Abstract

Because of recent corporate frauds and scandals the use of options as a compensation device has become a controversial subject. In this paper we take a new look at the issue, by contrasting the use of options with that of pure stock. We do this by integrating the repricing or resetting aspect of options with that of industrial structure and accounting issues. We show that options may be correlated with recent tendencies toward overly conservative accounting practices. In addition, industry competition may play an important role in dictating which form of compensation is optimal. When aggressive competition for key professional staff is an issue, the flexibility of options may actually become a disadvantage and therefore pure stock compensation may survive as an equilibrium.

1 Introduction

One of the most significant trends of the 1990s was the extent to which equity-based pay accelerated at an incredibly rapid rate. As is documented in Hall (2002) the amount of equity-based pay (as a fraction of total top executive pay) at the beginning of 1990 was less than 10%. By 1992 this fraction was about 30% and by the end of the decade had reached over 60%. The vast majority of this trend was accounted for by increases in the use of executive stock options.

We appreciate the very helpful comments of Chongwoo Choe, Dan Givoly, Jack Hughes and seminar participants at UCLA.
Table 1: Percentage Ownership by Employees

<table>
<thead>
<tr>
<th>Category</th>
<th>0-10%</th>
<th>11-30%</th>
<th>31-50%</th>
<th>51-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Co. ESOPs</td>
<td>20%</td>
<td>20%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Public Co. ESOPs</td>
<td>62%</td>
<td>34%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>401(k) Plans</td>
<td>85%</td>
<td>10%</td>
<td>5%</td>
<td>0%</td>
</tr>
<tr>
<td>Stock Options</td>
<td>32%</td>
<td>65%</td>
<td>3%</td>
<td>0%</td>
</tr>
</tbody>
</table>

But executives were not alone in benefitting from options. This privilege was enjoyed in addition by many professional workers in high technology firms. As firms went public and the NASDAQ market skyrocketed, the use of stock as ‘currency’ for both acquisitions and professional compensation became commonplace. Data from the National Center for Employee Ownership (NCEO) has established that 8–10 million employees in the U.S. have received stock option grants. Predating the use of options for compensation, are various forms of stock grants. Since 1974 with the passage of ERISA, the growth in the use of employee stock ownership plans (ESOPs) has increased to the point where there are 11,000 ESOPs in the U.S. covering 8.8 million employees. Many of these plans are held in conjunction with defined contribution 401(k)s in which employer stock contributions often cannot be diversified. Trends such as these have been praised by academics and practitioners alike in terms of resolving agency problems and aligning the interests of shareholders and employees. Table 1 shows the distribution of percent ownership granted to employees in firms with various stock-based incentive plans.\(^1\) It is noteworthy that option plans feature a concentration of ownership at a higher level, between 11-30%, as compared with public company ESOPs and 401(k) plans. This fact is an important feature of the analysis contained in this paper.

As we now know, the apparent panacea of stock options was short-lived. The corporate frauds and scandals beginning with Enron in 2001 highlighted incidents of extraordinarily large compensation paid to executives and option exercises in the millions of dollars while workers suffered precipitous losses in their 401(k) plans. This has led to renewed interest in stock options as an optimal form of compensation and indeed whether it is capable of aligning interests and resolving agency problems. In a recent study Blasi, Kruse and Bernstein (2003) looked at the difference in performance between firms that provided broad distribution of options to many employees as compared to those that distributed them predominantly to top executives. They found that firms that gave the most to top executives had significantly lower shareholder

\(^1\)Data are from the NCEO.
Table 2: Trends in stock and option compensation

<table>
<thead>
<tr>
<th></th>
<th>Fiscal 2002</th>
<th>Fiscal 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Restricted stock grants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of recipients</td>
<td>29</td>
<td>22</td>
</tr>
<tr>
<td>Median value</td>
<td>$929,600</td>
<td>$563,200</td>
</tr>
<tr>
<td><strong>Stock-option grants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of recipients</td>
<td>81</td>
<td>85</td>
</tr>
<tr>
<td>Median binomial option pricing value</td>
<td>$3,409,800</td>
<td>$4,157,600</td>
</tr>
</tbody>
</table>

returns than those with the widest distribution of options.

As a result of these features, option compensation has come under renewed attack as one of the failures of the U.S. corporate governance system. One strand of criticism has been that options should be expensed as a form of current compensation. A second issue that has been brought forward is whether options or outright stock grants might be a better form of compensation. It is this latter issue, stock vs. options, that this paper is concerned with.

Indeed, there is some recent evidence that the trend towards option compensation is reversing. Based on a study by Mercer Consulting, Table 2 reports a dramatic increase in the number of CEOs who received restricted stock grants between 2001 and 2002 while there was a concomitant decrease in the value of options grants.²

One major advantage of options is the ability to readjust the terms of the options issue on an ex post basis as new information is received. This is facilitated by the well-known practice of option repricing or recission and reissuance. However the very practice of repricing may create adverse incentive effects ex ante, as it may induce agents to increase the probabilities of ‘down states’. Stock, on the other hand, retains its positive incentive properties no matter how bad interim information is. Stock is often mentioned as an important retention device.

In this paper, we explore the use of stock and options compensation in a model where there are important industry and accounting implications. We find that when firms are viewed in isolation, the benefit of option repricing allows the firm to extract surplus from a professional staff whose effort is unobservable. This derives from the fact that bad information could come from either exogenous sources or from lack of innovative effort commitment from the employees. Thus, indeed in a single firm environment it would

²As reported in Lubin (March 3, 2003).
appear that options are better than using stock.

We then explore two avenues to see how robust these findings are. We consider the choice of accounting systems that may lead to biases in reporting of financial variables that determine stock prices. It has been established (Givoly and Hayn, 2000) that there are increasing trends toward accounting conservatism in recent years. Indeed the scandals highlighted recently can be viewed in this context as ‘earnings management’. For instance, one form of conservative accounting practice involves building up ‘reserves’ on the balance sheet in good times (i.e., not reporting as much income) and drawing them down in bad times so as to meet analysts expectations. We find here that as equity-based compensation tends more toward options instead of straight stock, this could promote the use of conservative accounting. This is due to the ability to extract surplus from the employees when options are repriced, which is correlated with less than favorable information. Therefore we find that accounting choices may be interrelated with compensation in a structural context.

Our second avenue looks at the use of compensation in an industry equilibrium setting. Using a standard Cournot-Nash model of product competition, we extend this to competition in the realm of labor negotiations, where compensation may help to commit one firm from being a tougher competitor against its rival. Important papers that considered the commitment effect of capital structure in product market equilibria are Brander and Lewis (1986) and Maksimovic (1988). In our paper compensation plays a different role. One important aspect of option compensation is that it can create risks in a competitive environment that stock does not have. For instance, when an adverse shock occurs to the stock price, options will be ‘underwater’ and the key personnel may be subject to being bid away by a rival firm who has favorable information and would like to eliminate competition. Stock, unlike options, has the ability to make a rival into a tougher competitor in the labor market. This results from the ability of outright stock grants to provide appropriate incentives to existing employees with lower dilution than options on the upside. Therefore the firm who uses stock can make higher bids for the rival workers. We conduct a game theoretic analysis of a compensation game and look at the conditions under which a symmetric stock compensation equilibrium exists and the conditions under which an options compensation equilibrium exists. These conditions are related both to the nature of competition in industrial structure as well as the probability of adverse shocks. In a symmetric situation, we find that as the probability of adverse shocks rises, we find a greater tendency for firms to
favor option compensation, as when firms are viewed in isolation. However, as this probability diminishes, firms will utilize stock compensation because it makes them tougher labor market competitors when the key personnel are mobile and susceptible to being bid away.

