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Designing an Option Plan that Rewards Relative Performance: Indexed Options Revisited

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Abstract

This paper examines how an option plan that rewards managers for firm performance relative to some market or industry benchmark should be structured. Relative-performance-based compensation advocates contend that conventional stock options do not adequately discriminate between strong and weak managers, typically suggesting "indexed options," that is, options with an exercise price linked to a market or industry index, as a remedy. A close examination of indexed options, however, reveals a fundamental problem: indexed options do *not* function as its proponents intend. Instead, their payoff remains highly sensitive to market or industry price movements. This paper proposes an alternative option design, an option on a "performance-benchmarked portfolio," that *does* remove the effects of the specified market or industry benchmark from the value of the option. This structure uses an option with a fixed exercise price, where the underlying asset is a *portfolio* comprised of the firm's stock hedged against market and industry price movements.

I. Introduction

One weakness of traditional executive stock option compensation plans is that they have the potential to both reward and punish managers for factors outside of managers' control, such as market movements, compromising the hoped-for link between pay and performance. To restore this link, reformers, both from practice and from academia, have suggested substituting "indexed options," that is, options whose payoff is linked to some sort of market or industry-based index, in place of the conventional options in widespread use today. [1] Executive stock options that explicitly tie managers' pay to the firm's performance relative to a market or industry benchmark are just beginning to be used in practice, and much work remains on how to practically implement such a system.[2] This paper provides a starting point by evaluating an indexed option plan structured along the lines most frequently proposed by indexed performance advocates, where the option's exercise price changes to reflect the performance of the benchmark market or industry index.[3]

As it turns out, an option with an exercise price tied to a market or industry index remains highly sensitive to market and/or industry movements, and does *not* remove the effect of the benchmark index from the option's value. As the market increases, the value of the variable-exercise-price option will, too, even when the stock has failed to outperform the

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[1] See, for example Akhigbe and Madura (1996), Barr (1999), Johnson (1999), Johnson and Tian (2000), Kay (1999), Nalbantian (1993), Rappaport (1999), Reingold (2000), Schizer (2001).

[2] Level 3 Communications, for example, is one of the few firms to implement an indexed option system (see Meulbroek (2001b)). Rappaport (as quoted in Barr (1999)) predicts that indexed options "…will be easier to sell once the market cools. In a bull market, you want to be paid for absolute performance, but in a more stable or bear market, you want to be paid for relative performance."

[3] The sources listed in footnote 1 describe such an option.

market.[4] This paper presents an alternative design that achieves the desired effect of rewarding managers *only* for performance that is not due to overall gains in the market or industry. Instead of using the firm's stock as an underlying asset, this alternative design employs a performance-benchmarked portfolio. This performance-benchmarked portfolio consists of the firm's stock, hedged against market and industry movements. Under this proposed structure, the value of the *portfolio* changes to reflect the firm's performance, net of market and industry effects, while the *exercise price* remains fixed.

The paper proceeds as follows. Section II briefly describes the general motivation behind options as a compensation tool, and the more specific motivation behind relative-performance- based compensation. It also examines the extent to which relative-performance-based compensation is used in practice, and whether managers can affect a relative-performance-based compensation for themselves, without the company changing its compensation system. Section III demonstrates the need for restructuring the type of indexed option plan typically proposed by relative-performance compensation advocates—an indexed option with a variable exercise price—showing that such an option remains sensitive to movements in the benchmark index. Section IV proposes a practical and straightforward alternative to the indexed option with a variable exercise price, namely, an option on a performance-benchmarked portfolio. This market- and industry-adjusted option truly rewards for relative performance. Section V concludes.

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[4] This effect arises because the options are homogeneous of degree one with respect to strike price and exercise price.

II.   Paying Managers for their Relative Performance

A. The conceptual basis for option-based compensation

Compensation systems have three functions: to compensate managers for completed

work, to reduce principal-agent costs by more closely aligning managers interests with

those of shareholders, and to recruit or retain the manager. A form of compensation that

performs one of these functions effectively may not be as good at fulfilling the other

functions of a compensation system. Stock options, for example, are used to align

incentives. However, a firm that has no need to create such incentive alignment would be

very unlikely to use stock or stock options to compensate its managers, for better ways

exist. Cash compensation is one such form of compensation that a firm could use when

incentive alignment is deemed relatively unimportant. Cash compensation is "better" than

stock-option-based compensation when the incentive alignment effects created by options

are not needed, because cash avoids the deadweight costs that accompany any equity-

based compensation plan. Deadweight costs arise because the same exposure to firm-

specific risk that aligns incentives also compels managers to hold a less-than-fully-

diversified portfolio. This loss of diversification is costly for managers, who now must

bear both systematic and non-systematic risk.[5] As a consequence, managers value equity-

based compensation at less than its value to fully-diversified investors, that is, managers

value their equity-based compensation at less than its market value. By using cash, a firm

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[5] Meulbroek (2001a) describes these costs in greater detail, and proposes a practical way to estimate their magnitude. In practice, the costs associated with the manager's loss of diversification can be large and substantial. In Meulbroek (2001a), I estimated that the private value that managers place on conventional executive stock options is roughly half of their market value in rapidly-growing entrepreneurially-based firms, such as Internet-based firms. Even for less-volatile NYSE firms, the deadweight loss associated with stock options is 30% of their market value. For a utility-function-based approach to distinguishing the value

avoids such costs: the value of cash to the manager is exactly its cost to the firm. While

stock options can surely can be used as a form of payment to compensate managers, and,

when combined with vesting requirements, stock options can also help with retention,

stock options are *not* the most efficient form of compensation to achieve these goals: their

comparative advantage lies in their ability to align incentives.

Of course, options are not unique in this respect: stock-based compensation also aligns

the incentives of managers with those of shareholders. Options, however, allow the firm

to create a specific risk exposure at a lower price than stock. Suppose that the desired risk

exposure for a manager is equivalent to 100,000 shares on a $100 stock. The firm would

need to pay the manager $10 million (100,000 x $100) to create this exposure if it used

stock. But suppose further that ten million dollars is much more than the firm wanted to

pay the manager, so it looks for other ways to expose managers to an amount of risk

equivalent to 100,000 shares. One possibility is to give the manager $10 million in stock

of which $2 million is an outright grant, and $8 million is in the form of a loan from the

company to the manager. The levered grant structure, however, has the potential to make

managers too risk averse: a 20% drop in the stock price would bankrupt the manager,

who would still be responsible for re-paying the $8 million loan. To reduce the excess

risk aversion that can result from the manager's highly-levered position, the loan could be

made non-recourse, that is, secured by the stock and nothing more. This compensation

structure, a levered stock position with a non-recourse loan is the functional equivalent of

a call option. Thus, one justification for compensating managers with call options is that

of compensation to a manager from the cost of that compensation to the firm, see Lambert, Larcker and Verrecchia (1991), Huddart (1994), Hall and Murphy (2000a), and Hall and Murphy (2000b).

the company reduces its cost of exposing managers to a given amount of risk from the amount that would otherwise be required if the company relied exclusively on a stock grant. At the same time, the call option ameliorates the excessive managerial risk aversion that might result from a stock position coupled with a full-recourse loan.[6]

Stock grants coupled with non-recourse loans (or equivalently stock options) are not the only way for the company to expose its managers to the risk that leads to proper incentive alignment. Just as the firm can use executive stock options to lower the cost (relative to using stock-based compensation) of exposing managers to risk, so too can a highly-levered management buyout, by giving managers a large equity share for a small amount of money, lower the cost of exposing managers to a given amount risk.[7] In so doing, it gives managers a greater incentive to increase firm value, aligning their incentives with those of other shareholders.[8] While the equity stake managers acquire in a management buyout allows them to reap large rewards if successful, one critical difference between the management buyout structure and executive stock-option-based compensation is that the company itself is levered in a management buyout, whereas executive stock options lever the manager's risk exposure without levering the firm. Out-of-the-money executive stock options affect the manager, but do not force the firm into financial distress. The

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[6] Some observers note that options could have the opposite effect, for the value of an option increases with its volatility, giving a manager an incentive to increase the firm's volatility by taking on excess risk. But theoretical and empirical work casts doubt on whether options cause excessive managerial risk-taking, and some work suggests that options might provide managers with an incentive to decrease risk. See Carpenter (2000), Haugen and Senbet (1981), Detemple and Sundaresan (1999), Cohen, Hall and Viceira (2000), and Rajgopal and Shevlin (1999).
[7] Kaplan (1989) reports that top level managers receive on average 37 percent of the newly-reorganized firm's equity, results similar to those of Schipper and Smith (1991).
[8] Kaplan (1989) provides evidence supporting the effectiveness of this management buyouts. Of course, improved incentive alignment is not the only benefit attributed to LBOs or MBOs. As outlined in Jensen

high leverage associated with a management buyout, however, puts more than the

manager's wealth at risk. Leverage increases the probability of financial distress, which

imposes costs not only on managers, but on creditors, suppliers, customers, as well as

other employees. Consequently, as Jensen (1986) points out, leveraged management

buyouts are appropriate for "…firms or divisions of larger companies that have stable

business histories and substantial free cash flow." Moreover, because a leveraged

management buyout increases the probability of financial distress, it is best left for firms

that have low costs if distress were to occur.[9] In sum, while the company's ownership

structure can certainly be used to motivate managers, option-based compensation can

motivate managers without putting the firm at risk.[10]

B. The conceptual basis for performance indexing

Even so, conventional stock options sometimes fail to achieve their intended goal of

aligning managers' incentives with those of shareholders. For conventional options to

effectively align incentives, the value of managers' options must increase with their

abilities and efforts. Without this connection between managerial performance and firm

performance, managers have little incentive to work hard. Just as our recent long-running

bull market de-coupled the link between managers' effort and firm performance, the

increased volatility levels we are currently experiencing have also eroded the relation

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(1986), leverage itself, by decreasing the discretionary amount of cash available to managers (free cash flow), can reduce the likelihood of managers engaging in negative net-present-value projects.

[9] Such firms are typically characterized as having tangible assets that can be easily liquidated, employees who can be easily replaced, if need be, suppliers who are not required to deliver inputs to the company that they have customized at a high cost, customers who do need not invest much to buy the firm's products, and relatively low levels of business (as opposed to financial) risk.

[10] Some have argued that the ability of managers to use financial instruments to hedge risk on their own allows them to "undo" their equity-based compensation plans, a limitation that would not occur if the firm

between firm value and managerial performance. When mangers have limited influence

over that volatility, the risk exposure created by conventional stock options is not a

particularly helpful incentive-alignment tool. Questioning their effectiveness, one critic

of conventional stock option plans notes that

> "In the bull market of the past decade, many companies generously compensated
> management even when the companies underperformed the market. Significant unearned
> compensation not only wastes shareholders' money but also sends an inappropriate
> motivational message. It increases the skepticism of employees, customers, the press, and
> the public at large, giving the impression that compensation systems represent a kind of
> lottery rather than a serious way to reward performance. At the other extreme, a poor
> overall market or weakness in particular sectors provides few opportunities for
> companies to use conventional stock options to reward real performance." Johnson
> (1999)

Or, as Warren Buffet laconically puts it, "…[stock options] are wildly capricious in their

distribution of rewards, inefficient as motivators, and inordinately expensive for

shareholders."[11] Academic research, too, has noted the problems with traditional stock

options: Gibbons and Murphy (1990), for example, suggest that compensation contracts

based upon firm performance, not adjusting for industry or market performance,

"…subject executives to vagaries of the stock and product markets that are clearly

beyond management control."[12] Such observations have renewed the call for

compensation based upon relative performance. Relative- performance-based

compensation aims to tighten the link between managerial efforts and compensation by

rewarding managers only for that portion of performance under their control, filtering out

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itself were levered (see, for example, Garvey (1997)). Moreover, as discussed below, managers face
practical limitations in their ability to "undo" the compensation plan by decreasing risk on their own.
[11] Cairncross (1999)
[12] Gibbons and Murphy (1990) p. 31-S

the effect of performance that derives from factors outside managers' control, such as

industry-wide or market-wide gains or losses.[13]

Options indexed to firm performance are one way to implement a relative-performance-

based compensation system. Until recently, however, the same strong stock market

performance that has rewarded managers for stock price performance unrelated to their

own efforts has also impeded their acceptance of a compensation plan based on relative

performance. Managers were reluctant to give up the potentially huge rewards conferred

by the bull market, especially when they perceived the probability of a downturn in the

stock market as being low.[14] To be sure, relative-performance-based compensation *does*

have the advantage that it protects managers during market downswings. Under

traditional stock option plans, adverse market performance results in vastly reduced

compensation for managers. In contrast, relative-performance based compensation

protects managers against such market downturns; even if the market declines, managers

can still be well-compensated if they outperform their market or industry benchmark.[15]

This protection, of course, is not particularly valuable to managers who view poor stock

market performance as a remote possibility, a view that, at least until recently, seemed to

be the prevailing managerial outlook.

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[13] Of course, as Gibbons and Murphy (1990) rightly note, the industry and market factors that drive the firm's stock price may not be entirely out of the managers control, meaning that removing such effects might not be a perfect mechanism for filtering out factors beyond managers' control. Nonetheless, as Gibbons and Murphy (1990) do in their paper, in this paper I use industry and market movements as a shorthand form for factors outside the control of managers.

[14] The current drop in the prices of technology stocks may alter that perception.

[15] Even under conventional plans, managers have some degree of protection against falling markets. When options move too far out-of-the-money, firms sometimes either re-strike the options, or issue new options

While managerial support for compensation based upon relative performance has so far been sparse, the theoretical underpinnings for this type of compensation are compelling. Murphy (1998) presents the framework supporting performance-based compensation generally, and relative-performance-based compensation more specifically.[16] The justification for relative-performance-based compensation rests upon the observation that the incentive induced by a compensation scheme depends upon how "informative" the measure used to reflect performance is. In other words, an effective managerial incentive system requires a strong link connecting managers' effort and productivity to observable firm performance, and, as Holmstrom (1982) argues, relative-performance-based compensation provides just such a link by allowing principals to extract better information about managerial effort and performance.

C. The extent of relative-performance-based compensation

Relative performance based compensation can take many forms, implicit or explicit, in the manager's compensation contract. A substantial empirical literature explores whether companies' compensation schemes reflect implicit relative performance compensation. Murphy (1998) describes and analyzes much of this literature, reporting that such implicit compensation schemes exist, but may not predominate. Gibbons and Murphy (1990), for example, report that firms do compensate their CEO's based upon relative performance. They find that the salary and bonus of CEOs appeared to be positively and significantly related to firm performance, but negatively and significantly related to market and industry performance. Antle and Smith (1986) and Hall and Liebman (1998) provide

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with lower strike prices. See Carter and Lynch (2001), Jin and Meulbroek (2001),Gilson and Vetsuypens (1993), Chance, Kumar and Todd (2000), Brenner, Sundaram and Yermack (2000), and Saly (1994)

limited evidence that firms compensate managers based upon relative performance, and Himmelberg and Hubbard (2000) observe relative performance evaluation compensation among smaller firms with "less-highly skilled" CEOs. In contrast, Bertrand and Mullainathan (1999) report that CEOs are paid for market-wide and industry movements (what they term "luck"), but the better-governed firms compensate their CEOs less for such movements than other firms. Sloan (1993)'s work also supports the hypothesis that firms base CEO compensation, at least in part, on earnings, as way to help filter market-wide movements from compensation. Other researchers, however, find less evidence of implicit relative performance-based compensation. For instance, Aggarwal and Samwick (1999), investigating pay-performance sensitivities, uncover little evidence that compensation contracts reward relative performance, as do Janakiraman, Lambert and Larcker (1992) and Jensen and Murphy (1990).

