The Temporal Structure of Equity Compensation*
(Preliminary Version)

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Abstract

It is well accepted that aligning managerial incentives with those of stock holders enhances shareholder value. In theory models, such alignment is usually modeled as giving managers a stake in the realized cash flows of the firm's projects. However, such a stake, which entails a manager holding on to her equity position until all cash flow uncertainty is resolved, can lead a risk averse manager to turn down risky positive NPV projects. In this paper, we argue that equity-linked incentives can mitigate the manager's bias against assuming risk, provided the manager is allowed the flexibility of trading out her equity position early. Thus, allowing managers to hedge away partially the risks associated with their firm's stock price may actually be in the shareholders' best interests. However, it can lead to excessive risk-taking when the firm has debt in its capital structure.

Keywords: executive compensation, corporate governance, corporate diversification

1 Introduction

The current financial crisis has intensified debate about the need to reform executive compensation practices. One focal point of the debate is whether executives are rewarded too much for short-term rather than long-term stock price performance. For example, Bebchuk (2005) argues that "broad freedom to unload options and shares has given executives incentives to produce short-term stock price increases instead of long-term value." Since shareholders presumably care about long-term rather than short-term value, rewards for short-term performance seem likely to misalign managerial and shareholder interests. Commentators have argued that this misalignment resulted in Wall Street executives taking excessive risks in an attempt to push up stock prices, thereby contributing to the financial crisis. Our objective in this paper is to examine how pay for short-term stock price performance might impact firm value by altering executives' risk-taking incentives.

It has long been understood that aligning manager and shareholder interests through the grant of managerial equity stakes is essential to reducing moral hazard costs (Jensen and Meckling 1976; Harris and Raviv 1978; Holmstrom 1979; Shavell 1979; Jensen 1986). For such stakes to be effective, however, the manager must be required to hold them until the market at least partially observes the effects of her actions on future cash flows. The resulting long-term nature of these stakes imposes significant undiversified risk on the manager, which would predispose a risk-averse manager to choose less risky projects than what other, better diversified shareholders might prefer (Treynor and Black 1976; Amihud and Lev 1981; May 1995). So long-term equity incentives are unlikely to promote excessive risk-taking, and may in fact result in the manager passing up positive NPV projects simply due to the risk they entail.

We argue, however, that short-term stock price-based incentives actually have the opposite effect: they bias the manager towards taking on *more* risk, offsetting the bias against risk-taking that long-term incentives create. In an all-equity firm, this unambiguously moves the firm towards the first best level of risk (i.e., it never results in excessive risk-taking). So, at least along one dimension, short-term stock price-based incentives improve the alignment of managers and shareholder interests, even though shareholders care only about long-term firm value.

Of course, Wall Street banks, whose risk-taking behavior is currently at the heart of the debate over compensation practices, can hardly be characterized as all-equity financed. We show that if a firm has substantial debt in its capital structure, as financial firms typically do, then short-term incentives can indeed result in excessive (i.e., greater than first best) risk-taking. This reduces firm value ex ante, even though shareholders benefit ex post from risk-shifting. This argument suggests that schemes to limit compensation for short-term stock price performance in industries like finance that are characterized by high leverage may be beneficial. However, the threat of excessive risk-taking could also be eliminated simply by limiting the amount of leverage that firms in such industries can maintain.

Our general argument is straightforward. Faced with long-term incentives, a manager chooses less risk than risk neutral shareholders would prefer. So an increase in observed risk would lead to an increase in the firm's stock price. However, since most uncertainty about payoffs associated with different decisions is not resolved until well into the future, an increase in project risk would have little effect on the variance of the stock price in the short run. Since greater risk would increase the short-term stock price with little effect on its variance, linking the manager's pay to the firm's stock price over a short time horizon gives her an incentive to take on greater risk.

To examine the optimal contracting and value implications of this argument, we build a simple model in which a risk-averse manager makes two decisions that influence the distribution of a firm's future cash flow: 1) the choice of a project from a set of projects with differing payoff risk, and 2) a level of costly effort to provide. The firm's future cash flow is equal to the uncertain project payoff plus the contribution of the manager's effort and a random component that is uncorrelated with project payoff. Expected project payoff increases with risk, up to a point. While the manager's choice of project is observable, it is assumed to be complex to describe and therefore non-contractible. The manager's effort choice is never observed.

Linking compensation to the firm's long-term cash flows is necessary in this setting to induce the manager to provide effort, since the effect of effort on the firm's cash flows is not observed in the short-run. We show that while these long-term incentives do indeed lead to the manager choosing a less risky project than risk neutral shareholder would prefer, short-term stock price-based incentives offset this bias for the reason explained above. However, improving risk-taking incentives by linking pay to the short-term stock price comes at a cost. If the market is able in the short-run to forecast the purely random component of future cash flow, then the short-term stock price will be risky, even though no intermediate cash flows are realized. Therefore, linking pay to short-term stock price imposes additional risk on the undiversified manager, for which she must be compensated. The optimal contract trades off this cost against the benefit of inducing the choice of a riskier project with a higher expected cash flow.[1]

Short-term and long-term incentives interact in surprising ways in our model. Holmstrom and Tirole (1993) argue, following the logic of Holmstrom (1979), that compensation should be linked to the short-term stock price for a very different reason: because it is incrementally informative about managerial effort. In this case, the short-term stock price can substitute partially for the long-term stock price in the manager's contract. This substitution maintains the same level of incentives while reducing risk, since short-term and long-term stock price are imperfectly-correlated. However, we show that when the action about which the short-term stock price is informative is the choice of project risk instead of effort, the short-term stock price can actually complement long-term performance measures in the manager's contract. Strengthening the link between pay and the short-term stock price raises the marginal cost to the manager of lowering risk and therefore reduces the negative effect on risk-taking of placing greater weight on long-term performance. Thus optimal long-term incentives may be stronger if the contract also places weight on the short-term stock price than if it does not.

Our model also has surprising implications for the effect of stock price informativeness on the optimal weight on the short-run stock price in the manager's contract. An improvement in the ability of the market to forecast future cash flow innovations makes the stock price more variable over the short-run, as the price reacts to information about factors affecting cash flow that are beyond the manager's control. This increases the risk imposed on a manager whose pay is tied to the short-run stock price, reducing the weight on the short-run stock price in the optimal contract. Thus our theory suggests somewhat counter-intuitively that, as the informativeness of the short-run stock price increases, its role in the manager's contract should diminish.