While many models of the shareholder-manager agency relationship in the firm do not really distinguish between options and stock, merely arguing in favor of equity-based compensation, a number of recent papers have begun to consider this distinction. For instance, Hall and Murphy (2000) propose a method of assessing the optimality of exercise prices and show via numerical methods that options should be issued near the money. This can be regarded, therefore as a justification for the use of options instead of stock. Their proposed metric depends on the benefits implicit in option leverage but also on the fact that risk aversion negatively impacts the personal value ascribed to options by executives. It is this tradeoff that generates the optimality of the exercise price. On the other hand, Feltham and Wu (2001) consider an explicit agency model and show that such a result is sensitive to the functional relation between effort and risk. When effort does not affect the risk of cash flow outcomes, they find that stock dominates at-the-money options. Risk aversion and inherent illiquidity also highlights the paper by Kahl, Liu and Longstaff (2003) who derive the implications for an undiversified portfolio on personal valuation and portfolio composition in a continuous time model. Cadenillas, Cvitanic and Zapatero (2002) consider the optimal choice of exercise price in a moral hazard cum delegation model in which there is a tradeoff between effort and volatility choice. In each of these papers the original contract represents a commitment by the firm throughout the relevant time horizon.

The issue of option repricing has been extensively analyzed both from theoretical as well as empirical perspectives in recent years. Acharya, John and Sundaram (2000) consider the conditions under which re-setting instead of precommitment to maintain exercise prices are optimal. Their tradeoff, which is the rent appropriated by the agent in down states with the efficiency induced by reincentivization in those states is basically the same as in our model of accounting choice. However we adopt the perspective that precommitting not to reset is not credible. In a related paper Saly (1994) develops both a theoretical model as well as an empirical test of option repricing following an exogenous negative shock (i.e., not under the control of an agent). Her model is somewhat more general than in other papers, because the optimal contract is endogenized. The predictions are borne out when confronted with the data following the 1987 stock mar-
ket crash. Tax and accounting effects on option repricings are investigated in detail in Yang and Carleton (2002). Using recent data Chidambaran and Prabha (forthcoming) examine repricings and conclude that they are not related to corporate governance concerns. They also find that repricings are concentrated in the technology and service sectors and that repricings are often asymmetric, with the executives of the firm not included in the program. Jin and Meulbroek (2002) argue that stock option repricings are unnecessary given their typically long maturity period of ten years. In this case high volatility helps to align incentives because the option value becomes more like the underlying stock.

In section 2 we propose a simple agency model under which the use of stock and options can be explored. This model is extended in section 3 to look at accounting choice. In section 4 we investigate an industry equilibrium situation with labor market competition as well as product market competition. Section 5 is the concluding section.

2 The Basic Model

In this section we develop the most simple basic version of our model in a single firm setting. The firm is in a multiperiod environment in which its professional staff must be incentivized in each period in order to create the highest possible market value. We look at the respective roles of the use of stock and option compensation in this respect. The model is based on that of Acharya et al. (2000). As in their paper, we assume that both the firm and its workers are risk-neutral.

Consider a firm which lasts for two periods with three dates, $t = 0, 1, \text{ and } 2$. At $t = 0$, owners of the firm hire a manager and professional staff who all have to exert an unobservable effort at a personal cost, $\nu$, in order to innovate a new product, technology or a production process. As we are not considering conflicts between managers and the staff, we model them together as an aggregate agent. At some future date, $t = 2$, which could be in the distant future, the ‘true’ market value of the firm will be realized. Let $c_1$ represent the cost associated with the innovation. If all goes well, the firm will be a monopolist at time $t = 2$ and its market value will be equal to $\pi_m(c_1)$.

However, at an interim date, $t = 1$, there is the possibility of an adverse shock. Examples of such shocks are unforeseen circumstances such as the failure of clinical trials in the case of biotechnology, shifts in market demand for products, or changes in governmental policy. If the adverse shock occurs the original level of
profits or market value will be impossible to achieve. In this section, we suppose that the shock is publicly observable so that the firms stock price at $t = 1$ will reflect such information. In section 3 this assumption is relaxed and the firm is able to choose selective release of information based on an optimal accounting policy.

If the staff has exerted effort at $t = 0$, it is less likely that the adverse shock will occur at $t = 1$. The probability that the shock does not occur is denoted by $p$, in which case the innovation will be successful for sure and the firm will receive $\pi_m(c_1)$ at $t = 2$. Nevertheless, despite initial effort expenditure there is a positive probability, $1 - p$ that the shock still occurs. In this case the innovation will fall through for sure and lead to a zero market value. However, the manager can exert an additional effort at a personal cost, $\mu$, at $t = 1$ in order to remedy the perverse situation. We term this a restructuring process. As a result of the restructuring, an inferior production process is improved, which can be described by a cost, $c_2$, where $c_2 > c_1$. Based on this production process, the firm can still generate a positive monopoly profit, $\pi_m(c_2)$ at $t = 2$, where $\pi_m(c_2) < \pi_m(c_1)$.

If the professional staff do not expend effort at any time, it is more likely that the shock occurs, which we simply assume to be certain. However through the expenditure of additional effort the staff can remedy the process as above by expending additional effort at the interim date. Again, for simplicity, we assume that the same market value will be received as in the restructuring process after initial effort expenditure, $\pi_m(c_2)$. This means that the firm is in the same position at the interim date when initial effort is expended but an adverse shock occurs as when there is no initial effort. This is due to the unobservability of effort and allows the staff to acquire some rent from the firm. In summary, the ex ante probability of the shock is endogenously determined and positively correlated with the level of initial effort.

Figure 1 illustrates the evolution of information from the perspective of the market value of the firm and the final distribution of terminal cash flows.

### 2.1 Compensation Contracts

We now consider two alternative compensation systems for the professional staff. Although clearly the actual set of compensation contracts in practice can be very complex and based on a wide variety of subjective and objective bonus and promotion-based criteria, here our purpose is to contrast the use of straight stock
compensation and option compensation. Since both stock and option compensation can both satisfy a vesting
criterion, the major difference that we focus on deals with the possibility of resetting the exercise price of
options at the interim date for reincentivization purposes.

First consider the use of pure stock compensation. In this case, at the initial date the firm grants the staff
a fraction, \( s_0 \), of ending firm value. If necessary, at the interim date, the firm can grant the employees an
additional share, \( s \geq s_0 \), in order to induce effort in the second period. In no case is the firm allowed to
reduce stock compensation granted at the initial date.

Thus, in this case, the firm solves the following principal-agent problem:

\[
\begin{align*}
\max_s & \quad p(1 - s_0)\pi_m(c_1) + (1 - p)(1 - s)\pi_m(c_2) \\
\text{subject to} & \quad ps_0\pi_m(c_1) + (1 - p)[s\pi_m(c_2) - \mu] - \nu \geq s\pi_m(c_2) - \mu, \\
& \quad s\pi_m(c_2) \geq \mu,
\end{align*}
\]
where (2) is the staff’s incentive compatibility constraint for the provision of effort at \( t = 0 \), (3) is the incentive compatibility constraint for effort at \( t = 1 \) and (4) ensures that the firm may not withdraw a stock grant.

In the solution to (1) either (4) is binding or not. If it holds as a strict inequality then the firm would want to start out with a lower level of stock compensation and raise it if necessary at the interim date so that (3) is binding. Otherwise, the initial stock grant provides sufficient effort incentives at the interim date.

