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Managerial ability and the valuation of executive stock options

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ABSTRACT

The executive compensation literature argues that executives generally value stock options at less than market value because of suboptimal ownership and risk aversion. Implicit in this finding is the assumption that executives are, like shareholders, price takers. That is, they have no ability to influence the outcomes of the firm's investments. Clearly, executives do have the ability to influence these outcomes, because that is the purpose of granting them the options. In this paper, we develop a model in which managers can exert effort and alter the distribution of the returns from the firm's investments. We find that when executives choose their optimal effort, the values of their options are much higher than generally thought and potentially higher than the market values of the options. In empirical evidence, we show that firms having better stock performance use stock options more efficiently. In addition, the pay-for-performance sensitivity is also stronger among these firms. Therefore, we conclude that the manager's ability plays an important role in the abnormal performance.

CHAPTER 1 INTRODUCTION

It is a widely accepted result that executives usually value stock options at lower than market values. Hall and Murphy (2002) argue that executives are undiversified and risk averse, so they value their stock options at lower than market values. In addition, they also argue that stock options are inefficient relative to restricted stock because of the lower sensitivity of option values to the change in stock prices. Moreover, Meulbroek (2001) argues that executives bear more than the optimal level of firm-specific risk and, therefore, require a higher risk premium.

These arguments have some explanatory power for low executive option values, and these factors affect substantially the incentives of stock options. Hall (2003), however, mentions that one of the striking features of executive pay during the previous two decades is the remarkable increase in the use of stock options. As shown in Figure 1,

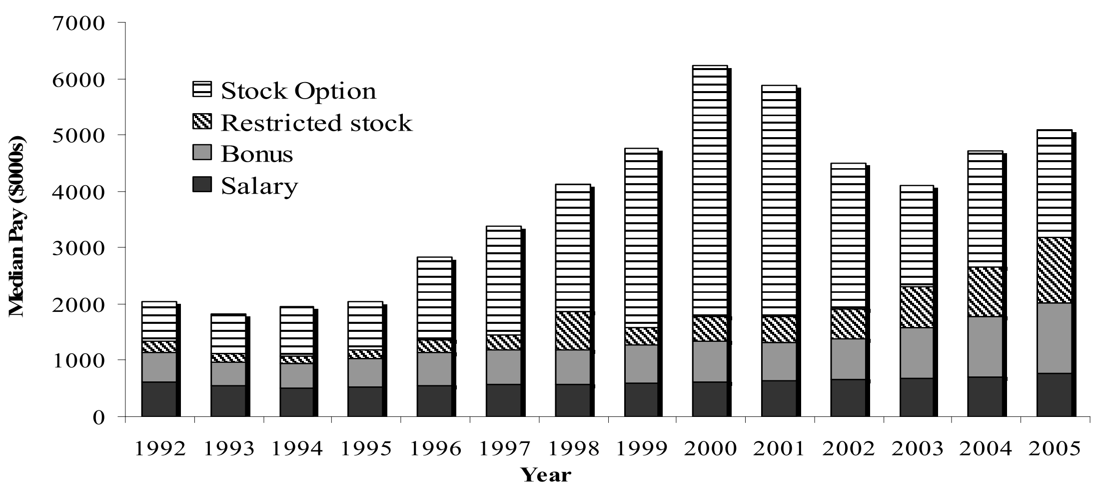


Figure 1: The Distribution of Executive Compensation

The median pay of each component is computed for the top five executives of each firm in the Standard and Poor's ExecuComp database for the S&P500, S&P600 SmallCap, and S&P400 MidCap firms from 1992 to 2005. We calculate only the median for stock options (evaluated by the Black-Scholes model), restricted stock, bonus, and salary and ignore other components of compensation. All values are unadjusted in dollar terms.

the percentage of stock options in median executive compensation increased dramatically from 1992 to 2000. After 2000, options still account for more than 40% of executive pay. Accordingly, one interesting question is why most companies still use stock options to compensate their executives if stock options have low option values and are as inefficient as argued in the literature. We propose one possible answer that managerial ability, which reflects both managerial effort and quality, increases the attractiveness of stock options to managers.

Jensen and Meckling (1976) point out the conflict of interests between managers and shareholders, which is well known as the agency problem or principal-agent problem. Some researchers, such as Grossman and Hart (1983), attempt to resolve this problem through the theory of optimal contracts. In the principals' maximization problem, there is an incentive compatibility constraint. That is, optimal contracts should incentivize managers to exert optimal effort to maximize shareholder wealth. Even though managerial ability is a key factor in these contracts, it is ignored in many academic papers on executive compensation. Lambert and Larcker (2004) and Feltham and Wu (2001) mention a similar problem in the literature, and they argue that incentive effects should be considered in the evaluation of stock-based compensation.

In the executive compensation literature, the pay-for-performance sensitivity has attracted the attention of many researchers. Jensen and Murphy (1990b) define the pay-for-performance sensitivity of stock options as the partial derivative of the Black-Scholes value with respect to the stock price. One implicit assumption in the pay-for-performance relationship is that better performance comes from managerial effort that creates firm value and, therefore, these executives should receive higher pay than their counterparts.[1] Because managerial effort is an unobservable variable in the analysis, it causes some problems in analyzing or interpreting the pay-for-performance relationship. In addition, the values of executive stock options are an important issue in the analysis of executive compensation, because they affect the efficiency and incentives of these options. How executives value stock options depends on not only firm or managerial characteristics but also the effect of how their effort influences firm performance. This paper sheds some light on the effect of managerial ability and develops a model that connects managerial effort with incremental expected stock return given managerial quality.

We assume that managers can use their abilities to improve firm performance. Later, the better performance will be reflected in the stock price when investors are aware of it, causing an increase in the expected return. Under this assumption, we can focus on the effect of managerial ability on the incremental expected return. Applying this assumption in the expected utility analysis, we find the optimal managerial effort under different settings. In simulation results, we find that it is optimal for managers to exert extra effort to maximize their expected utility net of the disutility of effort. In addition, the values of their stock options also increase when managers exert effort. After taking managerial ability into account, we find that option values are underestimated when managerial effort is not considered. Furthermore, we also find some values of these options to be higher than their market values as derived from the Black-Scholes model. From this evidence, we conclude that the values of executive stock options are not as low as generally thought. In addition, these values increase with many factors, such as the

[1]Bertrand and Mullainathan (2001) show that some part of executive pay comes from luck, which is defined as an observable market shock beyond the executive's control. Even though this argument may be correct, the evidence still cannot rule out the effect of managerial effort on the performance of the firm.

elasticity of stock prices with respect to managerial effort, expected market returns, and systematic risk of the firm. A substantial part of the change in executive option values is driven by managerial ability.

We also analyze the early exercise behavior after taking managerial ability into account. Kulatilaka and Marcus (1994) show that the tendency to exercise early increases with risk aversion and stock option wealth. We find, however, that more capable managers exercise their options at higher stock prices, which implies they are willing to postpone exercising their options. This result occurs because high stock wealth magnifies the effect of managerial ability on their expected utilities. Therefore, capable managers prefer waiting longer to exercise their options than they usually do in other models that do not distinguish managers by quality.

Finally, managerial effort is an unobservable factor but its consequences should be reflected in the abnormal return, which can be estimated from market data. In the empirical tests, we find supportive evidence for the impact of managerial effort. First, the portion of firm stock in the manager's wealth, which we call the stock-wealth ratio, has a positive effect on managerial effort but the manager's total wealth has a negative effect. This result supports our argument that managers are willing to exert more effort when they are heavily invested in the firm or have low personal wealth relative to their investment in the firm. In addition, when overall conditions revealed by the abnormal return are preferable for managers to exert effort, either cash- or stock-based compensation can induce more effort that is reflected in market performance. When these conditions are not preferable, executive compensation has a negative impact on managerial effort.

Second, because stock-based compensation is more frequently used when it has positive impact or when these overall conditions are preferable, we conclude that stock-based compensation is efficiently used in the market. In contrast, cash-based compensation does not provide substantial incentives when it has a positive impact on abnormal return. Therefore, it is in general not efficiently used relative to stock-based compensation. Finally, we also find that firms with managers who have a higher stock-wealth ratio and lower total wealth provide the strongest incentives represented by pay-for-performance sensitivity. This finding is consistent with the pay-for-performance hypothesis that higher pay comes from better performance or more managerial effort. Based on these empirical results, we conclude that firm-specific characteristics, such as stock volatility, and executive-specific characteristics, such as the stock-wealth ratio and total wealth, affect managerial effort significantly. Stock-based compensation is in general efficiently used to provide incentives for managers to exert effort.

CHAPTER 2 LITERATURE REVIEW

2.1 Theoretical Literature

In the conventional principal-agent model, such as Grossman and Hart (1983), principals design the compensation package by maximizing the expected payoff net of the cost of compensation. The maximization is subject to the constraint that agents choose the optimal effort by maximizing their own expected utility. The effect of managerial effort is reflected in the probability and/or the payoff of each outcome of the firm's projects. Starting from this fundamental intuition, many researchers search for optimal sharing rules, or contracts, between agents and principals under different assumptions. For example, Holmstrom and Weiss (1985) show the relationship between the optimal incentive contract and investment level in different states of nature when investment and output are observable. In addition, Holmstrom and Milgrom (1987) analyze the problem of intertemporal incentives in a continuous-time framework. They find that the principal problem can be solved under the static framework in which the manager can change the mean of the normal distribution and principals use a linear sharing rule. From their result, we make a similar assumption about the effect of managerial effort on the expected stock return.

There is another stream in the executive compensation literature to find the values of different components of the executive compensation package. This approach recognizes that managers are different from individual investors in several respects. For example, managers cannot sell short their firms' stock and legal requirements restrict their ability to hedge the risk of their stock and stock options. In addition, managers must follow other specific constraints, such as vesting periods or disclosure regulations.

Therefore, conventional market-based valuation is not appropriate for stock-based compensation. Lambert, Larcker, and Verrecchia (1991) recognize this problem and use a certainty equivalent approach to find option values while taking executive and firm characteristics into account. Hall and Murphy (2000, 2002), Henderson (2005), Hall and Knox (2004), and others also define the certainty equivalent values of stock options as executive values and analyze the relationship between executive values and other variables. Due to the differences between managers and individual investors, these authors conclude that undiversified risk-averse managers value their stock options at less than the market values of those options based on the Black-Scholes model.[2] Meulbroek (2001) mentions that managers bear the total risk of the firm but are rewarded only for the systematic part of it. Hence, there exists a deadweight loss for stock-based compensation.

