Stock Options for Undiversified Executives*

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Abstract

We develop a certainty-equivalence framework to analyze the cost and value of, and incentives provided by, non-tradable options held by undiversified risk-averse executives. We derive "Executive Value" lines, the risk-adjusted analogues to Black-Scholes lines, and distinguish between "executive value" and "company cost." We show that this framework explains (or sheds light on) virtually all of the major stylized facts about stock option practices, including:

1. Why executives often argue that Black-Scholes values are too high,
2. Why executives typically demand large premiums to exchange options for cash (suggesting that options are an expensive way to convey pay),
3. Why executive reported pay levels have increased substantially over the past decade (while risk-adjusted increases have been far more modest),
4. Why virtually all options are granted at-the-money,
5. Why "indexed options" and "premium options" are rarely observed in practice despite their strong advocates and seemingly attractive features,
6. Why companies often re-set the exercise price on underwater options,
7. Why executives often exercise stock options well before expiration (even for non-dividend paying stocks), forfeiting substantial option value,
8. Why companies allow executives to exercise options prior to expiration (and why this policy is advantageous to both executives and shareholders),
9. Why short vesting periods (which have modest effects on executive value and company cost) are the norm (and why long vesting periods are almost never observed in practice).

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by

Brian J. Hall and Kevin J. Murphy

Stock options, which give the recipient the right to buy a share of stock at a pre-specified exercise price for a pre-specified term, have emerged as the single largest component of compensation for US executives (Hall and Liebman, 1998; Murphy, 1999). In fiscal 1998, 97% of S&P 500 companies granted options to their top executives, compared to only 82% in 1992. Moreover, the grant-date value of stock options accounted for 40% of total pay for S&P 500 CEOs in 1998, up from only 25% of total pay in 1992.[1] Stock-options have become increasingly important for rank-and-file workers as well: 45% of US companies awarded options to their exempt salaried employees in 1998, while 12% and 10% awarded options to their non-exempt and hourly employees, respectively.[2]

In addition to conveying compensation, executive stock options provide a direct link between executive wealth and company stock-price performance, and therefore mitigate agency problems between shareholders and managers (Jensen and Meckling, 1976). Indeed, as documented by Jensen and Murphy (1990) and Hall and Liebman (1998), virtually all of the sensitivity of pay to corporate performance for the typical CEO is attributable to his or

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[1] Data extracted from Compustat's ExecuComp database, using grant-date option values based on ExecuComp's Black-Scholes' calculations.

[2] Prevalence data are based on the American Compensation Association's *1997-1998 Salary Budget Survey*, and include survey results from 735 publicly traded corporations.

her holdings of company stock and stock options, and not to accounting-based bonuses or year-to-year changes in other components of compensation.

Given the emerging dominance of stock options in the provision of both compensation and incentives, it is important to find ways to measure both the value and the incentives provided by executive stock options. Virtually all research in the area, including papers written by both authors and the "facts" noted in the previous two paragraphs, have relied on option pricing formulas such as Black-Scholes (1973) to evaluate executive options. But, executive stock options differ in critical ways from the options "priced" in the valuation formulas. In particular, while option pricing theory assumes that options are freely tradable and that option holders can hedge the risk of options by short-selling stock, executive options are non-tradable and held by risk-averse undiversified executives who cannot easily hedge. While researchers and practitioners have routinely noted the shortcomings of using standard option formulas to value executive options, there have been few attempts to "correct" for the non-tradability of executive options, or to explore the implications of such a correction.[3]

The purpose of this paper is to analyze the valuation of, and incentives provided by, non-tradable stock options held by risk-averse undiversified executives. Section 2 develops our framework, which provides an operationally useful alternative to Black-Scholes for both valuing stock options and measuring the incentives created by such options. We distinguish between the cost to the company and the value to the executive-recipient. Ignoring (for the moment) complications related to early exercise, potential forfeiture, and executive inside information, option-pricing methodologies such as Black-Scholes are appropriate for

[3] Noteworthy exceptions include Lambert, Larcker, and Verrecchia (1991), Kulatilaka and Marcus (1994), Rubenstein (1995), Carpenter (1998), Murphy (1999), DeTemple and Sundaresan (1999), Muelbroek (2000) and Hall and Murphy (2000).

measuring the amount outside investors would pay for an option, and therefore provide an estimate of the company's cost of granting an option. We estimate the value of non-tradable options to an undiversified risk-averse executive using the "certainty equivalence" approach, following Lambert, Larcker, and Verrecchia (1991), and show that option-pricing formulas such as Black-Scholes systematically overstate the value an executive places on a non-tradable option.

In addition to introducing our framework, Section 2 explores several implications of our comparison of the cost and value of executive stock options. Our analysis supports frequent claims by executives that Black-Scholes values are "too high," and also explains why executives often demand large premiums to accept options in lieu of cash payments. We show that these premiums depend on whether the option is in-the-money or out-of-the-money, which in turn depends on the probability that the option will expire unexercised. Finally, our results also have implications for academic research that adds options values to other risky components of pay to establish "total compensation." At best, this aggregate calculation is a measure of the company's cost of the compensation package, and not an estimate of the executive's value of the compensation package. We show that, while the reported level of total compensation for S&P 500 executives has risen dramatically from 1992 to 1998, the growth in "risk-adjusted pay" has been relatively modest.

Section 3 analyzes the incentives created by non-tradable executive options. We define incentives as the derivative of the executive's value with respect to the stock price, and consider the incentive effects of setting the exercise price above the grant-date market price (premium options) or below the grant-date price (discount options), "indexing" the exercise price to the performance of the market, and repricing options following declines in stock prices. Although academics and the business press have routinely called on companies to issue premium or indexed options, and to refrain from repricing, we show that such policies are not generally in the interest of shareholders. First, we show that, holding constant the company's cost of making an option grant, incentives are maximized by setting exercise prices at or below grant-date market prices. Next, we show that indexed options are less efficient than traditional (fixed exercise price) options in providing incentives to undiversified executives. Finally, we show that repricings structured to hold constant the total cost of the options can simultaneously benefit shareholders and executives.

Section 4 relaxes our maintained assumption that options are held for their full term, and analyzes the timing of exercise decisions by risk-averse executives. Several researchers have documented that executive (and employee) options are exercised relatively early in their term, even when the underlying stock pays no dividends. We show that such behavior is entirely consistent with our framework: risk-averse executives will exercise early following price run-ups to "lock in" a gain. More importantly, we demonstrate that allowing early exercise is advantageous to both executives and shareholders. Allowing early exercise increases the executive's value from receiving an option, while also reducing the company's cost of granting the option (precisely because the executive will exercise "too early" from an outside investor's standpoint).

Overall, our framework demonstrates the importance of incorporating risk into analyses of executive compensation, and explains or gives insights into virtually all stock option pay practices and behaviors. In addition, our framework offers some general implications for the design of employee bonus plans. Section 5 summarizes and generalizes these findings.

2. Option Values for Undiversified Executives

Central to modern option theory is the idea that option holders can fully hedge the risk associated with holding options by short-selling the underlying stock or taking similar actions that achieve the same purpose. Black and Scholes (1973) and Merton (1973) demonstrated that, since investors can hedge, options can be valued as if investors were risk neutral and all assets appreciate at the risk-free rate. Under these assumptions, the value of options can be estimated by computing the expected value of the option upon exercise assuming that the expected return on the stock is equal to the risk-free rate, and then discounting the expected value to the grant date using the risk-free rate. This risk-neutrality assumption is central to all option pricing models and methodologies, including the Black-Scholes model (as amended by Merton to account for dividends), binomial models, arbitrage pricing models and Monte Carlo methodologies.[4]

Compensation consultants, practitioners, and academic researchers have routinely used Black-Scholes or similar methodologies to value executive stock options. However, while the assumptions underlying option-pricing methodologies reasonably describe the situation faced by sophisticated outside investors holding freely traded options, they do not describe the situation faced by executives (and other employees) holding options on their own company's stock. In contrast to outside investors, company executives cannot trade or sell their options, and are also forbidden from hedging the risks by short-selling company stock; such actions would obviously defeat a primary purpose of the option grants, which is to align

4 See Hull (1997) and Merton (1997) for a comprehensive treatment of these issues.

the financial interests of the managers with those of the shareholders.[5] In addition, while outside investors tend to be well-diversified (holding small amounts of stock in a large number of companies), company executives are inherently undiversified, with their physical as well as human capital invested disproportionately in their company.[6] These substantive violations of the underlying assumptions suggest that traditional methodologies are not appropriate in determining the value of executive stock options.

When defining the "value" of executive stock options, it is critical to distinguish between two fundamentally distinct option valuation concepts: the economic cost to the company, and the economic value to the executive-recipient. The economic or opportunity cost of granting an option is the amount the company could have received if it were to sell the option to an outside investor rather than giving it to the executive. Ignoring for the moment complications related to potential forfeiture, early exercise, and executive inside information, traditional valuation formulas provide an estimate of how much outside investors would pay for an option, and therefore represent an estimate of the company's *cost* of granting an option. However, traditional valuation methodologies do not measure the *value* of a non-tradable option to an undiversified, risk-averse executive.

We estimate the value of a non-tradable option to an undiversified risk-averse executive as the amount of riskless cash compensation the executive would exchange for the option, using a "certainty equivalence" approach similar to that adopted by Lambert,

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5 Although executives cannot explicitly short-sell company stock they may engage in related transactions (such as zero-cost collars) that reduce their risk. Existing evidence suggests that such transactions are observed but are not widespread (Bettis, Bizjak, and Lemmon, 1999).

6 Indeed, in addition to being "forced" not to trade or hedge their options, executives are routinely required (through ownership guidelines imposed by the board) or pressured (by informal board requirements or through the desire to signal to markets) to hold more company stock than dictated from an optimal-portfolio standpoint.

Larcker, and Verricchia (1991). In particular, we suppose that an executive has non-firm-related wealth of *w*, holds *s* shares of company stock, and is granted *n* options to buy *n* shares of stock at exercise price *X* in *T* years. Assuming that *w* is invested at the risk-free rate, r_f, and that the realized stock price at *T* is P_T, the executive's wealth at time *T* is given by

(1) $$W_T \equiv w(1+ r_f)^T + sP_T + n \bullet max(0,P_T-X).$$

If, instead of the option, he were awarded *V* in cash that he invested at the risk-free rate, his wealth at time *T* would be:

(2) $$W_T^V \equiv (w+V)(1+ r_f)^T + sP_T.$$

We assume the executive's utility over wealth is *U(W)*, and define the executive's value of *n* options as the certainty equivalent *V* that equates expected utilities (1) and (2):

(3) $$\int U(W_T^V)f(P_T)dP_T \equiv \int U(W_T)f(P_T)dP_T$$

Solving (3) numerically requires assumptions about the form of the utility function, *U(W)*, and the distribution of future stock prices, $f(P_T)$. We assume that the executive has constant relative risk aversion ρ, so that $U(W) \equiv ln(W)$ when $\rho=1$, and $U(W) \equiv \frac{1}{1-\rho} W^{1-\rho}$ when $\rho\neq 1$. We adopt the Capital Asset Pricing Model (CAPM) and assume that the distribution of stock prices in *T* years is lognormal with volatility σ and expected value equal to $(r_f + \beta(r_m- r_f) - \sigma^2/2)T$, where β is the firm's systematic risk and r_m is the return on the market portfolio.[7] Unless otherwise noted, the figures and numerical calculations in this article are derived assuming no dividends, σ = .30 (the median volatility for S&P 500 firms), β = 1 (the market

[7] For tractability, we assume that the distribution of future stock prices is the same whether the executive receives options or cash. If the grant provides incentives that shift the distribution, and if the shift is not already incorporated into stock prices as of the grant date, we will underestimate both the cost and value of the option. Since most of our results hinge on the *difference* between (rather than the levels of) cost and value, this assumption does not affect our main qualitative results.

average beta, by definition), r_f = 6%, and an equity premium of r_m- r_f = 6.5%. The qualitative results in this paper are not sensitive to reasonable changes in these parameters.

2.1 Executive Value Lines

Figure 1 illustrates our methodology by showing how the value of a ten-year non-tradable stock option with an exercise price of $30 varies with changes in stock prices. The "intrinsic value" is defined as the (positive) spread between the market price and exercise price, and the Black-Scholes value, *C(P)*, approximates the company's cost of granting an option. These two lines, showing option payouts and values, are of course standard in option analyses. What is new in Figure 1 are the "executive value" lines, which plot the certainty-equivalent values as a function of stock prices. The figure depicts the per-share values of non-tradable options to undiversified executives, assuming that executives have $5 million in initial wealth split between company stock and safe cash, and assuming that executives receive a grant of options to purchase 5,000 share of stock at an exercise price of $30. Four executive-value lines are drawn, for different pairs of risk aversion and diversification, representing executives with relative risk aversion of ρ=2 or ρ=3 and holding either 50% or 66% of their wealth in company stock.

Under traditional valuation methodologies, option values depend on six factors: the exercise price, stock price, dividend yield, stock-return volatility, risk-free rate, and the time until expiration. Our numerical analysis of equation (3) shows that the certainty-equivalent value (that is, the value of a non-tradable option to an executive recipient) depends on these six parameters, but also depends on the executive's risk-aversion, initial wealth, and diversification. Figure 1 illustrates these new comparative static results. For example, executive values are strictly decreasing in risk-aversion: the executive value lines for executives with relative risk aversion of ρ=3 lie strictly below those for executives with ρ=2. In addition, executives with large holdings of company stock (relative to their wealth) place lower values on options: the executive value lines for executives holding 66% of their initial wealth in company stock (rather than safe cash) lie strictly below those for executives holding 50% of their wealth in stock.

The executive value lines in Figure 1 lie below the Black-Scholes line, $V(P)<C(P)$, indicating that risk-averse executives value non-tradable options at significantly less than their cost to the company.[8] Table 1 shows the ratio of the executive's value to the company's cost, for a variety of stock prices and combinations of risk-aversion and diversification. The table shows, for example, that an option granted at-the-money is worth 63.5% of its Black-Scholes cost (of $16.55) to an executive with ρ=2 and 50% of his wealth in company stock, but only worth 21.1% of its cost for an executive with ρ=3 and 66% of his wealth in stock.[9] The table also shows that the value:cost ratio increases with stock prices (holding the exercise price fixed at $30). For example, for an executive with ρ=2 and 66% of his wealth in company, an option with a $30 exercise price is worth 55% of its Black-Scholes cost (of $44.40) when the stock price is $60, but is only worth about 32% of its cost (of $4.95) when the stock price is $15.