Suppose first that (4) is binding. In this situation, (3) is not binding, but (2) will bind in which case we can substitute for \( s = s_0 \) into (2) and solve for equality. This yields the following optimal solution which we denote as \( s^* \):

\[
s^* = \frac{(\nu - p\mu)}{p[\pi_m(c_1) - \pi_m(c_2)]}.
\]  

(5)

Substituting into (3), we find a necessary condition for this constraint not to bind as:

\[
\nu\pi_m(c_2) > p\mu\pi_m(c_1).
\]  

(6)

On the other hand, if (4) is not binding then (3) will be satisfied with equality and the solution is

\[
s^*_0 = \frac{\nu}{p\pi_m(c_2)}
\]  

(7)

and

\[
s^* = \frac{\mu}{\pi_m(c_2)}
\]  

(8)

Therefore a necessary condition for the firm to start with a lower level of stock and increase just to the minimum necessary for the second period is the opposite of (6), or

\[
\nu\pi_m(c_2) < p\mu\pi_m(c_1).
\]  

(9)

Whether (6) or (9) holds depends on whether the ratio of efforts exceeds the ratio of expected profitabilities. Equation (6) will hold when the first period effort cost is large compared to the second period effort.
cost, or if the probability of the shock is small, or if there is relatively little difference between the profit in the respective states, $\pi_m(c_1) - \pi_m(c_2)$. This is the case we focus on here. Substituting (5) into (1) yields the shareholders (firm - workers) equilibrium payoff:

$$V(\text{stock}) = p\pi_m(c_1) + (1 - p)\pi_m(c_2) - \nu - (1 - p)\mu - [s^*\pi_m(c_2) - \mu]. \quad (10)$$

Notice that equation (10) shows that the shareholders value is equal to the aggregate expected market values minus the expected costs of effort expenditure less the rent given to the workers, which in this case is equal to $s^*\pi_m(c_2) - \mu$, the excess value that they capture over the second period due to the fact that the stock grant cannot be adjusted downward after the shock occurs.\(^3\) This rent is greater under the same conditions as when the second-period incentive compatibility condition is not binding, e.g., when the probability of the shock is sufficiently small.

Now we consider options-based compensation. Here the firm grants the staff $\alpha$ call options on firm value with an exercise price, $x$.\(^4\) The firm sets the exercise price, $x$, such that the call options are at the money at $t = 0$.\(^5\) Thus, we have $\pi_m(c_2) < x < \pi_m(c_1)$. It is clear that when the adverse shock occurs at $t = 1$, the call options will be underwater. If resetting of the call options is not allowed, the staff will have no incentives to devise the restructuring process at $t = 1$ since $\mu > 0$. To give them manager proper incentives, the firm grants $\beta$ new call options with an exercise price, $x'$, to the staff. The firm now has to choose the options to be ‘in the money’ in order to provide the requisite incentives at $t = 1$. Thus, we have $0 < x' < \pi_m(c_2)$.\(^6\)

The principal-agent problem faced by the firm using options is similar to that of (1), except that the ability to reset the options allows the two incentive compatibility constraints of $t = 0$ as well as $t = 1$ effort to be satisfied with equality. At $t = 0$, the firm solves the following principal-agent problem:

$$\max_{\alpha, \beta} p[\pi_m(c_1) - \alpha[\pi_m(c_1) - x]] + (1 - p)[\pi_m(c_2) - \beta[\pi_m(c_2) - x']] \quad (11)$$

\(^3\)If instead (9) holds, then the last term in (10) is zero.
\(^4\)We neglect the second-order effects from the fact that options are typically written on stock, not overall firm value.
\(^5\)Current accounting rules would call for expensing options if they were issued in the money at the initial time.
\(^6\)The necessity to reset the options in the money is due to the lack of further uncertainty at time $t = 1$. In a slightly more general model, it would be possible to achieve the same incentives by resetting them at the money.
subject to
\[ pa[\pi_m(c_1) - x] + (1 - p)\beta[\pi_m(c_2) - x'] - \mu - \nu \geq \beta[\pi_m(c_2) - x'] - \mu, \quad (12) \]
\[ \beta[\pi_m(c_2) - x'] - \mu \geq 0, \quad (13) \]

where equations (12) and (13) are the two incentive compatibility constraints. Substituting (13) with equality into (12) and then again in the firm’s problem (11) yields the equilibrium payoff to shareholders of the firm at \( t = 0 \).

\[ V(\text{option}) = p\pi_m(c_1) + (1 - p)\pi_m(c_2) - \nu - (1 - p)\mu. \quad (14) \]

By comparing equations (10) and (14) we note that the same aggregate benefit is present with options as with stock, except that whenever condition (6) holds, options allow the firm to reduce the rent to the staff due to resetting. Thus, we get the following proposition:

**Proposition 1.** The use of options-based compensation strictly dominates the use of stock based compensation whenever \( \nu\pi_m(c_2) > p\mu\pi_m(c_1) \). Otherwise, options-based compensation and stock compensation are equivalent.

**Proof.** The result is simply obtained from the same condition that generates a rent to the staff in the case of the stock compensation solution:

\[ V(\text{option}) - V(\text{stock}) = s\pi_m(c_2) - \mu \]

This result confirms the usual implications of optimal contracting theory in the context of our simple model. Since options have an additional contract parameter compared to stock, they can often provide the same incentives at cheaper cost. Absent additional considerations, there is no need to consider stock compensation. We now explore whether this is still true when optimal accounting choice and product market interaction occurs.
3 Accounting System Choice

In this section we explore the implications of accounting choice of conservatism versus liberalism as determined by the compensation method employed by firms. There is both anecdotal as well as empirical support for the notion that accounting has grown significantly more conservative since the 1990s. By conservatism is meant the decision of the firm to utilize reporting standards that casts current outcomes in the least favorable light. It is of interest, therefore to see whether this trend toward conservatism might be motivated by the increased use of option-based compensation.

In a recent empirical paper, for instance, Givoly and Hayn (2000) document a decline in average profitability (earnings). They find that this does not stem from a decline in underlying cash flows, but rather changes in the nature of accounting accruals. On average, firms have tended to accumulate negative accruals.

Some more specific evidence is provided by the behaviors of Microsoft and America Online. When Microsoft sells software such as its Office Suite of products it ‘holds back’ a significant percentage of its sales revenue as a reserve to use for later expenditures on updates and maintenance. On the other hand, America Online (AOL) would treat its subscriber acquisition cost as an asset instead of recording it as an expense. Thus we would define Microsoft as following a conservative accounting practice while AOL follows liberal accounting practices.

In implementing this idea in the context of our model, we now relax the assumption that the adverse shock is publicly observable. The firm makes a choice of accounting system (conservative or liberal) in the way that it discloses information to the market at the interim date (t = 1) concerning whether the adverse shock has occurred or not. We utilize the approach of Kwon, Newman and Suh (2001) in modeling accounting choice.

Specifically, let $\zeta = \{H, L\}$ denote the occurrence of the shock, where $H$ and $L$ refer to the absence and presence of the shock, respectively. Instead of observing $\zeta$ directly, the firm observes a signal, $y = \zeta + \epsilon$, where $\epsilon$ is uniformly distributed over $[−d, d]$ with $d > (H − L)/2$. This signal represents the “disaggregated” detailed information on which financial reports are based. As such, we assume that $y$ cannot be used for contracting purposes.

