Journal of Financial Economics 119 (2016) 533–558

Contents lists available at ScienceDirect

Journal of Financial Economics

journal homepage: www.elsevier.com/locate/finec

Executive overconfidence and compensation structure☆

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ARTICLE INFO

Article history:
Received 28 March 2014
Revised 20 April 2015
Accepted 13 May 2015
Available online 22 January 2016

JEL classifications:
J33
M52

Keywords:
Overconfidence
Compensation structure
Incentive compensation

ABSTRACT

We examine the impact of overconfidence on compensation structure. Our findings support the *exploitation hypothesis*: firms offer incentive-heavy compensation contracts to overconfident Chief Executive Officers (CEOs) to exploit their positively biased views of firm prospects. Overconfident CEOs receive more option-intensive compensation and this relation increases with CEO bargaining power. Exogenous shocks (Sarbanes-Oxley Act of 2002 (SOX) and Financial Accounting Standard (FAS) 123R) provide additional support for the findings. Overconfident non-CEO executives also receive more incentive-based pay, independent of CEO overconfidence, buttressing the notion that firms tailor compensation contracts to individual behavioral traits such as overconfidence.

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1. Introduction

We investigate whether overconfidence affects the compensation structure of CEOs and other senior executives. There is a burgeoning literature on the impact of CEO overconfidence on corporate policies. Overconfident CEOs are prone to overestimate returns to investments and to underestimate risks (Dittrich, Guth, and Maciejovsky, 2005; Malmendier and Tate, 2005, 2008; Kolasinski and Li, 2013).[1] Little is known, however, about the nature of incentive contracts offered to overconfident managers or even whether firms "fine-tune" compensation contracts to match a manager's personality traits. We help fill this gap.

While we expect compensation contracts to differ for overconfident managers relative to rational managers, the

☆ We thank an anonymous referee, Robert Durand, Justin Hopkins, Mark Ma, Ron Masulis, Lasse Mertins, and Bill Schwert (Editor) for helpful comments. We also thank the seminar participants at Binghamton University, George Mason University, Kent State University, Loyola Marymount University, Macquarie University, Marquette University, Nanyang Technological University, Rutgers University, University of Akron, University of Arkansas, University of Connecticut, University of Massachusetts at Lowell, University of Memphis, University of North Carolina at Greensboro, University of Technology Sydney, University of Tennessee, University of Texas Dallas, University of Washington Bothell, and Virginia Commonwealth University. We additionally benefited from comments received at the Fourth Behavioral Finance and Capital Markets Conference (2014), the American Accounting Association Mid-Atlantic Regional Meeting (2014), the J.P. Morgan & Co. Quantference (2014) and the Virginia Accounting Research Conference (2014). Mark Humphery-Jenner acknowledges the support of DECRA grant DE150100895. Ling Lei Lisic gratefully acknowledges a summer research award from the School of Business at George Mason University.

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http://dx.doi.org/10.1016/j.jfineco.2016.01.022
S0304-405X(16)00028-3/© 2016 Elsevier B.V. All rights reserved.

[1] As a result, overconfident CEOs are often associated with more innovative outcomes and a willingness to take risks (Galasso and Simcoe, 2011; Hirshleifer Low, and Teoh, 2012).

nature of these differences is not obvious. On the one hand, an overconfident manager might need weaker incentives in the form of options or restricted stock given the higher probability the manager associates with a successful outcome. With their positively biased view of future firm prospects, a smaller equity stake might be sufficient to induce overconfident managers to deliver the required effort or to make the appropriate decisions.[2] It is also possible for strong incentives to be counterproductive as such incentives could exacerbate risk-taking by an already overconfident manager. We refer to this as the *weak-incentive hypothesis*, which predicts a negative relation between overconfidence and the proportion of incentive-based compensation a manager receives.

On the other hand, as Gervais, Heaton, and Odean (2011) [hereafter GHO] argue, it can be optimal to offer incentive-intensive contracts to overconfident CEOs.[3] Their insight is that if an overconfident CEO places a sufficiently high probability on good outcomes, it is relatively inexpensive for the firm to offer a compensation package with high option and stock intensity. Hence, at the margin, the purpose of an incentive-heavy compensation contract is to take advantage of the CEO's misvaluation rather than to provide incentives. We call this the *exploitation hypothesis*, which predicts a positive relation between overconfidence and the proportion of incentive-based compensation a manager receives.

A question, though, is whether the only reason to give overconfident managers incentive-heavy compensation contracts is to exploit their overvaluation. We develop an alternative hypothesis, based on a simple extension of GHO's model, to show that the need to provide incentives—rather than exploitation—can also lead to overconfident managers receiving greater incentive-based compensation. The reason is that some incentives are only worth providing by the firm when the CEO is overconfident and that, when this is the case, stocks and stock options serve mainly to align the CEO's incentives with those of the firm's shareholders. That is, additional options are only provided to CEOs who are known or are expected to be overconfident. We refer to this as the *strong-incentive hypothesis*.

We conduct empirical tests to explore the relation between CEO overconfidence and incentive compensation and to differentiate among the three hypotheses (weak-incentive, exploitation, and strong-incentive hypotheses). We use the compensation data of CEOs between 1992 and 2011 to create option-based measures of overconfidence.[4] These measures are premised on the idea that a manager's human capital and compensation are tied to the company, rendering the CEO undiversified. Consequently, a rational CEO exercises deep in-the-money options as soon as they vest. Thus, holding deep in-the-money options indicates overconfidence. Our results are robust to using media-based measures of overconfidence.

Consistent with both the exploitation and the strong-incentive hypotheses, but not with the weak-incentive hypothesis, CEO overconfidence increases both option and equity intensity, measured as the proportion of total compensation that comes from option and equity grants, respectively. We also find some evidence that overconfident CEOs receive even greater option and equity intensity in innovative and risky firms.

We complement the CEO-level results with evidence on the compensation of overconfident non-CEO executives. We hypothesize and find that overconfidence impacts non-CEO executive compensation in a similar manner to which it impacts CEO compensation. That is, we find overconfident executives also receive higher levels of option and equity intensity than do rational executives.[5] Importantly, the impact of executive overconfidence on compensation is independent of CEO overconfidence, i.e., regardless of whether the CEO is overconfident or not, overconfident non-CEO executives receive higher levels of option and stock intensity. This is an important finding since it indicates incentive compensation for CEOs and non-CEO executives is being driven by the same economic rationale, reflecting individual traits and not merely firm-level characteristics.

We next conduct tests to differentiate between the exploitation and the strong-incentive hypotheses. In particular, we first examine the impact of CEO bargaining power. As discussed in GHO, under the exploitation hypothesis an increase in CEO bargaining power results in an increase in option intensity. The argument is that since overconfident (but risk-averse) CEOs overvalue options relative to the firm (and relative to the rational CEO), an increase in compensation resulting from an increase in CEO bargaining power takes the form of more options-based pay. On the contrary, the strong-incentive hypothesis predicts a decrease in option intensity: as incentive conditions are satisfied and, with risk-averse overconfident CEOs valuing options less than the firm (but more than their rational counterparts) any additional compensation takes the form of cash. We find empirically that the positive relation between overconfidence and option intensity increases with CEO bargaining power, consistent with the exploitation hypothesis but not the strong-incentive hypothesis.

We then use the passage of the Sarbanes-Oxley Act of 2002 (SOX) as an exogenous shock to also help differentiate between the exploitation and the strong-incentive hypotheses. Given increased board monitoring post-SOX, if incentive compensation and board monitoring are substitute governance mechanisms, then firms will lower the option intensity of compensation contracts. However, under the exploitation hypothesis, options-based pay at the margin is used to exploit CEO overconfidence. Hence, there

[2] Throughout the paper, when we refer to equity we refer to both options and stock.

[3] GHO differentiate between mild overconfidence and excessive overconfidence. The weak-incentive hypothesis we outlined above aligns with GHO's mild overconfidence scenario. Throughout the paper, when we refer to overconfidence, we refer to excessive overconfidence within the GHO framework.

[4] We follow the recent finance literature in creating our overconfidence measures. See, among others, Campbell, Gallmeyer, Johnson, Rutherford, and Stanley (2011), Malmendier, Tate, and Yan (2011), and Hirshleifer Low, and Teoh (2012).

[5] For ease of exposition, throughout the paper we will refer to non-overconfident executives (and non-overconfident CEOs) as "rational" rather than "relatively rational" or "more rational."

is reduced scope to substitute option compensation with monitoring. We find that the reduction in option intensity post-SOX is less severe for overconfident CEOs, consistent with the exploitation hypothesis.

We also use the passage of FAS 123R as another natural experiment to differentiate between the exploitation and the strong-incentive hypotheses. FAS 123R requires firms to report options-based compensation at fair value on their income statement, thus rendering options-based compensation more expensive from an accounting perspective.[6] Both Hayes et al. (2012) and Skantz (2012) show that option intensity decreases following the passage of FAS 123R. We find that this trend similarly affects overconfident and rational CEOs. However, while the percentage decrease in option intensity is similar, the dollar amount of cash and stock compensation increases more for overconfident CEOs post-FAS 123R. This is again consistent with the exploitation hypothesis as under this hypothesis the CEO places a greater value on options than the firm does, so a reduction in option pay requires the firm to give the CEO a relatively larger offsetting increase in cash and stock compensation.

We take steps to mitigate various econometric concerns. The two natural experiments (SOX and FAS 123R) help mitigate endogeneity concerns as both are exogenous shocks that affect the optimal compensation contract, and thus, the impact of CEO overconfidence on compensation. Our results are robust to using propensity score matching and weighting-based approaches, which help mitigate selection bias concerns. The results are also robust to using Fama and MacBeth (1973) type regressions and Tobit regressions. In addition, our inferences are unaffected when we control for anti-takeover provisions (Gompers, Ishii, and Metrick, 2003; Bebchuk, Cohen, and Ferrell, 2009) or the general ability of CEOs (Custodio, Ferreira, and Matos, 2013). Our results are similar when we use alternative measures of overconfidence or use pay-to-performance sensitivity as an alternative measure of incentive compensation. Further, since incentive intensity and our overconfidence measure are both options-based, there may be a concern that our results are affected by a mechanical relation between the two. We conduct a series of tests to show that this is not the case. We also find our results are robust to using non-options-based measures of overconfidence.

In a related paper, Otto (2014) distinguishes between the CEO overconfidence modeled in GHO and CEO optimism. Focusing on CEO optimism and the *level* of compensation, he finds that optimistic CEOs receive smaller stock option grants and less total compensation than their peers. In contrast, our analysis focuses on overconfidence (as modeled in GHO) and the *structure* of compensation (i.e., the proportion, rather than the level, of incentive compensation) for *both* CEOs *and* executives. In addition, our results are robust to controlling for the CEO optimism measure used in Otto (2014).

Our analysis of overconfidence and compensation contributes to the literature in several ways. Supporting the theoretical arguments in GHO that firms exploit overconfident managers' positively biased views of firm prospects, we show empirically that overconfident CEOs receive greater option and equity intensity than do their rational counterparts. As Malmendier, Tate, and Yan (2011) point out, it is imperative for boards to calibrate incentives to account for behavioral traits. Our results suggest that firms "fine-tune" their contracts to match personality traits such as overconfidence. We also investigate whether the overconfidence of top executives outside of the CEO impacts compensation. To the best of our knowledge, we are the first to do so. We find executive overconfidence impacts compensation for non-CEO executives in a similar manner to which it impacts CEOs.

Our results also help reconcile a recent finding in the literature. Hayes, Lemmon, and Qiu (2012) show option use decreases after FAS 123R without significant changes in firm financial and investment policies related to risk-taking. Thus, they question why option compensation continues to be used. However, at least for overconfident CEOs—and for overconfident executives more broadly—the continued use of options can be explained. To the extent that options are overvalued by overconfident executives and are used by firms to exploit rather than incentivize CEOs at the margin, options provide a relatively cheap form of compensation from the firm's perspective.

The remainder of our paper is organized as follows. In Section 2 we develop the hypotheses, in Section 3 we discuss the data, and in Section 4 we present the empirical analyses. In Section 5 we report robustness tests and we conclude in Section 6.

2. Hypotheses

This section discusses alternative hypotheses about the impact of CEO overconfidence on incentive compensation. We start by discussing the GHO model and the resulting predictions. We then discuss an extension to GHO's model and develop additional empirical predictions.

2.1. Contracting with overconfident CEOs

GHO model the relation between CEO overconfidence and incentive compensation. Two hypotheses obtain from their model, the first being the *weak-incentive hypothesis*. This hypothesis is based on the notion that since an overconfident manager underestimates a project's risks and/or overestimates a project's payoffs, she requires relatively weaker incentives. If a manager is extremely overconfident, however, GHO show it is optimal for the firm to offer incentive-intensive compensation to exploit the CEO's overconfidence. We refer to this as the *exploitation hypothesis*. The idea is that an extremely overconfident manager may value incentive compensation more than the firm does. Hence, the firm provides incentive-intensive contracts to take advantage of CEO overvaluation, rather than to provide incentives per se.

In Appendix A, we develop a simple extension to the GHO model to show it is possible that firms, at the margin, use option compensation to incentivize, rather than to exploit, overconfident CEOs. Hence, firms could provide option-intensive contracts even when an overconfident

[6] Prior to the implementation of FAS 123R, firms were allowed to expense stock options at intrinsic value, which in most cases was zero as firms usually grant at-the-money stock options.

CEO does not value options more than the firm. We label this the *strong-incentive hypothesis*. The intuition is that it is cheaper for the firm to incentivize overconfident CEOs since they place a greater likelihood on successful outcomes than their rational counterparts. Thus, in some circumstances it can be cost-effective to use option-based contracts to incentivize overconfident CEOs, whereas it might be too costly to provide the incentives required to elicit a similar response from rational CEOs. The important point is that, under the strong-incentive hypothesis, options at the margin serve an incentive purpose for overconfident CEOs.

