Underwater Options and the Dynamics of Executive Pay-to-Performance Sensitivities*

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Abstract

We empirically analyze the dynamics of executives’ pay-to-performance sensitivities. Option pay-to-performance sensitivities become weaker as options fall underwater, often leading to pressures to reprice options or restore pay-to-performance sensitivity in other ways. Building a detailed data set on executives’ portfolios of stock and options, we find that the responsiveness of pay-to-performance sensitivities (created by all executive holdings of stock and options) to changes in stock price is quite large. The elasticity of pay-to-performance sensitivities with respect to stock price decreases is about 0.7, and is larger for high-option executives and for executives with high percentages of options already underwater. The dominant mechanism through which companies offset declines in option pay-to-performance sensitivities is larger option grants following stock price declines; on average, these larger grants restore approximately 40% of the stock-price-induced pay-to-performance sensitivity declines. Option repricings are inconsequential in this regard, despite the attention they have attracted. Interestingly, in looking at positive returns, we find the reverse: higher returns both directly increase pay-to-performance sensitivities and lead to larger option grants, which raise pay-to-performance sensitivities further. Thus, option grants to executives tend to be largest following large stock price increases or large stock price decreases.

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1. Introduction

Stock options form the largest component of pay for top executives in the U.S., representing more than half of their pay in 2002. Moreover, approximately 40% of all large U.S. companies have broad-based option programs, whereby grants are made to at least half of all employees. The striking increase in options during the past two decades represents a significant change in the way that U.S. executives are paid. This, in turn, has dramatically affected the pay-to-performance sensitivities facing executives, since most U.S. executives now have large holdings of company equity (stock and options) that vary greatly with typical changes in company stock prices (Hall and Lieberman, 1998). The desire, by increasingly influential shareholders and their representatives, to create a stronger link between executive wealth and stock returns is one of the major causes of the option revolution (Holmstrom and Kaplan, 2003).

But the non-linear payoff of options has important implications for the way that executive pay-to-performance sensitivities change over time. In particular, an option’s pay-to-performance relationship changes as the price of the underlying stock changes. Stock price declines can push stock options “underwater” (or “out-of-the-money”) if the stock price falls below the exercise price of the option. As options move farther out-of-the-money, the pay-to-performance sensitivity of those options decreases as executives (and employees) come to believe that their options have little chance of paying off by moving “into-the-money.” The poor performance of many U.S. companies’ shares in 2000 and 2001 has highlighted the potential for large declines in option-induced pay-to-performance sensitivities.

The dynamic behavior of the pay-to-performance sensitivities created by an instrument that has in the last twenty years become the largest component of top executive pay in the U.S.—in both value and pay-to-performance sensitivity provision—is a subject of obvious importance. Yet there has been little academic research on the topic. This paper attempts to fill that gap.

We do not formally model the principal-agent interaction, or test specific hypotheses regarding the optimality of the contracts and behavior we observe. Instead, our approach is empirical and descriptive. We address some of the most basic questions about the dynamics of executive pay-to-performance sensitivities, such as: How responsive are pay-to-performance sensitivities to stock price changes, especially given that actual executive portfolios consist of large amounts of options (which can fall underwater) and stock (which cannot fall underwater)?

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2 This would require us to make specific assumptions regarding executives’ production technologies and the impacts their actions have on company stock prices, which in turn has implications for whether the optimal contract is linear, concave or convex. See, for example, Hemmer, Kim and Verrecchia (2000) for a model along these lines.
What are the key factors that affect this responsiveness? How much (if at all) is this responsiveness larger on the downside (because of underwater options) than on the upside? Do companies restore pay-to-performance sensitivities when stock price declines cause them to fall? If so, by how much? And how do they do it?

We also explore how the behaviors of executives—their patterns of option exercises and net purchases of stock—affect the way pay-to-performance sensitivities change over time. For example, executives may mitigate declines in pay-to-performance sensitivities by selling fewer shares or exercising fewer options in response to a stock price decline. Although it is an entirely different mechanism, this type of executive behavior, like company granting behavior, affects the dynamics of pay-to-performance sensitivities.

In conducting our empirical analysis, we make use of a data set that contains each executive’s entire portfolio of stock and options, including all of the relevant details required to value such packages (exercise prices, time to maturity, the number of options, etc.). Such a data set is necessary for our purposes since we require precise measures of the pay-to-performance sensitivities generated by the entire equity portfolios of executives in response to stock price changes, which requires us to understand the degree to which every option in the executive’s portfolio is in- or out-of-the-money.

Several studies have demonstrated the importance of adjusting equity pay, holdings and pay-to-performance sensitivities for the fact that risk-averse and undiversified executives value company equity and options at less than market values. Following this work, we employ a technique that enables us to risk-adjust pay-to-performance sensitivities by converting executive equity holdings into certainty equivalents (or “executive values”). Our method, described later, is based on the certainty-equivalent approach used by Lambert, Larcker and Verrecchia (1991) and Hall and Murphy (2000, 2002, 2003), but is an extension of this method since it enables us to create executive values for an executive’s whole portfolio of stock and options instead of a single option (or stock) grant. In addition, we extend the model to allow executives to optimally invest their outside wealth in the market portfolio and the risk-free asset, as described later.

A number of papers relate to ours. Boschen and Smith (1995) study the dynamics of executive compensation in response to performance based on a sample of 16 firms from 1948 to 1990 and find evidence that long-run pay-to-performance is stronger than short-run pay-to-performance. The key difference between their paper and ours is that they ignore pay-to-performance generated by executive holdings of stock and options. But this type of pay-to-

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performance sensitivity is necessarily the focus of our analysis following the dramatic increase in stock and options since the mid-1980s.

Core and Guay (1999) attempt to test for the optimality of executive incentives. In contrast to the approach taken here, they fit a tightly-parameterized cross-sectional model to obtain standards for (non-risk-adjusted proxies of) pay-to-performance sensitivities, and are interested in responses to deviations from these standards. They interpret their findings as evidence in favor of the view that executive compensation is set optimally by boards.

Hemmer, Matsunaga and Shevlin (1996) present evidence that executives tend to exercise options based on factors such as stock return volatility and the degree to which their option-portfolio risks are hedged by firms. Their finding that companies partially hedge executives’ option-portfolio risks is consistent with our evidence that companies tend to significantly offset stock-price-induced decreases in pay-to-performance sensitivities.

Huddart and Lang (1996) use a non-public sample of eight companies’ employees to empirically investigate the determinants of employee stock option exercises. Although their focus, sample (of employees rather than executives) and approach are all quite different from ours, their evidence that option exercises increase following stock-price increases is broadly congruent with our findings regarding the way that executive exercises affect pay-to-performance sensitivities in a dynamic setting.

Finally, a recent paper by Jin and Meulbroek (2001) is the closest to ours since they examine the link between underwater options and pay-to-performance sensitivity. We discuss their analysis, and its relation to ours, in Section 3.1.

The paper proceeds as follows. In the next section, we describe our data and our methodology for building up executive portfolios of stock and options. We also describe our methodology for measuring the pay-to-performance sensitivity of an executive’s option portfolio, with particular attention to how we calculate risk-adjusted executive values from executives’ portfolios.

The third section shows that actual year-to-year fluctuations in pay-to-performance sensitivities are quite large and demonstrates that these fluctuations are strongly related to stock price fluctuations. For our preferred measure of pay-to-performance sensitivity, the elasticity of pay-to-performance sensitivity with respect to stock price changes is about 0.7 when stock prices decline. Moreover, this elasticity is higher for high-option executives, for executives with a high fraction of options already underwater, and for executives in low-volatility companies.

We explore company reactions to changes in executive pay-to-performance sensitivities in the fourth section. We find evidence that company granting policies partially offset stock-price-
induced declines in pay-to-performance sensitivities, but augment stock-price-induced increases in pay-to-performance sensitivities. The offsetting effect of granting policies following stock price decreases is quite large: approximately 40% of any stock-price-induced decline in pay-to-performance sensitivity is offset by an above-average option grant the following year. We also find that executive behavior affects these dynamics. Specifically, executive option exercising behavior further offsets stock-price-induced declines in pay-to-performance sensitivities but has essentially no significant effect when stock price increases raise pay-to-performance sensitivities.

In the fifth section, we explore the specific mechanisms through which companies respond to stock-price-induced decreases in pay-to-performance sensitivities. We show that companies do not typically respond through option repricings, “out of cycle” refresher option grants or new stock grants. Instead, the dominant way that companies respond to large stock price decreases is by making a larger-than-usual option grant the following year. This is, of course, a form of backdoor repricing—although it reduces the responsiveness of option pay-to-performance sensitivities to stock price changes, it also reduces ex ante pay-to-performance sensitivities since poor performance is being rewarded. Likewise, companies augment stock-price-induced increases in pay-to-performance sensitivities through larger option grants, which implies that option grants are largest following large stock price increases or large stock price decreases. We also find strong evidence of relative performance evaluation (RPE) in option-granting behavior, using industry-based returns. In addition, we explore the mechanism through which executives react to stock-price-induced decreases in pay-to-performance sensitivities and find that executives exercise options less frequently when stock prices fall. We discuss implications and potential extensions of our findings in the sixth and concluding section.

2. Data and Pay-to-Performance Measurement

In this section, we describe the data and the methodology that we use to construct our equity-based pay-to-performance measures.

2.1 Data

The data come from Execucomp, which contains detailed information on the compensation of the top five executives of every company in the S&P 500, the S&P MidCap 400, and the S&P SmallCap 600 indices from 1992 to 2000. The data include approximately 6,000 executives per year in the later years of the sample. Our goal is to measure pay-to-performance sensitivities—and the evolution of these sensitivities over time—as precisely as possible, including (critically)
how the pay-to-performance relationship is affected when option packages move in- and out-of-the-money. Therefore, we need to have time series of each executive’s equity holdings, including details regarding the number of options held, the maturity of the options, the exercise price of each option grant, and the number of shares held by the executive. Unfortunately, Execucomp does not provide detailed information about an executive’s entire portfolio of options, although the data set does provide the details about each option grant in the year in which it is granted, as well as information regarding option exercises and changes in stock holdings.\(^5\)

Thus, we use an approach similar to that of Hall and Liebman (1998) to infer an executive’s portfolio of stock and options from past and current-year grants, exercises, and holdings. Although this approach has the advantage of giving us the most precise picture possible of an executive’s portfolio given data availability, it does require multiple years of past data since this approach uses yearly data to construct the portfolio over time, “building up” holdings when restricted stock or stock options are granted and “drawing down” holdings when shares are sold or options are exercised. As a result, the final panel data set that we create begins in 1996, even though the Execucomp data begins in 1992. The details regarding our methodology for measuring an executive’s portfolio of stock and stock options are given in Appendix A.

### 2.2 Measuring Pay-to-Performance Sensitivities: Methodology

Two potential complications hamper our attempt to calculate the pay-to-performance sensitivity of an executive’s stock and stock option holdings. First, we must determine the relevant measure of sensitivity. Second, we must adjust the sensitivity of the pay-to-performance relationship for risk since equity is held by risk-averse and undiversified executives. We discuss each issue in turn.

#### 2.2.1 Measures of Sensitivity

A standard measure of pay-to-performance sensitivity is the change in executive wealth for a given dollar change in shareholder value. For example, following Jensen and Murphy (1990), many studies measure pay-to-performance sensitivity as the dollar change in executive wealth for a $1,000 change in firm value. This is effectively the ownership percentage of the executive (multiplied by 1,000).\(^6\) Using a linear approximation, we see that it is roughly equal to the delta

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\(^4\) As a general matter, we can make no claims regarding the optimality (or non-optimality) of the behavior or contracts we describe in this paper since doing so would require us to make strong assumptions consistent with a particular model of the principal-agent interaction.

\(^5\) This is due to the fact that proxy statements only report information regarding option exercises, option grants, stock sales or purchases, and restricted stock grants. More generally, proxies include information on flows of equity-based holdings, whereas pay-to-performance sensitivity measurement requires information on the level of these holdings.

\(^6\) If the executive owns only shares, then this is simply the number of shares held by the executive divided by the total number of shares outstanding (multiplied by 1,000, as noted above). If the executive also owns
of the executive’s portfolio, divided by the total number of shares outstanding, then multiplied by 1,000.

Another measure of pay-to-performance sensitivity is the change in executive wealth for a given percent change in firm value (Hall and Liebman, 1998). This latter measure recognizes the fact that executives of large companies often have large equity stakes, in dollar terms, in their companies—which may provide strong incentives since small percentage changes in the value of the firm may lead to multimillion-dollar changes in executive wealth, even when effective ownership percentages are trivial. Core and Guay (1999, 2001), for example, use this measure of pay-to-performance sensitivity in arguing that companies and firms contract on a certain, optimal, dollar amount of equity incentives, which is consistent with contracting on “dollars at stake” rather than “percent owned.”

Baker and Hall (2001) argue that both measures are helpful for understanding incentive strength. Specifically, the former measure (percent owned) is most appropriate when analyzing incentives to allocate resources (e.g., the use of a corporate jet) while the latter measure (dollars at stake) is most appropriate when analyzing incentives to embark on strategies that scale with firm size (e.g., corporate reorganization). For this reason, we report results using both measures of pay-to-performance sensitivity. We measure executive wealth with both market values and risk-adjusted executive values (separately; see below), and show changes in executive wealth in response to a $1,000 change in firm value (“percent owned,” hereafter denoted b pay-to-performance sensitivity) and to a 1% change in firm value (“dollars at stake,” hereafter denoted d pay-to-performance sensitivity). In some cases where the results are quite similar, we report only the results using one of the measures (percent owned) for the sake of brevity.

2.2.2 Adjusting Pay-to-Performance Sensitivities for Risk

Most studies of equity-based pay-to-performance sensitivities use market values of executives’ stock and options—as measured by standard option pricing models such as Black and Scholes (1973) and Merton (1973)—to measure sensitivity. However, as emphasized by Lambert, Larcker and Verrecchia (1991), Hall and Murphy (2000, 2002), Meulbroek (2001) and others, standard option pricing models are based on risk-neutral pricing of tradable securities, and are therefore not appropriate for valuing nontradable options held by risk-averse and options, then the effective percent owned is approximately equal to the number of shares plus the number of options divided by the total number of shares outstanding, where the options are adjusted downward—often multiplied by 0.6 or 0.7—to account for the fact that they have a lower delta than shares (which have a delta of 1 by definition).