It is a common finding among these papers that executive option values are in general lower than market option values. We propose that one major reason is that managerial ability is not taken into account. The conventional principal-agent model assumes that managers can exert effort to maximize firm value. The goal of principals is to choose a compensation scheme to motivate managers to exert the target, or desired, effort. If this is the case, then the effect of managerial effort should affect the values of stock options awarded to management. Cadenillas, Cvitanic, and Zapatero (2004) show that levered stock is an optimal compensation policy in many situations, such as for firms

[2]There is an extensive body of literature that argues that executives value their options at lower than market price or firm cost. In addition to the literature mentioned in this paragraph, interested readers can refer to Kulatilaka and Marcus (1994) and Cai and Vijh (2005) for the comparison of option value between risk-averse and risk-neutral employees within a utility-based model and to Detemple and Sundaresan (1999), Johnson and Tian (2000), Hall (2003), and Ingersoll (2006) for the comparison between option value and Black-Scholes value.

with high expected return or large size or managers with high quality. They, however, do not analyze the effect of managerial effort on executive option values. In addition, they do not consider the effect of other components of managerial wealth, such as cash or the firm's stock, which can affect optimal effort. To bridge this gap, we take into account cash and the firm's stock in the managerial portfolio and examine how effort affects executive option values.

Hodder and Jackwerth (2004) focus on similar issues. They assume that the manager has the ability to control the risk level of the firm, and they develop a discrete-time model to value executive stock options. They find that the certainty equivalent values of these options are higher than the Black-Scholes values under some circumstances. There are four major differences between their model and ours. First, they assume that the manager can dynamically control the stochastic process for the firm's value by using forward contracts to hedge the firm's risky technology. In contrast, we assume that managers have the ability to influence the firm performance that is reflected in a deviation from the expected return but they choose to fix the risk level of the firm.[3] Under their assumption, the terminal return distribution can be trimodal, which is uncommon in the literature. Second, they implicitly assume that the manager's effort is costless, which is not consistent with the assumption of disutility of managerial effort in the literature.[4] In our model, we follow the literature and measure the disutility of the effort by using a quadratic disutility function. Third, in their analysis of early exercise,

[3]In this assumption, we want to reflect a means by which managerial effort increases shareholder wealth. Managers can influence either expected return or stock volatility or both. To simply the analysis and distinguish our paper from others, we assume managers can influence only expected return. Holding risk constant to analyze the effect of a factor is a common approach in finance as in the original Modigliani-Miller analysis of the effect of financial leverage.

[4]They assume there is a lower boundary on the firm value that will trigger dismissal of the manger for poor performance, which is a penalty function from the manager's perspective.

the possibility of exercising earlier is independent of the time period, which is inconsistent with the general motivation of early exercise. The interest on exercise proceeds is a major factor in the early exercise decision. Therefore, it should be taken into account in the behavior of early exercise. Finally, they assume that because hedging strategies are represented by the portion of the hedged assets there is no difference in hedging strategy among managers. We argue that different managers have different abilities, which result in different outcomes from their effort. Therefore, we assume managers have different qualities that have diverse effects on firm values.

There are some researchers who focus on the effect of managerial effort on the incentives of stock-based compensation. Schaefer (1998) develops a simplified agency model and derives the functional form for optimal effort. He finds that optimal effort is positively related to firm size and marginal productivity of effort, but negatively related to risk aversion and the variance of firm value. Feltham and Wu (2001) analyze the incentive effects of stocks and options with consideration of managerial effort. Under the assumption of a normally distributed terminal stock price, they find that the number of options granted to induce a certain level of effort increases with the exercise price when the effort does not influence the firm's operating risk. They conclude that the cost of compensation increases with the exercise price. Because most options are granted at-the-money, the compensation cost increases with the stock price. If the effort influences both the mean and the variance, then conclusions about incentive effects of stock and options depend on the impact of effort on firm risk. When the impact is large, then the compensation cost decreases with the exercise price.

There are two major differences between their model and ours. In their model, the manager has only stock or options and, therefore, they ignore the effect of the other component of the agent's wealth. The consideration can affect the number of shares of stock or options needed to induce the managerial effort in their analysis. In addition, their assumption of normality for the terminal stock price is not consistent with the conventional assumption of the stock price distribution, which is lognormal. To determine how the assumption about the stock price distribution can affect the terminal stock price, we simulate the processes of normal and lognormal stock prices with respect to different volatilities in Figures 2a and 2b.

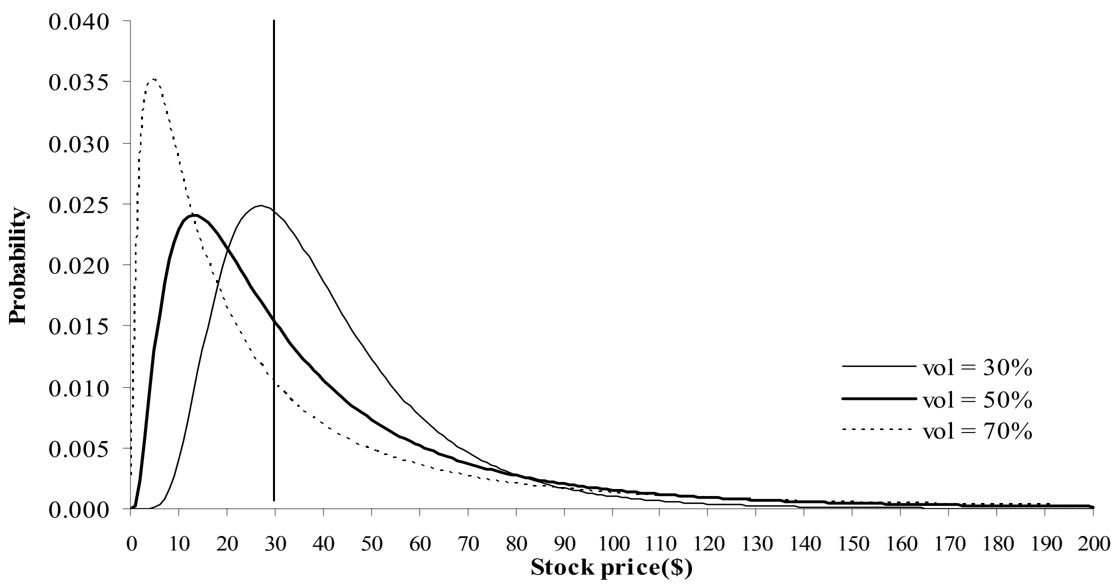


Figure 2a: The Probability Density of a Lognormally Distributed Stock Price

The probability distribution of the lognormal stock price is simulated by using a $30 stock price, 10% expected return and 30%, 50%, and 70% volatilities. The time period in the simulation is three years. The probabilities of a stock price lower than $30 are 38%, 53%, and 64% with volatilities 30%, 50%, and 70% respectively. Under the assumption of a normal distribution, the expected stock price in three years is $39.93 and the probabilities of stock price lower than $30 are 32%, 39%, and 42% with volatilities 30%, 50%, and 70% respectively. Hall and Knox (2002) also analyze the underwater probability, which is similar to the out-of-the-money probability in Figure 2a.

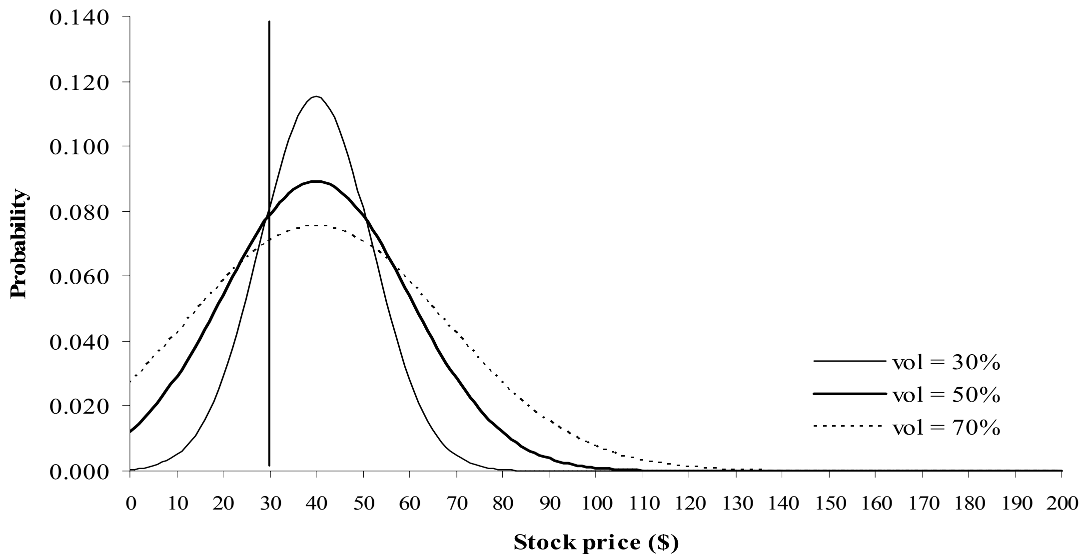


Figure 2b: The Probability Density of a Normally Distributed Stock Price

From Figures 2a and 2b, we find that the probability that the terminal stock price is less than or equal to the current stock price in three years increases with volatility in both the normal and lognormal distributions, and the magnitude of the difference increases with volatility. In addition, the normal probability density function is truncated at $0. In our model, we add non-option wealth, which includes cash and the firm's stock, in the manager's portfolio. The normal distribution assumption is clearly not appropriate because it implies unlimited loss. Therefore, we assume a lognormal distribution of stock price and maintain the lognomality in the simulation analysis.