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8 The executive-value line can actually lie above the Black-Scholes line if executives are sufficiently diversified and have sufficiently low risk aversion. This seemingly counterintuitive result is actually quite intuitive. Stock prices include a risk premium, $\beta(r_m-r_f)$, characterizing the risk-preferences of the marginal investor. Executives with high wealth and low risk aversion may value shares of stock higher than would the marginal investor. Our results here differ from Lambert, Larcker, and Verrechia (1991), who ignore the risk premium and conclude that the Black-Scholes value is the upper-bound value for undiversified executives.

9 These low executive values are consistent with other estimates. For example, Muelbroek (2000) uses a non-utility based approach to isolate the effect of (non)diversification on stock option values. Her results, which produce a *lower bound* estimate of the value:cost discount, also show very low executive values (relative to costs), particularly for (undiversified) executives of internet companies.

In addition to reporting value:cost ratios, Table 1 also reports the probabilities that the ten-year option will be in-the-money at the end of its term.[10] For example, an option granted at $30 when the stock price is $60 will expire in the money with probability 93%, while the same option granted when the stock price is only $5 will expire in the money with probability 13%. These probabilities provide useful intuition in explaining why the value:cost ratios increase with stock prices: value:cost ratios are higher when the payout probability is higher. Black-Scholes option values are substantially affected by small probabilities of large outcomes, while risk-averse individuals naturally discount small probabilities of large outcomes.

This section began by noting that Black-Scholes or similar methodologies are widely used in valuing executive stock options. Our analysis demonstrates that, at best, the traditional approach yields an estimate of the company's cost of granting an option, but will generally overstate the value of the option to the executive recipient by a substantial margin. This seemingly obvious, but often overlooked, result has important implications for understanding executive stock option plans and, more generally executive compensation practices.

2.2 Implications

2.2.1 Black-Scholes values are too high

Under current accounting rules, the value of stock options granted to executives and other employees is not considered compensation expense and is not deducted from corporate

[10] The probability that the market price at expiration, P_T, exceeds the exercise price, X, is calculated under the standard CAPM assumption that $Ln(P_T/P_0)$ is normally distributed with mean $\mu \equiv Ln(r_f + \beta(r_m - r_f) - \sigma^2/2)T$ and variance $\sigma^2 T$.

earnings upon grant. In 1993, the Financial Accounting Standards Board (FASB) proposed rule changes that would force companies to deduct the grant-date value of options from corporate earnings. Although FASB ultimately adopted enhanced footnote disclosure rather than explicit accounting charges, the proposal created a storm of criticism among business executives, high-tech companies, accountants, compensation consultants, the Secretary of the Treasury, and shareholder groups.[11] The chief concern offered by the business community, especially the Business Roundtable and Silicon Valley, was that traditional pricing methodologies such as Black-Scholes substantially overstate the value of executive stock options.

Our analysis of the cost and value of non-tradable options lends support to the claim that the Black-Scholes formula overstates the value of options from the executive's perspective. As reported in Table 1, an executive with risk aversion $\rho=3$ holding 66% of his wealth in stock will only value an at-the-money option at about one-fifth of its Black-Scholes value. However, while the executive objections are understandable, they are misplaced: for financial accounting purposes, what should matter is the company's cost of granting an option—not the value of the option to the executive recipient—and Black-Scholes provides a reasonable estimate of the company's cost.

Our assertion that Black-Scholes is appropriate in measuring the company's cost of stock options merits a couple of caveats. First, executive stock options typically "vest" over

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11 See, for example, Lee Berton, "Business chiefs try to derail proposal on stock options," *Wall Street Journal* (February 5, 1992); Christi Harlan and Lee Berton, "Accounting Firms, Investors Criticize Proposal on Executives' Stock Options," *Wall Street Journal* (February 19, 1992); "Bensten Opposes FASB On Reporting Stock Options," *Wall Street Journal* (April 7, 1993); "Clinton Enters Debate Over How Companies Reckon Stock Options," *Wall Street Journal* (December 23, 1993); Lee Berton, "Accounting Rule-Making Board's Proposal Draws Fire," *Wall Street Journal* (January 5, 1994); Christi Harlan, "High Anxiety: Accounting Proposal Stirs Unusual Uproar In Executive Suites," *Wall Street Journal* (March 7, 1994).

three to five years following grant, and are subject to forfeiture if the executive ceases employment prior to vesting. Although estimating the impact of forfeiture requires information on departure probabilities, the potential forfeiture clearly lowers both the value and cost of executive options. Second, while executive options are typically exercisable upon vesting, Black-Scholes valuations are appropriate only for options held until expiration. As discussed at length below in Section 4, early exercise provisions can simultaneously lower the company's cost of granting the option, while raising the value to the executive recipient.

Third, executives may posses private information about company prospects. While this inside information will not generally affect the company's cost of granting options, it will certainly affect (either positively or negatively) the perceived value to the executive recipient. While admitting its potential importance, we ignore the effects of inside information in this paper. Finally, the "net cost" of granting an option is clearly less if the executive receives the option in lieu of lower cash compensation, or if (as if hopefully the case) the option improves managerial incentives. We consider both of these factors "benefits" of options that must be weighed against their cost in determining optimal option granting practices.

2.2.1 Exchanges of Cash for Stock-Based Compensation

In recent years, many companies have shifted the pay "mix" away from base salary and towards stock-based compensation. In most cases, these shifts have been subtle and gradual, with little or no formal discussion or disclosure. A significant number of companies, however, have conducted explicit exchanges of cash for stock-based compensation.[12].

[12] Companies recently completing such exchanges include Arkla, Avon, Baxter, Black & Decker, Clorox, EKCO, General Mills, Harnischfeger, International Multifoods, Mead, Merck, PacifiCorp, Panhandle

Although the exchanges have taken a variety of forms, most involve exchanging cash bonuses or current or future increases in base salaries for restricted stock or options. Executives participating in exchanges typically receive a "risk premium" for accepting stock-based pay rather than cash. For example, consider EKCO's exchange program as described in its 1995 proxy statement.

> The 1995 Incentive Plan provides the participants with the option to have all or a portion of any bonus and any increase in base compensation paid either (i) in cash, (ii) deferred until a specified date or time with interest to be paid by the Company at a rate agreed to by the Committee, (iii) in shares of restricted stock valued at 130% of the foregone cash payment based upon the market price of such Common Stock on the last trading day of the year preceding the year to which the payment relates, or (iv) stock options valued at 250% of the foregone cash payment according to the Black-Scholes method of valuation and calculated as of the last trading day of the year preceding the year to which the payment relates.

As our analysis above suggests, risk premiums such as that offered by EKCO are necessary because risk-averse and undiversified executives will be willing to exchange cash for stock or options only if the dollar value of the stock or options received substantially exceed the dollar value of cash foregone. Figure 2 plots indifference curves showing the amount of stock-based pay required to offset a loss of $300,000 in cash compensation, while keeping the executive at the same expected utility. That figure shows, for example, that an executive with $\rho=2$ and 50% of his wealth in company stock will be indifferent between receiving $300,000 in cash (representing 6% of his initial wealth), $375,000 in restricted stock (representing a 25% risk premium), $500,000 in options issued at fair market value (FMV) (a 67% risk premium), or $750,000 in options with an exercise price double the

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Eastern, Santa Fe Pacific, Sun Company, Teledyne, Toro, Triarc, Union Carbide, United Airlines, and USAir.

current market price (a 150% risk premium). As evident from the graph, the required risk premiums increase substantially for more risk-averse and less diversified executives, and are especially large for options issued out of the money with lower payout probabilities.

Proponents of broad-based stock option plans extending to all company employees often argue that options are an efficient way to pay employees because there is no accounting charge and no company cash outlay upon grant. Figure 2 illustrates that options are, in fact, an unusually expensive and therefore *inefficient* way to convey compensation to executives and employees: the economic cost to shareholders of granting options often far exceeds the value that employee-recipients place on the option. Stock options are efficient only when the incentive benefits of the options (including both pay-to-performance and retention incentives) exceed their "inefficiency cost." In many cases, this suggests focusing (or even limiting) grants to senior executives and other key employees who have a reasonably direct impact on company stock prices. And although some broad-based plans may well be justified on the basis of (hard-to-model) beneficial effects on employee morale and company culture, we suspect that many of these plans are driven by the favorable but ultimately irrelevant accounting treatment of options—not a careful weighing of the benefits of stock options against their full economic costs.

2.2.3 Risk-adjusted pay

Figure 3 illustrates the relative importance of the various components of compensation for CEOs in S&P 500 Industrials (that is, the S&P 500 companies excluding utilities and finance firms), and also documents how the level and composition of pay has varied from 1992-1998. The bar height depicts median total compensation in CPI-adjusted 1998-constant dollars, including salaries, realized bonuses, stock-based compensation, and other pay.

Stock-based pay includes the grant-date cost of stock options (valued using the Black-Scholes formula), restricted stock grants (valued at year-end stock prices), and performance shares (valued as the target grant multiplied by the year-end stock price). Pay component percentages are derived from Compustat's ExecuComp data by computing the percentages for each CEO, and averaging across CEOs.

As reported in Figure 3, median CEO pay levels in S&P 500 Industrials has nearly tripled from less than $2.0 million in 1992 to over $5 million in 1998. The increase primarily reflects a dramatic growth in stock-based compensation, which swelled from 30% to 53% of total compensation, representing a five-fold increase in dollar terms. Most of the increase in stock-based compensation, in turn, reflects the growth in stock options grants, which grew from 23% of compensation in 1992 to 44% of compensation in 1998. (Over the same time period, the value of restricted stock and performance shares tripled in dollar value, but increased only slightly, 7% to 9%, as a percentage of total compensation.) The biggest increase, both in dollar and percentage terms, was from 1997 to 1998, when median pay increased by nearly $1 million (22%) from its prior-year level.

The columns in Figure 3 represent an estimate of the company's cost of the CEO's pay package, and not the value of the package as perceived by the CEO recipient. Following our analysis of option valuation above, risk-averse undiversified executives will value all risky performance-based elements of their contract lower than their cost to the company. We extend our option-value methodology to measure executive-specific "risk-adjusted pay," defined as the certainty equivalent value of the full CEO pay package, and calculate risk-adjusted pay levels for S&P 500 CEOs from 1992 to 1998. The details of our methodology our relegated to Appendix A, but we extend equation (1) and (2) to allow for previously granted options, and extend (1) to include the full compensation package, including salaries, bonuses, stock options, restricted stock, and performance shares. Executive-specific data from Compustat or ExecuComp are available for all but two critical inputs: the executive's risk aversion and the executive's non-firm-related wealth. We compute risk-adjusted pay for relative risk aversion of $\rho=2$ and $\rho=3$, and (somewhat arbitrarily) assume that non-firm-related wealth is equal to the greater of $5 million or four times cash compensation.

In addition to showing the cost of the CEO's pay package, Figure 3 shows the median risk-adjusted pay for CEOs in S&P 500 Industrials, based on two risk-aversion assumptions. Assuming that $\rho=2$ for all executives, median risk-adjusted pay grew from $1.6 million in 1992 to $2.5 million in 1998, increasing by nearly 60% over the period. Assuming that $\rho=3$, median risk-adjusted pay grew from $1.4 million in 1992 to $2.1 million in 1998, increasing by about 50%. In contrast, the cost of the median CEO's pay package increased by 160% over this period. Therefore, the growth in risk-adjusted pay is modest relative to the growth in unadjusted pay. Indeed, from 1997 to 1998 (when the median cost increased by $1 million), the median risk-adjusted value of pay remained flat (assuming that $\rho=2$) or actually fell (assuming that $\rho=3$).

The modest growth in risk-adjusted pay levels (relative to the more-impressive growth in the cost of compensation) reflects, in part, the growing importance of stock options in executive pay packages. In addition, the recent "bull market" in the U.S. has made stock-holding executives less diversified, which in turn has reduced the value of their current stock-based compensation. Figure 4 shows the median value of stock and options held by S&P 500 CEOs from 1992-1998; stock is measured at year-end prices and options are measured as the fiscal-year-end "spread" between the stock price and exercise price of all outstanding options (all amounts are in 1988-constant dollars). As shown in the figure, the median holdings of S&P Industrial CEOs has grown from $10 million in 1992 to nearly $30 million in 1998. Over the same time period, the median holdings among S&P Financial CEOs grew from $14 million to $55 million, while the holdings among S&P Utility CEOs grew from $1.3 million to $5 million.

One of the most widely noted findings in the executive compensation literature is that CEOs in utilities are paid less than CEOs in other sectors (Joskow, Rose and Wolfram, 1996; Murphy, 1999). However, it is also well-documented (and suggested by Figure 4) that utility CEOs hold less stock and receive less of their pay in the form of stock-based pay than do other executives. Table 2 explores the extent to which lower pay in utilities reflects that utility CEOs are better diversified and have less risky pay than do CEOs in non-utilities. The dependent variables are the logarithm of the total cost of the compensation package (that is, total pay without risk adjustments), and the logarithms of risk-adjusted pay with $\rho=2$ and $\rho=3$. Independent variables include logarithm of sales and dummy variables for finance and utility firms.

The coefficient on "Utility" in column (1) of Table 2 of -0.650 indicates that, after controlling for company size, the cost of CEO pay in utilities is 48% lower than pay in the general industry.[13] The corresponding coefficients in columns (2) and (3) of -0.364 and -0.276, respectively, indicate that *risk-adjusted* pay is 30% (when $\rho=2$) or 24% (when $\rho=3$) lower in utilities. Therefore, controlling for CEO diversification and the riskiness of pay explains a significant fraction—between a third and one-half—of the observed pay differences in utilities.

The regressions in Table 2 include year dummy variables from 1992 to 1997, with 1998 as the omitted category. The coefficient on the 1996 dummy variable in column (1) is negative and statistically significant, whereas the corresponding coefficients in columns (2) and (3) are positive but insignificant. Similarly, the coefficient on the 1997 dummy variable in column (1) is negative but insignificant, whereas the corresponding coefficients in columns (2) and (3) are positive and statistically significant. These results suggest that, after controlling for company size and (broad) industry, risk-adjusted pay actually fell rather than rose between 1996 to 1998. Taken together, the risk-adjustments have dramatic effects on both the level and growth rates of CEO pay over time.