7 See surveys by Murphy (1999), Bushman and Smith (2001) and Core, Guay and Larcker (2001) for evidence and analysis.
undiversified executives. Market value models are therefore also not appropriate for measuring pay-to-performance sensitivities, since these sensitivities are based on changes in the value of equity-based holdings in response to changes in company stock price performance.

We follow Lambert, Larcker and Verrecchia (1991) and Hall and Murphy (2000, 2002) by measuring executive pay-to-performance sensitivity as the change in the certainty equivalent—or *executive value*—of the executive’s equity-based portfolio in response to a given change in firm value. While difficult to implement, especially for a large portfolio of option grants, each with its own characteristics (i.e., time to maturity and exercise price), it is especially important in a study such as ours to adjust for executive risk aversion when measuring option pay-to-performance sensitivities. Much of our analysis concerns the pay-to-performance sensitivities provided by equity-based holdings, including options, following a stock price decline, and pay-to-performance sensitivities measured using risk-adjusted values decrease more than pay-to-performance sensitivities measured using market values following stock price declines. This is because the executive value of an option far underwater is fairly unresponsive to changes in the stock price since risk-averse executives severely discount options that have little chance of moving into-the-money (Hall and Murphy, 2002).

Thus, while we generally report results using pay-to-performance sensitivities based on both the market value and executive value of executive portfolios, we believe that the results based on executive values are more accurate. The results based on the market value of equity are reported in various places as conservative (lower bound) estimates of how pay-to-performance sensitivities decrease following share price declines.

Our methodology for measuring executive value, and thus risk-adjusting pay-to-performance sensitivity, extends the approach described in Hall and Murphy (2000, 2002) in two ways. First, rather than looking at the pay-to-performance sensitivity created by a single grant of options, we measure the pay-to-performance sensitivity created by the executive’s entire portfolio, including stock and options. Although this complicates the methodology used to measure executive value, it is a necessary complication since we are interested in measuring the pay-to-performance sensitivity generated by the executive’s entire portfolio rather than the pay-to-performance sensitivity generated by a single grant. The methodology for calculating executive value is described below, with the details relegated to Appendix B.

Second, to compute executive values of equity-based instruments we must make assumptions about both the amount and the type of outside wealth held by each executive, as noted in the

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introduction. We assume that executives hold their outside wealth in a combination of the market portfolio and risk-free bonds—in a proportion that maximizes their utility—rather than restricting executives to hold only risk-free bonds in their outside portfolios.9,10

Specifically, the executive value of a non-tradable option to an undiversified risk-averse executive is the certainty equivalent of the option—the amount of riskless cash compensation the executive would accept in lieu of the option to remain indifferent. We assume an executive’s outside wealth is \( w \), that he holds \( s \) shares of company stock, and that he has been granted \( k \) option packages. The packages are indexed by \( i = 1, \ldots, k \) so that option package \( i \) is composed of \( n_i \) options, each on one share of company stock, with a strike price of \( X_i \) expiring in \( T_i \) years. Let the realized price of company stock in \( T_i \) years be \( P_{T_i,j} \). Suppose that there is just one other risky asset available: the market portfolio, each unit of which is normalized to cost one dollar today, with a realized price in \( T_i \) years of \( M_{T_i,j} \). Let \( r_f \) denote the risk-free rate, and assume that the executive always allocates a proportion \( p \) of his discretionary wealth to the riskless asset, with the remainder being allocated to the market portfolio.

The executive’s realized wealth at the end of the horizon is:

\[
W_{T_i} = w \left[ p \left( 1 + r_f \right)^{T_i} + (1 - p) M_{T_i,k} \right] + s P_{T_i,k} \\
+ \sum_{i=1}^{k} \left[ p \left( 1 + r_f \right)^{T_i-T_i} + (1 - p) \frac{M_{T_i,k}}{M_{T_i,j}} \right] n_i \max \{ 0, P_{T_i,j} - X_i \},
\]

(2.1)

The executive has a utility function over final (i.e., period \( T_i \)) wealth, which we denote \( U() \). \( f \) is defined as the joint density of \( \{(P_{T_i,j}, M_{T_i,j}) : i = 1, \ldots, k\} \), so that the executive’s expected utility is:

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9 Our analysis, therefore, incorporates the insight that the cost of forcing executives to bear market (systematic) risk may not be as great as the cost of forcing them to bear idiosyncratic risk, since executives may hedge their systematic risk exposure by changing how much of their outside wealth they invest in the market portfolio. See Jin (2002) for evidence.

10 Allowing the executive to hold the bonds and the market portfolio (rather than just bonds) in his non-firm portfolio has little effect on executive value when analyzing a single option grant, as in Hall and Murphy (2000, 2002) or Lambert, Larcker and Verrecchia (1991), and thus would do little to change their qualitative results. However, we are analyzing the certainty equivalents of entire portfolios, some of which contain only company stock, which has a higher expected return than risk-free bonds. In such cases, failing to model the executive’s ability to hold the market portfolio as part of his non-firm wealth causes the executive to value his company stock portfolio too highly. Since we found that modeling the executive’s ability to hold the market portfolio had significant effects on executive value in these cases—and in a way that mattered, since we are analyzing differences in the pay-to-performance sensitivities created by stock and options—we found it necessary to model the executive’s portfolio choice regarding non-firm wealth.
As described in more detail in Appendix B, the executive optimally balances the proportion of the risky market holdings and the riskless asset by choosing $p$ to maximize this expected utility.

The certainty equivalent of the executive’s portfolio of company stock and options is the amount of cash payment $V$ that makes him indifferent to holding the cash instead of the company portfolio. Specifically, if the executive is given a cash payment of $V$ instead of stock and options, his realized wealth at time $T_k$ would be:

$$W^V_{T_k} = (w + V) \left( p \left(1 + r_f \right)^{T_k} + (1 - p) M_{T_k} \right).$$  \hspace{1cm} (2.3)

The executive value of the executive’s company stock and option portfolio is the certainty equivalent $V^*$ that equates the expected utilities in (2.2) and (2.3). So $V$ is chosen to equate:

$$\int U(W^V_{T_k}) g(M_{T_k}) dM_{T_k} = \int \cdots \int U(W_{T_k}) f(P_{T,1}, M_{T,1}, \ldots, P_{T,k}, M_{T,k}) dP_{T,k} dM_{T,k} \cdots dP_{T,1} dM_{T,1}. \tag{2.4}$$

In the above expression, $g$ is the marginal density of $M_{T,k}$ — the distribution of the return on the market portfolio over the entire horizon. Note also that $p$, the amount of the executive’s outside wealth invested in the market portfolio, is chosen—separately on each side of the equation—to maximize each expected utility.

In order to operationalize our method, we must assume a functional form for $U$ and for $f$, which implies a functional form for $g$. We assume that the executive has constant relative risk aversion $\rho$, which implies a utility function of the form, $U(x) = \frac{1}{1-\rho} x^{-\rho}$, when $\rho$ does not equal one and $U(x) = \ln(x)$ when $\rho = 1$. We report results based on $\rho = 2.5$, the midpoint of the two values of relative risk aversion used by Hall and Murphy (2000, 2002), but we conducted extensive robustness checks on the level of risk aversion (and other parameters mentioned later) and none of our results are substantively affected by (reasonable) changes in our assumptions. In making this choice, we were guided by conservatism: we chose a level of relative risk aversion that is at the low end of the reasonable ranges in the literature. Our goal is to adjust for risk aversion since we believe it is important, but to make conservative, yet plausible, assumptions about executive risk aversion.\footnote{Note that the level of risk aversion we chose is quite low relative to estimates in the asset pricing literature. For example, Campbell, Lo and MacKinlay (1997), Kandel and Stambaugh (1991) and others argue that the coefficient of risk aversion must be quite high—in the range of 20—to solve the “equity premia” puzzle.}

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Following a vast body of financial literature, we assume that the gross returns on the market portfolio and the gross returns on the company stock are independent and identically distributed from one period to the next, with a bivariate lognormal distribution in each period. We also adopt the Capital Asset Pricing Model (CAPM) structure on the raw (not the log) returns. To be precise, we assume that:

\[
\begin{pmatrix}
\ln\left(P_{T,j}\right) \\
\ln\left(M_{T,j}\right)
\end{pmatrix}
\sim N\left(
\begin{pmatrix}
\mu_{\log,p} + \ln\left(P_{T,j-1}\right) \\
\mu_{\log,m} + \ln\left(M_{T,j-1}\right)
\end{pmatrix},
\begin{pmatrix}
\sigma_{\log,p}^2 & \sigma_{\log,pm}^2 \\
\sigma_{\log,pm}^2 & \sigma_{\log,m}^2
\end{pmatrix}\right),
\tag{2.5}
\]

This assumption fully specifies the distribution of all the random variables (as jointly lognormal) since the initial stock price is known and the initial value of one unit of the market portfolio is normalized to one. Refer to Appendix B for the derivation of the relationships between the parameters given here and the parameters of the CAPM for raw returns. Using the CAPM to obtain the mean, standard deviation and covariance parameters of raw returns, we:

- set \( r_f = 6\% \) (the approximate three-month T-bill rate during the period),
- set \( \mu_{raw,m} = r_f + 6.5\% = 12.5\% \) (so that the risk premium is 6.5%, which approximates the equity premium since 1926),\(^{12}\)
- set \( \sigma_{raw,m} = 20\% \) (roughly equal to estimates formed from long-horizon U.S. data),\(^{13}\)
- set \( \mu_{raw,p} = r_f + \hat{\beta}\left(\mu_{raw,m} - r_f\right) \) (following the CAPM, where we estimate \( \hat{\beta} \) for each stock as discussed in Appendix B),
- estimate \( \hat{\sigma}_{raw,p} \) for each stock as described in Appendix B,
- set \( \sigma_{raw,pm} = \hat{\beta}\sigma_{raw,m}^2 \).\(^{14}\)

Finally, we must also make an assumption about the level of each executive’s outside (non-firm) wealth. We assume that the typical executive holds 50% of his total wealth in company stock and options (based on market values) but we do so in a way that allows for meaningful heterogeneity among executives. The assumption of 50% is consistent with that used by Hall and premium puzzle” (Mehra and Prescott, 1985). But Lucas (1994) and Kocherlakota (1996) state that the “majority of economists” believe the coefficient of relative risk aversion is much lower than that implied by studies of the equity premium puzzle, and argue that estimates in the range of 2.5 are much more convincing. See Hall and Murphy (2002) for a discussion.

\(^{13}\) See Table 8.1 of Campbell, Lo and MacKinlay (1997).
Murphy (2002). We allow for heterogeneity in these proportions—while keeping the *average* the same as in Hall and Murphy (2002)—since it seems likely that executives with very high (low) levels of measurable compensation have higher (lower) outside wealth. This, combined with our precise estimates of inside wealth, enables us to introduce heterogeneity in the outside wealth proportion.

First we (somewhat arbitrarily) estimate outside wealth as the greater of six times total compensation and $3 million. If this estimate causes the executive to hold more than 90% or less than 10% of his total wealth in company stock and stock options—which we measure using our data—then we adjust outside wealth so that the fraction of the executive’s total wealth that is held in company stock or stock options is 90% (if it was previously above 90%) or 10% (if it was previously below 10%). Using this procedure, the median (average) executive in our sample has 52.5% (50.9%) of his total wealth in company stock and stock options. Note that although we believe that introducing heterogeneity improves the accuracy of our risk adjustment, we also—as a check—re-ran our results making the simplifying assumption (consistent with the literature) that all executives hold the same proportion of wealth in company equity, and the key empirical results that follow are substantively unchanged.

3. **The Response of Pay-to-Performance Sensitivities to Stock Price Changes**

Before analyzing the degree to which pay-to-performance sensitivities respond to stock price changes—and the causes and consequences of that responsiveness—we list some basic facts regarding equity-based pay-to-performance sensitivity. This will provide some perspective for our later analysis. We then estimate the responsiveness (elasticity) of pay-to-performance sensitivities to stock price returns.

3.1 **The Response of Pay-to-Performance Sensitivities to Stock Price Changes: Basic Facts**

As emphasized in Hall and Murphy (2002), the fact that options may expire underwater decreases both the value of, and the pay-to-performance sensitivities provided by, options to risk-averse and undiversified executives. That analysis, however, applies to the value of, and pay-to-performance sensitivities provided by, options *at the time of grant*. It is a static analysis. Our focus, instead, is how the pay-to-performance sensitivities of options *change*—how they *decline* as options fall underwater, and *rise* as options move into-the-money. More generally, the claim that options frequently fall—or expire—underwater is not the same as the claim that underwater

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14 Again, we note that reasonable changes in our assumptions, and our procedures for estimating variances and CAPM regression parameters, do not affect our qualitative results.

15 Unless this would cause outside wealth to fall below $3 million, in which case we fix outside wealth at $3 million.
options provide weak pay-to-performance relationships. If a given option has a reasonable chance of moving back into-the-money before expiration—or before the executive plans to leave the company—that option may still provide a reasonably strong pay-to-performance relationship.

Indeed, the fact that underwater options can provide meaningful pay-to-performance sensitivities is the theme of a recent paper by Jin and Meulbroek (2001). They explore pay-to-performance sensitivity changes following the NASDAQ decline of 2000 and argue that executives did not experience large decreases in pay-to-performance sensitivities. They focus on options with long maturities and companies with very high volatilities, since daily volatilities measured around the period of the NASDAQ decline were quite high. We corroborate their findings, but find—over the several years covered by our data and using the precise maturity measures calculated from our data—a much greater decrease in pay-to-performance sensitivities when stock prices decline, especially when we adjust for executive risk aversion.