Firms are not limited to implicit relative performance plans. Explicit compensation contracts, such as options indexed to an industry or market benchmark, can be used to reward managers for their relative performance. While indexed options are frequently proposed as a straightforward way to measure relative performance, they seem to be little used in practice. Level 3 Communications, a telecommunications company, is currently the only U.S. firm that has implemented an indexed option program, although other firms have made a portion of their compensation (which might consist of restricted stock, conventional option grants or cash bonuses) contingent on achieving certain target stock

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[16] See also Baker, Jensen and Murphy (1988) for a discussion of both relative-performance-based compensation and other compensation structures.

price levels, taking into account overall stock price movements. [17] Boeing, for example,

grants what it calls "performance shares" –restricted stock that vests when the company

performance exceeds the S&P 500. Contributing to the rarity of explicit indexed option

plans is both managers' traditional reluctance to accept this type of compensation and the

accounting treatment of the options (i.e. the value of indexed options are deducted from

the firm's earnings, whereas conventional stock options are not).[18] Rappaport (1999)

discusses this unfavorable accounting treatment of indexed options, suggesting that such

treatment is a misplaced concern: "bad accounting policy should not be allowed to dictate

compensation." The perceived outsized magnitude of recent conventional option grants

has intensified the call for some form of performance indexing. One also imagines that

the current poor performance of the stock market has the potential to diminish the

traditional reluctance of managers to adopt relative-performance-based option plans.

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[17] Level 3 Communications indexed its options to the S&P 500. The Compensation Committee chose the S&P 500 index because it wanted an index immediately recognizable and familiar to its employees and its investors, and immune from manipulation or perceived manipulation by its managers. See Meulbroek (2001b) for a more detailed description of Level 3's indexed option plan.

[18] Hall and Liebman (1998) comment on the rarity of indexed options, characterizing this scarcity as puzzling. Levmore (2000) explores how risk might affect the use of indexed options, and Schizer (2001) points to the tax consequences of indexed options. Murphy (1998) has a detailed discussion of the paucity of indexed options and relative performance plans more generally. Referring mostly to compensation based upon performance relative to co-workers, Gibbons and Murphy (1990) suggest potential costs associated with such relative performance evaluation: "basing pay on relative performance generates incentives to sabotage the measured performance of co-workers (or any other reference group), to collude with co-workers and shirk, and to apply for jobs with inept co-workers." Continuing on, however, they also state that these reasons are less important for top managers, such as CEOs, who "…tend to have limited interaction with CEOs in rival firms, [so] sabotage and collusive searching seem unlikely." Oyer (2000) attributes the lack of observable relative performance evaluation to what he terms the "participation constraint," that is, the market return proxies for the manager's outside opportunities, and one therefore would expect to find the manager's wages correlated with the market return.

D. *The ability and inclination of managers to use financial instruments to create the functional-equivalent of relative-performance-based compensation*

Will managers gravitate towards a relative-performance-based compensation system on their own, without the need for the firm to introduce a formal compensation plan that rewards relative performance? That is, might not managers want to eliminate risk not under their direct control, thereby reducing their overall risk exposure and the vagaries of the market and other factors? We discussed above that a manager might want to retain market exposure if she has a view about the future direction of the market. Even if she has no particular opinion on future market movements, the manager may *still* want to maintain the market component of her risk exposure. Consider the composition of the manager's portfolio. To properly align incentives, the manager must be exposed to firm-specific risk, a forced concentrated exposure that prevents the manager from optimal portfolio diversification. Undiversified managers are exposed to the firm's total risk, but rewarded (through expected returns) for only the systematic portion of that risk. If the manager were able to eliminate the systematic portion of that risk exposure, her sole exposure would be to firm-specific risk, an exposure for which the expected return is the risk-free rate. To the extent that the manager would like to have *some* exposure to systematic risk in her portfolio, given that her wealth is concentrated in the firm's stock and options, she may indeed want to keep the exposure to systematic risk that derives from holding company stock and options without any hedging. More precisely, the only type of "diversification" that she can obtain while her wealth is invested in company stock comes from forgoing financial instruments that would strip away that market

exposure. [19] Consequently, at least some managers will prefer to leave their holdings unhedged to market risk, meaning that the board of directors cannot assume that managers will hedge on their own accounts; if the board wants to compensate managers based upon relative performance, it will need to build such a function into the firm's compensation system.

Even managers who do want to lower their overall risk exposure will find some practical limitations to doing so. One potential way managers might seek to limit their exposure to market risk is to short S&P 500 futures to offset the systematic risk inherent in their long positions in company stock. While a theoretical possibility, in practice, few managers appear to engage in such transactions, perhaps because of the liquidity risk induced by this strategy. That is, managers would have to mark-to-market their S&P 500 positions daily, and post additional margin in case of a market increase, but they would not be able to use their holdings in company stock or options to meet the margin call, making this course of action difficult at best.[20] Managers might also be able to reduce risk through equity swaps (see Bolster, Chance and Rich (1986)), but changes in the tax code have made such swaps considerably less attractive. Finally, managers might use "zero-cost collars" (i.e. sell a call, but a put) to offset much of both their systematic and their firm-

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[19] See Meulbroek (2001c) for further discussion of the effect of relative-performance-based compensation on managers' exposure to systematic and non-systematic risk, and how the risk exposure created by relative-performance-based compensation can cause managers to apply a larger loss-of-diversification discount to indexed options as compared to conventional options. This loss-of-diversification discount will in turn affect the full cost of awarding indexed options to managers.
[20] If the manager's wealth is partially-diversified with wealth both in and outside the company, the manager might be able to scale back existing diversified holdings (e.g. mutual funds) to offset some of the systematic risk of company stock and options. See Jin (2000) and Garvey (1997).

specific risk exposures.[21] For the manager, this action is economically equivalent to selling her position in company stock.[22] This action would almost entirely "undo" the compensation plan by eliminating the risk exposure necessary for incentive alignment, and it is far from clear that the board of directors would allow that elimination, just as they impose restrictions on when and how much stock managers can sell.[23] Thus, managers might prefer the risk exposure offered by a conventional option system, or they may find themselves unable to replicate the effect of a relative-performance-based compensation plan that removes market and/or industry effects. In both instances, a firm desiring to compensate managers with a relative-performance-based system cannot rely upon managers to hedge out market risk; the firm itself must put such a compensation system in place.

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[21] Zero-cost collars are economically similar to selling the stock, but have different tax implications, and seem not to attract the same degree of public scrutiny as simple selling of company stock does. Bettis, Bizjak and Lemmon (2000) describe these contracts, and reports that the number of such transactions reported to the SEC has, so far, been relatively small. Bettis, Bizjak and Lemmon (2000) also find, however, that the SEC's reporting requirements for these transactions have only recently been clarified, so that the true incidence of zero-cost collars is perhaps higher than the historical statistics would suggest. Boczar (1998) describes several (economically-equivalent) methods for an executive to manage risk, and the tax implications of such methods. See also Schizer (2000) on managerial hedging of stock option positions. Hedging of options can be difficult for managers as many firms prevent executive stock options from being pledged as collateral.

[22] This is not strictly true because in order to receive favorable tax treatment, the manager must retain some small degree of risk exposure, but this exposure is rather minor.

[23] In addition to company-specific regulations, SEC regulation precludes managers from short-selling company stock, increases the costs of stock sales by requiring them to be reported directly to the SEC (which then publicly discloses this information), and, in the case of restricted (unregistered) stock, imposes a strict (and low) limitation on the volume of stock that the manager can sell. SeeBettis, Coles and Lemmon (2000) for a description of company-specific policies on insider trading, Meulbroek (1992) for a description of SEC regulations concerning insider trading, and Murray (1992), Van Vleet and Gerber (2000), and Silber (1991) on SEC regulations about restricted stock.

III.   Can options with variable exercise prices be used for relative-performance-based compensation?

Advocates of indexed options generally propose a structure that ties the option's exercise price to a selected index. Rappaport (1999) describes such a plan:

> "Let's assume that the exercise price of a CEO's options are reset each year to reflect changes in a benchmarked index. If the index increases by 15% during the first year, the exercise price of the option would also increase by that amount. The option would then be worth exercising only if the company's shares had gone up by more than 15%. The CEO, therefore, is rewarded only if his or her company outperforms the index."

Table 1 shows how the value of a conventional 10-year European call option responds to changes in the exercise price and the underlying stock.[24] The initial price of the stock in Table 1 is $100, as is the exercise price. The three panels in the table correspond to three possible changes in the exercise price: an increase of 10%, a decrease of 10%, and a no-change scenario. These changes are intended to represent hypothetical fluctuations in the market. Table 1 displays call prices (calculated from the Black-Scholes option-pricing model) for different levels of stock volatility – 30%, 50%, 75%, and 100%.[25] We can see from this table that if the market increases by 10% and the firm's stock increases by 10%, the net-of-market return (i.e. the "outperformance") is exactly zero, yet the price of the conventional European option is exactly 10% higher than its initial baseline level, irrespective of the underlying stock volatility. By examining Panel B, the scenario where exercise price is held fixed, we can see that when the stock price falls by 10% (producing a net-of-market return of –10%), the value of the call option drops by more than 10%: for

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[24] This example is intended to motivate how the sensitivity of option value to different exercise prices might differ from one's initial intuition. Below, I employ the Margrabe-Fischer-Stulz (Margrabe (1978), Fischer (1978), Stulz (1982)) approach to formally value indexed options.

[25] Other assumptions used in pricing the options: the risk-free rate is 4.49% continuously-compounded, the time to expiration is ten years, and the stock pays no dividends.

the stock with 30% volatility, the call option price is 16% lower than its baseline level; a

stock with 50% volatility has a call option price 13% lower than its baseline; stocks with

75% or 100% volatility have prices 11% lower than their baselines. Panel C displays the

scenario with an exercise price 10% below its initial level, representing a fall in the

market index by 10%. We can see that when a stock drops in price by 10% (an amount

exactly matching the market drop), the net-of-market return is zero (suggesting that

managers should be neither rewarded nor punished), but the value of the option still falls

by 10% for all volatility levels. Table 1 shows that the net-of-market return, which

measures whether a firm outperforms its benchmark, can be quite different from the

return on the conventional European call option. This straightforward example suggests

that we need to closely examine the sensitivity of the indexed option with a variable

exercise price, for it may not behave as one might initially expect it to.

To price the type of indexed option proposed by many relative-performance-based

compensation advocates (i.e. an option with a variable exercise price linked to a

benchmarked index, usually interpreted as a market or industry index), one can use the

Margrabe-Fischer-Stulz approach recently outlined by Johnson and Tian (2000). [26] The

Margrabe-Fischer-Stulz formula values a European option to give up an asset worth S_1

and receive in return an asset worth S_2 (for our purposes S_1 represents the firm's initial

stock price adjusted for market and/or industry movements, that is, the strike price of the

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[26] Merton (1973)'s option-pricing model incorporates stochastic interest rates, which is functionally-equivalent to an option-pricing model with a stochastic exercise price. Margrabe (1978) models the option to exchange one asset for another where the value of both assets is stochastic and in contemporaneous work Fischer (1978) prices an indexed bond. Stulz (1982) uses a similar model to price an option on the minimum or the maximum of two risky assets. Johnson and Tian (2000) adopt this approach in their paper on indexed stock options, as do Angel and McCabe (1997).

option; S_2 represents the firm's stock price without any such adjustments). They assume that S_1 and S_2 both follow geometric Brownian motion with volatilities $\boldsymbol{s}_1$ and $\boldsymbol{s}_2$, and that the instantaneous correlation between S_1 and S_2 is $\boldsymbol{r}$, and the yields provided by S_1 and S_2 are q_1 and q_2. $N(\cdot)$ represents the standard normal cumulative distribution function, and T represents the time remaining until option maturity. The value of the option at time zero is then:

$$S_2 \, e^{-q_2 T} N(d_1) - S_1 \, e^{-q_1 T} N(d_2)$$

where

$$d_1 = \frac{\ln(S_2 / S_1) + (q_1 - q_2 + \boldsymbol{s}^2 / 2)T}{\boldsymbol{s}\sqrt{T}}$$

$$d_2 = d_1 - \boldsymbol{s}\sqrt{T}$$

and

$$\boldsymbol{s} = \sqrt{\boldsymbol{s}_1^2 + \boldsymbol{s}_2^2 - 2\boldsymbol{r}\boldsymbol{s}_1\boldsymbol{s}_2}$$

The variable $\boldsymbol{s}$ is the volatility of S_1/S_2. This option price is the same as the price of S_1 European call options on an asset worth S_1/S_2 when the strike price is 1, the risk-free interest rate is q_1, and the dividend yield on the asset is q_2.

As the above equation illustrates, the price of the option increases proportionally to its stock price and its exercise, that is, the option is homogeneous in degree one with respect to the stock price and the exercise price. For example, suppose the stock price increases by 10% (that is, S_2 increases to $1.1 S_2$), and the benchmark index also increases by 10% (S_1 increases to $1.1 S_1$). In this instance, the manager has not outperformed the

benchmark, so the value of the option *should* remain unchanged. However, the value of

an option designed with a variable exercise price does not remain unchanged, as intended

by the proponents of indexed options. Instead, the value of the option *increases* by 10%,

just the effect the proponents of indexed options hoped to eliminate. By substituting the

new prices in the equation above, one can clearly see that this unintended outcome indeed

arises. Specifically, under the newly changed prices, the value of the option will be:

$$(1.1 \times S_2) \, e^{-q_2 T} N(d_1) - (1.1 \times S_1) \, e^{-q_1 T} N(d_2)$$

where d_1 and d_2 remain unchanged. The 1.1 can be factored out, so that the value of the

option after the price movements outlined above is:

$$1.1 \times [S_2 e^{-q_2 T} N(d_1) - S_1 e^{-q_1 T} N(d_2)]$$

or 10% above its initial value. That is, the value of the option has *increased* by 10% even

though the stock *failed* to outperform the market index. The value of this option with an

exercise price linked to market movements is still very sensitive to market movements: it

will increase or decrease along with the market.[27]

This proportionate response of the option price to like changes in the exercise and stock

price defeats the intended outcome. Recall that the proponents of indexed options seek an

instrument that does *not* increase in value when the stock price appreciates the same

amount as the designated index. Therefore, an option with a variable stock price linked to

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[27] Of course, one could generalize the above example. If both the stock and the market increase by α percent, the value of an option with a variable exercise price will increase by α percent. If the stock increases by α percent, and the market increases by β percent, the value of an option with an exercise price linked to the market will *not* increase by α minus β percent. To achieve this goal of having an option that increases in value by α minus β percent, one can use the portfolio approach outlined below. More broadly, an option with a variable exercise price will not be the best way to "adjust" the value of the option for any benchmark. So, for example, if one wanted the link the value of the option so that it changed with the EVA

an index is *not* an effective way to implement a relative performance compensation system. Managers awarded such an option will find that their compensation remains highly sensitive to movements in the underlying index.[28]

To give a more complete sense of the sensitivity of the indexed option value to changes in stock price and market levels, Table 2 illustrates its magnitude for various scenarios. The scenarios for market performance in Table 2 are similar to those in Table 1, discussed above, but Table 2 specifically addresses the value of an indexed option with a variable exercise price linked to a market benchmark, where the Margrabe-Fischer-Stulz approach is used to calculate indexed option values.[29] This approach explicitly incorporates the variability of the exercise price into the calculation of option value. As before, the net-of-market stock return is the extent to which the firm has (or has not) outperformed the market, representing the percentage change in option value hoped for (and expected) by indexed option advocates. Panel A displays the change in indexed option value associated with a 10% market increase. Here we see that if the firm's stock increases by 10% as well (implying that the stock has not outperformed the market), the

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of the firm, one would need to change the value of the underlying asset, instead of the exercise price. The approach outlined below can be modified to reflect any benchmark.