3. Incentives from Executive Stock Options

Executive stock options provide incentives to the extent that the recipients can affect the perceived value of their options. As demonstrated in Section 2, executive option values depend on the usual Black-Scholes parameters (stock price, exercise price, dividend yield, volatility, risk-free rate, and term) and also on the executive's risk-aversion, initial wealth, and diversification. Most of these parameters—including the exercise price, risk-free rate, term, risk aversion, and initial wealth—are outside management control once the option is granted. As a simplification, we ignore dividends (as we have throughout this paper)[14] and treat an executive's stockholdings as exogenous.[15] The effects of options on risk-taking,

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13 Calculated as $e^{-.650}-1\approx 0.48$.

14 Dividends can be easily incorporated into our model, and the results in this paper have been re-calculated for various dividend yields. We replicate the standard result that stock options provide incentives to reduce dividends (Lambert, Lanen, and Larcker, 1989), but do not generate any additional insights driven by diversification considerations.

15 Ofek and Yermack (1998) present evidence that many executives receiving options simultaneously reduce their stockholdings, thus approximately maintaining their prior exposure to company risk. The results

while interesting, are beyond the scope of this paper. We focus on the main incentive generated by stock option grants: how options affect the executive's motivation to increase the company's stock price.

Assuming executives understand how their actions affect share prices, option holdings provide incentives for executives to take actions that increase share prices, and avoid actions that decrease share prices. The incentives from a single option will naturally depend on the slope of the executive-value line, $\partial V / \partial P$, which defines how the certainty-equivalent value changes with an incremental change in the stock price. Figure 5 plots the slopes from the Black-Scholes and executive value lines illustrated in Figure 1 (which depicted the per-share cost and value of a grant of 5,000 ten-year options with an exercise price of $30). The figure shows that the slope of the executive-value line is less than the slope of the Black-Scholes line, $\partial C / \partial P$, for undiversified executives. For example, when the stock price and exercise price are both $30, the slope of the Black-Scholes function is 0.86 (86¢ per $1 price change), but the slope of the executive-value line is only 0.63 for an executive with ρ=2 and 50% of his wealth in company stock, and only .27 for an executive with ρ=3 and 66% of his wealth in stock. For a premium option granted with P=$15 and X=$30, the Black-Scholes slope is 0.63 compared to an executive-value slope of only 0.38 and 0.10 for executives with ρ=2, 50% in stock or, ρ=3, 66% in stock, respectively.

Many recent academic studies of executive incentives have followed Jensen and Murphy (1990) in defining the "pay-performance sensitivity" from stock options as the

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suggest that boards cannot rely on executives to voluntarily hold shares, and must induce "effective" ownership though stock options, restricted stock, or through implicit or explicit stock ownership guidelines. Supporting this interpretation is the fact that, while the *value* of shares owned (excluding options) by S&P 500 CEOs has increased substantially from 1992 to 1998, the *number* of shares owned (adjusting for splits) has actually fallen.

derivative of the Black-Scholes value with respect to the stock price. While this construct is an appropriate measure of how the market value of the executives' wealth (due to options) changes with stock prices, it overstates incentives from non-tradable options: at any stock price, the slope of the Black-Scholes line always exceeds the slope of the executive value line for risk-averse undiversified executives. As illustrated in Figure 5, measured pay-performance sensitivities are particularly overstated for more risk-averse and less diversified executives, and for options that are deeply out-of-the-money.

3.1 Implications

3.1.1 Optimal Exercise Prices[16]

One of the most striking facts about executive stock options is that the exercise price of virtually all options is set equal to the current stock price at the grant date. For example, 94% of option grants to S&P 500 CEOs in 1998 were at-the-money grants. In theory, however, exercise prices can be set below the grant-date stock price (discount options), above the grant-date stock price (premium options), or indexed to some industry or market index (indexed options). Setting the exercise price, like setting the "performance threshold" in any incentive plan, defines the standard against which performance is measured, and determines the likelihood of an ultimate payout.

Figure 5 (which is drawn for a fixed exercise price of $30) suggests that incentives are maximized when the stock price significantly exceeds the exercise price. But, we know from Figure 1 that discount options are much more costly to grant than at-the-money or premium options (that is, the Black-Scholes cost is higher when the stock price significantly exceeds

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16 See Hall and Murphy (2000) for a more detailed examination of optimal exercise prices.

the exercise price). Herein lies the trade-off faced by the board when setting exercise prices for executive options: increasing the exercise price, X, reduces the incentives of each option granted, $\partial V / \partial P$, but also reduces the company's cost of granting each option, C. In other words, holding the company's total cost of granting n options constant, $nC = k$, the company could grant a few options at a low exercise price, or more options at a higher exercise price.

For example, suppose that a company's stock price is $30, and that the board has decided to award the executive an option package with a total cost of $300,000**.** The company could award the executive 10,000 shares of restricted stock (essentially options with a zero exercise price). Alternatively, based on our maintained assumptions regarding dividend yield, volatility, etc., the company could award 18,130 at-the-money options (with a Black-Scholes value of $16.55 each) or 30,300 premium options with an exercise price of $60 (with a Black-Scholes value of $9.90 each). Each of these alternatives has the same Black-Scholes value and thus the same total cost to the company. But, which alternative maximizes total incentives (defined as $\partial V / \partial P$ multiplied by the number of options granted)?

Figure 6 depicts the total incentives from a $300,000 option grant, for exercise prices varying from 0% (restricted stock) to 300% of the grant-date stock price. The executive is assumed to have $5 million in wealth, split between non-firm-related cash and company stock.[17] The figure shows that the incentives for an executive with ρ=2 and 50% of his wealth in company stock are maximized by setting an exercise price equal to 130% of the market price of the stock on the date of grant. Incentive-maximizing exercise prices are lower for more risk-averse and less diversified executives: for an executive with ρ=3 and 66% of his

[17] Given our assumption of constant *relative* risk aversion, the dollar amounts are arbitrary. What matters is the grant size relative to the executive's initial wealth (in this case, 6%). That is, we will get the same

wealth in company stock, incentives are maximized by setting an exercise price equal to only 40% of the grant-date market price.

Interestingly, the incentive loci in Figure 6 are relatively flat around the maximum, suggesting that there is a range of exercise prices that yield "close to" maximum incentives. In Hall and Murphy (2000), we show that, for a wide range of parameters (including different total costs of the option grant), setting exercise prices at (or near) the grant-date market price maximizes pay/performance incentives for risk-averse, undiversified executives. Executive value, however, is maximized by setting the exercise price as low as possible. We believe that US accounting rules, which require some accounting charges for discount options, help explain why exercise prices are seldom set below grant-date market prices. Our analysis suggests that, in general, avoiding the accounting charge is not likely to be very costly to companies in terms of providing incentives. That is, even in cases where the optimal grant is a discount option, granting at-the-money options instead of discount options provides incentives that are nearly as strong.

In addition to showing how executive incentives vary with changes in the exercise price, Figure 6 also shows how the Black-Scholes' slope of options costing $nC=k$ varies with the exercise price. The figure shows that $\partial nC / \partial P$ is monotonically increasing throughout the depicted range. In fact, $\partial nC / \partial P$ is monotonically increasing for *all* exercise prices. This result suggests that, if managers valued stock options at their Black-Scholes value, the optimal granting policy would be to grant an infinite number of options at an infinite exercise price. The absurdity of this result underscores the need to introduce managerial risk aversion

qualitative results if we assume (i) a $3000 grant for an executive with $50,000 in wealth; or (ii) a $60 million grant for an executive with $1 billion in wealth.

into any analysis of executive stock option valuations and incentives.

3.1.2 Indexed Options

Economists have long embraced the idea that option exercise prices should be "indexed" to the market.[18] Since executives holding indexed options are rewarded only to the extent that their performance exceeds the market, these plans utilize a less-noisy performance measure, protect executives from market shocks, and also protect shareholders from rewarding poorly performing executives in bull markets. In addition, since the volatility of an indexed option is generally lower than the volatility of a traditional option, and since the expected appreciation is zero, indexed options are less costly to grant than traditional options.[19] Therefore, indexing allows companies to grant a larger number of options at the same total compensation cost, thus (presumably) increasing managerial incentives.

Our framework for analyzing the cost and value of non-tradable options suggests that the economic rationale for indexing, while persuasive, is incomplete. In fact, our analysis shows that indexed options are typically less efficient than traditional options in both conveying option compensation and in providing incentives, because indexing lowers the executive's value of the option to a much greater extent than it reduces the company's cost of granting the option. This result is consistent with observed practice: firms rarely grant indexed options. But is clearly at odds with conventional wisdom and assertions made by

[18] Economists' affinity for indexed options stems from the literature on relative performance evaluation (Holmstrom, 1982; Antle and Smith, 1985; and Gibbons and Murphy, 1990). See Aggarwal and Samwick (1999) for a contrary view.

[19] The valuation of indexed options is derived from Margrabe (1978), and is easily computed using Black-Scholes by assuming a risk-free rate of zero and a volatility equal to $\sqrt{\sigma^2 - 2\upsilon\sigma\sigma_m + \sigma_m^2}$, where σ_m is the volatility of market returns and υ is the correlation coefficient between the firm return and the market return. Note that the correlation in the square-root term will dictate whether relative performance is a less noisy or more noisy measure than absolute performance.

academics, the business press, and other proponents of indexing (e.g., Rappaport, 1999). Before reporting our results, it is worthwhile to sketch the intuition of why the conventional wisdom is wrong.

The economic rationale for indexing executive stock options hinges on the reduction in the volatility of the performance measure: measuring performance relative to the market, r-r_m, is efficient when r-r_m, provides a less noisy measure of performance than r. In practice, this volatility reduction is fairly small: the median annual volatility of returns for Compustat firms is approximately 30%, while the median volatility of relative returns is approximately 25%.[20] Therefore, the reduction in the cost and value of an indexed option due to the volatility reduction is also relative small.

More important than the volatility reduction in determining the cost and value of an indexed option is the implied change in the expected appreciation. Investors holding traditional options expect an annual appreciation equal to the risk-free rate r_f (because they have hedged away the risk of the option by short-selling stock), while executives holding traditional non-tradable options expect an annual appreciation equal to $r_f + \beta(r_m$-$r_f)$. Investors and executives holding indexed options expect annual appreciation (relative to the index) of zero. Therefore, indexing reduces the executive's expected appreciation by a greater amount than it reduces the investor's expected appreciation. Since the cost of the option is the value to an outside investor, indexing lowers the executive's value of the option to a much greater extent than it reduces the company's cost of granting the option.

Table 3 replicates the analysis in Table 1, but for indexed options rather than for traditional options. Comparing these two tables shows that indexing does, indeed, reduce the cost of granting options. For example, while the traditional "at-the-money" option in Table 1 has a Black-Scholes cost of $16.55, an indexed option with the same exercise price has a Black-Scholes cost of only $9.22.[21] But, the comparison also shows that indexing reduces the value to the executive recipient to a much greater extent than it reduces the cost to the company. For example, while the value of a traditional option to an executive with ρ=2 and 66% of his wealth in company is $7.41 (44.8% of the Black-Scholes cost $16.55), the value of an indexed option to the same executive is only $1.44 (15.6% of of the Black-Scholes cost $9.22). Therefore, indexing reduces the cost of the option by 44%, while reducing the value of the option to the executive by 80%. The fact that indexing reduces the value to the undiversified executives falls by more than it reduces the cost to the company suggests that indexing is not an efficient way to convey option compensation.

In addition, our framework for analyzing the *incentives* from options suggests that indexing is not an efficient way to provide executive incentives. Figure 7 depicts the total incentives from a $300,000 grant of indexed options, for exercise prices varying from 0% (restricted stock) to 300% of the grant-date stock price. Figure 7 is directly comparable to Figure 6: the only difference is that indexed options are granted in Figure 7, while traditional options are granted in Figure 6. The figure shows that the incentives for an executive with ρ=2 and 50% of his wealth in company stock are maximized by setting an exercise price for the indexed option equal to 40% of the market price of the stock on the date of grant.

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20 Volatilities are estimated for each firm as the standard deviation of continuously compounded monthly returns (or monthly returns minus the CRSP return on the market) over the prior 48 months, multiplied by $\sqrt{12}$.

21 The per-share cost and value of indexed options is based on a 5,000 share grant and calculated assuming volatility σ =.25 (the median volatility of market-adjusted returns), $r_f = 0$, and $\beta(r_m - r_f) = 0$.

Incentive-maximizing exercise prices are lower for more risk-averse and less diversified executives: incentives for an executive with ρ=3 and 66% of his wealth in company stock are maximized by setting an exercise price equal to only 20% of the grant-date market price.

Several interesting results emerge from comparing Figures 6 and 7. First, at a given exercise price, indexed options are much less likely to be in-the-money at expiration than are traditional options. For example, while there is a 78% chance that a traditional ten-year option granted at-the-money will expire in-the-money, there is only a 35% chance that a similar indexed option will expire in-the-money.[22] Similarly, while there is a 51% chance that the share price increase by 100% in ten years, there is only 10% chance that the stock price will "beat the market" by 100%. Third, the change in the Black-Scholes value is much steeper for indexed options. This result reflects the leveraging effect; indexed options cost less to grant, so more can be granted. Fourth, the incentive-maximizing exercise prices for indexed options is much less than for traditional options. This result has straightforward intuition: to offset the lost expected appreciation, indexed options must be granted in-the-money rather than at-the money. Fifth, the height of the "hills" in Figure 7 are considerably lower than the height of the hills in Figure 6. The height of the hill depicts the total incentives (the number of options multiplied by the slope) when exercise prices are chosen optimally. The result that heights are lower for indexed options implies that traditional options provide incentives more efficiently than do indexed options.

In practice, only a handful of US companies have adopted indexed option plans. While

[22] The probability that $r-r_m>0$ is only 35% (and not 50%) because the distribution of stock prices is skewed: the mean relative return is zero, but the median relative return is less than zero.

the scarcity of indexed option plans in part reflects accounting considerations,[23] we believe that our analysis helps show the benefit of traditional option plans over indexed plans. Although index options are less costly than traditional options to grant, they are disproportionately less valuable to the executive-recipients. Moreover, the incentives provided by indexed options are weaker than the incentives provided by an equal-dollar cost of traditional options.