Lambert and Larcker (2004) use a principal-agent model to find the optimal contract and compare their results with those in Feltham and Wu (2001). They find that option-based contracts in general dominate restricted stock-based contracts and that most options in the optimal contracts are premium options.[5] In addition, they also point out the invalidity of the first order condition in the agent's maximization problem. They argue that expected utility is not a concave function of managerial effort when the convexity of the option's payoff dominates that of the agent's disutility of effort. We find, however, one major reason for this problem is because the number of options increases with the level of effort in their model. In contrast, we fix the number of options granted to an executive, and then find the optimal managerial effort. Therefore, the first-order condition is valid in our model. To verify this result in Section 3, we examine the executive's expected utility within a reasonable range of managerial effort and show that it is a well-behaved concave function of effort.

2.2 Empirical Literature

The empirical evidence on managerial effort is rare because effort is not directly observable. Bitler, Moskowitz, and Vissing-Jørgensen (2005) use unique survey data on entrepreneurial effort to test the effect of effort. Their proxy for entrepreneurial effort is working hours, which implies the more working hours, the more effort is exerted. They find that effort increases with ownership of the firm and that effort can improve firm performance. Because an entrepreneur can affect firm performance by working longer, we expect the values of stock options from their perspective should be higher than those in the conventional utility model. In addition, Ittner, Lambert, and Larcker (2003) compare the structure and performance consequences of stock-based compensation

[5]Premium options are stock options with an exercise price above the current stock price on the grant date. Thus they are options issued out-of-the-money. In contrast, discount options are stock options with an exercise price lower than the current stock price on the grant date, meaning they are options issued in-the-money.

between "new economy firms" and traditional firms.[6] They find a positive relation between lower-than-expected option grants or low existing option holdings and lower accounting and stock price performance. They, however, do not find a significant relationship when equity grants or holdings are higher than expected. It seems to be that higher-than-expected grants or holdings cannot significantly affect a firm's past performance. But the result does not rule out the effect of expected grants or holdings on future performance.

There are two fundamental hypotheses about the relationship between managerial ownership and firm value. On the one hand, Morck, Shleifer, and Vishney (1988) mention that firm value increases with management ownership, which is known as the convergence-of-interest hypothesis. On the other hand, managers can entrench themselves under high ownership, which is known as the entrenchment hypothesis. In empirical tests, they find that the relationship between firm value and management ownership is not monotonic, which implies that different degrees of management ownership have different effects on firm value. This result will affect our design of empirical tests between managerial effort and managers' stock wealth. McConnell and Servaes (1990) identify a curvilinear relation between the market value of a firm and insider ownership. Thus, from the empirical evidence, we expect that stock-based compensation should be positively related to firm performance within a certain range of ownership, because stock-based compensation increases management ownership.

In addition, because better performance comes from managerial effort, we expect that management ownership is positively related to effort. Core and Larcker (2002) test

[6]They define new economy firms as firms in the computer software, internet, telecommunications, and networking industries.

the performance consequences after firms adopt target ownership plans that require managers to hold at least a certain amount of the firm's stock. They find that accounting returns and stock returns of these firms are significantly higher than those before adoption of these plans. The mean one-year excess stock return is 5.7% and one-year excess return on assets (ROA) is 1.2% that is significant at the 5% level. Mehran (1995) also finds a similar result by using data from the early 1980's. Firm performance, measured by either Tobin's Q or ROA, increases with the percentage of stock-based components in executive compensation.

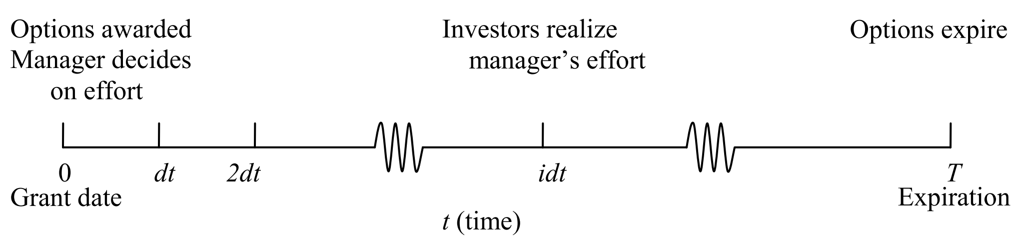
Another relative issue is the quality of management. One common measure of management quality is the marginal productivity of managerial effort (Cadenillas, Cvitanic, and Zapatero (2004) and Lamber and Larcker (2004)). Suppose there are two managers in two similar firms. Due to different marginal productivity, they can choose to exert different levels of effort. Alternatively, the effect of the same effort can have a different impact on the values of the two firms. The empirical evidence in Baker and Hall (2004) shows that marginal productivity of effort increases significantly with firm size. Under the assumption that the observed sharing rules are optimal for all firms in the sample, they find that the elasticity of marginal productivity with respect to firm value is significant, and approximately equal to result 0.4. This result implies that larger firms have managers with higher marginal productivity. Furthermore, in their multitask model, they show that managerial effort is allocated among different tasks according to the marginal productivity of effort on each task. We also find similar results in the simulation of our model.

CHAPTER 3 THEORETICAL MODEL

We start the analysis from a time line of an option grant and add the feature of managerial effort to see how managerial effort influences stock prices and when these effects occur. Managers determine their optimal effort to maximize expected utility, which reflects the benefit and the cost of the effort. We also analyze whether the effort can substantially affect the value of the stock options. Assuming that the manager has a negative exponential utility function and that non-option wealth includes cash that earns the risk-free rate, and the firm's stock, we find the value of the manager's stock options by applying the certainty equivalent approach of Lamber, Larcker, and Verrecchia (1991).

3.1 Determination of Optimal Effort

Managerial effort is unobservable but it should be reflected in the stock price when this effort produces the result of improved firm performance. When the effect of effort is realized, investors then adjust the expected return. Because the manager's quality and effort are private information, we assume that there is no stock price reaction on the grant date. At some point in time prior to maturity, managerial effort, however, will be identified by the manager's performance evaluation, which is reflected in the abnormal performance of the stock. Let us use a time line below to explain the setting.



The firm grants stock options with a maturity T to its manager at time 0, at which time the manager decides on his optimal effort over the lifetime of the options. At time 0, the current stock price is S_0 and the expected return is $E(r)$. At time *idt*, the effect of managerial effort is reflected in the stock price and results in an abnormal return over the period of $t = 0$ to $t = idt$. From that point forward investors price the manager's effort into the stock, so no further abnormal returns arising from this grant would be observed. Managers will, however, most likely receive additional grants before the expiration of the first grant, and these additional grants can produce new abnormal returns.

Let S_t be the stock price that would exist in the absence of an option grant. We are interested in determining the stock price that would exist if the option is awarded and the manager decides to put forth additional effort. As noted, the market determines the results of the manager's effort at time *idt* and the stock price changes to

$$S^*_{t+i} = S_{t+i} q^{\delta}, \quad q \geq 1, \tag{1}$$

where S^*_{t+i} is the after-effort stock price or the stock price after taking the effort into account at time *idt*.[7] S_t is the stock price on the grant date with minimum effort equal to one, q is the measure of managerial effort over the period of time $t = 0$ to time $t = idt$, and δ is the measure of managerial quality, which is the elasticity of the stock price with respect to managerial effort, $\delta \geq 0$.[8] Under the same effort, the higher the δ, the higher is the after-effort stock price, that is, high quality managers have high δ.[9]

[7]Camara and Henderson (2005) use this relation to analyze the manipulation of stock price and accounting earning. Palmon, Bar-Yosef, Chen, and Venezia (2004) assume that managers can exert effort to increase the upper and lower bound of the cash flow distribution. From our assumption in (1), managers can shift the distribution of the stock price, which is similar to their assumption.

[8]When managers exert minimum effort, $q = 1$, the stock price is independent of managerial quality. Later in this paper, when we mention the elasticity of stock price, we mean the elasticity of stock price with respect to managerial effort.

[9]This interpretation is the same as that in Cadenillas, Cvitanic, and Zapatero (2004). They mention that δ is an indicator of the quality of the manager.

We do not specify when the effort is expended during the interval $t = 0$ to $t = idt$. It could come early, late, or evenly spaced. We assume, however, that investors do not realize the results of the effort until the end of the interval, and these results will translate into an abnormal return. Given the use of annual reviews, we will assume for empirical purposes that the period $t = 0$ to $t = idt$ is one year, and we will measure annual abnormal returns. Keep in mind that the manager continues to expend the effort after $t = idt$, but it generates no abnormal return because investors are now aware of the manager's effort and build it into the stock price. In facts, if the manager fails to expend the effort after $t = idt$, there will be a negative abnormal return.

We assume the stock price without effort, S_t , follows a Geometric Brownian motion process, which is

$$dS_t = \alpha S_t dt + \sigma S_t dw_t ,$$

where α is the mean, σ is the standard deviation of the raw stock return, and w_t is the standard Brownian motion. We assume the continuously compounded Capital Asset Pricing Model (CAPM) holds so that $\alpha = r_f + \beta\left(E\left(r_m\right) - r_f\right)$, where r_f the risk-free rate, β is the measure of systematic risk, and $E\left(r_m\right)$ is the expected market return. In this paper, we also assume that early exercise decisions have no effect on the manager's choice of optimal effort.[10] Therefore, managers determine their optimal effort immediately after accepting the compensation contract. We can view Equation (1) in terms of the expected return by dividing S_t and taking expectation for the log returns on both sides:

[10]In Section 3.3., we analyze the effect of optimal effort on the early exercise decision. To limit the interaction between optimal effort and the early exercise decision, we make the assumption that there is no effect of early exercise on optimal effort.

$$E\ln\left(\frac{S^*_{t+i}}{S_t}\right)=E\left(\ln\left(\frac{S_{t+i}}{S_t}\right)+\delta\ln q\right)$$
$$\mu^* idt=\left(\mu+\eta\right)idt. \quad (2)$$

Assuming that the log returns without effort follow a normal distribution with mean μ and standard deviation σ, μ^* is the after-effort expected log return and η is the incremental expected return resulting from managerial effort. Therefore, we can connect managerial effort with incremental expected return as follows:[11]

$$\delta\ln q=\eta idt$$
$$q=e^{\eta idt/\delta}. \quad (3)$$

From Equation (3), we know that managerial effort is an exponential function of incremental expected return, time length, and manager quality.[12] As noted the market price converges to the price that reflects effort at $t = idt$. Any price prior to that time, such as S_{dt}, does not reflect effort. Nonetheless, the manager will have a private opinion of the price, S^*_{dt}, which by recursive evaluation, will equal, $S_{dt}q^{\delta}$.[13]

What is happening is that the manager's effort shifts the expected return upward.[14] The manager's effort is creating larger returns in at least some states without offsetting smaller returns in other states. But we must be careful about the terminology used. Because we observe the fruits of the manager's effort in the abnormal return, we

[11]Grout and Zalewska (2006) apply a similar assumption that the mean of the terminal firm value increases by ε when managers make the additional effort. In addition, they also assume there is no impact on the variance of the distribution.

