STOCK, OPTIONS, AND DEFERRED COMPENSATION

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I. INTRODUCTION

Firms use a large number of devices to motivate workers. A vast array of incentive pay mechanisms provides at least some incentive for workers to take actions that they view as unpleasant. Early analyses of incentive pay include sharecropping and strict piece rates, where workers are paid according to some function of output.[1] More recently, relative pay approaches have been analyzed, where comparisons between workers in tournament-type settings serve to provide incentives.[2] Others have examined stock ownership as a method of worker motivation.[3]

The focus of this paper is narrower. Specifically, the comparison is between deferred compensation, stock, and stock options as motivating devices. The goal is to compare the different forms of compensation by a number of criteria: incentive effects, default probabilities, risk, control, project choice, and some other minor factors. We will emphasize differences between new and old firms in the choice of compensation method. We omit tax considerations. Perhaps extremely important to choice between methods of payment, the tax issues are complicated and changing

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in light of recent tax reform legislation. Other authors are considering these problems in depth.[4]

II. DEFINITIONS

Three compensation schemes are considered: deferred compensation, stock, and stock options. We define them as follows in the context of a two period model.

Deferred compensation: The worker receives wages in period 0 and period 1. The wage in period 0 is specified in advance. The wage in period 1 is made contingent directly on the worker's performance in period 0.

Stock: Payment is made in period 0 in the form of a fixed amount plus an ownership claim to the firm. The claim entitles the worker to an amount in period 1 that depends (as determined by the market) on the firm's performance in period 0.

Stock option: Payment is made in period 0 in the form of a fixed amount plus a call on the firm's stock in period 1. Thus, the option has value only if the stock value in period 1 exceeds the exercise price. As above, the stock value depends (as determined by the market) on the firm's performance in period 0. Discussion of puts is deferred until later.[5]

Workers dislike effort e associating with it a cost $C(e)$, which is increasing and convex in e. Effort produces output, normalized so that one unit of effort increases the firm's output by one dollar. Assume that effort choice is only a factor in period 0. For simplicity, suppose that no work occurs in period 1.

III. INCENTIVE EFFECTS

The incentive effects of the various schemes are well-known. In this section, we briefly state the major differences between the motivating effects of compensation schemes for risk-neutral workers. The workers are thus assumed to maximize

$$W_0 + W_1 - C(e),$$

where W_0 is the wage paid in period 0, and W_1 is the wage paid in period 1 and $C(e)$ is the cost or pain of effort.

If effort can be observed perfectly or, equivalently, if output is a perfect proxy for effort and it can be observed perfectly, then a deferred-compensation scheme achieves the first-best level of effort.[6] The wage in period 1 is given by

$$W_1 = e.$$

The wage in period 0 is a rent-splitting parameter. If firms earn zero profit, then $W_0 = 0$. If rent can be extracted from workers, then

$$W_0 + W_1 = C(e^*) \qquad \text{or} \qquad W_0 = C(e^*) - e^*,$$

where e^* is the efficient level of effort, that is, such that $C'(e^*) = 1$. The deferred-compensation scheme achieves first-best even when there are large numbers of workers so long as each worker's effort can be observed perfectly.

It may often be the case, however, that the worker's effort is not directly observable, in which case deferred compensation is not possible. This brings us to a discussion of the incentive effects of stock and stock options.

Generally, stock or stock option ownership does not motivate as well as deferred compensation (when effort or output is observable). Since ownership is diluted, the worker's effort only contributes a fraction of a dollar to his or her earnings. Before showing this formally, we point out that stock is a special case of a stock option so that the analysis for stock options encompasses straight stock. Define a stock option formally as the right to buy β of the firm at a price $R\beta$ in period 1. The firm is worth V in period 0 before the worker puts any effort into the firm. The worker contributes e to the value of the firm, where e is the effort choice variable described above. Let ν be a random variable with a continuous distribution with density function $f(\nu)$ and distribution function $F(\nu)$. The market value of the firm in period 1 is given by

$$V_1 = V + e + \nu. \tag{1}$$

The expected value of the option in period 0 is

$$\text{Prob}(V_1 > R)E(\beta V_1 - \beta R \mid V_1 > R).$$

The first term is the probability that the call is in the money and the second term is its expected value conditional on being in the money. The option is in the money if

$$V_1 > R \qquad \text{or} \qquad R - V - e < \nu,$$

that is, $1 - F(R - V - e)$ of the time. The expected value of the option can be written as

$$S = \beta \int_{R-V-e}^{\infty} (V + e + \nu - R) f(\nu)\, d\nu \tag{2}$$

or

$$S = \beta(V + e - R)[1 - F(R - V - e)] + \beta \int_{R-V-e}^{\infty} \nu f(\nu)\, d\nu. \tag{2$'$}$$

It is easily seen that stock is equivalent to a stock option with exercise price $R \le 0$. If $R \le 0$, then the probability that V_1 exceeds R is 1, so the option is always exercised, which is equivalent to giving the worker the stock in period 0, and a lump sum payment of $-\beta R$.