3.1.3 Option Repricing

One of the most controversial executive pay practices involves resetting the exercise price on outstanding options following a decline in the company's stock price (Saly, 1994). As shown in Figure 5, options lose incentive value once the stock price falls sufficiently below the exercise price that the executive perceives little chance of exercising: this "loss of incentives" is a common justification for option "repricings" following share-price declines. Since repricing effectively "forgives" executives for dismal performance, companies adopting repricing policies create perverse incentives for executives holding options.

A recent twist on standard share-for-share repricing practices is "Black-Scholes repricing," in which the executives exchange their options with a high exercise price for a smaller number of options with a lower exercise price. The exchange is structured so that the total Black-Scholes value of the option is the same immediately before and after the exchange. From the executive's perspective, the exchange is beneficial since both options have the same expected value but the lower-priced options are less risky (i.e., have a higher

[23] Under US accounting rules, as long as stock options have a pre-specified exercise price and expiration date, companies incur an accounting charge equal to the grant-date "spread" between the market price and the exercise price (amortized over the life of the option). Indexed options do not have a fixed exercise price, and therefore do not qualify for favorable accounting treatment.

probability of ultimately being exercised). From the shareholder's perspective, the cost is the same with or without the exchange. Executive incentives can either increase or decrease, depending on the specific parameters involved.

One of the first companies to adopt Black-Scholes repricing was General Dynamics in 1991. As described in Dial and Murphy (1995), the CEO of General Dynamics exchanged 105,000 options with an exercise price of $45 (the market price on the original grant date) for 51,500 options with an exercise price of $25.50 (the market price on the exchange date). The number of options offered in the exchange was determined to maintain the pre-exchange Black-Scholes cost of approximately $388,000. Assuming that CEO Anders had risk aversion of ρ=2 and $4 million in wealth (67% in stock), he valued the 105,000 out-of-the-money options at $190,000 and the 51,500 at-the-money options at $255,000.[24] Clearly participating in the exchange made sense from Anders' perspective, while imposing little cost on the shareholders. According to our model, Anders' option incentives fell slightly from $18,500 (the change in Anders' value of the old options for a $1 change in the stock price) to $17,500 (the change in his value of the new options for each $1 change in stock prices).

4. Early Exercise

Our valuation analysis in Sections 2 and 3 assumed that executives hold options until their expiration date. However, in practice, executive options vest and become exercisable within a few years from grant, and executive (and employee) options are routinely exercised

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[24] Details of our calculation are available upon request, but are based on σ = .2425, dividend yield of 4%, β = 1, r_f = 8%, and r_m- r_f = 6.5%. The $4 million in total wealth is an assumption, but the 67% in stock is

relatively early in their term (Huddart and Lang, 1996; Huddart, 1998). In this section, we relax our maintained assumption that executives hold their options until the expiration date and analyze the decision to exercise early.[25] In particular, we analyze how the company's cost, the executive's value, and the incentive strength are affected by allowing early exercise. In order to isolate how risk aversion and diversification drive executive exercise decisions, we continue to ignore dividends. While investors holding freely tradable American call options on non-dividend paying stocks will never exercise early (Merton, 1973), we show that risk-averse executives holding non-tradable options will exercise early to "lock in" an option gain.

4.1 Methodology

We analyze executive option values and early exercise decisions using a modified binomial approach, described in detail in Appendix B. Our approach is similar to traditional binomial option valuation (Cox, Ross, and Rubinstein, 1979) with two major differences. First, while binomial price "trees" under the traditional model are based on expected returns equal to the risk-free rate (reflecting that option holders perfectly hedge the risk of options), price trees under our modified approach are based on CAPM expected returns, $E(r)=r_f+\beta(r_m-r_f)$. Second, while under the traditional approach the payout from exercising is compared to the expected value of holding for another period, under our modified approach we compare the *expected utility* from exercising (and holding cash until the final period) to

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consistent with Anders' stock holdings (relative to the $4 million). The new options were granted with a ten year term; the old options had nine years remaining.

25 Related analyses of early-exercise decisions include Huddart (1994), Carpenter (1998), and DeTemple and Sundaresan (1999). Our framework for analyzing early exercise is closest to Huddart's (1994), who focuses primarily on measuring the cost of options to the firm. Relative to his model, our framework allows the executive to hold a richer set of assets prior to exercise—cash, stock and options rather than options only—and employs a more flexible utility framework.

the "expected" expected utility from holding the option for another period. We estimate the executive value of the option grant by finding the grant-date cash award (invested until T at the risk-free rate) that yields the expected utility at the first node of the binomial tree.

We assume that stock acquired through exercise is sold immediately, with the cash proceeds invested at the risk-free rate.[26] In addition, we assume that options are exercisable immediately upon grant (alternative vesting schedules are analyzed below in Section 4.4) We maintain our other assumptions from Sections 2 and 3. In particular, we assume the option is granted for T=10 years at an exercise price of X=$30 (the grant-date market price), and assume $\sigma = .30$, $\beta = 1$ $r_f = 6\%$, and $r_m - r_f = 6.5\%$. We compute executive values for a grant of 5,000 options for executives with constant relative risk aversion of ρ=2 or ρ=3 and holding either 50% or 66% of their $5 million initial wealth in company stock. Our binomial tree is calculated for h=50 periods per year, or a total of hT=500 periods and 125,250 individual nodes. For each node, we record information on the stock price, the expected utility, and an indicator for whether the option has been exercised.

4.2 Early-Exercise Decisions

Undiversified executives with exercisable options face a tradeoff. If they exercise early, they can invest the "spread" between the market and exercise price at the risk-free rate, thereby locking in the gain. However, by exercising early (and immediately selling the acquired shares), they sacrifice both upside potential in stock prices and the ability to defer payment of the exercise price. The exercise decision in each period will naturally depend on the realized stock price (relative to the exercise price). If the price is sufficiently high, the

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26 Ignoring taxes, which we do throughout, it would be irrational for an executive to exercise an option early and to hold the stock.

expected utility from locking in the gain will exceed the utility from holding the option for another period. But, at sufficiently low stock prices, even risk-averse, undiversified executives will not exercise options early.

We define the "threshold price" as the stock price where the executive is just indifferent between exercising early or holding the option for another period. Figure 8 shows how the threshold price varies over the 10-year term of the option for managers with the same pairs of risk aversion and diversification as before.[27] Several results emerge. First, in any period, more risk-averse and less diversified executives have lower threshold prices (that is, they will choose to exercise early at lower realized stock prices). For example, an executive with $\rho = 2$ and half of his wealth in company stock has a first-year price threshold of more than \$90. The price would have to more than triple (from its \$30 initial value) in the first year for such an executive to exercise early. However, a more risk averse ($\rho = 3$) and less diversified (66% of his wealth in stock) executive has a first-year exercise price boundary of less than \$60.

Second, Figure 8 reveals that threshold prices decrease over time. As time passes, the benefits of holding the option (deferring the payment of the exercise price, and missing out on future price increases) fall, and an executive's threshold for locking in option gains is lower. On the expiration date, of course, the threshold price falls to the exercise price (in this case, \$30). But, the day before exercise, the threshold price is above \$50 for an executive

[27] Within our binomial framework, we estimate the threshold price for each period as the average of the lowest price that induces early exercise and the highest price that induces holding the option for another period. Because of the discreteness in the binomial model (which considers only "n" possible stock prices in the n^{th} period), our estimated threshold prices vary within a range from period to period (depending, for example, on whether "n" is even or odd in a period). As an expositional simplification, the threshold prices in Figure 7 have been smoothed somewhat by using linear interpolation and a larger number of periods per year (h=75 rather than 50) than in the rest of the analysis.

with ρ = 2 and 50% of his initial wealth in stock, and about $35 for an executive with ρ = 3 and 66% of his initial wealth in stock.

Figure 9 shows the cumulative probabilities of early exercise for executives.[28] The figure indicates that there is a relatively high probability of early exercise after the first two years, although the probabilities differ greatly (consistent with the very different threshold prices in Figure 8) with differences in risk aversion and diversification. For example, the likelihood that a (relatively) high-risk-aversion (ρ = 3) and low-diversification (wealth in stock at 66%) executive will exercise within the first 4 years is about 50%, and within 8 years is 75%. Conversely, an executive with ρ = 2 and 50% of his wealth in stock has only an 18% chance of exercising within the first 4 years, and 50% chance of exercising within the first eight years. As of the day before expiration, the cumulative exercise probabilities range from 65% (for a ρ = 2, 50% executive) to 84% (for a ρ = 3, 66% executive). Since all in-the-money options are exercised in the last period, the cumulative probabilities of exercise by the expiration day are quite close for executives with different characteristics, ranging from 78 percent to 85 percent.[29]

Early exercise is therefore entirely consistent with our framework: risk-averse executives will exercise early following price run-ups to "lock in" a gain. This result has important implications for the value, cost, and incentive strength of executive stock options, the subject to which we now turn.

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[28] The probabilities are based on a simulation with 100,000 sample price paths (through the tree). At each period t, the cumulative probability of early exercise is calculated as the percentage of price paths (out of 100,000) that surpassed the threshold price at t or earlier.

[29] The difference reflects options that were in-the-money earlier in the term (and exercised by high risk-averse low diversified executives), but out-of-the-money at expiration.

4.3 Cost, Value, and Incentives

Allowing executives to exercise prior to the full term affects both the cost and value of executive stock options. Allowing early exercise unambiguously increases the value of an option to an undiversified executive, since executives could always hold the option to full term but in practice choose not to. In contrast, allowing early exercise actually *reduces* the company's cost of granting an option. As discussed in Section 2, the economic cost of granting an option is the amount the company could have raised if it were to sell the option to an outside investor instead of giving it to the executive. If outside investors made the exercise decision, then the company's cost would be the usual binomial valuation of an American option (which, for non-dividend-paying stocks, is simply the Black-Scholes value). But, in this case, the exercise decision is not made by the investor but rather by an executive who for a variety of reasons is not expected to make the same exercise decisions as an unrestricted outside investor. Since the executive exercise decisions are suboptimal from the standpoint of the outside investor, the amount the investor is willing to pay for the option is clearly reduced when exercise decisions are made by the executive, rather than by the investor.

The cost reduction comes from the fact that early exercise essentially removes the right-hand tail of payoffs to executive option holders, who truncate the huge payoffs that would otherwise come from dramatic increases in the company's stock price. For example, consider the executives who prematurely exercised their options in the mid-1990s at Cisco, Microsoft, General Electric and other high-flying companies of the decade. Such early exercises led to far lower company costs than would have been the case if these executives had not exercised their options early.

As before, we measure the value of an immediately exercisable executive option as the grant-date cash award that yields the expected utility as receiving an option, and measure the incentives from the option as the slope of the executive-value line, $\partial V / \partial P$, which defines how the option value changes with an incremental change in the stock price. We measure the cost of the executive option as the usual binomial valuation of an American option (under risk-neutral pricing) but with a catch: the exercise decision is made by an undiversified executive rather than by the investor. In particular, we measure the cost of the option under the assumption that the investor is "forced" to exercise when even the stock price exceeds the threshold prices in Figure 8.[30]

Table 4 shows how the company's cost, the executive's value, and incentives (defined as the derivative of value with respect to changes in stock prices) are affected by the possibility of early exercise for various pairs of risk aversion and diversification. The data depict the per-share costs, value, and incentives from a grant of 5,000 ten-year stock options with an exercise price of $30 (the market price on the date of grant). The columns under "Options Exercisable at Expiration" basically replicate the results in Table 1 (for an at-the-money grant): the cost is the Black-Scholes cost of $16.55, executive values range from $3.49 to $10.51, and the incentives range from $0.17 to $0.45. The calculations under "Options Exercisable at Grant" allow executives to exercise options anytime during their term. Compared to the case without early exercise, the company's cost is lower, and the executive's value and incentives are higher, for grants that allow early exercise. For example, for an executive with $\rho = 2$ and 66% of his wealth in company stock, allowing early exercise increases his value from $7.41 to $9.96, while reducing the company's cost of granting the

[30] Formally, we compute the value of a path-dependent barrier option (Hull, 1997), where the barrier (the

option from \$16.55 to \$13.60.

In addition to increasing executive value while reducing company cost, Table 4 shows that allowing early exercise also increases executive incentives. For example, for an executive with $\rho = 2$ and 50% of his wealth in stock, a one dollar increase in the stock price will increase the value of an option without an early exercise provision by only 45¢, but will increase the value of an otherwise identical exercisable option by 61¢. Allowing early exercise doubles the option incentives for a $\rho = 3$ and 50% executive (from 26¢ to 53¢), and nearly triples the incentives for a $\rho = 3$ and 66% executive.

Overall, our results help explain not only why executive options are so often exercised early, but why it is in the interest of shareholders to allow early exercise. Early exercise reduces the company's cost of granting options, while increasing the value and incentives to the executive recipient.

4.4 Vesting Schedules

The analysis so far in this section has assumed that options are immediately exercisable upon grant, and can be freely exercised at anytime during the term of the option. In practice, however, options typically become exercisable only when they "vest" (that is, when the options are no longer subject to forfeiture if the executive leaves the firm). Although there is a range of observed practices, the most common schedules vest options 33% annually over three years, 25% annually over four years, or 20% annually over five years.

Huddart and Lang (1996) have noted that executives (and employees) exercise a disproportionate number of options immediately upon vesting, creating spikes in option-

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price path above which the executive exercises) varies over time as shown in Figure 8.

exercise patterns. Table 5 replicates this empirical result for our hypothetical risk-averse, undiversified executives. The table shows the likelihood of exercising on the vesting date, for options with cliff-vesting in two, three, or four years. For example, the table shows that an executive with $\rho = 3$ and 50% of his wealth in company stock has a 17% chance of exercising his options on the vesting date if they vest in two years, and a 33% chance if they vest in four years. The spike is naturally smaller for executives who are more risk tolerant and more diversified: the likelihood of exercising on the vesting date for a $\rho = 2$, 50% executive is only 1.4% for options vesting in two years, and 10% for options vesting in four years.

