Economics Bulletin

Volume 33, Issue 2

Stock option contract design and managerial fraud

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Abstract

Stock option contracts provide managers with dual incentives, motivating both effort and fraud. We show that although there exists an infinity of stock option contracts that induce a given level of effort, no contract behaviorally dominates another in the sense that it induces relatively greater effort and relatively less fraud. We also characterize the schedule of implementable effort-fraud pairs.

We wish to thank William S. Neilson and Phillip Daves for helpful comments on earlier versions of this paper. We are responsible for any remaining errors.
Citation: Rudy Santore and Martin Tackie, (2013) "Stock option contract design and managerial fraud", *Economics Bulletin*, Vol. 33 No. 2 pp. 1283-1289.
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Submitted: February 25, 2013.   **Published:** May 24, 2013.

1. Introduction

A common strategy for aligning the interests of managers with those of shareholders is to give the managers equity-based incentive contracts. Typically such contracts provide top management with either equity or stock options that allow the managers to purchase the firm's stock at a fixed price.[1] However, there is mounting evidence that these types of contracts may have the unintended consequence of inducing managerial fraud, such as the intentional misrepresentation of the firm's financial health. Beyond the anecdotal evidence provided by recent corporate scandals (such as Tyco International, Enron, and Worldcom), there is also theoretical and empirical evidence linking managerial fraud to equity-based compensation.[2]

The unintended consequences associated with equity compensation lead naturally to the question of how to minimize a manager's incentive to commit fraud. Owners have at least two means to control fraud. One is through monitoring of management and stronger accounting controls. The other is through contract design, the focus of this paper.

Our goal is to determine whether certain stock option contracts 'behaviorally dominate' other stock options by inducing relatively greater effort and relatively less fraud. To this end, we provide a model that allows us to compare the incentive effects of various stock option contracts. In our model, the owner of the firm gives the manager stock options in an attempt to induce managerial effort. The manager can boost the firm's value by increasing his/her effort investment. However, unlike standard agency models (Ross, 1973; Holmstrom, 1979), the manager can also fraudulently misreport the firm's financial status, thereby artificially inflating the market value of the firm.

We show that, although there are an infinite number of stock option contracts that induce a given level of effort, all such contracts induce the same level of fraud. The result implies that there is no way for owners to mitigate fraud through contract design while maintaining a manager's incentive to provide effort. We also provide a schedule of effort-fraud pairs that can be induced with stock options.

Andergassen (2008) compares the performance of equity and stock option contracts when a manager can commit fraud. [3] He finds that it is optimal for the firm owner to compensate the manager with a simple equity contract if and only if the negative effects of fraud are sufficiently high; otherwise, stock option contracts are optimal. The key difference between Andergassen (2008) and our paper is that he compares contracts that have the same financial cost to the firm owner, while we compare contracts that induce the same level of effort.

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[1]Hall and Murphy (2003) document that stock options were heavily used in the U.S. during 1980s and 1990s.
[2] Goldman and Slezak (2006) and Andergassen (2008) provide theoretical evidence of this relationship. Johnson et al. (2008), Bergstresser and Philippon (2006), and Burns and Kedia (2006) provide evidence from field data. Bruner et al. (2008) provide experimental evidence that greater equity compensation increases fraud.
[3] Goldman and Slezak (2006) consider how the optimal pay-for-performance sensitivity changes when managers can manipulate information regarding the firm's true value.

2. The Model

A risk-neutral manager of a firm is compensated with a stock option contract, (α, K, ω), which allows the manager to buy share α $(0 < \alpha \leq 1)$ of the firm at price $K \geq 0$ (the strike price), and also pays the manager a fixed salary ω. Note that when $K = 0$, the stock option contract is equivalent to giving the manager a share of equity. We assume that the contract satisfies the manager's participation constraint, and focus on the manager's behavior for a given stock option contract. Our results do not depend on whether the manager's participation constraint binds or has slack.