We now turn to examining the responsiveness of pay-to-performance sensitivities to stock price changes. In order to organize the empirical analysis, we summarize some of the relationships we expect to observe, which derive from our definitions above combined with the basic differences between linear and convex functions. In response to stock price changes, ceteris paribus:

1) pay-to-performance sensitivities provided by stock change less than pay-to-performance sensitivities provided by options,

2) option pay-to-performance sensitivities (measured in any way) are more responsive on the downside than on the upside for equivalent stock price changes,

3) option pay-to-performance sensitivities measured by executive values change more (in percentage terms) than sensitivities measured by market values,

4) $d$ sensitivity changes proportionately more in response to stock price changes than $b$ sensitivity,

5) pay-to-performance sensitivity changes are proportionately smaller when return volatility is higher, and

6) changes in pay-to-performance sensitivity can be quite substantial.

Our primary interest is in the strength of these relationships in the data.

3.2 Estimation of Elasticities

To measure the economic significance of the facts listed in (1) - (6) above, we estimate the elasticity of pay-to-performance sensitivities to stock price changes using actual executives’ portfolios. We begin by examining how large pay-to-performance sensitivity changes are from year to year in order to quantify the qualitative fact (6) above. In Table 1, we show the mean and
median of the (absolute value of) annual percent changes in each of the pay-to-performance sensitivity measures. They are reported in the first column in the table. The second column shows the same mean and median, but under the (counterfactual) assumption that each executive’s portfolio did not change during the year. That is, we measured the pay-to-performance sensitivity at the beginning of the year, and then, holding the portfolio constant—not allowing new grants by the company, or option exercises or stock sales/purchases by the executive—we measured the pay-to-performance sensitivity at the end of the year. This enabled us to isolate the changes in pay-to-performance sensitivities that come from changes in the stock price.\footnote{To a much lesser extent, changes in volatility and expected return may influence our results, since pre-response pay-to-performance sensitivities are calculated using updated estimates of volatility and expected return.} We refer to these changes as \textit{pre-response pay-to-performance sensitivities} since there is no within-year response to stock-price-induced changes in pay-to-performance sensitivities by either the company (through grants) or the executive (through option exercises or stock purchases and sales). Conversely, \textit{post-response pay-to-performance sensitivities} are pay-to-performance sensitivities after companies and executives have responded to stock-price-induced changes in pay-to-performance sensitivities during the year. That is, they are the actual pay-to-performance sensitivities at the end of the year. The distinction between \textit{pre-response} and \textit{post-response} pay-to-performance sensitivities is crucial to the analysis in the next section.

The basic message of the table is that year-to-year percentage changes in pay-to-performance sensitivities are large, showing the empirical relevance of the fact \hspace{1em} \footnote{We will see below that this occurs because companies grant more options in response to higher returns when returns are positive, which increases the annual percent change in pay-to-performance sensitivities. Thus, this is not inconsistent with our later finding that companies partially offset decreases in pay-to-performance sensitivities.} above. Although the median percentage change of the $b$ sensitivity using the market-value measure is fairly small at 9\% per year, the mean is much larger, and the median using the executive-value measure is nearly 20\%. Not surprisingly, the percentage changes in $d$ sensitivity are much larger—generally about twice as large—as those of the $b$ sensitivity at the median. Likewise, percentage changes in post-response pay-to-performance sensitivities are larger than percentage changes in pre-response pay-to-performance sensitivities.\footnote{We will see below that this occurs because companies grant more options in response to higher returns when returns are positive, which increases the annual percent change in pay-to-performance sensitivities. Thus, this is not inconsistent with our later finding that companies partially offset decreases in pay-to-performance sensitivities.} There is also evidence that the fact \hspace{1em} \footnote{To a much lesser extent, changes in volatility and expected return may influence our results, since pre-response pay-to-performance sensitivities are calculated using updated estimates of volatility and expected return.} above involves economically significant quantities: executive-value pay-to-performance sensitivity measures are more volatile than market-value measures.

We proceed to estimate the elasticity of pay-to-performance sensitivities with respect to stock price changes under each of the four sensitivity measures. Since option pay-to-performance sensitivities are expected to have a larger responsiveness on the downside—especially when
sensitivities are measured with executive values—we allow for a differential—presumably larger—elasticity for negative returns than for positive returns.

Some notation is necessary to explain our econometric specifications. Let \( POST_{it} \) be the post-response pay-to-performance sensitivity (or actual pay-to-performance sensitivity) of executive \( i \) in period \( t \). This is the pay-to-performance sensitivity calculated from the portfolio of stock and stock options actually held by executive \( i \) at the end of year \( t \). Critically, we account for the fact that executives’ pay-to-performance sensitivities are not linear in the size of the grants they receive: that is, in measuring how pay-to-performance sensitivities change due to new grants, we add each grant to the appropriate previously-held portfolio of stock, options, and non-company investments, reoptimize over the executive’s portfolio choice of non-company investments, and measure the (risk-adjusted) pay-to-performance sensitivity provided by the new portfolio.

We denote by \( PRE_{it} \) the pre-response pay-to-performance sensitivity of executive \( i \) in period \( t \), that is, the pay-to-performance sensitivity executive \( i \) would have had at the end of year \( t \) in the absence of any selling or purchasing of company stock or any options exercises and in the absence of any grants by the company of additional options or restricted stock. Let

\[
POSRET_{it} = \ln \left(1 + r_{it}\right) 1\{r_{it} \geq 0\} \quad \text{and} \quad NEGRET_{it} = \ln \left(1 + r_{it}\right) 1\{r_{it} < 0\},
\]

where \( r_{it} \) is the return on the stock of executive \( i \)'s company in period \( t \). We define the “percent change in pre-response pay-to-performance sensitivity” as

\[
PCPRE_{it} = \ln \left(1 + \frac{PRE_{it} - POST_{it-1}}{POST_{it-1}}\right).
\]

More precisely, \( PCPRE_{it} \) is the natural logarithm of one plus the change in pay-to-performance sensitivity due to stock price behavior, as a percentage of last year’s actual pay-to-performance sensitivity. This is the percent change in pay-to-performance sensitivity that would have occurred if neither the company nor the executive responded to stock-price-induced changes in pay-to-performance sensitivity. Finally, \( \delta_{it} \) is a dummy variable equal to one in period \( t \), in order to control for year fixed effects.

We begin with pre-response pay-to-performance sensitivities since we wish to isolate the effect of stock price changes on pay-to-performance sensitivities prior to any company or executive response to stock-price-induced changes in pay-to-performance sensitivities. Specifically, we regress:

\[
PCPRE_{it} = \delta_{it} + \beta_{1}POSRET_{it} + \beta_{2}NEGRET_{it} + \varepsilon_{it}.
\]
An advantage of this specification is that it is unitless, and its coefficients can be interpreted as elasticities. The specification also includes year fixed effects. In order to avoid the influence of outliers, which is virtually always an issue with executive compensation and pay-to-performance sensitivity measures, we perform robust regression and also exclude from our analysis any observation having $POSRET_{it} > 1$ or $NEGRET_{it} < -1$. Note that this does not bias our results, since we are selecting observations on the basis of the right-hand side variables. In addition, we re-ran the regressions with the outliers included and found the coefficients were less stable but had the same signs and statistical significance. The standard errors reported are those generated by the STATA procedure “rreg,” which come from a weighted least-squares calculation.

3.3 Elasticity Results

The results are shown in the first four columns of Table 2. When pay-to-performance sensitivity is measured by $b$, the elasticities are relatively small for positive returns but are large and significant for negative returns. As expected, this asymmetry is particularly large when executive values, rather than market values, are used. For example, the elasticity is only 0.05 on the upside, but is 0.69 on the downside, when $b$ sensitivity is measured with executive values. The elasticities are much larger when the $d$ measure of sensitivity is used, but the asymmetry—though still statistically significant at a 5% level—is much smaller.

Evaluating these results, we see that both (2) and (3) above are shown to have economic importance. Pay-to-performance sensitivities are much more responsive on the downside than on the upside and downside responsiveness is larger when pay-to-performance sensitivities are measured with executive values rather than market values. Our analysis also demonstrates the empirical relevance of (4): pay-to-performance sensitivities as measured by $d$ are much more responsive to stock price changes than pay-to-performance sensitivities as measured by $b$.

In order to explore (1) and (5), we interact $POSRET$ and $NEGRET$ with an indicator for whether an executive is a “high option” executive or not. $HIOPT$ is an indicator for whether or not an executive-year is in the top quintile of all executive-years in our sample on the basis of the number of options owned relative to the number of company shares owned. This allows us to evaluate not only the empirical relevance of the fact that higher-option executive portfolios induce greater responsiveness of pay-to-performance sensitivities to stock price changes, but also the importance of the fact that pay-to-performance sensitivities are particularly responsive when executives have many options and their companies experience decreases in stock prices. We interact $POSRET$ and $NEGRET$ with $VOL$, the calculated volatility of the executive’s company stock returns in the given year (see Appendix B), in order to measure how much lower
responsiveness is for high volatility firms ((5) above), and to test for any asymmetry in this relationship.

We also include a variable, $POUT_{it}$, which is equal to the percentage of executive $i$’s options that are underwater in period $t$. As with our other variables, we interact $POUT$ with $POSRET$ and $NEGRET$. We include $POUT$ because initial conditions may matter. Since options that are deeply in-the-money begin to have pay-to-performance sensitivity properties similar to those of stock, we expect high-$POUT$ portfolios to be more “option-like” and therefore to generate pay-to-performance sensitivities that have greater responsiveness to stock price changes. Finally, we interact $POSRET$ and $NEGRET$ with NASDAQ, a dummy that is one when an executive’s company is listed on NASDAQ. We include this variable both as a control, and in order to determine if there are any systematic differences in pay-to-performance sensitivity responsiveness to stock price changes between NASDAQ and NYSE firms, after controlling for volatility.

To facilitate interpretation, we subtract from $VOL$ and $POUT$ their means over all observations before estimating the regression. Absent demeaning, interpreting the coefficients on $POSRET$ and $NEGRET$ is difficult: if we do not subtract means from the interaction variables $VOL$ and $POUT$, the coefficients on $POSRET$ and $NEGRET$ are the (extrapolated) sensitivities when $VOL$ and $POUT$ take on the value zero, which is unlikely to be a relevant baseline. Our demeaned approach, however, enables us to interpret the coefficients of $POSRET$ and $NEGRET$ when $VOL$ and $POUT$ are at their means.

The results are reported in the next four columns of Table 2. The results quantify the extent to which high-option firms have greater responsiveness of option pay-to-performance sensitivities to stock price changes ((1) above) and the extent to which this responsiveness is larger on the downside ((2) above). For example, analyzing the $h$ measure of sensitivity with executive values, $HIOPT$ companies have an elasticity that is 0.26 greater on the downside and 0.08 greater on the upside. Further, the responsiveness of pay-to-performance sensitivities to returns is lower for executives at high-volatility firms ((5) above). As we expected, the responsiveness of pay-to-performance sensitivities is higher for executives with a higher percentage of options that are underwater. There are generally statistical differences between NASDAQ and NYSE companies, but these differences are quite small—around 0.03—and therefore economically insignificant. Moreover, they do not have consistent signs.

Finally, as a precursor to our analysis in the next section of how companies and executives respond to stock-price-induced changes in pay-to-performance sensitivities, we estimate the

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18 This variable is set to zero in the small number of executive-years in which executives hold no options.
relationship between post-response pay-to-performance sensitivities and stock price changes. We estimate the elasticity of post-response (or actual) pay-to-performance sensitivities to changes in the stock price, again allowing for an asymmetric response. The results are shown in Table 3. The key difference between these results and our earlier results using pre-response pay-to-performance sensitivities is that the elasticities are notably smaller on the downside. These results suggest that when the portfolio management of executives and the granting behavior of companies are both taken into account, the very high responsiveness of pay-to-performance sensitivities to downward stock price changes is markedly attenuated. That is, these results suggest that year-to-year pay-to-performance sensitivity changes are offset somewhat, whether by executives, by companies, or by both. In what follows, we explore the issue of company and executive responses to stock-price-induced changes in pay-to-performance sensitivities in greater detail.

4. Company and Executive Reactions to Stock-Price-Induced Changes in Pay-to-Performance Sensitivities

We now turn to the issue of how, and to what degree, companies and executives react to stock-price-induced changes in pay-to-performance sensitivities. Pay-to-performance sensitivities can be influenced by the reactions of the company or of the executive (or both), and we analyze each separately using our pay-to-performance sensitivity measures.

4.1 Company Responses to Stock-Price-Induced Changes in Pay-to-Performance Sensitivities

To the extent that companies respond to stock-price-induced changes in pay-to-performance sensitivities, they do so through their re-pricing and granting behavior. If an executive’s pay-to-performance sensitivity declines because of a stock price fall, companies can offset that decline by re-pricing or by offering a larger option (or stock) grant. In some cases, companies offer an extra, out-of-cycle grant (called a “refresher” grant) in order to restore pay-to-performance sensitivity following a stock price decline. For example, Microsoft made a well-publicized refresher grant after its stock price declined from $117 at its January 2000 open to a low of $65 on April 24, 2000. Finally, companies can simply reprice the options of their executives—which involves changing the exercise prices of old options rather than granting a larger number of new options—although this practice is very uncommon, especially following FASB Interpretation 44, effective December 15, 1998, which forces firms that reprice to recognize compensation expenses related to their repricing in subsequent years (Carter and Lynch, 2001). As will be shown later, only 1.4% of executive-years in our sample had their options repriced, and this low percentage is
consistent with fractions reported in other studies.\textsuperscript{19} Although repricing is quite uncommon, we do adjust our data to reflect the impact of repricings using repricing data generously provided to us by Callaghan, Saly and Subramaniam (2000).\textsuperscript{20}

Irrespective of the mechanism, the reaction of companies to stock-price-induced changes in pay-to-performance sensitivities leads to proportionately larger (smaller) boosts to pay-to-performance sensitivities in response to stock-price-induced declines (increases) in pay-to-performance sensitivities. In the polar case of perfect offsetting, any decline (increase) in pay-to-performance sensitivity due to a stock price change would be offset by a larger (smaller) grant in the next period.

The granting policies of companies can also augment stock-price-induced changes in pay-to-performance sensitivities. We conjecture that equity pay is sometimes granted as a reward for good performance. In such cases, a large stock price increase will be associated with a larger equity grant in the next period—and therefore a greater boost to pay-to-performance sensitivity—than a small (or negative) stock price performance. The natural variations in pay-to-performance sensitivities that result from stock price changes are therefore magnified—a stock-price-induced increase in pay-to-performance sensitivity leads to yet greater pay-to-performance sensitivity and vice versa—when equity awards are used to reward good performance and punish poor performance.