While both the exploitation and the strong-incentive hypotheses predict that overconfident CEOs receive greater incentive-based compensation, there are two key testable differences between the hypotheses. The first relates to what we call 'incentive slack.' Under the exploitation hypothesis there is incentive slack: firms, at the margin, compensate overconfident CEOs with options to exploit their overvaluation of risky outcomes rather than to provide incentives. By contrast, under the strong-incentive hypothesis, options at the margin have an incentive effect for overconfident CEOs, i.e., there is no incentive slack. The second key difference relates to CEO bargaining power. As argued in GHO, increases in CEO bargaining power under the exploitation hypothesis will be associated with relatively greater increases in incentive intensity for overconfident CEOs. The intuition is that since overconfident CEOs overvalue incentive compensation relative to the firm, an increase in compensation on account of greater bargaining power takes the form of additional incentive pay rather than cash. By contrast, the strong-incentive hypothesis predicts the opposite. With an increase in CEO bargaining power, the gain in compensation comes from cash compensation. The reason is that under the strong-incentive hypothesis, the risk-averse manager values incentive pay less than the firm. Hence, increases in CEO compensation on account of bargaining power are provided by the firm in the form of cash. Consequently, greater CEO bargaining power is associated with a decrease in the proportion of incentive pay.

2.2. Empirical predictions

This section presents the empirical predictions that flow from the *weak-incentive hypothesis*, the *exploitation hypothesis*, and the *strong-incentive hypothesis*. We test these predictions in subsequent sections.

2.2.1. Overconfidence and compensation

As discussed above, under the weak-incentive hypothesis a smaller equity stake is sufficient to induce overconfident managers to deliver the required effort or to make the appropriate decisions. On the other hand, under both the exploitation and strong-incentive hypotheses we expect firms to provide incentive-intensive compensation contracts to overconfident CEOs.

Hypothesis 1a. (weak-incentive): CEO overconfidence reduces the proportion of compensation that comes from options and equity.

Hypothesis 1b. (exploitation and strong-incentive): CEO overconfidence increases the proportion of compensation that comes from options and equity.

For the remainder of this section we focus on predictions from the exploitation and strong-incentive hypotheses. Indeed, our empirical evidence indicates that overconfident managers are offered stronger incentive contracts, supporting Hypothesis 1b, and so the rest of our empirical analysis is aimed at identifying the underlying mechanism. We first discuss implications that are similar for the exploitation and strong-incentive hypotheses and then develop predictions that can help distinguish between these two hypotheses. We also discuss predictions for non-CEO executives.

2.2.2. Corporate innovativeness and risk

We expect overconfident CEOs to receive relatively more incentive compensation in firms that are more innovative or riskier. It is in such firms that we might expect a starker difference in compensation structure between overconfident and rational CEOs. GHO argue that highly overconfident CEOs are attracted to riskier and innovative companies, which are more likely to use incentive-based compensation. Consistent with the exploitation hypothesis, overconfident CEOs are more likely to believe they can increase corporate value and thus, are more likely to accept, and potentially pursue, incentive-intensive compensation contracts. Likewise, it is in firms that are riskier and innovative that we would expect the strong-incentive hypothesis to be more evident. In line with this, prior literature suggests that overconfident CEOs tend to perform better in more innovative companies (Galasso and Simcoe, 2011; Hirshleifer, Low, and Teoh, 2012). Thus, we have the following hypothesis:

Hypothesis 2. The incentive intensity of compensation awarded to overconfident CEOs (i.e., the proportion of compensation that comes from options and equity) is greater in more innovative firms and riskier firms.

2.2.3. Non-CEO executive overconfidence and compensation

To the extent that the arguments with respect to overconfident CEOs carry over to senior executives, we expect overconfident non-CEO executives to also receive incentive-heavy compensation contracts.

Hypothesis 3. Overconfidence increases the incentive intensity of non-CEO executive compensation.

Tests to differentiate between the exploitation and strong-incentive hypotheses are discussed next.

2.2.4. Impact of CEO bargaining power

As discussed earlier, under the exploitation hypothesis, an increase in CEO bargaining power leads to overconfident CEOs receiving even greater incentive pay. Under the strong-incentive hypothesis, an increase in an overconfident CEO's bargaining power results in incentive pay becoming a smaller fraction of total pay (i.e., a drop in incentive intensity).

Hypothesis 4a. Under the exploitation hypothesis, CEO bargaining power positively impacts the relation between *overconfidence and the incentive intensity of compensation*.

Hypothesis 4b. Under the strong-incentive hypothesis, CEO bargaining power negatively impacts the relation between overconfidence and the incentive intensity of compensation.

2.2.5. Impact of the Sarbanes-Oxley Act (SOX) of 2002

We expect SOX to cause a reduction in option intensity for at least two reasons. First, monitoring and incentive compensation are arguably substitutes. For example, Cadman, Klasa, and Matsunaga (2010) find that incentive compensation decreases with institutional monitoring. Guo, Lach, and Mobbs (2015) argue that exogenous increases in internal monitoring (as mandated by listing rules) substitute for other governance mechanisms (such as reduced usage of anti-takeover provisions and shareholder activism). SOX increased monitoring by, for example, mandating a majority independent board and a fully independent audit committee. Prior literature indicates that SOX makes it more difficult for insiders to extract rents from minority shareholders (Duarte, Kong, Young, and Siegel, 2014). Thus, to the extent that monitoring and incentive compensation are substitutes, SOX leads to a shift away from options-based compensation. Second, corporations are cognizant of the CEO's risk exposure when designing optimal incentive contracts (Aggarwal, 2008). SOX exposed CEOs to significantly more personal liability by, for example, requiring them to personally certify financial statements (Arping and Sautner, 2013). This increased risk exposure may lead to compensation contracts that are less risky.

SOX, however, is likely to have a relatively weaker impact on the compensation structure of overconfident CEOs under the exploitation hypothesis. The reason is that, under this hypothesis, options-based compensation is a relatively inexpensive way to compensate overconfident CEOs and, at the margin, is not used as a means to incentivize CEOs due to a lack of monitoring. Thus, we have the following hypotheses:

Hypothesis 5a. SOX reduces the incentive intensity of CEO compensation.

Hypothesis 5b. Under the exploitation hypothesis, but not the strong-incentive hypothesis, SOX reduces the incentive intensity of CEO compensation less for overconfident CEOs.

2.2.6. Impact of FAS 123R

FAS 123R requires firms to report option-based compensation at fair value on their income statement, rather than intrinsic value which was often zero. Thus, FAS 123R had the effect of making options-based compensation more expensive from an accounting perspective. Both Hayes, Lemmon, and Qiu (2012) and Skantz (2012) show option use substantially declined after the introduction of FAS 123R.

Under the exploitation hypothesis, overconfident CEOs place a greater value on options than do firms. Hence, we expect any reduction in option intensity post-FAS 123R to be accompanied by a significantly greater increase in cash and stock compensation to offset the decrease in the overconfident CEO's perceived compensation. This follows from the notion that under the exploitation hypothesis, options valued by the market at, say, $100 are valued higher than that by an overconfident CEO. Hence, if there is a reduction in the options awarded to the CEO, she would need to be given an amount larger than $100, the market's valuation of the options, if the CEO is to remain indifferent. Relative to rational CEOs, we expect overconfident CEOs to receive significantly greater cash and stock compensation for a given reduction in option intensity.

On the other hand, under the strong-incentive hypothesis, overconfident CEOs are not being exploited and value the options at less than the market or the firm (but more than the rational CEO). Hence, relative to rational CEOs, a reduction in their options post-FAS 123R is not expected to lead to a significantly greater increase in non-option (especially cash) compensation. This leads to the following:

Hypothesis 6. Under the exploitation hypothesis, but not the strong-incentive hypothesis, for the same decrease in option intensity post-FAS 123R there will be a significantly greater increase in the cash and stock compensation for overconfident CEOs.

3. Data

3.1. Sample construction

We examine the relation between overconfidence and compensation structure over the 1992–2011 period. We obtain compensation data from ExecuComp and merge these data with the Center for Research in Securities Prices (CRSP) and Compustat datasets to obtain financial and accounting variables. Patent and citation data are from the National Bureau of Economic Research (NBER) (these data are only available up until 2006). The overall CEO sample contains 12,810 CEO-year observations and the overall executive sample contains 48,703 executive-year observations. However, the sample sizes decrease when we require additional data (for example, patent data). The dependent variables (i.e., the compensation structure variables) are measured in year t and the independent variables such as overconfidence are measured in year $t-1$.

3.2. Measures of CEO and executive compensation structure

We construct three main dependent variables: *Option intensity, Equity intensity*, and *Cash intensity. Option intensity* measures the proportion of total annual CEO compensation that comes from option grants. The option valuation is as reported in ExecuComp, where option values are based on the Black-Scholes methodology before FAS 123R and based on grant-date fair value after FAS 123R.[7] Our

[7] The inputs to the Black-Scholes option valuation calculation are available on the Wharton Research Data Services (WRDS) website (https://wrds-web.wharton.upenn.edu/wrds/support/Data/_001Manuals%20and%20Overviews/_00 1Compustat/_007Execucomp/_004Modified%20Black-Scholes%20Option%20Valuation%20Methodology.cfm).

results are robust to ending the sample period in 2005 where only the ExecuComp computed Black-Scholes option values are used. *Equity intensity* measures the proportion of total annual CEO compensation that comes from option and stock grants. *Cash intensity* measures the proportion of total annual CEO compensation that comes from cash. The total annual compensation does not reflect changes in the value of the CEO's *existing* stock and option holdings.

3.3. Measure of CEO and executive overconfidence

We follow the literature in primarily using an options-based measure of overconfidence. For robustness, we employ media-based measures along with alternative options-based measures. The intuition behind our primary measure is that since a CEO's wealth is undiversified, a rational CEO will exercise deep in-the-money options soon after the options vest. Therefore, retaining vested deep in-the-money options signals a degree of overconfidence. Using publicly available data, we construct a *Holder67* measure of overconfidence following the literature (see, e.g., Campbell, Gallmeyer, Johnson, Rutherford, and Stanley, 2011; Malmendier, Tate, and Yan, 2011; Hirshleifer, Low, and Teoh, 2012; Ahmed and Duellman, 2013). To do this, we start by calculating a continuous *Confidence* measure as follows:

$$Confidence = \frac{Average\ value\ per\ vested\ option}{Average\ strike\ price} \quad (1)$$

where,

$$Average\ value\ per\ vested\ option = \frac{Value\ of\ vested\ unexercised\ options}{Number\ of\ vested\ unexercised\ options}$$

$$Average\ strike\ price = tock\ price - \ Average\ value\ per\ vested\ option$$

We define the *Average strike price* as the *Stock price* at the end of the fiscal year less the *Average value per vested option*. We then define the *Holder67* measure as an indicator that equals one if the *Confidence* measure is at least 67% in two or more years, in which case, we classify the CEO as overconfident from the first time that the *Confidence* measure is at least 67%. We follow an identical procedure to classify an executive as overconfident (*Exec Holder67*).

3.4. Control variables

We control for a variety of factors that the compensation literature suggests are potentially important. At the CEO level we control for ownership, tenure, and age. At the firm level we control for size, age, free cash flows, Research and Development (R&D) expenses, tangible assets, leverage, market-to-book ratio, stock return, stock return volatility, and the degree of industry competition the firm faces. Appendix B describes the control variables in detail along with all other variables we use in the paper.

3.5. Summary statistics

The summary statistics are reported in Table 1. The numbers for the full sample are largely consistent with the literature.[8] In Panel A we also present summary statistics for the overconfident ($Holder67 = 1$) and rational ($Holder67 = 0$) CEO samples separately. There are significant differences between the two samples. Overconfident CEOs have greater option intensity, equity intensity, and smaller cash intensity than their rational counterparts, consistent with the exploitation and strong-incentive hypotheses. They also have greater stock ownership and are longer-tenured. Overconfident CEOs also tend to be at companies that are younger, have higher market-to-book ratios, and greater innovation intensity (*Cites*/*Patents*). This is consistent with the idea that overconfident CEOs gravitate toward innovative companies, where they are shown to add value (Galasso and Simcoe, 2011; Hirshleifer, Low, and Teoh, 2012). In Panel B, we also find overconfident non-CEO executives have greater option intensity, equity intensity, and smaller cash intensity than their rational counterparts.

4. Does overconfidence influence compensation?

4.1. Overconfidence and CEO compensation

We first examine whether overconfidence impacts CEO incentive compensation. We analyze this within an ordinary least squares (OLS) regression framework. The dependent variables are *Option intensity, Equity intensity* and *Cash intensity*, respectively.

Table 2 reports regression results testing the first set of hypotheses relating CEO overconfidence to incentive compensation (Hypotheses 1a and 1b). Models 1–6 use year and Fama-French 48 industry fixed effects; Models 7–12 use year and firm fixed effects. Since CEO overconfidence is a behavioral trait that mainly changes with CEO turnover (i.e., *Holder67* is often time-invariant for firms, potentially changing if the CEO changes), controlling for firm fixed effects potentially reduces the power of the tests. However, firm fixed effects allow us to capture whether the same firm compensates an overconfident CEO differently from a rational CEO, mitigating concerns that the results could reflect firm-level compensation-setting policies. All models cluster standard errors by firm. In each case, we report models that use *Holder67* to measure CEO overconfidence and also report results for models in which we divide CEO overconfidence into three categories: *Holder30-Holder67, Holder67-Holder100*, and *Holder100* (defined shortly).

As the results controlling for year and industry fixed effects are very similar to those controlling for year and firm fixed effects, our discussion below focuses on the former. The main finding is that CEO overconfidence is associated with increased option intensity and that option intensity monotonically increases with the degree of overconfidence. Models 1–3 show that overconfident CEOs have significantly higher levels of option intensity and equity

[8] The sum of cash and equity intensity is not equal to one because CEOs also receive other types of compensation such as long-term incentive plans (LTIPs). Hayes, Lemmon, and Qiu (2012) find that while the use of LTIPs increased on average with the passage of FAS 123R, the median LTIP value both before and after FAS 123R is zero. Moreover, they find little evidence LTIPs replace the convexity options provide.

Table 1
Summary statistics.
Panel A of this table contains sample means for the full sample (Column 1), companies run by overconfident CEOs (Column 2), and rational CEOs (Column 3). Column 4 contains the difference in means between Column 2 and Column 3. Panel B contains sample means for the non-CEO executive characteristics (Column 1), overconfident executives (Column 2) and rational executives (Column 3). Column 4 contains the difference in means between Column 2 and Column 3. *** denote significance at 1%. See Appendix B for variable definitions.

