of the option portfolio is computed as of the fiscal year end using the Black-Scholes formula; for pre-2006, the values of the three option portfolios are summed up: current year grants, previously-granted unvested options, and vested options; for post-2006, the values of all the tranches of options outstanding are summed up; the value of the share portfolio is computed by multiplying the number of shares (Execucomp: *SHROWN-EXCL-OPTS*) by the fiscal year end price (Execucomp: *PRCCF*); the sum of the two provides the value of the CEO's equity portfolio as of the end of the year	Coles et al. (2006) and Core and Guay (2002)
Firm Variables		
total assets_t	(log) total value of assets reported for 2004 in millions USD; Compustat variable name: AT	Compustat
employment_t	(log) number of company workers in 2004 (in thousands); Compustat variable name: EMP	Compustat
sales_t	gross sales in millions USD; Compustat variable name: SALE	Compustat
$\text{market capitalization}_t$	annual arithmetic mean of number of common shares (CSHOC) × daily closing price (PRCCD) in millions USD	Compustat

Notes: The Table contains descriptions of all empirical variables. Note that the variables $\text{firm-related wealth}_t$, sales_t and $\text{market capitalization}_t$ are used in our quantitative analysis.

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

Column 1 in Table 9 reveals that for option-paying firms the average depreciation rate increased by 1.58 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 16.81% in 2004. This rate converts into a durability of $2,171$ days ($\frac{1}{0.1681} \times 365$ days) for the capital stock. The FAS-123R-induced depreciation rate for option-paying firms is equal to 18.39% (16.81%+1.58%), which implies a durability for the firms' capital stock of 1,985 days. Therefore, FAS 123R decreased the durability of the capital stock by 186 days. Assuming an annual refinancing interest rate of 3%, this lower durability would be associated with an additional amount of interest payments of USD 15.29 for each USD 1,000 invested ($0.03 \times \frac{186}{365} \times$ USD $1,000$).

A.3 Robustness and Additional Results

This Appendix presents several robustness analyses and additional results.

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 either equity volatility or current CEO pay.

Pre-Trends: Table A.5 presents placebo treatments for other years and shows that the effect is absent in earlier years before actual treatment occurs.

CEO Turnover: Table A.6 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: Tables A.7 and A.8 show robustness regarding the measurement of investments. Table A.7 replicates our findings based on either Box-Cox transformation or logarithmized investments. Table A.8 replicates results when negative investments are either treated as disinvestments or as 0 expenditures.

R&D Investment and Intangibles: Table A.9 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.

Structural Parameters: Table A.10 exploits time variation in the model-derived parameter β to study its effect on investment and firm-specific depreciation rates.

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

Variable	Option-Paying (Treated, N=515)	Non-Option-Paying (Control, N=181)	t-test	p-value
Total Assets	8,884	5,585	1.72	**0.09**
Sales	8,062	5,690	1.28	0.20
Capital Stock	4,051	2,100	2.95	**<0.01**
Employment	33.19	17.79	3.20	**<0.01**
Labor Productivity	115.5	102.2	1.17	0.24
Depreciation Rate	0.17	0.18	-1.17	0.23
Intangible Share	0.50	0.52	-0.58	0.57
Investment Rate	0.05	0.04	0.37	0.71
Leverage Ratio	0.20	0.18	1.20	0.23
Liquidity Ratio	0.17	0.16	0.44	0.66
Equity Volatility	0.34	0.38	-2.73	**<0.01**
Current CEO Compensation	1,951	1,558	2.36	**0.02**