As discussed in Hall (1999, 2000), the multi-year granting policies of companies affect the dynamic relationship between stock price performance and option awards. For example, some companies offer fixed-value plans (where the Black-Scholes value of the annual option grant remains constant or a constant fraction of salary over time), which causes the value of options to remain fairly constant over time but induces a negative relationship between stock price changes and the subsequent number of options awarded. Other companies offer fixed-number plans, in which the number of options offered is constant over time. These plans induce a positive relationship between share price changes and the value of future awards. Still others award options on a fairly \textit{ad hoc} basis.

Thus, there can be a positive relationship between stock price performance and subsequent option awards (measured in terms of value or number) if options are used as a reward for past

\textsuperscript{20} In the event of a repricing, we make the conservative assumption that all of the executive’s options whose exercise prices are above the current stock price are repriced to have exercise prices equal to the current stock price. In response to the finding of Brenner, Sundaram and Yermack (2000) that repricings are typically accompanied by an increase in the time to expiration of the repriced options, we set the expiration dates of all repriced options to ten years from the time of repricing.
performance, or a negative relationship between stock price performance and subsequent option awards if options are granted as a way to offset changes in pay-to-performance sensitivities following stock-price-induced declines (or increases) in pay-to-performance sensitivities. In short, option-granting policies can either mitigate or magnify stock-price-induced changes in pay-to-performance sensitivities. Which effect prevails in practice, and under what conditions, is ultimately an empirical question.

4.2 Empirical Strategy

Our empirical strategy for measuring the response of the companies in our sample to stock-price-induced changes in pay-to-performance sensitivities is to regress post-company-response pay-to-performance sensitivity changes, defined as the post-grant change in pay-to-performance sensitivity, on pre-response pay-to-performance sensitivity changes, defined as the change in pay-to-performance sensitivity absent any new company grant of stock or options. We let \( POSTC_{it} \) denote the post-company-response pay-to-performance sensitivity of executive \( i \) at time \( t \), and define \( POSTC_{it} \) as follows:

\[
POSTC_{it} = PCPOSTC_{it} = \ln \left( 1 + \frac{POSTC_{it} - POST_{i,t-1}}{POST_{i,t-1}} \right).
\]

We then examine the relationship between post-company-response and pre-response pay-to-performance sensitivities, differentiating between increases and decreases in pre-response pay-to-performance sensitivities. We thus estimate:

\[
PCPOSTC_{it} = \delta + \beta PCPOSTC_{it} + \beta_1 POSPCPRE_{it} + \beta_2 NGPCPRE_{it} + \nu_{it},
\]

which includes time fixed effects. Our econometric methods are otherwise identical to those employed to produce Table 2, and are described in the headings of Tables 4 through 6.
pick up the increase in pay-to-performance sensitivity due to grants that are not related to changes in pre-response pay-to-performance sensitivity.)

If, however, companies tend to offset declines (increases) in pre-response pay-to-performance sensitivities by making bigger (smaller) grants, then the coefficient will be less than one and the relationship will be depicted by a line such as $FOF'$. In the polar case of perfect offsetting, any stock-price-induced decline in pay-to-performance sensitivity is completely offset by future grants. The coefficient will then be equal to zero; post-company-response pay-to-performance sensitivities will always change by a constant ($G$ in the diagram).\(^{21}\)

If company responses augment stock-price-induced changes in pay-to-performance sensitivities, then stock-price-induced increases (decreases) in pay-to-performance sensitivities will be associated with proportionately larger increases (decreases) in pay-to-performance sensitivities. This corresponds to a line such as $AOA'$ and will lead to a coefficient on pre-response pay-to-performance sensitivity that is greater than one. The polar case of augmenting response asymptotically approaches the vertical line.

Estimation of (4.1) is helpful in determining the magnitude of—and any asymmetry in—company responses to stock-price-induced changes in pay-to-performance sensitivities. However, in order to further investigate the factors that affect company responses to stock-price-induced changes in pay-to-performance sensitivities, we employ a richer specification that adds other regressors to the right-hand side of our basic regression. As before, we include $HIOPT_t$, $VOL_t$, $POUT_t$, and $NASDAQ_t$ as right-hand side variables and interact each of these variables with $POSPCPRE_t$ and $NEGPCPRE_t$ in order to determine whether there are asymmetries in the way that companies respond to stock-price-induced changes in pay-to-performance sensitivities.

As emphasized in Hall (1999, 2000), there are systematic differences in the way that high-technology companies and “old economy” companies distribute options. In particular, old economy companies are more likely to have annual option plans that are either fixed-value or fixed-number, as described earlier. Companies in the high-technology sector, however, are more likely to grant options up-front (a large grant when the executive joins) followed by additional

\(^{21}\) The polar case of perfect offsetting cannot hold for sufficiently large increases in pre-response pay-to-performance sensitivity, unless the company were to engage in (virtually unheard-of) “reverse repricings” in which the strike price of previously granted options is raised. This is because the most extreme possible response to an increase in pre-response pay-to-performance sensitivity is a grant of zero, which may not be large enough, relative to the average positive grant, to offset a very large increase in pre-response pay-to-performance sensitivity. Thus, practically, it is easier for companies to offset changes in pre-response pay-to-performance sensitivities in response to stock price declines than in response to stock price increases.
grants on a more flexible, \textit{ad hoc} basis. This motivates our inclusion of an interaction with the dummy \textit{NASDAQ} to detect any possible systematic differences between NASDAQ companies and NYSE companies (the interaction is with our pre-response pay-to-performance sensitivity variables).

Since NASDAQ companies’ stock returns tend to be more volatile, we also interact $VOL$ with our pre-response pay-to-performance sensitivity variables ($POSPCPRE$ and $NEGPCPRE$) as a control. The coefficient on volatility is of independent interest. We expect higher volatility companies to respond less to stock-price-induced changes in pay-to-performance sensitivities since, for a given change in pay-to-performance sensitivity, higher volatility companies are more likely to see stock-price-induced changes naturally reversed, and therefore might take a wait-and-see approach in deciding whether to offset stock-price-induced changes in pay-to-performance sensitivity.\footnote{A given stock return changes pay-to-performance sensitivities less in a company whose stock returns are more volatile; however, larger returns are more likely if returns are more volatile, and this latter effect is dominant, so that (pre-response) pay-to-performance sensitivities are more volatile in a company whose stock returns are more volatile. Thus, a given change in pay-to-performance sensitivity is more likely to be reversed by subsequent stock price variation in a company with more volatile stock returns.}

We also test whether high-option companies, which have pay-to-performance sensitivities that are more responsive to stock price changes, react more or less than low-option companies to stock-price-induced changes in pay-to-performance sensitivities, and we test for whether any such reaction is asymmetric. Thus, we interact our key right-hand side variables—$POSPCPRE$ and $NEGPCPRE$—with $HIOPT$. Finally, we interact $POSPCPRE$ and $NEGPCPRE$ with the percentage of options that are underwater, $POUT$, to determine whether or not companies whose executives have options that are already underwater tend to react more to stock-price-induced changes in pay-to-performance sensitivities. In particular, we expect companies with a significant fraction of options underwater to respond more to declines in pay-to-performance sensitivity that are due to stock price decreases.\footnote{Although there are quantitative differences between the coefficients using risk-adjusted and market-value pay-to-performance sensitivities, the results are qualitatively similar. We include only the results using risk-adjusted pay-to-performance sensitivities in order to save space and because we believe they more closely approximate actual pay-to-performance sensitivities.}

Finally, before turning to the empirical results, we discuss the timing of company responses. Companies may respond to stock-price-induced changes in pay-to-performance sensitivities within the same year as the stock price change. For example, if the stock price falls sharply in the first half of the year, a company may give a refresher grant, or give more options than planned, in the latter half of the year. However, since approximately half of all options in our sample are granted in the first quarter of the year, most company reactions to stock-price-induced changes in
pay-to-performance sensitivities are next year’s granting responses to this year’s stock-price-induced changes in pay-to-performance sensitivities.\footnote{This claim is further buttressed by the fact that refresher grants—extra grants given in response to stock price declines—appear to be a very small part of the story of how companies respond to stock-price-induced changes in pay-to-performance sensitivities. We discuss this in more detail in Section 5.} We will report some results for same-year company responses to stock-price-induced changes in pay-to-performance sensitivities, but our focus will be on total company response (which we will simply refer to as “company response”), which includes the increment to pay-to-performance sensitivity from same-year grants ($t$) and next year’s ($t+1$) grants.\footnote{We found no interesting differences when we defined “response” in narrower ways—for example, only next year’s grants—so we do not report these results.} That is, the dependent variable is formed using the one-year lead of post-company-response pay-to-performance sensitivity, $POSTC_{t+1}$, instead of $POSTC_t$. Specifically, the dependent variable is the natural logarithm of one plus the change from actual pay-to-performance sensitivity in $t-1$ to post-company-response pay-to-performance sensitivity in $t+1$, as a percentage of actual pay-to-performance sensitivity in $t-1$.

\subsection*{4.3 Empirical Results}

Table 4 contains the results of the estimations of equation (4.1), using the same four pay-to-performance sensitivity measures as before. As discussed, we allow for differential responses to positive and negative pre-response pay-to-performance sensitivity changes since company response is likely to differ depending on whether pre-response pay-to-performance sensitivity rose or fell. The first four columns show same-year company response and the next six columns show total company response. The results show that there is some augmenting response to stock-price-induced increases in pay-to-performance sensitivity, especially when we consider total response, but significant offsetting response to stock-price-induced decreases in pay-to-performance sensitivity. For example, in column 5, where pay-to-performance sensitivity is measured using $b$ and executive values, the coefficient on stock-price-induced increases in pay-to-performance sensitivity is 1.43 and is statistically different from one at conventional levels, while the coefficient on stock-price-induced decreases in pay-to-performance sensitivity is 0.61 and also significantly different from one. A similar pattern emerges for same-year company-response, with a coefficient of 1.22 on increases and 0.78 on decreases.

The key result is that the granting policies of companies result in augmenting when pre-response pay-to-performance sensitivities increase, but company granting policies appear to significantly offset declines in pre-response pay-to-performance sensitivities. Such granting activities reduce the reaction of post-company-response executive pay-to-performance...
sensitivities to changes in the underlying stock price.\textsuperscript{26} That is, while (on average) companies magnify a given increase in pay-to-performance sensitivity, they offset approximately 39\% (1.0 – 0.61 in column 5) of a given decrease in risk-adjusted $b$ sensitivity and 23\% (1.0 – 0.77 in column 7) of a given decrease in risk-adjusted $d$ sensitivity.\textsuperscript{27}

Recall that the pay-to-performance sensitivities of high-option executives are more responsive to stock price changes than those of low-option executives. This raises the question of whether companies’ granting policies are used to offset the responsiveness of pay-to-performance sensitivities induced by options. The results suggest that they are. Indeed, the degree of offsetting for HIOPT executives is large and striking. For example, when $b$ pay-to-performance sensitivities are used, the coefficient on the downside falls to 0.20 (0.64 plus -0.44), suggesting that, on average, 80\% of a drop in pay-to-performance sensitivity is offset. When $d$ sensitivities are used, on average slightly more than half of a drop in pay-to-performance sensitivity is offset. Interestingly, the results are reversed, in both specifications, on the upside, where we find augmenting company responses in general (so that stock-price-induced increases in pay-to-performance sensitivities tend to lead companies to increase pay-to-performance sensitivities further still) and more augmenting for HIOPT companies. It appears that executives, and especially HIOPT executives, are rewarded most when they do very well, augmenting stock-price-induced increases in pay-to-performance sensitivities, and when they do very poorly, offsetting stock-price-induced decreases in pay-to-performance sensitivities. We will confirm, and elaborate on, these results in the next section when we look at the mechanisms through which companies respond to stock-price-induced changes in pay-to-performance sensitivities.

The coefficients on the $POUT$ interactions show that the fraction of an executive’s options that are underwater does not seem to affect company response if pre-response pay-to-performance sensitivity increases; however, if pre-response pay-to-performance sensitivity decreases, companies offset this decrease more for executives with larger fractions of their options underwater. This accords well with expectations, as discussed above.

Finally, although NASDAQ companies display less company response to stock-price-induced changes in pay-to-performance sensitivities, the effects appear to be operating mostly through high volatility. For instance, if the volatility interaction is dropped from the regression, results not shown reveal that the coefficients on the NASDAQ interactions become significantly

\textsuperscript{26} Of course, as discussed in the introduction, company offsetting of stock-price-induced decreases in pay-to-performance sensitivity takes away some of the downside risk to executives, which may weaken pay-to-performance sensitivity \textit{ex ante}. We return to this issue in the conclusion.

\textsuperscript{27} In addition to checking for asymmetry, we also checked for further non-linearities and found no significant departure from our piecewise linear model.
positive. In the full specification reported in columns 9 and 10 of Table 4, only two of the four NASDAQ interactions are significant at a 5% level, and none are large in absolute value. Volatility does, however, have large effects on company responses to stock-price-induced changes in pay-to-performance sensitivities. High-volatility firms offset less of a stock-price-induced decrease in pay-to-performance sensitivity and augment less of a stock-price-induced increase in pay-to-performance sensitivity than low volatility firms, regardless of how we measure pay-to-performance sensitivities.

4.4 Executive Responses to Stock-Price-Induced Changes in Pay-to-Performance Sensitivities

We now turn to analysis of executive responses to stock-price-induced changes in pay-to-performance sensitivities. Executives sell stock, buy stock, and exercise options. These transactions can magnify stock-price-induced changes in pay-to-performance sensitivities, or they can mitigate them. One factor that should lead to executive mitigation of stock-price-induced changes in pay-to-performance sensitivities is option exercise behavior. Executives are more (less) likely to exercise options following stock price increases (decreases). As stock price increases push options into-the-money, early exercise becomes profitable and perhaps optimal, since risk-averse, undiversified executives rationally exercise options early when they move sufficiently into-the-money.28 Thus, exercise behavior should tend to mitigate stock-price-induced changes in pay-to-performance sensitivities, since such transactions decrease pay-to-performance sensitivities when pay-to-performance sensitivities have risen the most (following large increases in stock price).