Panel A: CEO compensation sample

Sample	All firms [1]	Overconfident (Holder67 = 1) [2]	Rational (Holder67 = 0) [3]	Difference [4] = [2] − [3]
Option intensity	0.309	0.347	0.270	0.077***
Equity intensity	0.430	0.456	0.403	0.054***
Cash intensity	0.434	0.413	0.456	−0.043***
log(Cash)	6.848	6.875	6.820	0.055***
log(Total pay)	7.923	8.021	7.821	0.200***
Holder30	0.700			
Holder67	0.508			
Holder100	0.384			
Holder30-Holder67[a]	0.193			
Holder67-Holder100[b]	0.124			
Ownership (%)	0.019	0.024	0.015	0.009***
Tenure	7.509	9.264	5.697	3.568***
Age	54.726	55.024	54.418	0.606***
Firm size	7.250	7.116	7.389	−0.272***
Financial leverage	0.226	0.205	0.248	−0.043***
Firm age	26.131	22.547	29.830	−7.283***
Stock volatility	0.028	0.030	0.027	0.002***
Stock return	0.217	0.317	0.113	0.205***
Market-to-book	2.045	2.402	1.676	0.726***
HHI	1,307	1,335	1,273	62***
Free cash flows	0.027	0.027	0.027	0.000
R&D	0.507	0.513	0.502	0.010
PP&E	0.565	0.512	0.619	−0.106***
Cites/Patents	18.050	19.724	16.350	3.374***
Cites/Patents (5 years)	14.025	15.729	12.262	3.467***

Panel B: non-CEO executive characteristics

Sample	All firms [1]	Exec overconfident (Exec Holder67 = 1) [2]	Exec rational (Exec Holder67 = 0) [3]	Difference [4] = [2] − [3]
Exec option intensity	0.269	0.305	0.238	0.067***
Exec equity intensity	0.373	0.393	0.348	0.045***
Exec cash intensity	0.500	0.494	0.517	−0.024***
Exec Holder67	0.442			

[a]This number represents the proportion of observations for which Holder30 equals one and Holder67 equals zero.
[b]This number represents the proportion of observations for which Holder67 equals one and Holder100 equals zero.

intensity and lower levels of cash intensity compared to rational CEOs. These results are not consistent with the weak-incentive hypothesis (Hypothesis 1a) but are consistent with both the exploitation and the strong-incentive hypotheses (Hypothesis 1b). The results are also economically significant. For example, from Model 1 CEO overconfidence is associated with an increase of 3.7% in option intensity in absolute terms. Given the unconditional mean of 30.9% (Table 1, Panel A), this represents a more than 10% proportional increase in option intensity.

In Models 1–3 we use *Holder67* as our measure of overconfidence. However, the weak-incentive hypothesis may be more apt at describing the incentive compensation of moderately overconfident managers as in GHO. That is, moderately overconfident CEOs will have lower option intensity than their rational counterparts. Similar in spirit to Campbell et al. (2011), we measure various degrees of overconfidence by using a range of cutoffs for the *Confidence* variable defined earlier when computing our *Holder67* variable. For example, the variable *Holder30-Holder67* represents CEOs whose *Confidence* variable (vested option moneyness) is between 30% and 67%. In Models 4–6 of Table 2 we include a range of overconfidence measures and set the base case to the low overconfidence group. We find a monotonically increasing relation between overconfidence and option intensity as evidenced by the significant coefficients on the gradations of overconfidence. Thus, we do not find support for moderate levels of overconfidence leading to smaller option intensity relative to the rational group (i.e., we do not find support for the weak-incentive hypothesis).

The results in relation to the control variables are largely consistent with the literature (e.g., Hill and Phan, 1991; Hayes, Lemmon, and Qiu, 2012; Skantz, 2012). The CEO's stock *Ownership*, *Tenure* and *Age* are negatively associated with option and equity intensity but positively associated with cash intensity. *Firm size* is associated with greater option/stock intensity and highly levered firms

Table 2
Baseline regression results.

This table contains OLS regression results for the relation between overconfidence and CEO compensation. Columns 1–6 include year and Fama-French 48 industry fixed effects. Columns 7–12 include firm and year fixed effects. All models include a constant (suppressed) and use standard errors clustered by firm. See Appendix B for variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively

Dependent variable	Option intensity [1]	Equity intensity [2]	Cash intensity [3]	Option intensity [4]	Equity intensity [5]	Cash intensity [6]	Option intensity [7]	Equity intensity [8]	Cash intensity [9]	Option intensity [10]	Equity intensity [11]	Cash intensity [12]
Holder67	0.037***	0.018***	−0.024***				0.042***	0.034***	−0.031***			
	[0.000]	[0.007]	[0.000]				[0.000]	[0.000]	[0.000]			
Holder30-Holder67				0.030***	0.018**	−0.015*				0.036***	0.027***	−0.027***
				[0.000]	[0.030]	[0.060]				[0.000]	[0.004]	[0.003]
Holder67-Holder100				0.035***	0.023**	−0.033***				0.047***	0.034***	−0.035***
				[0.000]	[0.021]	[0.000]				[0.000]	[0.004]	[0.001]
Holder100				0.057***	0.028***	−0.031***				0.068***	0.056***	−0.051***
				[0.000]	[0.001]	[0.000]				[0.000]	[0.000]	[0.000]
Ownership (%)	−0.319***	−0.455***	0.483***	−0.316***	−0.454***	0.482***	−0.221*	−0.225	0.223	−0.222*	−0.226	0.223
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.091]	[0.137]	[0.141]	[0.087]	[0.133]	[0.138]
Tenure	−0.000	−0.001**	0.002***	−0.000	−0.002***	0.002***	−0.001	−0.003***	0.002**	−0.002**	−0.003***	0.003***
	[0.889]	[0.015]	[0.002]	[0.574]	[0.009]	[0.002]	[0.120]	[0.006]	[0.011]	[0.050]	[0.002]	[0.005]
Age	−0.003***	−0.004***	0.002***	−0.003***	−0.004***	0.002***	−0.004***	−0.005***	0.002***	−0.004***	−0.005***	0.003***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.003]	[0.000]	[0.000]	[0.002]
Firm size	0.042***	0.063***	−0.071***	0.042***	0.063***	−0.071***	0.036***	0.036***	−0.045***	0.036***	0.036***	−0.045***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Financial leverage	−0.085***	−0.078***	0.062***	−0.083***	−0.077***	0.061***	−0.073**	−0.079***	0.101***	−0.067**	−0.074**	0.097***
	[0.000]	[0.000]	[0.003]	[0.000]	[0.000]	[0.003]	[0.015]	[0.009]	[0.000]	[0.027]	[0.014]	[0.001]
Firm age	−0.001***	−0.002***	0.001***	−0.001***	−0.002***	0.001***	−0.027*	−0.029*	0.014	−0.027*	−0.029*	0.014
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.081]	[0.069]	[0.276]	[0.080]	[0.068]	[0.281]
Stock volatility	1.753***	0.871***	−0.737***	1.802***	0.911***	−0.780***	1.209***	−0.077	−0.457	1.213***	−0.081	−0.460
	[0.000]	[0.002]	[0.005]	[0.000]	[0.001]	[0.003]	[0.000]	[0.807]	[0.139]	[0.000]	[0.798]	[0.137]
Stock return	−0.001	0.004	−0.012***	−0.002	0.004	−0.012***	−0.002	0.000	−0.010**	−0.002	0.000	−0.010**
	[0.793]	[0.361]	[0.003]	[0.696]	[0.401]	[0.004]	[0.610]	[0.918]	[0.013]	[0.608]	[0.911]	[0.014]
Market-to-book	0.036***	0.031***	−0.025***	0.034***	0.030***	−0.024***	0.029***	0.026***	−0.019***	0.028***	0.025***	−0.017***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
HHI	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000**	−0.000	−0.000	−0.000**	−0.000	−0.000
	[0.110]	[0.369]	[0.671]	[0.115]	[0.363]	[0.691]	[0.015]	[0.340]	[0.568]	[0.016]	[0.349]	[0.564]
Free cash flows	−0.062***	−0.073***	0.031	−0.062***	−0.073***	0.032	−0.026	−0.024	0.009	−0.026	−0.024	0.009
	[0.006]	[0.003]	[0.189]	[0.005]	[0.003]	[0.180]	[0.236]	[0.329]	[0.704]	[0.241]	[0.334]	[0.711]
R&D	0.026**	0.019*	−0.031***	0.027***	0.020*	−0.031***	−0.012	−0.015	0.009	−0.012	−0.015	0.009
	[0.013]	[0.077]	[0.003]	[0.010]	[0.073]	[0.003]	[0.566]	[0.543]	[0.714]	[0.570]	[0.555]	[0.720]
PP&E	−0.028**	−0.028**	0.026**	−0.025**	−0.027**	0.025**	−0.045*	−0.089***	0.086***	−0.043*	−0.087***	0.084***
	[0.023]	[0.034]	[0.036]	[0.035]	[0.039]	[0.038]	[0.060]	[0.000]	[0.000]	[0.072]	[0.000]	[0.000]
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Firm fixed effects	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,772	12,772	12,772	12,772	12,772	12,772	12,810	12,810	12,810	12,810	12,810	12,810
R-squared	0.238	0.197	0.305	0.240	0.197	0.305	0.152	0.064	0.196	0.154	0.065	0.197

Table 3
Impact of innovation and risk.

Dependent variable	Option intensity [1]	Equity intensity [2]	Cash intensity [3]	Option intensity [4]	Equity intensity [5]	Cash intensity [6]
Cites/Patents						
Holder67	0.015	−0.002	−0.012	0.018	0.017	−0.026**
	[0.151]	[0.858]	[0.210]	[0.196]	[0.207]	[0.028]
Cites/Patents (/100)	−0.008	−0.001	−0.007	0.067**	0.113***	−0.152***
	[0.549]	[0.905]	[0.601]	[0.016]	[0.000]	[0.000]
Holder67∗Cites/Patents (/100)	0.089***	0.119***	−0.094***	0.086*	0.087**	−0.060
	[0.001]	[0.000]	[0.000]	[0.050]	[0.050]	[0.131]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	6,677	6,677	6,677	6,701	6,701	6,701
R-squared	0.255	0.211	0.294	0.168	0.076	0.162
Cites/Patents (5 years)						
Holder67	0.025**	0.003	−0.019*	0.038**	0.025*	−0.025**
	[0.027]	[0.776]	[0.054]	[0.014]	[0.070]	[0.036]
Cites/Patents (5 years) (/100)	0.042***	0.042**	−0.049***	0.064***	0.081***	−0.088***
	[0.010]	[0.031]	[0.003]	[0.005]	[0.000]	[0.000]
Holder67∗Cites/Patents (5 years) (/100)	0.063*	0.102***	−0.079***	0.051	0.071	−0.112***
	[0.062]	[0.001]	[0.006]	[0.258]	[0.109]	[0.004]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	5,800	5,800	5,800	5,823	5,823	5,823
R-squared	0.256	0.206	0.291	0.170	0.065	0.146
Stock volatility						
Holder67	0.017	−0.010	−0.002	0.034**	0.022	−0.015
	[0.187]	[0.412]	[0.899]	[0.012]	[0.107]	[0.228]
Stock volatility	1.339***	0.283	−0.260	1.069***	−0.305	−0.127
	[0.000]	[0.402]	[0.432]	[0.006]	[0.456]	[0.756]
Holder67∗Stock volatility	0.759**	1.057***	−0.836**	0.270	0.417	−0.589
	[0.048]	[0.007]	[0.029]	[0.518]	[0.329]	[0.166]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	12,772	12,772	12,772	12,810	12,810	12,810
R-squared	0.238	0.197	0.306	0.152	0.064	0.196

This table contains OLS regressions that examine how innovation and risk influence the relation between overconfidence and CEO compensation. The models include all control variables from Table 2 (suppressed). Columns 1–3 include year and Fama-French 48 industry fixed effects. Columns 4–6 include firm and year fixed effects. All models include a constant (suppressed) and use standard errors clustered by firm. See Appendix B for variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

(*Financial leverage*) tend to pay compensation more in the form of cash, rather than equity. Higher growth firms tend to feature higher levels of option/stock intensity and lower levels of cash intensity (see, e.g., the coefficients on *Market-to-book*, *R&D*, and *PP&E*). Similarly, risky firms also tend to feature higher levels of option/stock intensity and lower levels of cash intensity (see the coefficients on *Stock volatility* and *Free cash flows*).

4.2. Impact of innovativeness and risk

Hypothesis 2 predicts that corporate innovativeness and risk are associated with higher levels of option and equity intensity for overconfident CEOs. We interact the *Holder67* measure with the number of citations scaled by the number of patents in year $t-1$ (*Cites/Patents*) and over the prior five years (*Cites/Patents (5 years)*). In both cases, we scale the number by 100. We measure risk by the volatility of the firm's daily stock return over the prior year (*Volatility*). In Table 3 we report models with year and industry fixed effects (Models 1–3) and models with year and firm fixed effects (Models 4–6).

The key finding in Models 1–3 is that overconfident managers have even greater option intensity and equity intensity in innovative firms (as shown by the positive coefficients on *Holder67∗Cites/Patents* and *Holder67∗Cites/Patents (5 years)*).[9] Similarly, *Holder67∗Volatility* is positively related to *Option intensity*, implying that overconfidence is

[9] The level of *Cites/Patents (5 years)* is positively and significantly related to option intensity, whereas the level of *Cites/Patents* is not. This suggests innovative performance measured over a five-year window is more linked to the use of incentive-based pay.

even more positively associated with options-based compensation in risky firms. These results are consistent with both the exploitation hypothesis and the strong-incentive hypothesis. Models 4–6 show that the results are significantly weaker in the models that use firm fixed effects. This likely reflects the relatively low degree of variation in *Holder67* and the firm's degree of innovation (relative to other firms) over time.

4.3. Non-CEO executive overconfidence and compensation

We expect overconfident non-CEO executives will also have greater option (and equity) intensity (Hypothesis 3). For each executive in ExecuComp we calculate an *Exec Holder67* measure. The reported models contain industry and year fixed effects. The results are robust to using executive and year fixed effects.