[28] It is possible to alter the terms of an indexed option with a variable exercise price to alter this sensitivity. Level 3 Communications, for instance, uses a "multiplier" in the construction of its outperform options. When the firm's stock return and the index's stock return increase by the same amount, Level 3 multiplies the value of the option by zero. If the firm's stock outperforms the index, the value of the indexed option is multiplied by a number that depends on the degree of outperformance. This construction effectively increases the leverage of the option.

[29] The assumptions used in the option-pricing calculations of Table 2 are that the market volatility level equals 23% (approximate volatility of the S&P500 as well as the market composite index), the firm-market correlation equals 0.48 (approximately equal to the average for NYSE, Amex, and Nasdaq stocks), and the dividend yield of the stock and of the market is zero. With these assumptions, the individual stock volatility levels of 30%, 50%, 75%, and 100% are associated with volatility inputs into the Margrabe-Fischer-Stulz model of 28%, 44%, 67%, and 91%, respectively. The volatility of the indexed option is lower than that of the conventional European option with a fixed exercise price (as in Table 1) because the market is positively correlated with the firm's stock return.

value of the option increases uniformly by 10%, irrespective of volatility level. If the

stock price remains at $100 when the market has increased by 10% (indicating that the

stock has underperformed the market), the value of the indexed option falls, but not by

the amount that the stock underperforms the market. That is, for a stock with a volatility

level of 30%, a market increase of 10% combined with a stock return of 0% (a –10% net-

of-market return), produces a decrease in option value of 9%. The higher the volatility,

the wider the gap between the stock's net-of-market return and return on the options. So,

for the particular scenario of +10% market and 0% stock, the option value for a 50%

volatility-level drops by 5% , half the expected and hoped-for amount, and stocks with an

even higher volatility level of 100% (roughly equal to the volatility of an average

Internet-based stock), the value of the option drops by only 1%. In other words, a

manager at a highly-volatile firm who has underperformed the market by 10% will find

that her options drop in value by only 1%. [30] Table 2, Panel A, also indicates that when

the manager has outperformed the market, the change in option value exceeds the

manger's outperformance. For example, when the stock price increases by 50% (relative

to an overall market increase of 10%), the manager's indexed option value increases by

97% for a 30% volatility-level stock, meaning that the manager's option holdings will

more than double even though the net outperformance of the stock is +40% (= 50%

stock return-10% market return). As volatility increases, this gap decreases, but is still

significantly more than the manager's percent outperformance.

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[30] It is certainly possible that the board of directors wants a financial instrument that increases more than the firm's net-of-market performances when that outperformance is positive, and decreases more than the firm's "outperformance" is negative. Perhaps the most disconcerting quality of an indexed option with a variable exercise price is that it increases in value when the firm's performance matches that of the market (presuming both firm and market have increased—if they both have decreased and the firm's performance matches that of the market, the manager's options will drop in value), that is, when there is absolutely no outperformance.

Panel B of Table 2 illustrates how the value of an indexed option fluctuates when the overall market remains steady. A firm with a stock price that increases by 25% (translating into a net-of-market return of 25% since the market has remained constant) is associated with a change in indexed option value that exceeds 25%. So, if the stock volatility equals 30%, the value of the indexed option increases by 53%, again more than double the manager's outperformance of 25% (25% stock return – 0% market return). For a stock with a volatility level of 50%, the 25% increase in stock price leads to a 38% increase in indexed option value, significantly higher than the sought-after level of 25%. In general, when the market does not change, a stock price decrease results in a decrease in indexed option value that exceeds what indexed option advocates expect, and a stock price increase results in indexed option value that also exceeds the expected increase. In short, indexing to market value by using a variable exercise price does *not* eliminate the manager's exposure to market movements, the outcome expected by proponents of indexing, and can indeed even magnify that exposure.

Finally, Panel C of Table 2 illustrates the changes in indexed option value that occur in a falling market (specifically, a market return of –10%). We see that a manager who neither over- nor underperforms the market suffers a loss equal to 10% of her indexed option holdings when the market falls by 10%, exactly the outcome indexing hopes to prevent. Similar to the results in Panels A and B, Panel C illustrates that the changes in indexed option value are not equal to the relative performance of the firm. To be sure, the changes in indexed option value that accompany the firm's relative performance may well be

those sought after by the firm's compensation committee, but it seems important to understand that the common belief that indexed options with a variable exercise price eliminate the manager's exposure to market and industry conditions that are not under her control is not true.

Why do option prices with variable exercise prices behave so differently from many relative-performance-based advocates expect? One reason is that they are correct if one is willing to make some very restrictive assumptions. Specifically, if the option begins at-the-money with the strike price (S) equal to the exercise price (X), and both the stock price and the exercise price increase by the same amount (say 15%), the *intrinsic* value (value realized upon immediate exercise, equal to S-X) of the option is zero. The option's initial intrinsic value is S-X, which equals zero if the option is at-the-money. After the 15% increase in both stock price and exercise price, the new intrinsic value is (1.15 x (S-X)), which again equals zero if S=X. In any other circumstances (i.e. S>X), the intrinsic value will be 15% greater than it was initially, which is not the effect indexed options advocates intended. Even so, concentrating on the option's intrinsic value ignores the value created by the uncertainty about any movements in the stock price and the exercise price over the option's remaining life. In order to fully capture this value, we must rely upon option pricing model such as the Margrabe-Fischer-Stulz model used in Table 2. When we do so, we find that the value of the indexed option with variable exercise price simply does not perform as intended, even if the option is at-the-money.

Another intuitive explanation behind the market sensitivity of the variable-exercise price option reframes the problem as one of quantity. Suppose one option on a $100 stock with a $100 exercise price is worth $66.33 (as it is in Table 1 for a stock with a volatility of 50%). Now ask how much one should be willing to pay for an option on a $200 of the same stock with a $200 exercise price: it must be exactly twice as much as the first option, or $132.66, for otherwise an arbitrage opportunity would exist. So, in terms of our current problem, how much should one be willing to pay for a $115 stock with an exercise price of $115? Again, it must be 1.15 times the value of the original option, which is the scenario we started with initially (a stock price that increases by 15% and an exercise price that increases by 15%). Hence, the value of an indexed option where the stock price increases by 15% and the market price increases by 15%, will be 15% higher than its initial value.

To remedy this outcome, and restore the link between relative performance and changes in the value of managers' option portfolios, I depart from the standard approach of using an option with a variable exercise price. In the work to follow, I use an indexed portfolio-based approach to solve for an option that is *not* sensitive to movements in the index, referring to this proposed solution as an option on a "Performance-Benchmarked Portfolio," where the value of this portfolio is hedged against changes in the designated index.

IV. Designing a Relative Performance Compensation System

One way to devise an option plan that rewards managers only for their relative performance is to base the option on a *portfolio* whose value depends upon relative performance. The idea underlying the portfolio-based indexed option, which I refer to as an option on a *Performance-Benchmarked Portfolio* is straightforward. The value of this portfolio is initially set to the firm's stock price. The value of the portfolio then either increases by the percentage that the firm outperforms its market- or industry-benchmark or decreases by the percentage that the firm underperforms its market- or industry-benchmark. The exercise remains fixed and, following standard practice, equals the firm's stock price at the time the option is awarded.

Notation:

Let $\quad e^{r_f} \equiv (1 + R_f)$ where R_f represents the riskless arithmetic return, and r_f is

therefore its continuously-compounded equivalent.

$e^{r_j} \equiv (1 + \text{yearly expected rate-of-return of security } j \text{ under CAPM pricing})$

$e^{r_i} \equiv (1 + \text{yearly expected rate-of-return for industry } i \text{ under CAPM pricing})$

$(r_m - r_f) \equiv$ market risk premium (continuously-compounded)

$r_m \equiv$ expected market return (continuously-compounded)

$s_m \equiv$ market volatility

$b_j \equiv$ firm j's beta from CAPM

$s_j \equiv$ firm j's volatility

$s_i \equiv$ industry i's volatility

$b_i \equiv$ industry i's beta relative to the market

$r_{jm} \equiv$ correlation between firm j returns and market returns

$r_{im} \equiv$ correlation between industry i returns and market returns

$h_{ji} \equiv$ correlation between industry i's returns and firm j's ex-market

returns

We assume that CAPM in continuous-time obtains[31], so

$$r_j = r_f + b_j \left(r_m - r_f \right) \tag{1}$$

$$r_i = r_f + b_i \left(r_m - r_f \right) \tag{2}$$

A. Designing a Portfolio Hedged Against Market Movements

Let the value of a portfolio of the firm's equity return hedged against market movements

be denoted:[32]

$P_j(t) \equiv$ value of the "ex-market" portfolio for stock j

where "ex-market" means that the portfolio is hedged against market movements.

Consider a strategy that is long the stock and short the market, and is constructed to have

a zero-beta. Specifically, the portfolio, P_j, is long fraction 1.0 in stock j, short fraction b_j

in the market, and is long fraction b_j in the riskless asset, as displayed in Figure 1.

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[31] This assumption is consistent with the underlying assumption of the Black-Scholes-Merton option-pricing model, which we use later to value the executive stock options. Unlike the original single-period discrete-time version of the CAPM, the continuous-time version of the CAPM and its implied mean-variance optimizing behavior is consistent with limited-liability, lognormally-distributed asset prices, and concave expected utility functions. See Merton (1992) and Black and Scholes (1973). In the Black-Scholes model, and in continuous-time portfolio theory, the security market line relation is expressed in "instantaneous" expected-rates-of-return (i.e. exponential, continuous-compounding). Use of the CAPM in this derivation is not essential; any asset-pricing model could be substituted.

[32] While we do not show the derivation here, one could, in a similar fashion, construct a portfolio hedged solely against industry-wide movements.

Establishing the Market-Adjusted Portfolio at time t=0		
Asset	**Long Position**	**Short Position**
Stock	V_j	
Market		$-\boldsymbol{b}_j V_j$
Riskless Asset	$\boldsymbol{b}_j V_j$	
Cost of Long or Short Position	$V_j + \boldsymbol{b}_j V_j$	$-\boldsymbol{b}_j V_j$
Total Portfolio Value	V_j	

Figure 1: Initial market-adjusted portfolio

This construction creates a portfolio hedged against market movements, with the

following expected return and volatility:

$$\frac{dP_j}{P_j} = r_f\, dt + \boldsymbol{s}_j \boldsymbol{g}_j\, d\boldsymbol{e}_j \tag{3}$$

where $\boldsymbol{g}_j \equiv \sqrt{\left(1 - \boldsymbol{r}_{jm}^2\right)}$

The standard deviation of this portfolio is $\boldsymbol{s}_j \sqrt{\left(1 - \boldsymbol{r}_{jm}^2\right)}$, the cost of establishing this

portfolio is $V_j(t)$ (firm j's stock price), and the expected return on this zero-beta portfolio

is the risk-free rate, r_f.

Value of the Market-Adjusted Portfolio at time t=1		
$\bar{r}_j \equiv$ realized return for firm j; $\bar{r}_m \equiv$ realized return of the market		
Asset	**Long Position**	**Short Position**
Stock	$V_j(1+\bar{r}_j)$	
Market		$-\boldsymbol{b}_j V_j(1+\bar{r}_m)$
Riskless Asset	$\boldsymbol{b}_j V_j(1+r_f)$	
Value of Long or Short Position	$V_j(1+\bar{r}_j) + \boldsymbol{b}_j V_j(1+r_f)$	$-\boldsymbol{b}_j V_j(1+\bar{r}_m)$
Total Portfolio Value	$V_j\left[1 + \left(\bar{r}_j - \beta_j\left(\bar{r}_m - r_f\right)\right)\right]$	

Figure 2: The market-adjusted portfolio after one period

As Figure 2 illustrates, the one-period realized return on this portfolio can therefore be

expressed as $\bar{r}_j - \boldsymbol{b}_j\left(\bar{r}_m - r_f\right)$, that is, the firm return net of the appropriate market risk

premium, where the bar above the returns $\bar{r}_j$ and $\bar{r}_m$ represents the actual return from time

0 through 1.

Does this portfolio hedged against market movements increase in value only if the firm's

performance exceeds its market benchmark? Consider our earlier test using the variable

exercise approach to designing an indexed option. We found that if the stock price

increased by 10% and the market increased by 10% (leading to an exercise increase of

10%), the value of the option would also increase by 10%. Following this example and

using the market as a benchmark, we find that under the proposed alternative design the

value of the underlying asset (the portfolio hedged against market movements) remains

unchanged.[33] Specifically, the long position in the stock increases in value by 10%, and the short position in the market exactly offsets this increase with its own 10% value decrease. Hence, the value of managers' options remains unchanged, and in general, the value of the option on this performance-benchmarked portfolio will not change unless the firm's performance exceeds its market benchmark.

B. *Designing a Portfolio Hedged against both Industry and Market Movements*

The performance-benchmarked portfolio described above removed only the effect of market movements on the firm's stock price. The performance-benchmarked portfolio presented in this section removes the effect of both industry and market returns on firm j's returns, and its value therefore depends solely upon firm $j's$ idiosyncratic risk. To implement such a portfolio, one goes long the stock, and short both the market, and the industry "ex-market" (that is, the industry after the market component has been removed). Specifically, the market- and industry-adjusted portfolio has fraction 1 in stock j, fraction

b_j short in the market portfolio, fraction $\dfrac{g_j s_j h_{ji}}{g_i s_i}$ short in the industry (ex-market)

portfolio, and $\left[\dfrac{g_j s_j h_{ji}}{g_i s_i} + b_j\right]$ in the riskless asset, where $g_j \equiv \sqrt{1 - r_{jm}^2}$ and

$g_i \equiv \sqrt{1 - r_{im}^2}$.

