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Executive Stock Options: Early Exercise Provisions and Risk-taking Incentives

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ABSTRACT

Traditional executive stock option plans allow fixed numbers of options to vest periodically, independent of stock price performance. Because such options may climb deep in-the-money long before the manager can exercise them, they can exacerbate risk aversion in project selection. Making the proportion of options that vest a gradually increasing function of the stock price can ensure that appropriate numbers of options are retained while they provide risk-taking incentives, but are exercised once they have lost their convexity. "Progressive performance vesting" can allow the firm more efficiently to rebalance the manager's risk-taking incentives.

DURING THE COURSE OF THE 1990S, EXECUTIVE STOCK OPTIONS (ESOs) became the single largest component of CEO compensation. While ESOs typically have a long-term (10-year) expiration date, the holder is permitted to exercise prior to maturity once the option has "vested." The most common ESO plan typically allows a *fixed* number of options to vest at predetermined calendar dates, independent of stock price performance. We refer to such options as "calendar vesting" stock options, to stress that it is the mere passage of time that causes them to vest. In contrast, "performance vesting" stock options vest contingent on the achievement of a performance hurdle, which is often defined in terms of an accounting measure of profitability or stock price appreciation. For example, in 2001 the top executives of The Kroger Co. were granted options that vest conditional on stock price performance. As the proxy statement discloses,

> These performance based options vest during the first 4 years from the date of grant only if the Company's stock price has appreciated 78% from the option price. Thereafter, those options vest if the Company's stock

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price has achieved a minimum of a 15% appreciation per annum or 208% appreciation, whichever is less.

FW Cook & Co.'s 2002 report on the executive compensation practices of the 250 largest firms in the S&P index documented that, of the 99% that use executive stock options, 16% use performance vesting stock options.

In this paper, we analyze the impact of ESO vesting conditions on the dynamic incentives for managers to select profitable (positive net present value (NPV)) risky projects. Issued at-the-money, ESOs can provide incentives for managers to take risks. However, if traditional calendar vesting options move deep in-the-money, perhaps years prior to vesting, they lose their convexity in payoffs and may generate counterproductive incentives that cause risk-averse managers to *reject* profitable risky projects. We address this problem and propose an alternative vesting schedule. We show that by making the proportion of options that vest a gradually increasing function of the realized stock price, the firm can ensure that an appropriate number of options are retained while they still provide risk-taking incentives, but that they are exercised once they have lost their convexity, thereby allowing the firm more efficiently to rebalance the manager's risk-taking incentives. We refer to this refinement as "*progressive* performance vesting" to distinguish it from performance vesting plans such as that of The Kroger Co., where typically *all* the options vest upon achievement of a single performance hurdle.

While most traditional calendar vesting options qualified, until 2005, for favorable accounting treatment and avoided expensing through the firm's income statement, some forms of performance vesting options did not enjoy this advantage and may have been avoided for this reason. However, now that all forms of ESO will be compulsorily expensed, a leveling of the accounting playing field and ever-increasing pressures to improve corporate governance may lead more firms to consider adding performance-related conditions to the vesting of ESOs. We contribute to the understanding of this important but little-researched aspect of executive compensation. Our results suggest that to ensure continued risk-taking, firms should consider adopting vesting schedules that are contingent on stock price appreciation.

The previous literature documents some variation in the vesting terms of options (Aboody (1996)) and seeks to explain such variation by differences in investment horizon (Kole (1997)). Moreover, a large theoretical and empirical literature finds that the convex payoff profile that stock options provide can be used to induce risk-averse managers to take more risky but profitable projects.[1] The theoretical work of Lambert, Larcker, and Verrechia (1991) and Carpenter (2000) expands this literature by recognizing the potential risk-reducing incentives that result as options move in-the-money. However, these last two papers consider European options, which are exercisable at expiration only, and thus they do not contemplate the possibility of dynamically rebalancing incentives with the help of an early exercise provision. The main contribution of our paper

[1] See, for example, Amihud and Lev (1981), Smith and Stulz (1985), Hirshleifer and Suh (1992), DeFusco, Johnson, and Zorn (1990), Tufano (1996), and Rajgopal and Shevlin (2002).

is to show that the vesting conditions of stock options can be used to manage dynamically the convexity of the manager's incentive contract.

We construct a model in which a risk-averse manager receives a number of long-term stock options. At a later date, the underlying stock price has evolved and the manager faces the choice of accepting or rejecting a risky project with positive expected net present value. Accepting the project is in the interests of value-maximizing shareholders.[2] We demonstrate that when the manager is not permitted to exercise any of his options early, if those options are sufficiently deep in-the-money the manager's risk aversion can cause him to reject the project. Effectively, the higher the stock price relative to the option strike price, the less is the convexity of the existing options and the more linear ("stock-like") become the payoffs. Exposure to down-side risk on his unvested options can therefore cause the manager to reject the profitable risky project.

We find that in the absence of any early exercise provision, one way to provide the manager renewed risk-taking incentives is to grant "new" at-the-money options. However, this solution becomes rapidly more costly to the firm, that is, requires many more new options, with both the moneyness of the unexercised existing options and the number of them that are outstanding. Thus, the firm's task of motivating risk-taking is made more expensive because the new options need first to overcome the counterproductive incentives that the existing options generate. We show that permitting the early exercise of existing options (by allowing them to vest) can mitigate this problem, removing managerial incentives that have become counterproductive and reducing the number of new options that are required to ensure sufficient risk-taking.[3]

The early exercise of existing options can reduce a firm's costs in two ways. First, it dissipates the time value left in those options, were they to be held to maturity. Second, early exercise can reduce the number of additional new options needed to provide sufficient risk-taking incentives. Hence, an appropriate amount of early exercise can be in the firm's interest and vesting conditions emerge as a natural device with which the firm can permit and control early exercise. This result provides an answer to Murphy's (1999) puzzle, "Why are executives allowed, if not encouraged, to exercise options immediately upon vesting rather than holding them until expiration?" Going a step further, we ask "*How many* options should the executive be allowed to exercise early?" In our model, allowing some of the existing options to be exercised early can reduce the number of new options required to ensure risk-taking. However, because unvested options still contribute to satisfying the manager's retention (participation) constraint for the following period, allowing too many of the existing

[2] Numerous empirical studies (e.g., Smith and Watts (1992), Gaver and Gaver (1993), Mehran (1995), Guay (1999)) find that the use of stock options is associated with firms that face large growth opportunities. For this reason we model our manager as facing a risky but profitable growth opportunity. We are interested in the design characteristics of options intended to *promote* risk-taking. Firms that face the problem of *over*investment in *negative*-NPV risky projects probably should not be using stock options in the first place.

[3] Huddart and Lang (1996) find that option exercise usually involves immediate resale of the purchased shares. When we use the term "exercise," we implicitly refer to the exercise and resale of the underlying stock, consistent with a managerial risk aversion motive for early exercise.

options to be exercised early would increase the number of new options required to retain the manager. Given this trade-off we derive explicit expressions for the number of existing options that the firm should permit to be exercised early and we show that the manager will rationally exercise these vested options early. The resulting expression is an increasing function of stock price, which suggests that firms should consider vesting schedules that allow more options to be exercised the greater the realized stock price gains, that is, *progressive* performance vesting.