To investigate incentives for conservative reporting, we introduce an accounting system that is designed
Figure 2: Distribution of $y$

by the firm. We assume that at $t = 1$ the accounting system produces a report, $z \in \{H, L\}$, such that $z = L$ when $y \leq w$ and $z = H$ when $y > w$. That is, we assume that the accounting system’s message dimensionality is identical to the outcome dimensionality. Thus, the system we consider reduces the dimensionality of the underlying information within the firm. The parameter, $w$, is the threshold level to be chosen by the firm.

Figure 2 illustrates the situation. Suppose for instance that $w = L + d$. This indicates that whenever the actual outcome is $L$, the report will also be $L$. On the other hand it will only be the case that the report $z = H$ will be generated when $y \in [L + d, H + d]$, i.e., when $y$ is above the support associated with $L$. For $y \in (H - d, L + d)$ the report $z = L$ will be generated despite the favorable signal. This is an example of a conservative accounting system.

We assume the following conditional probabilities for the accounting report given the outcome:

$q_H = \text{Prob}(z = H|\zeta = H) = \text{Prob}(y > w|\zeta = H),

q_L = \text{Prob}(z = L|\zeta = L) = \text{Prob}(y \leq w|\zeta = L).

The probability, $q_H$, indicates the likelihood of reporting a favorable outcome when a favorable outcome occurs, while $q_L$ represents the likelihood of reporting an unfavorable outcome when an unfavorable outcome occurs. That is, $q_H$ or $q_L$ represents the probability of a “correct” report. Note that the choice of $w$ determines both $q_H$ and $q_L$. Since the only choice variable of the accounting system is $w$, $q_H$ and $q_L$ are not independent of one another.

The accounting system is conservative if $q_H < q_L$, neutral if $q_H = q_L$, and liberal if $q_H > q_L$. It is always the case that a favorable report is more likely if the underlying signal is favorable and an unfavorable report is more likely if the underlying signal is unfavorable. Therefore a rational stock price at the interim date will be perfectly correlated with the accounting report. That is, the stock price is higher when $z = H$. 

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and is lower when \( z = L \).

3.1 Compensation

The purpose of this section is to examine accounting choice, rather than the optimal choice of compensation contract.\(^7\) We begin by considering the case of stock compensation and for the sake of brevity, we focus on the situation where the initial stock grant is sufficient to provide incentives for subsequent effort, without upward revisions.

Suppose that the firm grants the workers a fraction, \( s \), of firm value. We assume that \( \mu \) is sufficiently small so that the manager still has incentives to exert effort when the adverse shock is believed to have occurred at \( t = 1 \), i.e., \( \mu < s \pi_m(c_2) \).

Similar to the analysis of the previous section, the firm solves the following principal-agent problem:

\[
\max_{s,w} pq_H(1-s)\pi_m(c_1) + p(1-q_H)(1-s)\pi_m(c_1) + (1-p)q_L(1-s)\pi_m(c_2)
\]

subject to

\[
pq_H s\pi_m(c_1) + p(1-q_H)[s\pi_m(c_1) - \mu] + (1-p)q_L[s\pi_m(c_2) - \mu] - \nu \geq q_L[s\pi_m(c_2) - \mu],
\]

where (16) is the manager’s incentive compatibility constraint. Setting this as an equality and substituting into the objective function yields the shareholders payoff as a function of the optimal shareholding, \( s^* \) given \((q_H, q_L)\):

\[
V(\text{stock}) = p\pi_m(c_1) - p(1-q_H)\mu + q_L[(1-p-s^*)\pi_m(c_2) + p\mu] - \nu.
\]

Observe that (10) is a special case of (17) with \( q_H = q_L = 1 \). However this is infeasible now given the overlapping support of the signals. As before there is a term involving the rent given to the staff. But in addition, there are terms involving the efficiency of technology choices. That is, there are situations where the relative degree of informativeness may lead to the wrong choice of restructuring decisions. Nevertheless there can be a tradeoff with the rent allocated to the workers. By examining these we arrive at the following proposition.

\(^7\)In the subsequent section we show that either form of compensation may arise in product market competition.
Proposition 2. Suppose that the optimal share given to the professional staff is sufficiently low, \(s^* < 1 - p\). Then the optimal accounting system is conservative: \(q_L = 1\) and \(q_H = (H - L)/2d < 1\).

Suppose that the optimal share satisfies \(s^* > 1 - p\). Then there are two cases. First, when \(0 < (1 - p - s^*)\pi_m(c_2) + p\mu < p\mu\), the accounting system is liberal: \(q_H = 1\) and \(q_L = (H - L)/2d < 1\). Second, when \((1 - p - s^*)\pi_m(c_2) + p\mu < 0 < p\mu\), the accounting system is extremely liberal in that \(q_H = 1\) and \(q_L = 0\).

Proof. Given the optimal share, \(s^*\), the objective function (17) is linear in \(q_H\) and \(q_L\). If \(s^* < 1 - p\) then the coefficients on both \(q_L\) and \(q_H\) are positive. However the weight on \(q_L\) is larger than that on \(q_H\) so \(q_L\) is maximized while \(q_H\) is chosen to be as large as possible. This leads to the first result. The other cases can be proven similarly. \(\square\)

In summary, we have seen that when the optimal share is low, the accounting system is conservative. This occurs because the rent given in the low state is less significant so the firm is less concerned about mistakenly giving this up than it is about allowing the restructuring to go forward. On the other hand, when the rent allocated to the agent is larger, then it may be better (in extreme circumstances) to avoid this state completely even if it means that restructuring never is implemented.

Next we consider the use of options. Suppose that the firm grants the manager \(\alpha\) call options on firm value with an exercise price, \(x\). The firm sets the exercise price, \(x\), such that the call options are at the money at \(t = 0\). Thus, we have \(\pi_m(c_2) < x < \pi_m(c_1)\). To give the manager proper incentives when the adverse shock is believed to have happened at \(t = 1\), the firm grants \(\beta\) new call options with an exercise price, \(x'\), to the manager. The firm sets the exercise price such that the call options are in the money at \(t = 1\). Thus, we have \(0 < x' < \pi_m(c_2)\). At \(t = 0\), the relevant principal-agent problem is:

\[
\max_{\alpha, \beta, w} pq_H[\pi_m(c_1) - \alpha[\pi_m(c_1) - x]] + p(1 - q_H)[\pi_m(c_1) - \beta[\pi_m(c_1) - x']] + (1 - p)q_L[\pi_m(c_2) - \beta[\pi_m(c_2) - x']] \tag{18}
\]

subject to

\[
pq_H\alpha[\pi_m(c_1) - x] + p(1 - q_H)[\beta[\pi_m(c_1) - x'] - \mu] + (1 - p)q_L[\beta[\pi_m(c_2) - x'] - \mu] - v \geq q_L[\beta[\pi_m(c_2) - x'] - \mu], \tag{19}
\]
\[ \beta[\pi_m(c_2) - x'] - \mu \geq 0, \]  

where the inequalities, (19) and (20) are the incentive compatibility constraints.

Solving as before yields the shareholders payoff given \((q_H, q_L)\):

\[ V(\text{option}) = p\pi_m(c_1) - p(1 - q_H)\mu + (1 - p)q_L[\pi_m(c_2) - \mu] - v. \]

We can now derive the relation between the potential profits and the cost of restructuring efforts in the form of the next proposition.