Notes: A firm is considered as treated if it has granted 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 $\times$ 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-Dummy × Depr	0.0441*	0.564**	0.0498**	0.586**	0.0497**	0.584**
	(0.0242)	(0.235)	(0.0244)	(0.243)	(0.0246)	(0.248)
Option-Dummy × Depr	0.0233	-0.418	0.00847	-0.450	0.00948	-0.406
	(0.0363)	(0.352)	(0.0363)	(0.357)	(0.0368)	(0.365)
FAS123 × Firm Size × Depr	0.00775	0.0554	-0.00214	0.00288	-0.00124	-0.00490
	(0.00670)	(0.0638)	(0.00646)	(0.0623)	(0.00571)	(0.0554)
Firm Size × Depr	-0.0224*	0.264***	0.00745	0.203**	0.00646	0.163**
	(0.0120)	(0.0956)	(0.0117)	(0.0920)	(0.0100)	(0.0800)
Investment-Year FE	×	×	×	×	×	×
Firm-Year FE	×	×	×	×	×	×
Observations	13,348	13,348	13,414	13,414	13,380	13,380
No. Firms	662	662	666	666	664	664
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 options are awarded 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)
Firm Control:	*Equity Volatility*		*Current CEO Compensation*	
Measure of Depreciation:	*Ordering*	*Depreciation Rate*	*Ordering*	*Depreciation Rate*
FAS123 × Option-Dummy × Depr	0.0530**	0.701***	0.0461*	0.559**
	(0.0241)	(0.233)	(0.025)	(0.246)
Option-Dummy × Depr	0.00954	-0.484	0.00547	-0.585
	(0.036)	(0.349)	(0.0374)	(0.375)
FAS123 × Firm Control × Depr	0.132**	1.206**	0.00609	0.062
	(0.0614)	(0.552)	(0.0137)	(0.131)
Firm Control × Depr	-0.0855	-3.306***	0.0163	0.600***
	(0.0937)	(0.924)	(0.0223)	(0.196)
Investment-Year FE	×	×	×	×
Firm-Year FE	×	×	×	×
Observations	13,422	13,422	13,352	13,352
No. Firms	667	667	664	664
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 options are awarded 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 - Placebo Treatments

	Investments				
	(1)	(2)	(3)	(4)	(5)
Treatment Year:	*2002*	*2003*	*2004*	*2005*	*2006*
	placebo	*placebo*	*placebo*	*real*	*placebo*
FAS123 × Option-Dummy × Depr	-0.00223	-0.000425	-0.00348	0.0478**	0.0326
	(0.0282)	(0.0322)	(0.0256)	(0.0240)	(0.0236)
FAS123 × Depr	0.00566	0.00747	0.00446	-0.0409**	-0.0113
	(0.0239)	(0.0289)	(0.0218)	(0.0207)	(0.0200)
Option-Dummy × Depr	-0.0548	0.0358	-0.0237	0.0135	0.0523
	(0.0433)	(0.0405)	(0.0346)	(0.0361)	(0.0337)
Investment FE	×	×	×	×	×
Firm-Year FE	×	×	×	×	×
Observations	12,428	12,689	13,079	13,422	13,538
No. Firms	665	665	666	667	670
Sample Time	1999 - 2004	2000 - 2005	2001 - 2006	2002 - 2007	2003 - 2008

Notes: The Table reports placebo estimates on the relationship between managerial incentives and investment decisions. Compared to the baseline estimation in column 4, we shift the *Option-Dummy*, *FAS123* and the sample time to earlier or later years, accordingly. *Depr* is the measure of depreciation, following an ordinal scale. 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 - CEO Turnover

	Investments					
	(1)	(2)	(3)	(4)	(5)	(6)
Measure of Depreciation:	*Ordering*		*Depreciation Rate*			
FAS123 × Option-Dummy × Depr	0.0970***	0.0964***	1.010***	1.009***	1.244***	0.973***
	(0.0300)	(0.0301)	(0.288)	(0.289)	(0.367)	(0.303)
Option-Dummy × Depr	-0.0384	-0.0388	-0.775	-0.780	-0.772	-0.942*
	(0.0512)	(0.0513)	(0.478)	(0.479)	(0.483)	(0.482)
FAS123 × Depr	-0.0847***		-0.908***			
	(0.0238)		(0.216)			
Investment FE	×		×			
Investment-Year FE		×		×	×	×
Firm-Year FE	×	×	×	×	×	×
Observations	5,939	5,939	5,939	5,939	14,886	6,319
No. Firms	286	286	286	286	292	310
Sample Period	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007
Sample	same CEO	same CEO	same CEO	same CEO	same CEO	same CEO incl. fin. & util.