Our research question could be interpreted as conceptually analogous to the problem of option repricing. When the stock price decreases, leaving executive options deep out-of-the-money, incentives may become counterproductive. One controversial solution to this problem is for the firm to reprice (reduce the exercise price of) these options. We consider the converse problem that arises when the stock price increases. Concentrating on ex post incentives, we highlight potential drawbacks of the most commonly observed contracts that allow fixed numbers of options to vest at pre-determined calendar dates. Aboody (1996) finds that a typical grant of 10-year options vests 25% after 1 year, 25% after 2 years, etc., with all options vesting after 4 years. Such a calendar vesting schedule may allow either "too many" or "too few" options to be exercised early. In particular, a manager who holds a large number of deep in-the-money (but unvested) options is likely to reject profitable risky projects, unless the firm reconvexifies his incentives with a large new grant of at-the-money options. Conversely, a manager whose options have vested despite being only marginally in-the-money might exercise those options even though they still provide risk-taking incentives, thereby leaving the firm the problem of reinstating incentives.

Undiversified risk-averse managers rationally exercise more options early the deeper they are in-the-money (Huddart (1994), Detemple and Sundaresan (1999), Heath, Huddart, and Lang (1999)). Under calendar vesting, we conjecture that in some circumstances this exercise behavior might go some way toward approximating the outcomes of progressive performance vesting and we interpret this as a possible explanation for why the firm may be prepared to allow the manager discretion over the timing of his exercise decisions—paradoxically, it can be his own risk aversion that causes the manager to remove those incentives that would otherwise stop him from taking risks. However, should this alignment of objectives not occur under calendar vesting, for instance when fewer options have vested than would be optimal to exercise from both the manager's and the firm's points of view, the firm may be vulnerable to missing out on valuable growth opportunities.

Our results on the role of vesting conditions in dynamic incentives have managerial implications for compensation committees, consultants, and others who are concerned with the design of executive compensation contracts. These parties should be aware of how risk-taking incentives change as the stock price evolves. We show that option vesting conditions can be designed to provide the firm with a mechanism for adapting these incentives over time. While regulatory moves to expense all forms of stock options may lead to a reduced use of stock options in general, they may encourage the more thoughtful design of vesting terms where options continue to be used. However, the playing field has not been perfectly leveled; Statement of Financial Accounting Standard No. 123 (revised 2004) makes compulsory the expensing of share-based payments such as employee stock options. The standard permits firms to *deduct* from expenses the cost of options that fail to vest due to the nonfulfillment of a performance condition. Strikingly, this deduction is specifically *disallowed* by the standard when the performance condition is related to the firm's stock price. Therefore, to the extent that the CEO's most pertinent performance measure is stock price appreciation, the new regulation may still provide some impediment to efficient contracting.

The remainder of the paper is organized as follows. We present the model in Section I, and a discussion of the results in Section II. Section III summarizes and concludes. The Appendix contains proofs of propositions.

I. The Model

We study a principal-agent model in which "the manager" acts as an agent for "the firm," by which we refer to the shareholders, perhaps represented by a Board of Directors or a Compensation Committee (we abstract from any conflicts of interests among such parties). There are three dates, t_0, t_1, t_2. Figure 1 provides a timeline of events and decisions. The manager is compensated with

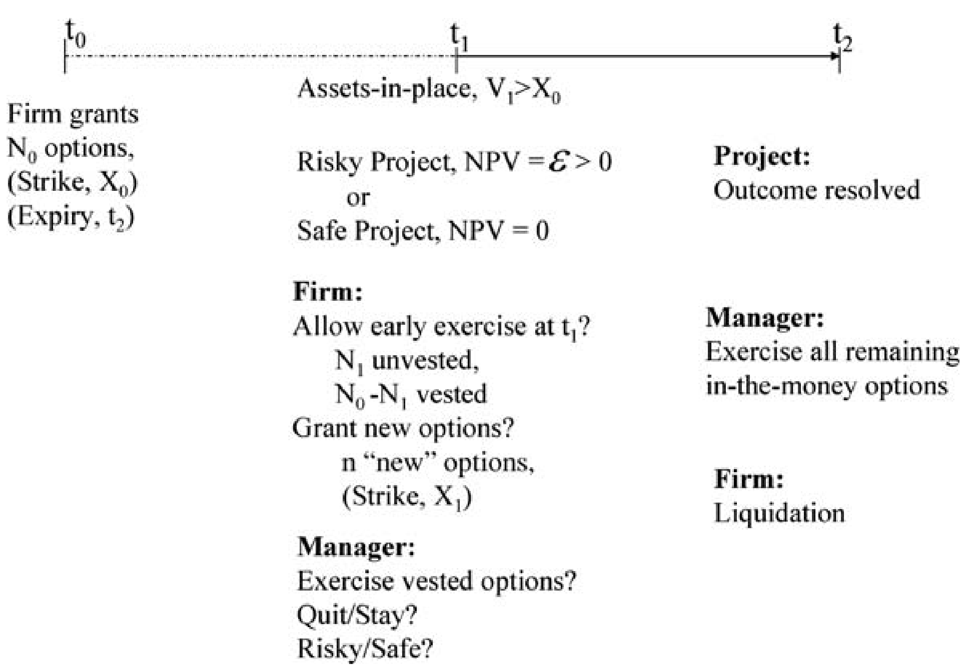

Figure 1. Timeline of events.

stock options; because we are interested primarily in the risk-taking incentives provided by convex option payoffs, we abstract from other compensation components such as salary, bonus, restricted stock, and pension rights. Stock options are the most significant component of U.S. CEO pay. One reason for this is Section 162(m) of the U.S. tax legislation, which limits the deductibility of pay unrelated to performance at \$1 million. Indeed, this is a binding constraint for the CEOs of many firms, with base salary often capped at \$1 million and the bulk of compensation coming from long-term ESOs that are structured to satisfy the requirements of Section 162(m).

At the initial date, t_0, the manager is granted N_0 call options with exercise price X_0 and expiration date t_2, where t_2 represents the long-term horizon of these instruments. In practice, virtually all stock options have a 10-year maturity.[4] We take N_0 and X_0 as exogenously given and thus we do not model the t_0-environment that presumably led to their granting. Rather, we are interested in the effect that their vesting conditions have on incentives *at the interim date*, t_1, when the value of assets-in-place has evolved to V_1 and when the firm faces a risky but profitable growth opportunity with net present value (NPV) $\varepsilon > 0$. The manager decides at t_1 whether or not to undertake this project. Also at t_1, the firm affects his incentives to do so by choosing jointly $n \geq 0$, the number of *new* options to grant at t_1, and $N_1 \in [0, N_0]$, the number of previously granted options that remain unvested until t_2, and allowing the other $N_0 - N_1$ options to vest "early" at t_1. We shall derive N_1 as a function of the t_1-stock price, therefore this vesting schedule can be written into the option contract ex ante at t_0.

Below we specify in detail the preferences of the agents, the projects available, the option remuneration structure, and the resulting objectives of the agents. We then solve the vesting problem.