**Proposition 3.** For the situation where options compensation is used, suppose that the expected loss from not restructuring when otherwise optimal is sufficiently large, i.e., \((1 - p)\pi_m(c_2) > \mu\). Then the accounting system is conservative in that \(q_L = 1\) and \(q_H = (H - L)/2d < 1\). On the other hand, suppose that the loss from not restructuring is small, i.e., \((1 - p)\pi_m(c_2) < \mu\). Then the optimal accounting system is liberal and \(q_H = 1\) and \(q_L = (H - L)/2d < 1\).

**Proof.** The nature of proof is the same as in proposition 2. □

By comparing the results of propositions 2 and 3 we learn under what conditions conservatism obtains. Notice that if the firm chooses the conservative accounting system under pure stock compensation, it will choose the same accounting system under stock option compensation. This is because conservatism with stock occurs only if \(s^* < 1 - p\), in which case \(\mu < s^*\pi_m(c_2) < (1 - p)\pi_m(c_2)\) so that the first case of proposition 3 pertains. The converse is however not true. When the amount of stock compensation is sufficiently large to motivate ex ante effort, stock compensation promotes liberalism in the accounting system to avoid excess extraction of rent by the staff. Options, on the other hand, can be tailored to the downward revision of information and this makes conservatism more likely when options are utilized. However, even in this case there are significant circumstances where liberal accounting would be employed.

Liberal accounting procedures in the case of stock options leads to instances where the exercise price is not reset, even though it would be optimal under full information. It is important to recognize that this does not take place because commitment might be optimal as in Acharya et al. (2000), but rather because it would imply that restructuring is undertaken incorrectly too frequently.
4 Competition Among Firms

In this section, we extend our model to a Cournot industry with two competing firms (indexed by $i = 1$ and 2). We consider first the case where the adverse shock is firm-specific, i.e., the shocks are independent of each other. Let $\pi_d(c_i, c_j)$ be the duopoly profit of firm $i$ given that firm $i$ and firm $j$ have production processes described by the technological costs, $c_i$ and $c_j$, respectively. From the properties of Cournot-Nash competition it is easily shown that it is better to be the low cost competitor in a duopoly compared to an identical cost duopoly, i.e., $\pi_d(c_1, c_2) > \pi_d(c_1, c_1) > \pi_d(c_2, c_2)$. Moreover it is better to better to be a monopolist than to own both firms in a duopoly with different costs. That is, $\pi_m(c_1) > \pi_d(c_1, c_2) + \pi_d(c_2, c_1)$.

The key additional ingredient in the competitive situation is that the professional staff of both firms are assumed to be mobile, that is once there is information at the interim date, they will work for the highest bidder. While it is certainly true that some firms are able to get their chief executives to sign ‘non-compete’ clauses at the initial signing date, it is far less clear that such contractual restrictions are enforceable at lower levels, either for management or professional staff such as engineers. Therefore we assume that workers are not bound to the initial firm that they sign up with. We adopt the simplified structure in our model that when a successful offer is made for the workers of another firm, the latter firm goes out of existence and the former firm is able to capture monopoly power in the product market.

For simplicity, we go back to the setting in which the shocks are publicly observable so that accounting systems reveal this information perfectly. We now consider the three respective choices of compensation in a game theoretic situation (stock-stock, option-stock and option-option). Firms choose their compensation simultaneously at the initial time.

4.1 Stock Compensation

Suppose that both firms choose pure stock compensation. Now suppose at the interim date that one firm has the adverse shock but not the other. If firm $j$ realizes the shock but not firm $i$, which occurs with probability $p(1 - p)$, the maximum amount that firm $j$ can pay to keep its staff is the whole of its future profit: $\pi_d(c_2, c_1)$. Thus, firm $i$ finds it optimal to bid away the workers from firm $j$ and becomes a monopoly if (after sharing
its profit with current and new employees) it is better in the monopoly than in the duopoly:

\[(1 - s)\pi_m(c_1) - \pi_d(c_2, c_1) > (1 - s)\pi_d(c_1, c_2),\]

or, equivalently,

\[s < \frac{\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)}{\pi_m(c_1) - \pi_d(c_1, c_2)},\]  \hspace{1cm} (22)

which we assume to be the case. The critical value on the right hand side of (22) is related to the total gain in monopoly profit when one firm obtains monopoly power. If this is larger than the fraction of shares required to induce initial effort, then (22) is satisfied.

When both firms realize or do not realize the adverse shock, which occurs with probabilities \(p^2\) and \((1 - p)^2\), respectively, we assume that neither firm has incentives to hire the rival’s employees. Thus, firm \(i\) solves the following principal-agent problem at \(t = 0\):

\[
\max_s p^2(1 - s)\pi_d(c_1, c_1) + (1 - p)p[(1 - s)\pi_m(c_1) - \pi_d(c_2, c_1)] + (1 - p)^2(1 - s)\pi_d(c_2, c_2) \hspace{1cm} (23)
\]

subject to

\[
p^2s\pi_d(c_1, c_1) + p(1 - p)\pi_d(c_2, c_1) + (1 - p)p s\pi_m(c_1) + (1 - p)^2[s\pi_d(c_2, c_2) - \mu] - \nu \\
\geq p\pi_d(c_2, c_1) + (1 - p)[s\pi_d(c_2, c_2) - \mu], \hspace{1cm} (24)
\]

where (24) is the incentive compatibility constraint for committing initial period effort. Firm \(i\)'s profit in equation (23) represents the positive profit in the three states (out of four) in which it remains in business. The right hand side of equation (24) is the rent, or the compensation gained by firm \(i\)'s employees if the shock occurs. Conditional on the shock for firm \(i\), the probability that firm \(j\) does not get the shock is equal to \(p\) and the workers move in this case receiving total compensation equal to \(\pi_d(c_2, c_1)\). With probability \(1 - p\), the workers remain with firm \(i\) and receive only the net compensation they would have received through
their original stock compensation. Firm $i$’s payoff is then:

$$V(\text{stock}|\text{stock}) = p^2\pi_d(c_1, c_1) + (1 - p)p[\pi_m(c_1) - \pi_d(c_2, c_1)] + p(1 - p)\pi_d(c_2, c_1) + (1 - p)^2\pi_d(c_2, c_2) - \nu - (1 - p)^2\mu - p\pi_d(c_2, c_1) - (1 - p)[s^*\pi_d(c_2, c_2) - \mu],$$

(25)

where

$$s^* = \frac{p^2\pi_d(c_2, c_1) + \nu - p(1 - p)\mu}{p^2\pi_d(c_1, c_1) + (1 - p)p\pi_m(c_1) - p(1 - p)\pi_d(c_2, c_2)}. \quad (26)$$

There are two differences in the competitive environment that differ from the firm payoff in the single firm case. Both pertain to the implications of winding up in the down state when the competitor has favorable news. Firstly the firm loses its workers and so it has zero profit in this situation. Secondly the workers are bid away by the competitive firm and paid the potential duopoly profit they could have received by their original employer. This potential profit leads to increased rent that the firm has to bear ex ante. Therefore both effects wind up hurting the firm.

Equation (26) reflects the share that must be allocated to the initial staff to provide maximum incentives so that the firm either winds up in a duopoly with an equally strong competitor, or as a monopolist.