Table 4 showed that allowing early exercise reduced the company's cost of granting the option and increasing the perceived value of the option to the executive. Therefore, the ratio of the executive's value to the company's cost is higher for companies with immediately exercisable options than for companies not allowing early exercise. Figure 10 plots the intermediate cases, showing value:cost ratios for option grants with vesting periods that range from 0 years (complete early exercise is allowed) to 10 years (no early exercise is allowed).

Two primary results emerge from Figure 10. First, the value:cost ratios fall more dramatically in the cases in which executives are more risk-averse and less diversified. Second, the value:cost ratios are very flat at low vesting durations, especially in cases in which risk-aversion is relatively low and diversification is relatively high. This results suggests that reasonably short vesting periods do not decrease the value:cost efficiency of options very much. To the extent that short vesting periods create benefits to companies—in terms of retention and ensuring that options are held and provide positive incentives for some minimum period of time—our analysis suggests that the counterbalancing “efficiency” costs of short vesting may not be too large. Thus, our analysis helps explain why short vesting periods are so common while long vesting periods (of more than five years) are virtually non-existent.

5. Conclusion

Stock options have become an increasingly important source of compensation and incentives for top-level executives. We develop a framework for analyzing the cost and value of, and the incentives provided by, non-tradable options held by undiversified and risk-averse executives (and other employees). Our framework enables us to derive “Executive Value” lines (the risk-adjusted analogues to the Black-Scholes lines) and provides an operationally useful alternative to standard option pricing models for understanding and analyzing a very wide range of stock option pay practices—and indeed, compensation and incentives design issues more broadly.

Our methodology allows us to adjust option values, and total compensation packages, for executive risk-aversion. Executive risk aversion is at the heart of the agency problem (Jensen and Meckling, 1976; Holmstrom, 1979) and it creates the tradeoff between incentives and risk that has been explored extensively by economists (Aggarwal and Samwick, 1999). Conversely, the implications of adjusting compensation for risk have not been explored extensively by economists and are not well understood. Indeed, neither academics nor practitioners make risk-adjustments to options. Economists routinely use Black-Scholes to measure the value and pay-performance sensitivity of options. And practitioners continue to use Black-Scholes (or some non-risk adjusted modification of

Black-Scholes) in order to measure option compensation.

Our analysis "explains" or sheds light on virtually every major stylized fact about stock option pay practices and leads to reinterpretation of major trends in, and facts about, the level of top executive pay. For example, our analysis demonstrates that, while Black-Scholes represents a reasonable measure of the *company cost* of stock options, it is not a reasonable measure of *executive value*. Indeed, for plausible parameter estimates, Black-Scholes overestimates executive value by a substantial margin. This helps explain why executives often claim that Black-Scholes values are too high and why they demand large premiums for accepting stock options in lieu of cash compensation. Although the complexity of stock options may contribute to low executive value somewhat, our analysis suggests that these "low" executive valuations are perfectly consistent with rationality on the part of undiversified executives. The Black-Scholes "benchmark" is simply not appropriate for measuring executive value.

Our analysis has implications for the central design issue with regard to stock options: the setting of the exercise price. One of the most striking facts about option design is that nearly all executive stock options are issued "at the money." Premium options and indexed options are exceedingly rare, despite their strong advocates among academics and the business press. Although accounting rules may explain some of the paucity of these plans, our analysis suggests an economic justification that does not rely on accounting considerations. In particular, we find that increasing the exercise price or indexing the exercise price to the market reduces the executive's value far more than it reduces the company's cost of granting the option, thus making such options a bad deal for executives and a costly proposition for shareholders. Moreover, options granted with premium or indexed exercise prices provide poor incentives for risk-averse executives, because of the high probability that they will expire out of the money. We find instead that, for a given "company cost" of options, option incentives are maximized by setting exercise prices at or near the grant-date market price.

Our analysis helps explain why options are often repriced when they fall out of the money. Canceling and reissuing an outstanding option at a lower exercise price increases the executive's perceived value of the option by a greater amount than it increases the company's cost. It is therefore easy to see why boards often succumb to repricing pressures from executives. In addition, we show that repricings can actually be in shareholders' interest when they are structured to hold constant the total cost of the options (i.e. executives are given a smaller number of options in return for a reduction in the exercise price). In this case, the repricing is cost-neutral for the company, but is value-increasing and often incentive-increasing to the executive recipient. Therefore, although a formal policy of option repricings creates a set of new problems, our analysis suggests that one-time repricings are not only understandable, but also typically optimal.

Executives often exercise their options well before expiration, sometimes sacrificing substantial (Black-Scholes) option value in doing so. This behavior is entirely consistent with our framework: risk-averse executives exercise their options when the price rises above a "price threshold" in order to lock-in early gains. The most striking fact about early exercise, however, it not that it happens, but rather that allowing early exercise represents a "win-win" design policy. Allowing early exercise substantially raises the value (and by extension, the incentives) of options: risk-averse executives prefer to lock-in gains. It also substantially lowers the cost to shareholders: by exercising early, executives forfeit the very large option gains that come with very large stock price increases.

Our analysis also enables us to analyze vesting rules. For the same reason that American options are preferable to European options, vesting (which restricts executives from selling early for a specified period) lowers executive value while raising company cost. However, we find that the relationship between vesting periods and the value:cost "efficiency" ratio of options is highly non-linear: for short vesting periods (one to three years), the value:cost ratio is fairly flat. Thus, if there are (unmodeled) benefits associated with short vesting (such as retention), companies can reap those benefits with only modest effects on the value:cost efficiency of their options. Consistent with our analysis, long vesting periods, which significantly reduce the value:cost efficiency of options, are almost never observed in practice.

Our framework is also useful for examining and understanding longitudinal and cross-sectional trends in pay levels. For example, one of the most striking features about executive pay over the past two decades is the dramatic increase in the level of CEO pay. We show, however, that the results are far less dramatic when the level of CEO pay is risk-adjusted. Between 1992 and 1998, reported CEO pay rose by 160 percent. However, on a risk-adjusted basis, the increase was a third as large. Moreover, the most dramatic increase in average CEO pay during the period was between 1997 and 1998. On a risk-adjusted basis, CEO pay actually declined over the same period.

The framework we have advanced is completely general. That is, it applies to all risky components of pay, not just options. One of the key results of this paper is that options are a particularly expensive way to convey compensation. But the same is true for risky bonuses and other forms of contingent pay. There are important incentive benefits to both types of pay (obviously, since without such benefits, our analysis suggests that companies would never offer risky pay), but there is a strong need for a framework for researchers and practitioners to understand, and quantify, the value:cost efficiency of risky compensation. Moreover, this need continues to grow as companies increasingly put higher percentages of pay at risk for increasingly higher percentages of their managers and employees, a trend that also appears to be spreading beyond the borders of the US. We believe that there is a high return to future research that broadens our framework in precisely this way.

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Appendix A

Risk-Adjusted Pay Calculations

Our risk-adjusted pay calculations for S&P 500 executives are based on the following data available from Compustat's ExecuComp (unless otherwise sourced):

s	Shares of stock owned,
n_0	Number of previously granted options held at year-end,
X_0.	Average exercise price for previously granted options,
Salary	Base salary plus all non-variable compensation,
Bonus	Bonus plus the target award from accounting-based long-term plans,
n_i	Number of shares in the i^{th} option, restricted stock, or target performance-share grant,
X_i	Exercise price for the i^{th} option grant (equals 0 for restricted stock and performance-share grants),
T	Option term
σ	Annualized standard deviation of continuous returns, measured over 48 months,
β	Equity beta, calculated from monthly data over 48 months,
r_f	Average yield on U.S. government securities over the fiscal year (Source: Federal Reserve System),
(r_m-r_f)	Equity premium (assumed to be 6.5%).

In calculating risk-adjusted pay we also make assumptions regarding executive relative risk aversion, ρ, and non-firm-related wealth, w. Our calculations are based on ρ=2 or ρ=3, assuming that w is equal to the greater of $5 million or four times cash compensation. In addition, we (somewhat arbitrarily) discount Bonuses by 20%, to account for the risk in bonuses. Assuming that *w*, *Salary*, and *Bonus* is invested at the risk-free rate, r_f, and that the realized stock price at T is P_T, the executive's wealth at time T is given by

(A1)
$$W_T \equiv w(1+r_f)^T + sP_T + n_0 \cdot max(0, P_T - X_0) +$$
$$(Salary + .8*Bonus)(1+r_f)^T + \sum n_i \cdot max(0, P_T - X_i),$$

where the summation in $\sum n_i \cdot max(0, P_T - X_i)$ allows for multiple option and stock grants.[31] If, instead of the option, he were awarded V in cash that he invested at the risk-free rate, his wealth at time T would be:

(A2)
$$W_T \equiv (w+V)(1+r_f)^T + sP_T + n_0 \cdot max(0, P_T - X_0)$$

As before, we assume the executive's utility over wealth is $U(W)$ with constant relative risk aversion, and define the executive's risk-adjusted compensation as the certainty equivalent V that equates the expected utilities of (1) and (2):

(A3)
$$\int U(W_T^V) f(P_T) dP_T \equiv \int U(W_T) f(P_T) dP_T$$

where the distribution of stock prices in T years is lognormal with volatility σ and expected value equal to $(r_f + \beta(r_m - r_f) - \sigma^2/2)T$.

[31] Our methodology requires that the grant-date market price and the expiration term be the same for all grants made to a single executive during the year. When grants were made at different dates (and different prices), we "normalized" the price by adjusting the exercise price and the shares granted. When grants were made for various terms, we used the term for the largest grant. This restriction was seldom required: 98% of the sample executives had only single grants or multiple grants with a common expiration term.

Appendix B

A Binomial Framework for Non-tradable Options

We begin by building a traditional binomial tree (Cox, Ross, and Rubinstein, 1979), starting with an initial stock price of P_0. The stock prices in the second period are either $P_0 \lambda$ (with probability π) or P_0/λ probability 1-π; subsequent prices are determined similarly for h periods per year and Y years (the total number of periods is $T \equiv Yh$). In the traditional model with risk-neutral growth, the probabilities π are determined so that the expected return is the risk-free rate. We depart from the traditional model by assuming an expected continuously compounded annual return of $\mu \equiv ln(1+r_f+\beta(r_m-r_f))$ and (therefore) a per-period return of $m \equiv e^{\mu/h}$. The "uptick" λ and probability π are chosen to solve:

$$\pi\lambda + (1\text{-}\pi)(1/\lambda) = m,$$

$$\pi\lambda^2 + (1\text{-}\pi)(1/\lambda)^2 - m^2 = \gamma,$$

where m and $\gamma \equiv m^2\left(e^{\sigma^2/h} - 1\right)$ are (respectively) the mean and variance of the assumed lognormal distibution of stock prices. Applying the quadratic formula,

$$\lambda = \frac{1}{2m}\left((m^2 + \gamma + 1) - \sqrt{(m^2 + \gamma + 1)^2 - 4m^2}\right),$$

$$\pi = \frac{m - \frac{1}{\lambda}}{\lambda - \frac{1}{\lambda}}.$$

In order to determine executive option values and early exercise decisions, we employ a backward induction algorithm combined with same utility function (and parameter assumptions) used in our previous analysis. As before, we assume the executive holds non-firm-related wealth, w, invested at the risk-free rate, r_f, holds s shares of company stock, and is given a grant of n options at exercise price X. If the executive decides to exercise his options early, the profits from the exercise are invested in the riskless asset, which is then held until the final period.

The executive's exercise decision rule is: exercise at any period t if the expected utility from exercise is greater than the expected utility from holding the option to the next period. Specifically, utility based on final period T wealth is calculated at each final period node. (The final period exercise decision is trivial since, at in-the-money nodes, all options will be exercised, and at out-of-the-money nodes, all options expire worthless.) Then, in the period prior to the final period (T-1), the executive solves:

$$Max\left\{\pi U_T^+ + (1-\pi)U_T^-),U_{T-1}^E\right\}$$

where U_T^+ is the expected utility in T if the stock price increases by λ (an uptick), U_T^- is the expected utility in *T* if the stock price increases by 1/λ (a downtick), and U_{T-1}^E is the expected if utility in *T-1* if the executive exercises in *T-1*. Evaluating utility in the event of exercise is straightforward since no further decisions are made by the executive. Expected utility under early exercise is based on post-exercise holdings of safe wealth and stock evaluated at all possible (given the current node) final-period stock prices. Following evaluation at *T-1*, the same process is repeated at *T-2* and backward induction is then used until the root node is reached and the tree is fully grown. At completion, each of the *nY* nodes of the final tree contains a stock price $P_{t,i}$, an expected utility, and an indicator for whether the option has been exercised.

The expected utilities in each node of the binomial tree assume cash, stock, and options are held until period T, and therefore denote final-period utilities. We estimate the executive value of the option grant by finding the grant-date cash award (invested until T at the risk-free rate) that yields the expected utility at the first node of the binomial tree.

Table 1

Ratio of Executive Value to Black-Scholes Cost for Option with $30 Exercise Price, for Various Pairs of Relative Risk Aversion (ρ) and Diversification

Stock Price	*B-S Cost*	ρ = 2 50% Stock	ρ = 2 66% Stock	ρ = 3 50% Stock	ρ = 3 66% Stock	*Payout Probability*
$5	$0.39	24.5%	13.4%	5.8%	2.2%	*13.1%*
$15	$4.95	49.7%	31.6%	22.3%	10.7%	*51.5%*
$30	$16.55	63.5%	44.8%	36.7%	21.1%	*77.9%*
$45	$30.11	69.1%	51.2%	44.0%	27.8%	*88.4%*
$60	$44.40	71.9%	54.9%	48.0%	32.0%	*93.3%*

Note: B-S cost is the Black-Scholes value of one option with an exercise price of $30. Executive values are estimated numerically assuming that the executive has constant relative risk aversion, $\rho=2$ or $\rho=3$, and assuming (using the Capital Asset Pricing Model, CAPM) that the distribution of stock prices in T=10 years is lognormal with volatility $\sigma = .30$ and expected value $(r_f + \beta(r_m-r_f) - \sigma^2/2)T$, where $\beta = 1$ is the firm's systematic risk, $r_f = 6\%$ is the risk-free rate, and $r_m - r_f = 6.5\%$ is the equity premium. The payout probability that the market price at expiration, P_T, exceeds the exercise price, X, is calculated under the standard CAPM assumption that $Ln(P_T/P_0)$ is normally distributed with mean $\mu \equiv Ln(r_f + \beta(r_m-r_f) - \sigma^2/2)T$ and variance $\sigma^2 T$.