The incentive effects in this special case of stock and a risk-neutral worker are easily analyzed. When $R = 0$, the value of the stock to the worker is simply

$$\beta V_1 = \beta(V + e + \nu).$$

The worker's optimal choice of effort is characterized by setting the marginal cost of effort $C'(e) = \beta$. For $\beta < 1$, this implies inefficiency. When $\beta < 1$, too little effort is exerted when the incentive device is straight stock.

There are two variables of choice in Equation (2): R and β . Thus, for any given value S of the option, there is a continuum of combinations of R and β that yield S. The value of the option decreases in R since increases in R lower the probability that the option is in the money and imply that the worker pays a greater amount per share of stock. The value of the option increases in β, however, since the worker is entitled to buy more stock with increases in β , when the option is in the money. Thus, risk-neutral workers are willing to trade off increases in R for increases in β, such that S remains constant.

The interesting question concerns the firm's optimal choice of R and β in designing a compensation scheme. For a given utility function there are continua of R and β that will yield the same expected utility to the worker. The firm will choose R and β to maximize its expected profit under the constraints that the worker selfishly chooses effort to maximize expected utility and that the compensation must be great enough so that the worker can be hired in period 0.

This is a standard principal–agent problem, which we describe in general and solve under certain parametric assumptions.

Assume that the worker has Von Neumann–Morgenstern utility for wealth W and effort e, given by $U(W, e)$. Utility is increasing in W and decreasing in e and wealth is described by

$$W = \begin{cases} \beta(V + e + \nu - R), & \text{if} \quad V + e + \nu \geq R, \\ 0, & \text{otherwise.} \end{cases}$$

Express the worker's expected utility as a function of β, R, and e by

$$EU(\beta, R, e) = \int_{R-V-e}^{\infty} U(\beta(V + e + \nu - R), e) f(\nu)\, d\nu + U(0, e) F(R - V - e)\,.$$

Define $e(\beta, R)$ to be the choice of effort that maximizes the worker's expected utility given β and R, so[7]

$$e(\beta, R) \equiv \arg\max_{e} \mathrm{EU}(\beta, R, e)\,.$$

The general compensation problem that the firm faces may now be stated as

$$\max_{(\beta,R)\in\Omega} V + e(\beta,R) + E(\nu) - \beta \int_{R-V-e(\beta,R)}^{\infty} (V + e(\beta,R) + \nu - R)\mathrm{f}(\nu)\,d\nu$$

$$\text{subject to } EU(\beta, R, e(\beta,R)) \geq \overline{U},$$

where $\Omega = \{(\beta,R) \mid 0 < \beta \leq 1\}$.

There are various cases of interest. Adjust V so that ν is normalized to have a minimum value of zero. In the first case, the optimal β and R are such that $0 < \beta < 1$ and $R \leq V + e$ so that the worker receives straight stock entitling ownership to a portion of the firm. The interpretation of R < 0 is that a fixed wage of $-\beta R$ is paid to the worker and he or she is given stock to β of the firm. A second case has $\beta = 1$ and $R > V + e$, so that with some positive probability, the worker is given an option to buy the entire firm. Third, $0 < \beta < 1$ and $R > V + e$, which is an interior solution. The worker is given an option that is only in the money sometimes. Our goal is to describe these cases and discuss which are likely to prevail in the real world.

The three situations can be illustrated by the following example. Let

$$U(W, e) = W^{\alpha} \exp(-\gamma e),$$

where $0 < \alpha < 1$ and $\gamma > 0$. For simplicity, let $V = 0$ so that the value of the firm from (1) is $V_1 = e + \nu$. Assume the worker has no other wealth, so that

$$W = \begin{cases} \beta(e+\nu) & \text{if } \; R < e + \nu, \\ 0, & \text{otherwise.} \end{cases}$$

Let ν be distributed uniformly over $[0, b]$. Under these assumptions,[8] expected utility is

$$EU = \frac{1}{b} \int_{R-e}^{b} \exp(-\gamma e)\beta^{\alpha}(e + \nu - R)^{\alpha}\, d\nu, \tag{3}$$

or

$$EU = \frac{\beta^{\alpha}\exp(-\gamma e)}{b(\alpha+1)} (b + e - R)^{\alpha+1}. \tag{4}$$

Given β and R, the worker chooses e to maximize expected utility. The first-order condition from (4) implies[9] that the worker's choice of e is given by

$$e = \frac{\alpha+1}{\gamma} + R - b. \tag{5}$$

Using the optimal e from (5) and substituting into the constraint that $EU = \overline{U}$, where EU is defined in (4), one can write

$$\beta = [\overline{U} b \gamma^{\alpha+1}]^{1/\alpha} (\alpha+1)^{-1} \{\exp[(R-b)\gamma + \alpha + 1]\}^{1/\alpha}, \tag{6}$$

so that β is solved explicitly in terms of R and $\overline{U}$.[10]

The firm wants to choose R and β to maximize expected profit, taking into account the worker's behavior in (5) and the constraint that $E(U) = \overline{U}$ in (6). The firm's expected profits are

$$E(\pi) = e + E(\nu) - \frac{\beta}{2b}(b + e - R)^2 .$$

The first two terms are the expected value of the firm. The last term is the expected payment to the worker, taking into account that the worker gets to buy β of the firm at price $R\beta$ only when the option is in the money.