Consistent with Hypothesis 3, we find in Models 1–3 of Table 4 that overconfidence affects non-CEO executive compensation in a similar manner to which it impacts CEO compensation. Specifically, overconfident non-CEO executives feature greater option and stock intensity and lower cash intensity. Next, we split the sample by whether the CEO is overconfident. Models 4–6 analyze firms where the CEO is overconfident and Models 7–9 analyze firms where the CEO is not overconfident. The main finding is that the coefficient on *Exec Holder67* is of the same sign and of similar magnitude and statistical significance in both subsamples. This important finding suggests that the impact of non-CEO executive overconfidence on compensation does not depend on whether the CEO is also overconfident. That is, the compensation contract accounts for individual behavioral traits such as overconfidence and not merely firm-level characteristics.

In unreported tests we analyze samples that contain only the most overconfident or the highest paid non-CEO executive in each firm and find similar results to those reported.[10] We also analyze whether the results we obtain for overconfident CEOs in Table 3 similarly extend to overconfident non-CEO executives and find the results carry over. Specifically, we find that option and equity intensity significantly increases and cash intensity significantly decreases for overconfident non-CEO executives in innovative firms and riskier firms. Overall, both the reported and unreported results highlight that compensation practices are similar at both the CEO and non-CEO executive level, presumably being driven by the same economic rationale.

4.4. Impact of bargaining power

The results thus far are consistent with both the exploitation and strong-incentive hypotheses. We next examine the impact of bargaining power on overconfident CEOs' compensation contracts to differentiate between the two hypotheses. The exploitation hypothesis predicts that an increase in bargaining power increases incentive intensity (Hypothesis 4a) while the strong-incentive hypothesis predicts that an increase in bargaining power reduces incentive intensity (Hypothesis 4b).

We capture the CEO's bargaining power using two sets of variables. The first set is based on the CEO's "pay slice" (Bebchuk, Cremers, and Peyer, 2011). We create a pay slice measure: the CEO's total compensation scaled by the sum of the total compensation of the top-three highest remunerated non-CEO executives and denote this variable by *Pay slice*.[11] We then create an indicator for whether the CEO's pay slice measure is in the top quartile of all firms in that year. We also create an indicator that equals one if the CEO's total compensation is in the top 25% of the sample for that year, which connotes a relatively strong bargaining position. The results, reported in Table 5, indicate that an increase in CEO bargaining power is associated with a significant increase in incentive intensity both statistically and economically. For example, from Model 1 of Panel A the coefficient on the interaction term indicates that option intensity increases by 3.5% in absolute terms for overconfident CEOs in the top quartile of bargaining power (as measured by the CEO's pay slice). Given the unconditional mean of 30.9% (Table 1, Panel A), this represents a more than 10% proportional increase in option intensity. Moreover, compared to overconfident CEOs not in the top quartile of bargaining power, the option intensity more than doubles from 2.7% to 6.2% (=2.7% + 3.5%) in absolute terms. The results in Table 5 are consistent with the exploitation hypothesis and inconsistent with the strong-incentive hypothesis.

The second set of bargaining power variables relate to labor market competition in the CEO's state and industry. We capture this by analyzing whether the CEO is in a state and four-digit (or two-digit) Standard Industrial Classification (SIC) industry that has experienced compensation growth in the top 25% (or conversely, bottom 25%) in that year. The results, reported in Table 6, generally indicate that overconfident CEOs in industries and states that experience significant compensation growth experience significantly higher levels of option and equity intensity. That is, an overconfident CEO's incentive intensity increases with her bargaining power. This result is again consistent with the exploitation hypothesis and inconsistent with the strong-incentive hypothesis.

4.5. Impact of SOX

We expect SOX to be associated with a shift away from incentive compensation in general (Hypothesis 5a), but the effect to be weaker for overconfident CEOs under the exploitation hypothesis (Hypothesis 5b). We construct a *SOX* dummy that equals one if the observation is in 2003 or later and zero otherwise. We interact this *SOX* dummy with *Holder67*. We restrict the sample to observations from 1998

[10] In these tests, we retain only one executive at each company. To identify the most confident executive we use the continuous measure of confidence underlying *Holder67*. That is, we keep the executive with the highest value of the following ratio: *Average value per vested option/Average strike price*.

[11] Our results are very similar when we use the average or the median of the total compensation of the top-three highest remunerated non-CEO executives as the denominator.

Table 4
Non-CEO executive compensation.

This table contains models that examine the relation between non-CEO executive overconfidence and compensation. The unit of analysis is the company executive. *Exec Holder67* is the executive's Holder67 measure. Columns 1–3 examine the full sample of executives. Columns 4–6 and 7–9 analyze executives at firms where the CEO is, or is not (respectively), overconfident. The models include all firm-level control variables from Table 2, year and industry fixed effects, a constant (suppressed), and use standard errors clustered by firm. See Appendix B for variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively

Sample	All executives			All execs when CEO is overconfident			All execs when CEO is not overconfident		
Variables	Exec option intensity [1]	Exec equity intensity [2]	Exec cash intensity [3]	Exec option intensity [4]	Exec equity intensity [5]	Exec cash intensity [6]	Exec option intensity [7]	Exec equity intensity [8]	Exec cash intensity [9]
Exec Holder67	0.021***	0.016***	−0.019***	0.014***	0.013**	−0.015***	0.012**	0.010*	−0.016***
	[0.000]	[0.000]	[0.000]	[0.005]	[0.012]	[0.003]	[0.016]	[0.099]	[0.005]
Firm size	0.044***	0.065***	−0.074***	0.045***	0.066***	−0.074***	0.040***	0.062***	−0.072***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Financial leverage	−0.066***	−0.086***	0.068***	−0.046*	−0.073***	0.049**	−0.089***	−0.097***	0.087***
	[0.000]	[0.000]	[0.000]	[0.066]	[0.003]	[0.040]	[0.000]	[0.000]	[0.000]
Firm age	−0.002***	−0.002***	0.001***	−0.002***	−0.002***	0.001***	−0.001***	−0.002***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Stock volatility	1.878***	1.049***	−0.911***	1.918***	1.429***	−1.375***	1.725***	0.390	−0.181
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.214]	[0.547]
Stock return	0.001	0.004	−0.010***	−0.000	0.002	−0.007	0.003	0.006	−0.015***
	[0.818]	[0.296]	[0.002]	[0.959]	[0.633]	[0.134]	[0.500]	[0.264]	[0.002]
Market-to-book	0.039***	0.035***	−0.031***	0.035***	0.033***	−0.029***	0.041***	0.035***	−0.032***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
HHI	−0.000	0.000	−0.000	−0.000	0.000	−0.000	−0.000	0.000	−0.000
	[0.814]	[0.540]	[0.224]	[0.582]	[0.801]	[0.500]	[0.849]	[0.856]	[0.540]
Free cash flows	−0.032*	−0.031	0.002	0.001	−0.001	−0.062*	−0.049**	−0.044*	0.042*
	[0.064]	[0.109]	[0.934]	[0.974]	[0.973]	[0.054]	[0.015]	[0.064]	[0.094]
R&D	0.028***	0.022**	−0.033***	0.043***	0.030**	−0.038***	0.014	0.017	−0.028***
	[0.001]	[0.011]	[0.000]	[0.001]	[0.019]	[0.008]	[0.132]	[0.108]	[0.006]
PP&E	−0.027***	−0.025**	0.019*	−0.018	−0.009	0.008	−0.032***	−0.036***	0.022*
	[0.005]	[0.021]	[0.067]	[0.224]	[0.577]	[0.582]	[0.002]	[0.003]	[0.065]
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	48,703	48,703	48,703	26,821	26,821	26,821	21,882	21,882	21,882
R-squared	0.272	0.212	0.308	0.270	0.199	0.256	0.225	0.206	0.374

Table 5
Impact of bargaining power measured by pay slice.
This table contains models that analyze the impact of CEO bargaining power as measured by pay slice on the relation between overconfidence and compensation-structure. Columns 1–3 include year and Fama-French 48 industry fixed effects. Columns 4–6 include firm and year fixed effects. The models include all firm-level control variables from Table 2 (suppressed), a constant (suppressed), and use standard errors clustered by firm. Appendix B contains the variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	Option intensity [1]	Equity intensity [2]	Cash intensity [3]	Option intensity [4]	Equity intensity [5]	Cash intensity [6]
Panel A						
Holder67	0.027***	0.013*	−0.028***	0.031***	0.030***	−0.037***
	[0.000]	[0.063]	[0.000]	[0.001]	[0.001]	[0.000]
Pay slice top 25%	0.069***	0.130***	−0.168***	0.079***	0.138***	−0.169***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Holder67 × Pay slice top 25%	0.035***	0.012	0.023**	0.044***	0.020	0.017
	[0.004]	[0.325]	[0.026]	[0.000]	[0.121]	[0.109]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	12,772	12,772	12,772	12,810	12,810	12,810
R-squared	0.257	0.242	0.366	0.182	0.125	0.267
Panel B						
Holder67	0.027***	0.007	−0.020***	0.017*	0.010	−0.021**
	[0.000]	[0.310]	[0.005]	[0.072]	[0.292]	[0.018]
Total compensation top 25%	0.100***	0.184***	−0.218***	0.118***	0.205***	−0.240***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Holder67 × Total compensation top 25%	0.035**	0.034***	−0.004	0.061***	0.050***	−0.005
	[0.017]	[0.008]	[0.668]	[0.000]	[0.001]	[0.665]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	12,772	12,772	12,772	12,810	12,810	12,810
R-squared	0.262	0.263	0.383	0.198	0.167	0.308

to 2004 to mitigate the confounding effects of FAS 123R.[12] We also require CEOs to hold nonzero options before SOX to allow for option holdings to change in both directions. As before, we report results with industry fixed effects and results with firm fixed effects separately. Since *SOX* is a time-period indicator variable, to facilitate its interpretation we also report results with and without year fixed effects. The various combinations of year, industry, and firm fixed effects are indicated at the bottom of each column.

The results, reported in Table 7, support our predictions. In models with incentive intensity as the dependent variable, the *SOX* coefficient is significantly negative, indicating SOX is associated with a reduction in incentive intensity, consistent with Hypothesis 5a. The interaction term *Holder67*∗*SOX* is positively and significantly related to option intensity, i.e., overconfident CEOs experience smaller reductions in options-based compensation following SOX relative to rational CEOs, consistent with the exploitation hypothesis (Hypothesis 5b). We find similar, albeit weaker, supporting evidence for equity intensity.

4.6. Impact of FAS 123R: evidence from a natural experiment

To further differentiate between the exploitation and strong-incentive hypotheses, we examine the impact of FAS 123R on overconfident CEOs' compensation contracts. We follow Hayes, Lemmon, and Qiu (2012) by defining fiscal year 2005 as the start of the post-FAS 123R period.[13] We create a *FAS 123R* dummy that equals one if the observation occurs in 2005 or later and zero otherwise and interact *FAS 123R* with *Holder67*. We restrict the sample to observations from 2003 to 2007 to mitigate the influence of SOX.[14] We also require CEOs to hold non-zero options before FAS 123R to allow for option holdings to change in both directions.

Table 8 reports the results. The models include firm fixed effects but not year fixed effects since *FAS 123R* is essentially a time indicator variable.[15] Consistent with Hayes, Lemmon, and Qiu (2012) and Skantz (2012), FAS 123R significantly reduces option intensity. The interaction term *Holder67*∗*FAS 123R* is statistically indistinguishable from

[12] Our results are robust to dropping 2001 and/or 2002 as those are transition years and firms may have made changes in anticipation of SOX.

[13] FAS 123R became effective for large public firms with fiscal year-end dates after June 15, 2005 and for all firms with fiscal year-end dates after December 2005. Hayes, Lemmon, and Qiu (2012) define year 2005 as the beginning of the post-FAS 123R period to account for the possibility that firms might begin changing their compensation strategies in anticipation of the rule change. Our results are unaffected if we instead use fiscal year 2006 as the start of the post-FAS 123R period.

[14] We end the sample in 2007 to mitigate the impact of the 2008 financial crisis. Our results are qualitatively similar if we end the sample in 2006 or 2008 or if we drop 2005 (a transition year).

[15] We control for firm but not industry fixed effects in this test because we are focusing on within-firm changes in overconfidence and compensation.

Table 6
Impact of bargaining power measured by labor market competition.

This table contains models that analyze the impact of CEO labor market competition (as proxied by changes in the compensation in the CEO's state and industry) on the relation between overconfidence and compensation-structure. Columns 1–3 include year and Fama-French 48 industry fixed effects. Columns 4–6 include firm and year fixed effects. The models include all firm-level control variables from Table 2 (suppressed), a constant (suppressed), and use standard errors clustered by firm. Appendix B contains the variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	Option intensity [1]	Equity intensity [2]	Cash intensity [3]	Option intensity [4]	Equity intensity [5]	Cash intensity [6]
Panel A						
Holder67	0.031***	0.012	−0.023***	0.031***	0.024***	−0.026***
	[0.000]	[0.103]	[0.001]	[0.001]	[0.006]	[0.002]
Δ State & 4D-industry compensation top 25%	0.034***	0.058***	−0.084***	0.040***	0.072***	−0.092***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Holder67 × Δ State & 4D-industry compensation top 25%	0.028***	0.030***	−0.009	0.038***	0.032***	−0.014
	[0.005]	[0.004]	[0.325]	[0.000]	[0.003]	[0.142]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	12,762	12,762	12,762	12,800	12,800	12,800
R-squared	0.244	0.210	0.324	0.167	0.094	0.233
Panel B						
Holder67	0.045***	0.023***	−0.025***	0.046***	0.035***	−0.030***
	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Δ State & 4D-industry compensation bottom 25%	−0.037***	−0.076***	0.090***	−0.045***	−0.085***	0.098***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Holder67 × Δ State & 4D-industry compensation bottom 25%	−0.026**	−0.012	−0.000	−0.021**	−0.009	−0.003
	[0.010]	[0.269]	[0.988]	[0.033]	[0.386]	[0.755]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	12,762	12,762	12,762	12,800	12,800	12,800
R-squared	0.244	0.212	0.325	0.164	0.093	0.231
Panel C						
Holder67	0.034***	0.013*	−0.022***	0.035***	0.025***	−0.026***
	[0.000]	[0.079]	[0.002]	[0.000]	[0.004]	[0.002]
Δ State & 2D-industry compensation top 25%	0.015**	0.033***	−0.052***	0.020***	0.039***	−0.057***
	[0.029]	[0.000]	[0.000]	[0.004]	[0.000]	[0.000]
Holder67 × Δ State & 2D-industry compensation top 25%	0.017*	0.027***	−0.011	0.024**	0.030***	−0.016*
	[0.079]	[0.008]	[0.237]	[0.012]	[0.003]	[0.088]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	12,769	12,769	12,769	12,807	12,807	12,807
R-squared	0.239	0.202	0.313	0.156	0.076	0.212
Panel D						
Holder67	0.044***	0.023***	−0.023***	0.046***	0.036***	−0.029***
	[0.000]	[0.001]	[0.001]	[0.000]	[0.000]	[0.000]
Δ State & 2D-industry compensation bottom 25%	−0.021***	−0.043***	0.064***	−0.026***	−0.049***	0.065***
	[0.003]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Holder67 × Δ State & 2D-industry compensation bottom 25%	−0.022**	−0.013	−0.010	−0.019**	−0.010	−0.009
	[0.023]	[0.223]	[0.301]	[0.048]	[0.341]	[0.339]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	12,769	12,769	12,769	12,807	12,807	12,807
R-squared	0.240	0.202	0.313	0.157	0.075	0.209

zero, suggesting that FAS 123R does not affect overconfident CEOs' option intensity significantly more than rational CEOs. However, when we examine stock and cash compensation, we find that overconfident CEOs experience significantly greater increases in the level of cash and stock pay than do rational CEOs post FAS 123R. This is the case even if we scale the cash and stock compensation by the level of pre-FAS-123R compensation (Column 5). These findings indicate that while overconfident and rational CEOs experience a similar decrease in option intensity post FAS

Table 7
Impact of SOX.