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-Dummy* is a dummy that indicates if any options are awarded 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 to 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.7: Robustness: Incentives and the Durability of Investments - Alternative Transformation of the Investment Variable

	Investments							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Investment Measure:	*Box-Cox Transformation*				*Logarithms*			
FAS123 × Option-Dummy × Depr	0.924**	0.924**	0.934**	0.881**	0.490*	0.490*	0.862***	0.431
	(0.376)	(0.377)	(0.402)	(0.380)	(0.282)	(0.283)	(0.291)	(0.284)
Option-Dummy × Depr	-0.799	-0.800	-0.702	-1.167**	-0.430	-0.431	-0.428	-0.533
	(0.524)	(0.524)	(0.539)	(0.533)	(0.374)	(0.373)	(0.367)	(0.368)
FAS123 × Depr	-0.709**				-0.627**			
	(0.314)				(0.250)			
Investment FE	×				×			
Investment-Year FE		×	×	×		×	×	×
Firm-Year FE	×	×	×	×	×	×	×	×
Observations	13,422	13,422	33,737	14,200	12,400	12,400	31,080	13,106
No. Firms	667	667	684	721	664	664	682	711
Sample Period	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007
Sample				incl. fin. & util.				incl. fin. & util.

Notes: This Table reports the results on the relationship between managerial incentives and investment decisions. The following transformation applies to the dependent variable y: $y = ln(x + 0.001)$ for columns $1 - 4$ and $y = ln(x)$ for columns $5 - 8$. *Option-Dummy* is a dummy that indicates if any options are awarded 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: Robustness: Incentives and the Durability of Investments - Allowing for Negative Investments

	Investments							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Investment Sample:	*Include Negative Investments*				*Treat Negative Investments as 0s*			
FAS123 × Option-Dummy × Depr	1.024***	1.039***	1.132***	0.892**	0.707***	0.720***	0.832***	0.603**
	(0.389)	(0.390)	(0.336)	(0.391)	(0.262)	(0.262)	(0.260)	(0.260)
Option-Dummy × Depr	0.0448	0.0393	0.226	-0.156	-0.0289	-0.0346	0.0816	-0.198
	(0.414)	(0.415)	(0.404)	(0.413)	(0.356)	(0.356)	(0.355)	(0.352)
FAS123 * Depr	-1.084***				-0.770***			
	(0.330)				(0.224)			
Investment FE	×				×			
Investment-Year FE		×	×	×		×	×	×
Firm-Year FE	×	×	×	×	×	×	×	×
Observations	15,281	15,281	38,607	16,223	15,281	15,281	38,607	16,223
No. Firms	668	668	686	722	668	668	686	722
Sample Period	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007
Sample				incl. fin. & util.				incl. fin. & util.

Notes: This Table reports the results on the relationship between managerial incentives and investment decisions. Columns 1 – 4 treat negative investment as true negatives, whereas in columns 5 – 8 negative values are set to zero. *Option-Dummy* is a dummy that indicates if any options are awarded 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.9: Robustness: Incentives and the Durability of Investments - Assessing the Role of R&D and Intangibles

	Investments					
	(1)	(2)	(3)	(4)	(5)	(6)
Measure of Depreciation:	*Ordering*		*Depreciation Rate*			
Panel A: Omitting R&D						
FAS123 × Option-Dummy × Depr	0.0570**	0.0588**	0.605**	0.614**	0.885***	0.565**
	(0.0259)	(0.0259)	(0.244)	(0.244)	(0.250)	(0.248)
Option-Dummy × Depr	-0.0271	-0.0283	-0.391	-0.398	-0.351	-0.464
	(0.0350)	(0.0350)	(0.343)	(0.343)	(0.339)	(0.339)
FAS123 × Depr	-0.0663***		-0.694***			
	(0.0229)		(0.217)			
Observations	10,480	10,480	10,480	10,480	26,331	11,037
No. Firms	659	659	659	659	677	704
Panel B: Controlling for Intangibles						
FAS123 × Option-Dummy × Depr	0.0664*	0.0688*	0.760***	0.770***	0.932***	0.707**
	(0.0358)	(0.0360)	(0.277)	(0.276)	(0.312)	(0.284)
Option-Dummy × Depr	-0.0279	-0.0294	-1.007	-1.014	-1.081	-1.235*
	(0.0585)	(0.0588)	(0.675)	(0.678)	(0.671)	(0.652)
FAS123 × Depr	-0.0648**		-0.795***			
	(0.0301)		(0.236)			
Observations	13,422	13,422	13,422	13,422	33,737	14,200
No. Firms	667	667	667	667	684	721
Investment FE	×		×			
Investment-Year FE		×		×	×	×
Firm-Year FE	×	×	×	×	×	×
Sample Period	2002 - 2007	2002 - 2007	2002 - 2007	2002 - 2007	2000 - 2014	2002 - 2007
Sample						incl. fin. & util.