Equivalently, one can express the portfolio in terms of the unadjusted industry portfolio, rather than the "industry ex-market" portfolio. So, in these terms, the market- and

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[33] To maintain symmetry with the variable exercise option example, the market-adjusted portfolio is structured as if the beta of the stock equals one.

industry-adjusted portfolio contains fraction 1.0 in stock j,

$$\boldsymbol{b}_j\left[1-\left(\frac{\boldsymbol{b}_i}{\boldsymbol{b}_j}\right)\left(\frac{\boldsymbol{s}_j}{\boldsymbol{s}_i}\right)\sqrt{\frac{1-\boldsymbol{r}_{jm}^2}{1-\boldsymbol{r}_{im}^2}}\ \boldsymbol{h}_{ji}\right]$$ short in the market, fraction $\dfrac{\boldsymbol{g}_j\boldsymbol{s}_j\boldsymbol{h}_{ji}}{\boldsymbol{g}_i\boldsymbol{s}_i}$ short in the

industry portfolio, and $\left[\dfrac{\boldsymbol{g}_j\boldsymbol{s}_j\boldsymbol{h}_{ji}}{\boldsymbol{g}_i\boldsymbol{s}_i}+\boldsymbol{b}_j\right]$ in the riskless asset.

Figure 3 displays the market- and industry-adjusted performance-benchmarked portfolio

strategy.

Establishing the Market-and Industry-Adjusted Portfolio at time t=0		
Asset	**Long Position**	**Short Position**
Stock	V_j	
Market		$-\boldsymbol{b}_j V_j$
Industry (ex-market)		$-\dfrac{\boldsymbol{g}_j\boldsymbol{s}_j\boldsymbol{h}_{ji}}{\boldsymbol{g}_i\boldsymbol{s}_i}V_j$
Riskless Asset	$\left[\dfrac{\boldsymbol{g}_j\boldsymbol{s}_j\boldsymbol{h}_{ji}}{\boldsymbol{g}_i\boldsymbol{s}_i}+\boldsymbol{b}_j\right]V_j$	
Cost of Long or Short Position	$V_j+\left[\dfrac{\boldsymbol{g}_j\boldsymbol{s}_j\boldsymbol{h}_{ji}}{\boldsymbol{g}_i\boldsymbol{s}_i}+\boldsymbol{b}_j\right]V_j$	$-\boldsymbol{b}_j V_j-\dfrac{\boldsymbol{g}_j\boldsymbol{s}_j\boldsymbol{h}_{ji}}{\boldsymbol{g}_i\boldsymbol{s}_i}V_j$
Total Portfolio Value	V_j	

Figure 3: Cost of establishing market- and industry-adjusted portfolio

Thus, letting $P_j^*(t)$ represent the value of this "stock j - indexed" portfolio, the expected

return and volatility are denoted:

$$\frac{dP_j^*}{P_j^*}=r_f\ dt+\boldsymbol{s}_j'\ dq_j \tag{4}$$

where dq_j is uncorrelated with the industry and the market portfolios and

$$s'_j \equiv \left(g_j d_j \right) s_j$$

$$g_j \equiv \sqrt{1 - r_{jm}^2}$$

$$d_j \equiv \sqrt{1 - h_{ji}^2}$$

The standard deviation of this market- and industry-adjusted performance-benchmarked

portfolio is therefore:

$$s'_j = s_j \sqrt{\left(1 - r_{jm}^2\right)\left(1 - h_{ji}^2\right)}$$

The cost of establishing the portfolio is $V_j(t)$ (the stock price of firm j) and the expected

return is the risk-free rate.

<table>
<tr><td colspan="3">

Value of the Market- and Industry-Adjusted Portfolio at time t=1

$\bar{r}_j \equiv$ realized return for firm j

$\bar{r}_m \equiv$ realized return of the market

$\bar{r}_i \equiv$ realized return on the industry ex-market portfolio
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Asset	Long Position	Short Position
Stock	$V_j(1+\bar{r}_j)$	
Market		$-b_j V_j(1+\bar{r}_m)$
Industry (ex-market)		$-\dfrac{g_j s_j h_{ji}}{g_i s_i}V_j(1+\bar{r}_i)$
Riskless Asset	$\left[\dfrac{g_j s_j h_{ji}}{g_i s_i}+b_j\right]V_j(1+r_f)$	
Value of Long or Short Position	$V_j(1+\bar{r}_j)+\left[\dfrac{g_j s_j h_{ji}}{g_i s_i}+b_j\right]V_j(1+r_f)$	$-b_j V_j(1+\bar{r}_m)-\dfrac{g_j s_j h_{ji}}{g_i s_i}V_j(1+\bar{r}_i)$
Total Portfolio Value	$V_j\left[1+\left(\bar{r}_j-\beta_j\left(\bar{r}_m-r_f\right)-\left(\dfrac{?_j s_j ?_{ji}}{?_i s_i}\left(\bar{r}_i-r_f\right)\right)\right)\right]$	

Figure 4: Realized value of the market- and industry-adjusted portfolio after one period

Thus, as illustrated in Figure 4, the one-period realized return on the market- and industry-adjusted portfolio is $\bar{r}_j-b_j\left(\bar{r}_m-r_f\right)-\left(\dfrac{g_j s_j h_{ji}}{g_i s_i}\left(\bar{r}_i-r_f\right)\right)$, which is the firm return net of the market risk premium and net of the return that is correlated with the industry. One can again confirm that the value of the performance-benchmarked portfolio increases only if the firm's stock price movement exceeds its industry and market benchmarks. The appendix details the derivation of this portfolio.

In sum, "indexed options" as popularly envisioned with a variable exercise price reward managers for performance unrelated to their efforts. Performance-benchmarking the portfolio using the straightforward modifications to the option structure described above *does* have the desired properties of a relative-performance based compensation scheme. These proposed modifications require an option using a market- and/or industry-adjusted performance-benchmarked portfolio as the underlying asset. For the remainder of the paper, I refer to this "indexed portfolio" structure as an "option on a performance-benchmarked portfolio", or a "performance-benchmarked indexed option," or simply the "indexed-portfolio option." Even though the option on the performance-benchmarked portfolio differs in form from an indexed option with a variable exercise price, both structures have the same conceptual goal, that is, to reward relative performance.

C. Valuing the Option on the Performance-Benchmarked Portfolio

Because the exercise price of an option on the performance-benchmark portfolio is fixed, the Margrabe-Fischer-Stulz option approach outlined above earlier for the indexed option with a variable exercise price reduces to the familiar Black-Scholes option-pricing formula typically used to price conventional executive stock options. The application of the Black-Scholes formula to the option on the performance-benchmarked portfolio differs from the conventional application only in that the volatility figure required as an input to the formula is the volatility of the performance-benchmarked portfolio, rather than the volatility of the stock alone. All other inputs into the Black-Scholes option pricing formula remain identical to the inputs to the Black-Scholes formula as applied in the conventional case, provided that the option on the performance-benchmarked portfolio is struck at-the-

money (as it would typically be in the conventional stock option program), and that the initial value of the portfolio is set equal to the value of stock.

Notice that the volatility of the performance-benchmarked portfolio is lower than that of the firm's stock. This inequality arises because the performance-benchmarked portfolios, by design, remove the portion of volatility that comes from market and/or industry movements. Mathematically, the specific volatility levels of the market and/or industry-adjusted performance-benchmarked portfolios are:

$$\boldsymbol{s}_{market-adjusted\,port\,j} \; = \; \boldsymbol{s}_{j}\sqrt{\left(1-\boldsymbol{r}_{jm}^{2}\right)}$$

$$\boldsymbol{s}_{marketandindustryadjusted\,port\,j} \; = \; \boldsymbol{s}_{j}\sqrt{\left(1-\boldsymbol{r}_{jm}^{2}\right)\left(1-\boldsymbol{h}_{ji}^{2}\right)}$$

where $\boldsymbol{s}_{j}$ is the volatility of stock j. Since $\boldsymbol{r}_{jm}^{2}$ and $\boldsymbol{h}_{ji}^{2}$ are both less than one, [34] we have that:

$$\boldsymbol{s}_{j} \; < \; \boldsymbol{s}_{j}\sqrt{\left(1-\boldsymbol{r}_{jm}^{2}\right)} \; < \; \boldsymbol{s}_{j}\sqrt{\left(1-\boldsymbol{r}_{jm}^{2}\right)\left(1-\boldsymbol{h}_{ji}^{2}\right)} \quad \Rightarrow$$

$$\boldsymbol{s}_{j} \; < \; \boldsymbol{s}_{market-adjusted\,port\,j} \; < \; \boldsymbol{s}_{marketandindustryadjusted\,port\,j}$$

The lower volatility level of the performance-benchmarked portfolio has two related implications. First, the lower volatility level of the performance-benchmarked portfolio decreases the manager's risk exposure, at least on a per option basis. Table 3 provides some sense of how sizeable the effects of removing market- and/or industry-related volatility might be for industries defined by Value Line's *Investment Survey* and for

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[34] This ignores the case where either $\boldsymbol{r}_{jm}^{2}$ and $\boldsymbol{h}_{ji}^{2}$ exactly equal one, but for our purposes, these instances are not particularly interesting, because if the stocks were perfectly correlated to market and/or industry, then awarding stock options would be a poor way to create incentive alignment, as they do not expose the manager to any firm-specific risk (meaning risk under her control).

Internet-based firms identified by Hambrecht and Quist's (H&Q) Internet Index (firms included are those covered by Value Line or in H&Q's index as of December 31, 1998).[35]

For each industry, the table displays mean and median values for total firm volatility (s_j), industry volatility (s_i, defined as the volatility of the specified value-weighted industry index), the correlation between the firm and the market (r_{jm}), with the market defined as CRSP's Value-Weighted Composite Index), and the correlation between the firm and the industry after removing market effects (h_{ij}). For the entire set of Value Line firms, the mean firm volatility is 52%, and the mean correlation between firm and market returns is 0.48, suggesting that on average roughly 23% ($=(0.48)^2$) of volatility in daily firm returns derives from systematic sources, and the mean correlation between firm and ex-market industry returns is 0.28, so an additional 8% of the remaining volatility is due to industry effects ($=(0.28)^2$).[36] Benchmarking therefore has the potential to reduce the manager's risk exposure by a significant amount, although the manager will still be exposed to substantial idiosyncratic risk. while the majority of volatility appears to be idiosyncratic, benchmarking the portfolio to market and/or industry should relieve the manager from bearing at least some risk. Together, these numbers suggest that benchmarking the portfolio to market and/or industry should relieve the manager from bearing at least some risk, but much of a stock's volatility is not industry or market

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[35] Value Line's industry classifications are widely-held to be more accurate than industries formed using SIC codes. The database of firms and their industry classifications used in this paper are provided by Erik Stafford and Gregor Andrade, and is described in Stafford (2001). This paper updates that database through year-end 1998 The Stafford-Andrade Value Line data lists all firms and industry assignments collected from fourth quarter editions of Value Line, excluding foreign industries (e.g. "Japanese Diversified" or "Canadian Energy"), ADR's, REIT's, investment funds, and firms with industry classifications of "unassigned" or "recent additions" that are not subsequently assigned to an industry by Value Line. The database uses Value Line's industry classifications, with a few exceptions. For example, industries that differ merely by geographic classifications (e.g., "Utilities (East)" and "Utilities (West)") are merged into one classification; industries where the product lines seem particularly similar (e.g., "Auto Parts (OEM)" and "Auto Parts (Replacement)") are also combined into one category. In total, the sample consists of 1496 Value Line firms classified into 56 industries. The beta estimates for each firm use the market model, incorporating the last 150 trading days of returns data prior to December 31, 1998, and using CRSP's value-weighted market composite index. The same 150 trading days of returns data are used to estimate each individual firm's volatility, σ_j, as well as the market's volatility, σ_m, calculated from CRSP's value-weighted market composite index. Continuously-compounded daily excess returns (net of daily riskless rates) are used in all calculations. The Value Line industry components over the six-month period ending December 31, 1998 are used to create both value-weighted and equal-weighted daily industry returns.

related, meaning that the manager will still bear significant firm-specific risk even if options are performance-benchmarked, that is, indexed. [37]

The second effect of the lower volatility level of the performance-benchmarked portfolio relative to a conventional executive stock option is that the market value of the performance-benchmarked option will be lower than that of the conventional option on the firm's stock. Many proponents of indexed options have therefore advocated that the number of indexed options awarded to the manager be increased relative to the number of options that would otherwise be awarded in a traditional executive stock option program, an increase designed to equate the manager's dollar amount of option-based compensation. [38] Underlying this equation of the dollar amount of compensation awarded by the two systems is the notion that the proposed re-design of option-based compensation system should not be a back-door way to lower the manager's compensation, but is instead intended to change the type of incentive given managers.

There are other ways, however, to hold constant the dollar amount of compensation given the managers, and good reason to explore these other choices. More specifically, whenever the firm can decrease the amount of equity-based compensation (which would include, of course, indexed options or options on the performance-benchmarked portfolio) without impairing the degree of incentive-alignment, it has an opportunity to increase shareholder value. This opportunity results from the gap between the firm's cost to produce executive stock options (i.e. their market value), and the value that managers place on those options. [39] Managers will always value their stock and option-based

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[36] The median correlation between firm and ex-market industry returns is a bit lower at 0.23, suggesting that 5% of the remaining volatility is due to industry effects.

[37] It is not obvious that removing systematic risk is optimal from the manager's perspective, since the manager gets "compensated" through expected returns for bearing that risk, leaving the manager with a purely idiosyncratic exposure. See Meulbroek (2001a) for a discussion of the effect of idiosyncratic and systematic risk and how they affect the private value that managers place on stock and options, and Jin (2000) for an analysis of managers' utility from the two different types of risk. Meulbroek (2000) describes compares the efficiency of conventional and market and/or industry benchmarked options in terms of these differential risk exposures.

[38] See, for example Akhigbe and Madura (1996), Barr (1999), Johnson (1999), Johnson and Tian (2000), Kay (1999), Nalbantian (1993), Rappaport (1999), Reingold (2000), Schizer (2001).

[39] The wedge between the firm's cost and the manager's private value is widely-recognized in the principal-agent literature. See, for example, Murphy (1998), Carpenter (1998), and Detemple and Sundaresan (1999).

compensation at less than its market value because the same exposure to firm-specific risk that properly aligns incentives also leaves them with less-than-fully-diversified investment portfolios. [40] Since undiversified managers are exposed to the firm's total risk, but rewarded (through expected returns) for only the systematic portion of that risk, managers will value stock or option-based compensation at less than its market value. The firm, then, always faces a tradeoff between the benefits attained through incentive alignment and the deadweight cost of paying managers in a currency that is worth less to them than its cost to the firm. Cash compensation, for example, is perfectly efficient in the sense that its cost to the firm is identical to the value managers place on it, but it does not have the benefit of aligning managers' incentives with those of shareholders.