Using (5), $E(\pi)$ can be written

$$E(\pi) = \frac{\alpha + 1}{\gamma} + R - \frac{b}{2} - \frac{\beta(R)}{2b}\left(\frac{a + 1}{\gamma}\right)^2 ,$$

where $\beta(R)$ is given by (6). The problem is now reduced to choosing R to maximize the above expression for $E(\pi)$. The necessary first-order condition is[11]

$$\frac{\partial E(\pi)}{\partial R} = 1 - \frac{1}{2b}\left(\frac{\alpha + 1}{\gamma}\right)^2 \frac{\partial \beta}{\partial R} = 0.$$

From (6),$\partial\beta/\partial R = \gamma\beta/\alpha$, so

$$\frac{\partial E(\pi)}{\partial R} = 1 - \frac{\beta(\alpha + 1)^2}{2b\alpha\gamma} = 0.$$

This implies that at an optimal choice of R and β

$$\beta = \frac{2b\alpha\gamma}{(\alpha + 1)^2} . \tag{7}$$

R is calculated explicitly using (6) and (7):

$$R = b - \frac{\alpha + 1}{\gamma} + \frac{1}{\gamma}\log\left[\frac{(2\alpha)^\alpha b^{\alpha-1}}{\overline{U}\gamma(\alpha + 1)^\alpha}\right].$$

Case 1: Straight Stock

The first case is that of straight stock: $R \leq e$ so that the worker is always in the money, and the worker owns a portion of the firm. Let $\alpha = 1/3$, $\gamma = 1$, and $b = 4/3$. Then from (5) we have $e = R$. Therefore, the option is never out of the money. (The minimum value of the firm, when $\nu = 0$, is e. For $\nu > 0$, $e + \nu > R$.) Thus, the worker always exercises the option and essentially owns stock. From (7), $\beta = 1/2$, so the worker is allowed to own half of the firm. It is common for workers to be given stock in a firm and this case fits that observation from the real world.

Case 2: Corner Solution in β

The worker, under some circumstances, is given the entire firm.

Let $\alpha = 1/2$, $b = 9/4$, and $\gamma = 1$. Then from (7), $\beta = 1$. Also, from (5), $R - e = 9/4 - 3/2 = 3/4 > 0$. The option is in the money sometimes, but not always. For high values of v, the worker is given the entire firm for R. For low values of v, the worker receives nothing.

This case seems somewhat unrealistic. Although workers sometimes do take over the firm (for example, the Northwestern Railroad and Eastern Airlines), the takeover usually occurs when the value of the firm is low, not high. Generally, bad "luck" or poor management brings this on. In this example, good luck induces the worker to exercise his or her option.

Case 3: Interior Solution

The worker is given an option that he or she sometimes exercises and buys less than the entire firm.

Let $\alpha = 1/10$, $b = 9/4$, and $\gamma = 1$. From (7), $\beta = 45/121$. From (5), $R - e = 23/20$.

Notice that the option is in the money less often than it was in case 2, and when it is in the money, the worker is allowed to buy only 45/121 of the firm, rather than the entire firm.

This is a most common case. The worker is given options with a strike price sufficiently high to prevent certain exercise. The amount that he or she is given falls short of allowing purchase of the entire firm. In this situation the low value of α reflects a low utility of wealth relative to the cost of effort. The constraint that the worker obtain a minimum utility level implies that at the optimum, less effort will be exerted. A comparison of case 2 and case 3 shows that the characteristics of the worker are important in determining the optimal payment scheme as well as the effort level obtainable.

Risk-Neutrality

Consider what happens when the worker, like the firm, is risk-neutral in wealth. In the current example, this is shown as $\alpha = 1$. The result is that the worker always receives straight stock. No risk-neutral worker should ever be given an option that is sometimes out of the money.

Proof: If $\alpha = 1$, then from (7), $\beta = b\gamma/2$. But $\beta \le 1$ so $b\gamma \le 2$. An option that is sometimes out of the money requires $R - e > 0$, or from (5) that

$$b - \frac{2}{\gamma} > 0,$$

since $\alpha = 1$. Rewrite this as $b\gamma > 2$. But $\beta \le 1$ implies $b\gamma \le 2$, which is a contradiction. Therefore, $R - e \le 0$, so the worker receives straight stock.

Although this is merely an example, in every example we have worked out explicitly, risk-neutral workers receive straight stock. We have not been able to prove the result in general, but offer it as a conjecture.

It may seem somewhat surprising that risk-neutral workers receive straight stock, whereas risk-averse workers receive true options. After all, options seem to magnify the risk rather than to reduce it. The key is that options have different incentive value than stock. The incentive aspect, rather than the security aspect, induces a shift toward options. The idea is akin to Bergson (1978). If workers are risk-averse, then at high levels of wealth, additional income has little incentive effect. To offset this and maintain incentives, the payoff function must be convexified. Options convexify the payoff function and improve incentives to risk-averse workers.

What is clear from the preceding is that the choice of β and R are not arbitrary. There is a particular pair that maximizes profit, subject to $E(U) = \overline{U}$. Sometimes the choice is a corner that is not observed in the real world: Set $\beta = 1$ and select R so that $E(U) = \overline{U}$. This means that when the option is in the money, the worker buys the entire firm, but that R is chosen sufficiently high so that it is unlikely that the value of the firm is high enough to warrant a buy. It is not infrequent to choose an exercise price equal to par value of the stock, which is very close to zero. But β is rarely close to 1 in practice. When there are many workers, it seems that β cannot be one for every worker.