Notes: The Table reports the results on the relationship between managerial incentives and investment decisions. The upper panel omits R&D investments and the lower panel controls for interactions between a dummy that indicates intangible investment categories (R&D and advertising), *FAS123* and *Option-Dummy*. *Option-Dummy* is a dummy that indicates if any options are awarded 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 to 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.10: 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*	
$(1-\beta)\times$ Depr	0.428***	0.416***			
	(0.108)	(0.117)			
FAS123 $\times$ Option-Dummy $\times$ Depr			0.028***		
			0.004		
$\widehat{(1-\beta)\times}$ Depr				1.849***	
				(0.648)	
$(1-\beta)$					0.027***
					(0.009)
Investment FE	×		×	×	
Investment-Year FE		×			
Firm-Year FE	×	×	×	×	
Firm FE					×
Year FE					×
Observations	29,940	29,940	29,940	29,940	9,015
No. Firms	656	656	656	656	676
Sample Time	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014	2000 - 2014
Kleibergen-Paap F-Statistic			60.55		

Notes: The Table reports the results on the relationship between the model-specific incentive measure β and the durability of investments/capital stock depreciation. 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-Dummy* is a dummy that indicates if any options are awarded in 2004. *FAS123* takes value 0 for each year until 2005 and value 1 afterwards. In columns 1 and 2, we investigate the relationship between the firm-specific β and the durability of investments. In column 4, we address endogeneity concerns related to β by instrumenting $(1-\beta)$ $\times$ *Depr* with *FAS123* $\times$ *Option-Dummy* $\times$ *Depr*. First-stage results are given in column 3. Column 5 estimates the effect of β on the capital stock depreciation by taking a firm-specific capital-stock-weighted depreciation rate as dependent variable. Standard errors (reported in parentheses) are clustered at the firm-level. ***, **, and * indicate statistical significance at the 1%-, 5%- and 10%-level.

B Theoretical Appendix

B.1 Derivation of Managers' Optimal Behavior

To derive a manager's decision problem, we express the manager's optimization problem in recursive form. Formally, manager t chooses an action $a_t = (\mathbf{K}_{t+1}, N_t) \in \mathbb{R}^3_+$ depending on the history of previous managers' decisions $\mathcal{H}_t = (a_s | s < t)$. Denote by s_τ a strategy of manager τ. Manager t's problem in general follows as

$$\begin{aligned} &\max_{a_t} \Gamma_t \\ s.t.\; &(4), (5), (6), (14), \\ &\text{given } \mathcal{H}_t \\ &\text{given beliefs regarding } s_\tau, \tau > t. \end{aligned} \tag{B.1}$$

Generally, this type of problem has an extremely large strategy space, and a multitude of equilibria can occur, which can be enforced through trigger strategies etc. This, potentially, makes non-monotonic or discontinuous policy functions sustainable. Although a thorough examination of the strategy space of such a game seems interesting, it is beyond the scope of this paper. In line with most macroeconomic models, we focus on symmetric, smooth Markov perfect equilibria, where the state of the game is entirely described by a_{t-1}. More specifically, we assume that the variable factor labor is always set optimally within each period such that strategies only effectively map from $\mathbf{K}_t$ into $\mathbf{K}_{t+1}$ and N_t.

Since we are interested in a symmetric equilibrium, we denote the policy function for capital as $\mathcal{K}(\mathbf{K}, \xi)$, i.e. if manager t follows this strategy profile, they will set $\mathbf{K}_{t+1} = \mathcal{K}(\mathbf{K}_t, \xi)$ 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, $\mathcal{N}(\mathbf{K}, \xi)$ denotes the policy function for N_t. Note that $\mathcal{K}(\cdot)$ is a vector-valued function with two outputs (one for each capital good), which in turn we denote by $\mathcal{K}_j(\mathbf{K}, \xi), j = l, s$. In particular, we denote

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

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 (6),(4) and (5) to obtain a function for the period-profits, $\Pi = \pi(\mathbf{K}, \mathbf{K}', N, \xi)$:

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

Next, the value of equity $E(\cdot)$ 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