This table contains OLS regressions that examine how the passage of the Sarbanes-Oxley Act of 2002 (SOX) influences the relation between overconfidence and CEO compensation. The sample in this model goes from 1998 to 2004. The SOX dummy equals one if the observation occurs in 2003 or after and equals zero otherwise. The models include fixed effects as denoted in the column footer and all models include standard errors clustered by firm. See Appendix B for variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	Option intensity [1]	Equity intensity [2]	Cash intensity [3]	Option intensity [4]	Equity intensity [5]	Cash intensity [6]	Option intensity [7]	Equity intensity [8]	Cash intensity [9]	Option intensity [10]	Equity intensity [11]	Cash intensity [12]
Holder67	0.020*	0.008	−0.020*	0.021*	0.008	−0.020*	0.036*	0.029	−0.041**	0.035*	0.028	−0.040**
	[0.085]	[0.482]	[0.084]	[0.078]	[0.494]	[0.085]	[0.065]	[0.131]	[0.021]	[0.072]	[0.157]	[0.025]
SOX	−0.084***	−0.036**	0.036**	−0.090***	−0.042***	0.036***	−0.117***	−0.082***	0.054***	−0.093***	−0.047***	0.028**
	[0.000]	[0.017]	[0.013]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.014]
Holder67*SOX	0.041***	0.027*	−0.009	0.040***	0.028*	−0.010	0.031**	0.025	−0.006	0.033**	0.024	−0.006
	[0.007]	[0.080]	[0.521]	[0.008]	[0.072]	[0.506]	[0.039]	[0.107]	[0.668]	[0.031]	[0.125]	[0.711]
Ownership (%)	−0.530***	−0.595***	0.545***	−0.525***	−0.592***	0.541***	−0.572**	−0.396	0.274	−0.539*	−0.383	0.263
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.047]	[0.174]	[0.399]	[0.063]	[0.196]	[0.425]
Tenure	−0.001	−0.001*	0.002**	−0.001	−0.001*	0.002**	−0.006***	−0.006***	0.003	−0.006***	−0.006***	0.003
	[0.389]	[0.092]	[0.029]	[0.383]	[0.093]	[0.030]	[0.004]	[0.002]	[0.103]	[0.003]	[0.003]	[0.113]
Age	−0.003***	−0.003***	0.002**	−0.003***	−0.003***	0.002**	−0.002	−0.003	0.002	−0.002	−0.003	0.002
	[0.001]	[0.000]	[0.032]	[0.001]	[0.000]	[0.034]	[0.307]	[0.108]	[0.157]	[0.273]	[0.111]	[0.158]
Firm size	0.050***	0.061***	−0.068***	0.050***	0.062***	−0.069***	0.025	0.029*	−0.046***	0.031**	0.046***	−0.059***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.144]	[0.087]	[0.006]	[0.037]	[0.003]	[0.000]
Financial leverage	−0.134***	−0.101***	0.086***	−0.132***	−0.100***	0.085***	−0.110**	−0.099*	0.138***	−0.105**	−0.099*	0.136***
	[0.000]	[0.001]	[0.005]	[0.000]	[0.001]	[0.006]	[0.035]	[0.060]	[0.005]	[0.044]	[0.061]	[0.006]
Firm age	−0.068***	−0.062***	0.043***	−0.067***	−0.061***	0.042***	−0.054	−0.040	0.058	−0.052	−0.032	0.052
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.165]	[0.368]	[0.136]	[0.193]	[0.465]	[0.184]
Stock volatility	1.684***	1.182***	−0.992**	1.828***	1.381***	−1.088***	−0.945*	−0.893	0.485	0.149	0.159	−0.366
	[0.000]	[0.008]	[0.022]	[0.000]	[0.001]	[0.004]	[0.090]	[0.119]	[0.370]	[0.760]	[0.747]	[0.423]
Stock return	0.003	0.005	−0.007	0.002	0.005	−0.008	−0.001	0.002	−0.005	−0.004	0.003	−0.005
	[0.651]	[0.432]	[0.213]	[0.789]	[0.375]	[0.176]	[0.818]	[0.749]	[0.465]	[0.514]	[0.671]	[0.417]
Market-to-book	0.034***	0.034***	−0.026***	0.034***	0.034***	−0.026***	0.027***	0.025***	−0.024***	0.029***	0.027***	−0.025***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
HHI	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
	[0.296]	[0.783]	[0.455]	[0.246]	[0.888]	[0.423]	[0.146]	[0.750]	[0.607]	[0.131]	[0.891]	[0.521]
Free cash flows	−0.099***	−0.099***	0.062*	−0.097***	−0.097***	0.062*	−0.048	−0.048	0.039	−0.042	−0.046	0.036
	[0.005]	[0.005]	[0.065]	[0.005]	[0.006]	[0.059]	[0.196]	[0.225]	[0.298]	[0.247]	[0.242]	[0.337]
R&D	0.010	−0.000	−0.026*	0.009	−0.001	−0.025*	−0.067	−0.072	0.068	−0.068	−0.075*	0.070
	[0.502]	[0.987]	[0.090]	[0.524]	[0.932]	[0.097]	[0.132]	[0.107]	[0.124]	[0.122]	[0.089]	[0.111]
PP&E	−0.030	−0.031	0.030	−0.029	−0.031	0.029	−0.050	−0.087*	0.092*	−0.053	−0.081	0.086*
	[0.107]	[0.110]	[0.103]	[0.113]	[0.110]	[0.104]	[0.329]	[0.096]	[0.058]	[0.295]	[0.115]	[0.069]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No	No
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Firm fixed effects	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,479	5,479	5,479	5,479	5,479	5,479	5,487	5,487	5,487	5,487	5,487	5,487
R-squared	0.235	0.215	0.220	0.234	0.214	0.219	0.073	0.045	0.041	0.066	0.039	0.036

Table 8
Impact of FAS 123R on compensation.
This table contains OLS regressions that examine how FAS 123R influences the relation between CEO overconfidence and compensation. The sample in this model goes from 2003 to 2007. The FAS 123R dummy equals one if the observation occurs in 2005 or later and equals zero otherwise. The models include fixed effects as indicated in the table footer. All models use standard errors clustered by firm. All models include a constant (suppressed). See Appendix B for variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	Option intensity	ln(Cash)	ln(Stock)	ln(Cash + Stock)	$\ln(\frac{(\text{Cash + Stock})}{\text{Compensation}(2004)})$
	[1]	[2]	[3]	[4]	[5]
Holder67	0.079***	−0.025	−0.405	0.040	0.038
	[0.000]	[0.601]	[0.209]	[0.498]	[0.561]
FAS 123R	−0.101***	−0.144***	0.975***	0.086**	0.078**
	[0.000]	[0.000]	[0.000]	[0.023]	[0.046]
Holder67∗FAS 123R	−0.009	0.083**	0.482*	0.081*	0.102**
	[0.621]	[0.017]	[0.061]	[0.092]	[0.030]
Ownership (%)	−0.341	0.398	−3.453	0.607	0.869
	[0.503]	[0.623]	[0.356]	[0.559]	[0.442]
Tenure	−0.008**	−0.006	−0.024	−0.001	−0.011
	[0.031]	[0.387]	[0.678]	[0.896]	[0.433]
Age	−0.004	0.003	−0.017	−0.001	0.010
	[0.268]	[0.557]	[0.744]	[0.937]	[0.524]
Firm size	−0.017	−0.310***	0.106	−0.218***	−0.246***
	[0.517]	[0.000]	[0.765]	[0.005]	[0.002]
Financial leverage	−0.058	0.258**	−1.786*	−0.145	−0.245
	[0.409]	[0.044]	[0.056]	[0.425]	[0.181]
Firm age	−0.004	0.024	0.013	0.247	0.124
	[0.924]	[0.803]	[0.979]	[0.131]	[0.306]
Stock volatility	2.350***	−1.831	−50.569***	−8.933***	−7.256***
	[0.004]	[0.166]	[0.000]	[0.000]	[0.000]
Stock return	0.019**	0.106***	0.277**	0.134***	0.123***
	[0.026]	[0.000]	[0.014]	[0.000]	[0.000]
Market-to-book	0.045***	−0.034*	−0.245*	−0.040	−0.024
	[0.000]	[0.085]	[0.056]	[0.156]	[0.378]
HHI	0.000**	0.000**	−0.000	−0.000	0.000
	[0.025]	[0.023]	[0.586]	[0.924]	[0.894]
Free cash flows	0.001	−0.031	−1.111	−0.062	−0.034
	[0.986]	[0.756]	[0.176]	[0.670]	[0.824]
R&D	−0.067	−0.061	−0.154	−0.106	−0.064
	[0.204]	[0.546]	[0.840]	[0.411]	[0.610]
PP&E	−0.135*	0.040	0.207	−0.009	−0.088
	[0.074]	[0.767]	[0.854]	[0.966]	[0.663]
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No
Observations	3,393	3,393	3,393	3,393	2,811
R-squared	0.164	0.095	0.111	0.062	0.062

123R—this decrease is accompanied by a significantly greater increase in the cash and stock compensation for overconfident CEOs. From Hypothesis 6, such a pattern is consistent with the exploitation hypothesis but not with the strong-incentive hypothesis.

In untabulated analysis, we also examine the impact of the reduction in option compensation resulting from FAS 123R on firm value as measured by Tobin's *Q* (the firm's market-to-book ratio).[16] Our results indicate that the reduction in option compensation did not lead to overconfident CEOs performing significantly worse. This is consistent with the exploitation hypothesis, whereby the CEO's incentive contract has incentive slack so that a reduction in option compensation does not affect CEO incentives. We cannot, however, conclude that the finding is inconsistent with the strong-incentive hypothesis. As indicated, there was a substantial increase in stock intensity post-FAS 123R which potentially offsets the decrease in CEO incentives from the reduction in options. We also cannot exclude the possibility that the lack of a significant finding on firm value is due to a lack of power.

5. Additional robustness tests

This section contains additional robustness tests. For brevity, we mainly report the robustness results in relation to the baseline models of Table 2.

5.1. Options on both sides of the equation

The dependent variable *Option intensity* and the independent variable *Holder67* are both options-based. As this could potentially give rise to a mechanical relation between the two induced, for instance, by the effect of past option grants on incentive contracts, we conduct a number of tests to ensure that this is not the case. Before we proceed, it is important to note that *Holder67* is largely

[16] These and other untabulated results are available in the online appendix posted on http://jfe.rochester.edu/appendix.htm.

time-invariant for a given CEO. That is, once a CEO is identified as overconfident, *Holder67* takes the value one for the remainder of the CEO's tenure. Thus, *Holder67* is relatively constant whereas compensation structure can and does vary over time. Moreover, *Holder67* is set to the value of one based on the *moneyness* of, rather than the number of, unexercised vested options. In addition, *Holder67* reflects an active decision to not exercise options rather than the mere receipt of those options.

We first examine the time-series property of *Holder67* around the introduction of FAS 123R, an exogenous shock that lowers the use of option compensation by firms (Hayes, Lemmon, and Qiu, 2012). We find that there is little variation in *Holder67* around this accounting rule change.[17] As the exogenous reduction in option compensation had little impact on the overconfidence measure, this suggests that a mechanical relation between *Holder67* and *Option intensity* is unlikely to drive our results.

Second, we check whether the results hold when we use the CEO's *Holder67* measure from her prior ExecuComp role. By measuring overconfidence prior to becoming CEO, we alleviate concerns of a mechanical relation between the overconfidence measure and current compensation structure. We construct *Prior-role Holder67*, an indicator variable that equals one if the CEO is overconfident in a prior ExecuComp role (in an analogous manner to the *Holder67* metric) and zero otherwise. The first two columns of Table 9 report regressions for which we can compute *Prior-role Holder67*. The results in Columns 1 and 2 are consistent with our baseline results, namely, overconfident CEOs' compensation contracts are more option-intensive.

Third, we check that results are robust to analyzing the first year of a CEO's tenure. We construct *Holder67^*, an indicator variable which equals one if the CEO is overconfident at any time during her tenure as CEO and zero otherwise. This again alleviates concerns of a mechanical relation between the overconfidence measure and current compensation structure as only the incentive contract in the first year is considered. Thus, the regression results are not driven by the potential effect of subsequent allocations of options on the *Holder67* measure. The sample size is much smaller for this regression, which we report in Column 3 of Table 9. The results are, however, again consistent with our baseline regression, i.e., overconfident CEOs' compensation contracts are more option-intensive.

Fourth, we split the sample in two halves based on the ratio of vested unexercised options to total compensation and estimate the baseline regression for the subsamples. If our results merely reflect a mechanical relation, then one would expect the relation between *Holder67* and *Option intensity* to be much weaker or insignificant when the vested options account for a relatively low portion of the CEO's salary. The regression results are reported in Table 10. We find results similar to our baseline regression results in both subsamples, particularly for the regressions that control for firm fixed effects.