But it is not quite true that the sum of β's across workers cannot exceed 1. For example, phantom stock allows every worker to have $\beta = 1$. Actual stock need not be sold to the worker. Instead, each worker is told that if the V_1 rises above R, he or she will receive $V_1 - R$ as compensation. There are some problems here. First, for sufficiently low R, the firm cannot make its payments. Second, after the promise is made, the owners of the firm hope that V_1 does not rise above R, which creates adverse incentive effects for managers who own a significant part of the firm. (These adverse incentives are discussed in more detail in the next section.)

Although neither stock options nor straight stock perform as well as contingent deferred compensation does under ideal circumstances of perfect observability, stock and stock options have the advantage that they tie compensation to a variable that is easily observed. In some cases, it is sufficient to tie reward to stock price. The CEO's output is, in some sense, the value of the firm, and observing his output through any other variable is likely to be difficult. For other individuals, for example, a salesman, output is easily observed, so the advantages of using contingent deferred compensation are greater for this type of worker.

IV. DEFAULT CONSIDERATIONS

If the man or woman on the street were asked why start-up firms cannot attract workers by promising to pay high salaries in the future, a likely response would be that such promises are not credible. The firm may go out of business or may consciously decide to break its promise. Giving the worker stock or stock options seems different. Management, however, can lower the value of the stock or can render the option useless by intentionally reducing the value of the stock below exercise price. In this section, the firm's incentive to default on the three kinds of incentive pay is considered.

First, let us examine the decision to default on deferred compensation. If there were no cost of default, firms would never pay their workers. But default may have associated with it legal costs, reputation costs, and costs associated with poorer labor relations, among others. Let the default cost θ be a real-valued random variable that is unknown to the firm and worker until period 1. Assume that θ is distributed according to the distribution function $G(\theta)$. The firm defaults on its promise to pay W_1 when $W_1 > \theta$, which occurs with probability $G(W_1)$. If the amount that is at risk is X, so that $W_1 = X$, default occurs with probability $G(X)$.

Stock and stock options can be considered together since, as stated, stock is merely a special option where $R \leq V + e$. As before, the worker has the right to purchase β of the firm at price βR in period 1. Management defaults by taking actions that benefit managers at the worker's expense. Specifically, management can take actions that depreciate the value of the firm so that the option is no longer in the money.[12] Suppose that the firm would be worth V_1 if management did nothing adverse. To put the stock out of the money, the firm must be depreciated such that the value is R or below. Thus, default requires depreciation of the firm from V_1 to R. Since the worker whose option is in the money has β of the firm, he or she loses

$$\beta(V_1 - R) - \lambda_W(V_1 - R),$$

where λ_W is the amount that the worker receives per dollar of depreciation. For example, management may depreciate the firm by spending too much on expensive art. Then λ_W is the dollar value of the utility that the worker derives from the art, per dollar of depreciated value. Similarly, λ_F is the dollar value that management receives from depreciation of the firm, per dollar of depreciation. Suppose additionally that there are absentee owners who have claim to β_s of the firm. For simplicity, it is assumed that $\lambda_s = 0$.

To make the comparison equivalent to default in the case of deferred compensation, it is necessary that the amount at risk be the same, so that

$$\beta(V_1 - R) - \lambda_W(V_1 - R) = X,$$

where X, as defined above, is the amount at risk with deferred compensation. (Think of V_1 as nonstochastic for the purposes of this analysis.) Rewrite this as

$$V_1 - R = X/(\beta - \lambda_W). \tag{8}$$

Now consider the manager's incentives. If management does not depreciate the stock, then the option is exercised and management owns $(1 - \beta - \beta_s)$ of V_1 and receives $R\beta(1-\beta_s)$ from the worker. If management does depreciate the stock, it keeps $(1-\beta_s)$ of the firm, now worth R, and receives $\lambda_F(V_1-R)$ in services. Additionally, it suffers θ in reputation costs.[13] Thus, the default occurs iff

$$(1-\beta_s)R+\lambda_F(V_1-R)-\theta > (1-\beta-\beta_s)V_1+R\beta(1-\beta_s). \tag{9}$$

Since $V_1-R=X/(\beta-\lambda_W)$, the firm's default condition becomes default when

$$X\left(\frac{\lambda_F+\beta+\beta_s-1}{\beta-\lambda_W}\right)+R\beta\beta_s > \theta, \tag{10}$$

so it defaults with probability

$$G\left[X\left(\frac{\lambda_F+\beta+\beta_s-1}{\beta-\lambda_W}\right)+R\beta\beta_s\right].$$

Suppose that $\beta_s=0$ so that there are no absentee owners. Then the default probability is smaller with options than with standard deferred compensation whenever

$$\frac{\lambda_F+\beta-1}{\beta-\lambda_W}<1$$

or whenever

$$\lambda_F+\lambda_W<1.$$

When $\beta_s=0$, $\lambda_F+\lambda_W\geq 1$ implies that the firm is making an efficient move by turning V_1 into compensation for worker and management in the form of the art purchase. Thus, if the move to devalue the firm is really a devaluation, it must be that $\lambda_F+\lambda_W<1$, and so when $\beta_s=0$ default is less likely with stock options than with deferred compensation.