A. Preferences

The manager has exogenous initial wealth, W, and his only other source of income comes from his option compensation package. His utility function, U, is separable in total terminal t_2-wealth, x, and his cost, of participation in the second period; $F \in \{0, Q\}$, that is,

$$U(x, F) = u(x) - F. \tag{1}$$

The manager is risk averse, $u' > 0, u'' < 0$, and his participation for the second period demands a personal nonmonetary cost of $F = Q > 0$. If he quits the firm at

[4] If only short-lived options (expiring at t_1) had been issued at t_0, then they could not be contributing to a risk avoidance problem at t_1. However, we do not observe short-dated options in practice. While we do not model *why* the firm chooses to grant long-term options, in practice this may be i) to ensure managers have a long-term investment horizon, ii) to ensure management retention by acting as deferred compensation and thereby raising exit costs, or iii) to limit the number of options issued (repeated grants of short-dated options are likely to exhaust more quickly the number of options for which boards have obtained permission to issue under an ESO plan).

t_1, he "saves" this cost and so $F = 0$. We can think of Q as a private benefit to the manager, which he enjoys if he quits the firm at t_1. Following Murphy (1999), who observes "... it is widely acknowledged that the fundamental shareholder–manager agency problem is *not* getting the CEO to work harder, but rather getting him to choose actions that increase rather than decrease shareholder value," we do not formally introduce costly effort into the model. If the manager has in-the-money options that have vested at t_1, he rationally decides whether or not to exercise them based on the expected utility of doing so.[5] The proceeds from any option exercises at t_1 are held at the risk-free interest rate of zero until t_2.

The firm is owned by shareholders whose objective is to maximize terminal cash flows, net of any compensation costs required to motivate the manager. There is no debt and we normalize the total number of shares in the firm to be one. The shares are publicly traded on a stock exchange so that the t_1-stock price is observable. The firm can make a take-it-or-leave-it offer to the manager, the latter accepting any offer at t_1 that gives expected utility at least as high as that from quitting the firm.

B. Project Selection

At t_1, the expected value of the firm's assets-in-place is denoted by V_1, an exogenous parameter that determines the degree to which the previously granted options are in-the-money at t_1. If the options are out-of-the money at t_1, the manager will not want to exercise any options in which case the number vesting at t_1 is irrelevant to the manager and the firm.[6] We therefore assume that no options vest when they are out-of-the money and we concentrate our analysis on values $V_1 > X_0$, that is, when the existing options are indeed *in*-the-money.

The manager's t_1-project selection decision is an unverifiable choice, $q \in \{r, s\}$, between a "risky" or a "safe" strategy. The safe strategy has zero NPV and so the terminal t_2-payoff maintains the interim asset value, V_1, with certainty. The risky project has positive expected NPV, ε, and so is preferred by shareholders. Moreover, the risky project has three equiprobable outcomes, namely, adding

[5] The efficacy of ESOs as an incentive tool depends on their ability to expose the manager to the risks of the outcomes that his actions will provoke. If the manager were able to diversify or could somehow negate this risk, then the utility of ESOs as performance-based pay would be undermined. For this reason, ESOs are inalienable, that is, they cannot be sold, transferred, or assigned to a third party, even when they have vested. Hedging via third party contracts is theoretically possible but there is little evidence of widespread and systematic hedging. In contrast, there is much evidence of early exercise involving substantial dissipation of option value (e.g., Huddart and Lang (1996)). The absence of hedging may be due to reputation and transaction cost reasons or the "potentially chilling tax consequences" of hedging options (Schizer (2000)).

[6] Out-of-the-money "underwater" options do have incentive effects: They may make the manager take on excessive risk as he seeks to pull them back into-the-money or, conversely, they may lose all incentive value whatsoever as their value to a risk-averse manager becomes insignificant. Recent papers (Brenner, Sundaram, and Yermack (2000), Acharya, John, and Sundaram (2000)) consider repricing options and we do not contribute further to that debate.

$H + \varepsilon$, ε, or $-H + \varepsilon$ to the assets-in-place; this uncertainty in payoffs is potentially unattractive to a risk-averse manager compensated via performance-related pay. We normalize the NPV to $\delta = \frac{\varepsilon}{H}$, which is a measure of the NPV relative to the size of the project. We assume that the NPV, ε, is sufficiently large that the firm finds it efficient to induce the manager to choose "risky." This is true provided that the compensation cost of inducing "risky" is not more than ε higher than the cost of inducing "safe."

To ensure that the firm finds it optimal to avoid the manager quitting the firm, we assume that the manager's continued presence is essential for the realization of the assets-in-place (and their liquidation at t_1 is not possible). Quitting the firm is an observable and verifiable event that causes unexercised options to be forfeited and the value of the firm to fall to zero. Consideration of the costs of management turnover and replacement are beyond the risk-taking scope of the present paper.

With the above assumptions, the firm's problem becomes one of motivating "risky" at minimum compensation cost. Equivalently, it becomes a problem of minimizing compensation cost subject to the manager's incentive compatibility constraint and the participation constraint. Letting $\bar{U}$ represent the manager's expected utility from his course of action, these are

Incentive compatibility (risk-taking) constraint

$$\bar{U}(risky) \geq \bar{U}(safe), \tag{2}$$

Participation constraint

$$\bar{U}(risky) \geq \bar{U}(quit). \tag{3}$$

C. Option Remuneration

The focus of our study is the design of the vesting characteristics of the long-term options granted at t_0. Specifically, we ask: If the firm conditions fully upon the stock price gain achieved in the first period, what proportion of these options should the firm allow the manager to exercise "early" at t_1 and what proportion should remain unvested until t_2? The firm anticipates the incentives that vesting will create for option exercise, participation, and project selection decisions to be taken at t_1, and the firm takes into account the costs of option exercises and awards. Our vesting schedules will define, as a function of the t_1-stock price, the number, $N_0 - N_1$, of options that vest at t_1, leaving N_1 unvested until t_2.

In order to reestablish risk-taking incentives, the firm is also able to grant additional ("new") options at t_1. They expire at t_2. We denote their number by n and their exercise price by X_1. For clarity of exposition, we assume that the firm follows the almost universal practice of granting options *at-the-money*, fixing the exercise price, X_1, equal to the t_1-stock price, P_1; we show later that this assumption is not crucial to our analysis. The equilibrium stock price is thus $P_1 = V_1 + \varepsilon$ because a rational market impounds into stock prices both the value of assets-in-place and expected payoffs from future growth opportunities.[7]

All option exercises are settled in cash, so the number of outstanding shares remains unchanged and equal to one. Option grant sizes N_0 and n are thus small fractions of one, for example, $N_0 = 0.01$ would indicate that the manager has a claim on 1% of the increases in firm value over the two periods. We denote the moneyness of the existing options at t_1 as $M = P_1 - X_0$, which is the intrinsic (immediate exercise) value of these options. This we normalize to define a measure of relative moneyness, $\lambda = \frac{M}{H}$, which plays a central role in our results. We consider values $V_1 > X_0$, which implies that $M > \varepsilon$ (equivalently, $\lambda > \delta$) and that the options are in-the-money. In our setup, options such that $M > H$ have no remaining time value, as they have lost all of their convexity, so we also assume that $M \leq H$. This assumption implies that the options are not so deep in-the-money that they can never again fall out-of-the-money. Thus, $\lambda \in (\delta, 1]$ and it can be thought of as a measure of the convexity that the existing options have lost due to stock price increases. Any existing option that vests and is exercised early at t_1 gives a payoff of M. Existing options that are held to maturity, t_2, give equiprobable payoffs of $M + H$, M, or 0 when the risky project is selected or the certain payoff $M - \varepsilon$ if the out-of-equilibrium safe project is selected.

Each new option is worthless in the case of the safe project and provides a payoff of H in the "up" state of the risky project. The risk-taking incentives of n such at-the-money options can therefore be replicated exactly by instead granting $\frac{H}{H + P_1 - X_1} n$ out-of-the-money options ($X_1 > P_1$) that each give a payoff $H + P_1 - X_1$ in the up state. As such, the choice of exercise price is arbitrary in our model and we choose $X_1 = P_1$ both for notational simplicity and for consistency with industry practice. The incentives are more complex when project outcomes follow a continuous distribution, but Hall and Murphy (2000) present an analysis of why granting options at-the-money may nevertheless be optimal.