Table 2

Explanatory Regressions for Risk-Adjusted and Unadjusted Pay for S&P 500 CEOs

	Dependent Variables: CEO Total Compensation		
Independent Variable	No Risk Adjustment	Risk-Adjusted with ρ=2	Risk-Adjusted with ρ=3
	(1)	(2)	(3)
Intercept	5.90 (49.7)	4.97 (49.4)	4.96 (51.2)
Ln(Sales)	0.302 (23.2)	0.332 (30.2)	0.311 (29.4)
Finance (Dummy)	0.226 (5.4)	0.310 (8.8)	0.306 (9.0)
Utility (Dummy)	-0.650 (-12.4)	-0.364 (-8.2)	-0.276 (-6.5)
Year 1992 (Dummy)	-0.766 (-13.8)	-0.327 (-6.9)	-0.243 (-5.4)
Year 1993 (Dummy)	-0.621 (-11.2)	-0.238 (-5.1)	-0.161 (-3.6)
Year 1994 (Dummy)	-0.519 (-9.5)	-0.139 (-3.0)	-0.079 (-1.8)
Year 1995 (Dummy)	-0.400 (-7.4)	-0.046 (-1.0)	-0.005 (-0.1)
Year 1996 (Dummy)	-0.221 (-4.1)	0.058 (1.3)	0.055 (1.3)
Year 1997 (Dummy)	-0.076 (-1.4)	0.127 (2.8)	0.113 (2.6)
R^2	0.266	0.287	0.263

Note: t-statistics in parentheses. Sample size is 3,351 for all regressions. Total compensation defined as the sum of salaries, bonuses, benefits, share options (valued on date of grant using the Black-Scholes formula), LTIP-related stock grants (valued at 80% of face value for performance-contingent awards), and other compensation. Risk-adjusted compensation is computed assuming constant relative risk aversion and assuming that CEO has “safe wealth” equal to the greater of $5 million or four times cash compensation. All monetary variables in 1988-constant dollars.

Table 3

Ratio of Executive Value to Cost for an *Indexed* Option with $30 Exercise Price, for Various Pairs of Relative Risk Aversion (ρ) and Diversification

Stock Price	*B-S Cost*	ρ = 2 50% Stock	ρ = 2 66% Stock	ρ = 3 50% Stock	ρ = 3 66% Stock	*Payout Probability*
$5	$0.04	2.7%	1.3%	0.4%	0.1%	*0.4%*
$15	$1.68	12.2%	7.0%	4.3%	1.8%	*10.2%*
$30	$9.22	24.1%	15.6%	12.2%	6.1%	*34.6%*
$45	$20.41	32.2%	22.4%	19.1%	10.8%	*54.7%*
$60	$33.35	37.8%	27.5%	24.4%	14.9%	*68.5%*

Note: B-S cost is the Black-Scholes value of one indexed option with an exercise price of $30. Executive values are estimated numerically assuming that the executive has constant relative risk aversion, $\rho=2$ or $\rho=3$, and assuming volatility $\sigma=.25$ (the median volatility of market-adjusted returns), $r_f=0$, $\beta(r_m-r_f)=0$.

Table 4

Cost, Value, and Incentives from Executive Options with and without Early Exercise

		Options Exercisable at Expiration				Options Exercisable at Grant			
Risk Aversion	% of Wealth in Stock	Company Cost	Executive Value	Value / Cost	Incentives ∂V∂/P	Company Cost	Executive Value	Value / Cost	Incentives ∂V∂/P
2	50%	$16.55	$10.51	63.5%	$0.45	$14.76	$12.40	84.0%	$0.61
2	66%	$16.55	$7.41	44.8%	$0.35	$13.60	$9.96	73.2%	$0.56
3	50%	$16.55	$6.07	36.7%	$0.26	$13.06	$9.42	72.1%	$0.53
3	66%	$16.55	$3.49	21.1%	$0.17	$11.57	$7.33	63.4%	$0.49

Note: The data depict the per-share costs, value, and incentives from a grant of 5,000 ten-year stock options with an exercise price of $30 (the market price on the date of grant). The cost is estimated as the binomial valuation of an American option (under risk-neutral pricing), where the exercise decision is determined not by the investor but rather by the threshold prices in Figure 7. The value is estimated as the grant-date cash award that yields the same expected utility as receiving an option, and incentives are measured as the derivative of this value with respect to an incremental change in the stock price. The executive is assumed to have initial wealth of $5 million, split between riskless cash and company stock.

Table 5

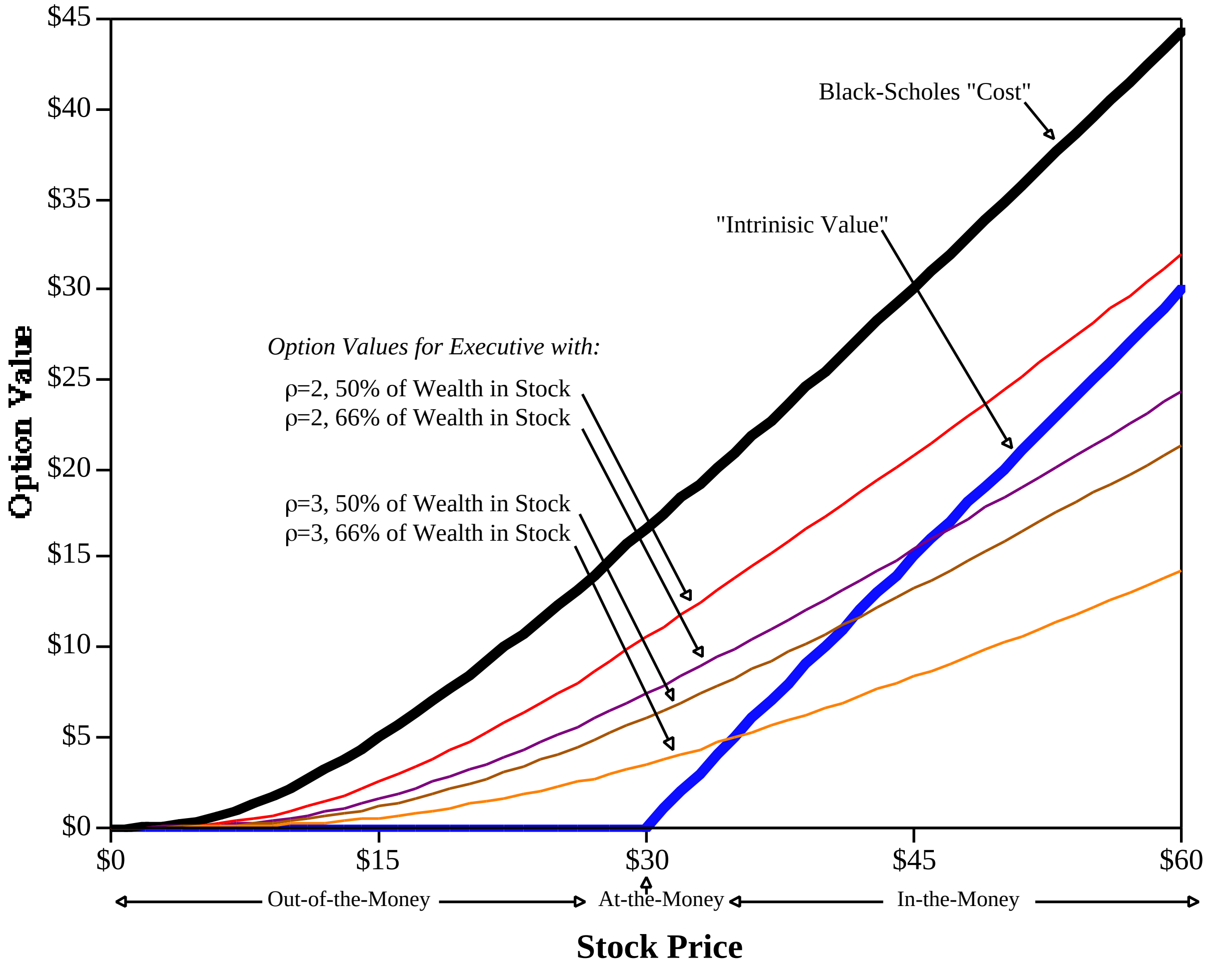
Likelihood of Exercising on Vesting Date

Risk Aversion	Diversification (% of Wealth in stock)	Likelihood of Exercising on Vesting Date		
		Vesting at 2 Years	Vesting at 3 Years	Vesting at 4 Years
2	50%	1.4%	5.8%	10.0%
2	66%	5.9%	12.9%	19.8%
3	50%	5.9%	16.7%	23.7%
3	66%	17.0%	26.3%	33.3%

Note: The executive, with initial wealth of $5 million, split between riskless cash and company stock, is assumed to receive 5,000 ten-year stock options with an exercise price of $30 (the market price on the date of grant). Exercise probabilities are based on a simulation with 100,000 sample price paths (through the tree) for each risk/diversification/vesting group. The likelihood of exercising at vesting date is calculated as the percentage of price paths (out of 100,000) that exceed the threshold price at the executive's first opportunity to exercise.

Figure 1

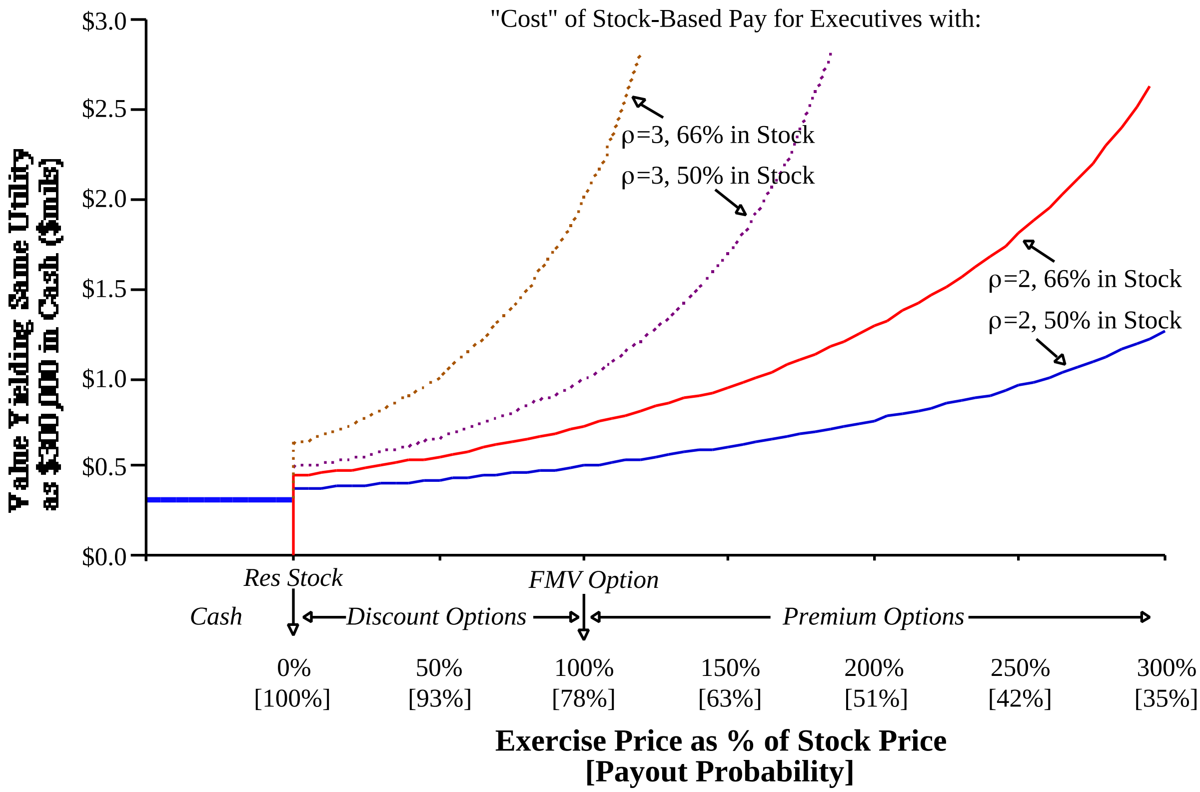
Executive Value Lines: Option Values for Undiversified Executives



Note: Executive values for ten-year options with an exercise price of $30 are estimated using the "certainty equivalence" approach, and are defined as the amount of riskless cash compensation the executive would exchange for the option. Certainty equivalents are estimated numerically assuming that the executive has constant relative risk aversion, $\rho=2$ or $\rho=3$, and assuming (using the Capital Asset Pricing Model, CAPM) that the distribution of stock prices in T=10 years is lognormal with volatility σ = .30 and expected value $(r_f + \beta(r_m-r_f) - \sigma^2/2)T$, where β = 1 is the firm's systematic risk, r_f = 6% is the risk-free rate, and r_m- r_f = 6.5% is the equity premium.