4.2 Asymmetric Strategies

Suppose now that firm $i$ switches to stock option compensation but firm $j$ remains using pure stock compensation. If firm $j$ realizes the shock but not firm $i$, the maximum amount that firm $j$ can pay to keep its employees is $\pi_d(c_2, c_1)$. If firm $i$ were to recruit the workers of firm $j$, the net payoff to the firm would therefore be equal to $\pi_m(c_1) - \alpha[\pi_m(c_1) - x] - \pi_d(c_2, c_1)$ after subtracting the option-based compensation of the existing employees. Thus, firm $i$ does not find it optimal to bid away the employees of firm $j$ and to become a monopoly if

$$\pi_m(c_1) - \alpha[\pi_m(c_1) - x] - \pi_d(c_2, c_1) < \pi_d(c_1, c_2) - \alpha[\pi_d(c_1, c_2) - x],$$

or, equivalently,

$$\alpha > \frac{\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)}{\pi_m(c_1) - \pi_d(c_1, c_2)}. \quad (27)$$
which we assume to be the case.

Notice the difference between the conditions (22) and (27). We are assuming that the number of shares required for provision of incentives is less than the critical amount on the right hand side of (22), while the number of shares obtained by exercising options is above this same amount. This is motivated by the fact that setting the initial option exercise price at the money requires a substantially larger share allocation for incentive purposes. It therefore conforms to the data mentioned in the introduction on the higher proportion of ownership concentration in employees with stock option plans. In other words, we are assuming that the potential dilution due to option compensation is significantly larger than that of stock compensation.

Thus, firm $i$ solves the following principal-agent problem:

$$
\max_{\alpha, \beta} \ p^2[\pi_d(c_1, c_1) - \alpha[\pi_d(c_1, c_1) - x]] + (1 - p)p[\pi_d(c_1, c_2) - \alpha[\pi_d(c_1, c_2) - x]]
$$

$$
+ (1 - p)^2[\pi_d(c_2, c_2) - \beta[\pi_d(c_2, c_2) - x']]
$$

subject to

$$
p^2\alpha[\pi_d(c_1, c_1) - x] + p(1 - p)\pi_d(c_2, c_1) + (1 - p)p\alpha[\pi_d(c_1, c_2) - x]
$$

$$
+ (1 - p)^2[\beta[\pi_d(c_2, c_2) - x'] - \mu] - \nu \geq p\pi_d(c_2, c_1) + (1 - p)[\beta[\pi_d(c_2, c_2) - x'] - \mu],
$$

$$
\beta[\pi_d(c_2, c_2) - x'] - \mu \geq 0.
$$

As in the previous case, because firm $j$ uses stock, firm $i$ loses its staff when it has the adverse shock and firm $j$ does not. Thus its profit is zero for this state in equation (28). The critical term in the incentive compatibility condition of (29) is $p\pi_d(c_2, c_1)$, which is the compensation gained by the workers in this state when they leave firm $i$. This generates a rent that they get even though firm $i$ uses options and is the major difference between product market competition and the single firm situation. Solving for the shareholders of firm $i$’s payoff yields:

$$
V(\text{option}|\text{stock}) = p^2\pi_d(c_1, c_1) + p(1 - p)\pi_d(c_2, c_1) + (1 - p)p\pi_d(c_1, c_2)
$$

$$
+ (1 - p)^2\pi_d(c_2, c_2) - \nu - (1 - p)^2\mu - p\pi_d(c_2, c_1).
$$

It is instructive to contrast the firm’s payoff here in equation (31) with that of (25). In the symmetric
stock case, firm $i$ is able to attract the rival workers and become a monopolist when it does not realize the shock but its rival does. But the expected compensation, $(1 - p)p\pi_d(c_2, c_1)$, paid to the rival workers must be subtracted out of the organizational surplus in this case, and it coincides exactly with the surplus obtained in the opposite state where firm $i$ loses its workers to firm $j$. In the asymmetric case firm $i$ never becomes a monopolist and the organizational surplus always consists of the duopoly profits. Notice that in both relations – in contrast with the single firm case – the workers do get non-zero rents. The term $p\pi_d(c_2, c_1)$ which occurs in both equations represents the increase in compensation when the workers shirk but the rival firm gets good news and they threaten to leave unless they receive all the profit. This is due to the necessity of increasing their compensation to prevent them from being bid away by the rival firm when the rival’s interim news is good.

We can now take the results of (25) along with (31) together to solve for a sufficient condition for a pure strategy Nash equilibrium where both firms in a Cournot duopoly utilize stock compensation.

**Proposition 4.** Both firms in Cournot competition will choose a pure strategy equilibrium involving the use of stock if $V(\text{stock}|\text{stock}) > V(\text{option}|\text{stock})$ or, equivalently, if

$$\theta \equiv p[\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)] > s^*\pi_d(c_2, c_2) - \mu,$$

where $s^*$ is defined by equation (26).

Therefore we have found the possibility that pure stock compensation can survive if the rival firm uses stock compensation. In similarity with the single firm case stock compensation yields rents to the workers that cannot be adjusted. However, there is a benefit from pure stock compensation that is not present in the single firm case. This is due to the possibility that the required shares allocated to the workers is lower than what is required under option compensation. Hence the firm has a higher residual value with which to compete for the workers of a rival firm when that firm has interim negative news (the adverse shock). If this possibility of monopoly is significantly better than either duopoly possibility then the firm will stay with stock compensation when its rival employs the same.
4.3 Option Compensation

In the final case, we suppose that both firms choose stock option compensation. Firm $i$ solves the following principal-agent problem at $t = 0$:

$$
\max_{\alpha, \beta} \ p^2(\pi_d(c_1, c_1) - \alpha[\pi_d(c_1, c_1) - x]) + p(1 - p)[\pi_d(c_2, c_1) - (1 - \alpha j)[\pi_m(c_1) - \pi_d(c_1, c_2)])
$$

$$
+ (1 - p)p[\pi_d(c_1, c_2) - \alpha[\pi_d(c_1, c_2) - x]) + (1 - p)^2[\pi_d(c_2, c_2) - \beta[\pi_d(c_2, c_2) - x']] 
$$

subject to

$$
p^2\alpha[\pi_d(c_1, c_1) - x] + p(1 - p)((1 - \alpha j)[\pi_m(c_1) - \pi_d(c_1, c_2)] - \mu)
$$

$$
+ (1 - p)p\alpha[\pi_d(c_1, c_2) - x] + (1 - p)^2[\beta[\pi_d(c_2, c_2) - x'] - \mu] - \nu
$$

$$
\geq p((1 - \alpha j)[\pi_m(c_1) - \pi_d(c_1, c_2)] - \mu) + (1 - p)[\beta[\pi_d(c_2, c_2) - x'] - \mu] - \mu,
$$

$$
\beta[\pi_d(c_2, c_1) - x'] - \mu \geq 0.
$$

Notice that in equation (33) the term $(1 - \alpha j)[\pi_m(c_1) - \pi_d(c_1, c_2)]$ represents firm $j$’s willingness to pay to attract the employees of firm $i$ since it is the difference between the potential monopoly and duopoly multiplied by the amount retained by the shareholders of the firm. In this case firm $i$ must increase the compensation to its own workers by this amount to retain them.

Solving yields firm $i$’s payoff:

$$
V(\text{option|option}) = p^2\pi_d(c_1, c_1) + p(1 - p)\pi_d(c_2, c_1) + (1 - p)p\pi_d(c_1, c_2) + (1 - p)^2\pi_d(c_2, c_2)
$$

$$
- \nu - (1 - p)\mu - p((1 - \alpha j)[\pi_m(c_1) - \pi_d(c_1, c_2)] - \mu).
$$

The firm payoff in this case has a similar interpretation to that of equation (31). The firm never goes out of business by losing its workers to the rival. However there is a rent that must be paid to the workers to prevent them from being bid away.