D. Agent Objectives

The firm's objective is to minimize expected total compensation costs, subject to satisfying the incentive compatibility and participation constraints. If the

[7] We also assume that the variation of compensation costs in different final states of the world is small compared to the total value of the firm and so does not materially affect the stock price. This assumption is consistent with Hall and Liebman (1998), who state "Even if the typical CEO had in wealth ... almost 14 times annual total compensation at the median—the CEO could purchase only about 0.9% of the firm" (657). This assumption enables the manager to ignore any effect that exercise of his own options will have on stock price in the different outcomes and makes the problem tractable. Relaxing this assumption, the net option payoffs (i.e., after the dilution effect) to the risky project would be slightly *a*symmetric and the resulting problem would be very difficult to solve analytically. However, the slight quantitative adjustments necessary would lead to the same qualitative conclusions and the intuition carries through.

manager exercises $N_0 - N_1$ vested options at t_1, holds N_1 unvested options until t_2, and receives n new options at t_1, then this objective can be written

$$\min_{N_1 \in [0, N_0], n \geq 0} N_0 M + N_1 \left(\frac{1}{3}(H - M)\right) + n\frac{H}{3}. \tag{4}$$

The minimand is increasing in both N_1 and n, so the firm prefers to encourage strictly higher early exercise (early exercise reduces the expected cost of these options) and to grant strictly fewer new options; later we show that these two goals are congruent.

Given the terms of his incentive contract, the manager chooses his actions at t_1 to maximize his expected utility, that is,

$$\max_{q \in \{r,s\}, F \in \{0,Q\}} \bar{U}(\tilde{x}(q, F), F) = E[u(\tilde{x})] - F. \tag{5}$$

E. Solving the Vesting Problem

Having reduced the firm's problem to the use of options to satisfy the incentive compatibility and participation constraints in the most efficient manner, we now consider each constraint in turn. Because we focus on options as an antidote to managerial risk aversion, we first consider the incentive compatibility constraint. We derive the conditions for there to exist a risk avoidance problem and show how different degrees of early vesting can be used in conjunction with grants of new options to solve this problem. We then optimize subject to satisfying the participation constraint. The result is that the firm monotonically reduces the expected cost of the vesting/granting solution to the risk avoidance problem until the participation constraint binds.

To make the solutions tractable, we give the manager a logarithmic utility function over his final wealth, $u(x) = \ln x$, which exhibits decreasing absolute risk aversion (DARA)[8] and constant relative risk aversion (CRRA). His exogenous initial wealth, $W > 0$, ensures that this specification is well defined even if all of his options expire worthless. When using the normalizations $\lambda = \frac{M}{H}$ and $\delta = \frac{\varepsilon}{H}$, we also normalize the manager's wealth to $\omega = \frac{W}{N_0 H}$, his wealth relative to the maximum potential (further) option gain from holding his initial options through the second period.

As a benchmark case, we begin by considering the situation in which none of the existing options are permitted to be exercised at t_1, and n new options are granted. Substituting the manager's prospective payoffs into the risk-taking incentive compatibility constraint (2), we obtain

$$\frac{(W + N_0 M)(W + N_0(M + H) + nH)W}{(W + N_0(M - \varepsilon))^3} \geq 1, \tag{6}$$

[8] While we do not vary the utility function, we can change the manager's degree of absolute risk aversion by varying W.

where the left-hand side can be interpreted as a measure of the relative attractiveness of the risky project, compared to the safe project.

PROPOSITION 1: *In the absence of early exercise and given no new options are granted,*

i) *There exists a threshold number,* $\underline{N}_0(\lambda)$*, (explicitly defined in the proof) such that constraint (6) is satisfied at* t_1 *if and only if*

$$N_0 \leq \underline{N}_0(\lambda). \tag{7}$$

ii) $\underline{N}_0(\lambda)$ *is decreasing in* λ.

PROPOSITION 2: *If* $N_0 > \underline{N}_0(1)$*, then*

i) *There exists a threshold moneyness,* $\underline{\lambda}(N_0) \in (\delta, 1)$ *(explicitly defined in the proof), such that constraint (6) is satisfied if and only if*

$$\lambda \leq \underline{\lambda}(N_0). \tag{8}$$

ii) $\underline{\lambda}(N_0)$ *is decreasing in* N_0.

Thus, if N_0 exceeds $\underline{N}_0(\lambda)$ (equivalently, λ exceeds $\underline{\lambda}(N_0)$), then the manager will not choose the risky project unless existing options are exercised and/or new options are granted. The intuition is as follows. Options that conferred risk-taking incentives upon the manager when they were granted at t_0 may generate decidedly counterproductive incentives at t_1, and they are more likely to induce risk avoidance the deeper in-the-money they go because they lose their convexity and become more linear and stock-like in their payoffs. Thus, while options certainly impose risk on the manager, once they have moved deep in-the-money they may impose the wrong kind of risk on him, failing to sufficiently convexify his concave preferences and exposing him to painful down-side risk.

Figure 2 illustrates the result that too many options, too far in-the-money, cause the manager to reject the risky project. The following proposition shows that resolving this problem merely by granting new options becomes progressively more expensive for the firm, the deeper in-the-money are the existing options.

PROPOSITION 3: *In the absence of early vesting, if* $N_0 \geq \underline{N}_0(\lambda)$,

i) *There exists a threshold number,* $n_r'(N_0, \lambda)$*, (explicitly defined in the proof) such that constraint (6) can be satisfied by granting* $n \geq n_r'(N_0, \lambda)$ *new options.*
ii) $n_r'(N_0, \lambda)$ *is increasing and convex in* N_0.
iii) $n_r'(N_0, \lambda)$ *is increasing and convex in* λ.

Note that, by construction, for each moneyness, λ, $n_r'(N_0, \lambda)$ becomes positive once $N_0 > \underline{N}_0(\lambda)$.

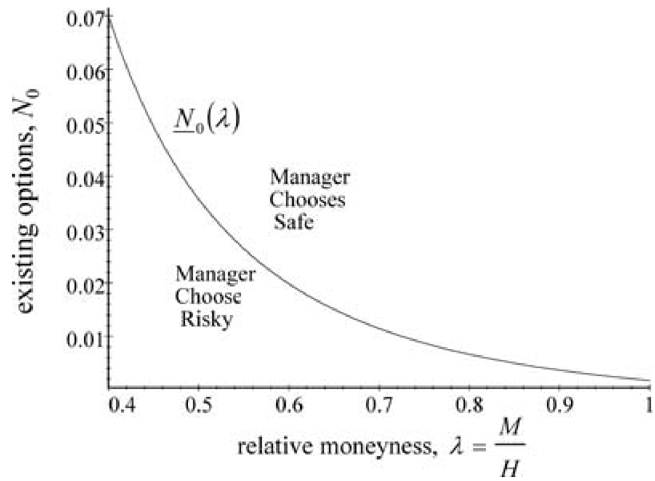

Figure 2. Project selection. Graph of $\underline{N}_0(\lambda)$, the threshold number of existing options above which the manager will reject the risky project (in the absence of any early exercise or the granting of new options). The graph is decreasing in moneyness, showing that "too many options, too far in-the-money, cause the manager to reject the risky project."