Figure 2

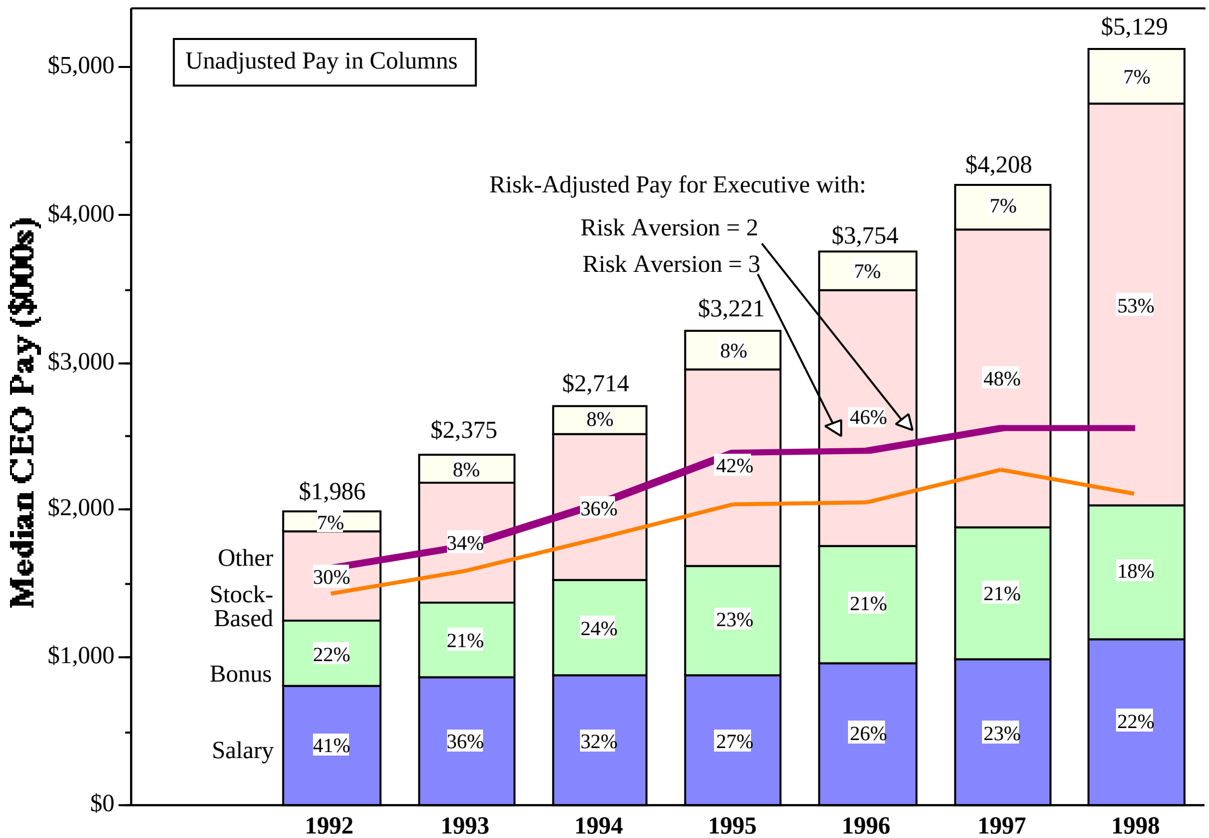
Executive Indifference Curves:
Amount of Stock-Based Pay Required to Offset $300,000 in Cash Compensation



Note: Executive values are estimated numerically assuming that the executive has constant relative risk aversion, ρ=*2* or ρ=*3*, and assuming (using the Capital Asset Pricing Model, CAPM) that the distribution of stock prices in T=10 years is lognormal with volatility σ = .30 and expected value $(r_f + \beta(r_m - r_f) - \sigma^2/2)T$, where β = 1 is the firm's systematic risk, r_f = 6% is the risk-free rate, and $r_m - r_f$ = 6.5% is the equity premium

Figure 3

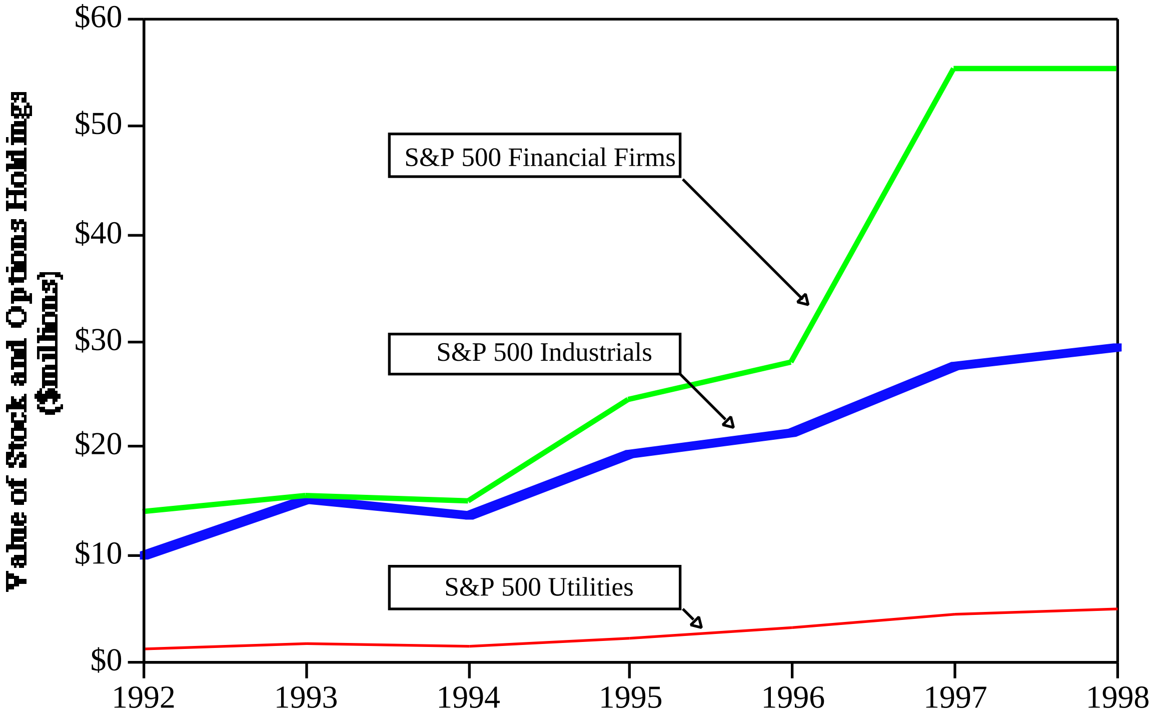
CEO Pay and Risk-Adjusted Pay in S&P 500 Industrials, 1992-1998



Note: Median pay levels (in 1998-constant dollars) based on ExecuComp data for S&P 500 CEOs (financial firms and utilities excluded). Total compensation (in columns) defined as the sum of salaries, bonuses, benefits, stock options (valued on date of grant using the Black-Scholes formula), stock grants, and other compensation. Executive values are estimated using the "certainty equivalence" approach, and are defined as the amount of riskless cash compensation the executive would exchange for his stock and option grants, conditional on his current stock and option holdings. The risk-adjusted value of accounting-based bonuses are assumed to be worth 80% of actual bonuses. The CEO's safe wealth is assumed to be the greater of $5 million or four times cash compensation. Certainty equivalents are estimated numerically assuming that the executive has constant relative risk aversion of 2 or 3, and assuming (using the Capital Asset Pricing Model, CAPM) that the distribution of stock prices over the actual term of the options granted is lognormal with volatility σ and expected value $(r_f + \beta(r_m\text{-}r_f) - \sigma^2/2)T$, where σ and β are determined using monthly stock-return data over 48 months, r_f is the average yield on US government securities during the year of grant, and $r_m - r_f = 6\%$ is the equity premium.

Figure 4

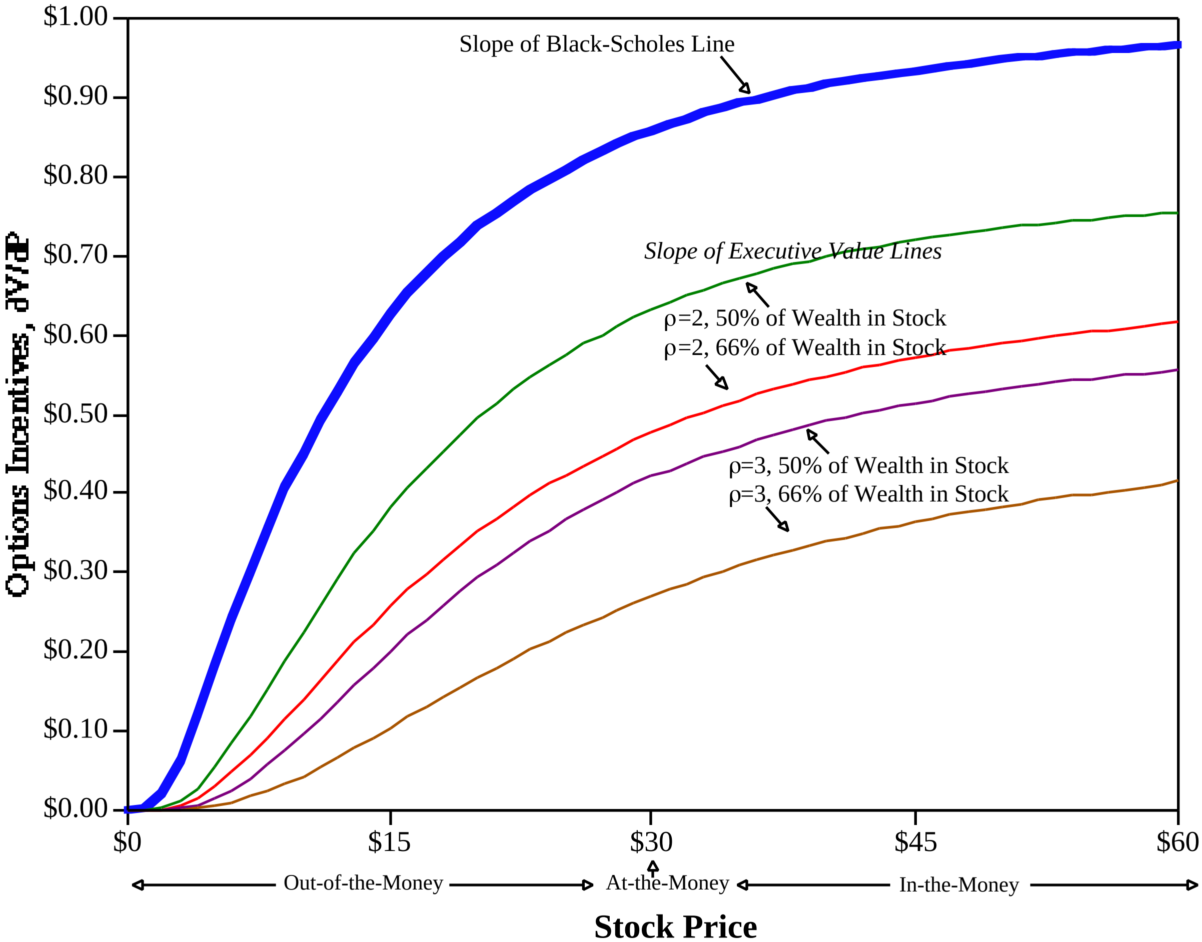
Value of Stock and Options Held by S&P 500 CEOs, 1992-1998



Note: Data from Compustat's ExecuComp database, and are in 1998-constant dollars. The value of option holdings is defined as the in-the-money value of all exercisable and non-exercisable options held at the end of the fiscal year.

Figure 5

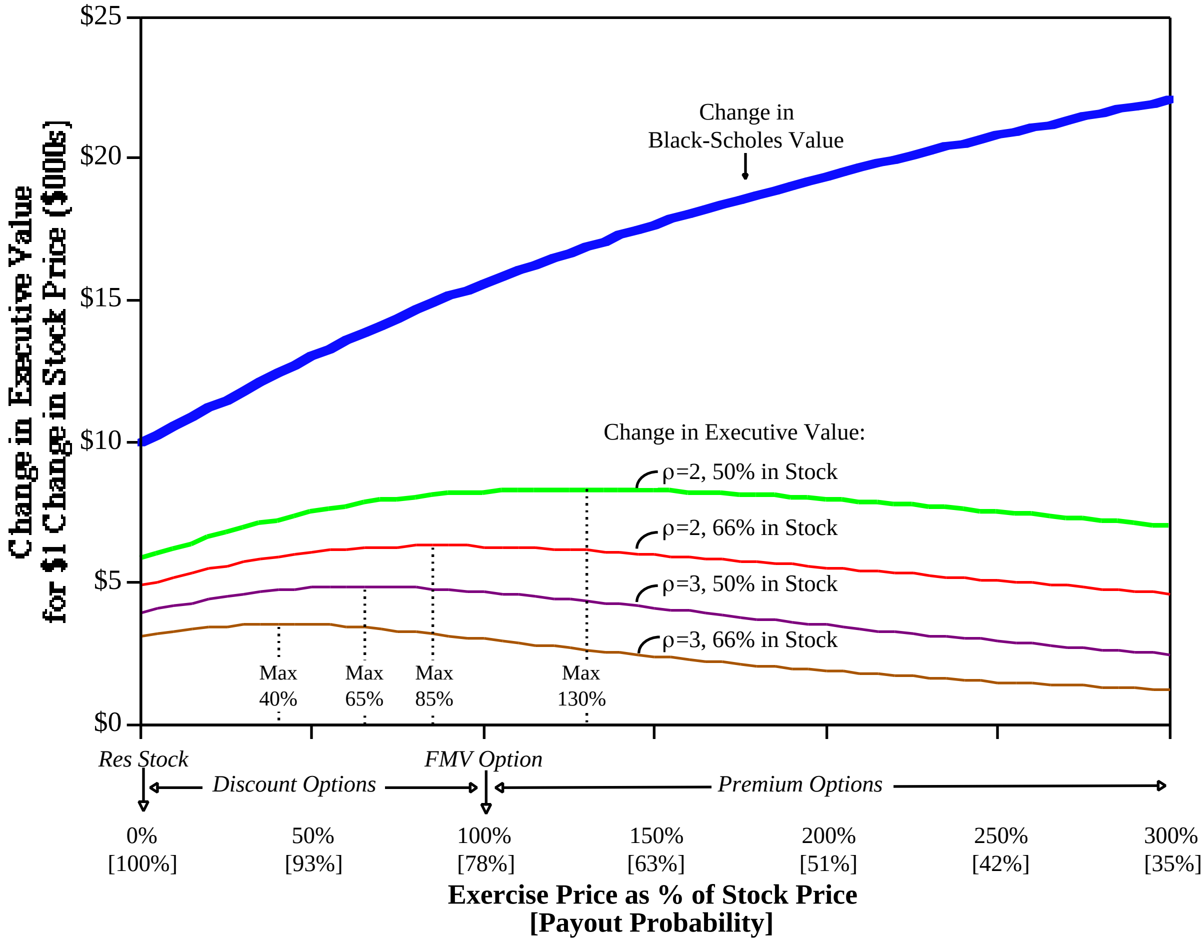
Incentives (per share) from 5,000 Options Granted to Undiversified Executives



Note: The figure shows the "slopes" of the Black-Scholes and executive valuations in Figure 1, which in turn depict the per-share cost and value of a grant of 5,000 ten-year options with an exercise price of $30. We define "incentives" as the change in the certainty-equivalent option value for each $1 change in the stock price.