Less is known about how executives respond to stock price changes by purchasing and selling company stock. Many companies have formal and informal guidelines that require or encourage executives to accumulate shares of company stock over time. One possibility is that executives tend to accumulate disproportionately more shares following stock price increases, since one convenient way to accumulate shares is to exercise options, though evidence by Ofek and Yermack (2000) suggests that the conversion of exercised options into net new share holdings, at least in the aggregate, is small. On the other hand, many ownership guidelines require executives to hold a number of shares sufficient to maintain the value of holdings above some multiple of salary (or salary and bonus). Thus, stock price increases would tend to push the value of holdings above the required levels, leading to net sales following stock price increases. Stock price decreases would lead to the opposite reaction: holdings would fall below the required levels, triggering mandatory purchasing by the executive. It is, therefore, not obvious whether the
net effect of stock purchases and sales leads to offsetting or augmenting of stock-price-induced changes in pay-to-performance sensitivities.

4.5 Executive Offsetting or Augmenting of Stock-Price-Induced Changes in Pay-to-Performance Sensitivities?

Our empirical approach for determining whether executive transactions lead to offsetting or augmenting of stock-price-induced changes in pay-to-performance sensitivities is analogous to our approach in the case of company response, except that we replace post-company-response pay-to-performance sensitivities with post-executive-response pay-to-performance sensitivities. That is, post-response pay-to-performance sensitivities now include executive sales, purchases and exercises instead of company grants (which are removed to isolate the effect of executive actions). We again test for asymmetries in the response to stock-price-induced changes in pay-to-performance sensitivities, and then analyze the determinants of executive response. Table 5 gives our results for executive response, in the same format used in Table 4. The results for single-year response are not shown since all of the coefficients are quite close to one—there is essentially no offsetting or augmenting of stock-price-induced changes in pay-to-performance sensitivities due to executive behavior within the year.

There is significant executive response, however, in the following year, but only to stock-price-induced decreases in pay-to-performance sensitivities. These results are shown in the first four columns of the table. For example, using executive value $b$ sensitivity, executives offset 46% ($1 – 0.54$ in column 1) of any decline in pre-response pay-to-performance sensitivity. The executive offsetting effect for risk-adjusted $d$ sensitivity is lower, but still large, at 22% ($1$ minus $0.78$ in column 3). For stock price increases, there is evidence of very modest augmenting. In general, however, the coefficients are fairly close to one, suggesting little offsetting or augmenting in response to stock-price-induced increases in pay-to-performance sensitivities.

Including the interaction regressors of our extended specification has little effect on the coefficients on $POSPCPR$ and $NEGPCPR$, as columns 5 and 6 make clear. However, the coefficients on the interactions reveal interesting contrasts between executive and company responses to stock-price-induced changes in pay-to-performance sensitivities. High-option executives appear to offset more on the upside and offset less on the downside than low-option executives, and these differences are statistically significant at a 5% level. These differences show that executive responses and company responses conflict somewhat for high-option executives: companies augment stock-price-induced increases in pay-to-performance sensitivities

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26 See Hall and Murphy (2000, 2002) and Huddart and Lang (1996) for evidence and analysis consistent with this. Also, Heath, Huddart and Lang (1999) and Core and Guay (2001) find that executives exercise
more and offset stock-price-induced decreases in pay-to-performance sensitivities more for these executives, while these executives offset more of stock-price-induced increases and offset less of stock-price-induced decreases. Volatility appears to influence executive responses less than company responses, especially for reactions to a stock-price-induced increase in pay-to-performance sensitivities. The fraction of an executive’s options that are underwater seems to be largely irrelevant for executive reactions to stock-price-induced increases in pay-to-performance sensitivities, but decreases executive offsetting a bit in reaction to a stock-price-induced decrease in pay-to-performance sensitivity. As for company response, being a NASDAQ executive appears to make little difference to executive response once volatility and other factors are taken into account. The key result in this table, however, is the fact that executive behavior—much like company behavior, but for different reasons—leads to offsetting of stock-price-induced decreases in pay-to-performance sensitivities.

4.6 Total Response to Stock-Price-Induced Changes in Pay-to-Performance Sensitivities: Company and Executive Response Combined

We now explore the total response to stock-price-induced changes in pay-to-performance sensitivities, the combined response of companies and executives. Our approach is the same as that used to analyze company and executive responses separately, but we now allow for pay-to-performance sensitivity changes generated by both companies and executives. The results are shown in Table 6 and, not surprisingly given earlier results, show significant augmenting of stock-price-induced increases in pay-to-performance sensitivities and significant offsetting of stock-price-induced decreases in pay-to-performance sensitivities. For example, in the case where executive value $b$ sensitivity is used, the coefficient on the upside is 1.26—indicating a 26% augmentation of pre-response pay-to-performance sensitivity increases—and is 0.54 on the downside—46% of declines in pre-response pay-to-performance sensitivity are offset by combined response. This basic asymmetry is robust to different measures of pay-to-performance sensitivity and to the inclusion of the various controls.

The other interesting result in this table is that $HIOPT$ executives have more combined offsetting response to stock-price-induced decreases in pay-to-performance sensitivity, which suggests that the effects of company response (from Table 4) tend to dominate the effects of executive response (from Table 5) for $HIOPT$ executives. Of course, as noted in the introduction, our evidence does not speak to whether or not the combination of company response and executive response is optimal. The other results are unsurprising. Tying the key result of our combined response analysis back to Figure 1, the evidence suggests that the relationship between early following increases in stock prices because of psychological biases.
post-response and pre-response pay-to-performance sensitivities is characterized by a line such as $FOA'$—offsetting response to stock-price-induced decreases in pay-to-performance sensitivities and augmenting response to stock-price-induced increases in pay-to-performance sensitivities. We now explore the mechanisms that may lead to such a relationship.

5. The Mechanism of Company and Executive Reactions to Stock-Price-Induced Changes in Pay-to-Performance Sensitivities

The fact that executive transactions and company granting behavior lead to offsetting of stock-price-induced decreases in pay-to-performance sensitivities raises a key question: what is the mechanism? Do larger stock price decreases lead companies to grant more options? To be more likely to reprice? What explains executives’ offsetting reaction? Is it caused by fewer exercises when stock prices fall? Or by more net purchases of shares? In this section we investigate this issue. We begin by showing some medians and distributions of raw data; we then present some econometric evidence.

Table 7 shows the number and market value of the variables related to company and executive reaction for different lagged stock price returns: options granted, stock granted, net shares bought and options exercised. We show the mean, median, 25th and 75th percentile of each variable. In the cases where the median is not zero, we focus on medians in our discussion since means are driven by outliers.

Columns 1 and 2 show the number and value of option grants for different groupings of companies, where the four groupings are separated by negative 10%, 25%, and 50%. The results show that, as expected, both the number and value of options (at the median, and also at the mean for the number) tend to increase as the stock price falls. That is, when the companies perform poorly, executives get larger rewards for worse performance, both in dollar and number terms. These results will be corroborated with regression analysis shortly, and show an important mechanism of how companies respond to stock-price-induced decreases in pay-to-performance sensitivities.

The results for stock grants (in the next two columns) are, not surprisingly, quite different. The median grant is zero for all groupings and the mean grant is dramatically smaller than the size of option grants. While there is modest evidence for company offsetting of stock-price-induced decreases in pay-to-performance sensitivities with the mean number of shares—again, medians are uninformative since they are all zero—the numbers are small relative to those of
options. This evidence suggests that it is primarily through option grants, not stock grants, that companies offset stock-price-induced declines in pay-to-performance sensitivities.

In terms of executive reaction, we first look at option exercises, shown in the next two columns. Although exercises are always zero at the median, the pattern at the mean level of exercises is quite consistent with an offsetting reaction to stock-price-induced decreases in pay-to-performance sensitivities. Both the number and value of exercises fall when companies do worse. The results with net share purchases do not show a consistent pattern. (Note that these net share purchases are in addition to shares received from option exercises. That is, if an executive exercised and decided to hold the shares, which the evidence suggests is uncommon (Ofek and Yermack, 2000), it would show up in our data as a purchase of shares.) The means and medians often move in different directions, and the number of shares at the median is nonmonotonic and relatively flat across groupings. Overall, there is no consistent evidence of either an augmenting or an offsetting reaction using net share purchases. This is at least suggestive that it is option exercises (which lead to sales of the stock received), and not net stock purchases that lead to executive offsetting of stock-price-induced decreases in pay-to-performance sensitivities.

We explore these issues further in Table 8, which shows both the change in the number of options granted and the change in the number of grants. Consistent with our level results in Table 7, the number of options granted tends to increase between the years $t$ and $t+1$ in response to a stock price decline in year $t$. Does this reflect an increase in the number of options granted in a given grant? Or do the results reflect an increase in the number of grants, that is, a refresher grant? As shown in the table, the number of grants rarely changes and does not increase in a significant way from year to year in response to a stock price decline. For example, when companies do very poorly, there is a 0.013 increase in the average number of grants. Note that we also looked for evidence of refresher grants within the year (instead of in the following year), and found no such evidence. There is no evidence that extra refresher grants are a significant contributor to company reaction to stock-price-induced changes in pay-to-performance sensitivities.

The number of repricings is shown in the third column. As suggested earlier, repricings are quite uncommon and barely increase when companies do poorly. For example, in the year following a 50% decline in stock prices, the percentage of repricings was less than 2%. The

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number of within-year repricings, not shown, was even lower. This analysis suggests that neither refresher grants nor repricings, although highly publicized when they do happen, are significant drivers of company response to stock-price-induced decreases in pay-to-performance sensitivities.

We now explore the key findings with regression analysis. We begin with company reaction, exploring how option granting behavior changes with company performance. Taken together, our earlier results—both the response results of Tables 4 through 6 and the mechanism median and mean tables—suggest a rather strange relationship between option grants and company performance. Specifically, the results suggest that company granting behavior follows a “V” shape: large stock price increases lead to larger option grants (augmenting responses to stock-price-induced increases in pay-to-performance sensitivities) and, large stock price decreases also lead to larger option grants (offsetting responses to stock-price-induced decreases in pay-to-performance sensitivities). That is, the way for managers to get the most options—the biggest boost to their pay-to-performance sensitivities—is to do very well and receive a reward, or very poorly and receive a “pay-to-performance sensitivity restoration” grant. We now test this more formally.

Table 9 shows the results of regressing the number of options, and then the value of options, on the log of the stock price return. We interact dummy variables for stock price increases and decreases with the stock price return to check for the “V” shape relationship. We include executive fixed effects and year effects. Executive fixed effects are important here since there are large differences in both the average number and the average value of options across executives, which may confound our results. The “V” shape is strongly present for both the number and value of options—with a positive coefficient on positive log returns and a negative coefficient on negative log returns—although the negative coefficient for option values is only statistically significant at the 10% level. The elasticity of the option number with respect to negative returns is quite large (in absolute value) at almost (negative) 0.4. When the stock price declines, executives receive 4% more options for each 10% decrease in the stock price return. Executives receive more options following poorer stock price performance, which reduces the responsiveness of pay-to-performance sensitivities to changes in stock price.

Following the large literature on relative performance evaluation (RPE) (Antle and Smith, 1986, Bertrand and Mullainathan, 2001, Gibbons and Murphy, 1990 and Holmstrom, 1982), we also explore whether company granting behavior is affected by industry stock price performance. A key notion behind RPE is that incentives can be improved if executives are not punished (or
rewarded) for factors beyond their control, such as industry performance. Indeed, some companies explain the need to adjust pay-to-performance sensitivities following company stock price declines by appealing to the notion that “it was not the executive’s fault since the decline was industry-wide.” Such logic would lead companies to grant fewer (more) options in response to industry stock price increases (decreases), holding company stock price changes constant.

However, as Oyer (2000) points out, one of the attractive features of stock options is that they have appealing retention characteristics precisely because their values are sensitive to industry stock price performance. For example, when there is an industry-wide stock price decrease, companies may well want to lower wages since retention is less of a concern in less tight labor markets, and stock options provide a nice, automatic mechanism for doing so. To the extent that retention considerations of this sort are driving responses to stock-price-induced changes in pay-to-performance sensitivity, we expect to find anti-RPE: as industry stock prices decline, labor markets loosen, and companies find less need to restore option value through larger grants.

The results, which now include industry returns, are shown in the next two columns of Table 9. For both option numbers and values, the regressions point strongly to the presence of RPE. Both coefficients are approximately equal to -0.2 and are highly significant. Although only suggestive, the results are consistent with the view that granting behavior is more affected by incentive considerations than retention considerations.

6. Conclusion

We demonstrate that executives’ pay-to-performance sensitivities decline significantly following stock price decreases, primarily because of their option holdings. Our main contribution, however, is to show that company option-granting behavior tends to offset these declines. This is not because companies reprice options, but rather because companies actively react to stock-price-induced changes by making larger-than-average option grants in the following year. Our estimates suggest that these larger-than-average grants offset 40% of all stock-price-induced declines in pay-to-performance sensitivities for the typical executive. Thus, we have uncovered the primary mechanism through which companies offset stock-price-induced declines in pay-to-performance sensitivities—larger option grants.

31 We also included other right-hand side variables such as age and tenure of the executive. Because executive fixed effects largely knocked out their significance, these variables did not affect our main results and were therefore dropped.