In related work (Meulbroek (2001c)), I explore in greater detail the possibility of equating compensation levels across the two types of plans by supplement the grant of options on the performance-benchmarked portfolios with a "market-value-equivalent" amount of cash compensation, that is, the amount required to bring the manager's total compensation level up to the market value of a conventional option. Meulbroek (2001c) shows that the market-value-equivalent cash supplement increases the efficiency of a market or industry-adjusted option plan by allowing the manager to diversify her holdings a bit, boosting efficiency. So, assuming that the option on a performance-benchmarked portfolio were to maintain or even improve the degree of incentive alignment per option granted, the firm would be better off by supplementing the award of options on performance-benchmarked portfolios with the market-value-equivalent

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Meulbroek (2001a) explores how different types of risk (i.e. systematic versus idiosyncratic) impose different costs on the manager: the manager is "compensated" through market returns for systematic risk, but not compensated for holding idiosyncratic risk. Meulbroek (2000) specifically examines the costs of systematic and idiosyncratic risk in the context of indexed options. Other factors, beyond the scope of this paper, can contribute to the costs borne by the firm when awarding executive stock options. One example of such a cost is the additional agency costs that may arise when managers alter the firm's investment profile in non-value creating ways in order to lower their total level of risk. Carpenter (2000) formally models this problem. Jin (2000) shows that firms appear to recognize this deadweight loss: empirically, the pay-to-performance sensitivity is decreasing in firm-specific risk, but not in systematic risk.

[40] One might even argue that managers' wealth is not fully-diversified even before considering the composition of their securities portfolios as at least some of their human capital may be specific to their employer.

amount of cash, instead of issuing additional options to equate the value of the two compensation plans.[41]

Table 4 illustrates the cost difference between a conventional executive stock option and the option on the performance-benchmarked portfolio, providing aggregate statistics for both Value Line industries and H&Q Internet-based firms. The average (across Value Line industries) value of an option on a portfolio that removes market risk is 93% of the value of a conventional stock option. By removing industry effects as well, that ratio decreases to 89%.

V. Conclusions

Current market volatility has strengthened the call for indexed options, that is, options whose payoff is linked to some sort of market or industry-based index. Indexed options compensation, assert its proponents, tightens the link between managerial efforts and compensation by removing overall stock market gains (or losses), or perhaps industry-level gains (or losses) from managers' compensation. With the recent derailment of the long-running bull stock market has come an increasing effort to both re-align the incentives of and retain managers who have been left with out-of-the-money, or "underwater," options.[42] Indexing option payoff to a market or industry benchmark holds the promise of awarding managers options that automatically adjust to movements in the designated benchmark, without the need for the ex-post adjustments to exercise prices or additional option grants that chafe at shareholders. So far, however, only one U.S.

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[41] It is not obvious how the incentive effects of an indexed or performance-benchmarked option should be measured. The traditional estimate of the strength of the incentive effect produced by an option is its delta, that is, the first derivative of option value with respect to stock value. Delta answers the question of how much the managers' options will increase in value when the stock price increases. What delta does not incorporate is the benefit of getting rid of the "wrong" incentive: the incentive to increase the firm's exposure to market risk in order to boost the stock price.

company, Level 3 Communications, has put an indexed option plan into place, in part

because the quondam strength of the market made managers reluctant to adopt

compensation plans that would deprive them of the seemingly-unending bounty offered

by the bull market.

Proponents of indexed options typically suggest a structure where the option's exercise

price varies with a benchmark market or industry index.[43] Rappaport (1999) describes

such a plan:

> "Let's assume that the exercise price of a CEO's options are reset each year to reflect changes in a benchmarked index. If the index increases by 15% during the first year, the exercise price of the option would also increase by that amount. The option would then be worth exercising only if the company's shares had gone up by more than 15%. The CEO, therefore, is rewarded only if his or her company outperforms the index."

While the intention motivating such an option is clear, the actual result of using an option

with a variable exercise price falls far short of the mark. In fact, the value of the option

increases by 15%, right in line with the 15% increase in both the stock and the market.[44]

In this paper, I generalize this example showing that when an indexed option plan has a

variable exercise price, the structure typically envisioned by its advocates, its value is *still*

sensitive to the very market and industry movements that it was designed to eliminate. To

remedy this unintended outcome, I propose an alternative option structure that has as its

underlying asset uses a zero-beta *portfolio* hedged against those price movements, such

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[42] See Jin and Meulbroek (2001) for an empirical analysis of how recent market movements have affected the ability of options to retain and motivate managers.

[43] See footnote 1 for a variety of sources that describe just such a structure, that is, an option where the exercise price varies with a market or industry-based benchmarked index.

[44] The intrinsic value of a stock option is the stock price minus the exercise price. The Black-Scholes option-pricing model is one way to incorporate the additional value that accrues due to the possibility that the stock price might increase before option maturity.

as market or industry movements, thought to be outside of managers' control. The value of the *portfolio* varies to reflect the stock's performance net of market and/or industry effects, but the *exercise* price of the option on the portfolio remains fixed. I then show that this "performance-benchmarked portfolio" performs as intended, effectively removing the effects of market or industry performance from the value of the option.

I also empirically compare the volatility of the performance-benchmarked portfolio (adjusted for CRSP value-weighted market composite and Value Line value-weighted industry movements) to the volatility of the stock alone. Adjusting the option's payoff for market and/or industry performance indeed reduces the overall volatility of the performance-benchmarked portfolio relative to that of the stock by an average of 30%. This comparison of manager's risk exposure in a traditional stock option program and in the relative-performance-based compensation plan using options on the performance-benchmarked portfolio, however, is incomplete without considering how other aspects of a firm's compensation plan might change if a relative-performance-based compensation plan were adopted. For example, advocates of indexed options, seeking to hold the dollar amount of option grants constant, frequently recommend that compensation committees boost the number of performance-benchmarked options over the number they would have otherwise awarded in a conventional stock option program. If this recommendation is implemented, the manager's total risk exposure will also change, and the volatility per share comparison described above is no longer appropriate.

The magnitude of the manager's risk exposure per se is not the only aspect of the compensation plan that firms considering adopting a relative-performance based option plan must address. An indexed option plan, if successfully designed, tightens the link between managerial pay and performance. With this greater degree of incentive alignment, the firm's optimal mix between cash and equity-based compensation may shift. Indeed, if the incentive alignment gains from moving to a performance-benchmarked plan are large enough, the firm can produce the same degree of incentive alignment using *fewer* options, making up the difference between the former dollar amount of compensation awarded and the value of the new options with cash. Cash, of course, does not align incentives, but it does allow managers more freedom to invest as they see fit, perhaps investing in the market to at least partially-diversify their holdings, or investing in treasuries (the riskless asset) to lower the overall level of risk they must bear. The more equity-based compensation a manager receives, the less well-diversified a manager is and the higher the discount from market value the manager applies to that compensation. If the new performance-benchmarked options lower the cost to create a given level of incentive alignment, by supplementing the options with more cash, the firm might be able to decrease the gap between the firm's cost to produce executive stock options (i.e. their market value), and the value that less-than-fully-diversified managers place on those options. [45] While a better understanding of the costs and benefits of

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[45] The wedge between the firm's cost and the manager's private value is widely-recognized in the principal-agent literature. See, for example, Murphy (1998), Carpenter (1998),and Detemple and Sundaresan (1999). Meulbroek (2001a) explores how different types of risk (i.e. systematic versus idiosyncratic) impose different costs on the manager: the manager is "compensated" through market returns for systematic risk, but not compensated for holding idiosyncratic risk. Meulbroek (2000) specifically examines the costs of systematic and idiosyncratic risk in the context of indexed options. Other factors, beyond the scope of this paper, can contribute to the costs borne by the firm when awarding executive stock options. One example of such a cost is the additional agency costs that may arise when managers alter the firm's investment profile in non-value creating ways in order to lower their total level of risk. Carpenter (2000) formally

performance-benchmarked options is needed before a compensation committee can decide on the optimal amount of cash and equity-based compensation, it seems safe to assume that this mix will not remain at its former level.

Other important implementation details must also be considered. One such factor is the choice in benchmark index, which we have discussed in the context of a market- and/or industry-adjusted index in this paper. Theory advises an index that filters out the elements of performance that are beyond a manager's control, yet practicality suggests that the index must be one that managers and employees recognize, understand, and is beyond the reach of manipulation or the perception of manipulation by the recipients of the options. These considerations prompted Level 3 Communications, a pioneer in introducing indexed options, to choose the S&P 500 as its benchmark index when it first introduced its "outperformance options." The precipitous decline in the telecommunications industry, however, far outweighed the movement in the S&P 500, leaving Level 3's managers and employees exposed to enormous risk despite the adoption of an indexed option plan.[46] If relative-performance-based options do become more widely-adopted, one would imagine that firms will find it easier to adopt an industry-specific index either to supplement or replace a broader-based market index.

In sum, the indexed option, while straightforward in concept, must be carefully structured so as to achieve the goal of rewarding relative-performance-based compensation If the

models this problem. Jin (2000) shows that firms appear to recognize this deadweight loss: empirically, the pay-to-performance sensitivity is decreasing in firm-specific risk, but not in systematic risk.
[46] From March 2000 through August 2001, the S&P 500 lost 18% of its value; over the same time period, the Nasdaq Telecommunications Index fell 80%.

compensation committee does move forward with an indexing scheme, it should avoid a

structure that links the *exercise price* with the benchmark index, instead relying upon an

option on an appropriate *performance-benchmarked portfolio* with a *fixed* exercise price

as outlined above. As a practical matter, benchmarking to the market without considering

industry effects may not always result in a plan that removes the major sources of

volatility outside managers' control. Finally, as the compensation plan is restructured to

reflect relative-based-performance compensation, other features, such as the optimal mix

between options and cash, must be re-evaluated, for adopting such a plan is likely to

change that balance.

Appendix

This appendix details the derivation of the market- and industry-adjusted portfolio for stock j. The derivation has two steps. First we create a portfolio for industry that is hedged against the market (referred to in the text as the industry ex-market portfolio).[47] Then we use the industry ex-market portfolio to create the stock j portfolio hedged against market and industry effects.

Terminology and definitions:

$V_j(t)$ denote the price of stock j at time t

$V_m(t)$ denote the value of a market portfolio (with all dividends reinvested)

$V_i(t)$ denote the value of an industry portfolio (with all dividends reinvested for

  stock j's industry)

$$\frac{dV_j}{V_j} = r_j\, dt + \boldsymbol{s}_j\, dZ_j \tag{1}$$

$$\frac{dV_m}{V_m} = r_m\, dt + \boldsymbol{s}_m\, dZ_m \tag{2}$$

$$\frac{dV_i}{V_i} = r_i\, dt + \boldsymbol{s}_i\, dZ_i \tag{3}$$

CAPM (continuous-time) obtains so,

$$r_j = r_f + \boldsymbol{b}_j\left(r_m - r_f\right) \tag{4a}$$

where $\boldsymbol{b}_j = \dfrac{\mathrm{cov}\left(dZ_j, dZ_m\right)\boldsymbol{s}_j}{\boldsymbol{s}_m}$, $\boldsymbol{r}_{jm} =$ correlation between firm j's

returns and the market return, which is equal to $\mathrm{cov}\left(dZ_i, dZ_m\right)$.

$$r_i = r_f + \boldsymbol{b}_i\left(r_m - r_f\right) \tag{4b}$$

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[47] Note that the derivation of the stock j market-adjusted portfolio exactly parallels that of the industry ex-market portfolio detailed below (substitute stock *j* for industry *i* in the proof).

where $b_i = \dfrac{\text{cov}(dZ_i, dZ_m)\ s_i}{s_m}$ and r_{im} = correlation between industry and

market returns $= \text{cov}(d\,Z_i, d\,Z_m)$

A. Create A Portfolio for Industry (hedged against the market)

Let $P_i(t) =$ value of this (ex-market) portfolio for industry

We can decompose dZ_i into a component correlated with the market and a component

uncorrelated with the market:

$$dZ_i \equiv r_{im}\, dZ_m + g_i\, de_i \qquad\qquad (5)$$

where de_i is defined by (5), where $g_i \equiv \sqrt{\left(1 - r_{im}^2\right)}$ and where $\text{cov}(de_i,\ dZ_m) = 0$

From (3) and (5),

$$\dfrac{dV_i}{V_i} \;=\; r_i dt + s_i\, r_{im}\, dZ_m + s_i g_i\, de_i \qquad\qquad (6)$$

Suppose we create a portfolio with a strategy in which we invest

i)   fraction $1.0\ (= 100\%)$ long in industry portfolio i

ii)   fraction w_i short in the market portfolio

iii)   fraction w_i long in the riskless asset.

If P_i = value of the portfolio, then

$$\dfrac{dP_i}{P_i} \;=\; \dfrac{dV_i}{V_i} \;-\; w_i\!\left(\dfrac{dV_m}{V_m} - r_f\ dt \right)$$

$$\hspace{4em} (7)$$

$$\;=\; \left(r_i - w_i\left(r_m - r_f \right) \right) dt \;+\; \left(s_i\, r_m - w_i\, s_m \right) dZ_m \;+\; s_i g_i\, de_i$$

If we set $w_i = b_i = \dfrac{s_i r_{im}}{s_m}$, then from (7) and (4b), the return on the (ex-market) industry portfolio is

$$\frac{dP_i}{P_i} = r_f\, dt + s_i\, g_i\, de_i \tag{8}$$

B. Create a portfolio for stock j which is hedged against the market and against industry returns

Suppose we create a portfolio with a strategy in which we invest:

  i) fraction 1 (=100%) long in the stock j

  ii) *shorts* fraction b_j in the market portfolio

  iii) *shorts* fraction x_j in the industry (ex-market) portfolio

  iv) goes long fraction $(x_j + b_j)$ in the riskless asset

Let $P_j(t) =$ value of this "stock j-indexed" portfolio

If we decompose dZ_j into a component correlated with the market (dZ_m), and a component orthogonal to the market, we get

$$dZ_j = r_{jm}dZ_m + g_j de_j \tag{9}$$

where de_j is defined by (9), $g_j = \sqrt{\left(1 - r_{jm}^2\right)}$ and $\mathrm{cov}\left(de_j, dZ_m\right) = 0$

If we decompose de_j into a component correlated with the industry (de_i) and an orthogonal component, then we get

$$de_j = h_{ji}de_i + d_j dq_j \tag{10}$$

where dq_j is defined by (10), $d_j = \sqrt{\left(1 - h_{ji}^2\right)}$, and $\mathrm{cov}\left(dq_j, de_i\right) = 0$, $\mathrm{cov}\left(dq_j, dZ_m\right) = 0$

From (1), (9), (10)

$$\frac{dV_j}{V_j} = r_j dt + \boldsymbol{s}_j \left[\boldsymbol{r}_{jm} dZ_m + \boldsymbol{g}_j \boldsymbol{h}_{ji} de_i + \boldsymbol{g}_j \boldsymbol{d}_j dq_j \right] \tag{11}$$

$$= r_j dt + \boldsymbol{s}_j \boldsymbol{r}_{jm} dZ_m + \boldsymbol{g}_j \boldsymbol{s}_j \boldsymbol{h}_{ji} de_i + \boldsymbol{g}_j \boldsymbol{s}_j \boldsymbol{d}_j dq_j$$