[12]If $\delta = 0$, then $\eta = 0$. The stock price process becomes the original process with minimum level of effort, which is $q = 1$. Therefore, the case of $\delta = 0$ has the same effect on expected return as $q = 1$, even though the interpretations of these two cases are different.

[13] At time *idt*, $S^*_{idt}=S_{idt}q^{\delta}$. One period prior to time *idt*, $S^*_{(i-1)dt}=E\left(S^*_{idt}\right)e^{-\alpha dt}=E\left(S_{idt}\right)e^{-\alpha dt}q^{\delta}$ $=S_{(i-1)dt}q^{\delta}$. Repeating back to any time *jdt* gives $S^*_{jdt}=S_{jdt}q^{\delta}$, which is the manager's private assessment of the value of the stock and reflects the additional information he knows about his effort.

[14]Recall that we are not changing the risk.

must be careful in how we define the expected return. The manager shifts the distribution by η. If we incorporate η into the expected return, there is naturally no abnormal return. Thus, prior to $t = idt$, we will distinguish the expected return without effort from the expected return with effort, the latter of which is not observed by investors. From the conventional CAPM, we know that $E(r) = r_f + \beta\left(E(r_m) - r_f\right)$ is called an expected return or, more accurately, a required return. This return is what investors require from a firm with systematic risk β. The expected return from the manager's standpoint, however, is $E(r^*)$ in Equation (6), because managers have private information about their quality and effort that can influence firm performance. We will call this measure the "expected return with effort." In addition to the expected return from the conventional CAPM, $E(r^*)$ also includes managerial effort that is reflected in the incremental expected return η. Before managerial effort is fully revealed, $E(r)$ is different from $E(r^*)$ by the incremental expected return. After time *idt*, shown in the time line above, $E(r)$ converges to $E(r^*)$ and η converges to zero. Managers still exert the same level of optimal effort but there is no incremental expected return.[15]

Upon receipt of the grant, the manager must decide on the amount of effort. We assume the manager has three components in his portfolio, which are \$*c* in cash, *m* shares of the firm's stock, and *n* stock options. The terminal wealth is

$$W_T = c \times \left(1 + r_f\right)^T + m \times S_T^* + n \times Max\left(S_T^* - K, 0\right),$$

where T is the maturity of the stock options, r_f is the risk-free rate, S_T^* is the terminal after-effort stock price, and K is the exercise price of n options. As described, we assume that the manager can affect firm value by choosing his level of effort and therefore

[15]Managers can, however, receive new grants that can lead to more abnormal returns.

increasing the return of the stock.[16] On the one hand, the benefit of the effort is to change the values of the stock and option components of the manager's wealth through S_T^*. The effort, however, causes some disutility in the manager's utility function. Therefore, there is a trade-off relation between the change in stock return and disutility of managerial effort. We consider the disutility of effort as the cost of the effort. Following the related literature, we define the disutility function of the effort as a quadratic function.[17] To analyze the trade-off relationship mentioned above in the expected utility model, we represent managerial effort and disutility in terms of incremental expected return. Therefore, the distutility function of effort is

$$C\left(q\right)=\frac{1}{2}q^2=\frac{1}{2}e^{2\eta T/\delta}. \tag{4}$$

Recall that $q=e^{\eta idt/\delta}$ where *idt* is the period over which the effort converts into the abnormal return. As noted before, investors are aware of the results of managerial effort at time *idt* and adjust the expected return toward the expected return with effort. After that, the abnormal return from managerial effort does not exist but managers must maintain the same level of effort. Otherwise investors can identify the change of effort at the next observation point and there will be a negative abnormal return. To compute the disutility of effort over the entire option life, we assume that the total effort from time 0

[16]In general, if the effort comes from the manager's ability, then it should have a long-term effect. In contrast, if the effort comes from inside information or stock price manipulation, then its effect should last only for a very short term. Because effort is unobservable, the market will know the manager's effort gradually through observing other proxies for the effort and updating the information in the stock price. If the effort comes from insider information or manipulation, then the stock price will reflect the information immediately after it becomes public. Therefore, the effect of this kind of effort exists in only the short term.
[17]Interested readers can refer to Baker and Hall (2004), and Cadenillas, Cvitanic, and Zapatero (2004). Some researchers use a modified version of a quadratic function in the agency model for tractability. See Prendergast (1999).

to time T is the product of effort in each interval of *idt*. From Equation (3), the total effort can be expressed as $q = e^{\eta T / \delta}$.

To compare the results between our model and other valuation models that do not take managerial effort into account, we consider only the disutility of the extra effort.[18] The disutility function becomes

$$c(q) = \frac{1}{2}(q-1)^2 = \frac{1}{2}\left(e^{\eta T/\delta} - 1\right)^2.$$

Finally, to find the optimal effort in the expected utility model, we assume the manager has negative exponential utility with coefficient of absolute risk aversion ρ:

$$U(W_t) = -\frac{1}{\rho}e^{-\rho W_t}.$$

The manager determines the optimal effort by maximizing the expected utility with respect to terminal wealth net of the disutility of effort. In the objective function, we assume additively separable utility for terminal wealth and the disutility of effort.[19] Hence, the problem faced by the manager is

$$\underset{\eta}{Max}\ E\left(U\left(W_T\right)\right) - c(q).^{20} \tag{5}$$

Due to the assumptions of the components in the terminal wealth and stock price process, it is not appropriate to assume that terminal wealth is normally distributed. Therefore, we

[18]In this paper, we assume that the cost of minimum effort is zero. Because the incremental expected return is zero in the minimum effort case, the original expected return is determined by co-movement with the market, which is out of the manager's control. Therefore, no extra cost is needed in the minimum effort case.

[19]To be sure of the comparability between the utility of terminal wealth and cost of effort, we assume the manager has negative exponential utility rather than power utility. Both types of utility functions, however, are extensively used in the literature.

[20]Originally, the choice variable in this maximization problem should be *q,* managerial effort over the entire option life. Because optimal effort is an unobservable variable, we maximize the objective function with respect to incremental expected return, which is a measurable variable in empirical analysis, and then convert into effort through (3).

cannot simply use the mean and variance of terminal wealth in the maximization of expected utility (Lambert and Larcker (2004)). Two possible structures for the maximization problem are binomial and continuous-time models. Under these two types of models, we can maintain the lognormality of the stock price while maximizing the expected utility net of the disutility.

3.1.1 Discrete Time Model

The basic binomial model without managerial effort comes from Hall and Murphy (2002), which differs from traditional risk-neutral valuation by using the expected stock return rather than the risk-free return in a binomial tree. Under the previous assumptions, we demonstrate how to obtain the optimal managerial effort through a simple one-period binomial tree. We assume the stock price has an up move, *u*, with true probability, *p*, and a down move, $d = 1/u$, with true probability, $1 - p$. Because the stock price follows a lognormal distribution, the two parameters, *u* and *p*, need to fit the expected return, $\pi = \alpha^{1/h}$, and variance, $\xi = \pi^2\left(e^{\sigma^2/h} - 1\right)$, where *h* is the length of each period and equal to 1 in this example. Hence, the two parameters in the binomial tree can be derived from the following equations,[21]

$$u = \left(\left(\pi^2 + \xi + 1\right) + \sqrt{\left(\pi^2 + \xi + 1\right)^2 - 4\pi^2}\right) \Big/ 2\pi \ ,$$

$$p = \frac{\pi - d}{u - d} .$$

After taking managerial effort into account, the after-effort up and down moves are u^* and d^* respectively, and the true probability does not change after taking effort into

[21]The down move, *d*, is the other solution of the quadratic formula. The "uptick" in Appendix B of Hall and Murphy (2002) is actually a down move.

account. Applying Equations (1) and (3), we find that $u^* = ue^{\eta}$ and $d^* = de^{\eta}$.[22] In this binomial tree of stock prices, we maximize the expected utility of terminal wealth net of the cost of effort by changing η to maximize

$$pU\left(W_T^{u^*}\right) + (1-p)U\left(W_T^{d^*}\right) - \frac{1}{2}\left(e^{\eta/\delta} - 1\right)^2, \tag{6}$$

where $W_T^{u^*}$ and $W_T^{d^*}$ are the terminal wealth for up and down stock price moves respectively. The optimal effort comes from the solution for optimal incremental expected return in Equation (6).

3.1.2 Continuous Time Model

Following the same maximizing strategy, we use the after-effort stock price to simulate terminal stock prices and then maximize the expected utility of terminal wealth net of the disutility of effort by changing η. The process of the after-effort stock price under the assumption of Geometric Brownian motion is

$$S_{t+i}^* = S_t e^{(\mu+\eta)idt+\sigma w_t},$$

where $w_t = \varepsilon\sqrt{dt}$ is standard Brownian motion and $\varepsilon \sim N(0,1)$. Based on this solution, we can simulate the terminal stock prices by using a standard normal distribution. The optimal effort is determined by finding the solution for Equation (5).