We now consider the firm's position if it reduces the number of outstanding existing options to N_1 by allowing $N_0 - N_1$ of them to be exercised by the manager. Denote $k_1 = \frac{N_1}{N_0}$.

PROPOSITION 4: *In the presence of early exercise, if $N_0 \geq \underline{N}_0(\lambda)$, then*

i) Constraint (2) can be satisfied by letting a number $N_0 - N_1$ (equivalently, a proportion $1 - k_1$) of old options be exercised and granting $n \geq n_r(k_1, \lambda)$ new options, where

$$\frac{n_r(k_1,\lambda)}{N_0} = \begin{cases} \dfrac{k_1\left(-k_1^2\delta^3 + (3\delta^2+\lambda)(\omega+\lambda)k_1 - (\omega+\lambda)^2(1+3\delta-\lambda)\right)}{(\omega+(1-k_1)\lambda)(\omega+\lambda)} & \text{if} \quad k_1 > \underline{k}_1 \\ 0 & \text{if} \quad k_1 \leq \underline{k}_1 \end{cases} \tag{9}$$

and $\underline{k}_1$ represents a threshold below which no new options are required to satisfy constraint (6), that is,

$$\underline{k}_1 = \frac{\underline{N}_1}{N_0} = \frac{\omega+\lambda}{2\delta^3}\left(3\delta^2 + \lambda - \sqrt{\lambda^2 + \delta^2(6+4\delta)\lambda - \delta^3(4+3\delta)}\right). \tag{10}$$

ii) $n_r(k_1, \lambda)$ is increasing and convex in k_1.
iii) $n_r(k_1, \lambda)$ is increasing in λ.
iv) $\underline{k}_1$ is decreasing in λ and increasing in δ.

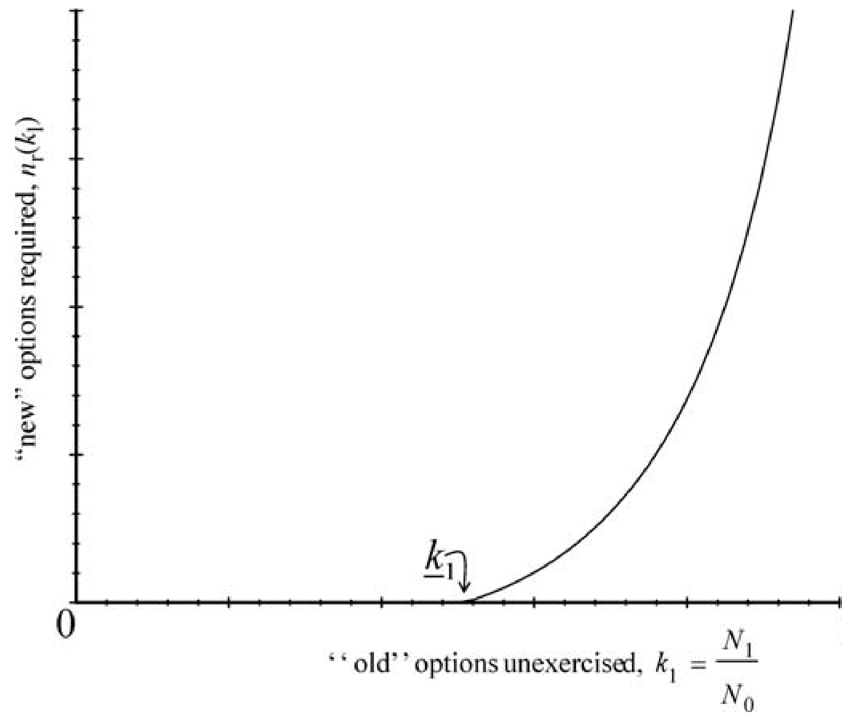

Figure 3. Number of new options required to solve the risk avoidance problem. When the existing "old" options are sufficiently in-the-money to cause a risk avoidance problem, the number of newly issued options required to induce the manager to take the risky project is a rapidly increasing function of k_1, the proportion of old options left unexercised.

Proposition 4 gives us a recipe for solving the risk avoidance problem. Part (i) says that if a proportion $1 - k_1$ of the existing options are exercised, then the firm needs to issue exactly $n_r(k_1, \lambda)$ new options to restore risk-taking incentives. Part (ii) says that n_r is convex and rapidly increasing with the proportion of unexercised existing options, as Figure 3 illustrates. Part (iv) says that deeper moneyness increases the amount of existing options that would need to be exercised in order to negate the need for any new options to ensure risk-taking.

As expression (4) shows, the firm's compensation costs are decreasing in the exercise of existing options and increasing in the granting of new options. The firms two objectives, therefore, are to minimize k_1 and to minimize n. These two objectives do not conflict—from Proposition 4(ii), n_r is increasing in k_1, so minimizing k_1 also minimizes the expected cash cost of new options. Thus, when the firm satisfies risk-taking constraint (2) by allowing the proportion $1 - k_1$ options to vest and granting $n_r(k_1)$ new options, the firm's objective is simply to minimize k_1, subject to satisfying the participation constraint (3).

It is now clear that the firm can motivate risk-taking incentives at the lowest possible cost by sliding down and left along the curve in Figure 3, subject to satisfying the participation constraint (3). Accordingly, we consider the satisfaction of this constraint along the locus $(k_1, n_r(k_1))$ satisfying the risk-taking constraint. We show that participation incentives are monotonic along this locus and so for any particular level of moneyness, the firm will reduce k_1 (and hence $n_r(k_1)$) until the participation constraint binds.

If the manager were to quit the firm before the second period, he would "save" the personal cost of participation and enjoy cash payoffs from exercising any in-the-money options vested at t_1, but would forfeit any unvested options. In equilibrium, he prefers to stay with the firm and choose "risky," and his participation constraint (3) reflects that he exercises $N_0 - N_1$ existing options, retains the remaining N_1 existing options, and receives n new ones. This leads to the following proposition.

PROPOSITION 5: *Along the locus $(k_1, n_r(k_1))$ that satisfies risk-taking constraint (2),*

i) The participation constraint becomes

$$\beta(k_1, n_r(k_1)) \geq \underline{\beta}(Q), \tag{11}$$

where $\underline{\beta}(Q) = \exp 3Q$ and

$$\beta(k_1, n_r(k_1)) = \begin{cases} \dfrac{(\omega + \lambda - k_1\delta)^3}{(\omega + \lambda(1 - k_1))^3} & if \quad k_1 \geq \underline{k}_1 \\ \dfrac{(\omega + \lambda + k_1)(\omega + \lambda)}{(\omega + \lambda(1 - k_1))^2} & if \quad k_1 < \underline{k}_1. \end{cases} \tag{12}$$

ii) $\beta(k_1)$ is increasing in k_1.
iii) $\beta(k_1)$ is increasing in λ, $\forall \omega \geq 0.5$.
iv) If $\omega < 0.5$, then $\beta(k_1)$ is increasing in $\lambda \, \forall k_1 \geq \min\{\underline{k}_1, \frac{(1-2\omega)(\omega+\lambda)}{(2\omega+\lambda)}\}$ but decreasing in λ for $k_1 < \min\{\underline{k}_1, \frac{(1-2\omega)(\omega+\lambda)}{(2\omega+\lambda)}\}$.