Suppose now that firm $i$ switches to pure stock compensation but firm $j$ remains using stock option compensation. Firm $i$ solves the following principal-agent problem:
\[
\text{max}_s \ p^2(1 - s)\pi_d(c_1, c_1) + p(1 - p)[\pi_d(c_2, c_1) - (1 - \alpha_j)[\pi_m(c_1) - \pi_d(c_1, c_2)] \\
+ (1 - p)p[(1 - s)\pi_m(c_1) - \pi_d(c_2, c_1)] + (1 - p)^2(1 - s)\pi_d(c_2, c_2)
\] (37)

subject to

\[
p^2s\pi_d(c_1, c_1) + p(1 - p)((1 - \alpha_j)[\pi_m(c_1) - \pi_d(c_1, c_2)] - \mu) + (1 - p)ps\pi_m(c_1) \\
+ (1 - p)^2[s\pi_d(c_2, c_2) - \mu] - \nu \\
\geq p((1 - \alpha_j)[\pi_m(c_1) - \pi_d(c_1, c_2)] - \mu) + (1 - p)[s\pi_d(c_2, c_2) - \mu].
\] (38)

The payoff to the shareholders of \(i\) is then:

\[
V(\text{stock}|\text{option}) = p^2\pi_d(c_1, c_1) + p(1 - p)\pi_d(c_2, c_1) + (1 - p)p[\pi_m(c_1) - \pi_d(c_2, c_1)] + (1 - p)^2\pi_d(c_2, c_2) \\
- \nu - (1 - p)\mu - p((1 - \alpha_j)[\pi_m(c_1) - \pi_d(c_1, c_2)] - \mu) - (1 - p)[s^{**}\pi_d(c_2, c_2) - \mu],
\] (39)

where

\[
s^{**} = \frac{p^2((1 - \alpha_j)[\pi_m(c_1) - \pi_d(c_1, c_2)] - \mu) + \nu - p(1 - p)\mu}{p^2\pi_d(c_1, c_1) + (1 - p)p\pi_m(c_1) - p(1 - p)\pi_d(c_2, c_2)}.\] (40)

Equation (39) corresponds with (25). Now the firm in question has the possibility of gaining a monopoly; however it suffers rent to its own workers in the down state. Equation (40) represents the share necessary to provide ex ante incentives to the workers when the rival chooses option compensation.

As before, comparing equations (36) and (39) yields the necessary conditions for a pure strategy equilibrium in which both rival firms compete by offering options to their professional staffs.

**Proposition 5.** The use of option compensation by both firms in a Cournot duopoly setting is a Nash equilibrium if \(V(\text{option}|\text{option}) > V(\text{stock}|\text{option})\) or, equivalently, if

\[
s^{**}\pi_d(c_2, c_2) - \mu > p[\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)] = \theta,
\] (41)
where \( s^{**} \) is given by equation (40), and the equilibrium quantity of options by \( \alpha_j = \alpha^o \) defined by

\[
\alpha^o = \frac{p^2\pi_m(c_1) - p^2\pi_d(c_1, c_2) + \nu - p^2\mu}{p^2\pi_m(c_1) + p^2\pi_d(c_1, c_1) + p(1 - 2p)\pi_d(c_1, c_2) - px}.
\] (42)

**Proof.** The equilibrium condition for \( \alpha^o \) is obtained by setting both incentive compatibility conditions, (34) and (35), as equalities and solving for \( \alpha \) with \( \alpha = \alpha_j \).

Generally speaking which of the two symmetric pure strategy equilibria occurs depends on the magnitude of the term \( \theta = p[\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)] \). This is greater the greater is the likelihood that initial effort does not result in an adverse shock. It is also larger in product market situations where the payoff to monopoly is substantially larger than the sum of both duopoly situations. We know that where there are technological ‘races’ the payoff to establishing either explicit monopolies (via patents) or implicitly by locking up the most valuable and innovative professional staffs is very large. This by itself would tend to indicate a greater likelihood of realizing the stock-based compensation equilibrium. However along with such technology-driven monopolies also often arises a greater need for frequent revisions of plans and adjustments. This indicates that \( p \) may be lower. This has a countervailing effect. Now one would tend to see situations where firms optimally respond by incentivizing workers with options.

There is also the possibility of an asymmetric pure strategy equilibrium in which one firm uses stock compensation and its rival uses stock option compensation. This occurs when both the conditions in propositions 4 and 5 are violated. Proposition 6 characterizes this form of equilibrium.

**PROPOSITION 6.** The use of option compensation by one firm and stock by its rival in a Cournot duopoly setting is a Nash equilibrium if neither (32) nor (41) holds. In this case the firm that uses stock grants \( s^{**} \) shares satisfying (40), with the equilibrium quantity of options given by \( \alpha_j = \alpha^a \) defined by

\[
\alpha^a = \frac{p^2\pi_d(c_2, c_1) + \nu}{p^2\pi_d(c_1, c_1) + p(1 - p)\pi_d(c_1, c_2) - px}.
\] (43)

**Proof.** The equilibrium condition for \( \alpha^a \) is obtained by setting both incentive compatibility conditions, (29) and (30), as equalities and solving for \( \alpha \) with \( \alpha = \alpha_j \).
4.4 Uniqueness

Propositions 4 and 5 provide the conditions under which either type of symmetric Nash equilibrium can occur. As is clear from examining conditions (32) and (41) the key determinant will be how \( s^{**} \), the optimal stock incentives when a rival uses options, is related to \( s^* \), the optimal stock compensation response when a rival uses stock. We show below in proposition 7 that \( s^{**} < s^* \), which then implies that the Nash equilibrium form is always unique. The reason that \( s^{**} < s^* \) is due to the payoff received by the workers in the downward state where their initial employer receives the shock. When the rival uses options, it has to give its own existing workers such a large share of the potential monopoly profits that it cannot afford to recruit additional staff. Hence the employees do not benefit as much from shirking as when the rival firm uses stock. Now the rival firm can afford to, and will pay the duopoly profit to attract them and this makes shirking more profitable. As a result their initial employer has to pay a higher level of stock compensation to motivate the initial effort. We prove this formally in the following proposition.

**Proposition 7.** The equilibrium in the industrial competition game is unique and is determined by the following respective conditions.

(a) If condition (32) holds, (stock,stock) is the unique Nash equilibrium.

(b) If condition (41) holds, (option,option) is the unique Nash equilibrium.

(c) If neither (32) nor (41) holds, the equilibrium is asymmetric and one firm chooses option compensation while the other firm chooses stock compensation.