By the proposed strategy, we have that

$$\frac{dP_j}{P_j} = \frac{dV_j}{V_j} - \boldsymbol{b}_j \left(\frac{dV_{jm}}{V_m} - r_j \right) dt - x_j \left(\frac{dP_i}{P_i} - r_f \right) dt \tag{12}$$

$$= \left(r_j - \boldsymbol{b}_j \left(r_m - r_f \right) \right) dt + \left(\boldsymbol{s}_j dZ_j - \boldsymbol{b}_j \boldsymbol{s}_m dZ_m - x_j \boldsymbol{s}_i \boldsymbol{g}_i de \right) \qquad \text{(from (1), (2), (8))}$$

$$= r_f dt + \left(\boldsymbol{s}_j \boldsymbol{r}_{jm} - \boldsymbol{b}_j \boldsymbol{s}_m \right) dZ_m + \left(\boldsymbol{g}_j \boldsymbol{s}_j \boldsymbol{h}_{ji} - x_j \boldsymbol{s}_i \boldsymbol{g}_i \right) de_i + \boldsymbol{g}_j \boldsymbol{s}_j \boldsymbol{d}_j dq_j \qquad \text{(from (11) and}$$

(4a))

Now, if we select $x_j = \dfrac{\boldsymbol{g}_j \boldsymbol{s}_j \boldsymbol{h}_{ji}}{\boldsymbol{g}_i \boldsymbol{s}_i}$, then

$$\frac{dP_j}{P_j} = r_f dt + \boldsymbol{s}_j{}' dq_j$$

where dq_j is uncorrelated with the industry and the market portfolios, and where

$\boldsymbol{s}_j{}' \equiv \left(\boldsymbol{g}_j \boldsymbol{d}_j \right) \boldsymbol{s}_j$ which is $\leq \boldsymbol{s}_j$

We can therefore create a program of options (or other contingent claims) on firm performance that is not related to either market or industry returns (purely idiosyncratic risk) with the features that:

$$\frac{dP_j}{P_j} = r_f dt + \boldsymbol{s}_j{}' dq_j$$

where the porfolio has fraction 1 in stock j, fraction $\boldsymbol{b}_j$ short in the market portfolio,

fraction $\dfrac{\boldsymbol{g}_j\boldsymbol{s}_j\boldsymbol{h}_{ji}}{\boldsymbol{g}_i\boldsymbol{s}_i}$ short in the industry (ex-market) portfolio, and $\left[\dfrac{\boldsymbol{g}_j\boldsymbol{s}_j\boldsymbol{h}_{ji}}{\boldsymbol{g}_i\boldsymbol{s}_i}+\boldsymbol{b}_j\right]$ in the

riskless asset.

Equivalently, this can also be expressed as a portfolio with fraction 1 in stock j, fraction

$\dfrac{\boldsymbol{g}_j\boldsymbol{s}_j\boldsymbol{h}_{ji}}{\boldsymbol{g}_i\boldsymbol{s}_i}$ short in industry portfolio, fraction $\boldsymbol{b}_j\left[1-\left(\dfrac{\boldsymbol{b}_i}{\boldsymbol{b}_j}\right)\left(\dfrac{\boldsymbol{s}_j}{\boldsymbol{s}_i}\right)\sqrt{\left[\dfrac{1-r_{jm}^2}{1-r_{im}^2}\right]}\,\boldsymbol{h}_{ji}\right]$ short

in the market, and $\left[\dfrac{\boldsymbol{g}_j\boldsymbol{s}_j\boldsymbol{h}_{ji}}{\boldsymbol{g}_i\boldsymbol{s}_i}+\boldsymbol{b}_j\right]$ in the riskless asset.

The industry- and market-adjusted portfolio can therefore be expressed as:

$$\frac{dP_j}{P_j}=r_f\,dt+\boldsymbol{1}_j\boldsymbol{s}_j\,dq_j$$

where $\boldsymbol{1}_j=\boldsymbol{g}_j\boldsymbol{d}_j=\sqrt{\left(1-r_{jm}^2\right)\left(1-h_{ji}^2\right)}$

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TABLE 1

The Sensitivity of Black-Scholes Option Value to Hypothetical Changes in the Stock Price and Exercise Price

Initial stock price equals $100. The baseline option value represents a call option issued at-the-money with a 10-year maturity, with annual volatility level (σ) of 30%, 50%, 75%, or 100%. The riskless interest rate is 4.49% continuously-compounded. *New Stock Price* represents the hypothetical stock price movement, ranging from a decrease of $99 to an increase of $200. *Stock Return* is the return based upon that hypothetical stock price movement. The *Market Return* is the return of the market index, which takes on the value specified in each panel (+10%, 0%, -10%). *Net of Market Stock Return* is the *Stock Return* minus the *Market Return*, which equals the desired percentage change in the manager's stock option value. The *New Call Price* is the price of call option using the new stock price, with the exercsie price adjusted upwards or downwards by the hypothesized market movement. D *in Option Value* represents the actual percentage change in the value of the call for the specified stock price and market movement. All call option values calculated using the Black-Scholes Option Pricing Formula, with an assumed dividend rate of 0.

Panel A: Market Increases by 10%

Hypothetical Stock Return for Firm with Initial Stock Price of $100			Stock Market Increases by 10% => Exercise Price Increases by 10%							
			s=30% => Call = 50.95		s=50% => Call = $66.33		s=75% => Call = $81.37		s=100% => Call = $90.97	
New Stock Price ($)	Stock Return	Net of Mkt Stock Return	New Call Price ($)	D in Option Value	New Call Price ($)	D in Option Value	New Call Price ($)	D in Option Value	New Call Price ($)	D in Option Value
1.00	-99%	-109%	0.00	-100%	0.01	-100%	0.17	-100%	0.47	-99%
25.00	-75%	-85%	2.59	-95%	8.64	-87%	15.65	-81%	20.40	-78%
50.00	-50%	-60%	13.09	-74%	24.83	-63%	36.12	-56%	43.28	-52%
75.00	-25%	-35%	28.94	-43%	43.87	-34%	57.90	-29%	66.74	-27%
90.00	-10%	-20%	40.03	-21%	56.07	-15%	71.33	-12%	80.97	-11%
100.00	0%	-10%	47.89	-6%	64.44	-3%	80.38	-1%	90.50	-1%
110.00	10%	0%	56.04	10%	72.96	10%	89.50	10%	100.06	10%
125.00	25%	15%	68.72	35%	85.97	30%	103.30	27%	114.45	26%
150.00	50%	40%	90.74	78%	108.17	63%	126.52	55%	138.54	52%
175.00	75%	65%	113.55	123%	130.83	97%	149.97	84%	162.73	79%
200.00	100%	90%	136.91	169%	153.85	132%	173.60	113%	187.00	106%
300.00	200%	190%	233.26	358%	248.21	274%	269.30	231%	284.61	213%

TABLE 1 (cont'd): The Sensitivity of Black-Scholes Option Value to Hypothetical Changes in the Stock Price and Exercise Price

Panel B: Market Unchanged

Hypothetical Stock Return for Firm with Initial Stock Price of $100			Stock Market Increases by 10% => Exercise Price Increases by 10%							
			s=30% => Call = 50.95		s=50% => Call = $66.33		s=75% => Call = $81.37		s=100% => Call = $90.97	
New Stock Price ($)	Stock Return	Net of Mkt Stock Return	New Call Price ($)	Δ in Option Value	New Call Price ($)	Δ in Option Value	New Call Price ($)	Δ in Option Value	New Call Price ($)	Δ in Option Value
1.00	-99%	-99%	0.00	-100%	0.01	-100%	0.18	-100%	0.48	-99%
25.00	-75%	-75%	3.01	-94%	9.14	-86%	16.00	-80%	20.58	-77%
50.00	-50%	-50%	14.48	-72%	25.88	-61%	36.73	-55%	43.58	-52%
75.00	-25%	-25%	31.24	-39%	45.37	-32%	58.72	-28%	67.13	-26%
90.00	-10%	-10%	42.81	-16%	57.81	-13%	72.25	-11%	81.41	-11%
100.00	0%	0%	50.95	0%	66.33	0%	81.37	0%	90.97	0%
110.00	10%	10%	59.36	17%	74.98	13%	90.55	11%	100.56	11%
125.00	25%	25%	72.37	42%	88.18	33%	104.43	28%	114.98	26%
150.00	50%	50%	94.87	86%	110.65	67%	127.79	57%	139.13	53%
175.00	75%	75%	118.05	132%	133.56	101%	151.36	86%	163.37	80%
200.00	100%	100%	141.70	178%	156.79	136%	175.10	115%	187.69	106%
300.00	200%	200%	238.78	369%	251.80	280%	271.15	233%	285.47	214%

Panel C: Market Decreases by 10%

Hypothetical Stock Return for Firm with Initial Stock Price of $100			Stock Market Increases by 10% => Exercise Price Increases by 10%							
			s=30% => Call = 50.95		s=50% => Call = $66.33		s=75% => Call = $81.37		s=100% => Call = $90.97	
New Stock Price ($)	Stock Return	Net of Mkt Stock Return	New Call Price ($)	Δ in Option Value	New Call Price ($)	Δ in Option Value	New Call Price ($)	Δ in Option Value	New Call Price ($)	Δ in Option Value
1.00	-99%	-89%	0.00	-100%	0.02	-100%	0.19	-100%	0.50	-99%
25.00	-75%	-65%	3.52	-93%	9.71	-85%	16.38	-80%	20.79	-77%
50.00	-50%	-40%	16.07	-68%	27.04	-59%	37.38	-54%	43.90	-52%
75.00	-25%	-15%	33.80	-34%	47.01	-29%	59.59	-27%	67.55	-26%
90.00	-10%	0%	45.85	-10%	59.69	-10%	73.23	-10%	81.87	-10%
100.00	0%	10%	54.28	7%	68.35	3%	82.42	1%	91.46	1%
110.00	10%	20%	62.94	24%	77.15	16%	91.67	13%	101.08	11%
125.00	25%	35%	76.29	50%	90.54	37%	105.64	30%	115.55	27%
150.00	50%	60%	99.24	95%	113.29	71%	129.14	59%	139.76	54%
175.00	75%	85%	122.77	141%	136.44	106%	152.83	88%	164.05	80%
200.00	100%	110%	146.70	188%	159.89	141%	176.68	117%	188.42	107%
300.00	200%	210%	244.44	380%	255.55	285%	273.09	236%	286.37	215%

TABLE 2

The Sensitivity of Indexed-Option Value (using Exercise Price that Varies with Market Movements and Margrabe-Fischer-Stulz Pricing) to Hypothetical Changes in Stock Price and Market Index Values

Initial stock price and Initial Market Index value equal $100. Baseline option value is a 10-yr. indexed call option issued at-the-money, with annual volatility level (σ) of the underlying assets (ln (Stock Price/Exercise Price)) = 27.7%, 43.9%, 67.1%, or 91.2% (corresponds to individual stock volatility levels (σ_{stock}) of 30%, 50%, 75%, or 100% when market volatility = 23%, firm-market correlation = 0.48). *New Stock Price* represents the firm's hypothetical stock price movement, ranging from -$99 to +$200. *Stock Return* is the return based upon that hypothetical stock price movement. The *Market Return* is the return of the market index, which takes on the value specified in each panel (+10%, 0%, -10%). *Net of Market Stock Return* is the *Stock Return* minus the *Market Return*. The *New Call Price* is the price of call option using the new stock price, with the exercise price adjusted upwards or downwards by the hypothesized market movement. D *in Option Value* represents the actual percentage change in the value of the call for the specified stock price and market movement. Call option values calculated using Margrabe-Fischer-Stulz method (assumed div. rates = 0).

Panel A: Market Increases by 10%

Hypothetical Stock Return for Firm with Initial Stock Price of $100			Stock Market Increases by 10% => Exercise Price Increases by 10%							
			s_{stock}=30% ; s=27.7% => Call = $33.86		s_{stock}=50% ; s=43.9% => Call = $51.24		s_{stock}=75% ; s=67.1% => Call = $71.13		s_{stock}=100% ; s=91.2% => Call = $85.07	
New Stock Price ($)	Stock Return	Net of Mkt Stock Return	New Call Price ($)	D in Option Value	New Call Price ($)	D in Option Value	New Call Price ($)	D in Option Value	New Call Price ($)	D in Option Value
1.00	-99%	-109%	0.00	-100%	0.00	-100%	0.07	-100%	0.31	-100%
25.00	-75%	-85%	0.80	-98%	4.56	-91%	11.72	-84%	17.81	-79%
50.00	-50%	-60%	6.15	-82%	16.13	-69%	29.38	-59%	39.19	-54%
75.00	-25%	-35%	16.54	-51%	31.40	-39%	49.01	-31%	61.52	-28%
90.00	-10%	-20%	24.69	-27%	41.69	-19%	61.34	-14%	75.17	-12%
100.00	0%	-10%	30.75	-9%	48.91	-5%	69.74	-2%	84.35	-1%
110.00	10%	0%	37.25	10%	56.36	10%	78.24	10%	93.58	10%
125.00	25%	15%	47.68	41%	67.92	33%	91.18	28%	107.50	26%
150.00	50%	40%	66.55	97%	88.00	72%	113.13	59%	130.89	54%
175.00	75%	65%	86.82	156%	108.88	112%	135.46	90%	154.46	82%
200.00	100%	90%	108.12	219%	130.36	154%	158.09	122%	178.16	109%
300.00	200%	190%	199.36	489%	220.27	330%	250.63	252%	273.91	222%

Panel B: Market Unchanged

New Stock Price ($)	Stock Return	Net of Mkt Stock Return	$s_{stock}=30\%$; $s=27.7\%$ => Call = $33.86 New Call Price ($)	Δ in Option Value	$s_{stock}=50\%$; $s=43.9\%$ => Call = $51.24 New Call Price ($)	Δ in Option Value	$s_{stock}=75\%$; $s=67.1\%$ => Call = $71.13 New Call Price ($)	Δ in Option Value	$s_{stock}=100\%$; $s=91.2\%$ => Call = $85.07 New Call Price ($)	Δ in Option Value
			Stock Market Increases by 10% => Exercise Price Increases by 10%							
1.00	-99%	-99%	0.00	-100%	0.00	-100%	0.07	-100%	0.32	-100%
25.00	-75%	-75%	0.99	-97%	4.98	-90%	12.13	-83%	18.07	-79%
50.00	-50%	-50%	7.15	-79%	17.23	-66%	30.17	-58%	39.64	-53%
75.00	-25%	-25%	18.60	-45%	33.14	-35%	50.12	-30%	62.11	-27%
90.00	-10%	-10%	27.38	-19%	43.80	-15%	62.63	-12%	75.84	-11%
100.00	0%	0%	33.86	0%	51.24	0%	71.13	0%	85.07	0%
110.00	10%	10%	40.75	20%	58.91	15%	79.74	12%	94.35	11%
125.00	25%	25%	51.74	53%	70.77	38%	92.82	30%	108.34	27%
150.00	50%	50%	71.43	111%	91.31	78%	114.99	62%	131.83	55%
175.00	75%	75%	92.40	173%	112.60	120%	137.52	93%	155.49	83%
200.00	100%	100%	114.30	238%	134.45	162%	160.34	125%	179.27	111%
300.00	200%	200%	207.13	512%	225.51	340%	253.49	256%	275.32	224%