The function $\beta(k_1)$ is a measure of the manager's participation incentives when a proportion k_1 of the existing options remains unexercised and is augmented by the number $n_r(k_1)$ of new options required to generate sufficient risk-taking incentives. Part (i) says that these participation incentives need to be at least as high as a constant threshold level. Part (ii) corresponds to the intuition that the manager has greater incentive to stay with the firm the more of his option wealth remains unvested until t_2. The analytical importance of this is that the set $\{(k_1, n_r(k_1)) \in [0, 1] \times [0, \infty) : \beta(k_1, n_r(k_1)) \geq \underline{\beta}(Q)\}$ is continuous and connected. Thus, to satisfy the risk-taking and participation constraints at minimum cost, the firm need just reduce k_1 until the participation constraint binds. Part (iii) says that participation incentives increase with the moneyness of options and again corresponds to the intuition that the manager is more likely to stay with the firm the more valuable is his unvested option wealth. The caveat to this is given in part (iv), which says that when the manager has particularly low relative exogenous wealth levels ($\omega < 0.5$), then the wealth effect of moneyness on his vested option wealth can sufficiently reduce his marginal utility for wealth that the participation incentives are decreasing in moneyness. However, even this effect can only dominate for "small" k_1, not high enough to trigger a grant of new options.

PROPOSITION 6 (Optimal vesting schedule and granting of new options): *The firm's optimal proportion, k_{part}, of unexercised existing options (i.e., allowing $1 - k_{\text{part}}$ to be exercised at t_1) and corresponding number, n_{part}, of new options together ensure that the manager does not quit, but rather, stays and chooses the risky project. These optima depend on the manager's total cost of participation, Q, as follows:*

i) If $\underline{\beta}(Q) > \beta(1)$, then

$$k_{\text{part}} = 1, \tag{13}$$

$$n_{\text{part}} = \left(\frac{\omega^2}{(\omega+\lambda)}\underline{\beta} - (\omega+\lambda+1)\right) N_0 > n_r(1). \tag{14}$$

ii) If $\underline{\beta}(Q) \in (\beta(\underline{k}_1), \beta(1))$, then

$$k_{\text{part}} = \frac{(\omega+\lambda)(e^Q - 1)}{e^Q\lambda - \delta} \in (\underline{k}_1, 1), \tag{15}$$

$$\begin{aligned} n_{\text{part}} &= n_r(k_{\text{part}}) \\ &= \frac{\begin{pmatrix} e^{2Q}\lambda^2 - e^Q\lambda - 2\lambda\delta e^{2Q} - 2e^Q\lambda\delta \\ +\delta^2 e^{2Q} + \delta + \delta^2 e^Q + \delta^2 \end{pmatrix}(\omega+\lambda)(e^Q - 1)N_0}{(e^Q\lambda - \delta)^2} \\ &> 0. \end{aligned} \tag{16}$$

iii) If $\underline{\beta}(Q) \leq \beta(\underline{k}_1)$, then

$$k_{\text{part}} = \frac{(\omega+\lambda)}{2\underline{\beta}\lambda^2}\left(1 + 2\underline{\beta}\lambda - \sqrt{(1 + 4\underline{\beta}\lambda(1+\lambda))}\right) \in (0, \underline{k}_1], \tag{17}$$

$$n_{\text{part}} = n_r(k_{\text{part}}) = 0. \tag{18}$$

This proposition uses the recipe of Proposition 4 to ensure risk-taking, while satisfying the participation constraint (3) at minimum cost. Part (i) corresponds to the manager's participation requirements being so high that even keeping all existing options unvested and giving him $n_r(1)$ new ones would be insufficient to make him stay. Thus, nothing vests and an even higher number of new options are required. Because risk-taking is not even a binding constraint in this case, we pursue it no further. Risk-taking *is* binding in parts (ii) and (iii), however, where we find explicit solutions for the vesting schedule and the number of new

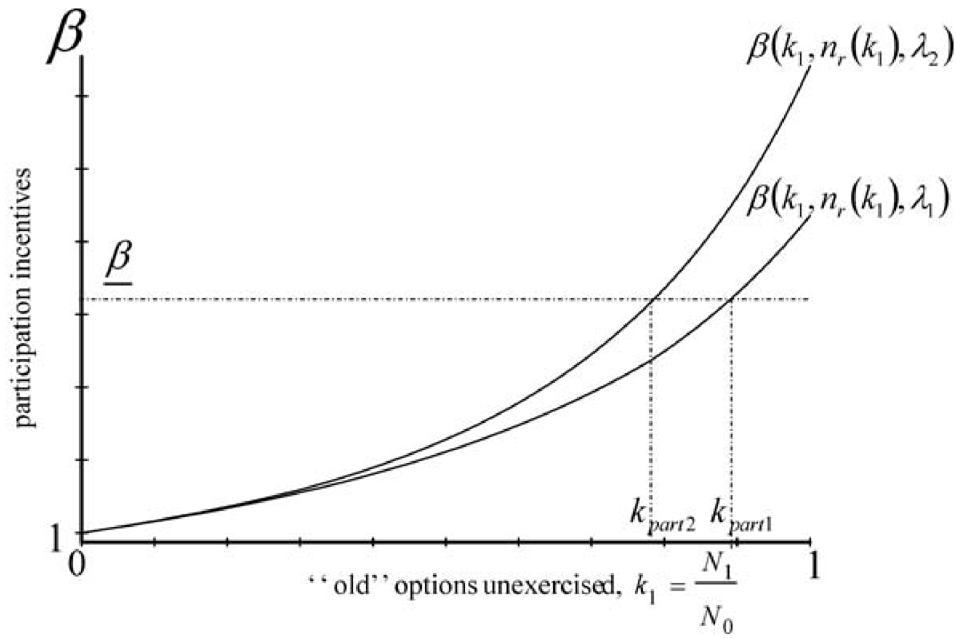

Figure 4. Participation incentives. For two distinct levels of moneyness, $\lambda_2 > \lambda_1$, of existing options, the participation incentives are shown as a function of the proportion, k_1, of old options that remain unexercised (causing $n_r(k_1)$ new options to be granted). To ensure the manager stays for the second period, these incentives need to attain $\underline{\beta}$. For moneyness λ_1, this constraint binds at k_{part1}, in which case $1 - k_{\text{part1}}$ is the optimal proportion of old options to be vested and exercised. At a deeper level of moneyness, $\lambda_2 > \lambda_1$, a greater proportion, $1 - k_{\text{part2}}$, of old options should be vested.

options that should be granted. These solutions have the following properties.

PROPOSITION 7 (Progressive Performance Vesting):

i) k_{part} *is decreasing and convex in* λ.
ii) n_{part} *is increasing in* λ *whenever* $\beta(1) < \underline{\beta}$.

Part (i) is the central result of our paper: The deeper in-the-money are the manager's existing options, the more the firm will want him to exercise and so the more it should allow to vest. Given that we paint the existing options as a risk-avoiding menace that needs to be removed, this result is quite intuitive and suggests that the firm should consider a vesting schedule that is increasing in the stock price attained at t_1, a policy that we refer to as progressive performance vesting. Figure 4 illustrates the result that the higher the moneyness, $\lambda_2 > \lambda_1$, the fewer existing options should be left unvested, $k_{\text{part2}} < k_{\text{part1}}$, because the required participation incentives are achieved with more vesting.

Part (ii) of Proposition 7 states that the size of the new option grant is increasing in moneyness. Increased moneyness increases the problem of existing options (tending to increase n_{part}) but also increases the vesting of existing options (tending to decrease n_{part}). Our result shows that the former effect can dominate—when the risk-taking constraint also binds (parts (ii) and (iii) of Proposition 6), then the number of new options granted is an increasing function of the moneyness of existing options. This suggests that the exercise of existing options is positively associated with the granting of new options.