Fifth, we split the sample based on the CEO's wealth-to-performance sensitivity (*WPS*) as estimated in Edmans, Gabaix, and Landier (2009).[18] If the results reflect a mechanical relation such that the option intensity is merely a function of CEO wealth or CEO exposure to performance, then one would expect the significance of *Holder67* to vary across wealth-to-performance sensitivity sorts. However, when we split the sample into quartiles based on the *WPS*, the results in each subsample, not tabulated for brevity, are qualitatively similar to those of our baseline model.

Sixth, we further ensure that the results hold when we control for the CEO's option holdings, the importance of those options, or the sensitivity of wealth-to-performance. If the results reflect a mechanical relation, then one would expect the *Holder67* variable to be statistically indistinguishable from zero in models that control for such factors. We find that controlling for each of these factors does not affect our baseline results (the results are not tabulated for brevity).

5.2. Impact of prior compensation structure

Dynamic contracting (e.g., Edmans, Gabaix, Sadzik, and Sannikov, 2012) suggests that compensation in past periods affects compensation in subsequent periods. We find in untabulated analyses that controlling for the CEO's lagged *Option intensity* or *Wealth-to-performance sensitivity* has little impact on the baseline results. Moreover, given that overconfidence is still significantly and positively related to *Option intensity* after controlling for lagged *Option intensity*, this result suggests that overconfidence is associated with greater growth in option intensity over time. We directly examine the change in option intensity and also find that overconfidence is related to greater increases in option intensity.

5.3. Systematic differences: propensity score and weighting regressions

One possible concern is that there are systematic differences in firms that hire overconfident CEOs versus rational CEOs. To mitigate this concern, we control for firm fixed effects in the prior analyses. We further address this issue in two ways.

First, we use a propensity score matching method. We estimate a first-stage logit model to estimate the likelihood of a CEO being classified as overconfident (reported in Model 1 of Table 11). Next, we obtain the propensity scores from this model. Then, for the overconfident CEOs we generate a distribution of propensity scores and obtain the critical point that identifies the lower 10% tail. Finally, we re-run the models excluding any rational CEO/firm whose propensity score is below this 10% cut-off point. We obtain similar results if we use a 5% or 20% cut-off. The results are reported in Models 2–4 of Table 11. Importantly, *Holder67* has the same relation with option, equity, and cash intensity as in the baseline models.

[17] The average value of *Holder67* is 52.6% in 2003, 55.7% in 2005, and 53.5% in 2007.

[18] See http://faculty.london.edu/aedmans/data.html for a description and a link to the wealth-to-performance sensitivity data.

Table 9
Impact of CEO's overconfidence in prior roles and first year as CEO.

This table contains OLS regression models that analyze the relation between *Option intensity* and the CEO's overconfidence in her prior role or in her first year as the CEO. In Columns 1–2, the variable *Prior-role Holder67* is an indicator that equals one if the CEO was overconfident in a prior ExecuComp role (according to the *Holder67* metric) and zero otherwise. The regressions only include CEOs for whom we can compute a *Holder67* measure in a prior role. Column 3 contains observations from the first year of a CEO's tenure only. The variable *Holder67^* is equal to one if the CEO is overconfident at any time during her tenure as CEO at that company. See Appendix B for variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	Option intensity		
	[1]	[2]	[3]
Sample	All (where CEO has prior ExecuComp role)		CEO's first year as CEO
Prior-role Holder67	0.048***	0.090*	
	[0.003]	[0.054]	
Holder67^			0.047*
			[0.056]
Ownership (%)	0.058	0.693	−0.251
	[0.816]	[0.559]	[0.308]
Tenure	0.001	−0.005	0.001
	[0.564]	[0.275]	[0.749]
Age	−0.007***	−0.001	−0.002
	[0.000]	[0.842]	[0.192]
Firm size	0.032***	0.014	0.045***
	[0.000]	[0.776]	[0.000]
Financial leverage	0.017	0.019	−0.058
	[0.724]	[0.906]	[0.447]
Firm age	−0.001	0.005	−0.001
	[0.229]	[0.969]	[0.488]
Stock volatility	1.288*	6.239***	3.203***
	[0.089]	[0.003]	[0.000]
Stock return	0.004	0.030	0.011
	[0.814]	[0.460]	[0.534]
Market-to-book	0.027***	−0.026	0.043***
	[0.002]	[0.360]	[0.000]
HHI	−0.000	−0.000**	−0.000
	[0.432]	[0.045]	[0.127]
Free cash flows	−0.008	−0.097	−0.064
	[0.902]	[0.626]	[0.543]
R&D	0.040*	0.168	0.059*
	[0.067]	[0.149]	[0.088]
PP&E	−0.037	0.145	−0.051
	[0.159]	[0.212]	[0.192]
Firm fixed effects	No	Yes	No
Industry fixed effects	Yes	No	No
Year fixed effects	Yes	Yes	Yes
Observations	1,180	1,182	603
R-squared	0.207	0.267	0.232

Second, we use a weighting approach following Busso, DiNardo, and McCrary (2014). We estimate the first-stage logit model as with the propensity score method. We next obtain a weighting measure as follows: $Weight = Holder67 + (1 - Holder67)*\Pr(Holder67)/(1 + \Pr(Holder67))$, where $\Pr(Holder67)$ is the propensity score from the first-stage model. We then weight each observation by this propensity score, assigning a greater weight to an observation if it is more likely that that observation is an overconfident type. This implicitly puts lower weight on observations that are dissimilar from firms run by overconfident CEOs. The results are reported in Models 5–7 of Table 11. Again, *Holder67* is positively and significantly related to option intensity and equity intensity. These results, coupled with the propensity score results, suggest that the relation between CEO overconfidence and compensation is not driven by selection bias.

5.4. Anti-takeover provisions

We next test whether the results are robust to controlling for the presence of anti-takeover provisions (ATPs). We control for ATPs because managerial entrenchment possibly influences CEO compensation. We measure ATPs by using the Gompers, Ishii, and Metrick (2003) index of 24 ATPs (*GIM*), the Bebchuk, Cohen, and Ferrell (2009) index of six ATPs (*BCF*), and an indicator that equals one if the firm has a classified board (*CBOARD*). We also examine interactions of the ATP measures with *Holder67*. The additional data requirements reduce the sample size. However, the results, reported in Panels A–C of Table 12, are consistent with the baseline results in Table 2. Specifically, *Holder67* continues to be positively related to option intensity and equity intensity. In addition, ATPs do not influence the impact of overconfidence on compensation, as indicated by the statistically indistinguishable from zero

Table 10
Regressions split by option value/total pay.

This table contains regression models that split the sample in half based on the CEO's vested unexercised options relative to total pay, *Option value/Total pay* (using ExecuComp terms: opt_unex_exer_est_val/tdc1). The regressions are OLS regressions with fixed effects as indicated in the table footer and cluster standard errors by firm. See Appendix B for all variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

	Option intensity			
Option value/Total pay half	Low	Low	High	High
Holder67	0.025***	0.043***	0.050***	0.049***
	[0.008]	[0.001]	[0.000]	[0.000]
Ownership (%)	−0.463***	−0.397**	−0.181	−0.086
	[0.000]	[0.024]	[0.144]	[0.696]
Tenure	0.001	−0.001	−0.001	−0.002
	[0.236]	[0.468]	[0.227]	[0.138]
Age	−0.003***	−0.004***	−0.003***	−0.004***
	[0.000]	[0.003]	[0.000]	[0.007]
Firm size	0.043***	0.036***	0.042***	0.039***
	[0.000]	[0.003]	[0.000]	[0.002]
Financial leverage	−0.076***	−0.195***	−0.102***	−0.038
	[0.005]	[0.000]	[0.001]	[0.403]
Firm age	−0.001***	−0.032	−0.001***	−0.019
	[0.000]	[0.116]	[0.000]	[0.498]
Stock volatility	1.915***	1.620***	1.663***	0.664
	[0.000]	[0.000]	[0.000]	[0.232]
Stock return	−0.005	0.005	0.002	−0.002
	[0.417]	[0.348]	[0.683]	[0.704]
Market-to-book	0.047***	0.031***	0.030***	0.028***
	[0.000]	[0.000]	[0.000]	[0.000]
HHI	−0.000*	−0.000***	−0.000	−0.000
	[0.098]	[0.006]	[0.545]	[0.306]
Free cash flows	−0.045*	−0.043	−0.098**	−0.001
	[0.075]	[0.106]	[0.032]	[0.981]
R&D	0.032**	0.034	0.020	−0.074*
	[0.017]	[0.214]	[0.159]	[0.083]
PP&E	−0.035**	−0.050*	−0.023	−0.080*
	[0.016]	[0.073]	[0.185]	[0.058]
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	No	Yes	No
Firm fixed effects	No	Yes	No	Yes
Observations	6,197	6,211	6,574	6,598
R-squared	0.263	0.202	0.218	0.117

coefficients on the *Holder67* and ATP interaction terms. Overall, our results are robust to accounting for ATPs.

5.5. Alternative measures of overconfidence and additional tests

We examine whether the results are robust to using alternative measures of CEO overconfidence. We find qualitatively similar results to those reported in Table 2 if we measure overconfidence as the natural log of the number of vested but unexercised options (see Panel A of Table 13).

We also address potential concerns with the *Holder67* measure. We classify CEOs as overconfident by examining the moneyness of their options. However, the quantity of options might not be economically meaningful. We address this concern by re-running the regressions using the set of CEOs whose quantity of vested unexercised options are in the top 50% of the sample for the year. The results, reported in Panel B of Table 13, are qualitatively similar to our baseline results. Another concern with the *Holder67* measure is that it ignores the possibility of an overconfident manager exercising her options and then maintaining a significant stock holding. We address this concern by restricting the sample to contain the set of CEOs who have not exercised options in year t or year $t-1$. The results, reported in Panel C of Table 13, are qualitatively similar to our baseline results.

We also use media-based measures of overconfidence following the approach in Hirshleifer, Low, and Teoh (2012). We create measures by counting the number of news reports that refer to the CEO as overconfident versus the number that refer to the CEO as non-overconfident. We use Factiva to search for articles referring to the CEO in *The New York Times, Business Week, Financial Times, The Economist, Forbes Magazine, Fortune Magazine*, and the *Wall Street Journal*.[19] We then create three media-based measures of overconfidence. In all cases, we require that the firm have at least one 'overconfident' article. This is to ensure that we are analyzing how the degree of confidence influences compensation (and thus, ensure that the

[19] For each CEO and year, we count the number of articles that contain the 'confidence' words "overconfidence," "over confident," "optimistic," or "optimism." We also count the number of articles that contain the 'non-confidence' words "cautious," "conservative," "practical," "frugal," or "steady." We further check the number of articles that contain the words "not confident" or "not optimistic" and distinguish between these and articles that use the words "optimistic" or "confident" by themselves.

Table 11
Propensity score and weighting models.
This table contains first-stage logit and second-stage OLS models that use either propensity score techniques or weighting techniques (as described in Section 5.3) to mitigate concerns about systemic differences between companies run by overconfident CEOs and those run by rational CEOs. The logit model includes all control variables from Table 2. The OLS models include all control variables from Table 2, year and industry fixed effects, a constant (suppressed), and use standard errors clustered by firm. See Appendix B for variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Method	First-stage	Propensity score			Weighting		
Dependent variable	Holder67	Option intensity	Equity intensity	Cash intensity	Option intensity	Equity intensity	Cash intensity
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Holder67		0.036***	0.018***	−0.023***	0.036***	0.018***	−0.025***
		[0.000]	[0.008]	[0.000]	[0.000]	[0.007]	[0.000]
Ownership (%)	−2.082***	−0.295***	−0.426***	0.456***	−0.332***	−0.480***	0.504***
	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Tenure	0.085***	−0.000	−0.002***	0.002***	−0.000	−0.001**	0.002***
	[0.000]	[0.759]	[0.009]	[0.001]	[0.789]	[0.028]	[0.008]
Age	0.008**	−0.003***	−0.004***	0.002***	−0.003***	−0.004***	0.003***
	[0.022]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Firm size	0.142***	0.042***	0.062***	−0.070***	0.042***	0.063***	−0.070***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Financial leverage	−0.658***	−0.087***	−0.082***	0.063***	−0.087***	−0.085***	0.060***
	[0.000]	[0.000]	[0.000]	[0.003]	[0.000]	[0.001]	[0.008]
Firm age	−0.025***	−0.001***	−0.002***	0.001***	−0.002***	−0.002***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Stock volatility	8.593***	1.802***	0.856***	−0.756***	1.857***	1.215***	−1.015***
	[0.000]	[0.000]	[0.003]	[0.005]	[0.000]	[0.000]	[0.001]
Stock return	0.148***	−0.001	0.004	−0.012***	0.000	0.005	−0.012***
	[0.000]	[0.779]	[0.340]	[0.004]	[0.933]	[0.302]	[0.005]
Market-to-book	0.601***	0.035***	0.030***	−0.024***	0.033***	0.028***	−0.022***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
HHI	0.000***	−0.000	−0.000	0.000	−0.000	−0.000	−0.000
	[0.000]	[0.110]	[0.284]	[0.893]	[0.197]	[0.619]	[0.601]
Free cash flows	−0.102	−0.065***	−0.078***	0.027	−0.048*	−0.052*	−0.004
	[0.571]	[0.008]	[0.003]	[0.282]	[0.090]	[0.095]	[0.870]
R&D	−0.371***	0.024**	0.017	−0.031***	0.032**	0.023*	−0.035***
	[0.000]	[0.027]	[0.129]	[0.005]	[0.010]	[0.064]	[0.005]
PP&E	−0.426***	−0.029**	−0.023*	0.018	−0.025*	−0.018	0.020
	[0.000]	[0.024]	[0.093]	[0.152]	[0.094]	[0.255]	[0.152]
Year fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,772	11,727	11,727	11,727	12,772	12,772	12,772
R-squared	0.1503	0.229	0.189	0.290	0.238	0.188	0.274

analysis is comparable to looking at the option-based measure of *confidence*). This also prevents thinly reported firms, or difficult-to-detect firms, biasing the sample (i.e., if there are no 'confident' reports it could simply imply more about the reporting likelihood, than confidence, making the measure even noisier than usual), and ensures that we capture the concept of CEO confidence and analyze the degree of confidence.[20]

We present the results in Table 14. First, Panel A of Table 14 contains an indicator that equals one if the number of overconfident articles exceeds the number of non-overconfident articles. Second, Panel B of Table 14 uses a 'net news' measure, which is the number of overconfident articles less the number of non-overconfident articles. Third, Panel C of Table 14 uses a net news ratio, which is defined as (Overconfident articles − Non-overconfident articles)/(Overconfident articles + Non-overconfident articles).[21] The key finding is that all three media-based measures of overconfidence are positively associated with option and equity intensity, supporting the baseline results in Table 2.