Figure 6

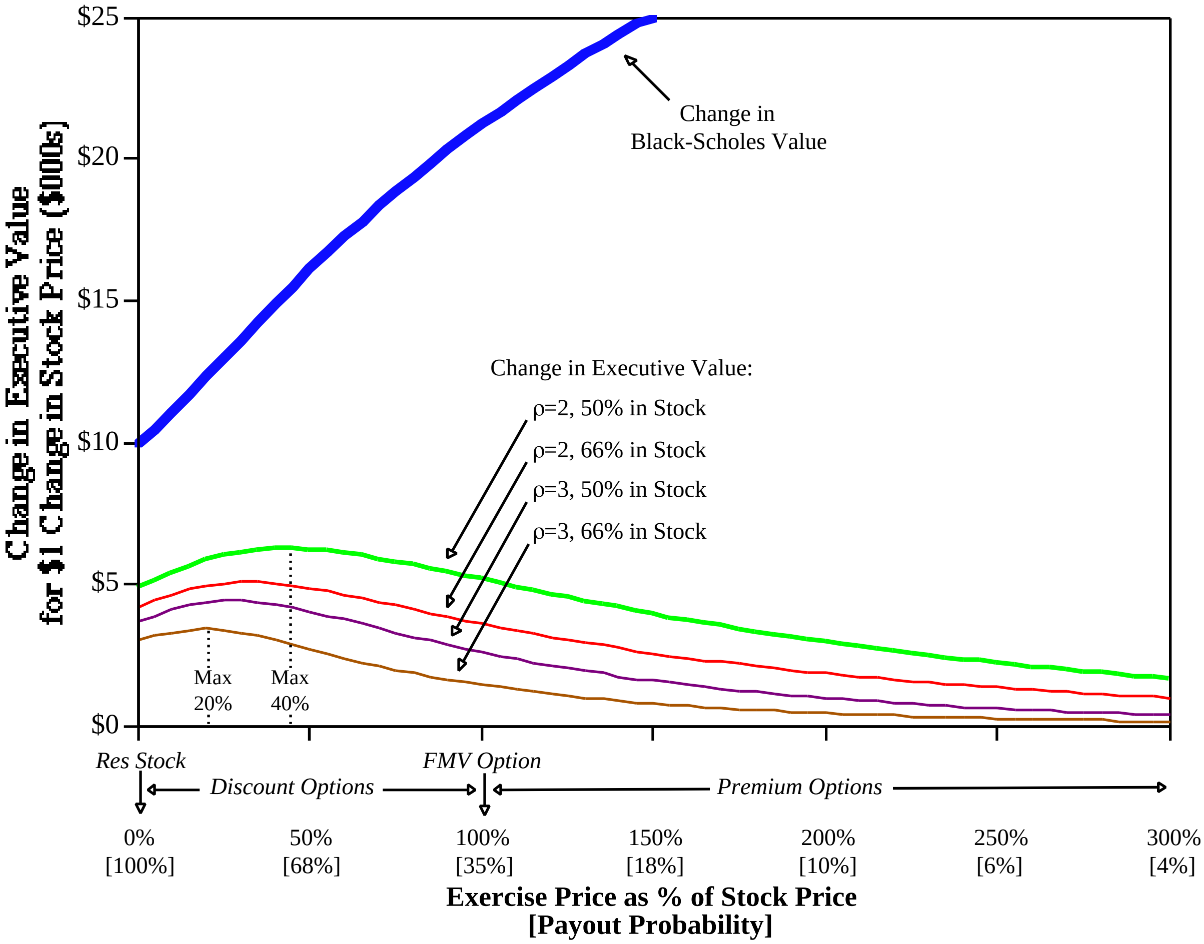
Incentives from $300,000 "worth" of Options Granted to Undiversified Executives



Note: The figure assumes that executives with $5 million in initial wealth are granted stock options with a Black-Scholes value of $300,000; the number of options granted naturally increases as the exercise price increases. We define "incentives" as the change in the certainty-equivalent option value for each $1 change in the stock price.

Figure 7

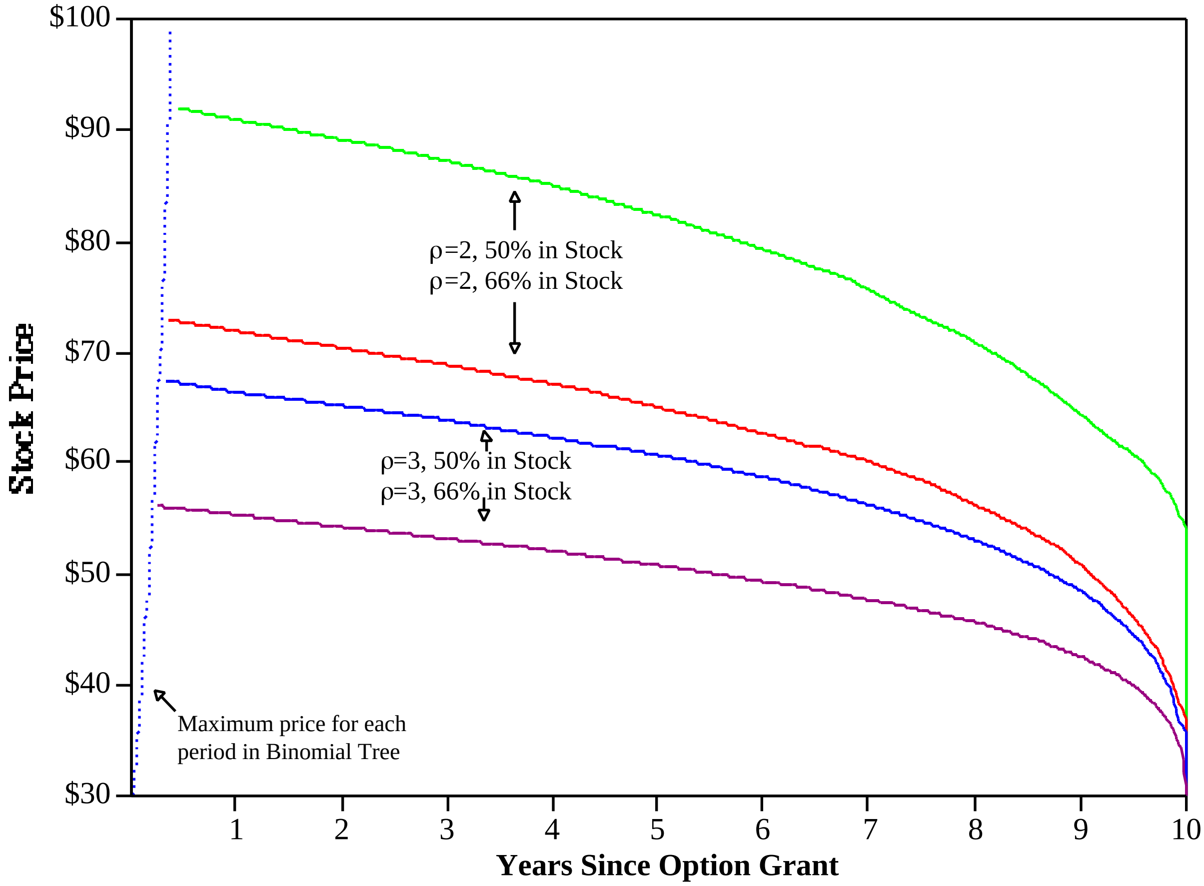
Incentives from $300,000 "worth" of *Indexed* Options Granted to Undiversified Executives



Note: The figure assumes that executives with $5 million in initial wealth are granted ten-year indexed stock options with a Black-Scholes value of $300,000; the number of options granted naturally increases as the exercise price increases. We define "incentives" as the change in the certainty-equivalent option value for each $1 change in the stock price. Indexed options are calculated assuming volatility σ =.25 (the median volatility of market-adjusted returns), $r_f = 0$, $\beta(r_m - r_f) = 0$.

Figure 8

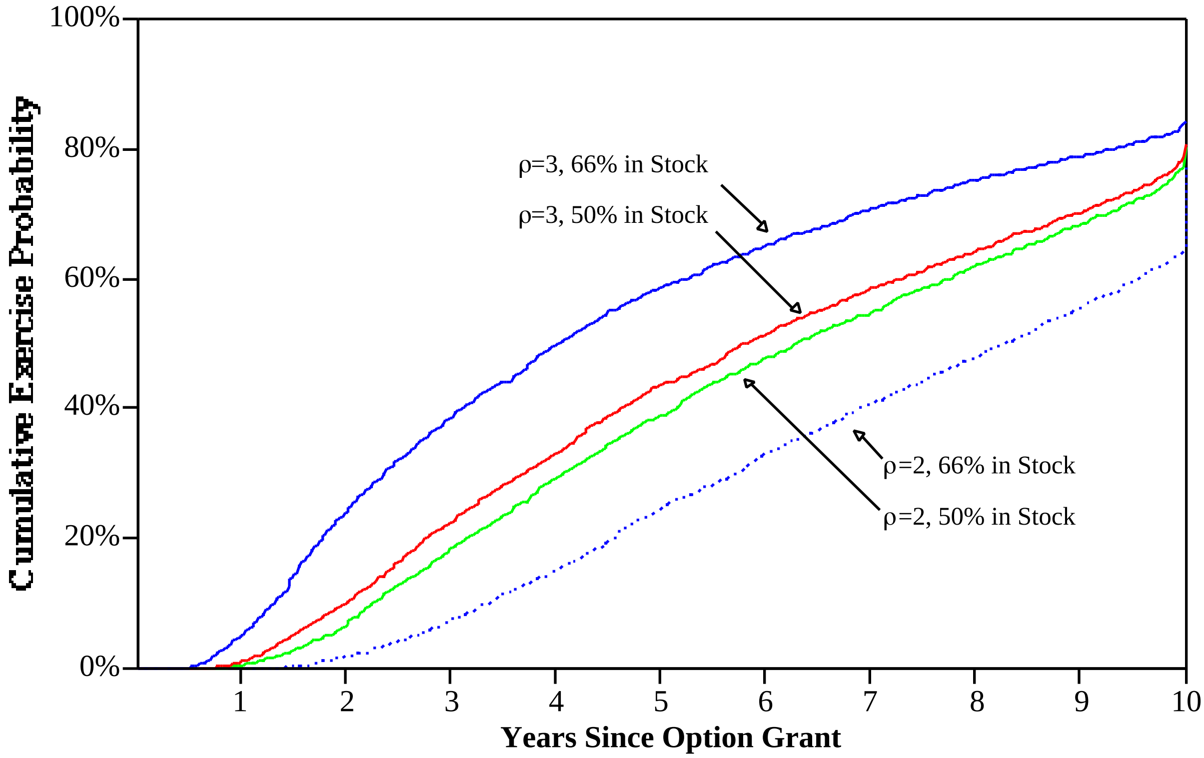
"Threshold Prices" for Early Exercise Decisions on Immediately Exercisable Options



Note: The threshold price is the stock price where the executive is just indifferent between exercising early or holding the option for another period. The figure assumes that executives with $5 million in initial wealth are granted 5,000 immediately exercisable stock options. At exactly T=10, the threshold price falls to the exercise price of $30.

Figure 9

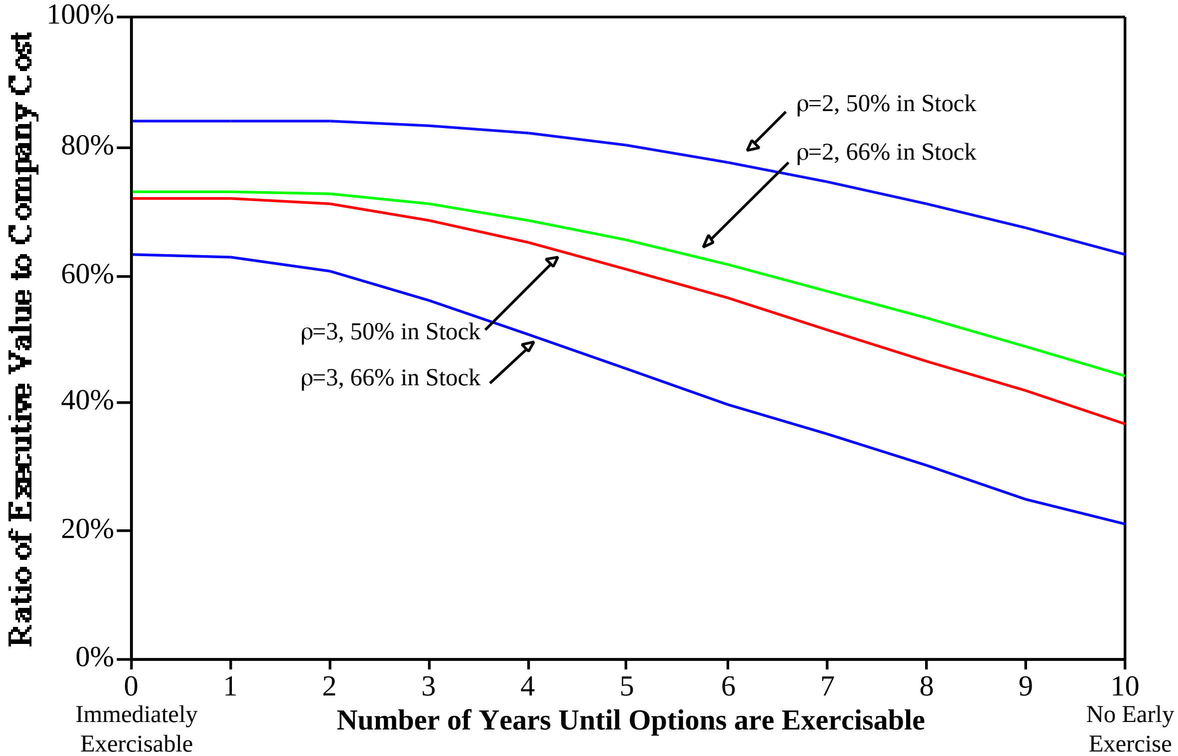
Cumulative Exercise Probabilities for Immediately Exercisable Options



Note: The threshold price is the stock price where the executive is just indifferent between exercising early or holding the option for another period. The figure assumes that executives with $5 million in initial wealth are granted 5,000 stock options.

Figure 10

The Ratio of the Executive Value to the Company's Cost, by Vesting Date



Note: The threshold price is the stock price where the executive is just indifferent between exercising early or holding the option for another period. The figure assumes that executives with $5 million in initial wealth are granted 5,000 stock options.