3.2 Executive Option Values

The common method of finding the value of an executive stock option is the certainty equivalent approach within a utility-based model. The basic concept is that the option value is the cash amount, *CE*, received at the beginning that has the same expected

[22] There are many different ways to take managerial effort into account in a binomial model. In this paper, we assume the up and down moves change with effort but the true probabilities hold unchanged. Alternatively, we could have managers change the probability of each outcome to increase the expected return, which could lead to other interesting inferences.

utility as the stock option. Therefore, the option value is determined by solving for *CE* in the following equation,

$$\int_0^\infty U\left((c+CE)\left(1+r_f\right)^T + mS_T\right) f\left(S_T\right) dS_T$$
$$= \int_0^\infty U\left(c\left(1+r_f\right)^T + mS_T + nMax\left(S_T - K, 0\right)\right) f\left(S_T\right) dS_T. \tag{7}$$

The value of one stock option is CE/n. This approach is commonly used to find executive option values in the literature. There are, however, some differences between our approach and others' in the valuation of stock options. First, in our case the future stock price on both sides is a function of the after-effort stock price. Because we assume that stock options provide incentives for executives to exert more effort than the minimum level, cash compensation does not have the same incentive.[23] In addition, because managers invest a portion of their wealth in firm stock, it also provides some incentives. After taking managerial ownership into account, we assume that the mean of the stock return distribution changes after granting stock options, but it does not change with cash compensation. Second, we have to find the optimal effort before we apply the certainty equivalent approach, because the maximum expected utility comes from the optimal effort. Third, the expected utility on both sides should be net of the disutility of effort. Therefore, we find the *CE* after taking these differences into account as follows:

$$\int_0^\infty U\left((c+CE)\left(1+r_f\right)^T + mS_T^{1*}\right) f\left(S_T^{1*}\right) dS_T^{1*} - \frac{1}{2}\left(e^{\eta_1 T/\delta} - 1\right)^2$$
$$= \int_0^\infty U\left(c\left(1+r_f\right)^T + mS_T^{2*} + nMax\left(S_T^{2*} - K, 0\right)\right) f\left(S_T^{2*}\right) dS_T^{2*} - \frac{1}{2}\left(e^{\eta_2 T/\delta} - 1\right)^2. \tag{8}$$

[23]This issue is also mentioned in Hall and Murphy (2002). They assume that the distribution of future stock prices does not change after granting either stock options or cash for the purpose of tractability. The change in the distribution of stock prices, however, is the central issue in our paper. We must take it into account in the analysis.

In Equation (8), S_T^{1*} is the stock price after taking the optimal effort from managerial ownership into account and S_T^{2*} is the stock price after consideration of the optimal effort from managerial ownership and option compensation. η_1 and η_2 are incremental expected returns on the left-hand and right-hand sides respectively. We find the *CE* in both discrete- and continuous-time models by using this approach.

3.3 Early Exercise

Other factors that can affect the executive option value are early exercise and the vesting schedule. Even though we do not analyze the effect of early exercise on optimal effort, effort could have an effect on early exercise. We cannot analyze this effect in a continuous-time framework, but it is observable in the binomial model. Therefore, we perform the comparative statics analysis under the continuous time model and analyze the effect of early exercise under the binomial model. We assume the proceeds from early exercise are invested in the risk-free asset until the maturity date of the options. The manager will exercise early only when the expected utility of early exercise is higher than that from holding the options. The expected utility at each node after time t is

$$E\left(U\left(W_{t-1}\right)\right) = Max\left\{pE\left(U\left(W_t^u\right)\right) + \left(1-p\right)E\left(U\left(W_t^d\right)\right), E\left(U\left(W_{t-1}^E\right)\right)\right\},$$

where $U\left(W_t^u\right)$ and $U\left(W_t^d\right)$ are the utilities at time *t* with up and down moves respectively, and $U\left(W_{t-1}^E\right)$ is the utility from early exercise. Following this rule, we can find the expected utility considering early exercise at time 0. Then, the value of the options is the cash amount received at time 0 and invested in the risk-free asset that provides the same expected utility.[24]

3.4 Parameter Setting

The continuous- and discrete-time models provide a useful tool to identify the optimal managerial effort under given situations represented by different model parameters. Because there is no closed-form solution for optimal effort, however, it is difficult to observe the sensitivity of the effort to these parameters from the partial derivatives. An alternative method is to simulate the optimal effort under different sets of parameters. To perform this analysis, we define a benchmark situation and then change one parameter at a time to find the sensitivity of the effort to the parameter.

There are twelve parameters in the continuous-time model and we classify them into three groups, which are Black-Scholes variables, CAPM variables, and managerial properties.

3.4.1 Black-Scholes Variables

To find the Black-Scholes value of stock options, we need to know the following variables: the current stock price, S_0, the exercise price, K, the risk-free rate, r_f, the volatility of the stock return, σ, and the time to maturity, T.[25] From the data in ExecuComp between 2000 and 2005, we find that more than 99% of stock options are granted at-the-money. In addition, the mean exercise price in 2005 is $32.47 and the median is around $29.20. Therefore, we use $30 as the exercise price and focus on at-the-money options. The extension to premium and discount options, with stock prices $20 and $40 respectively, is done to check the robustness of the results. For the risk-free rate,

[24]Chance and Yang (2005) show the detail of the derivation of the values of the options. The certainty equivalent approach used in this paper is similar to their model.
[25]To simplify the analysis and focus on the issue of optimal effort, we assume no dividends.

the three-month T-bill rate is 4.95% and 10-year treasury maturity rate is 5.09% in July 2006. We use 5% as the risk-free rate in our simulations.

The average volatility reported in ExecuComp between 2000 and 2005 to compute the Black-Scholes value is 47%. Therefore, we use 50% as the benchmark volatility and use 30% and 70% to represent less and more volatile companies respectively. For the maturity, the general time to maturity for original issue executive stock options is ten years. Huddart and Lang (1996) use a unique database of exercise behavior from eight corporations and show that holders of stock options in general do not exercise at expiration. Many of them exercise within one or two years after the grant date.[26] Carpenter (1998) uses data on option exercises of 40 firms and predicts that the average time to exercise is 5.83 years. Hence, we also use five- and three-year maturities for robustness checks.

3.4.2 CAPM Variables

There are three variables in the traditional CAPM, which are the risk-free rate, the expected market return, and the systematic risk measure, beta. We use the value-weighted return on all NYSE, AMEX, and NASDAQ stocks as a proxy for the expected market return. The average market return from 1992 to 2005 is 11.88%.[27] Therefore, we use 12% as the benchmark for the expected market return. To observe how changes in market conditions affect managerial effort and the values of executive stock options, we also run the simulations under 10% and 14% expected market returns. We use beta of 1 as the

[26] Huddart and Lang (1996) show that the median fraction of life elapsed at the time of exercise ranges from 0.21 to 0.92 and the average is 0.37, which is 3.7 years if the maturity is ten years.

[27] The data comes from the data library on Kenneth French's website. The data range from 1992 to 2005 and are consistent with the data in the ExecuComp database. The average market return from 1927 to 2005 is 12.20%.

benchmark and use betas of 0.5 and 1.5 to show the results for firms with different levels of systematic risk. The risk-free rate is the same as that mentioned in the previous section.

3.4.3 Managerial Properties

In this model there are three components in the executive's personal wealth, which are cash, the firm's stock, and stock options. In addition, we assume the executive has negative exponential utility, which has the characteristic of constant absolute risk aversion. Moreover, the elasticity of the stock price is also a crucial component in our model in relation to others. Therefore, we establish a benchmark value for the elasticity of the stock price, non-option wealth, number of shares of stock and options, and coefficient of absolute risk aversion.

First, Bitler at el. (2005) estimate the effect of managerial effort, represented by weekly working hours, on firm performance. They find that the elasticity of firm sales with respect to working hours is 0.40, and the elasticity of firm profit is 0.55 and both are significant at the 1% level. Based on their result, we set the elasticity of the stock price with respect to managerial effort of 0.25 as a benchmark, which implicitly assume that the elasticity of the stock price to firm sales and profit are 0.625 and 0.45 respectively.[28] We also use 0.1 and 0.5 to represent low and high quality managers.

Second, most managers hold their firms' stock more than the optimal level due to vesting requirements and/or a negative signaling effect. Therefore, the stock component of non-option wealth should be higher than the optimal level in the benchmark. Based on the optimal holding of risky assets from Merton (1969), the optimal holding in the

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[28]Because the elasticity of stock price is one of our parameters rather than the elasticity of sales or profit, we convert the elasticity of sales or profit into the elasticity of stock price. In the transformation, we need the elasticity of stock price with respect to sales and profit to generate the elasticity of stock price with respect to effort. Under the assumption that the elasticity of stock price with respect to sales and price is equal to 0.625 and 0.45 respectively, we find the elasticity of stock price with effort is 0.25.

benchmark is 24%.[29] We assume the manager invests 40% of his wealth in the firm's stock as a benchmark to show that the manager bears higher than optimal firm-specific risk. In addition, we extend the stock-wealth ratio to 30% and 50% for low and high stock holdings. From ExecuComp, we find that the average stock wealth in year-end 2005 is $39.2 million, but the median is $1.6 million. Using the median stock wealth and 40% stock-wealth ratio assumption, we use $4 million as a benchmark for total non-option wealth. The richer and poorer managers have $2 and $6 million in their non-option wealth respectively. The number of shares of stock is equal to the stock wealth divided by the current stock price.

From ExecuComp, we find that the median number of options granted in executive compensation is 21,000 and the mean is 78,970. So the distribution of granted options is highly skewed. When we use only the CEO in the database, the median and mean are 60,000 and 191,000 respectively. Assuming the median is a better measure, we set the number of granted options equal to 40,000 and use 20,000 and 60,000 options to observe the effect of low and high option grants.

The last parameter of managerial properties is the coefficient of risk aversion. From Pratt (1964), the relation between absolute risk aversion, *ARA*, and relative risk aversion, *RRA*, is

$$ARA_t = \frac{RRA_t}{W_t}.$$

The commonly used *RRA* is from 2 to 4. We use *RRA* = 2 as the benchmark and *RRA* = 1 and 3 as the lower and higher relative risk aversions. Because negative exponential utility

[29]The optimal holding of risky assets is the expected return divided by the product of relative risk aversion and the variance of the stock returns. In our benchmark case, the expected return is 12% and variance is 25%. Assuming the coefficient of relative risk aversion is 2, the optimal holding of the firm's stock is 24%.

has the characteristic of constant absolute, rather than relative, risk aversion, the coefficient of *ARA* is 0.0000005 in the benchmark and 0.00000025 and 0.00000075 are for *RRA* = 1 and *RRA* = 3 respectively. We also analyze executive values with consideration of early exercise in the binomial model.

We use a monthly time step, which means $h = 12$.[30] The optimal effort and executive option values are lower than those in the continuous-time model. The difference does not change our qualitative results. Lambert and Larcker (2004) identify a technical issue concerning the validity of the first-order condition in solving the agent's problem.[31] Because we use the first-order condition to find the optimal effort, we examine whether this problem occurs in our model. To verify that the executive's expected utility is well-behaved, we use the parameters in the benchmark and draw the relation between expected utility and effort in Figure 3. From Figure 3, we find the expected utility is a well-behaved concave function with respect to managerial effort. Therefore, within the parameters chosen, the first-order condition is valid in our model.