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

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 (B.1) as

$$\Gamma^*(\mathbf{K}, \xi) := \max_{(\mathbf{K}', N)} \{\Gamma(\mathbf{K}, \mathbf{K}', N, \xi)\} \tag{B.3}$$

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

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

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

$$\mathcal{N}(\mathbf{K}, \xi) = \left(\frac{bZ^{1-a-b}\left(K_l^{\nu} K_s^{1-\nu}\right)^a}{w}\right)^{\frac{1}{1-b}}. \tag{B.4}$$

This directly follows from the first-order condition

$$\frac{\partial}{\partial N}\Gamma(\cdot) \stackrel{!}{=} 0 \quad \Leftrightarrow \quad \varphi\frac{\partial}{\partial N}\pi(\cdot) \stackrel{!}{=} 0 \Leftrightarrow \quad \frac{\partial}{\partial N}\pi(\cdot) \stackrel{!}{=} 0$$

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

$$\begin{aligned}\mathcal{K}_j(\mathbf{K},\xi) = \Bigg\{K'_j \Bigg| \;\; 0 = &\frac{\partial}{\partial K'_j}\pi(\mathbf{K},\mathbf{K}',N,\xi) + \beta\theta\frac{\partial}{\partial K_j}\pi(\mathbf{K}',\mathcal{K}(\mathbf{K}',\xi),\mathcal{N}(\mathbf{K}',\xi),\xi) \\ &+ \theta(1-\beta)\sum_{k=l,s}\frac{\partial}{\partial K_j}\mathcal{K}_k(\mathbf{K}',\xi)\frac{\partial}{\partial K_k}V(\mathcal{K}(\mathbf{K}'),\xi)\Bigg\}\end{aligned} \tag{B.5}$$

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

$$\begin{aligned}&\frac{\partial}{\partial K'_j}\Gamma(\cdot) \stackrel{!}{=} 0 \\ \Leftrightarrow \varphi&\left(\frac{\partial}{\partial K_j}\pi(\cdot) + \beta\theta\frac{\partial}{\partial K_j}V(\cdot)\right) \stackrel{!}{=} 0\end{aligned} \tag{B.6}$$

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

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

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

$$\begin{aligned}\frac{\partial}{\partial K_j}V(\cdot) &= \frac{\partial}{\partial K_j}\pi(\mathbf{K},\mathcal{K}(\mathbf{K},\xi),\mathcal{N}(\mathbf{K},\xi),\xi) \\ &\quad + \sum_{k=l,s}\frac{\partial}{\partial K_j}\mathcal{K}_k(\mathbf{K},\xi)\left[\frac{\partial}{\partial K'_k}\pi(\mathbf{K},\mathcal{K}(\mathbf{K},\xi),\mathcal{N}(\mathbf{K},\xi),\xi) + \theta\frac{\partial}{\partial K'_k}V(\mathcal{K}(\mathbf{K},\xi)\right]\end{aligned} \tag{B.7}$$

Inserting equation (B.6) on the left-hand side and –iterated by one period– on the right-hand side of (B.7) gives equation (B.5).

Finally, by re-inserting time indices and suppressing functional dependencies, we can reformulate equations (B.4) and (B.5) to obtain equations (15) and (16) 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 10. 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 $F_s = \{f = 1, \ldots, \mathcal{N}_f | s_f = s\}$.

B.2.1 Demand

As before, we abstract from aggregate dynamics and we are only interested in the change of steady-state variables.[28] 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.

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

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

Here, the ψ_s are calculated from Table 10 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

$$\mathcal{P} = \prod_{s=1}^{S} \left(\frac{\mathcal{P}_s}{\psi_s} \right)^{\psi_s}, \tag{B.8}$$

where $\mathcal{P}_s$ denote sectoral price levels. Following standard logic, each sector thus faces a demand curve

$$\mathcal{Q}_s = \frac{\psi_s \mathcal{P} \mathcal{Q}}{\mathcal{P}_s}. \tag{B.9}$$

[28]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.

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

$$\mathcal{Q}_s = \left(\sum_{f \in F_s} Q_f^{\frac{\varepsilon_s - 1}{\varepsilon_s}} \right)^{\frac{\varepsilon_s}{\varepsilon_s - 1}}. \tag{B.10}$$

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

$$\mathcal{P}_s = \left(\sum_{f \in F_s} P_f^{1-\varepsilon_s} \right)^{\frac{1}{1-\varepsilon_s}}. \tag{B.11}$$

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

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

Note how this equation compares to (3): we can now deduce that in each sector, the demand shifter is given by

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

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 (2)–(16).