5.6. Alternative interpretations

An alternative explanation for our findings is that CEO overconfidence reflects relatively lower risk aversion (or higher risk tolerance) rather than positively biased views. However, a risk-averse CEO, even if she is more willing to bear risk than the typical (rational) CEO, would value options less than the (risk-neutral) firm does. Hence, while higher risk tolerance would imply that the CEO is offered stronger incentive contracts, the predictions would be similar to those from the strong-incentive hypothesis. For instance, accompanying an increase in CEO bargaining power, a risk-averse CEO would not experience an increase in option intensity—unlike the prediction from the exploitation hypothesis.[22] As indicated in Tables 5 and 6, an increase

[20] We obtain qualitatively similar results if we simply recode the missing news variables as zero, which would be to assume that any such CEO is non-overconfident.

[21] Given the time-intensive nature of the data collection, we restrict the sample to the years spanning 2000–2006.

[22] Under the exploitation hypothesis, the CEO values options more than the risk-neutral firm does and consequently, after an increase in CEO bargaining power, a risk-averse CEO would experience an increase in option intensity.

Table 12
Controlling for anti-takeover provisions.
This table contains OLS models that examine the relationship between overconfidence and CEO compensation after controlling for anti-takeover provisions. The models include all control variables from Table 2 (suppressed), year and industry fixed effects, a constant (suppressed), and use standard errors clustered by firm. See Appendix B for variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	Option intensity [1]	Equity intensity [2]	Cash intensity [3]	Option intensity [4]	Equity intensity [5]	Cash intensity [6]
Panel A: anti-takeover provisions: GIM index						
Holder67	0.039***	0.019**	−0.026***	0.070***	0.053**	−0.041
	[0.000]	[0.011]	[0.000]	[0.007]	[0.039]	[0.103]
GIM	0.000	0.002	−0.005***	0.002	0.004*	−0.006***
	[0.817]	[0.276]	[0.002]	[0.222]	[0.053]	[0.004]
Holder67∗GIM				−0.003	−0.004	0.002
				[0.192]	[0.158]	[0.508]
Observations	10,518	10,518	10,518	10,518	10,518	10,518
R-squared	0.247	0.205	0.323	0.247	0.205	0.323
Panel B: anti-takeover provisions: BCF index						
Holder67	0.038***	0.018**	−0.025***	0.041***	0.024	−0.022
	[0.000]	[0.014]	[0.001]	[0.008]	[0.124]	[0.139]
BCF	0.007**	0.009***	−0.016***	0.008**	0.010***	−0.016***
	[0.021]	[0.005]	[0.000]	[0.029]	[0.009]	[0.000]
Holder67∗BCF				−0.001	−0.002	−0.001
				[0.826]	[0.670]	[0.811]
Observations	10,518	10,518	10,518	10,518	10,518	10,518
R-squared	0.247	0.206	0.326	0.247	0.206	0.326
Panel C: anti-takeover provisions: classified board						
Holder67	0.039***	0.019**	−0.026***	0.041***	0.024***	−0.033***
	[0.000]	[0.010]	[0.000]	[0.000]	[0.004]	[0.000]
CBOARD	−0.001	−0.000	−0.002	−0.001	0.001	−0.004*
	[0.673]	[0.994]	[0.312]	[0.805]	[0.614]	[0.083]
Holder67∗CBOARD				−0.001	−0.002	0.003**
				[0.656]	[0.136]	[0.019]
Observations	10,518	10,518	10,518	10,518	10,518	10,518
R-squared	0.247	0.205	0.321	0.247	0.205	0.322

in CEO bargaining power is accompanied by an increase in option intensity, suggesting that higher risk tolerance is not driving our results.[23]

We also analyze whether our results are explained by CEO optimism. As noted earlier, Otto (2014) focuses on CEO optimism and argues that the concepts of optimism and overconfidence are distinct. He finds that CEO optimism is associated with a lower *level* of incentive pay. Interestingly, by Otto's measures, firms with optimistic CEOs tend to have a *lower* market-to-book ratio, a *lower* standard deviation of stock returns, and *lower* R&D expenditures than firms with non-optimistic CEOs (see Panel A, Table 3 of his paper). This is very different from the types of firms usually associated with overconfident CEOs (e.g., Galasso and Simcoe, 2011; Hirshleifer, Low, and Teoh, 2012) and contrasts with the predictions from GHO. It is also opposite of what we find for overconfident CEOs. Hence, at least by the optimism measures advanced in Otto (2014), our findings are reflective of CEO overconfidence, not optimism. In untabulated results, we are able to replicate Otto's (2014) findings and, importantly, we find that our baseline results in Table 2 are robust to controlling for Otto's CEO optimism measure.[24]

5.7. Other sensitivity tests

Custodio, Ferreira, and Matos (2013) find that a CEO's general ability impacts CEO compensation. Our results are robust to controlling for the CEO's general ability (the results for this subsection are not tabulated for brevity but can be found in the online appendix). Since we have panel data, we undertake Fama and MacBeth (1973) type regressions as a robustness test and find our inferences remain unaffected. Since the dependent variables are intensity variables that range between zero and one by construction, we verify that the results are qualitatively similar if we use Tobit models with a lower bound of zero and an upper bound of one. An alternative way to investigate whether overconfident CEOs receive greater incentives is to explore the pay-to-performance sensitivity. We find CEO overconfidence positively enhances the sensitivity

[23] We assume the CEO is not risk-seeking. Moreover, if higher risk tolerance drives our results, we would not expect to find overconfident CEOs substitute cash for options after the implementation of FAS 123R as we do in Table 7.

[24] We thank Clemens Otto for kindly providing us with the CEO optimism measure, *LongHolder*, that he uses in Otto (2014).

Table 13
Alternative measures of overconfidence.
This table contains OLS models that examine the relation between CEO compensation and alternative measures of overconfidence. The models include all control variables from Table 2 (suppressed). Columns 1–3 contain year and industry fixed effects. Columns 4–6 use firm and year fixed effects. All models use standard errors clustered by firm. See Appendix B for variable definitions. Brackets contain p-values and superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent variable	Option intensity [1]	Equity intensity [2]	Cash intensity [3]	Option intensity [4]	Equity intensity [5]	Cash intensity [6]
Panel A						
ln(Num options)	0.022***	0.018***	−0.020***	−0.005	−0.007*	0.001
	[0.000]	[0.000]	[0.000]	[0.125]	[0.054]	[0.699]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	12,771	12,771	12,771	12,809	12,809	12,809
R-squared	0.242	0.201	0.310	0.149	0.062	0.194
Panel B: subsample with num options held in top 50%						
Holder67	0.039***	0.016*	−0.022**	0.040***	0.029**	−0.026**
	[0.000]	[0.080]	[0.014]	[0.003]	[0.027]	[0.033]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	6,830	6,830	6,830	6,849	6,849	6,849
R-squared	0.223	0.167	0.263	0.180	0.067	0.148
Panel C: subsample with CEOs not exercising options in year t or t−1						
Holder67	0.024**	0.005	−0.008	0.035**	0.025*	−0.018
	[0.014]	[0.611]	[0.440]	[0.028]	[0.099]	[0.223]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	4,810	4,810	4,810	4,820	4,820	4,820
R-squared	0.207	0.195	0.324	0.104	0.050	0.173

of compensation to both Return-on-Assets (ROA) and stock returns. This is consistent with our prediction and supports the general idea that overconfident CEOs receive compensation contracts that are more sensitive to firm performance.

6. Conclusion

We analyze the relation between CEO overconfidence and compensation structure. We consider three alternative hypotheses. The existing literature (GHO) suggests two hypotheses. First, overconfident CEOs, with their positively biased view of future firm value, may require weaker incentives to exert the required effort. We term this the weak-incentive hypothesis. On the other hand, if the CEOs are sufficiently overconfident, it may be optimal to provide them greater incentive-linked compensation. The reason is that it is cheaper for the firm to offer contracts with greater option and equity intensity since overconfident CEOs are more bullish about their own ability and their company's prospects and thus overvalue such compensation. We term this the exploitation hypothesis. We develop an alternative hypothesis by extending the model in GHO to show that firms may offer more option-intensive contracts to overconfident CEOs in order to achieve effort and investment levels that are prohibitively costly to achieve with rational CEOs. We call this the strong-incentive hypothesis. We empirically test whether, and when, overconfident CEOs receive compensation contracts that are more option-intensive.

We find that overconfident CEOs receive more option-intensive compensation contracts. Moreover, option intensity is greater for overconfident CEOs at riskier firms and more innovative firms. These findings are consistent with both the exploitation hypothesis and the strong-incentive hypothesis.

To distinguish between the exploitation and strong-incentive hypotheses, we investigate the impact of CEO bargaining power. We find that option intensity increases for overconfident CEOs with greater bargaining power: this is supportive of the exploitation hypothesis and inconsistent with the strong-incentive hypothesis. We use the passage of SOX as an exogenous shock and find overconfident CEOs experience a less severe reduction in option intensity after SOX, consistent with the exploitation hypothesis. We also use the passage of FAS 123R as a natural experiment and find that the decrease in option intensity post-FAS 123R is accompanied by a significantly larger increase in cash and stock compensation for overconfident managers. These results, especially the finding on cash-based compensation, are most consistent with the exploitation hypothesis.

Table 14
Media-based measures of overconfidence.

This table contains media-based measures of overconfidence. The measures are available for the years 2000–2006. Panel A uses an indicator that equals one if the number of 'overconfident' media reports is greater than the number of 'non-overconfident' ones. Panel B uses the difference between the number of overconfident reports and the number of non-overconfident ones. Panel C uses a net news ratio, which is defined as (Overconfident news − Non-overconfident news)/(Overconfident news + Non-overconfident news). All models contain the control variables from Table 2 and use standard errors clustered by firm. Columns 1–3 contain year and industry fixed effects. Columns 4–6 use firm and year fixed effects. See Appendix B for variable definitions. Brackets contain p-values and superscript *** and ** denote significance at 1% and 5% respectively.

Dependent variable	Option intensity [1]	Equity intensity [2]	Cash intensity [3]	Option intensity [4]	Equity intensity [5]	Cash intensity [6]
Panel A						
Positive news indicator	0.070***	0.063***	−0.059***	0.050***	0.057***	−0.064***
	[0.000]	[0.000]	[0.000]	[0.007]	[0.005]	[0.001]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	4,946	4,946	4,946	4,953	4,953	4,953
R-squared	0.269	0.215	0.240	0.153	0.048	0.085
Panel B						
Net news	0.009***	0.006***	−0.008***	0.008***	0.008***	−0.011***
	[0.000]	[0.002]	[0.000]	[0.001]	[0.000]	[0.000]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	4,946	4,946	4,946	4,953	4,953	4,953
R-squared	0.268	0.213	0.239	0.154	0.049	0.087
Panel C						
News ratio	0.045***	0.032**	−0.045***	0.066***	0.066***	−0.085***
	[0.003]	[0.034]	[0.002]	[0.000]	[0.000]	[0.000]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	4,906	4,906	4,906	4,913	4,913	4,913
R-squared	0.265	0.210	0.236	0.153	0.047	0.087

We also investigate the role of overconfidence on compensation structure for non-CEO executives. We find that overconfidence impacts compensation structure for non-CEO executives in a similar manner to which it impacts CEOs. That is, overconfidence increases the level of option intensity in a non-CEO executive's compensation contract. Moreover, the impact of non-CEO executive overconfidence on compensation is independent of CEO overconfidence. This indicates that firms structure compensation contracts according to the characteristics of individual managers and not just firm characteristics.

More broadly, our results indicate that the beliefs and behavioral traits of managers introduce significant heterogeneity in the contracting between firms and managers. This is an interesting and important area for future research. For instance, there may be a concern that in an industry that attracts many overconfident managers, offering strong incentives could exacerbate the problems of excessive investment and risk-taking. However, to the extent that strong incentives are used to exploit rather than incentivize overconfident managers, our results suggest such a concern may not be justified and calls into question the necessity, or desirability, of regulating incentive pay.

Appendix A. Incentive contracting with overconfident CEOs

We build upon the intuition underpinning the GHO model to show that the *strong-incentive* hypothesis can hold in a context similar to their model. We show, therefore, that *exploitation*, i.e., compensating the CEO in the form of riskier contracts she overvalues, is not the only reason to offer strong incentive contracts to overconfident managers.

As in GHO, consider a project that requires the investment of $1 along with manager's utility cost of effort E. A priori, i.e., without additional information, the project is negative Net Present Value (NPV). What makes the project potentially valuable is that, prior to the investment decision, the CEO receives a private signal S: either positive (S+) or negative (S−) with (unconditional) probabilities λ and $1-\lambda$, respectively. A rational manager interprets S+ as indicating the probability of payoff outcomes σ and 0 to be π and $(1-\pi)$, respectively, where $\pi\sigma - 1 - E > 0$, i.e., the project is positive NPV. On the other hand, the likelihood of success when the signal is negative is taken to be zero so that CEOs have no incentive to invest in that

case.[25] Later we allow for the possibility of a more complex positive signal and consider the effect of managerial overconfidence. For now we characterize the incentive contract that would be offered to a rational manager.

We follow GHO and capture risk aversion by assuming that the value placed on σ by the CEO is $\rho\sigma$ where $\rho < 1$ (indicating a decreasing marginal utility of wealth). Further, the reservation utility of the CEO is denoted by R. In this context, an optimal contract has the following attributes: (1) it is incentive-compatible (IC), i.e., induces the manager to invest when the signal is positive; (2) the participation constraint (PC) is satisfied, i.e., the manager expects to receive at least R plus expected utility cost of effort; (3) it maximizes the payoff to the firm while satisfying IC and PC.

The optimal contract is characterized by the compensation that the CEO receives when the project succeeds, fails, or is not undertaken. We follow GHO and assume that if the project fails, the firm is worth zero and so is the CEO's compensation. If the project succeeds, her payment is β. If the CEO does not take up the project, she receives α.