In the case of an all-equity financed firm, short-term incentives never lead to the manager

[1]The cost of exposing the manager to risk in the short-term stock price is magnified by the fact that the short-term stock price is positively-correlated with long-term value. This positive correlation actually suggests that the short-term stock price can be used to hedge the manager against risk associated with compensation linked to long-term value. In a setting without managerial project choice, Diamond and Verrechhia (1982) provide a result suggesting that the weight on the short-term stock should indeed be negative in order to implement intertemporal relative performance evaluation.

choosing greater than the first-best level of project risk, since doing so would actually *reduce* the short-term stock price in addition to adding risk to the manager's compensation. However, when a firm has debt in its capital structure, the optimal level of risk from the standpoint of risk neutral shareholders will generally be greater than the first-best level of risk because of limited shareholder liability. By more effectively aligning managerial and shareholder interests regarding risk, short-term incentives can induce the manager to choose a level of project risk greater than the first best level. Creditors should take into account the manager's incentives to risk-shift when terms of the debt issue are negotiated, so shareholders bear the cost of this inefficiency ex ante. Recent events suggest that such excessive risk-taking can also impose externalities on other stakeholders in the firm.

Our analysis has major implications for the study of the effects of executive compensation structure on corporate risk-taking. For example, Amihud and Lev (1981) argue that managers with greater equity stakes should engage in more diversifying acquisitions in order to reduce firm-specific risk. Empirical support for this argument is mixed, with Amihud and Lev (1981) and May (1985) finding evidence in support of the argument and Denis, Denis and Sarin (1997), Anderson et al. (2000) and Aggarwal and Samwick (2003) finding evidence against it. However, our theory predicts that only *long-term* equity incentives result in more risk-taking, while short-term equity incentives actually result in *less* risk-taking. It is therefore unclear whether stronger equity incentives in general should lead to more or less diversification. a proper test of the diversification incentives of managers needs to take into account the temporal distribution of managerial incentives.

Research has also examined how the convexity of the relationship between managerial compensation and stock price performance affects corporate risk-taking. A number of studies have found that greater use of stock options leads to greater risk-taking, consistent with the convex payoff of stock options offsetting the concavity of a risk-averse manager's utility function (e.g. Agrawal and Mandelker 1987; DeFusco, Johnson and Zorn 1990; Rajgopal and Shevlin 2002).[2] However, Carpenter (2000) and Ross (2004) point out that the greater use of instruments such as stock options that have convex payoffs can actually reduce risk-taking incentives since they make pay sensitive to firm performance. While we focus on linear incentives, our arguments suggest that options with a

[2] Coles, Daniel and Naveen (2006) find evidence that risk-taking increases with the sensitive of CEO wealth to stock price volatility (vega) more generally.

short vesting period should have a strong positive effect on risk-taking, even if those with a longer vesting period have a negative or only slightly positive effect. It is therefore important to establish the vesting periods of options in the manager's portfolio when studying the link between options and risk-taking.

Indeed, our analysis has important implications for the optimal vesting horizons of executive stock and stock option grants. Linking managerial compensation to short-term stock price performance effectively gives the manager an equity claim with a short vesting horizon. Existing theories of optimal vesting horizons have focused primarily on the use of (possibly conditional) short-term vesting to rebalance the manager's portfolio. Such rebalancing is necessary to maintain the convexity of the manager's payoff so that she has the correct risk-taking incentives when making future decisions (Brisley 2006; Edmans et al 2009). Short-horizon vesting is potentially value-creating in our theory not because it provides the correct incentives for future decisions, but because anticipation of the vesting affects incentives for decisions made today.

The rest of the paper proceeds as follows. Section 2 presents a simple model of managerial investment. In this section, we analyze the effect of short- and long-term incentives on risk-taking, derive results regarding the optimal managerial contract, and examine the effect of introducing debt and asymmetric information regarding the return to risk. Section 3 concludes.

2 A model of managerial risk choice

We build a very simple stylized model of investment to illustrate how short-term incentives affect a manager's choice of risky projects to undertake. The key feature of the model is a deterministic relationship between risk and expected payoff. Linking managerial compensation to firm value is beneficial because it reduces wasteful shirking. However, a consequence of such a link and managerial risk aversion is that shareholders' optimal level of risk may not be implemented.

2.1 Description of the model

Consider the case of a publicly-traded, all-equity firm managed by a single risk-averse manager. The shareholders of the firm are comprised of the manager and a set of risk-neutral outside investors. The firm generates a single cash flow v at a future date. The stock price at any point in time is determined rationally by the beliefs of the outside investors. No dividends are paid in the model and the risk-free rate is normalized to zero. As a result, the value of the firm at any point of time is the expected cash flow. Letting Ω_t denote outside investors' information set at time t, the stock price is $p_t = E[v|\Omega_t]$.

After the firm's cash flow is realized, the manager receives compensation w. The manager is effort-averse and is assumed to have a mean-variance utility over terminal wealth and effort e. Since mean-variance utility does not exhibit a wealth effect, we assume without loss of generality that the manager's initial wealth is 0. So her terminal wealth is simply her compensation w. Thus the manager's expected utility is

$$EU(w) = E[w] - \frac{1}{2} r\, var(w) - e, \tag{1}$$

where r is a coefficient of risk aversion. The manager does not face a wealth constraint and has reservation expected utility $\bar{U}$.

The manager makes two decisions that affect the firm's cash flow. The first decision is the choice of a single project in which to invest. Projects are described by the variance of their payoffs, σ_x^2, and exist along a continuum $\sigma_x^2 \in [0, \infty]$. A project yields a payoff of $x = \mu(\sigma_x^2) + \epsilon_x$, where ϵ_x is a random variable with mean 0 and variance σ_x^2. The expected payoff of a project is increasing in the risk of the project up to a point $\hat{\sigma}_x^2$, but at a decreasing rate, and decreasing in risk beyond that point. In terms of notation, we have $\mu' > 0$ for $\sigma_x^2 < \hat{\sigma}_x^2$, $\mu' = 0$ for $\sigma_x^2 = \hat{\sigma}_x^2$, $\mu' < 0$ for $\sigma_x^2 > \hat{\sigma}_x^2$, $\mu'(0) = \infty$, and $\mu'' < 0$. The relationship between σ_x^2 and μ is public knowledge.

The second choice the manager makes is the level of costly effort e to provide. Effort increases the cash flow from the project by an amount $\phi(e)$. Effort is assumed to be efficient up to a point $\hat{e}$. This is captured by our assumptions that $\phi' \geq 0$, $\phi'' < 0$, $\phi(0) = 0$ $\phi'(0) = \infty$ and $\phi'(\hat{e}) = 1$. The firm's cash flow is $v = x + \phi(e) + \epsilon_y$, where ϵ_y is independently normally distributed with mean 0 and variance σ_y^2. We also refer to v as long-term firm value since it represents the only cash flow in the model.[3]

There are three dates. The manager begins at $t = 0$ with a compensation contract in place. At $t = 1$, the manager chooses a project. Project choice is observable but not verifiable. Investors also

[3]The assumption of normality is made for convenience only and is not necessary for any of the results of this paper to hold.

observe a signal s_y of the random component of cash flow ϵ_y, where $s_y = \epsilon_y + \epsilon_s$, with the random variable ϵ_s independently normally distributed with mean 0 and variance σ_s^2. After project choice and the signal are observed, the stock price updates to p in accordance with rational expectations. At $t = 2$, the manager expends effort e and project payoff x is realized, and the manager is paid as specified by her contract.