32 See Hall, Lane and Lim (2002a,b) for a case study example of this type of reasoning.

33 Defined as value-weighted returns from two-digit SIC codes.
Explicit option repricings are exceedingly uncommon. Our results, however, point to a type of backdoor repricing, which is both large and prevalent, and has virtues—in terms of restoring pay-to-performance sensitivity *ex post*—and flaws—in terms of degrading *ex ante* pay-to-performance sensitivity by rewarding poor performance—very similar to those of repricing itself. While we cannot make strong claims regarding the (non) optimality of this type of backdoor repricing, we note that shareholders and shareholder activists routinely decry explicit repricings in the press, and all of the major shareholder advisory firms (such as Institutional Shareholder Services, ISS) advise their investor-clients to “vote no” to any shareholder proposal that contains an explicit repricing.\(^{34}\) Having become frustrated by the problems created by underwater options, Microsoft recently announced that it would no longer grant options, but would grant restricted stock in the future instead.\(^{35}\)

Moving from examining stock price declines to considering stock price increases, our analysis suggests that companies do the opposite of “offsetting” when stock prices rise. When stock prices increase, option grants are positively related to stock price increases—stronger stock price performance leads to a type of “topping off” instead of “offsetting.” Thus, executives receive the largest option grants following large stock price decreases and large stock price increases—creating a “V” shape in the relationship between future grant size and stock price performance. This raises important questions regarding the long-run pay-to-performance relationship. Most studies of pay-to-performance sensitivities generated by equity holdings base their estimates on yearly changes in pay and performance (Jensen and Murphy, 1990, Hall and Liebman, 1998, Aggarwal and Samwick, 1999). But our analysis suggests that downside pay-to-performance sensitivity over long horizons may be lower than that measured over one-year horizons since large declines in the values of executives’ equity portfolios are partially offset by larger-than-average future grants. On the other hand, our finding of augmenting company response on the upside—very good performance today also leads to larger-than-average option grants in the future—suggests that upside pay-to-performance sensitivities measured over long periods may be larger than those measured over short periods. We believe that the way in which these responses combine to affect long-run pay-to-performance represents a fertile ground for future research.\(^{36}\)

\(^{34}\) Unless other features of the repricing – such as exchanges that give fewer new options for every option exchanged – are included in such a way as to make the deal more “shareholder friendly.”

\(^{35}\) Jensen (2001) and Jensen and Fuller (2002) are advocates of linear schemes because they believe that pay-to-performance sensitivities that are more robust to performance changes are generally more desirable.

\(^{36}\) Such future research could build on the approach of Boschen and Smith (1995), but would need to account for risk-adjusted changes in executive wealth due to changes in the values of stock and option holdings while allowing for the asymmetric response we have uncovered.
We focus on top executives’ pay-to-performance sensitivities, a subject whose importance has been widely recognized (Murphy, 1999). However, options are also potent retention devices, for executives and for rank-and-file workers, and we note that much of our evidence and analysis would have implications for, and shed light on, the role that options play in providing retention incentives. We only touch on this issue with our evidence in support of RPE in option-granting behavior, which is suggestive of an incentive motivation for executive option grants rather than a retention motivation as in Oyer (2000).37 A study of the effectiveness of options as retention devices would, however, represent an important extension of this analysis.

Finally, our results have implications for the way that options are valued. Specifically, if an increase or decrease in the company’s stock price has a reasonably predictable effect on future option grants, then an executive option implicitly includes contingent claims to options in the future and thus is very different from a standard option. Others, such as Brenner, Sundaram, and Yermack (2000), have developed option-pricing models that take repricing into account. They conclude that the *ex ante* value of the repricing feature is trivial because repricings are so rare.38 Our results, however, point to a type of backdoor repricing that is quite significant, and therefore, using similar models, likely to have a large impact on *ex ante* option value. More generally, there are potentially high returns to future research that models the value of multi-year option *plans*, rather than individual option *grants*.

37 This statement applies specifically to Oyer’s (2000) model of retention, which we discuss in Section 5; one could imagine other models in which RPE could be driven by retention concerns.

38 In a similar vein, Hemmer, Matsunaga and Shevlin (1998), Dybvig and Loewenstein (2002) and Saly, Jagannathan and Huddart (1999) model the values of options with reload features.
References


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Appendix A: Measuring Executives’ Total Holdings of Company Stock and Stock Options

We use data from proxies, as assembled in the Execucomp database, to construct a measure of each executive’s holdings of company stock and stock options at each fiscal year-end. Our methodology is based on that of Hall and Lieberman (1998), with a few minor improvements that add to precision. Proxies reveal the number, expiration date, and strike price of options, as well as the number of restricted shares, granted to each of a company’s top five executives in the preceding fiscal year. Thus, we have data on grants; however, to measure pay-to-performance sensitivities we need data on total holdings. Execucomp also contains information on option exercises and total executive holdings of company stock, but we must still make assumptions about each executive’s initial holdings of options. Given initial holdings of options, we use the data in Execucomp to build up each executive’s portfolio of company stock and stock options over time.

Four complications hinder our measurement of stock and option holdings. First, executives often hold options received prior to 1992, the first year for which data are available in Execucomp. Second, the exercise price of an option grant is sometimes missing. Third, because proxies report (and thus Execucomp contains) gains from option exercise as a dollar value and number of options exercised, it is often not possible to determine exactly which options were exercised in a given fiscal year. Fourth, stock splits force us to adjust option exercise prices, since exercise prices are typically changed automatically after a stock split. The data does, however, contain some variables that help us to check our calculations. A count of the total options (or the total number of vested options) held by executives is often available; when it is, we use it to verify and, if necessary, correct our algorithm’s results.

Initial Conditions

Because many of the executives in our sample already hold options when they come into our sample, we must make assumptions about these initial holdings. We then take steps to ensure that our results are not overly sensitive to our assumptions regarding initial holdings. First, we note that, although many executives hold company stock prior to becoming part of our sample, Execucomp contains information on total holdings of company stock, so stock holdings are less troublesome, from a data-preparation viewpoint, than option holdings. Execucomp often contains information on the total number of options held by an executive when that executive enters our sample. However, our analysis also requires the strike price and the time to expiration of these options, which Execucomp does not have.
We take the first year in which data on total option holdings is available, then subtract grants and add back option exercises (when necessary; that is, when the first year the executive appears in our sample is not the first year for which total options held is available) to get an estimate of the total number of options held by each executive when that executive enters our sample. We assume that these options expire in seven years, and that they have an exercise price set to the market price a year prior to the first grant for the executive in our sample (if this is missing, we use the price at the end of the previous fiscal year as provided by Execucomp; if even that is missing, we use the price at the end of the previous fiscal year as calculated from the CRSP stock file). Since Execucomp data begins in 1992, but we do not use any pay-to-performance sensitivities prior to 1995, our results should be very robust to changes in assumptions regarding initial conditions. To check this, we reran our algorithm on 100 randomly-selected firms under the assumption that initially held options expired in three years, and then under the assumption that they expired in ten years. The results were not appreciably different from those obtained under the assumption outlined above.

**Missing Exercise Prices**

When an exercise price is missing, we follow a procedure similar to that described above for initial conditions. We first use the market price at the grant date, as provided by Execucomp. If this is also missing, we use the price at the end of the fiscal year in which the options were granted, also as provided by Execucomp. If both of these two attempts result in an exercise price that is missing, we use the price at the end of the fiscal year in which the options were granted, as calculated from the CRSP stock file.

**Estimating Which Options Were Exercised**

Because Execucomp (and company proxies) report only the number of options exercised and the dollar gain from exercising them, we cannot, in general, infer exactly which options were exercised. If we knew the exact date on which the options had been exercised, we could get very good estimates of which options were sold by using the stock price on that date in combination with the number of options exercised. However, our data on exercises is at an annual frequency (unlike our data on grants; we know the precise dates on which grants were made). We thus disregard the dollar-gain data as having little information of interest to us (since we do not know the stock price at the date of exercise), and focus on the data on the number of options exercised.

We assume that executives exercise options that expire soonest first; between option grants with a given expiration date, they exercise their deepest-in-the-money (lowest exercise price)
options first; between option grants with the same expiration date and exercise price, they exercise those that were granted longest ago first; between option grants with the same grant date, expiration date, and exercise price, they exercise those from the largest grant (in number of options) first. This is our initial estimate of the options that have been exercised. We then use the information provided by Execucomp on the total number of options held by the executive to make sure that we have not subtracted too many options; if we have, we add back options to a random grant in the most recent year. (Note: this is evidence of a data discrepancy, not an error in our estimates, since our algorithm cannot make a mistake in calculating the number of options exercised). We do this recursively, so that the discrepancy between our total and Execucomp’s could only have arisen in the most recent year; thus, our procedure for correcting the discrepancy is reasonable and internally consistent.

Adjusting for Stock Splits

Because Execucomp’s data give the exercise price of the options in a grant when that grant was made, they are no longer valid after a stock split. Executive stock options typically adjust automatically to stock splits: their exercise prices and the number of options in the grant are changed to take the split into account. For a two-for-one stock split, for instance, an executive’s stock options would double in number and their exercise price would be halved.

To take this fact into account, we construct split adjustment factors from CRSP stock file price data. If the current month’s closing stock price, divided by last month’s closing stock price, differs from the gross monthly return listed in CRSP by at least 25% of that gross monthly return, and if the change in shares outstanding is at least 25% from the end of the previous month to the end of this month, we assume that a stock split occurred. We divide price by lagged price, then divide the result by gross return, to arrive at an adjustment factor. The adjustment factor is then rounded to the closest whole number between one and ten, or 1.5 (to allow for three-for-two splits). We then cumulate (take the product of) all adjustment factors between the present date and the grant date. We multiply the number of options in the grant by this cumulative adjustment factor and divide the exercise price of each option in the grant by the cumulative adjustment factor.
Appendix B: Risk-Adjusted Pay-to-Performance Sensitivity Calculations

Although Section 2 describes the methods we employ to calculate pay-to-performance sensitivities, it omits some critical but cumbersome details, which we delve into here. First, we show how to get log parameters from raw means, standard deviations, and CAPM betas. Next, we discuss the dimensionality problems that afflict us, and how we approach them. Finally, we give an explanation of how we numerically approximate the integrals given in Section 2.

For each executive, we begin with the following five quantities: \( \hat{\beta}_p, \hat{\sigma}_{\text{raw},p}, \mu_{\text{raw},m}, \sigma_{\text{raw},m}, r_f \). These are our estimate of the CAPM \( \beta \) of the executive’s company stock, our estimate of the standard deviation of returns on the company stock, the mean return on the market portfolio, the standard deviation of returns on the market portfolio, and the risk-free rate, respectively. We assume that \( r_f = 6\% \), \( \mu_{\text{raw},m} = r_f + 6.5\% = 12.5\% \), and \( \sigma_{\text{raw},m} = 20\% \). As mentioned in the footnotes to Section 2.2, this matches long-term historical data fairly well. We use 60-month company-by-company ordinary least squares regressions to compute estimates of the CAPM \( \beta_p \), but we constrain our estimates to lie in the interval \([0,2]\).

We then calculate \( \hat{\mu}_{\text{raw},p} = r_f + \hat{\beta}_p (\mu_{\text{raw},m} - r_f) = 6\% + \hat{\beta}_p \times 6.5\% \). Our estimate \( \hat{\sigma}_{\text{raw},p} \) of \( \sigma_{\text{raw},p} \), the standard deviation of returns on company stock, is obtained by taking the square root of the usual (unbiased) variance estimator computed over the most recent 36 months of returns.

Under our assumption of lognormality, we must now translate our parameters into log terms. We do so as follows:

\[
\begin{align*}
\hat{\sigma}_{\text{log},p} &= \sqrt{\ln \left( 1 + \frac{\hat{\sigma}_{\text{raw},p}^2}{\hat{\beta}_p^2} \right)} , \\
\hat{\mu}_{\text{log},p} &= \ln (\hat{\mu}_{\text{raw},p}) - \frac{1}{2} \hat{\sigma}_{\text{log},p}^2 , \\
\sigma_{\text{log},m} &= \sqrt{\ln \left( 1 + \frac{\sigma_{\text{raw},m}^2}{\mu_{\text{raw},m} \hat{\beta}_p} \right)} , \\
\mu_{\text{log},m} &= \ln (\mu_m) - \frac{1}{2} \sigma_{\text{log},m}^2 , \text{ and } \\
\hat{\sigma}_{\text{log},pm} &= \ln \left( 1 + \frac{\hat{\beta}_p \sigma_{\text{raw},m}}{\mu_{\text{raw},m} \hat{\beta}_p} \right) .
\end{align*}
\]

We can now employ a grid to approximate the joint distribution of the natural logarithms of market portfolio and company stock returns. But here we collide with the dimensionality of the problem: if the executive has options expiring in each of the following ten years, we require a grid over twenty dimensions (one dimension each for the market and company return in each of the ten years), jointly. If we asked for the crudest possible grid, a two-point approximation, that would still entail \( 2^{20} = 1,048,576 \) grid points. We would then be forced to sum over these grid points each time we desired to evaluate expected utility, which we must do several times for each executive.
Doing this for 48,746 executive-years (much larger than our regression sample sizes due in part to the fact that we lose one year for each executive by calculating changes in pay-to-performance sensitivities) is computationally infeasible, and would be even more so with a more realistic grid size.

In order to calculate pay-to-performance sensitivities, then, we need a more tractable approximation to the integral that gives expected utility. We obtain this approximation by grouping grants that expire in nearby years together into one expiration year. Although each grant keeps its own exercise price, their expiration dates may be shifted slightly. If fewer than three years of the following ten have an options package expiring in them, we alter nothing. If there are four separate expiration years, we do not alter the grants expiring in the first two of the four expiration years, but we group the final two grants together, so that both are given the same expiration year (the average of the actual expiration years), but each maintains its separate strike price. If there are five separate expiration years, we group the four final grants into two pairs in a similar fashion; if there are six, we group them into three pairs on the basis of expiration year; if there are seven, we group the four earliest grants into two pairs and the final three grants into one triple; if there are eight, we group the first two into a pair and the next six into two triples; if there are nine, we group them into three triples, and if there are ten, we group the earliest six into two triples and place the final four into one quadruple.

We have thus reduced the dimensionality of the space we must grid over to six, which is still fairly high-dimensional for numerical integration; we shall have to accept a reasonably coarse grid (a ten-point grid for each return at each time would result in a 1,000,000 point overall grid, which is intractable). Somewhat arbitrarily, we use a 100-point grid for each return if there is only one expiration year, a ten-point grid for each return in each year if there are two expiration years, and a six-point grid for each return in each year if there are three expiration years after our grouping approximation. Note that the total number of points in the joint grid is thus 10,000 if there are one or two expiration years, and is $6^6 = 46,656$ if there are three expiration years.