[30]The qualitative results do not change when we use a weekly time step, where $h = 52$.

[31]They find that expected utility function is not a well-behaved concave function with respect to effort when the convexity of the manager's disutility dominates that of the option payoff.

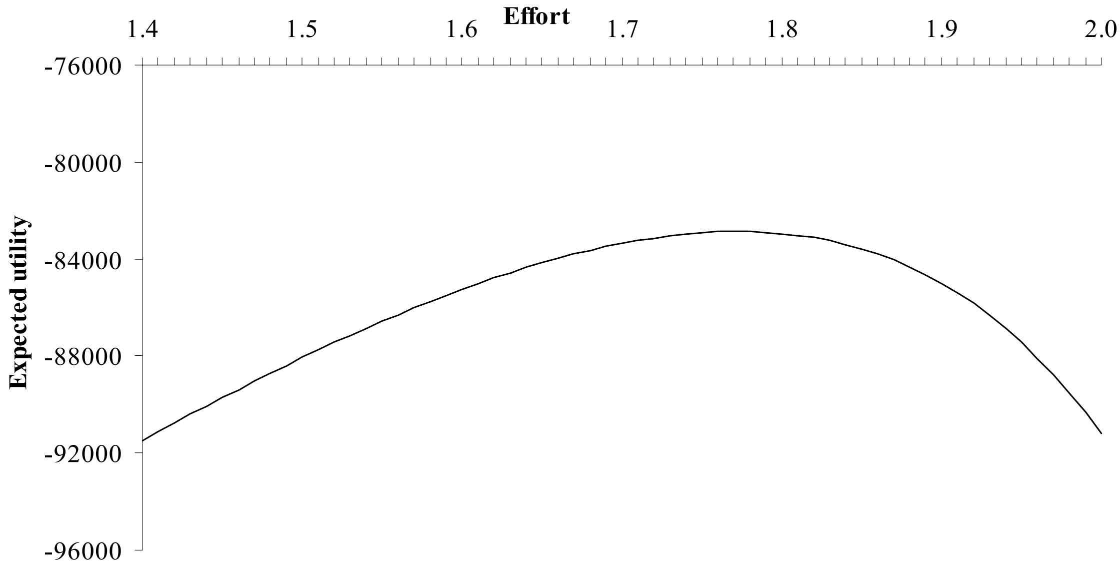

Figure 3: Expected Utility with Respect to Effort

Expected utility is computed under the benchmark assumptions of maturity = 10 years, volatility = 50%, expected market return = 12%, beta = 1, elasticity of stock price = 0.25, non-option wealth = $4 million, stock-wealth ratio = 40%, number of options = 40,000, and coefficient of absolute risk aversion = 0.0000005.

CHAPTER 4 SIMULATION RESULTS

The feature of managerial effort in both the binomial and continuous-time models provides an opportunity to analyze the effect of managerial ability on executive stock options. There is no unanimous proxy for managerial effort but managerial ability clearly affects firm values in the business world. Therefore, the interaction between effort and firm characteristics or managerial properties should affect the values of executive stock options. Because effort is unobservable, however, one way proposed in this paper to analyze their interaction is through simulations under different assumptions of firm characteristics and managerial properties. Based on the maximization of expected utility, we perform the comparative statics analysis of optimal effort and stock option value. Next, we summarize the simulation findings and provide possible explanations for these results. The detailed procedure of the simulation is summarized in Appendix I.

4.1 Optimal Managerial Effort

Using the continuous-time model, we estimate the annual optimal effort under different parameters and show the result in Table 1. Overall, the optimal efforts are greater than one, which means it is always optimal for the manager to exert extra effort. In addition, we find that optimal effort decreases with moneyness and this means that premium options induce more effort than discount options. Because effort is more valuable in low wealth, managers have a higher probability of having lower terminal wealth with premium options, ceteris paribus. Therefore, optimal effort decreases with moneyness. Moreover, we find that the optimal effort also decreases with maturity. There are two possible reasons for this negative relationship. The first reason is related to the time constraint. When the maturity becomes shorter, the manager would try harder to

Table 1: The Optimal Managerial Effort

The numbers in each cell are the optimal effort when the current stock prices are \$20, \$30, and \$40 respectively. When changing one parameter at a time, we keep all other parameters as their benchmark values. The bold values are the optimal effort of the at-the-money options.

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty (30%, 50%, 70%)	1.557	2.570	4.991	1.598	2.681	5.301	1.595	2.702	5.413
	1.547	**2.524**	**4.803**	**1.598**	**2.671**	**5.235**	**1.596**	**2.703**	**5.402**
	1.536	2.476	4.619	1.596	2.655	5.149	1.596	2.701	5.373
Elasticity, (0.1, 0.25, 0.5)	1.541	2.527	4.900				1.602	2.577	4.667
	1.542	**2.530**	**4.913**				**1.598**	**2.547**	**4.532**
	1.542	2.529	4.902				1.593	2.517	4.404
β (0.5, 1, 1.5)	1.606	2.705	5.366				1.589	2.655	5.233
	1.606	**2.697**	**5.311**				**1.587**	**2.642**	**5.160**
	1.604	2.684	5.230				1.585	2.624	5.066
Market return (10%, 12%, 14%)	1.603	2.694	5.338				1.593	2.667	5.262
	1.603	**2.686**	**5.279**				**1.592**	**2.655**	**5.193**
	1.601	2.672	5.196				1.589	2.638	5.101
Non-option wealth (2,000,000, 4,000,000, 6,000,000)	1.691	2.966	6.280				1.515	2.440	4.535
	1.688	**2.946**	**6.156**				**1.514**	**2.434**	**4.502**
	1.685	2.920	6.015				1.513	2.426	4.450
Stock ratio (30%, 40%, 50%)	1.580	2.654	5.274				1.617	2.709	5.332
	1.579	**2.642**	**5.201**				**1.616**	**2.700**	**5.276**
	1.577	2.625	5.105				1.615	2.686	5.197
Number of options (20,000, 40,000, 60,000)	1.599	2.682	5.308				1.598	2.680	5.291
	1.598	**2.676**	**5.273**				**1.597**	**2.665**	**5.205**
	1.597	2.667	5.222				1.595	2.645	5.091
Absolute risk aversion (0.00000025, 0.0000005, 0.00000075)	1.748	3.170	7.012				1.486	2.351	4.271
	1.747	**3.156**	**6.927**				**1.486**	**2.345**	**4.232**
	1.745	3.139	6.826				1.484	2.333	4.170

make the options expire in-the-money. In contrast, if the maturity is long, such as ten years, the manager has more time to exert his effort gradually, so the effort per period is low. That is, it is not necessary to work as hard in any one period to make the options expire in-the-money. The second reason is related to the disutility of effort. Because we assume that the manager determines optimal effort of each period at time 0 by the first-order condition and then keeps the same level of effort each period, the disutility of effort increases with time to maturity. In addition, the marginal disutility is an increasing function of the time period but the marginal utility is a decreasing function with respect to the time period. Therefore, the manager would reduce his effort to maximize his expected utility when the maturity is longer.

Second, the optimal effort decreases with non-option wealth, risk aversion, number of options, beta, and market return. The effect of non-option wealth is determined by the domain of the utility function. Even though the coefficient of absolute risk aversion is constant, managers with different levels of wealth require different risk premiums for the same risky assets. Due to the characteristics of negative exponential utility, we expect that managerial effort has a smaller effect on expected utility for relatively wealthier managers. Hence, under the same disutility function of effort, richer managers would exert less effort than those with lower wealth. From Table 1, we verify this result for non-option wealth. Effort decreases substantially with non-option wealth. For example, the effort decreases by 15% or 14% respectively when the manager's wealth increases from \$2 million to \$4 million or \$6 million dollars. Compared with the effect of beta or market return, the magnitudes of the changes in managerial effort due to different non-option wealth are greater. This finding implies that the effect of non-option wealth in the valuation of executive stock options dominates that of factors out of the manager's control.

In addition, risk aversion also has a substantial effect on managerial effort. Because the marginal utility with respect to effort decreases with risk aversion coefficient, more risk-averse managers should exert less effort to maximize their expected utility. In Table 1, the more risk-averse manager exerts lower effort than the less risk-averse manager when they face the same volatility. For example, we find that the manager with a risk aversion coefficient of 0.00000075 is willing to exert around 80% extra effort than the one with a risk aversion coefficient of 0.0000005 when options are issued at-the-money.

The effect of number of options on effort is relatively small, but negative, implying that managers work slightly harder the fewer options they have. This result seems to contradict the purpose of options. The main reason for the negative effect is the wealth effect of the option grant. Because an option grant is an add-on component in the manager's wealth, the more options in a grant, the lower the marginal effect of effort. Hence, larger option grants would reduce managerial effort. When comparing the optimal effort between restricted stock and options in Section 4.3, however, we find that options induce more effort than restricted stock under the same firm cost. For beta and market return, there exists a slightly negative relationship between optimal effort and beta or market return. Because the manager does not change the systematic risk in this model and cannot change the expected market return, the decrease in effort comes from the increase in the expected return of the firm. The increase in the expected return can increase managers' terminal wealth through their stock and option holding. From the analysis of non-option wealth above, we expect the negative relation between the portion of expected return that is out of the manager's control and the managerial effort.

Third, optimal effort has a positive relation with volatility and the stock-wealth ratio. The stock volatility affects the firm stock and options in the manager's portfolio. Therefore, the effect of volatility on effort is the sum of the effects of the firm stock and the options in the manager's portfolio. From Table 1, the firm stock, which is represented in the stock-wealth ratio, has a positive effect but the number of options has a negative effect on effort. Because the sum of both effects is positive, we expect that the effect of firm stock dominates that of options. To observe the effect of firm stock and options, we summarize the optimal effort in different combinations of stock and options under different volatility in Table 2. From Table 2, we find that both firm stock and options induce extra effort relative to the case of zero option and 0% stock-wealth ratio and this result is consistent with agency theory that managerial ownership can align the interests between shareholders and managers. Stock options provide a similar function to induce more effort in increasing firm value. The relationship between effort and stock-wealth ratio or number of options, however, is not monotonic. It depends on the magnitude of stock volatility, the stock-wealth ratio, and the number of options. When we look only at options, however, managerial effort decreases with the number of options in the low volatility case and the relation is not monotonic in the medium and high volatility cases.[32] We can explain this result from the partial derivative of marginal utility with respect to *n*:

[32]We compare the optimal effort with cash, restricted stock and option compensation separately under the same cost. We find that cash compensation induces more effort than restricted stock or options in the low volatility case. In medium and higher volatility cases, however, options induce more effort than restricted stock and cash compensation.