The manager's compensation contract is assumed to be of the form of a triple $(\alpha, \beta_1, \beta_2)$. The first term is a fixed wage component, the second the weighting on the $t = 1$ stock price p, and the third the weighting on the $t = 2$ cash flow v. Since v is the only cash flow in the model, β_2 can be thought of as the weight on the firm's long-term value and hence as an equity stake that the manager must hold until future cash flows are realized. Thus the manager's realized compensation is

$$w = \alpha + \beta_1 p + \beta_2 v. \tag{2}$$

2.2 First best outcome

We begin by establishing the first best choice of project and effort as a benchmark. By assumption, expected project payoff μ increases with project variance σ_x^2 up to the point $\hat{\sigma}_x^2$ and then decreases subsequently. Thus the first best project has payoff variance $\hat{\sigma}_x^2$. Effort is set to $\phi'(e) = 1$ in the first best, so $e = \hat{e}$. The following lemma captures the first best:

Lemma 1. *In the first-best, project variance is chosen to maximize expected project payoff ($\sigma_x^2 = \hat{\sigma}_x^2$) and effort is set to $e = \hat{e}$.*

Reducing effort below $\hat{e}$ is inefficient. However, a manager whose pay is not closely-linked to the value of the firm fails to internalize this inefficiency and does indeed provide less than the first best effort level. This moral hazard problem can be addressed by linking the manager's pay to the firm's terminal cash flow. However, such long-term incentives expose the risk averse manager to undiversified risk, which potentially distorts her project choice. We investigate the effect of long-term incentives now.

2.3 Effect of long-term incentives

We analyze here the effect of long-term incentives (β_2) on the manager's effort provision and investment decisions in the absence of short-term incentives - that is, we assume temporarily that $\beta_1 = 0$. Since $\beta_1 = 0$, the manager's compensation is $w = \alpha + \beta_2 v$. Since $v = x + \phi(e) + \epsilon_y$, the variance of the manager's compensation is $var(w) = \beta_2^2(\sigma_x^2 + \sigma_y^2)$. As the manager's decisions do not affect σ_y^2, her optimization problem is

$$\max_{e,\sigma_x^2}\{\beta_2[\mu(\sigma_x^2) + \phi(e)] - \frac{1}{2}r\beta_2^2\sigma_x^2 - e\}. \tag{3}$$

The first order conditions for the choice of e and σ_x^2 respectively are

$$\phi'(e) = \frac{1}{\beta_2} \tag{4}$$

and

$$\mu'(\sigma_x^2) = \frac{1}{2}r\beta_2. \tag{5}$$

Totally differentiating (4) results in

$$\frac{de}{d\beta_2} = -\frac{1}{\phi''(e)\beta_2^2}. \tag{6}$$

Since $\phi'' < 0$, effort provision is increasing in the manager's long-term stake in the firm. This is not surprising, as increasing the manager's long-term stake forces her to internalize more of the cost of shirking. As $\mu'' < 0$, the riskiness of the project chosen by the manager decreases in the manager's stake in the firm. This is also not surprising, as an increase in the manager's stake increases her exposure to the risk of terminal cash flows. Because she is risk-averse, the manager chooses a project risk level lower than that preferred by her risk-neutral outside shareholders (i.e., $\sigma_x^2 < \hat{\sigma}_x^2$. Increasing long-term incentives therefore improves the manager's incentives to provide costly effort but worsens her incentives to take on risk.

2.4 Effect of short-term incentives

As has long been understood, and as we have just shown formally, long-term incentives tend to mute risk-taking. What, then, about short-term incentives? By definition, the long-term component of the manager's wage is sensitive to the realization of terminal cash flows. The short-term component exposes the manager to variations in the stock price due to changes in market expectations of final cash flows. The t=1 stock price, which represents the expected cash flow of the firm, is

$$p = E[x|\sigma_x^2] + \phi(e^*) + E[\epsilon_y|s_y] = \mu(\sigma_x^2) + \phi(e^*) + \frac{\sigma_y^2}{\sigma_y^2 + \sigma_s^2} s_y, \tag{7}$$

where e^* denotes the equilibrium level of effort that the manager provides. The manager's actual choice of e is not observed by the stock market at $t = 1$. Therefore the market must conjecture what level of e the manager will choose. Since the market forms rational expectations, its conjecture must be correct in equilibrium.

Uncertainty in the short-term stock price is driven by information abut the random component of long-term cash flows ϵ_y that is outside of the manager's control. Therefore, her choice of project risk σ_x^2 and effort e have no effect on the variance of the short-term stock price or on the correlation between the short-term stock price and long-term cash flow. So, as in the case with long-term incentives only, the sole source of variance that the manager's decisions affect is the uncertainty about long-term cash flows. The manager's maximization problem when her compensation is exposed to both the t=1 stock price and the t=2 cash flow becomes

$$\max_{e,\sigma_x^2} \{\beta_2[\mu(\sigma_x^2) + \phi(e)] + \beta_1 E[p|\sigma_x^2] - \frac{1}{2} r \beta_2^2 \sigma_x^2 - e\}. \tag{8}$$

The manager rationally anticipates that the $t = 1$ stock price will, on average, be $E[p|\sigma_x^2] = \mu(\sigma_x^2) + \phi(e^*)$ after she selects a project with payoff variance σ_x^2. Since the stock price is not affected by the manager's actual choice of effort, the first order condition with respect to the choice of effort level remains the same as in our earlier derivation. As we now show, long-term incentives continue to dampen the risk chosen after short-term incentives are introduced. However, short-term incentives themselves have the opposite effect on risk choice.

Proposition 1. *The manager's choice of risk decreases in the strength of long-term incentives and increases in the strength of short-term incentives. For any given positive level of long-term incentives, the manager chooses inefficiently low project risk, regardless of the strength of short-term incentives.*

Proof. The first order condition for the manager's choice of project risk is now

$$\beta_2 \mu'(\sigma_x^2) + \beta_1 \frac{dp}{d\sigma_x^2} - \frac{1}{2} r \beta_2^2 = 0 \tag{9}$$

The $t = 1$ stock price is given by

$$p = \mu(\sigma_x^2) + \phi(e^*), \tag{10}$$

Therefore,

$$\frac{dp}{d\sigma_x^2} = \mu'(\sigma_x^2). \tag{11}$$

Substituting this in to the first order condition for the risk choice and re-arranging yields

$$\mu'(\sigma_x^2) = \frac{r\beta_2^2}{2(\beta_1 + \beta_2)}. \tag{12}$$

Totally differentiating this while holding β_1 constant yields

$$\frac{d\sigma_x^2}{d\beta_2} = \frac{r\beta_2(\beta_2 + 2\beta_1)}{2\mu''(\sigma_x^2)(\beta_1 + \beta_2)^2}, \tag{13}$$

which is negative for all β_2 because $\mu'' < 0$. Totally differentiating the first order condition while holding β_2 constant yields

$$\frac{d\sigma_x^2}{d\beta_1} = -\frac{r\beta_2^2}{2\mu''(\sigma_x^2)(\beta_1 + \beta_2)^2}, \tag{14}$$

which is positive for all β_1 because $\mu'' < 0$. From (12), $\mu' > 0$ for any $\beta_2 > 0$, so $\sigma_x^2 < \hat{\sigma}_x^2$. ■

The intuition behind the effect of long-term incentives on risk-taking remains the same. More long-term incentives means greater exposure to project payoffs, which induces the risk averse manager to choose less risky projects. The intuition behind the effect of short-term incentives on risk-taking is simple. If the manager is exposed to the short-term stock price, she has an incentive to increase the stock price. The only way to do this is to select a project with a higher level of risk. Furthermore, selecting a project with greater risk has no effect on the variance of the short-term stock price, since information about the actual project payoff is not revealed until $t = 2$. So short-term incentives increase the benefit to the manager of taking on more risk without affecting the cost. This gives the manager an incentive to take on more risk.