In all of the possible cases, the grid points are placed in an “equiprobable” fashion: the interval between any two adjacent grid points has the same probability as the interval between any other two adjacent grid points (for these purposes, $-\infty$ and $+\infty$ are considered grid points). Thus, the integral can be approximated by simply averaging over the grid points (due to their placement, which allows us to avoid explicitly weighting by density values).

In the executive’s expected utility calculation, Section 2 above notes the fact that we assume the executive to be optimizing over the fraction of his outside wealth he holds in the market portfolio versus the fraction he holds in the riskless asset. Computationally, we perform the
optimization through a simple grid search. Again, computational constraints limit the size of the
grid we may use; we choose to check every decile, so that the executive calculates his expected
utility if he holds 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% of his
outside wealth in the market portfolio (note that we do not permit short-selling or buying on
margin, though only the latter constraint is binding in practice). He then chooses the percentage,
of these eleven possible percentages, that maximizes his expected utility.

We have checked the quality of our approximations by doubling all grid sizes and checking
each 5% increment for outside wealth investment using a randomly-selected subsample of 50
firms. No significant difference in results was found.
Table 1

Yearly Changes in Pay-to-Performance Sensitivities

Each entry represents the mean (median) of the (absolute value of) percent changes in the pay-to-performance sensitivity measure. The sensitivity measures “b” and “d” are “effective fraction owned” and “dollars at stake,” respectively, as discussed in more detail in the text. Pre-response pay-to-performance sensitivities are calculated under the assumption that no changes have occurred within the year to executive holdings of stock or options. Post-response pay-to-performance sensitivities do include changes during the year (company and executive responses) and therefore are the actual percent changes in pay-to-performance sensitivities. The parenthetical descriptions “Market value” and “Executive value” mean, respectively, that pay-to-performance sensitivities are measured using market values (Black-Scholes values) and executive values.

<table>
<thead>
<tr>
<th></th>
<th>Post-response</th>
<th>Pre-response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (Median)</td>
<td>Mean (Median)</td>
</tr>
<tr>
<td>b (Market value)</td>
<td>44% (14%)</td>
<td>19% (9%)</td>
</tr>
<tr>
<td>b (Executive value)</td>
<td>44% (21%)</td>
<td>27% (19%)</td>
</tr>
<tr>
<td>d (Market value)</td>
<td>80% (37%)</td>
<td>48% (34%)</td>
</tr>
<tr>
<td>d (Executive value)</td>
<td>71% (38%)</td>
<td>49% (37%)</td>
</tr>
</tbody>
</table>

Annual sample sizes vary from 1,207 to 6,222.
The Responsiveness of Pre-response Pay-to-Performance Sensitivities to Returns

The dependent variables (PCPRE_{it}) are single-year log percent changes in pre-response pay-to-performance sensitivities. The sensitivity measures “b” and “d” are “effective fraction owned” and “dollars at stake,” respectively. “MV” indicates pay-to-performance sensitivities measured using market values, while “EV” indicates sensitivities measured using executive values. “POSRET” is the natural logarithm of one plus the return observed, if that return is non-negative (and zero otherwise). “NEGRET” is the natural logarithm of one plus the return observed, if that return is negative (and zero otherwise). “HIOPT” is an indicator that is one if the executive is in the top quintile of executives in our sample on the basis of the fraction: number of options held divided by number of shares held plus number of options held. “VOL” is volatility, which is calculated using monthly returns over the past 36 months. “POUT” is the fraction of an executive’s options that were underwater at the end of the previous year. “NASDAQ” is an indicator that is one if the executive’s company is listed on NASDAQ. “VOL” and “POUT” were demeaned (that is, grand means were taken over all of the data and then subtracted from the corresponding variable in each observation) in order to allow interpretation of the main effects of POSRET and NEGRET on pre-response pay-to-performance sensitivities. The main effects (the first two coefficients reported in each column) are interpretable in columns 5 through 8 as the elasticities, at the mean values of VOL and POUT and if the company is neither high-option nor NASDAQ, of percent changes in pre-response pay-to-performance sensitivities with respect to returns. Binary variables (HIOPT and NASDAQ) were not demeaned. Coefficient estimates and t-statistics were obtained using the STATA procedure “rreg.” This procedure implements robust regression using first Huber, then biweight weighting schemes to downweight the effects of outliers. In addition, observations with a log return of greater than 1 or less than −1 were dropped. Since this is a right-hand side variable, such censoring does not induce bias. Year fixed effects were included in each regression.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>b (EV)</th>
<th>b (MV)</th>
<th>d (EV)</th>
<th>d (MV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>POSRET</td>
<td>coeff.</td>
<td>0.05</td>
<td>0.07</td>
<td>1.09</td>
<td>1.08</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
<td>5.22</td>
<td>19.47</td>
<td>238.72</td>
<td>880.10</td>
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<tr>
<td>NEGRET</td>
<td>coeff.</td>
<td>0.69</td>
<td>0.24</td>
<td>1.17</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
<td>83.04</td>
<td>72.3</td>
<td>270.3</td>
<td>952.99</td>
</tr>
<tr>
<td>HIOPT *</td>
<td>coeff.</td>
<td>0.08</td>
<td>0.06</td>
<td>0.08</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
<td>5.52</td>
<td>11.27</td>
<td>10.7</td>
<td>25.41</td>
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<td>POSRET</td>
<td>coeff.</td>
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<td>-0.25</td>
<td>-0.42</td>
<td>-0.07</td>
</tr>
<tr>
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<td>t-stat.</td>
<td>-35.7</td>
<td>-19.86</td>
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<td>-16.05</td>
</tr>
<tr>
<td>VOL *</td>
<td>coeff.</td>
<td>-1.29</td>
<td>-0.26</td>
<td>-0.29</td>
<td>-0.11</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
<td>-35.85</td>
<td>-20.36</td>
<td>-16.05</td>
<td>-25.17</td>
</tr>
<tr>
<td>POUT *</td>
<td>coeff.</td>
<td>0.27</td>
<td>0.22</td>
<td>0.16</td>
<td>0.16</td>
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<tr>
<td></td>
<td>t-stat.</td>
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<td>39.00</td>
<td>20.38</td>
<td>86.24</td>
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<td>NASDAQ *</td>
<td>coeff.</td>
<td>0.06</td>
<td>0.22</td>
<td>0.65</td>
<td>0.28</td>
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<td>t-stat.</td>
<td>3.68</td>
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<td>-0.04</td>
<td>-0.02</td>
<td>-0.02</td>
</tr>
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<td>t-stat.</td>
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<td>-7.50</td>
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<td>-10.08</td>
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<tr>
<td></td>
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<td>0.01</td>
<td>-0.07</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
<td>1.91</td>
<td>2.81</td>
<td>10.1</td>
<td>-19.65</td>
</tr>
</tbody>
</table>

N = 27,379
Table 3

The Responsiveness of Post-response Pay-to-Performance Sensitivities to Returns

The dependent variables (PCPOST) are single-year log percent changes in post-response pay-to-performance sensitivities. The pay-to-performance sensitivity measures “b” and “d” are “effective fraction owned” and “dollars at stake,” respectively. “MV” indicates sensitivities measured using market values, while “EV” indicates sensitivities measured using executive values. “POSRET” is the natural logarithm of one plus the return observed, if that return is non-negative (and zero otherwise). “NEGRET” is the natural logarithm of one plus the return observed, if that return is negative (and zero otherwise). Coefficient estimates and t-statistics were obtained using the STATA procedure “rreg.” This procedure implements robust regression using first Huber, then biweight weighting schemes to downweight the effects of outliers. In addition, observations with a log return of greater than 1 or less than –1 were dropped. Since this is a right-hand side variable, such censoring does not induce bias. Year fixed effects were included in each regression.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>B (EV)</th>
<th>b (MV)</th>
<th>d (EV)</th>
<th>d (MV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>POSRET</strong></td>
<td>coeff.</td>
<td>-0.05</td>
<td>0.02</td>
<td>0.98</td>
<td>1.06</td>
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<td></td>
<td>t-stat.</td>
<td>-3.57</td>
<td>2.08</td>
<td>71.08</td>
<td>90.07</td>
</tr>
<tr>
<td><strong>NEGRET</strong></td>
<td>coeff.</td>
<td>0.29</td>
<td>0.20</td>
<td>0.94</td>
<td>0.87</td>
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<td></td>
<td>t-stat.</td>
<td>24.4</td>
<td>20.34</td>
<td>71.57</td>
<td>77.72</td>
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</table>

N = 26,815
The pay-to-performance sensitivity measures “b” and “d” are “effective fraction owned” and “dollars at stake,” respectively. “MV” indicates pay-to-performance sensitivities measured using market values, while “EV” indicates sensitivities measured using executive values. “POSPCPRE” is PCPRE if it is non-negative (and is zero otherwise). “NEGPCPRE” is PCPRE if it is negative (and is zero otherwise). “HIOPT” is an indicator that is one if the executive is in the top quintile of executives in our sample on the basis of the fraction: number of options held divided by number of shares held plus number of options held. “VOL” is volatility, which is calculated using monthly returns over the past 36 months. “POUT” is the fraction of an executive’s options that were underwater at the end of the previous year. “NASDAQ” is an indicator that is one if the executive’s company is listed on NASDAQ. In columns 1 through 4, the dependent variables are single-year log percent changes in pay-to-performance sensitivities (the natural logarithm of one plus the following quotient: pay-to-performance sensitivity if only the company acted to affect the executive’s portfolio, minus actual pay-to-performance sensitivity in the previous year, all divided by last year’s actual pay-to-performance sensitivity), while in columns 5 through 10, the pay-to-performance sensitivity measures are “total,” that is, measured over two years (so that the base on which the percent change is calculated is the actual pay-to-performance sensitivity value two years ago). The volatility and percent-underwater variables were demeaned (that is, grand means were taken over all of the data and then subtracted from the corresponding variable in each observation) in order to allow interpretation of the main effects of sensitivity value two years ago). The volatility and percent-underwater variables were demeaned (that is, grand means were taken over all of the data and then subtracted from the corresponding variable in each observation) in order to allow interpretation of the main effects of POSPCPRE and NEGPCPRE on post-company-response pay-to-performance sensitivities. The main effects (the first two coefficients reported in each column) are interpretable in columns 9 and 10 as the elasticities, at the mean values of the right-hand-side variable, such censoring does not induce bias. Any observation that does not have data for the corresponding pay-to-performance sensitivity measures in the executive- and combined-response regressions is dropped. Year fixed effects were included in each regression.

Table 4
Company Response to Stock-Price-Induced Changes in Executive Pay-to-Performance Sensitivities

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b (EV)</td>
</tr>
<tr>
<td>POSPCPRE</td>
<td>coeff.</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
</tr>
<tr>
<td>NEGPCPRE</td>
<td>coeff.</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
</tr>
<tr>
<td>HIOPT *</td>
<td>coeff.</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
</tr>
<tr>
<td>VOL *</td>
<td>coeff.</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
</tr>
<tr>
<td>POSPCPRE</td>
<td>coeff.</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
</tr>
<tr>
<td>NEGPCPRE</td>
<td>coeff.</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
</tr>
<tr>
<td>NASDAQ *</td>
<td>coeff.</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
</tr>
<tr>
<td>NEGPCPRE</td>
<td>coeff.</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
</tr>
<tr>
<td>NASDAQ *</td>
<td>coeff.</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
</tr>
</tbody>
</table>

^A Indicates a t-ratio testing the null hypothesis that the coefficient is equal to one.
### Table 5
Executive Response to Stock-Price-Induced Changes in Executive Pay-to-Performance Sensitivities

The pay-to-performance sensitivity measures “b” and “d” are “effective fraction owned” and “dollars at stake,” respectively. “MV” indicates pay-to-performance sensitivities measured using market values, while “EV” indicates pay-to-performance sensitivities measured using executive values. “POSPCPRE” is PCPRE if it is non-negative (and is zero otherwise). “NEGPCPRE” is PCPRE if it is negative (and is zero otherwise). “HIOPT” is an indicator that is one if the executive is in the top quintile of executives in our sample on the basis of the fraction: number of options held divided by number of shares held plus number of options held. “VOL” is volatility, which is calculated using monthly returns over the past 36 months. “POUT” is the fraction of an executive’s options that were underwater at the end of the previous year. “NASDAQ” is an indicator that is one if the executive’s company is listed on NASDAQ. The pay-to-performance sensitivity measures used in the dependent variable are “total,” that is, measured over two years (so that the base on which the percent change is calculated is the actual pay-to-performance sensitivity value two years ago). The volatility and percent-underwater variables were demeaned (that is, grand means were taken over all of the data and then subtracted from the corresponding variable in each observation) in order to allow interpretation of the main effects of POSPCPRE and NEGPCPRE on post-executive-response pay-to-performance sensitivities. The main effects (the first two coefficients reported in each column) are interpretable in columns 5 and 6 as the elasticities, at the mean values of VOL and POUT and if the company is neither high-option nor traded on NASDAQ, of percent changes in post-executive-response pay-to-performance sensitivities with respect to changes in pre-response pay-to-performance sensitivities. Binary variables (HIOPT and NASDAQ) were not demeaned, because the coefficients seem interpretable without demeaning. Coefficient estimates and t-statistics were obtained using the STATA procedure “rreg.” This procedure implements robust regression using first Huber, then biweight weighting schemes to downweight the effects of outliers. This procedure implements robust regression using first Huber, then biweight weighting schemes to downweight the effects of outliers. Any observation that does not have data for the corresponding pay-to-performance sensitivity measures in the company- and combined-response regressions is dropped. Year fixed effects were included in each regression.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>b (EV) 1</th>
<th>b (MV) 2</th>
<th>d (EV) 3</th>
<th>d (MV) 4</th>
<th>b (EV) 5</th>
<th>d (EV) 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSPCPRE</td>
<td>1.07</td>
<td>1.10</td>
<td>1.04</td>
<td>1.01</td>
<td>1.09</td>
<td>1.07</td>
</tr>
<tr>
<td>t-stat.(^A)</td>
<td>1.80</td>
<td>1.76</td>
<td>2.26</td>
<td>0.56</td>
<td>1.69</td>
<td>3.18</td>
</tr>
<tr>
<td>NEGPCPRE</td>
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<td>0.78</td>
<td>0.75</td>
<td>0.54</td>
<td>0.75</td>
</tr>
<tr>
<td>HIOPT *</td>
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<td>-0.15</td>
<td>-0.08</td>
</tr>
<tr>
<td>POSPCPRE</td>
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<td>4.97</td>
</tr>
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<td>VOL *</td>
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<td>0.11</td>
<td>-0.06</td>
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<tr>
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<td>0.63</td>
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<tr>
<td>t-stat.</td>
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<td>13.11</td>
<td>7.62</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>-0.07</td>
<td>-0.18</td>
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<tr>
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<td>7.88</td>
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<tr>
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<td>0.43</td>
<td>0.01</td>
</tr>
</tbody>
</table>

\(^A\) Indicates a t-ratio testing the null hypothesis that the coefficient is equal to one.