Table 2: Optimal Managerial Effort with Respect to Volatility, Stock-Wealth Ratio, and Number of Options

The numbers in each cell are the optimal effort when the current stock price is $30, which is an at-the-money option. When changing one parameter at a time, we keep all other parameters as their benchmark values. The maturity is three years for all cases.

Panel A: Low Volatility = 30%					
Stock-wealth ratio	Number of options (n)				
(*SR*)	*0*	*20,000*	*40,000*	*60,000*	*100,000*
SR=0%	1.000	5.245	5.119	4.948	4.678
SR=30%	5.194	5.017	4.866	4.742	4.557
SR=50%	5.010	4.867	4.750	4.654	4.508
SR=70%	4.870	4.760	4.669	4.595	4.479
Panel B: Medium Volatility = 50%					
Stock-wealth ratio	Number of options (n)				
(*SR*)	*0*	*20,000*	*40,000*	*60,000*	*100,000*
SR=0%	1.000	5.101	5.118	5.079	4.995
SR=30%	5.283	5.242	5.201	5.164	5.108
SR=50%	5.347	5.309	5.276	5.250	5.207
SR=70%	5.425	5.396	5.373	5.351	5.321
Panel C: High Volatility = 70%					
Stock-wealth ratio	Number of options (n)				
(*SR*)	*0*	*20,000*	*40,000*	*60,000*	*100,000*
SR=0%	1.000	4.886	4.967	4.980	4.976
SR=30%	5.288	5.296	5.294	5.285	5.273
SR=50%	5.523	5.518	5.513	5.508	5.499
SR=70%	5.760	5.755	5.751	5.747	5.735

$$\partial\left(\frac{\partial E\left(U\left(W_T\right)\right)}{\partial q_T}\right)\Big/\partial n = E\left(\frac{\partial\left(-\frac{1}{\rho}e^{-\rho W_T}\right)}{\partial q_T\partial n}\right) = E\left(e^{-\rho W_T}\left(-\rho\frac{\partial W_T}{\partial q_T}\frac{\partial W_T}{\partial n}+\frac{\partial^2 W_T}{\partial q_T\partial n}\right)\right) \tag{9}$$

$$= E_{S_T>K}\left(e^{-\rho W_T}S_T\delta q_T^{\delta-1}\left(-\rho n S_T^*+1\right)\right).$$

Because the marginal disutility is a linear function of q_t, the optimal level of effort increases with the marginal utility of terminal wealth. The marginal utility increases with the number of options when *n* is small or when volatility is high. This is what we observe in the medium and high volatility cases and the positive relationship exists only in smaller *n*.

Interestingly, when we add stock in the simulation, its effect dominates that of options. The positive relationship between volatility and effort also comes from the effect of firm stock. From Table 2, we find that managerial effort decreases with the stock-wealth ratio in the low volatility case but the relationship becomes positive in the medium and high volatility cases. We also use the partial derivative of marginal utility with respect to *m* to analyze this relation.

$$\partial\left(\frac{\partial E\left(U\left(W_T\right)\right)}{\partial q_T}\right)\Big/\partial m = E\left(\frac{\partial\left(-\frac{1}{\rho}e^{-\rho W_T}\right)}{\partial q_T\partial m}\right) = E\left(e^{-\rho W_T}\left(-\rho\frac{\partial W_T}{\partial q_T}\frac{\partial W_T}{\partial m}+\frac{\partial^2 W_T}{\partial q_T\partial m}\right)\right) \tag{10}$$

$$= E_{S_T>K}\left(e^{-\rho W_T}S_T\delta q_T^{\delta-1}\left(-\rho S_T^*\left(m+n\right)+1\right)\right)+E_{S_T\le K}\left(e^{-\rho W_T}S_T\delta q_T^{\delta-1}\left(-\rho S_T^* m+1\right)\right).$$

From Equation (10), we find that optimal effort increases with the number of shares when *m* is small and/or volatility is high. In Table 2, the positive relationship occurs in the medium and high volatility cases. In addition, we find the addition of options in the manager's portfolio reduces the effort. When *n* increases, the partial derivative (10) decreases unless the volatility is high enough to make the first term on the right-hand side positive. We see only two cases of high volatility that satisfy this condition, where the number of options changes from 0 to 20,000 or 40,000 with stock-wealth ratio of 0.3. This finding is consistent with that of Grout and Zalewska (2006). They show that the effect of high management ownership induced by an increase in options dampens the incentives to exert effort.

Finally, managerial effort has a non-monotonic relationship with the elasticity of stock price. This implies that medium quality managers work harder than low or high quality managers. This result has different explanations for different quality managers. From Equations (3), managerial effort is negatively related to δ, which means managers with high quality exert less effort. That is what we observe from benchmark quality to high quality. For managers with low quality, they exert less effort because they have the same disutility function as other managers. Therefore, one unit of effort from low quality managers has the same disutility but less influence on stock price. It is optimal for them to exert less effort. When we look at the incremental expected return with respect to the elasticity, the incremental expected return still increases with the elasticity. For 10-year at-the-money options, the incremental expected return is 4.33%, 11.72%, or 23.44% when the elasticity of stock price is 0.1, 0.25, or 0.5 respectively.

4.2 Option Values

To answer the question of how managerial effort affects the values of the options, we have to compute option values with optimal effort and minimum effort, where $\delta = 1$. We summarize the values with and without the optimal effort and the Black-Scholes values under different parameters in Table 3.

Table 3: Executive Option Values with and without Optimal Effort

The numbers in each cell are the option values when the current stock price is $30, which is an at-the-money option. When changing one parameter at a time, we keep all other parameters as their benchmark values. We use the optimal effort in the previous table to compute the option values in Panel A. When we change a parameter other than volatility, the Black-Scholes values are the same as those in the benchmark case in Panel C.

Panel A. Executive option value with optimal effort

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty	$12.88	$24.53	$35.46	$3.12	$7.56	$13.12	$1.05	$2.98	$5.75
Elasticity	$1.92	$3.78	$5.57				$5.95	$16.84	$32.79
β	$2.58	$6.69	$12.07				$3.71	$8.45	$14.19
Market return	$2.81	$7.06	$12.52				$3.46	$8.06	$13.73
Non-option wealth	$7.20	$15.42	$24.39				$1.52	$4.04	$7.54
Stock ratio	$4.38	$10.02	$16.62				$2.29	$5.83	$10.54
Number of options	$3.69	$8.83	$15.08				$2.71	$6.61	$11.63
Absolute risk aversion	$9.46	$20.04	$31.17				$1.31	$3.47	$6.47

Panel B. Executive option value without optimal effort

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty	$4.77	$5.36	$5.06	$1.38	$2.28	$2.83	$0.53	$1.12	$1.65
Elasticity	$1.38	$2.28	$2.83				$1.38	$2.28	$2.83
β	$1.07	$1.88	$2.43				$1.75	$2.72	$3.26
Market return	$1.20	$2.04	$2.59				$1.59	$2.52	$3.07
Non-option wealth	$3.02	$4.37	$4.89				$0.71	$1.29	$1.73
Stock ratio	$2.00	$3.11	$3.68				$0.98	$1.70	$2.20
Number of options	$1.62	$2.62	$3.21				$1.21	$2.01	$2.53
Absolute risk aversion	$3.73	$5.24	$5.70				$0.64	$1.16	$1.57

Panel C. Black-Scholes value

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty	$15.66	$10.71	$7.99	$20.12	$14.83	$11.53	$23.78	$18.54	$14.86

First, we find an interesting and counterintuitive result. Except for the low volatility case in Panel B, executive option values in Panels A and B decrease with maturity, which is opposite that of standard option valuation intuition.[33] A possible reason is that the manager who holds stock options is different from shareholders. Even though most options are European options, shareholders can sell them when they need liquidity. In contrast, the manager cannot sell their options so these option values can increase when the maturities decrease.[34] The only way to obtain liquidity is to exercise after the vesting period. Hence, the liquidity discount from the non-tradable constraint or legal restrictions can dominate the time value effect. If this is the main reason for the negative relation between executive option values and maturities, we expect that this relation should vanish when the manager can exercise early. We will check this result in the Section 4.4 when we allow the stock options to be exercisable after the grant date.

Second, comparing Panels A and B, we find, as expected, that option values increase after taking optimal effort into account. This finding is consistent with the result of the optimal effort in Table 1. The more effort the manager exerts, the more valuable the options will be. Because the values in Panel B are computed without extra effort, they are lower than those with extra effort in Panel A. Moreover, there exists a positive relationship between executive option values and the optimal efforts in each set of parameters between Table 1 and Panel A in Table 3. Combined with the discussion in the previous paragraph, we expect that the negative relation between the executive values

[33]This result is not unique to our model. When we use 50% volatility in the model of Hall and Murphy (2002), and keep other parameters the same with their assumptions, the option value also decreases when we change the maturity from 10 years to 15 years.

[34]This result does not always occur when managers can hedge their risk through other financial instruments or the market portfolio. Hence, it is not present in standard Black-Scholes analysis.

and maturities in Panel A results from not only the liquidity discount but also from the managerial effort.

Third, without consideration of managerial effort, these results are consistent with those in the literature in which executives value stock options at less than traded options. All values in Panel B are lower than those in Panel C.[35] This result, however, is not always the case when we take optimal effort into account. For example, we find in Panel A that executive option values are higher than Black-Scholes option values when the volatilities are low and the maturity is less than ten years. The Financial Accounting Standards Board (FASB) suggests that the fair value of a stock option should be estimated by taking into account the expected life of the option (FAS123, paragraph 19). The FASB's reasoning misses the point that the executive has the ability to affect the stock price. This ability can increase the value of stock options or restricted stock. Therefore, it is a misleading adjustment to use the expected life of the options because executive option values could be higher than the Black-Scholes values that would result from a maturity adjustment.