Expected project payoff is maximized when the chosen payoff variance is $\hat{\sigma}_x^2$. Increasing the variance beyond this point not only increases the risk faced by the manager due to her long-term incentives, but also reduces expected project payoff. Therefore, short-term incentives, no matter how strong, do not induce the manager to take on greater than the first best level of risk. In fact, the first best level of project risk is never reached, since the marginal benefit of increasing project variance is zero at the first best level. We show later that, when we introduce debt into the model, sufficiently strong short-term incentives can in fact induce the manager to take on more than the first best level of risk.

An increase in short-term incentives unambiguously improves risk-taking. This implies that a stronger link between managerial pay and the short-term stock price improves the alignment of managerial and shareholder interests, even though shareholders care only about the firm's long-term value. What is crucial here is that a forward-looking stock market incorporates into the firm's stock price information about future payoffs as soon as this information is observed. As a contracting instrument, the short-term stock price allows shareholders to effectively contract on an action (project choice) that is observable but not itself directly contractible.

While we fully investigate the implications of proposition 1 for the optimal contract choice shortly, the proposition has important direct implications for empirical work on executive compensation and risk-taking. Many researchers have investigated the effect of executive pay-performance sensitivity on risk-taking in firms, with an eye toward testing whether managers reduce risk when their pay is more sensitive to firm performance. However, proposition 1 shows that the predicted effect of incentive compensation on risk-taking depends on the time horizon over which it pays off. In fact, the predicted effect of short-term stock price-based compensation on risk-taking is the *opposite* of the predicted effect of long-term incentives.

Long-term incentives are needed to mitigate shirking behavior but can bias the manager against taking risk. Adding short-term incentives to the manager's contract can benefit shareholders by improving managerial risk-taking. However, exposing the risk-averse manager's compensation to the short-term stock price imposes extra risk on her, and she must be compensated for bearing this risk. As a consequence, further investigation is required to understand the role of short-term incentives in the optimal contract. We undertake this investigation now.

2.5 Optimal short-term incentives

We proceed in two steps. In the first, we take the long-term incentive component of the manager's contract, β_2, as given and investigate the optimal level of short-term incentives, β_1. We then allow the long-term component of the contract to be chosen optimally and investigate the resulting optimal contract.

As we have shown, linking the manager's compensation to the short-term stock price can offset the dampening effects of long-term incentives on risk-taking, to the benefit of shareholders. The reason is that the manager's choice of project risk affects the expected level of the short-term stock price but not its variance. This by no means implies, however, that placing weight on the short-term stock price in the manager's compensation contract has no effect on the level of risk she faces and for which she must be compensated. As we now show, the use of such incentives is indeed costly. This cost is traded off against the benefit of inducing the manager to choose a riskier project with a higher expected payoff. The cost of using short-term incentives depends on the variance of the manager's compensation w. The variance of the manager's compensation is given by the following lemma:

Lemma 2. *Define* $\eta \equiv \frac{(\sigma_y^2)^2}{\sigma_y^2+\sigma_s^2}$ *and* $\lambda(\beta_1, \beta_2) \equiv (\beta_1^2 + 2\beta_1\beta_2)\eta$. *Then*

$$var(w) = \lambda(\beta_1, \beta_2) + \beta_2^2(\sigma_x^2 + \sigma_y^2). \tag{15}$$

Proof. The variance of the manager's compensation is

$$var(w) = var(\beta_1 p + \beta_2 v) = \beta_1^2 var(p) + \beta_2^2 var(v) + 2\beta_1\beta_2 cov(p, v).$$

The individual terms are

$$var(v) = \sigma_x^2 + \sigma_y^2,$$

$$var(p) = \left[\frac{\sigma_y^2}{\sigma_y^2 + \sigma_s^2}\right]^2 (\sigma_y^2 + \sigma_s^2) = \frac{(\sigma_y^2)^2}{\sigma_y^2 + \sigma_s^2} = \eta,$$

and

$$cov(p, v) = E\left[\frac{\sigma_y^2}{\sigma_y^2 + \sigma_s^2} s_y \times \epsilon_y\right] = E\left[\frac{\sigma_y^2}{\sigma_y^2 + \sigma_s^2}\epsilon_y^2\right] = \frac{(\sigma_y^2)^2}{\sigma_y^2 + \sigma_s^2} = \eta. \blacksquare$$

Note that $\eta = var(p) = cov(p, v)$. Since the $\lambda(\beta_1, \beta_2)$ component of $var(w)$ increases with β_1, there is a tension between the objectives of improving the manager's risk-taking incentives by making her pay more sensitive to the short-term stock price and reducing the variance of the manager's compensation by making her pay less sensitive to the short-term stock price. To get a sense of how optimal incentives reflect this tradeoff, we now formally write down and solve shareholders' problem, taking β_2 as given. Since the manager is always held to her reservation utility, maximizing shareholders' payoff is equivalent to maximizing surplus. Shareholders' problem then can be written

$$\max_{\beta_1}\{\mu(\sigma_x^2) + \phi(e) - e - \frac{1}{2}r \times var(w)\}, \tag{16}$$

subject to the manager's incentive compatibility constraints (4) and (12). We employ the first order approach to solving shareholders' problem. That is, we first obtain the first order condition for shareholders' problem, ignoring the manager's incentive compatibility conditions. We then substitute into this condition the first order conditions for the manager's problem. Noting from (4) that β_1 does not affect the manager's choice of effort e, the first order condition for maximization of shareholders' objective function is

$$\mu'(\sigma_x^2)\frac{d\sigma_x^2}{d\beta_1} = \frac{1}{2}r\frac{dvar(w)}{d\beta_1}. \tag{17}$$

Substituting in from (4), (12) and (14), shareholders choose β_1 to solve

$$-\frac{r^2\beta_2^4(1-\beta_1-\beta_2)}{4\mu''(\sigma_x^2)(\beta_1+\beta_2)^3} = (\beta_1+\beta_2)r\eta. \tag{18}$$

The left-hand side of this equality is the marginal benefit associated with an increase in short-term incentives. This benefit takes the form of improved risk-taking, which increases firm value, offset by the additional amount that the manager must be paid to compensate her for the extra risk that she will choose to take on. The right-hand side represents the marginal cost associated with an increase in short-term incentives. This cost is the additional amount that the manager must be paid to compensate her for the increased exposure to the random component ϵ_y of the firm's cash flow. The following proposition reflects the outcome of the tradeoff between the desire to provide incentives for risk-taking and the desire to shield the risk-averse manager's compensation from risk for which she must be compensated.