The IC condition for the rational CEO to put in effort on observing signal S+ can be expressed as:

$$\beta\pi\rho - \alpha \geq E \qquad \text{(IC.1)}$$

The optimal choice of β minimizes the cost of compensating the CEO, conditional on satisfying the participation constraint:

$$\lambda\beta\rho\pi + (1-\lambda)\alpha = R + \lambda E \qquad \text{(PC.1)}$$

The left-hand-side of *PC.1* is the expected payoff to the rational manager; this is set equal to $R + \lambda E$ since the firm has no reason to give the manager anything more than she needs to participate. Given $\rho < 1$, the rational CEO values payoffs in the successful state at less than the firm does. Hence, it is cheapest for the firm to give the manager the minimum β that satisfies *IC.1* as an equality and an α that satisfies the *PC.1* condition. We label this contract as (α, β).

A.1. Effort levels and managerial overconfidence

We now introduce managerial overconfidence along with a modification of the above set-up. Specifically, we allow for two types of positive signals, say S^1+ and S^2+ with probabilities $\tau\lambda$ and $(1-\tau)\lambda$, with $0 < \tau < 1$. The signal S^1+ conveys that the project possibilities are precisely those in the set-up above, i.e., effort with utility cost of E results in payoff of σ with probability π and zero otherwise. The signal S^2+, however, conveys that in addition to the project possibility implied by S^1+, an incremental effort with utility cost of $E*$ (i.e., in addition to E) with (rational) probability η increases the payoff in the successful state (when σ is realized) by an incremental amount $\sigma*$. We also assume that there are CEOs that are recognized as being overconfident and are known to have beliefs that differ from those of rational managers in (only) one way: they expect the incremental project to succeed with a higher than rational probability $\hat{\eta} > \eta$.

The additional effort is assumed to be positive NPV from the perspective of the firm as well as that of the overconfident CEO, i.e., $\eta\sigma* > E*$ and $\rho\hat{\eta}\sigma^* > E^*$. However, there are parameter values such that the incremental effort is never worthwhile for the rational manager, i.e., $\rho\eta\sigma* < E*$. When this condition is satisfied it is never optimal to induce a rational CEO to take the incremental effort since the utility cost exceeds the expected incremental value added. Hence, a rational CEO would be offered the incentive contract (α, β) as above. On the other hand, because the overconfident CEO is positively biased about the success of the incremental effort, it is optimal to incentivize her to undertake this incremental effort. Since we are interested in the case with "no exploitation" we assume that $\eta\sigma^* > \rho\hat{\eta}\sigma^*$, so that, on account of risk aversion, even the overconfident manager values payoffs in the successful states at less than the firm does.

One way to structure the incentives for the overconfident CEO is to provide options with an exercise price of σ; hence, the options provide incentive only when the state is S^2+. The optimal contract could then consist of these options in addition to the (α, β) contract that is offered to rational CEOs. The incentive compatibility *(IC.2)* condition below indicates the required incremental compensation β_1 when the output is $\sigma + \sigma^*$:

$$\beta_1\rho\hat{\eta} = E^* \qquad \text{(IC.2)}$$

Hence, the optimal contract offered to the overconfident CEO will entail payments of $(\alpha, \beta, \beta + \beta_1)$ corresponding to output levels $(1, \sigma, \sigma + \sigma^*)$, respectively. The overconfident CEO is, therefore, offered stronger incentives in the form of options that induce the manager to put in incremental effort in state S^2+. This contract is the basis for the *strong-incentive* hypothesis according to which overconfident CEOs are provided stronger incentive pay to induce greater effort, rather than to exploit their overvaluation.

A.2. CEO bargaining power

GHO consider the impact of increasing an overconfident CEO's bargaining power under the exploitation hypothesis. They show that an increase in the demand for CEOs can increase their bargaining power, resulting in overconfident CEOs being offered even greater incentive pay. This argument is, however, *reversed*, under the *strong-incentive* hypothesis. If we treat the CEO's reservation utility R as a measure of CEO bargaining power, we can consider the effect that an increase in bargaining power would have on the fraction of the CEO's compensation that is in the form of incentive pay. As R increases, i.e., the CEO is in a stronger bargaining position, it follows from the assumption of no exploitation $(\eta\sigma^* > \rho\hat{\eta}\sigma^*)$, that the only change would be in terms of an increase in the fixed wage portion α. This is because (i) the firm places a higher value on payments in the successful states than the risk-averse overconfident CEO and (ii) there is no *incentive slack*, i.e., the incentive remains unchanged to induce appropriate actions on the part of the CEO, even as R increases. Therefore, an increase in R has the effect of decreasing the incentive intensity of overconfident CEOs.

[25] This follows since, based on the assumption in GHO (discussed subsequently), the CEO's compensation is zero when the project/firm fails. Hence, the manager has no incentive to take on the project when the signal is S−.

Appendix B. Variable definitions

Variable	Definition
Compensation variables (CEOs)	
Option intensity	The proportion of total annual CEO compensation that comes from option grants. This is the value of annual option awards (ExecuComp: "option_awards_blk_value" before FAS 123R and "option_awards_fv" after FAS 123R) scaled by the amount of total annual compensation (ExecuComp: "tdc1").
Equity intensity	The proportion of total annual CEO compensation that comes from option grants and stocks. This is the value of annual option awards (ExecuComp: "option_awards_blk_value" before FAS 123R and "option_awards_fv" after FAS 123R) plus the value of annual stock grants (ExecuComp: "stock_awards_fv") scaled by the amount of total annual compensation (ExecuComp: "tdc1").
Cash intensity	The proportion of total annual CEO compensation that comes from cash. This is the amount of annual cash (ExecuComp: "total_curr") scaled by total annual compensation (ExecuComp: "tdc1").
ln(Cash)	The natural log of the dollar value of the CEO's annual cash compensation (ExecuComp: "total_curr").
ln(Stock)	The natural log of the dollar value of the CEO's annual stock grants (ExecuComp: "stock_awards_fv").
ln(Cash + Stock)	The natural log of the dollar value of the CEO's annual stock grants and cash compensation (ExecuComp: "total_curr" + "stock_awards_fv").
ln(Total pay)	The natural log of the dollar value of the CEO's total annual compensation (ExecuComp: "tdc1").
Option value/Total pay	The value of vested but unexercised options (Execucomp: opt_unex_exer_est_val) relative to total annual compensation (ExecuComp: tdc1).
Compensation variables (non-CEO executives)	
Exec option intensity	The proportion of total compensation that comes from option grants for each non-CEO executive. This is the value of option awards (ExecuComp: "option_awards_blk_value" before the full implementation of FAS 123R at the end of 2005 and "option_awards_fv" afterward) scaled by the amount of total compensation (ExecuComp: "tdc1").
Exec equity intensity	The proportion of total compensation that comes from option grants and stock for each non-CEO executive. This is the value of option awards (ExecuComp: "option_awards_blk_value" before the full implementation of FAS 123R at the end of 2005 and "option_awards_fv" afterward) plus the value of stock grants (ExecuComp: "stock_awards_fv") scaled by the amount of total compensation (ExecuComp: "tdc1").
Exec cash intensity	The proportion of total compensation that comes from cash for each non-CEO executive. This is the amount of cash (ExecuComp: "total_curr") scaled by total compensation (ExecuComp: "tdc1").
Overconfidence measures (CEOs)	
Holder67	The Holder67 measure computed following the procedure in Malmendier, Tate, and Yan (2011). We start by computing a 'Confidence' variable, which is defined as the 'value per vested option' scaled by the 'average strike price' of those options. The 'value per vested option' in year t is the total value of the vested but unexercised options (ExecuComp: "opt_unex_exer_est_val") scaled by the number of those options (ExeuComp: "opt_unex_exer_num"). The average strike price is the stock price at the time the option-value is determined (CRSP: "prcc_f") less the value-per-vested option. This works on the premise that the value-per-vested option is essentially $S_t - X$, where S_t is the stock price at time t and X is the strike price. Holder67 is then an indicator that equals one from the first year in which the 'Confidence' variable equals 0.67 if this 'Confidence' variable equals 0.67 on at least two occasions.
Holder67^	An indicator variable which equals one if the CEO is overconfident (Holder67 = 1) at any time during her tenure as CEO and zero otherwise.
Holder30	The Holder30 measure is constructed in the same way as the Holder67 measure, but requires that the confidence variable equal at least 0.3.
Holder100	The Holder100 measure is constructed in the same way as the Holder67 measure, but requires that the confidence variable equal at least 1.0.
Holder30-Holder67	An indicator that equals one if Holder30 equals one but Holder67 equals zero. This captures a low-to-moderate degree of overconfidence.
Holder67-Holder100	An indicator that equals one if Holder67 equals one but Holder100 equals zero. This captures a relatively high degree of overconfidence.
ln(Num opt)	The natural log of the number of vested but unexercised options.

(*continued on next page*)

Variable	Definition
Positive news indicator	An indicator variable that equals one if the number of 'overconfident' media reports is greater than the number of 'non-overconfident' ones. We use Factiva to search for articles referring to the CEO in *The New York Times, Business Week, Financial Times, The Economist, Forbes Magazine, Fortune Magazine*, and the *Wall Street Journal*. For each CEO and year, we count the number of articles that contain the 'overconfident' words "overconfidence," "over confident," "optimistic," or "optimism." We also count the number of articles that contain the 'non-overconfident' words "cautious," "conservative," "practical," "frugal," or "steady." We further check the number of articles that contain the words "not confident" or "not optimistic" and distinguish between these and articles that use the words "optimistic" or "confident" by themselves.
Net news	The difference between the number of 'overconfident' media reports and the number of 'non-overconfident' ones.
News ratio	(Overconfident news − Non-overconfident news)/(Overconfident news + Non-overconfident news).
Prior-role Holder67	An indicator variable that equals one if the CEO was overconfident in a prior Execucomp role (using the *Holder67* methodology) and zero otherwise.
Overconfidence measure (non-CEO executives)	
Exec Holder67	The executive's Holder67 measure. It is constructed in the same manner as for CEOs.
Innovation and risk measures	
Cites/Patents	The number of cites to patents received in year $t-1$. The data are from the NBER patent database and are available only up until 2006.
Cites/Patents (5 years)	The number of cites to patents received over the past 5 years. The data are from the NBER patent database and are available only up until 2006.
Stock volatility	The firm's stock return volatility measured using the firm's daily stock returns over the prior year.
Bargaining power variables	
Pay slice top 25%	An indicator that equals one if the CEO's pay slice (as measured by the CEO's total compensation scaled by the sum of the total compensation of the top-three highest remunerated non-CEO executives) is in the top quartile of the sample for that year and equals zero otherwise.
Total compensation top 25%	An indicator that equals one if the CEO's total compensation is in the top quartile of the sample for that year and equals zero otherwise.
Δ State & 4D-industry compensation top 25%	An indicator that equals one if the CEO is in a state and four-digit SIC industry that has experienced compensation growth in the top quartile in that year and equals zero otherwise.
Δ State & 4D-industry compensation bottom 25%	An indicator that equals one if the CEO is in a state and four-digit SIC industry that has experienced compensation growth in the bottom quartile in that year and equals zero otherwise.
Δ State & 2D-industry compensation top 25%	An indicator that equals one if the CEO is in a state and two-digit SIC industry that has experienced compensation growth in the top quartile in that year and equals zero otherwise.
Δ State & 2D-industry compensation bottom 25%	An indicator that equals one if the CEO is in a state and two-digit SIC industry that has experienced compensation growth in the bottom quartile in that year and equals zero otherwise.
Exogenous shocks	
FAS 123R	An indicator that equals one if the observation occurs in 2005 or later and equals zero otherwise.
SOX	An indicator that equals one if the observation occurs in 2003 or later and equals zero otherwise.
Firm value variable	
Tobin's *Q*	The firm's market-to-book, defined in CRSP/Compustat codes as "(prcc_f∗csho+lt)/(ceq+lt)."
Anti-takeover provision (ATP) and general ability measures	
BCF	The Bebchuk, Cohen, and Ferrell (2009) index of six key anti-takeover provisions as derived from IRRC/Risk Metrics.
CBOARD	An indicator that equals one if the firm has a classified board and equals zero otherwise. The data are from Investor Responsibility Research Center (IRRC)/Risk Metrics.
GA Index	The general ability index as used in Custodio, Ferreira, and Matos (2013).
GIM	The Gompers, Ishii, and Metrick (2003) index of anti-takeover provisions as obtained by IRRC/Risk Metrics. IRRC/Risk Metrics only report data for some of the years in our sample. For missing years, we back-fill with the most recent prior year.
Control variables	
Age	The CEO's age as reported in ExecuComp.
Financial leverage	The firm's financial leverage, defined as its debt divided by its assets (in Compustat terms: "(dltt+dlc)/at").

(*continued on next page*)

Variable	Definition
Firm age	The firm's age, defined as the time between year t and the year in which the firm is first recorded in the CRSP stock database.
Firm size	The natural log of the firm's total assets (Compustat: "at").
Free cash flows	The firm's free cash flows scaled by its market cap. In CRSP/Compustat codes this is "(oancf-capx)/(prcc_f∗csho)."
HHI	The Herfindahl-Hirschman Index (HHI) for the firm's Fama-French industry. This is based on the sum of squared percentage market shares in sales.
Market-to-book	The firm's market-to-book, defined in CRSP/Compustat codes as "(prcc_f∗csho+lt)/(ceq+lt)."
Ownership (%)	The CEO's percentage ownership in the firm. This is derived by dividing the CEO's stock ownership (ExecuComp: "shrown") by the number of shares outstanding (CRSP/Compustat: "csho").
PP&E	The firm's property, plant, and equipment (Compustat: "ppegt") scaled by its assets (Compustat: "at").
R&D	An indicator that equals one if the firm spends on R&D (i.e., has a nonzero "xrd" variable in Compustat). This coincides with having an above-median level of R&D (as the median R&D expenditure is USD 1.3 m and 51% of companies have nonzero R&D).
ROA	The firm's return on assets, defined as the net income scaled by total assets (in Compustat codes: "ni/at").
Stock return	The firm's stock return over the prior year.
Tenure	The CEO's tenure, defined as the time between year t and the year in which the CEO became CEO.

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