To complete this section, we note that our derivations of optimal vesting schedules above are based upon the assumption that the manager exercises options when they vest. The following proposition confirms that this is indeed the case.

PROPOSITION 8: *When the firm follows the optimal vesting strategy for existing options and grants new options in accordance with Proposition 6, the manager does indeed maximize his own utility by exercising the whole* $1 - k_{\text{part}}$ *proportion of options that the firm allows to vest.*

If the manager were to leave some vested options unexercised (i.e., holding some fraction $k_1 > k_{\text{part}}$) then he would not have correct incentives to choose "risky" so would choose "safe." But this would mean he would want to exercise as many options as possible at the t_1 stock price because the effect of this out-of-equilibrium project decision would be a fall in stock price, reducing the moneyness of any unexercised options. Similarly, choosing "quit" he would want to exercise as many options as possible at t_1 because he will forfeit any unexercised options on departure.

II. Executive Stock Option Plans

In this section, we interpret our results and discuss their empirical and normative implications for the design of option schemes. We highlight what can go wrong with calendar vesting and outline the empirical implications. We also discuss the use of performance vesting options and show how their design may be refined in view of our results.

A. Calendar Vesting

Having derived our vesting schedules, it is clear that traditional calendar vesting schedules are unlikely to offer correct incentives for risk-taking. If the calendar vesting schedule permits a fixed proportion $1 - k_c$ to vest at t_1, leaving k_c unvested until t_1, then the following scenarios are possible:

i) $k_c > k_*$, and the firm does not allow sufficient options to vest. From Proposition 4 and Figure 5 we can see that to reestablish risk-taking incentives, the firm needs to grant an unnecessarily high number of new options, $n_r(k_c) > n_r(k_*)$.
ii) $k_c < k_*$, and the firm allows too many options to vest. If the manager exercises all of the $1 - k_c$ vested options, then the firm needs to grant an unnecessarily high number of new options, not to ensure risk-taking

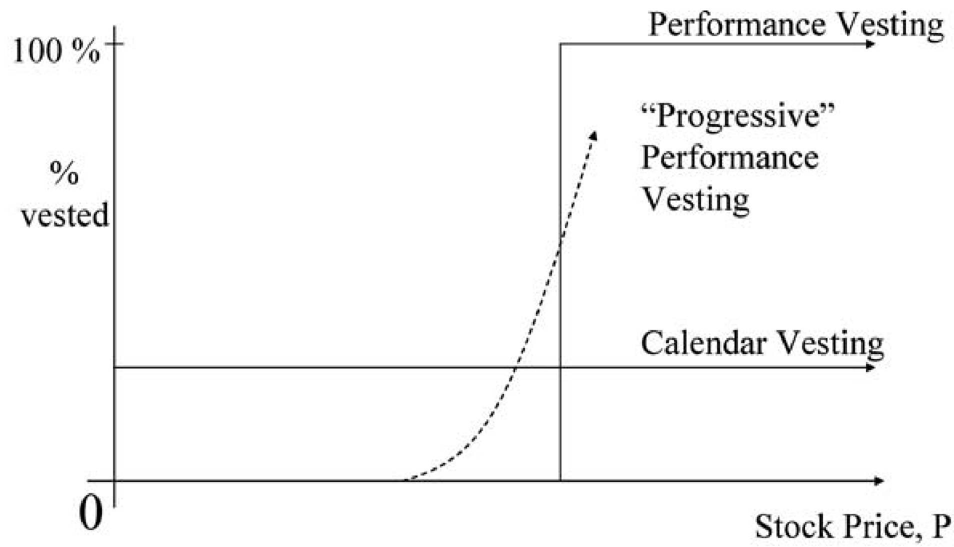

Figure 5. Vesting schedules. Comparison of the number of options vested at an intermediate date, as a function of the underlying stock price. Under "calendar vesting," a fixed proportion of options vest. Under plain vanilla performance vesting, attainment of a single performance hurdle leads to option vesting. Under "progressive" performance vesting, progressively more options vest the higher the stock price performance.

but rather to satisfy the binding participation constraint. (Indeed, absent the need for performance-based pay, a salary could achieve this aim.) It may be that the manager chooses rationally to exercise less than $1 - k_c$ options, which may mitigate the firm's failure to implement the optimal vesting schedule. Papers such as Huddart (1994), Detemple and Sundaresan (1999), and Heath, Huddart, and Lang (1999) show that undiversified risk-averse managers rationally exercise more options early the deeper they are in-the-money; we can show this to be true also in our model. We conjecture that under some circumstances this exercise behavior might enable calendar vesting to approximate the outcomes of progressive performance vesting, possibly explaining why the firm may be prepared to allow the manager discretion over the timing of his exercise decisions—paradoxically, it can be his own risk aversion that acts to remove those incentives that would otherwise stop him from taking risks. However, in the event this alignment of objectives does not occur with calendar vesting, for example, when fewer options have vested than would be optimal to exercise from both the manager's and the firm's points of view, the firm may be vulnerable to missing out on valuable growth opportunities.

Empirically, it would be interesting to document how risk-taking behavior and subsequent option grants are affected dynamically as options move in-the-money. We know that managers rationally exercise more, the deeper the options are in-the-money, and Heath et al. (1999) find evidence of particularly intense exercise activity immediately following vesting dates. This suggests the existence of a pent-up desire to exercise and provides evidence that vesting restrictions are often binding. We are aware of no study that examines the effect on risk-taking when managers are constrained by vesting requirements. Our results predict that when this is the case, risk-taking will decrease unless the firm issues a large number of new options to reconvexify the incentives. Moreover, numerous studies show how options (but not restricted stock) raise volatility. We conjecture that after a period of increasing stock prices, the risk-taking incentives of options may weaken (and even become disincentives) unless renewed and reinvigorated by the mechanisms of early exercise and the granting of further options that we analyze in this paper. Future research should examine dynamic portfolio incentives and their interaction with the temporal evolution of volatility.

Proposition 7 suggests that stock price run-ups that lead to high levels of option exercise may be followed by particularly large grants of new options. This result recalls "You can pay me now and you can pay me later . . ." of Boschen and Smith (1995). Their results on pre-1990 data show how managers reap the rewards for good performance not only contemporaneously, but also for up to 5 years following an innovation in firm performance. Our results provide further support for the notion that options are granted both to reward past success and to provide future incentives. Empirically, Ofek and Yermack (2000) find that in years in which boards grant equity-based compensation to managers, the latter tend to reduce their previously owned equity holdings, thereby counteracting the board's attempts to increase managers' exposure to firm value. Our results suggest that another interpretation may be that there is an implicit recognition of the mutual benefit to the manager and the firm of early option exercise, the sale of stock, and the granting of new options to reoptimize incentives.

B. Performance Vesting Options

The normative conclusion of the present paper is that when risk-taking incentives are important, the firm might be advised to use progressive performance vesting rather than calender vesting options. A justification sometimes given for the use of performance vesting options is that they strengthen the link between pay and performance, addressing the concerns of shareholder groups who resent managers receiving large option payouts for often mediocre performance. With a performance target, vesting becomes a reward for increasing stock price significantly rather than just an inevitable consequence of the passage of time. Performance targets are usually simple step functions of stock price, for example, "no options vest unless a 78% price gain is achieved, whereupon 100% of the options vest." Yet, theoretically, there is no limit to the complexity that could be built into a vesting schedule. While we would not necessarily advise practitioners to adopt our equation (15) in the design of their vesting schedules, the principle of "the higher the stock price, the more options vest" might be incorporated more imaginatively into option contracts. Figure 5 shows qualitatively how our proposed progressive performance vesting differs from typical calendar vesting and plain vanilla performance vesting schemes.