Proposition 2. *Holding long-term incentives fixed, there exists σ_{s0}^2 (possibly 0) such that the manager's compensation optimally increases with the short-term stock price (i.e. $\beta_1^* > 0$) if $\sigma_s^2 > \sigma_{s0}^2$. The optimal strength of short-term incentives increases with σ_s^2.*

Proof. (18) can be re-written as

$$-\frac{r\beta_2^4(1-\beta_1-\beta_2)}{4\mu''(\sigma_x^2)(\beta_1+\beta_2)^4} = \eta. \tag{19}$$

The left-hand side is decreasing in β_1. If η decreases, then the left-hand side must also decrease, so β_1 must increase. When $\beta_1 = 0$, the left-hand side is $-\frac{r(1-\beta_2)}{4r\mu''(\sigma_x^2)}$. Since the left-hand side decreases in β_1, $\beta_1 > 0$ if $\eta < -\frac{r(1-\beta_2)}{4r\mu''(\sigma_x^2)}$. Since η is decreasing in σ_s^2, the result holds. An increase in σ_s^2 results in a decrease in η and therefore an increase in β_1. ■

If η is sufficiently large, then a solution to (17) satisfying $\beta_1 > 0$ does not exist. Since η represents the variance of the short-term stock price, it will be large if the market reacts strongly to information about the long-term cash flow shock ϵ_y. The reaction will be strong if the market has a relatively precise signal about ϵ_y - that is, if σ_s^2 is small. There will therefore be a solution $\beta_1^* > 0$ only if σ_s^2 is sufficiently large, as the proposition makes clear. If σ_s^2 is small, then the variance of the short-term stock price is large, and linking managerial compensation to it can be too costly.

As proposition 1 shows, the manager always chooses less than the first best level of risk when faced with long-term incentives, regardless of the strength of short-term incentives. This, in fact, understates the severity of the distortion in project choice caused by managerial risk aversion. When $\beta_2 > 0$, the efficient level of project risk is less than the first best level of project risk, since risk imposes a cost on the manager. The efficient level of project risk is the solution to

$$\max_{\sigma_x^2}\{\mu(\sigma_x^2) - \frac{1}{2}r\beta_2^2\sigma_x^2\}.$$

The efficient level of risk, then, satisfies $\mu'(\sigma_x^2) = \frac{1}{2}r\beta_2^2$. Comparing this expression to the condition characterizing the incentive compatible level of risk in (12) shows that, as long as $\beta_1 + \beta_2 < 1$, the manager will choose a project with risk that is not only less than the first best level of risk, but also less than the efficient level. As the next proposition shows, the optimal choice of β_1 only implements the efficient level of risk if the market is completely uninformed about the shock to the long-term cash flow.

Proposition 3. *If the market's signal about t=2 cash flows is uninformative ($\sigma_s^2 = \infty$), then $\beta_1^* = 1 - \beta_2$ and the manager chooses the efficient level of risk, given the strength of her long-term incentives. If the signal is informative ($\sigma_s^2 < \infty$), then $\beta_1^* < 1 - \beta_2$, and the manager chooses less than the efficient level of risk.*

Proof. If $\sigma_s^2 = \infty$, then $\eta = 0$. If $\eta = 0$, then the left-hand side of (19) must also be 0, which requires $\beta_1 = 1 - \beta_2$. If $\sigma_s^2 < \infty$, then $\eta > 0$. If $\eta > 0$, then the left-hand side of (19) must be positive, which requires $\beta_1 < 1 - \beta_2$. ■

When the market learns nothing about the random component of t=2 cash flow at t=1 (i.e. $\sigma_s^2 = \infty$), optimal short-term incentives set $\beta_1 + \beta_2 = 1$. To understand this result, note that, when she receives only long-term incentives, the manager takes into account a fraction β_2 of the marginal value created by taking on more risk. When short-term incentives are included in the contract, she instead internalizes a fraction $\beta_1 + \beta_2$ of the marginal value created, since the short-term stock price incorporates the effect of an increase in project risk on expected cash flow. When $\beta_1 + \beta_2 = 1$, the manager fully internalizes the marginal value creation, and the efficient level of risk obtains. That is, $\beta_1 = 1 - \beta_2$ yields the most efficient project choice possible given the cost imposed by the inclusion of long-term incentives in the contract.

Investors form rational expectations and can predict the manager's choice of σ_x^2 and e after the manager's contract is established at t=0. The only uncertainty in the t=1 stock price arises from the signal that investors receive at t=1 about the shock to t=2 cash flow. Therefore, when this signal is completely uninformative (i.e. $\sigma_s^2 = \infty$), the t=1 stock price is known with certainty at t=0. Because there is no uncertainty about the t=1 stock price in this case, rewarding the manager based on the short-term stock price does not impose a direct cost on her for which she must be compensated. As a result, shareholders can costlessly induce the manager to choose the efficient level of risk, taking β_2 as given. The result is $\beta_1^* = 1 - \beta_2$.

However, when the market does receive an informative signal at t=1 ($\sigma_s^2 < \infty$), the stock price is uncertain at t=0. The manager must now be compensated for risk she bears as a result of her exposure to the short-term stock price. Therefore, making her pay sensitive enough to the short-term stock price that she chooses the efficient level of project risk is too costly. The result is a level of sensitivity $\beta_1^* < 1 - \beta_2$ that induces a choice of risk less than the efficient level.

Suppose now that $\sigma_s^2 < \infty$, so that the short-term stock price is risky. As proposition 2 shows, this risk lowers the amount of weight that shareholders want to place on the short-term stock price in the manager's compensation contract. One might anticipate that, since the cost of having the manager bear risk increases as her risk aversion increases, the optimal weight on short-term incentives would decline with her level of risk aversion as well. As the following proposition shows, however, this intuition is incorrect.

Proposition 4. *Suppose that $\sigma_s^2 < \infty$. Then the optimal sensitivity of the manager's compensation to the short-term stock price increases with her level of risk aversion.*

Proof. Fix $\sigma_s^2 < 0$ and therefore $\eta > 0$. If r increases, the left-hand side of (19) increases. To restore equality of the left-hand side with η, β_1 must also increase. ■

An increase in the manager's risk aversion has conflicting effects on the optimal strength of short-term incentives. On the one hand, an increase in risk aversion makes giving the manager more incentives costly, which has a negative effect on the optimal strength of short-term incentives. On the other hand, though, an increase in risk aversion further distorts the manager's project choice away from the first best. This has two subtly different effects on the benefit of increasing the strength of short-term incentives, both of which are positive.