Panel C: Market Decreases by 10%

New Stock Price ($)	Stock Return	Net of Mkt Stock Return	$s_{stock}=30\%$; $s=27.7\%$ => Call = $33.86 New Call Price ($)	Δ in Option Value	$s_{stock}=50\%$; $s=43.9\%$ => Call = $51.24 New Call Price ($)	Δ in Option Value	$s_{stock}=75\%$; $s=67.1\%$ => Call = $71.13 New Call Price ($)	Δ in Option Value	$s_{stock}=100\%$; $s=91.2\%$ => Call = $85.07 New Call Price ($)	Δ in Option Value
			Stock Market Increases by 10% => Exercise Price Increases by 10%							
1.00	-99%	-89%	0.00	-100%	0.00	-100%	0.08	-100%	0.33	-100%
25.00	-75%	-65%	1.24	-96%	5.47	-89%	12.59	-82%	18.35	-78%
50.00	-50%	-40%	8.36	-75%	18.47	-64%	31.03	-56%	40.12	-53%
75.00	-25%	-15%	21.00	-38%	35.08	-32%	51.33	-28%	62.75	-26%
90.00	-10%	0%	30.47	-10%	46.12	-10%	64.02	-10%	76.56	-10%
100.00	0%	10%	37.38	10%	53.80	5%	72.63	2%	85.84	1%
110.00	10%	20%	44.69	32%	61.69	20%	81.34	14%	95.17	12%
125.00	25%	35%	56.25	66%	73.87	44%	94.58	33%	109.23	28%
150.00	50%	60%	76.77	127%	94.89	85%	116.98	64%	132.83	56%
175.00	75%	85%	98.43	191%	116.60	128%	139.72	96%	156.58	84%
200.00	100%	110%	120.89	257%	138.83	171%	162.72	129%	180.46	112%
300.00	200%	210%	215.22	536%	231.05	351%	256.51	261%	276.80	225%

TABLE 3

Volatility Levels and Firm-Market and Firm-Industry Correlations for Value Line Industries and for Hambrecht & Quist Internet-Based Firms

The dataset consists of 1496 firms tracked by Value Line and 53 firms in Hambrecht & Quist Internet-Based Index as of 12/31/98. The calculations use daily continuously-compounded excess return (net of risk-free rate) over the six month period ending 12/31/98. If six months of data is not available, we use the available data, as long as that data covers at least three months. CRSP's Value-Weighted Composite Index is used for the market return. "Equity Value" is measured as of 12/31/98. "Beta" is a firm-level beta calculated using the market model with excess returns. "Firm Volatility" is the annualized volatility of daily returns. "Industry Volatility" is the annualized volatility of daily returns for a value-weighted industry index comprised of all firms within the specified Value Line Industry. "Firm-Mkt Corr." is the correlation between the firm's excess return and the industry's excess return calculated from daily data. "Firm-Ind. Corr." is the correlation between the firm's return and the "ex-market" industry return (where ex-market means that the market component of the industry return has been removed).

Panel A: Value Line Industries

Industry	Firms	Equity Value on 12/31/98 ($mm)			Beta (b_j)			Firm Volatility (s_j)			Industry Volatility (s_i)	Firm-Mkt Corr. (r_{jm})			Firm-Ind. Corr. (after taking out the mkt) (h_{ij})		
		MEAN	MED	STDDEV	**MEAN**	MED	STDDEV	**MEAN**	MED	STDDEV		**MEAN**	MED	STDDEV	**MEAN**	MED	STDDEV
Advertising, Publishing & Newspaper	33	**3716**	2378	3983	**0.83**	0.83	0.21	**0.41**	0.41	0.11	0.23	**0.56**	0.56	0.11	**0.29**	0.27	0.15
Aerospace & Defense	17	**5186**	1369	8498	**0.74**	0.67	0.27	**0.46**	0.43	0.12	0.30	**0.43**	0.45	0.09	**0.29**	0.30	0.22
Air Transport	14	**4014**	2071	4146	**1.26**	1.25	0.20	**0.58**	0.57	0.09	0.43	**0.59**	0.59	0.06	**0.54**	0.57	0.24
Apparel & Shoe	24	**1259**	552	1798	**0.88**	0.85	0.24	**0.61**	0.63	0.15	0.29	**0.40**	0.41	0.10	**0.26**	0.22	0.17
Auto & Truck	8	**14982**	1140	26408	**1.08**	1.08	0.19	**0.54**	0.51	0.09	0.38	**0.56**	0.54	0.10	**0.29**	0.17	0.28
Auto Parts	24	**2106**	1046	2187	**0.74**	0.70	0.25	**0.47**	0.44	0.15	0.21	**0.45**	0.44	0.15	**0.27**	0.26	0.16
Bank & Thrift	57	**14942**	6336	21215	**1.16**	1.16	0.24	**0.45**	0.43	0.09	0.36	**0.70**	0.71	0.08	**0.33**	0.33	0.20
Beverage	13	**22632**	2022	46221	**0.77**	0.85	0.30	**0.45**	0.47	0.11	0.32	**0.47**	0.49	0.16	**0.17**	0.07	0.30
Broadcasting & Cable TV	4	**9204**	4400	11418	**1.13**	1.17	0.14	**0.53**	0.53	0.09	0.36	**0.59**	0.60	0.05	**0.42**	0.34	0.37
Brokerage, Leasing & Financial Services	36	**12328**	5072	20528	**1.37**	1.42	0.35	**0.61**	0.58	0.16	0.47	**0.62**	0.63	0.09	**0.38**	0.41	0.22
Building Materials, Cement, Furniture & Homebuilding	53	**3382**	835	13218	**0.93**	0.93	0.35	**0.52**	0.51	0.16	0.37	**0.49**	0.50	0.14	**0.11**	0.09	0.17
Chemical	62	**3621**	1285	8562	**0.75**	0.76	0.22	**0.47**	0.43	0.14	0.25	**0.45**	0.45	0.12	**0.18**	0.16	0.19
Coal & Alternate Energy	2	**5304**	5304	4580	**0.94**	0.94	0.27	**0.52**	0.52	0.19	0.54	**0.50**	0.50	0.04	**0.66**	0.66	0.47
Computer	77	**17190**	3468	47556	**1.26**	1.22	0.35	**0.70**	0.68	0.18	0.38	**0.51**	0.50	0.14	**0.18**	0.14	0.20
Diversified	44	**5963**	1381	14750	**0.85**	0.85	0.25	**0.47**	0.43	0.10	0.26	**0.50**	0.52	0.13	**0.10**	0.08	0.17
Drug	37	**25760**	4052	46763	**1.05**	0.97	0.30	**0.57**	0.55	0.21	0.29	**0.52**	0.50	0.12	**0.14**	0.06	0.24
Drugstore	6	**10876**	7160	12416	**1.02**	0.99	0.29	**0.51**	0.47	0.14	0.41	**0.56**	0.58	0.17	**0.36**	0.34	0.45
Educational Services	5	**1160**	1158	738	**1.35**	1.23	0.49	**0.85**	0.64	0.51	0.44	**0.47**	0.49	0.08	**0.47**	0.41	0.21
Electrical Equipment & Home Appliance	25	**17080**	1240	66319	**0.78**	0.79	0.24	**0.43**	0.41	0.12	0.31	**0.51**	0.52	0.15	**0.04**	0.00	0.21
Electronics & Semiconductor	52	**7692**	1137	27801	**1.17**	1.24	0.39	**0.65**	0.67	0.17	0.37	**0.49**	0.50	0.13	**0.23**	0.21	0.21
Food Processing	43	**6006**	1895	9926	**0.68**	0.66	0.20	**0.44**	0.42	0.11	0.21	**0.44**	0.43	0.11	**0.20**	0.15	0.22
Food Wholesalers & Grocery Stores	20	**5696**	2279	7497	**0.68**	0.67	0.23	**0.43**	0.43	0.13	0.23	**0.44**	0.44	0.12	**0.27**	0.18	0.22
Hotel & Gaming	14	**1445**	1064	1397	**0.89**	0.94	0.20	**0.53**	0.53	0.12	0.30	**0.46**	0.47	0.09	**0.39**	0.48	0.21
Household Products	18	**12255**	1441	28612	**0.75**	0.76	0.21	**0.53**	0.43	0.23	0.31	**0.44**	0.48	0.17	**0.18**	0.14	0.27
Industrial Services (Including Environmental)	30	**2999**	1359	5002	**0.95**	0.84	0.40	**0.57**	0.56	0.20	0.31	**0.45**	0.45	0.11	**0.20**	0.16	0.18
Insurance	52	**7843**	4282	14550	**0.91**	0.93	0.29	**0.45**	0.43	0.13	0.30	**0.57**	0.58	0.13	**0.24**	0.24	0.18
Internet	6	**20387**	11498	26229	**2.17**	2.12	0.26	**1.06**	1.14	0.18	0.79	**0.57**	0.56	0.07	**0.69**	0.70	0.20
Investment	41	**499**	202	679	**0.85**	0.94	0.44	**0.38**	0.37	0.17	0.16	**0.60**	0.64	0.20	**0.36**	0.37	0.10
Machinery	42	**1654**	642	3048	**0.82**	0.84	0.29	**0.51**	0.47	0.16	0.27	**0.44**	0.45	0.11	**0.21**	0.20	0.18
Manufactured Housing & Recreational Vehicles	8	**828**	575	625	**0.75**	0.75	0.29	**0.46**	0.45	0.11	0.30	**0.44**	0.46	0.11	**0.44**	0.45	0.21

TABLE 3 (cont.)

Volatility Levels and Firm-Market and Firm-Industry Correlations for Value Line Industries and for Hambrecht & Quist Internet-Based Firms

The dataset consists of 1496 firms tracked by Value Line and 53 firms in Hambrecht & Quist Internet-Based Index as of 12/31/98. The calculations use daily continuously-compounded excess return (net of risk-free rate) over the six month period ending 12/31/98. If six months of data is not available, we use the available data, as long as that data covers at least three months. CRSP's Value-Weighted Composite Index is used for the market return. "Equity Value" is measured as of 12/31/98. "Beta" is a firm-level beta calculated using the market model with excess returns. "Firm Volatility" is the annualized volatility of daily returns. "Industry Volatility" is the annualized volatility of daily returns for a value-weighted industry index comprised of all firms within the specified Value Line Industry. "Firm-Mkt Corr." is the correlation between the firm's excess return and the industry's excess return calculated from daily data. "Firm-Ind. Corr." is the correlation between the firm's return and the "ex-market" industry return (where ex-market means that the market component of the industry return has been removed).

Panel A (cont.): Value Line Industries

Industry	Firms	Equity Value on 12/31/98 ($mm)			Beta (b_j)			Firm Volatility (s_j)			Industry Volatility (s_I)	Firm-Mkt Corr. (r_{jm})			Firm-Ind. Corr. (after taking out the mkt) (h_{ij})		
		MEAN	MED	STDDEV	MEAN	MED	STDDEV	MEAN	MED	STDDEV		MEAN	MED	STDDEV	MEAN	MED	STDDEV
Maritime	5	448	340	390	0.65	0.66	0.08	0.62	0.50	0.28	0.29	0.32	0.31	0.09	0.39	0.40	0.31
Medical Services	23	3537	1196	4029	1.05	1.04	0.24	0.77	0.71	0.28	0.34	0.41	0.40	0.14	0.31	0.31	0.17
Medical Supplies	45	7965	1450	20230	0.82	0.79	0.27	0.53	0.48	0.21	0.25	0.44	0.43	0.13	0.13	0.07	0.20
Metal Fabricating	12	1746	442	4055	0.71	0.69	0.30	0.48	0.46	0.13	0.30	0.42	0.42	0.15	0.19	0.14	0.25
Metals and Mining	19	2513	982	3395	0.60	0.69	0.42	0.59	0.54	0.19	0.35	0.34	0.36	0.25	0.55	0.55	0.22
Natural Gas	43	2141	984	3553	0.56	0.52	0.27	0.35	0.32	0.14	0.21	0.44	0.46	0.11	0.27	0.24	0.19
Office Equip. & Supplies	21	4336	959	9177	0.95	0.93	0.46	0.65	0.62	0.31	0.32	0.42	0.39	0.17	0.14	0.11	0.20
Oilfield Services & Equipment	20	3296	1382	5913	1.28	1.23	0.21	0.77	0.76	0.14	0.57	0.46	0.46	0.07	0.78	0.82	0.14
Packaging & Container	10	1990	1698	1536	0.76	0.80	0.16	0.50	0.48	0.16	0.28	0.43	0.43	0.11	0.34	0.27	0.24
Paper & Forest Products	25	3028	1990	3357	0.75	0.74	0.18	0.42	0.40	0.08	0.29	0.49	0.50	0.10	0.49	0.60	0.25
Petroleum	41	13515	3373	30972	0.77	0.75	0.21	0.47	0.43	0.13	0.25	0.46	0.44	0.09	0.41	0.45	0.24
Precision Instrument	23	1917	476	4827	1.00	0.90	0.39	0.66	0.64	0.18	0.30	0.42	0.44	0.10	0.16	0.11	0.20
Railroad	7	8694	9059	4988	0.95	0.81	0.47	0.46	0.38	0.17	0.25	0.54	0.54	0.10	0.47	0.55	0.16
Recreation	30	8626	2242	16790	1.11	1.07	0.41	0.60	0.54	0.22	0.33	0.52	0.57	0.15	0.19	0.16	0.15
REIT's	15	1839	1190	1483	0.61	0.53	0.23	0.33	0.29	0.12	0.20	0.50	0.48	0.07	0.49	0.50	0.18
Restaurant	27	3134	590	9904	0.84	0.80	0.29	0.53	0.51	0.15	0.31	0.44	0.46	0.10	0.13	0.13	0.19
Retail (Special Lines)	55	2177	1001	4536	1.17	1.24	0.38	0.70	0.67	0.21	0.38	0.46	0.50	0.13	0.19	0.19	0.16
Retail Store	20	15845	4941	39412	1.18	1.23	0.27	0.58	0.58	0.14	0.38	0.57	0.60	0.15	0.33	0.30	0.21
Steel	17	716	449	882	0.70	0.69	0.26	0.51	0.50	0.19	0.27	0.39	0.34	0.12	0.34	0.37	0.20
Telecommunications	41	24984	4153	42081	1.10	1.05	0.48	0.62	0.57	0.25	0.26	0.49	0.49	0.14	0.11	0.02	0.27
Textile	11	517	386	529	0.80	0.82	0.27	0.62	0.65	0.13	0.34	0.36	0.36	0.11	0.36	0.34	0.18
Tire & Rubber	5	2297	1549	3179	0.85	0.78	0.24	0.42	0.36	0.15	0.29	0.56	0.53	0.08	0.45	0.32	0.31
Tobacco	6	25059	4487	51655	0.62	0.59	0.11	0.36	0.35	0.07	0.25	0.46	0.46	0.06	0.40	0.39	0.34
Toiletries & Cosmetics	5	14286	5236	22115	0.94	0.96	0.05	0.45	0.41	0.07	0.43	0.57	0.57	0.08	0.40	0.32	0.35
Trucking & Transportation Leasing	15	765	636	507	0.87	0.93	0.21	0.59	0.60	0.11	0.30	0.40	0.41	0.09	0.38	0.37	0.15
Utilities	88	3961	2626	4221	0.28	0.26	0.11	0.25	0.23	0.06	0.16	0.31	0.31	0.09	0.57	0.61	0.22
H&Q INTERNET INDEX FIRMS** **Not Included in Summary Statistics	53	14128	1216	51129	2.00	2.06	0.47	1.17	1.19	0.33	0.47	0.49	0.48	0.12	0.29	0.27	0.15

TABLE 3 (cont.)