The intuition of the result is this: Since management must give up some value (in addition to θ) to default on the worker by depreciating the stock, default is less likely than with deferred compensation. Other things equal, the worker prefers to hold his or her contingent compensation in the form of stock options than in straight deferred wages. This is likely to be what the man or woman on the street had in mind.

When $\beta_s>0$, it is no longer true that default occurs only when efficient. Since management can steal not only from workers, but also from absentee owners, it is possible that default probabilities are actually increased by giving the worker stock rather than deferred compensation. For example, suppose that management owns none of the firm, so that $\beta_s=1-\beta$, $R=0$, and $\lambda_W>0$. Then (10) implies that default is more likely with stock than deferred compensation if probability of default by new firms that promise deferred compensation and those that give stock is

$$G(X) - G\left(X \frac{\lambda_F + \beta - 1}{\beta - \lambda_W}\right).$$

For old firms it is

$$G^*(X) - G^*\left(X \frac{\lambda_F + \beta - 1}{\beta - \lambda_W}\right).$$

Unfortunately, whether the first difference exceeds the second depends on the shape of G and G^* and on the relevant range. Our intuition relates to the extremes. If old firms have reputation costs that are so high that default is never a problem, then stock options are inferior to deferred compensation because incentive effects dominate. It is unlikely that new firms are ever in that situation, so that default considerations may be paramount.

V. TRADED VERSUS PRIVATELY HELD STOCK

Are incentive and default considerations different when options are traded publicly? As expected, neither is affected. It is clear that there is nothing in the incentive problem that changes when stock is traded publicly. The worker does not care about the identity of the supplier of the stock when it is called.

The default consideration is less straightforward. Suppose that the firm buys a call option on the market and gives it to the worker. As before, suppose that $\beta_s = 0$ so the firm (that is, management) owns $1-\beta$ of the stock. The only difference is that now someone else (either the worker or the rest of the market) holds β of the stock, whether it is called or not. If the firm defaults on the worker by reducing the value of the stock to R, the firm receives

$$(1 - \beta)R + \lambda_F(V_1 - R) - \theta.$$

If it does not default, it receives

$$(1 - \beta)V_1.$$

Thus, default occurs iff

$$(V_1 - R)(\lambda_F + \beta - 1) > \theta,$$

which is the same condition as held when the stock was given privately to the worker. [Substitute $\beta_s = 0$ into Equation (9).] Having a third party short the call does not alter management's incentive to default and does not change the attractiveness of options over straight deferred compensation.

VI. CONTROL AND RETENTION OF WORKERS

We have collapsed the analysis of stocks and options into one category, because stock is an extreme form of option with $R = 0$. Stock is a special case of stock option except for some institutional details that are explored in this section.

Timing is important in the distinction between stock and stock options. An exercise price of zero guarantees that the worker will purchase the stock in period 1, but he or she is not the owner of record until that time. Thus, the worker cannot exercise control over management until period 1. If stock is awarded in period 0, then he or she has some ability to guide the actions of managers during that period. The point is probably not of major significance for two reasons: First, the proportion of management's stock that is ascribed to unexercised call options for workers is a small proportion of the total. Start-ups may be the exception. Second, options generally contain stipulations that limit the ability of managers to dilute the stock and take other actions that might lower its value. Minority shareholders are protected to some extent even before they become shareholders.

A second point relates to vesting. Generally, stock options require that the employee remain with the firm in order to exercise the option, although options could, in theory, vest immediately. In that sense, they are like deferred compensation: The worker does not receive the reward for hard work in period 0 unless he or she opts to work in period 1. Straight stock awards do not impose the same requirement. Since the stock is given in period 0, work status in period 1 is irrelevant. Thus, stock options and deferred compensation induce reduced worker turnover.

Although reduced turnover sounds like a good idea, in fact it reflects an inefficiency in this context. The value of work in period 1 is zero (by construction). Yet the worker stays to receive the reward for period 0 work. The value of his or her alternatives necessarily exceeds what he or she produces here, but he or she stays anyway. Both firm and worker can be made better off if the worker is given appropriate incentives to leave the firm.

Reduced turnover is valuable, however, when firm-specific human capital or monopoly rents are an issue. In the case of specific human capital, the worker only takes his or her own lost wages into account when making the separation decision (see Kennan, 1979). But mature (period 1) workers are generally paid less than they are worth to the firm so as to split the costs and quasi-rents from human capital. This implies that they leave too often, moving whenever their alternatives are better than the current wage rather than their value to the firm. The amount that is given to workers in the form of nonvested option or straight deferred compensation solves a second-best contract, as in Hashimoto and Yu (1980) or Hall and Lazear (1984). Generally, that optimal amount exceeds zero.