First, since greater risk aversion results in the manager choosing a lower level of project variance, and the expected project return-variance relationship is concave, the impact of an increase in project variance on expected project return grows with the manager's risk aversion. Since strengthening short-term incentives effects an increase in project risk, the benefit of short-term incentives grows as the manager's risk aversion grows. Second, again because of the negative effect of risk aversion on project variance and the concave expected return-variance relationship, an increase in risk aversion magnifies the effect of short-term incentives on the manager's choice of project variance. Since she chooses a lower project variance when her risk aversion is greater, and therefore the return to increasing project variance is higher, greater risk aversion causes her to respond to a strengthening of short-term incentives with a greater increase in project variance. These two effects of risk aversion on the benefit of using short-term stock price-based compensation as an incentive for the manager to take on more risk are complementary, and therefore dominate the increased marginal cost of using short-term incentives.

An empirical prediction of the model, then, is that if firms take the strength of long-term incentives as a given, perhaps because the manager already owns restricted shares that cannot be sold for some time, an increase in risk aversion results in the greater use of short-term incentives. This prediction may not hold, though, once the firm is also allowed to choose long-term incentives optimally. An increase in risk-aversion in this case should result in a reduction in long-term incentives, which reduces the benefit of greater short-term incentives. Because of this added complexity, we are unable to answer the question of how risk aversion affects the use of short-term incentives when long-term incentives area also chosen optimally.

We have thus far taken the strength of long-term incentives, β_2, as a given and analyzed the optimal choice of β_1. We now examine the manager's contract when both β_1 and β_2 are chosen optimally.

2.6 Optimal short- and long-term incentives

We now consider the optimal level of both short- and long-term incentives in the manager's contract. Formally, shareholders' problem is

$$\max_{\beta_1,\beta_2}\{\mu(\sigma_x^2)+\phi(e)-e-\frac{1}{2}r\times var(w)\}, \tag{20}$$

subject to the manager's incentive compatibility conditions (4) and (12). As we now show, the optimal contract always includes long-term incentives. As in the case in which long-term incentives are taken as given, the optimal contract places positive weight on the short-term stock price as long as the market's information about the shock to long-term cash flows is not too precise.

Proposition 5. *The optimal contract places positive weight on the long-term cash flow v (i.e. $\beta_2>0$). There exists a value σ_{s1}^2 (possibly 0) such that the manager's compensation optimally increases with the short-term stock price (i.e. $\beta_1^*>0$) if $\sigma_s^2>\sigma_{s1}^2$.*

Proof. The derivative of (20) is

$$\frac{r^2\beta^2(2\beta_1+\beta_2)}{4\mu''(\sigma_x^2)(\beta_1+\beta_2)^2}-\frac{1}{\mu''}\frac{1-\beta_2}{\beta_2^3}-r[\beta_1\eta+\beta_2(\sigma_x^2+\sigma_y^2)]-\frac{r^2\beta_2^3(2\beta_1+\beta_2)}{4\mu''(\sigma_x^2)(\beta_1+\beta_2)^2}.$$

As β_2 approaches 0, the first and fourth terms approach 0, the second term approaches ∞, and the third term approaches $r\beta_1\eta$, which is finite. Thus the derivative is positive. Therefore, shareholders choose $\beta_2 > 0$ regardless of β_1. The first order condition for β_1 is given by (19). The right-hand side of this equality approaches 0 as σ_s^2 approaches ∞. Therefore, for $0 < \beta_2 < 1$, the solution to (19) is $\beta_1 > 0$ as long as σ_s^2 is sufficiently larger. ■

In the absence of long-term incentives, the manager exerts no effort. Because $\phi'(0) = \infty$, it is worth providing some long-term incentives to induce effort. Proposition 5 confirms that short-term stock price-based incentives also continue to be a part of the optimal contract when both short-term and long-term incentives are chosen optimally if the market is not too well-informed.

The ability to link the manager's pay to the short-term stock price improves project risk choice, holding the weight on the long-term cash flow in the contract fixed. A natural question, though, is whether being able to use short-term incentives allows shareholders to also increase firm value by increasing the sensitivity of the manager's compensation to the long-term cash flow. To make the problem slightly more tractable, we assume that the project risk-return relationship is quadratic, so that μ'' is a (negative) constant. We now show that, when the manager is sufficiently risk-averse, this complementarity can arise, at least for small β_1.

Proposition 6. *There exists r_0 such that the optimal strength of long-term incentives (β_2^*) increases with the strength of short-term incentives (β_1) for β_1 arbitrarily small if and only if $r > r_0$.*

Proof. Taking the derivative with respect to β_1 of the left-hand side of the first order condition for β_2, while holding β_2 fixed yields, and setting $\beta_1 = 0$ yields

$$\frac{r^2(1-2\beta_2)}{4\mu''}+r\eta. \tag{21}$$

This expression is negative if

$$r(1-2\beta_2) > -4\eta\mu''. \tag{22}$$

Since $\beta_2 < 1/2$ for r sufficiently large and β_2 decreases with r, there exists some r_0 such that this expression is satisfied if $r > r_0$. ■

This proposition shows that slightly relaxing a constraint on the ability to employ short-term incentives in the manager' compensation contract also makes it optimal for the firm to increase weight on long-term incentives as well. An increase in the manager's risk aversion has conflicting effects on the response of optimal long-term incentives to a relaxation of a constraint on the use of short-term incentives. On the one hand, the payoffs of the short- and long-term components of the manager's compensation are positively-correlated since the short-term stock price contains information about the uncertain portion of long-term cash flow. As a result, an increase in short-term incentives causes an increase in long-term incentives to have a larger positive effect on the variance of the manager's compensation. This makes increasing long-term incentives more costly as the strength of short-term incentives increases. The more risk averse the manager is, the greater the resulting cost to her of bearing greater compensation risk. Since she must be compensated for bearing this risk, greater risk aversion causes the relaxation of the constraint on the use of short-term incentives to have a negative effect on the use of long-term incentives.

On the other hand, an increase in short-term incentives mutes the reduction in the manager's choice of project risk that accompanies an increase in the strength of long-term incentives, since the manager bears more of the cost of reducing risk as the strength of her short-term incentives increase. An increase in risk aversion has two effects on how short-term incentives affect the connection between project risk choice and the strength of long-term incentives. First, as risk aversion increases, the manager chooses lower project variance. Because of the concave relationship between expected project return and variance, the benefit of reducing the amount by which the manager reduces risk in response to an increase in long-term incentives increases, making short-term incentives more valuable.

Second, again because of the lower choice of project variance that follows an increase in risk aversion results and because of the concave return-variance relationship, the effect of short-term incentives on the manager's risk choice is strengthened when risk aversion increases. This has the effect of reducing the negative response of project risk to an increase in the strength of long-term incentives. These two effects, which are complementary, cause an increase in short-term incentives to lower the cost of increasing long-term incentives. These effects dominate when managerial risk aversion is high.