In period 1, the manager chooses an effort level, *e*, and a fraud level, *f*. The manager's effort, along with an independent random productivity shock, $\tilde{\mu}$, determines the true short-run value of the firm. Throughout, random variables are indicated with a tilde (~), and realized values are indicated with no tilde. Managerial fraud artificially inflates the value observed by investors (perhaps through misrepresentation of the firm's financial health).

In period 2, the firm's true short-run value is a function of the manager's effort and the shock:

$$S_2^T(e,\mu) = v(e) + \mu, \tag{1}$$

where $v' > 0$, $v'' < 0$, and $\tilde{\mu} \in [-\infty, \infty]$ is a random variable with mean 0, density function $g(\mu)$> 0, and cumulative density function $G(\mu)$.[4] The value of the firm actually observed by investors is the true short-run value plus the amount of managerial fraud

$$S_2^O(e,f,\mu) = S_2^T(e,\mu) + f = v(e) + \mu + f. \tag{2}$$

This observed firm value can be interpreted as the value derived by an analyst if he or she assumed that the information provided to the public was accurate.

Although the market does not observe the true short-run value of the firm, the market is rational and anticipates the manager's choice of fraud and any resulting damages to the long-run value. Let f^e denote the level of fraud expected by investors in the market. In period 3, investors use their expectations, f^e, along with the observed value of the firm, S_2^O, to arrive at the market price, S_3^M. (Below we discuss the pricing rule used by investors.) Finally, the manager exercises the options if $S_3^M > K$; that is, if the options are "in the money."

In period 4, the market learns the true long-run value of the firm. We allow for the possibility that managerial fraud (weakly) decreases the long-term value. Let $D(f)$ denote the decrease in the firm's long-term value that arises from the manager's fraudulent activity, where $D(0) = 0$ and $D' \geq 0$. Thus, *regardless of whether the manager is sanctioned for fraud or not* (discussed more below), the long-term value of the firm is

$$S_4^T(e,f,\mu) = S_2^T(e,\mu) - D(f). \tag{3}$$

The price investors are willing to pay equals the observed value less the expected fraud, f^e, and less any expected long-term damages, $D(f^e)$:

$$S_3^M(e,f,\mu,f^e) = S_2^O(e,f,\mu) - f^e - D(f^e). \tag{4}$$

The above equation can be interpreted as a pricing rule, which incorporates the observed value and the investors' expectations regarding fraud. Note that if these expectations are correct, so

[4] The random term can be interpreted as the uncertainty that exists between the period when the manager chooses effort and develops a fraud and the period when the manager exercises the stock option.

that $f^e = f$, the pricing rule in (4) along with (2) and (3) implies $S_3^M(e, f, \mu, f) = S_4^T(e, f, \mu)$ for all μ. In other words, as long as the expectations are correct, the market price equals the true long-term value.

The effort and fraud both entail a cost to the manager. The monetary cost of effort is incurred in period 1 and is given by the function $\phi(e)$, where $\phi(e) = 0$, $\phi' > 0$ and $\phi'' > 0$. Fraud has an expected cost for the manager: If the manager commits fraud, then with probability p $(0 < p < 1)$, the fraud is detected in period 4 and the manager pays sanction $x(f)$, where $x(0) = 0$, $x'(0) = 0$, $x'(f) > 0$ for $f > 0$, and $x'' > 0$.[5] Throughout we ignore the uninteresting case when the manager chooses effort, $e = 0$.

To summarize, in period 1, the manager chooses *e* and *f*, incurs cost $\phi(e)$, and the random term is simultaneously realized. In period 2, the market observes the short-run value of the firm, S_2^O. In period 3, the market price is formed according to (4) and the manager exercises the option if $S_3^M > K$.[6] In period 4, the firm's long-term value S_4^T is realized, and with probability p, the fraud is detected and the manager pays sanction $x(f)$.