The monopoly case is similar. Suppose that a researcher invents a new technology to which no other firm has access. If the researcher were to leave to set up a rival company, monopoly rents would be dissipated. Although this is a socially efficient outcome, it is not one that either the firm or worker should desire. The problem arises because the worker does not capture the full monopoly rent at the original firm. Thus, he or she sets up the rival whenever its value exceeds his or her payment at the existing firm, not the total value of monopoly rents. Deferred compensation, either as a direct payment or stock option, can lessen the problem. The solution, which is worked out in Nitzan and Pakes (1983), is similar to the specific human capital story and yields only a second-best solution in the private sense.

VII. PROJECT CHOICE

The choice between deferred compensation, stock, and stock options is affected by project choice considerations. If managers are risk-averse, setting $R = 0$ so that they own pure stock may induce them to accept only safe projects. Since the loss of a given amount of money subtracts more utility than its gain adds, managers tend to select projects with low variance, even if the expected return on riskier projects is higher. A way around this problem is to offer managers stock options with $R > 0$. Then the manager receives nothing for small positive changes in the value of the stock. He or she is in the money only when the value of the firm increases by a substantial amount, which leads him or her to take on riskier projects. This is discussed in Lambert and Larcker (1985) and is related to Bergson (1978), where a convex payoff function undoes the concavity of the utility function.

The manager's choice variable is the shape of the distribution of the value of the firm at time 1. The firm observes only the outcome V and hence cannot infer what choice the manager made. The firm wishes to design a contract that motivates the manager to choose the firm's desired distribution. In particular, assume that the manager chooses a parameter $m \in (0,\infty)$, and then V is distributed exponentially with parameter λ, where $\lambda = 1/m$. Hence $E(V) = m$ and $E(V - m)^2 = m^2$.[14] The manager is compensated by means of a fixed payment W and an option to buy a portion $\beta \in [0,1]$ of the firm at exercise price $R \in [0,\infty]$.[15] We assume the manager has von Neumann–Morgenstern utility of income I, $U(I) = I - aI^2$, where $a \in (0,\infty]$). The manager's expected utility given a choice m can then be expressed as

$$EU = \int_0^R (W - aW^2)\frac{1}{m}\exp(-V/m)dV +$$

$$\int_R^\infty (W + \beta(V - R) - a[W + \beta(V - R)]^2)\frac{1}{m}\exp(-V/m)dV$$

so

$$EU = W - aW^2 + m\beta(1 - 2aW - 2am\beta)\exp(-R/m). \tag{11}$$

The manager's choice of m is the solution to $\max_m EU$, where EU is given by (11). The necessary first-order condition is

$$0 = \beta \exp(-R/m)\left[\frac{R}{m}(1 - 2aw) + 1 - 2aw - 2aR\beta - 4am\beta\right]$$

or

$$0 = (1 - 2aw)R + (1 - 2aw - 2aR\beta)m - 4a\beta m^2$$

The positive root for m is then

$$m^* = \frac{1 - 2aW}{8a\beta} - \frac{R}{4} + \left[\frac{(1 - 2aW)R}{4a\beta} + \left(\frac{1 - 2aw}{8a\beta} - \frac{R}{4}\right)^2\right]^{1/2}.$$

As we might expect,

$$\frac{dm^*}{da} < 0, \qquad \frac{\delta m^*}{\delta W} < 0, \qquad \frac{\delta m^*}{\delta \beta} < 0, \qquad \frac{\delta m^*}{\delta R} > 0.$$

These relations have intuitive interpretations. Higher levels of a indicate larger tradeoffs between risk and return. As the agent becomes more risk averse, he chooses safer projects. Higher levels of fixed payments W lead the agent to higher levels of risk aversion and thus safer projects. (Quadratic utility is increasingly risk averse. If utility were decreasingly risk averse, then we would expect higher fixed payments to induce choices of riskier projects.) If R is high, the option will only be valuable for high realizations of V. As a result, the manager wishes to increase m [thus increasing $E(V)$ and variance (V)]. However, for fixed R, higher β implies that more wealth is at risk and so the agent prefers a lower variance (even though this requires a lower expected value) and hence a lower m. The point is that choosing $R > 0$ so that the worker receives an option induces him or her to select riskier projects.

Whether managers need encouragement to take on riskier projects remains an issue. If managers and other shareholders have homogeneous preferences and wealth, then giving the manager a portfolio that replicates that of the representative shareholder would create harmony between shareholder and manager interests. There would be no need, or desire, to induce managers to accept more risk. Managers' conservative behavior generally results from the discrete nature of the job. Perhaps as a result of imperfect observability, when output falls below some level, managers' punishment is job (and, presumably, rent) loss. This additional concern makes managers conservative. Of course, placing the managers' job at risk is subject to choice. But when it is the best response to imperfect observability, managers are cautious.

VIII. OTHER NONLINEAR INCENTIVE SCHEMES

Although stock options with $R > 0$ provide incentives to take riskier projects, so does a deferred-compensation scheme that ties payment in a nonlinear way to output. In fact, a nonlinear piece rate generally dominates discrete payment structures, as Green and Stokey (1983) demonstrate. A preference for stock options over direct deferred compensation based on output is likely to rest on three related points: First, output may be difficult to observe. Accounting measures of output are inherently noisy and it is possible that the market sees through the noise to obtain a better estimate of output. Second, management may be able to manipulate measured output more readily than it can manipulate stock price. Third, stockholders care directly about stock price and only indirectly about output. It is generally preferable to tie compensation to the variable that is the focus of owner concern.