The result in proposition 6 is somewhat surprising. Following the logic of Holmstrom (1979), incrementally informative signals of output should be included in an agent's contract. Doing so allows the agent to be given stronger incentives to increase output, while, because of the diversification effect, simultaneously reducing the costly risk that she bears. One would generally expect that such signals will substitute for output in the compensation contract. However, in our setting, the short-term stock price can actually complement cash flow, in the sense that its inclusion allows greater weight to be placed on cash flow in the contract.

To further clarify the role of short-term stock price-based incentives in the optimal contract, and how these incentives can also affect the use of long-term incentives, we next solve an example based on the model.

2.7 Example

In this example, we assume that $\mu(\sigma_x^2) = \sigma_x - \frac{1}{2}\sigma_x^2$ and that $\phi(e) = 2\sqrt{e}$, where z is a constant parameter. These functional forms satisfy all of our assumptions about μ and ϕ. The first best is $z\hat{\sigma}_x^2 = 1$ and $e = 1$. Applying the functional form for μ to (12) shows that the manager will choose

$$\sigma_x^2 = \left(\frac{\beta_1 + \beta_2}{\beta_1 + \beta_2 + r\beta_2^2} \right)^2 z^2. \tag{23}$$

Confirming our earlier results, this expression makes clear that $\sigma_x^2 < \hat{\sigma}_x^2$ if $\beta_2 > 0$, regardless of β_1, and that σ_x^2 decreases with β_2 but increases with β_1. We now further assume that $z = 2$, $r = 3$, $\sigma_y^2 = 1$, and $\sigma_s^2 = 2$. The solution to the example will clearly change with the assumptions we make about these primitives. Our objective is not to examine all possible cases, but rather to show that reasonable assumptions result in an optimal contract with reasonable sensitivities of managerial compensation to short- and long-term stock price.

The first best level of project variance is now $\hat{\sigma}_x^2 = 4$, which yields expected project payoff of $\mu = 2$. Again, the first best level of effort provision is $e = 1$. This first best outcome, which yields a total expected surplus of 3, provides a benchmark against which the efficiency loss of second best outcomes can be measured. Suppose first that only long-term incentives are available ($\beta_1 = 0$). Then the optimal contract sets $\beta_2 = 0.058$. With this sensitivity to long-term performance, the manager chooses $\sigma_x^2 = 2.90$. This reduces the expected payoff on the project from the first best 2 to $\mu = 1.96$. The manager provides effort of $e = 0.0034$. Total surplus is 2.049.

Now suppose that short-term incentives can also be included in the contract. The optimal contract now sets $\beta_1 = 0.100$ and $\beta_2 = 0.089$. So consistent with the logic of proposition 6, the ability to include short-term incentives in the contract increases the optimal strength of long-term incentives. With this contract in place, the manager chooses $\sigma_x^2 = 3.16$, which yields $\mu = 1.98$. This represents an improvement of 0.02 to the expected payoff on the project from the case in which short-term incentives are unavailable. The manager provides effort of $e = 0.0079$. Total surplus increases to 2.082, which represents an improvement of 0.033 over what can be achieved with long-term incentives alone.

This example demonstrates that being able to employ short-term stock price-based incentives in the manager's contract can, as anticipated, increase firm value. It is important to note that this example, and in fact all of the analysis up to this point, proceeds under the assumption that the firm is all-equity financed. We now consider the effect and role of short-term incentives when the firm's capital structure also includes debt.

2.8 Risk choice when capital structure includes debt

In the absence of leverage, the optimal level of risk from the standpoint of risk-neutral shareholders is the first best level of risk. However, in the presence of leverage, the first best level of risk and the optimal level of risk from shareholders' standpoint diverge. Specifically, shareholders now prefer a level of risk greater than the first best because, other things being equal, an increase in risk transfers wealth from creditors to shareholders who are protected by limited liability (Merton 1977). As in the all-equity case, short-term stock price-based incentives will never induce the manager to choose a greater level of risk than the optimal level of risk from shareholders' standpoint, regardless of their strength. However, it is entirely conceivable that the manager will choose a greater level of risk than the first best. As we now show, sufficiently strong short-term incentives can indeed give rise to inefficiently high levels of risk-taking in the presence of leverage.

It is necessary, however, to first simplify the model by assuming that only two mutually-exclusive projects are available: a safe project (project S) and a risky project (project R). The safe project pays off an amount $x_S > 0$ with probability 1, while the risky project pays off $x_R > 0$ with probability p and 0 with probability $1-p$. To allow for the possibility of risk-shifting, we assume that the safe project has a higher expected payoff than the risky project: $x_S > px_R$. The variance of the risky project payoff is calculated as $p(1-p)x_R^2$, while the variance of the safe project payoff is 0. Thus the safe project is clearly the efficient choice: it yields a higher expected payoff than the risky project, while simultaneously being less risky.

We will need to introduce debt momentarily, but first consider the all-equity case. Regarding the manager's contract, we assume only that $\beta_2 > 0$ and $\beta_1 \geq 0$. The manager will choose the risky project if and only if

$$(\beta_1 + \beta_2)(px_R - x_S) \geq \frac{1}{2} r \beta_2^2 p(1-p)x_R^2.$$

But this is impossible, since $px_R < x_S$, making the left-hand side negative, while the right-hand side is always positive. This is not surprising since, with no debt in the capital structure, there is no potential for risk-shifting. Now suppose that the firm has non-interest bearing debt with face value F satisfying $0 \leq F < x_S$ due at t=2 (after project payoffs are realized). If the firm pursues the safe project, the payoff to shareholders is now $x_S - F$. If the firm pursues the risky project, the payoff to shareholders is $x_R - F$ with probability p and 0 with probability $1-p$. The bad-state payoff to shareholders remains 0 after debt is added because of limited shareholder liability. The variance of the risky project payoff is now $p(1-p)(x_R - F)^2$. The manager chooses the risky project if and only if

$$(\beta_1 + \beta_2)[(px_R - x_S) + F(1-p)] > \frac{1}{2} r \beta_2^2 p(1-p)(x_R - F)^2. \tag{24}$$

The left-hand side can now be positive if F is sufficiently large. The right-hand side decreases with F, creating the possibility that with sufficiently high leverage, the manager will choose the risky project, even though it has both lower expected payoff and higher variance. Notice that if the left-hand side is positive - a necessary (but not sufficient) condition for risk-shifting to occur - then it is increasing in β_1. The right-hand side is not a function of β_1. Therefore, if the expression is satisfied for $\beta_1 = 0$, it will also be satisfied for $\beta_1 > 0$. Assume for the moment that $\beta_1 = 0$. Then the manager will choose the risky project if and only if $F \geq F'$, where

$$F' \equiv x_R + \frac{\beta_1 + \beta_2}{rp\beta_2^2} - \sqrt{\left(x_R + \frac{\beta_1 + \beta_2}{rp\beta_2^2}\right)^2 - 2\frac{(\beta_1 + \beta_2)(x_S - px_R)}{rp(1-p)\beta_2^2}}.$$

We now assume now that $F < F'$, so that the manager chooses the more efficient safe project as long as $\beta_1 = 0$, and consider the effect of allowing $\beta_1 > 0$. This enables us to examine whether providing short-term incentives can cause the manager to take on excessive risk. Rearranging (24) yields the following result:

Proposition 7. *Define*

$$\beta_1' \equiv \frac{\frac{1}{2}r\beta_2^2 p(1-p)(x_R - F)^2 - \beta_2[F(1-p) - (x_S - px_R)]}{F(1-p) - (x_S - px_R)}.$$

The manager will choose the risky project if and only if $\beta_1 \geq \beta_1'$. The minimum weight on the short-term stock price for which the manager chooses the risky project, β_1', decreases with the face value of debt F.