In period 1, prior to the realization of $\tilde{\mu}$, the risk-neutral manager's expected utility is

$$E[\tilde{U}_M] = E[Max\{0, \alpha(\tilde{S}_3^M - K)\}] + \omega - \phi(e) - px(f). \tag{5}$$

The first term represents the share of the expected gain from the stock option when the stock price is above the strike price, and the last term represents the expected sanction if he/she is caught committing fraud.

3. Results

The manager chooses effort and fraud to maximize $E[\tilde{U}_M]$. From (2) and (4) it follows that $\tilde{S}_3^M < K$ iff $\tilde{\mu} < K - v(e) - f + f^e + D(f^e)$. Therefore, the manager's expected utility given in (5) can be written as

$$E[\tilde{U}_M] = \alpha \int_{K-v(e)-f+f^e+D(f^e)}^{\infty} [v(e) + f - f^e - D(f^e) + \tilde{\mu} - K]\, g(\mu) d\mu + \omega - \phi(e) - px(f). \tag{5'}$$

The first-order conditions for effort and fraud, respectively, reduce to

$$\alpha \int_{K-v(e)-f+f^e+D(f^e)}^{\infty} [v'(e)] g(\mu) d\mu - \phi'(e) = 0, \tag{6}$$

$$\alpha \int_{K-v(e)-f+f^e+D(f^e)}^{\infty} g(\mu) d\mu - px'(f) = 0. \tag{7}$$

Together (6) and (7) implicitly define the manager's choices in period 1 for arbitrary investor expectations.

In equilibrium, the market's expectations regarding fraud are correct. Define (e^*, f^*) as the manager's equilibrium choice of effort and fraud when the market's expectations are correct. Formally, if we substitute $f^e = f$ into (6) and (7), we get two equations that implicitly define (e^*, f^*):

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[5] The results continue to hold for a more general expected sanction function, such as $X(f) = p(f)x(f)$, as long as $X(f)$ is a convex function.

[6] Our assumption that the manager is able to exercise the option prior to fraud being detected is similar to Goldman and Slezak (2006).

$$\alpha\left[1 - G\left(K - v(e^*) + D(f^*)\right)\right] = \frac{\phi'(e^*)}{v'(e^*)}, \qquad (8)$$

$$\alpha\left[1 - G\left(K - v(e^*) + D(f^*)\right)\right] = px'(f^*). \qquad (9)$$

For notational convenience, we write (e^*, f^*) rather than $(e^*(\alpha, K, p), f^*(\alpha, K, p))$.

There exist many stock option contracts that induce the same equilibrium behavior. To see this, let (e^*, f^*) denote the equilibrium choice when the contract is (α, K, ω) and $f^e = f^*$. Now consider another contract $(\alpha^1, K^1, \omega^1)$ such that

$$\alpha^1\left[1 - G\left(K^1 - v(e^*) + D(f^*)\right)\right] = \alpha\left[1 - G\left(K - v(e^*) + D(f^*)\right)\right]. \qquad (10)$$

The reader should recall that we allow for simple equity contracts, so it is possible to have either $K = 0$ or $K^1 = 0$.[7] It is easily observed that (8), (9), and (10) imply

$$\alpha^1\left[1 - G\left(K^1 - v(e^*) + D(f^*)\right)\right] = \frac{\phi'(e^*)}{v'(e^*)}, \qquad (11)$$

$$\alpha^1\left[1 - G\left(K^1 - v(e^*) + D(f^*)\right)\right] = px'(f^*). \qquad (12)$$

Since the left-hand sides of (11) and (12) are, by construction, equal to the left-hand sides of (8) and (9), respectively, it follows that (e^*, f^*) are the manager's equilibrium choices when compensated with $(\alpha^1, K^1, \omega^1)$. The above discussion yields the following result.