Working against the use of stock options are two factors. Variance in the price of many stocks is closely related to the market as well as to the firm's idiosyncratic performance. This introduces noise into the process that might not be present if a direct measure of output were used. It is possible to condition the exercise price on the Dow-Jones or some other general index, but this is rarely done, perhaps for tax reasons. If the strike price moves too closely with spot price, then the option is always in the money. As a result, the stock option is closer to straight stock, which means that it must be declared as income at the time the option is awarded. Additionally, there is the controversy over the ability of the market price to predict accurately the true value of the firm. Shiller (1981) has been the strongest proponent of market irrationality arguments. Work by Kleidon (1986), Marsh and Merton (1983), and Merton (1987) casts doubt on the validity of Shiller's analysis. Still, recent dramatic movements in stock prices can hardly be attributed to variation in manager effort, or even output.

IX. NEW INFORMATION AND EFFORT

One apparent disadvantage to setting a high strike price is that new information can render the option useless and choke off incentives. For example, suppose that the stock currently sells for 100, and that R is set at 100. Let the market turn sour so that the current spot price of the stock drops to 10. The chances that the stock will ever be in the money are greatly diminished. Intuition suggests that managers would then discount totally the option as a motivator. The reason is that effort is only valuable when the option is in the money because only then does increased value of the firm translate into additional compensation for the manager.

While this intuition is correct, it is less obvious than it appears because effort changes the probability that the option is in the money. These second-order effects drop out, at least for risk-neutral managers.

To see this, consider the simplest case where managers receive all of their compensation in the form of stock options. Then the manager's problem is to choose e so as to maximize

$$\max_{e} S - C(e), \tag{13}$$

where S is defined in (2).

The optimum e is the solution to

$$\partial S/\partial e = C'.$$

Since C' is increasing in e, it is clear that effort increases when $\partial S/\partial e$ increases.

In order to determine whether current information has an effect on effort, it is necessary to evaluate the effect of V on $\partial S/\partial e$. A fall in the market value of the firm can best be interpreted as a fall in V relative to R, since this reduces the likelihood that the option will be in the money.

From (2)′, differentiate with respect to e to obtain

$$\begin{aligned}\frac{\partial S}{\partial e} &= \beta[1 - F(R - V - e)] + \beta(V + e - R)f(R - V - e)\\ &\quad + \beta(R - V - e)\,f(R - V - e)\\ &= \beta[1 - F(R - V - e)].\end{aligned}$$

It is apparent that $\partial S/\partial e$ is positive: more effort increases the expected value of the option. Further, the effect of effort on compensation is only the direct effect of raising the value of the stock, weighted by the share owned by the manager and by the probability that the stock is in the money. Changes in the probability drop out.

Now, differentiate again with respect to V to obtain

$$\frac{\partial^2 S}{\partial e\, \partial V} = \beta f(R - V - e). \tag{14}$$

The derivative is positive. Since the value of the option increases in the probability that the option is in the money, being farther below the goal decreases the value of effort.

Raising the strike price has two effects. Conservative tendencies of managers can be offset by giving them large numbers of options with high strike prices. The value of the option increases in variance, so managers with high strike price options have incentives to adopt riskier projects.

But this is offset by the direct effect of the high strike price on effort, which reduces the likelihood that the stock is in the money. However, much if not all of this disadvantage is eliminated as β increases to compensate for the decreased expected compensation.

X. WHY NO PUTS?

Workers are often given call options or warrants, but rarely put options. If the source of potential moral hazard is the worker, then making him long in puts has exactly the wrong incentives. The worker does well when the firm does poorly, so he or she has an incentive to make the firm fail. Of course, from an insurance point of view, giving a risk-averse worker put options may be desirable. If the worker had no control over the output of the firm, but owned some specific human capital in it, then owning put options insures him or her against exogenous declines in the value of the firm. The failure to see workers long puts in practice suggests that incentive considerations dominate.

Workers could be paid to short put options. In this case a fall in the value of the firm implies that the worker ends up paying a fee. This is similar to making the worker long on calls. It is analogous to replacing a subsidy with a tax and lump-sum payment. A worker who lowers the value of the firm is taxed for doing so if the put moves into the money.[16] The question of why long calls rather than short puts may be similar to why firms generally state compensation in terms of bonuses, rather than penalties, even though the compensation associated is identical.[17]

There are some real economic differences. Being long on calls has some different payoff characteristics than being short on puts. Floors and ceilings differ, which alters the actual payoffs. When workers are short on puts, the firm is long on them, which may create adverse incentives for management. However, the same is true when workers are long on calls. In fact, those adverse incentive effects are the ones analyzed in the earlier section on management default. Since the analysis is similar, it need not be repeated.

The incentive effects of puts on the risky project choice of an agent is different from that of calls. If an agent is long a call, he or she has an incentive to undertake risky projects (see Section VI). A call option rewards the employee for high payoffs, yet inflicts no punishment for bad outcomes. This induces choice of risky projects. In contrast, being short a put option punishes an employee for bad outcomes while not rewarding him or her for good ones. This would cause the employee to undertake safe projects, which never have bad outcomes, regardless of their potential for increasing the value of the firm (above the exercise value).[18]

XI. SUMMARY

There are many factors that affect a firm's choice between stock and deferred compensation. Incentives, default considerations, and risk factors all affect the choice, sometimes in subtle ways.