N 15,790 16,159 15,255 15,492 15,790 15,255

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### Table 6
Combined Response to Stock-Price-Induced Changes in Executive Pay-to-Performance Sensitivities

The pay-to-performance sensitivity measures “b” and “d” are “effective fraction owned” and “dollars at stake,” respectively. “MV” indicates pay-to-performance sensitivities measured using market values, while “EV” indicates pay-to-performance sensitivities measured using executive values. “POSPCPRE” is PCPRE if it is non-negative (and is zero otherwise). “NEGPCPRE” is PCPRE if it is negative (and is zero otherwise). “HIOPT” is an indicator that is one if the executive is in the top quintile of executives in our sample on the basis of the fraction: number of options held divided by number of shares held plus number of options held. “VOL” is volatility, which is calculated using monthly returns over the past 36 months. “POUT” is the fraction of an executive’s options that were underwater at the end of the previous year. “NASDAQ” is an indicator that is one if the executive’s company is listed on NASDAQ. The pay-to-performance sensitivity measures used in the dependent variable are “total,” that is, measured over two years (so that the base on which the percent change is calculated is the actual pay-to-performance sensitivity value two years ago). The volatility and percent-underwater variables were demeaned (that is, grand means were taken over all of the data and then subtracted from the corresponding variable in each observation) in order to allow interpretation of the main effects of POSPCPRE and NEGPCPRE on post-response pay-to-performance sensitivities. The main effects (the first two coefficients reported in each column) are interpretable in columns 5 and 6 as the elasticities, at the mean values of VOL and POUT and if the company is neither high-option nor traded on NASDAQ, of percent changes in post-response pay-to-performance sensitivities with respect to changes in pre-response pay-to-performance sensitivities. Binary variables (HIOPT and NASDAQ) were not demeaned, because the coefficients seem interpretable without demeaning. Coefficient estimates and t-statistics were obtained using the STATA procedure “rreg.” This procedure implements robust regression using first Huber, then biweight weighting schemes to downweight the effects of outliers. In addition, observations with a PCPRE of greater than 1 or less than –1 were dropped. Since this is a right-hand side variable, such censoring does not induce bias. Any observation that does not have data for the corresponding pay-to-performance sensitivity measures in the company- and executive-response regressions is dropped. Year fixed effects were included in each regression.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>b (EV)</th>
<th>b (MV)</th>
<th>d (EV)</th>
<th>d (MV)</th>
<th>b (EV)</th>
<th>d (EV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSPCPRE</td>
<td>1.26</td>
<td>1.42</td>
<td>1.12</td>
<td>1.13</td>
<td>1.21</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>5.06</td>
<td>5.33</td>
<td>5.32</td>
<td>5.49</td>
<td>3.00</td>
<td>4.65</td>
</tr>
<tr>
<td>NEGPCPRE</td>
<td>0.54</td>
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<td>0.64</td>
<td>0.54</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>27.62</td>
<td>38.15</td>
<td>13.36</td>
<td>16.09</td>
<td>22.55</td>
<td>10.56</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
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<td>0.22</td>
<td>0.16</td>
</tr>
<tr>
<td>POSPCPRE</td>
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<td>2.16</td>
<td>4.15</td>
</tr>
<tr>
<td></td>
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<td>-5.75</td>
<td>-4.37</td>
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<td>-1.52</td>
<td>-0.44</td>
</tr>
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<td>-4.96</td>
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<tr>
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<td></td>
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<td>1.52</td>
<td>1.37</td>
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<td>17.74</td>
<td>12.92</td>
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<td>-0.04</td>
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<tr>
<td>POSPCPRE</td>
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<td>-1.01</td>
</tr>
<tr>
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<td>-0.29</td>
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</tr>
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<td>-6.56</td>
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<td>NASDAQ *</td>
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<td>-0.07</td>
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<td></td>
<td></td>
<td></td>
<td>0.95</td>
<td>1.04</td>
</tr>
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</table>

N 15,790 16,159 15,255 15,492 15,790 15,255

^ Indicates a t-ratio testing the null hypothesis that the coefficient is equal to one.
Table 7
Company and Executive Reaction to Poor Stock Price Performance in the Previous Year

“Opts.” is an abbreviation for “options.” The dollar value of options granted is determined according to the Black-Scholes formula. The dollar value of options exercised is simply the cash gained from option exercises. The numbers of observations for the categories below are: 10,252 (for lagged return ≥ -10%), 2,396 (for lagged return < -10% and ≥ -25%), 2,646 (for lagged return < -25% and ≥ -50%) and 910 (for lagged return < -50%).

<table>
<thead>
<tr>
<th>Lagged Return</th>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ -10% mean</td>
<td># Opts. Granted</td>
<td>95,380</td>
<td>$1,502,916</td>
<td>8,050</td>
<td>$299,842</td>
<td>70,060</td>
<td>$3,990,281</td>
<td>54,884</td>
<td>$1,667,440</td>
</tr>
<tr>
<td>25th %ile</td>
<td>$ Opts. Granted</td>
<td>7,000</td>
<td>$44,294</td>
<td>0</td>
<td>$0</td>
<td>-2</td>
<td>-$62</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>median</td>
<td># Shares Granted</td>
<td>29,750</td>
<td>$295,623</td>
<td>0</td>
<td>$0</td>
<td>1,825</td>
<td>$53,221</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>75th %ile</td>
<td>$ Shares Granted</td>
<td>80,000</td>
<td>$1,024,610</td>
<td>0</td>
<td>$0</td>
<td>20,287</td>
<td>$669,206</td>
<td>32,163</td>
<td>$747,949</td>
</tr>
<tr>
<td>&lt; -10% and ≥ -25% mean</td>
<td># Opts. Granted</td>
<td>81,352</td>
<td>$965,121</td>
<td>4,777</td>
<td>$160,296</td>
<td>76,398</td>
<td>$5,799,773</td>
<td>37,703</td>
<td>$1,068,042</td>
</tr>
<tr>
<td>25th %ile</td>
<td>$ Opts. Granted</td>
<td>4,080</td>
<td>$26,290</td>
<td>0</td>
<td>$0</td>
<td>-2,199</td>
<td>-$52,540</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>median</td>
<td># Shares Granted</td>
<td>28,542</td>
<td>$244,695</td>
<td>0</td>
<td>$0</td>
<td>599</td>
<td>$12,970</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>75th %ile</td>
<td>$ Shares Granted</td>
<td>76,160</td>
<td>$801,529</td>
<td>0</td>
<td>$0</td>
<td>11,674</td>
<td>$317,118</td>
<td>15,000</td>
<td>$260,118</td>
</tr>
<tr>
<td>&lt; -25% and ≥ -50% mean</td>
<td># Opts. Granted</td>
<td>109,607</td>
<td>$1,203,890</td>
<td>6,453</td>
<td>$191,656</td>
<td>29,459</td>
<td>$1,102,409</td>
<td>45,019</td>
<td>$1,178,987</td>
</tr>
<tr>
<td>25th %ile</td>
<td>$ Opts. Granted</td>
<td>10,000</td>
<td>$63,246</td>
<td>0</td>
<td>$0</td>
<td>-2,600</td>
<td>-$51,843</td>
<td>0</td>
<td>$0</td>
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<tr>
<td>median</td>
<td># Shares Granted</td>
<td>37,278</td>
<td>$290,825</td>
<td>0</td>
<td>$0</td>
<td>500</td>
<td>$9,714</td>
<td>0</td>
<td>$0</td>
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<tr>
<td>75th %ile</td>
<td>$ Shares Granted</td>
<td>100,000</td>
<td>$937,124</td>
<td>0</td>
<td>$0</td>
<td>9,332</td>
<td>$203,283</td>
<td>18,500</td>
<td>$254,840</td>
</tr>
<tr>
<td>&lt; -50% mean</td>
<td># Opts. Granted</td>
<td>109,913</td>
<td>$962,233</td>
<td>7,196</td>
<td>$117,013</td>
<td>-9,572</td>
<td>-$22,851</td>
<td>39,537</td>
<td>$876,995</td>
</tr>
<tr>
<td>25th %ile</td>
<td>$ Opts. Granted</td>
<td>15,000</td>
<td>$70,255</td>
<td>0</td>
<td>$0</td>
<td>-2,295</td>
<td>-$42,424</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>median</td>
<td># Shares Granted</td>
<td>47,625</td>
<td>$325,381</td>
<td>0</td>
<td>$0</td>
<td>562</td>
<td>$7,321</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>75th %ile</td>
<td>$ Shares Granted</td>
<td>120,000</td>
<td>$901,713</td>
<td>0</td>
<td>$0</td>
<td>14,053</td>
<td>$227,365</td>
<td>16,799</td>
<td>$234,600</td>
</tr>
</tbody>
</table>
Table 8
Changes in Company Behavior in Response to Poor Stock Price Performance in the Previous Year

“Opts.” is an abbreviation for “options.” “Change” refers to the current value of the variable, minus the value of the variable two years ago. The number of option grants made is the number of separate grants received by the executive from the company during the year. The repricing indicator is one if an executive’s options were repriced during the year, and is zero otherwise. The numbers of observations for the categories below are: 3,558 (for lagged return \( \geq -10\% \)), 947 (for lagged return \( < -10\% \) and \( \geq -25\% \)), 1,118 (for lagged return \( < -25\% \) and \( \geq -50\% \)) and 394 (for lagged return \( < -50\% \)).

<table>
<thead>
<tr>
<th>Lagged Return</th>
<th>Change in # Opts. Granted</th>
<th>Change in # of Option Grants Made</th>
<th>Repricing Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Change</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>( \geq -10%)</td>
<td>mean</td>
<td>50,886</td>
<td>0.080</td>
</tr>
<tr>
<td></td>
<td>25th %ile</td>
<td>-1,787</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>median</td>
<td>9,000</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>75th %ile</td>
<td>49,500</td>
<td>0</td>
</tr>
<tr>
<td>(&lt; -10%) and ( \geq -25%)</td>
<td>mean</td>
<td>39,111</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td>25th %ile</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \geq -25%)</td>
<td>median</td>
<td>10,000</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>75th %ile</td>
<td>47,000</td>
<td>0</td>
</tr>
<tr>
<td>(&lt; -25%) and ( \geq -50%)</td>
<td>mean</td>
<td>37,811</td>
<td>-0.021</td>
</tr>
<tr>
<td></td>
<td>25th %ile</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \geq -50%)</td>
<td>median</td>
<td>16,000</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>75th %ile</td>
<td>55,000</td>
<td>0</td>
</tr>
<tr>
<td>(&lt; -50%)</td>
<td>mean</td>
<td>56,513</td>
<td>0.013</td>
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<tr>
<td></td>
<td>25th %ile</td>
<td>2,991</td>
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</tr>
<tr>
<td></td>
<td>median</td>
<td>25,770</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>75th %ile</td>
<td>100,000</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 9

The Mechanism of Response to Stock-Price-Induced Changes in Executive Pay-to-Performance Sensitivities and Relative Performance Evaluation

All regressions are run using executive fixed effects, year fixed effects, and robust regression. “# Opt. Grant.” is the natural logarithm of one plus the number of options granted during the year. “$ Opt. Grant.” is the natural logarithm of one plus the market (Black-Scholes) value of the options granted during the year. “# Opt. Exer.” is the natural logarithm of one plus the number of options exercised during the year. “$ Opt. Exer.” is the natural logarithm of one plus the number of dollars gained by the executive through option exercises during the year. “Log return” is the natural logarithm of one plus the lagged return observed. “Log ind. ret.” is the natural logarithm of one plus the lagged return on the value-weighted portfolio of all stocks in the same two-digit SIC code as the executive’s company. Coefficient estimates and t-statistics were obtained using the STATA procedure “rreg,” which corrects for the effects of outliers. Observations were included only if both return variables, for company and for industry, were less than 1 (or 100%) in absolute value. Since these are independent variables, this should not bias our estimates.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Log return</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>if positive</td>
<td>coeff.</td>
<td>0.05</td>
<td>0.11</td>
<td>0.07</td>
<td>0.12</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>t-stat.</td>
<td>1.98</td>
<td>3.54</td>
<td>2.60</td>
<td>4.11</td>
<td>5.33</td>
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<tr>
<td>Log return</td>
<td>coeff.</td>
<td>-0.38</td>
<td>-0.04</td>
<td>-0.36</td>
<td>-0.02</td>
<td>-0.01</td>
</tr>
<tr>
<td>if negative</td>
<td>t-stat.</td>
<td>-15.77</td>
<td>-1.42</td>
<td>-14.70</td>
<td>-0.59</td>
<td>-0.37</td>
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<td>Log ind. ret.</td>
<td>coeff.</td>
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<td>-0.20</td>
<td>-0.21</td>
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<tr>
<td></td>
<td>t-stat.</td>
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<td>-5.58</td>
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</tr>
</tbody>
</table>

N = 16,157 (except for $ opt. exer., for which N = 16,155)
Figure 1
The Relationship Between Changes in Pre-Response and Post-Response Pay-to-Performance Sensitivities

Percent Change in Post-Response Pay-to-Performance Sensitivity

Percent Change in Pre-Response Pay-to-Performance Sensitivity

Notes: G is equal to the increase in pay-to-performance sensitivity from new grants of stock or options, absent any change in the stock price between $t$ and $t+1$. 