When the firm's capital structure includes debt financing, making pay sufficiently sensitive to the short-term stock price can induce the manager to choose an inefficiently high level of risk. An increase in the face value of the firm's debt has two effects. First, it increases the gap between the expected payoff to equityholders from the risky and safe projects (a necessary condition for the manager to shift risk is that the risky project yields a higher expected payoff to equityholders). Therefore, the positive stock price reaction to the choice of the risky project increases, magnifying the effects of short-term incentives. This reduces the strength of short-term incentives needed to induce the manager to choose the risky project.

Second, an increase in the face value of debt makes the payoff of the risky project less risky (without a similar effect for the safe project), since the difference between the good and bad state payoffs of the risky project is reduced by an amount F. Since the manager is deterred from choosing the risky project by the amount of risk in her equity claims, this reduction in risk increases her willingness to choose the risky project. This also reduces the strength of short-term incentives required to induce the manager to choose the risky project. For both of these reasons, an increase in the face value of debt reduces the strength of short-term incentives required for the manager to willingly engage in risk-shifting.

Proposition 7 demonstrates that the combination of debt and short-term stock price-based incentives can lead to an inefficiently high level of risk-taking. This is consistent with the interpretation by critics of compensation practices that executives of financial firms, which operate with a large amount of leverage, took on excessive levels of risk in order to drive up their firms' stock prices in the short-run. The high level of risk transfers wealth from the firm's creditors to its shareholders. Therefore, once debt is in place, shareholders will choose to negotiate a contract with the manager that places weight on the short-term stock price and induces risk-shifting. Of course, shareholders bear this cost ex ante, since rational expectations-forming creditors will anticipate that the manager's contract will induce her to choose the risky project. This suggests that statutory constraints on rewards for short-term stock price performance can increase firm value by committing shareholders not to induce risk-shifting in the future. It should also be clear, though, that a similar improvement in efficiency can be attained by simply restricting the amount of debt that a firm can take on.

3 Conclusion

The importance of using stock price-based compensation to align the interests of management and shareholders is well-accepted. However, aligning incentives in this manner imposes significant risk costs on the manager which, in equilibrium, she must be compensated for. Alternatively, equity-based long-term compensation may give managers incentives to reduce risk at the expense of shareholder value. However, optimally adjusting the temporal composition of such incentives can ameliorate the negative effects on risk choice such incentives have. This is possible because market prices will reflect the effect of the manager's incentives on her risk choices. But, in order to attain such benefits, the manager must be allowed to take advantage of short-term prices by trading out of some of her equity-linked claims. As a result, trying to rigidly align managerial compensation to those of long-term shareholders who can diversify may not be in the right interests of long-term shareholders themselves.

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References

Aggarwal, Rajesh K., and Andrew A. Samwick, 2003, Why do managers diversify their firms? agency reconsidered, *Journal of Finance* 58, 71–118.

Agrawal, Anup, and Gershon N. Mandelker, 1987, Managerial incentives and corporate investment and financing decisions, *Journal of Finance* 42, 823–837.

Amihud, Yakov, and Baruch Lev, 1981, Risk reduction as a managerial motive for conglomerate mergers, *Bell Journal of Economics* 12, 605–617.

Anderson, Ronald C., Thomas W. Bates, John M. Bizjak, and Michael L. Lemmon, 1997, Agency problems, equity ownership, and corporate diversification, *Journal of Finance* 52, 135–160.

Brisley, Neel, 2006, Executive stock options: Early exercise provisions and risk-taking incentives, *Journal of Finance* 61, 2487–2509.

Carpenter, Jennifer N., 2000, Does option compensation increase managerial risk appetite?, *Journal of Finance* 55, 2311–2331.

Coles, Jeffrey L., Naveen D. Daniel, and Lalitha Naveen, 2006, Managerial incentives and risk-taking, *Journal of Financial Economics* 79, 431–468.

DeFusco, Richard A., Robert R. Johnson, and Thomas S. Zorn, 1990, The effect of executive stock option plans on stockholders and bondholders, *Journal of Finance* 45, 617–627.

Denis, David J., Diane K. Denis, and Atulya Sarin, 1997, Agency problems, equity ownership, and corporate diversification, *Journal of Finance* 52, 135–160.

Diamond, Douglas W., and Robert E. Verrecchia, 1982, Optimal managerial contracts and equilibrium security prices, *Journal of Finance* 37, 275–287.

Edmans, Alex, Xavier Gabaix, Thomasz Sadzik, and Yuliy Sannikov, 2009, Dynamic incentive accounts, *Working Paper*.

Harris, Milton, and Artur Raviv, 1978, Some results on incentive contracts with applications to education and employment, health insurance, and law enforcement, *American Economic Review* 68, 20–30.

Holmstrom, Bengt, 1979, Moral hazard and observability, *Bell Journal of Economics* 10, 74–91.

——— , and Jean Tirole, 1993, Market liquidity and performance monitoring, *Journal of Political Economy* 101, 678–709.

Jensen, Michael C., 1986, Agency costs of free cash flow, corporate finance and takeovers, *American Economic Review* 76, 323–329.

——— , and William H. Meckling, 1976, Theory of the firm: Managerial behavior, agency costs and ownership structure, *Journal of Financial Economics* 3, 305–360.

May, Don O., 1995, Do managerial motives influence firm risk reduction strategies?, *Journal of Finance* 50, 1291–1308.

Prendergast, Canice, 2002, The tenuous trade-off between risk and incentives, *Journal of Political Economy* 11, 1071–1102.

Rajgopal, Shivaram, and Terry Shevlin, 2002, Empirical evidence on the relation between stock option compensation and risk taking, *Journal of Accounting and Economics* 33, 145–171.

Ross, Stephen A., 2004, Compensation, incentives, and the duality of risk aversion and riskiness, *Journal of Finance* 59, 207–225.

Shavell, Steven, 1979, Risk sharing and incentives in the principal and agent relationship, *Bell Journal of Economics* 10, 55–73.

Treynor, J.L., and F. Black, 1976, Corporate investment decisions, *S.C. Myers ed., in Modern Developments in Financial Management,* New York: Praeger Publishers.