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

$$a_s = \alpha_s \frac{\varepsilon_s - 1}{\varepsilon_s} \tag{B.13}$$

$$b_s = (1 - \alpha_s) \frac{\varepsilon_s - 1}{\varepsilon_s} \tag{B.14}$$

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

$$Q_f = \widetilde{Z}_f \left(K_{lf}^{\nu_s} K_{sf}^{1-\nu_s}\right)^{\alpha_s} N_f^{1-\alpha_s} \tag{B.15}$$

$$Q_f = B_s P_f^{-\varepsilon_s} \tag{B.16}$$

$$R_f = P_f Q_f \tag{B.17}$$

$$= Z_f^{1-a_s-b_s} \left(K_{lf}^{\nu_s} K_{sf}^{1-\nu_s}\right)^{a_s} N_f^{b_s} \tag{B.18}$$

$$C_f^K = \sum_{j\in l,s} \left[\gamma \left(\frac{K'_{jf}}{K_{jf}} - 1\right)^2 K_{jf} + \left(K'_{jf} - (1-\delta_{js})K_{jf}\right)\right] \tag{B.19}$$

$$\Pi_f = R_f - C_f^K - w_s N_f \tag{B.20}$$

$$E_f = (1-\eta_{b,f})\Pi_f + \frac{1}{1+r}\mathbb{E}\left\{(1-\eta_{e,f})E'_f\right\} \tag{B.21}$$

$$\Gamma_f = \eta_{b,f}\Pi_f + \eta_{e,f}E_f \tag{B.22}$$

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

$$\beta_f := \frac{\eta_{e,f}(1-\eta_{b,f})}{\eta_{b,f} + \eta_{e,f}(1-\eta_{b,f})}, \tag{B.24}$$

$$\theta_f := \frac{1-\eta_{e,f}}{1+r} \tag{B.25}$$

$$N_f = \left(\frac{b_s Z_f^{1-a_s-b_s}\left(K_{lf}^{\nu_s} K_{sf}^{1-\nu_s}\right)^{a_s}}{w_s}\right)^{\frac{1}{1-b_s}} \tag{B.26}$$

$$0 = \frac{\partial \Pi_f}{\partial K'_{jf}} + \beta_f\theta_f \frac{\partial \Pi'_f}{\partial K'_{jf}} + \theta_f(1-\beta_f)\sum_{k=l,s}\frac{\partial K''_{kf}}{\partial K'_{jf}}\frac{\partial}{\partial K''_{kf}}V_f(\mathbf{K}''_f, \xi'_s) \tag{B.27}$$

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

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

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.[29]

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

$$\bar{N}_f = N_f + \sum_{j\in\{l,s\}} I_{jf} + \gamma\left(\frac{K'_{jf}}{K_{jf}} - 1\right)^2 K_{jf}, \tag{B.28}$$

where $I_{jf} = K'_{jf} - (1-\delta_{js})K_{jf}$ 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.

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

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

[29] 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.

Since we treat labor as numéraire, this becomes

$$C = \sum_{f=1}^{\mathcal{N}_f} \Pi_f + 1. \tag{B.29}$$

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

$$C = \mathcal{Q} \tag{B.30}$$

$$1 = \sum_{f=1}^{\mathcal{N}_f} \bar{N}_f. \tag{B.31}$$

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 13 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.11, we provide summary statistics on the key parameters η_b, η_e and β for our sample.

Table A.11: 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.[30]

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

[30]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.

capital goods, we get

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

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

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

Likewise, b directly follows from optimal labor demand as

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

This allows us to recover ε and α from

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

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.4), we can write per-period operating profits as a function of $\mathbf{K}, \mathbf{K}'$ only by defining:

$$\pi^*(\mathbf{K}, \mathbf{K}', \xi) = \max_N \{\pi(\mathbf{K}, \mathbf{K}', N, \xi)\}. \tag{B.32}$$