Proposition 1: *Let (e^*, f^*) denote the manager's equilibrium choices of effort and fraud when the contract is (α, K, ω) and $f^e = f^*$, then (e^*, f^*) are also the manager's equilibrium choices for any contract $(\alpha^1, K^1, \omega^1)$ satisfying (10) when $f^e = f^*$.*

According to Proposition 1, there exist an infinite number of contracts capable of inducing the same behavior. Rearranging (10) yields

$$\left(\frac{\alpha^1}{\alpha}\right)\left(\frac{1 - G\left(K^1 - v(e^*) + D(f^*)\right)}{1 - G\left(K - v(e^*) + D(f^*)\right)}\right) = 1. \qquad (13)$$

For two contracts to induce the same equilibrium behavior, the increase (decrease, respectively) in α must be accompanied by a proportionate decrease (increase, respectively) in the probability that the option will be exercised. Hence, the increase (decrease, respectively) in α must be accompanied by an increase (decrease, respectively) in the strike price.

The next proposition shows that it is not possible for one contract to *behaviorally dominate* another contract by inducing (weakly) greater effort and strictly less fraud.

Proposition 2: *Let (e^*, f^*) denote the manager's equilibrium choices of effort and fraud when the contract is (α, K, ω) and $f^e = f^*$, then $f^* = h(e^*)$, where $h(e^*) \equiv y\left(\frac{\phi'(e^*)}{pv'(e^*)}\right)$ is an increasing function of e^* and $y(\cdot)$ is the inverse function of $x'(f)$.*

Proof: The assumption that $x'' > 0$ implies that x' has an increasing inverse function. By definition, (8) and (9) define (e^*, f^*). Combining (8) and (9) yields

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[7] Goldman and Slezak (2006) have previously analyzed simple equity contracts and found that they may induce fraud in addition to productive effort.

$$x'(f^*) = \phi'(e^*)/pv'(e^*). \tag{14}$$

Since y is the inverse function of x', it follows that $y\left(x'(f^*)\right) = f^*$ which, along with (14), implies

$$f^* = y\left(\frac{\phi'(e^*)}{pv'(e^*)}\right). \tag{15}$$

Finally, the assumptions that $\phi'' > 0$ and $v'' < 0$ imply that the function $t(e) \equiv \frac{\phi'(e)}{pv'(e)}$ is an increasing function of effort. Therefore, the composite function $h(e) \equiv y(t(e))$ is also an increasing function of effort. ■

Proposition 2 is similar to Lemma 1 in Andergassen (2008). However, Andergassen restricts attention to contracts that yield the same expected compensation to the manager and holds the level of compensation fixed. Proposition 2 is a stronger result because it derives the schedule of implementable effort-fraud pairs with no restriction on the manager's expected compensation. The policy implication is that even if owners are willing to give more compensation to the manager, it is not possible to reduce his or her incentive to commit fraud without simultaneously reducing the manager's incentive to provide effort.

While the schedule of implementable effort-fraud pairs cannot be altered through contract design, it is clearly a function of the enforcement level. In particular, changes in the probability of detection will cause the schedule to shift. Differentiation of (15) with respect to f^* and p while holding e^* constant yields

$$\frac{df^*}{dp} = -\frac{1}{x''\left(\frac{\phi'(e^*)}{ppv'(e^*)}\right)}\left[\frac{\phi'(e^*)}{p^2pv'(e^*)}\right] < 0. \tag{16}$$

Thus, an increase in the probability of detection shifts the effort-fraud schedule down, implying less fraud for any given level of effort.

4. Conclusion

Our results have implications for both owners and regulators seeking to minimize a manager's incentive to fraudulently manipulate a firm's stock price. While it is possible to reduce fraud through contract design, holding other things equal, there is no way to do so without a corresponding reduction in managerial effort. Indeed, the fraud induced by a stock option contract is uniquely determined by the induced level of effort. Thus, a schedule of implementable effort-fraud pairs may be constructed. Increasing the probability of detection shifts the schedule downward so that less fraud accompanies a given level of effort.

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