III. Conclusion

This paper highlights the importance of setting appropriate risk-taking incentives for management as stock prices evolve over time. A firm that cares about risk-taking should care about the convexity of the compensation contracts offered to managers. In particular, when options become deep in-the-money, they lose their convexity and this may dramatically reduce risk-taking as managers concentrate on preserving the paper gains they have made. We suggest this is one reason for allowing partial early vesting of stock options. We derive vesting schedules as a function of realized stock price gains, which allows the manager to remove incentives when and only when they have lost their risk-inducing properties and makes the firm's attempts to reestablish risk-taking incentives more efficient. Our progressive performance vesting strategy costs the firm less in terms of dilution. Forcing the manager to bear risk is costly because he demands a risk premium, and forcing the manager to bear the wrong kind of risk is doubly expensive. Permitting early exercise and reoptimizing incentives can reduce this cost because the firm needs to give the manager less remuneration on a dollar basis but succeeds in rewarding him with reduced uncertainty. To the extent the firm is keen to reduce media and shareholder perceptions of inflated option awards, this may be one step towards achieving that objective.

Appendix: Proofs of Propositions

Complete versions of the following proofs are available in an earlier version of the paper, located at www.ssrn.com, or from the author on request.

Proof of Proposition 1:

i) Letting constraint (6) bind with equality yields a cubic equation in N with negative, zero, and positive roots. The positive root is

$$\underline{N}_0(\lambda) = \frac{W(-2\lambda^2 + \lambda(1+6\delta) - 3\delta^2 + \sqrt{\lambda^2 + 2\lambda\delta^2(3+2\delta) - \delta^3(4+3\delta)})}{2H(\lambda-\delta)^3}, \tag{A1}$$

and for $N_0 > \underline{N}_0(\lambda)$, risk-taking constraint (6) is not satisfied.

ii) By differentiation.

Proof of Proposition 2:

i) The condition says that there is a risk avoidance problem at least when the options are 100% in-the-money, that is, when $\underline{N}_0(1) < N_0$. Given $\underline{N}_0(\lambda)$ is decreasing in λ, it follows that $\underline{N}_0(\lambda) \nearrow \infty > N_0$ as $\lambda \searrow \delta$. Thus, $\exists \underline{\lambda} \in (\delta, 1)$ such that $\underline{N}_0(\underline{\lambda}) = N_0$, whereupon $\forall \lambda > \underline{\lambda}, \underline{N}_0(\lambda) < N_0$.

Note that $\underline{\lambda}$ is the positive root of

$$\lambda^3 + (2\omega - 3\delta)\lambda^2 + (-6\omega\delta + 3\delta^2 - \omega + \omega^2)\lambda - \delta^3 - 3\omega^2\delta + 3\omega\delta^2 - \omega^2 = 0. \quad \text{(A2)}$$

Proof of Proposition 3: i) From equation (6), without early exercise, if there is a risk avoidance problem when $n = 0$, then we need to increase n until equation (6) is satisfied. This gives

$$n_r' = \left(\frac{(\omega + (\lambda - \delta))^3}{\omega(\omega + \lambda)} - (\omega + \lambda + 1)\right) N_0. \quad \text{(A3)}$$

ii) and iii) follow by differentiation.

Proof of Proposition 4: With the cash-in of $(N_0 - N_1)$ existing options, each of moneyness M, and the granting of n new options, condition (2) becomes

$$\left(\omega + \lambda + k_1 + \frac{n}{N_0}\right)(\omega + \lambda)(\omega + \lambda(1 - k_1)) \geq (\omega + \lambda - \delta k_1)^3. \quad \text{(A4)}$$

i) This condition is satisfied with $n = 0$ (no new options need be granted) if

$$k_1\left[k_1^2\delta^3 - (\lambda + 3\delta^2)(\omega + \lambda)k_1 + (\omega + \lambda)^2(1 - \lambda + 3\delta)\right] \geq 0, \quad \text{(A5)}$$

that is,

$$k_1 \leq \underline{k}_1 = \frac{(\omega + \lambda)}{2\delta^3}(3\delta^2 + \lambda - \sqrt{\lambda^2 + \delta^2(6 + 4\delta)\lambda - (4 + 3\delta)\delta^3}). \quad \text{(A6)}$$

Otherwise, when $k_1 > \underline{k}_1$, this condition requires n new options, where

$$\frac{n}{N_0} = \frac{(\omega + \lambda - \delta k_1)^3}{(\omega + \lambda)(\omega + \lambda(1 - k_1))} - (\omega + \lambda + k_1)$$
$$= \frac{k_1\left(-\frac{\delta^3}{(\omega + \lambda)}k_1^2 + (3\delta^2 + \lambda)k_1 - (\omega + \lambda)(1 - \lambda + 3\delta)\right)}{(\omega + \lambda(1 - k_1))}. \quad \text{(A7)}$$

ii) and iii) follow by differentiation.

Proof of Proposition 5: If the manager exercises $N_0 - N_1$ options, retains N_1 options and receives n new options, his participation constraint (3) becomes

$$\frac{\left(\omega + \lambda + k_1 + \frac{n}{N_0}\right)(\omega + \lambda)}{(\omega + \lambda(1 - k_1))^2} \geq \exp 3Q. \quad \text{(A8)}$$

Substituting equation (9) into this inequality yields part (i). Differentiation yields parts (ii)–(iv).

Proof of Proposition 6:

i) If $\exp 3Q > \beta\,(1)$, then $k_{\text{part}} = 1$ and we need to grant strictly more than $n_r(1)$ new options to satisfy

$$\frac{\left(\omega + \lambda + 1 + \dfrac{n}{N_0}\right)(\omega + \lambda)}{\omega^2} = \exp 3Q, \tag{A9}$$

which gives equation (13) directly.

ii) If $\exp 3Q \in (\beta(\underline{k}_1), \beta(1))$, then $k_{\text{part}} \in (\underline{k}_1, 1)$ and $\beta(k_1) = e^{3Q}$ binding yields a cubic in k_1, which gives $k_{\text{part}} = (\frac{(\omega+\lambda)(e^Q-1)}{e^Q\lambda - \delta})$ as the unique real solution. Substituting into $n_{\text{part}} = n_r(k_{\text{part}})$ completes the proof.

iii) If $\exp 3Q \leq \beta(\underline{k}_1)$, then $n_{\text{part}} = 0, k_{\text{part}} < \underline{k}_1$, and $\beta(k_1) = e^{3Q}$ binding yields a quadratic in k_1, which gives k_{part}.

Proof of Proposition 7: i) and ii) by differentiation.

Proof of Proposition 8: Imagine first that the manager does as is hoped of him and exercises exactly $N_0 - N_{\text{part}}$ existing options. He then has the correct incentives to choose "risky," so this is an equilibrium.

In contrast, imagine he were to reserve some $N_1 > N_{\text{part}}$ existing options for the second period. He would then not have incentives to choose "risky," and thus would choose an alternative course of action. However, because his expected utility to "safe" or "quit" are both strictly decreasing in k_1, the manager would exercise *all* vested options. Hence, neither alternative course of action is an equilibrium.

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