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

$$\Gamma(\mathbf{K},\xi) = \max_{\mathbf{K}'}\{\pi^*(\mathbf{K},\mathbf{K}',\xi) + \beta\theta V(\mathbf{K}',\xi) \tag{B.33}$$

$$\text{s.t. } V(\mathbf{K}',\xi) = \pi^*(\mathbf{K}',\mathcal{K}(\mathbf{K}',\xi),\xi) + \theta V(\mathcal{K}(\mathbf{K}',\xi),\xi)\}. \tag{B.34}$$

Here, the future policy function $\mathcal{K}(\cdot)$ is defined as

$$\mathcal{K}(\mathbf{K},\xi) = \arg\max_{\mathbf{K}'}\{\pi^*(\mathbf{K},\mathbf{K}',\xi) + \beta\theta V(\mathbf{K}',\xi)\}. \tag{B.35}$$

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 $f(\mathcal{K},\xi)$ in terms of elements of $\mathcal{K}$ to be given by

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

We use similar notation for functions with multiple inputs, and the index of ∇ gives the input the gradient applies to. Then, the first-order conditions (B.6) can be stated as

$$\nabla_{\mathbf{K}'}\pi^*(\mathbf{K},\mathbf{K}',\xi) = -\beta\theta\nabla_{\mathbf{K}'}V(\mathbf{K}',\xi). \tag{B.36}$$

From (B.32), we can derive

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

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

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

Note that this can be readily solved for K_j:

$$K_j = \frac{K_j'}{1 + \frac{\frac{\partial V}{\partial K_j'}(\mathbf{K}',\xi) - 1}{\gamma}}. \tag{B.37}$$

Equation (B.37) 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 $\tilde{\mathcal{K}}' = (\tilde{\mathbf{K}}_h')_{h=1,\ldots,G}$, which represent different outcomes of $\mathbf{K}'$, and an initial (differentiable) guess $\hat{V}_0(\cdot)$ for $V(\cdot)$. By differentiating $V(\cdot)$, we get the gradient at each point in $\tilde{\mathcal{K}}'$. Then applying the backward induction step in (B.37), we can solve for the optimal solution of the previous manager. Next, we update our guess for the continuation value function $V(\cdot)$ according to the profit function and our current guess. 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 $\rho(\cdot)$ we opt for Chebyshev polynomials up to degree 10 in either dimension.[31] 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

[31] 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.

$\beta = 1$ 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.

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 $\tilde{\mathcal{K}}' = (\tilde{\mathbf{k}}'_g)_{g=1,\dots,G}$, 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 $\epsilon^v_{ig} = \left| \frac{\hat{V}_{i,g}}{\hat{V}_{i-1,g}} - 1 \right|$.
  - Set $\epsilon^{invp}_{jig} = \left| \frac{k_{j,i,g}}{k_{j,i-1,g}} - 1 \right|$.
- **if** $\max_{g \in (1,\dots,G)}\{\epsilon^v_{ig}\} < \bar{\epsilon}^v$ *and* $\max_{j \in (l,s), g \in (1,\dots,G)}\{\epsilon^{invp}_{ig}\} < \bar{\epsilon}^{invp}$ **then**
  - Set *continue*=false.
- **else**
  - Set i=i+1;

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

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 $\times$ 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:

$$\mathbf{K}' = \mathcal{K}\left(\mathbf{K}, B^{ind}, \xi\right). \tag{B.38}$$

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

$$\mathcal{K}(\mathbf{K}, B^{ind}, \xi) = B^{ind} \cdot \mathcal{K}\left(\frac{1}{B^{ind}}\mathbf{K}, 1, \xi\right). \tag{B.39}$$

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 $\mathcal{P}_s, \mathcal{P}$ using (B.11) and (B.8). From (B.9), it is possible to show that the demand shifter in any sector is then proportional to aggregate demand $\mathcal{Q}$ 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.9) and (B.12), we can obtain

$$Q_f = \psi_s P_f^{-\varepsilon_s} \mathcal{P}_s^{\varepsilon_s - 1} \mathcal{P} \mathcal{Q}, \tag{B.40}$$

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

$$Q_f = p_f \mathcal{Q}, \tag{B.41}$$

where $p_f = \psi_s P_f^{-\varepsilon_s} \mathcal{P}_s^{\varepsilon_s - 1} \mathcal{P}$ does not depend on $\mathcal{Q}$. 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 $\mathcal{Q}$. Total labor demand is then given by

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

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