**Proof.** Let \( \alpha^* \) be the equilibrium number of call options granted if one firm chooses option compensation in the equilibrium. From the requirement that workers are not bid away when the firm uses options, (27), we have

\[
\alpha^* > \frac{\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)}{\pi_m(c_1) - \pi_d(c_1, c_2)}.
\]

It follows from the above inequality that

\[
1 - \alpha^* < \frac{\pi_d(c_2, c_1)}{\pi_m(c_1) - \pi_d(c_1, c_2)}.
\]
Substituting this inequality into equation (40) yields

\[ s^{**} < \frac{p^2[\pi_d(c_2, c_1) - \mu] + \nu - p(1 - p)\mu}{p^2\pi_d(c_1, c_1) + (1 - p)p\pi_m(c_1) - p(1 - p)\pi_d(c_2, c_2)} < s^*, \]

where the second inequality follows from equation (26) and \( \mu > 0 \). Hence, if condition (32) holds, condition (41) cannot hold. However, if condition (32) does not hold, condition (41) may or may not hold. □

4.5 Example

To gain some further insight into which of these equilibria obtains we now illustrate our results with a simple numerical example. Let the aggregate demand function be linear: \( P = 1 - Q \), where \( Q \) is the industry output. Set \( c_1 = 0.1, c_2 = 0.2 \) and \( \nu = \mu = 0.01 \). Then, the Cournot duopoly profits are \( \pi_m(c_1) = 0.2025, \pi_d(c_1, c_1) = 0.09, \pi_d(c_1, c_2) = 0.1111, \pi_d(c_2, c_1) = 0.0544, \) and \( \pi_d(c_2, c_2) = 0.0711 \). From these, parameters, we find that the threshold condition for providing disparate incentives to bid away rival workers is as follows:

\[ \frac{\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)}{\pi_m(c_1) - \pi_d(c_1, c_2)} = 0.4048. \]

Thus, to support the basic assumption we require that \( s^* < 0.4048 < \alpha \).

Case 1: \( p = 0.5 \)

In this case, \( s^* = 0.3812 \). Note that \( s^*\pi_d(c_2, c_2) = 0.0271 > \mu = 0.01 \). Also,

\[ \theta = p[\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)] = 0.0185 > s^*\pi_d(c_2, c_2) - \mu = 0.0171. \]

Thus, (stock, stock) is the unique Nash equilibrium in this case.

Case 2: \( p = 0.4 \)

In this case, \( s^* = 0.3549 \), so that

\[ p[\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)] = 0.0148 < s^*\pi_d(c_2, c_2) - \mu = 0.0152. \]
Therefore at least one firm uses option compensation. To verify that the equilibrium is asymmetric, (option,stock) or (stock,option), occurs, we set the exercise price of the options at the money, \( x = V(\text{option}|\text{stock}) = 0.044 \). Then \( \alpha^a = 0.797 \), and \( s^{**} = 0.256 \). Hence

\[
s^{**} \pi_d(c_2, c_2) - \mu = 0.0082 < \theta = p[\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)] = 0.0148,
\]

which proves that the equilibrium is asymmetric according to proposition 7.

**Case 3: \( p = 0.25 \)**

In this case, \( s^* = 0.3808 \), so that

\[
p[\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)] = 0.00925 < s^* \pi_d(c_2, c_2) - \mu = 0.017.
\]

Therefore again one firm uses option compensation. To verify that the equilibrium is symmetric, (option,option), we set the exercise price of the options at the money, \( x = V(\text{option}|\text{option}) = 0.058 \). Then \( \alpha^o = 0.853 \), and \( s^{**} = 0.275 \). Hence

\[
s^{**} \pi_d(c_2, c_2) - \mu = 0.0096 > \theta = p[\pi_m(c_1) - \pi_d(c_1, c_2) - \pi_d(c_2, c_1)] = 0.00925,
\]

which proves that the equilibrium is indeed symmetric according to proposition 7.

Based on this numerical example, it appears that the probability of receiving the downward shock is of critical importance to which equilibrium obtains. If this probability is smaller (\( p \) large), then it is more likely that firms will want to capitalize on the monopoly possibilities and precommit to a tougher role by using stock compensation ex ante. When this probability increases then one firm stands ready to recruit the rivals workers while the other firm acquiesces in order to prevent excess rent extraction. Finally when the shock becomes very likely, both firms utilize option compensation.

### 4.6 Correlated Shocks

We conclude this section on product market competition by examining the sensitivity of our results to correlated information between the firm and its rival. In this more general case, the structure of the sufficient
conditions for existence of the pure strategy equilibria is preserved, although with a change in the interpretation of the probability, \( p \). Recall the key state in the model occurs when the firm is in a strong position having received no adverse news, while the rival firm has the shock. The threshold value, \( \theta \), that governs the nature of the equilibrium contained in (32) as well as (41) can be written as

\[
\theta = \text{Prob}(i \text{ no shock}| j \text{ shock})[\pi_m(c_1) - \pi_d(c_2, c_1) - \pi_d(c_1, c_2)].
\]

For the independent case this conditional probability is equal to \( p \).

Now, as the possible shocks to both firms become positively correlated, this means that this conditional probability is reduced and therefore \( \theta \) decreases. From the results of propositions 4 and 5 this makes it more likely that the option-based equilibrium will obtain. Intuitively, it less likely that news is asymmetric between the firms and so it makes it less necessary to adopt a tougher stance in order to profit from the demise of a rival firm. From this, we can conclude that if the economic environment is one where all firms are subject to similar shocks, we would expect a greater prevalence of options compensation.

On the other hand, if shocks are negatively correlated, then the conditional probability embodied in \( \theta \) increases, eventually to unity under perfect negative correlation. Now \( \theta \) also increases and it becomes more beneficial to profit from the difficulties of a rival firm. As a result stock compensation would tend to predominate. Therefore we can conclude that the macroeconomic climate and the degree of competitiveness play a significant role in determining the nature of stock-based compensation programs.

5 Conclusions

This paper has highlighted some important differences between straight stock compensation and option compensation in an agency model with multiple periods and information revelation over time. As compared with extant views, we do not find universal domination of options over stock. Stock has certain commitment properties that options do not have. We have related the respective uses to accounting conservatism as well as to the nature of industrial competition both from the product market as well as the labor market perspective.

It is often mentioned that the major benefit of options is that they have the same incentive properties as
stock, at lower cost, i.e., the firm can ‘afford’ to give up a greater share of potential dilution because it is receiving the exercise price as compensation. This potential benefit, however, has a serious limitation when product market competition is considered. The provision of options to existing employees means that they will also share in the appreciation of value if rival firms workers are bid away. This lessens the ‘toughness’ with which a given firm can compete in the product markets. As a result ex ante shareholder value may be lower than when stock is utilized. We do find evidence, however that when the benefits to market power are enormous, e.g., where substantial patent protection exists, then the flexibility of options is still better than the commitment afforded by the use of stock. The basic driving force for this result occurs when options are set at the money. It is clear that this result is preserved as long as options are set near the money.

This paper points out the importance that product market competition has when the supply of productive staff is limited. This is especially true for high technology industries. We have argued that when the need for frequent revisions is great and that when these revisions tend to occur contemporaneously across firms in the same industry, then firms respond by using options. However as this frequency becomes less because the industry is more stable, or if good news to one firm makes it more likely that bad news has occurred for its rival, then firms might optimally respond by changing their method of compensation to stock. This could have been one reason why option compensation became so prevalent during the initial phase of the commercial development of the internet. However as this industry has reached a more mature phase, we would expect more usage of pure stock compensation.

Because options have become such a widespread form of compensation even to employees far away from the executive suite, it is important to have an understanding of the implications these have for firm behavior as it relates to its financial statements as well as against its competitors. In this respect we have shown that financial reporting policy may be related to compensation choice. The tendency to manage earnings in a conservative way, which has strong empirical support, can therefore be rationalized as a response to limit the extent of unnecessary restructuring.

It is clear from these investigations that the extent to which firms disclose positive or negative information and the degree to which they can profit in competition with their rivals is determined by and therefore impacts their choice of incentive-based compensation. The optimal responses in this more interesting setting are not as obvious as when a firm views itself in isolation from others. As firms begin to recognize
there potential opportunities as well as vulnerabilities, one would predict that there will be greater degrees of heterogeneity in the way firms design and deploy their stock-based compensation systems in the future.

References