Volatility Levels and Firm-Market and Firm-Industry Correlations for Value Line Industries and for Hambrecht & Quist Internet-Based Firms

The dataset consists of 1496 firms tracked by Value Line and 53 firms in Hambrecht & Quist Internet-Based Index as of 12/31/98. The calculations use daily continuously-compounded excess return (net of risk-free rate) over the six month period ending 12/31/98. If six months of data is not available, we use the available data, as long as that data covers at least three months. CRSP's Value-Weighted Composite Index is used for the market return. "Equity Value" is measured as of 12/31/98. "Beta" is a firm-level beta calculated using the market model with excess returns. "Firm Volatility" is the annualized volatility of daily returns. "Industry Volatility" is the annualized volatility of daily returns for a value-weighted industry index comprised of all firms within the specified Value Line Industry. "Firm-Mkt Corr." is the correlation between the firm's excess return and the industry's excess return calculated from daily data. "Firm-Ind. Corr." is the correlation between the firm's return and the "ex-market" industry return (where ex-market means that the market component of the industry return has been removed).

Panel A (cont.): Value Line Industries

Summary Statistics Across Industries and Across Firms

		# of Firms	Equity Value on 12/31/98 ($mm)	Beta (b_j)	Firm Volatility (s_j)	Industry Volatility (s_i)	Firm-Mkt Corr. (r_{jm})	Firm-Ind. Corr. (after taking out the mkt) (h_{ij})
Industry	mean	26.7	7274	0.92	0.54	0.32	0.48	0.32
Summary Stats	median	22.0	3987	0.86	0.52	0.30	0.46	0.30
(Industries are	std dev	19.5	7060	0.28	0.13	0.10	0.08	0.16
equally-weighted)	max	88.0	25760	2.17	1.06	0.79	0.70	0.78
	min	2.0	448	0.28	0.25	0.16	0.31	0.04

		# of Firms	Equity Value on 12/31/98 ($mm)	Beta (b_j)	Firm Volatility (s_j)	Industry Volatility (s_i)	Firm-Mkt Corr. (r_{jm})	Firm-Ind. Corr. (after taking out the mkt) (h_{ij})
Firm	mean	-	7509	0.90	0.52	-	0.48	0.28
Summary Stats	median	-	1517	0.87	0.48	-	0.48	0.23
(Firms are	std dev	-	22919	0.40	0.20	-	0.15	0.25
equally-weighted)	max	-	342558	2.53	1.74	-	0.92	0.99
	min	-	13	-0.48	0.12	-	-0.17	-0.25

Panel B: Hambrecht & Quist's Internet-Based Firms

Industry Sub-Category	Firms	Equity Value on 12/31/98 ($mm)			Beta (b_j)			Firm Volatility (s_j)			Industry Volatility (s_i)	Firm-Mkt Corr. (r_{jm})			Firm-Ind. Corr. (after taking out the mkt) (h_{ij})		
		MEAN	MED	STDEV	**MEAN**	MED	STDEV	**MEAN**	MED	STDEV		**MEAN**	MED	STDEV	**MEAN**	MED	STDEV
Commerce	18	**3098**	576	5474	**2.39**	2.09	1.20	**1.51**	1.34	0.61	0.74	**0.43**	0.42	0.10	**0.36**	0.36	0.16
Communications	12	**15142**	1444	41426	**1.95**	2.03	0.35	**1.07**	1.07	0.34	0.56	**0.53**	0.51	0.12	**0.29**	0.27	0.25
Content	13	**8574**	1556	19756	**2.44**	2.31	0.75	**1.31**	1.22	0.48	0.77	**0.53**	0.55	0.13	**0.46**	0.50	0.32
Security	4	**2904**	954	4031	**1.72**	1.65	0.36	**0.91**	0.92	0.20	0.62	**0.52**	0.54	0.09	**0.46**	0.32	0.34
Software	11	**35371**	1080	102334	**1.91**	2.14	0.49	**1.23**	1.23	0.51	0.44	**0.47**	0.46	0.15	**0.25**	0.20	0.29
All H&Q INTERNET INDEX FIRMS	53	**14128**	1216	51129	**2.00**	2.06	0.47	**1.17**	1.19	0.33	0.47	**0.49**	0.48	0.12	**0.29**	0.27	0.15

TABLE 4

Cost of Options on Markets and/or Industry-Adjusted Performance-Benchmarked Portfolio Relative to Traditional Stock Options by Industry

Option values are priced with the Black-Scholes formula assuming a ten-year maturity. "Conventional Option" is a traditional option on the firm's stock. "Performance-Benchmarked Option" is an option on the market, industry, or market and industry adjusted portfolios. Panel A data consists of 1496 firms tracked by Value Line (VL) Industry Survey (excluding foreign firms and industries), and Panel B is firms in H&Q's Internet Index, both as of 12/31/98. Calculations use daily continously-compounded excess returns (net of the risk-free rate) over the six month period ending 12/31/98. Firms with less than three months of data during this period are excluded. The market return is CRSP's Value-Weighted Composite Index. The industry return is the value-weighted average of all firms in the specified VL or H&Q industry.

Industry	Ratio of Market Value of Performance-Benchmarked Option to Conventional Option		
	Market-Hedged Portfolio	Industry-Hedged Portfolio	Market & Industry Hedged Port.
Advertising, Publishing & Newspaper	0.92	0.90	0.89
	(0.03)	(0.04)	(0.04)
Aerospace & Defense	0.95	0.93	0.91
	(0.02)	(0.07)	(0.06)
Air Transport	0.90	0.81	0.81
	(0.02)	(0.10)	(0.09)
Apparel & Shoe	0.96	0.94	0.93
	(0.02)	(0.04)	(0.04)
Auto & Truck	0.91	0.88	0.87
	(0.04)	(0.10)	(0.10)
Auto Parts	0.94	0.92	0.92
	(0.04)	(0.05)	(0.05)
Bank & Thrift	0.85	0.83	0.82
	(0.04)	(0.06)	(0.06)
Beverage	0.94	0.93	0.91
	(0.04)	(0.09)	(0.08)
Broadcasting & Cable TV	0.90	0.84	0.82
	(0.02)	(0.13)	(0.12)
Brokerage, Leasing & Financial Services	0.89	0.85	0.84
	(0.04)	(0.07)	(0.07)
Building Materials, Cement, Furn. & Homebuilding	0.93	0.93	0.92
	(0.05)	(0.06)	(0.06)
Chemical	0.94	0.94	0.93
	(0.03)	(0.05)	(0.05)
Coal & Alternate Energy	0.93	0.72	0.71
	(0.01)	(0.29)	(0.27)
Computer	0.92	0.92	0.91
	(0.05)	(0.07)	(0.07)
Diversified	0.93	0.93	0.92
	(0.04)	(0.05)	(0.05)
Drug	0.92	0.92	0.91
	(0.04)	(0.07)	(0.06)
Drugstore	0.90	0.84	0.83
	(0.07)	(0.16)	(0.15)
Educational Services	0.95	0.88	0.88
	(0.03)	(0.09)	(0.09)
Electrical Equipment & Home Appliance	0.93	0.94	0.92
	(0.05)	(0.06)	(0.06)

TABLE 4 (cont.)

Cost of Options on Markets and/or Industry-Adjusted Performance-Benchmarked Portfolio
Relative to Traditional Stock Options by Industry

Option values are priced with the Black-Scholes formula assuming a ten-year maturity. "Conventional Option" is a traditional option on the firm's stock. "Performance-Benchmarked Option" is an option on the market, industry, or market and industry adjusted portfolios. Panel A data consists of 1496 firms tracked by Value Line (VL) Industry Survey (excluding foreign firms and industries), and Panel B is firms in H&Q's Internet Index, both as of 12/31/98. Calculations use daily continously-compounded excess returns (net of the risk-free rate) over the six month period ending 12/31/98. Firms with less than three months of data during this period are excluded. The market return is CRSP's Value-Weighted Composite Index. The industry return is the value-weighted average of all firms in the specified VL or H&Q industry.

Industry	Ratio of Market Value of Performance-Benchmarked Option to Conventional Option		
	Market-Hedged Portfolio	Industry-Hedged Portfolio	Market & Industry Hedged Port.
Electronics & Semiconductor	0.93	0.91	0.91
	(0.04)	(0.07)	(0.07)
Food Processing	0.95	0.94	0.93
	(0.03)	(0.05)	(0.05)
Food Wholesalers & Grocery Stores	0.95	0.93	0.92
	(0.03)	(0.06)	(0.06)
Hotel & Gaming	0.94	0.90	0.89
	(0.03)	(0.06)	(0.05)
Household Products	0.94	0.93	0.92
	(0.04)	(0.08)	(0.09)
Industrial Services (Including Environmental)	0.95	0.94	0.93
	(0.03)	(0.04)	(0.05)
Insurance	0.91	0.89	0.89
	(0.04)	(0.06)	(0.06)
Internet	0.93	0.79	0.79
	(0.04)	(0.14)	(0.14)
Investment	0.90	0.88	0.87
	(0.07)	(0.07)	(0.06)
Machinery	0.95	0.93	0.93
	(0.03)	(0.05)	(0.05)
Manufactured Housing & Recreational Vehicles	0.95	0.89	0.89
	(0.03)	(0.08)	(0.08)
Maritime	0.97	0.91	0.91
	(0.02)	(0.08)	(0.08)
Medical Services	0.95	0.93	0.92
	(0.04)	(0.05)	(0.05)
Medical Supplies	0.95	0.94	0.93
	(0.04)	(0.05)	(0.05)
Metal Fabricating	0.95	0.94	0.93
	(0.03)	(0.09)	(0.09)
Metals and Mining	0.95	0.88	0.85
	(0.05)	(0.06)	(0.07)
Natural Gas	0.95	0.94	0.93
	(0.02)	(0.04)	(0.04)
Office Equip. & Supplies	0.95	0.94	0.93
	(0.05)	(0.07)	(0.07)
Oilfield Services & Equipment	0.95	0.75	0.74
	(0.02)	(0.08)	(0.08)

TABLE 4 (cont.)

**Cost of Options on Markets and/or Industry-Adjusted Performance-Benchmarked Portfolio
Relative to Traditional Stock Options by Industry**

Option values are priced with the Black-Scholes formula assuming a ten-year maturity. "Conventional Option" is a traditional option on the firm's stock. "Performance-Benchmarked Option" is an option on the market, industry, or market and industry adjusted portfolios. Panel A data consists of 1496 firms tracked by Value Line (VL) Industry Survey (excluding foreign firms and industries), and Panel B is firms in H&Q's Internet Index, both as of 12/31/98. Calculations use daily continously-compounded excess returns (net of the risk-free rate) over the six month period ending 12/31/98. Firms with less than three months of data during this period are excluded. The market return is CRSP's Value-Weighted Composite Index. The industry return is the value-weighted average of all firms in the specified VL or H&Q industry.

Industry	Ratio of Market Value of Performance-Benchmarked Option to Conventional Option		
	Market-Hedged Portfolio	Industry-Hedged Portfolio	Market & Industry Hedged Port.
Packaging & Container	0.95	0.91	0.90
	(0.03)	(0.06)	(0.07)
Paper & Forest Products	0.93	0.87	0.86
	(0.03)	(0.08)	(0.07)
Petroleum	0.94	0.90	0.89
	(0.02)	(0.06)	(0.06)
Precision Instrument	0.96	0.95	0.94
	(0.02)	(0.06)	(0.06)
Railroad	0.92	0.87	0.86
	(0.04)	(0.04)	(0.04)
Recreation	0.92	0.91	0.91
	(0.04)	(0.05)	(0.05)
REIT's	0.94	0.89	0.89
	(0.02)	(0.05)	(0.05)
Restaurant	0.95	0.95	0.93
	(0.02)	(0.06)	(0.06)
Retail (Special Lines)	0.94	0.93	0.92
	(0.04)	(0.05)	(0.05)
Retail Store	0.90	0.87	0.87
	(0.05)	(0.09)	(0.09)
Steel	0.96	0.93	0.92
	(0.03)	(0.06)	(0.06)
Telecommunications	0.93	0.94	0.91
	(0.05)	(0.05)	(0.05)
Textile	0.97	0.93	0.92
	(0.02)	(0.05)	(0.05)
Tire & Rubber	0.92	0.87	0.85
	(0.03)	(0.10)	(0.10)
Tobacco	0.95	0.91	0.90
	(0.01)	(0.08)	(0.07)
Toiletries & Cosmetics	0.91	0.86	0.82
	(0.03)	(0.16)	(0.14)
Trucking & Transportation Leasing	0.96	0.92	0.91
	(0.02)	(0.04)	(0.05)
Utilities	0.98	0.92	0.92
	(0.01)	(0.04)	(0.03)
H&Q INTERNET INDEX FIRMS**	0.95	0.94	0.94
**Not Included in Summary Stats Below	(0.05)	(0.07)	(0.07)

TABLE 4 (cont.)

**Cost of Options on Markets and/or Industry-Adjusted Performance-Benchmarked Portfolio
Relative to Traditional Stock Options by Industry**

Option values are priced with the Black-Scholes formula assuming a ten-year maturity. "Conventional Option" is a traditional option on the firm's stock. "Performance-Benchmarked Option" is an option on the market, industry, or market and industry adjusted portfolios. Panel A data consists of 1496 firms tracked by Value Line (VL) Industry Survey (excluding foreign firms and industries), and Panel B is firms in H&Q's Internet Index, both as of 12/31/98. Calculations use daily continously-compounded excess returns (net of the risk-free rate) over the six month period ending 12/31/98. Firms with less than three months of data during this period are excluded. The market return is CRSP's Value-Weighted Composite Index. The industry return is the value-weighted average of all firms in the specified VL or H&Q industry.

Industry-Level Summary Statistics (Equally-weighting each industry)	Ratio of Market Value of Performance-Benchmarked Option to Conventional Option		
	Market-Hedged Portfolio	Industry-Hedged Portfolio	Market & Industry Hedged Port.
mean	0.93	0.90	0.89
median	0.94	0.92	0.91
std dev	0.02	0.05	0.05
max	0.98	0.95	0.94
min	0.85	0.72	0.71