Some results are:

1. Deferred compensation is a better motivator than stock or stock options when output or effort is observable. Stock and stock options are likely to

be used for individuals who are further up the hierarchy, the fruits of whose labor cannot be easily identified.

2. There are continua of option shares and exercise prices that yield a worker the same expected utility. However, incentive effects of straight stock, which is nothing more than an option with an exercise price sufficiently low to place it always in the money, differ from those of true options. For risk-neutral workers, straight stock seems to dominate. For risk-averse workers, options that are only sometimes in the money perform better.
3. Default by management is a greater problem for deferred compensation than for stock. Management defaults on stock by reducing its value and on deferred compensation by reneging on a promise to pay. The probability of default by management increases with the proportion of stock held by nonmanaging owners, which implies that start-ups should use options to a greater extent than established firms.
4. Making the stock publicly available does not change worker incentives. More surprising, it does not alter manager incentives to default.
5. Stock options, as compared with straight stock, result in too little worker turnover. The exception is when specific human capital is important or when monopoly rents are lost because former employees start spin-off firms.
6. Stock options, as compared with straight stock, may encourage managers to accept riskier projects.
7. The use of a high strike price may have some beneficial effects on risk-taking, but some adverse direct effects on effort. High strike prices mean the stock is more likely to be out of the money, which has adverse consequences for effort. This impediment to effort is offset at least in part by the natural requirement that the number of options offered increase as the strike price increases to keep expected present value the same.
8. An alternative to making workers long on calls is to pay them to short puts. Both have incentive effects. The former encourages risk-taking, while the latter discourages it.

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NOTES

1. Some references here are Johnson (1950), Cheung (1969), Ross (1973), Stiglitz (1975), and Holmstrom (1979).

2. See Lazear and Rosen (1981), Nalebuff and Stiglitz (1983), Green and Stokey (1983), Carmichael (1983), and O'Keeffe, Viscusi, and Zeckhauser (1984).

3. See, for example, Nitzan and Pakes (1983), Murphy (1985), and Antle and Smith (1986).

4. The basic reference on tax issues and compensation is Miller and Scholes (1982). See also Scholes and Wolfson (1988).

5. The distinction between the three is somewhat blurred. First, stock is a special case of stock option. Second, deferred compensation can be a function of stock value, as with phantom stock or bonuses that are contingent on the value of the firm.

6. See Becker and Stigler (1974) and Lazear (1979, 1981).

7. In general, regularity conditions on the distribution on v and on the structure of utility are necessary to ensure that $e(\beta,R)$ is well-defined and single-valued. In the cases we will consider, $e(\beta,R)$ is a well-defined function.

8. We require $b \geq (\alpha+1)/\gamma$. This ensures that $R - e \in [0, b]$, which will follow from (5). The limits of integration are then correct.

9. The second-order condition reveals a local maximum, since

$$\frac{\partial E(U)^2}{\partial e^2} = -\frac{(\alpha+1)E(U)}{(b+e-R)^2} < 0.$$

10. It is easy to see that the constraint $EU > \overline{U}$ can be written as $EU = \overline{U}$. For any (β, R) pair such that $EU > \overline{U}$, there exists a (β', R') with $\beta' < \beta$, $R' \geq R$, and $EU = \overline{U}$, which does not decrease the firm's expected profit.

11. Again, the second-order condition reveals a local maximum since

$$\frac{\partial^2 E(\pi)}{\partial R^2} = -\frac{1}{2b}\left(\frac{\alpha+1}{\alpha}\right)^2 \frac{\partial^2 \beta}{\partial R^2} < 0.$$

12. Since R is variable below, we need not consider intermediate cases where the stock value is depressed by some smaller amount. Equivalently, choose R so that a given depreciation amount puts the option out of the money.

13. We assume the cost of default is the same for deferred compensation and stock. Inasmuch as costs are tied to reputation and agents can recognize an intentional depreciation of the stock, this is a reasonable assumption.

14. An example where an exponential distribution seems natural is in the case of a start-up firm. The firm is initially worth zero and the manager is deciding what projects the firm should undertake. If he or she undertakes risky projects, corresponding to high values of m , the firm's stock value will have a high expectation m, but also a high variance m^2. If safer projects are undertaken, corresponding to low values of m, the firm's stock value will have a low expectation m, but also a low variance m^2.

15. Although stock is a special case of options, we include both stock and options since it may be the case that a mixture is optimal.

16. There is a difference having to do with the nonlinearity of the payoff structure.

17. For example, a firm announces that it pays \$10,000 per year plus a bonus of \$1 per unit of output produced. Alternatively, it announces that it pays \$15,000 per year minus a penalty for each unit under 5000. The two schemes are identical since the former can be written as \$10,000 + \$1Q and the latter as \$15,000 – \$(5000 – Q), which is also \$10,000 + \$1Q. The bonus way of stating the scheme predominates.

18. This is closely related to discussions of debt markets. See, for example, Diamond (1985) and Stiglitz and Weiss (1983).

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