It is common to think that the values of stock options are substantially lower than the cost to the firm, which is represented by the Black-Scholes values. This paper contributes to the literature that this viewpoint is not always true when managers have the ability to affect the stock price. Managers are not ordinary investors who have no power to affect the values of the firms in which they invest. Ordinary investors are well-diversified price takers. In contrast, executives invest their human capital in their firms,

[35]Among those eight variables in the comparative statics analysis, the volatility is the only one that can affect the Black-Scholes value. Therefore, we report only the Black-Scholes values with respect to the changes in volatilities in Panel C. All executive option values, except those on the volatility row, can be compared with the Black-Scholes values in the benchmark case.

and thus can have some impact on firm values and stock prices. From this viewpoint, executives are not simply price takers. Ignoring this ability undervalues stock options substantially. In some cases, the manager values the options at higher than the Black-Scholes values due to managerial or firm's characteristics or the term of the stock options, especially when the manager is more capable or less risk averse or when the maturities are shorter. Part of the effect of these factors, however, is reflected through the optimal effort. We analyze these problems in Tables 4 and 5.

From the ratios of option values in Table 4, option values with optimal effort are consistently higher than those with minimum effort. This result holds for both discount and premium options for all variations of parameters. Interestingly, the ratios of option values decrease with maturity, which is consistent with the pattern of optimal effort in Table 1. From the analysis in Section 4.1, we know that the manager exerts more effort when the maturity is shorter. This additional factor magnifies the difference between option values with and without optimal effort. In addition, the difference in option values is greater when the manager's quality is high. For example, the manager with elasticity of 0.5 values the at-the-money option at 4.3, 7.4, and 11.59 times higher than those without extra effort, for ten, five, and three year-maturities respectively. Even though high quality managers exert less effort, they still value their options higher than other managers. This result implies that the undervaluation of the option is the greatest for managers with high quality.

The next serious undervaluation happens for the manager in a low volatility firm. Because the manager is risk averse, bearing too much firm specific risk can lower the value of the option. This finding is consistent with the trade-off relationship between

Table 4: Ratios of Executive Option Values with Optimal Effort to Those without Optimal Effort

The numbers in each cell are the ratios of executive option values when the current stock prices are $20, $30, and $40 respectively. When changing one parameter at a time, we keep all other parameters as their benchmark values. The bold values are ratios of the at-the-money options. The ratios are computed as executive option value with effort divided by executive option value without effort.

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty (30%, 50%, 70%)	3.30	6.92	13.72	2.51	4.11	6.52	2.10	3.01	4.26
	2.70	**4.58**	**7.01**	**2.26**	**3.32**	**4.64**	**1.97**	**2.66**	**3.49**
	2.44	3.77	5.27	2.11	2.93	3.83	1.90	2.47	3.09
Elasticity, (0.1, 0.25, 0.5)	1.44	1.81	2.28				5.21	10.38	18.65
	1.38	**1.66**	**1.97**				**4.30**	**7.40**	**11.59**
	1.35	1.57	1.81				3.83	6.19	9.39
β (0.5, 1, 1.5)	2.70	4.45	7.09				2.35	3.81	6.03
	2.42	**3.57**	**4.97**				**2.12**	**3.11**	**4.35**
	2.25	3.12	4.07				2.00	2.77	3.63
Market return (10%, 12%, 14%)	2.62	4.30	6.84				2.41	3.93	6.24
	2.34	**3.46**	**4.83**				**2.18**	**3.20**	**4.47**
	2.19	3.04	3.96				2.04	2.83	3.71
Non-option wealth (2,000,000, 4,000,000, 6,000,000)	2.64	4.30	6.88				2.37	3.90	6.18
	2.38	**3.53**	**4.99**				**2.13**	**3.15**	**4.37**
	2.24	3.14	4.17				2.00	2.77	3.58
Stock ratio (30%, 40%, 50%)	2.41	3.92	6.21				2.61	4.31	6.87
	2.19	**3.22**	**4.51**				**2.33**	**3.43**	**4.79**
	2.06	2.87	3.77				2.17	3.00	3.91
Number of options (20,000, 40,000, 60,000)	2.53	4.17	6.64				2.49	4.06	6.42
	2.28	**3.37**	**4.70**				**2.24**	**3.29**	**4.59**
	2.13	2.96	3.86				2.10	2.91	3.81
Absolute risk aversion (0.00000025, 0.0000005, 0.00000075)	2.82	4.72	7.68				2.27	3.68	5.76
	2.54	**3.82**	**5.46**				**2.06**	**3.00**	**4.12**
	2.38	3.38	4.51				1.93	2.65	3.42

incentives and risk in agency theory.[36] In addition, from the Geometric Brownian motion assumption, the probability of expiring in-the-money is negatively related to volatility. Therefore, managerial effort enhances the payoff of those in-the-money options.

Finally, the ratio decreases with moneyness of the options. Even though the manager exerts less effort with discount options, managerial effort plays a more crucial role for out-of-the-money options than for in-the-money options. Therefore, the underwater options could still have some incentives for the manager to exert extra effort, especially for the shorter maturity, which also increase the option values. From this result, we find that the underestimation of these option values is more serious for premium options than for discount options.

To measure the efficiency of the options, we use the ratio of option value to firm cost as a proxy. Assuming the Black-Scholes values represent the firm cost, we compute the ratio of option value with effort to firm cost in Table 5. These ratios are low in the cases of ten-year maturities but they increase when maturities decrease. This result is consistent with the previous analysis of the "negative" time value effect, or liquidity discount of the executive values. The Black-Scholes values are the values of European options. We know there is no liquidity discount for the non-tradable constraint in the Black-Scholes value. Therefore, the time value is positive and increases with maturity in the Black-Scholes formula. In contrast, the liquidity discount can dominate the positive time value in executive options. Hence, these cases are more likely to happen in options with longer maturity. Interestingly, we find that the manager values the options more than the firm cost in many cases of a three-year maturity. This result is uncommon in the

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[36]In the high volatility case, the option values are low even though managers exert more effort in this case. Both results, however, are due to the same reason. That is because the expected utility is relatively low in the high volatility case.

Table 5: Ratios of Executive Option Values with Effort to Black-Scholes Option Values

The numbers in each cell are the ratios of executive option values to Black-Scholes option values when the current stock prices are $20, $30, and $40 respectively. When changing one parameter at a time, we keep all other parameters as their benchmark values. The bold values are ratios that are greater than one.

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty (30%, 50%, 70%)	0.76	**2.75**	**7.15**	0.11	0.41	**1.09**	0.03	0.11	0.30
	0.82	**2.29**	**4.44**	0.16	0.51	**1.14**	0.04	0.16	0.39
	0.83	**2.05**	**3.56**	0.18	0.55	**1.11**	0.06	0.19	0.43
Elasticity, (0.1, 0.25, 0.5)	0.06	0.18	0.38				0.22	**1.04**	**3.12**
	0.10	0.25	0.48				0.30	**1.14**	**2.84**
	0.12	0.29	0.52				0.33	**1.15**	**2.73**
β (0.5, 1, 1.5)	0.09	0.36	0.99				0.13	0.47	**1.20**
	0.13	0.45	**1.05**				0.18	0.57	**1.23**
	0.15	0.49	**1.03**				0.21	0.60	**1.19**
Market return (10%, 12%, 14%)	0.10	0.38	**1.03**				0.12	0.45	**1.15**
	0.14	0.48	**1.09**				0.17	0.54	**1.19**
	0.16	0.51	**1.07**				0.20	0.58	**1.16**
Non-option wealth (2,000,000, 4,000,000, 6,000,000)	0.32	**1.07**	**2.52**				0.04	0.18	0.51
	0.36	**1.04**	**2.12**				0.08	0.27	0.65
	0.36	0.99	**1.86**				0.10	0.33	0.71
Stock ratio (30%, 40%, 50%)	0.17	0.61	**1.52**				0.07	0.29	0.80
	0.22	0.68	**1.44**				0.11	0.39	0.91
	0.24	0.69	**1.35**				0.14	0.44	0.93
Number of options (20,000, 40,000, 60,000)	0.12	0.47	**1.23**				0.10	0.37	0.98
	0.18	0.60	**1.31**				0.13	0.45	**1.01**
	0.22	0.65	**1.29**				0.15	0.47	0.98
Absolute risk aversion (0.00000025, 0.0000005, 0.00000075)	0.41	**1.36**	**3.19**				0.04	0.15	0.44
	0.47	**1.35**	**2.70**				0.07	0.23	0.56
	0.49	**1.30**	**2.39**				0.09	0.28	0.61

literature.[37] The effect of effort could dominate the liquidity discount so that the option values of executive stock options would be higher than Black-Scholes values. Hence, the argument that some firms give that Black-Scholes gives too high a value at which to expense their options is wrong. In some cases Black-Scholes can lead to an expense figure that is too low.

From the comparison between discount and premium options in the previous analysis, we know that the exercise price has an effect on both optimal effort and executive option values. To find the relationship between optimal effort and exercise price, we compute optimal effort with respect to different exercise prices and show this relationship in Figure 4. There are two major findings in Figure 4. First, we find a positive relationship between optimal effort and exercise price in the 30% and 50% volatility cases. This implies that premium options induce more effort than discount options, which is consistent with what we found in Section 4.1. When the exercise price is higher, it decreases the manager's terminal wealth. Therefore, managerial effort becomes more valuable in the low wealth case. Second, Figure 4 also shows that options with positive exercise prices induce more effort than those with exercise price of zero. Restricted stock, which is introduced in detail in the next section, is similar to an option with an exercise price of zero.[38] From Figure 4, we find restricted stock, as proxied by an option with zero exercise price, induces less effort than stock options with positive exercise price.

[37] In perfect market assumptions, this result could not happen because no one can consistently create abnormal returns. If we consider managerial effort as a kind of intangible and unobservable asset of the firm and it can increase the expected firm value consistently, then this result could occur in some cases.

[38] In addition, restricted stock has some sales restrictions that differ from stock options. We ignore these restrictions in this model.

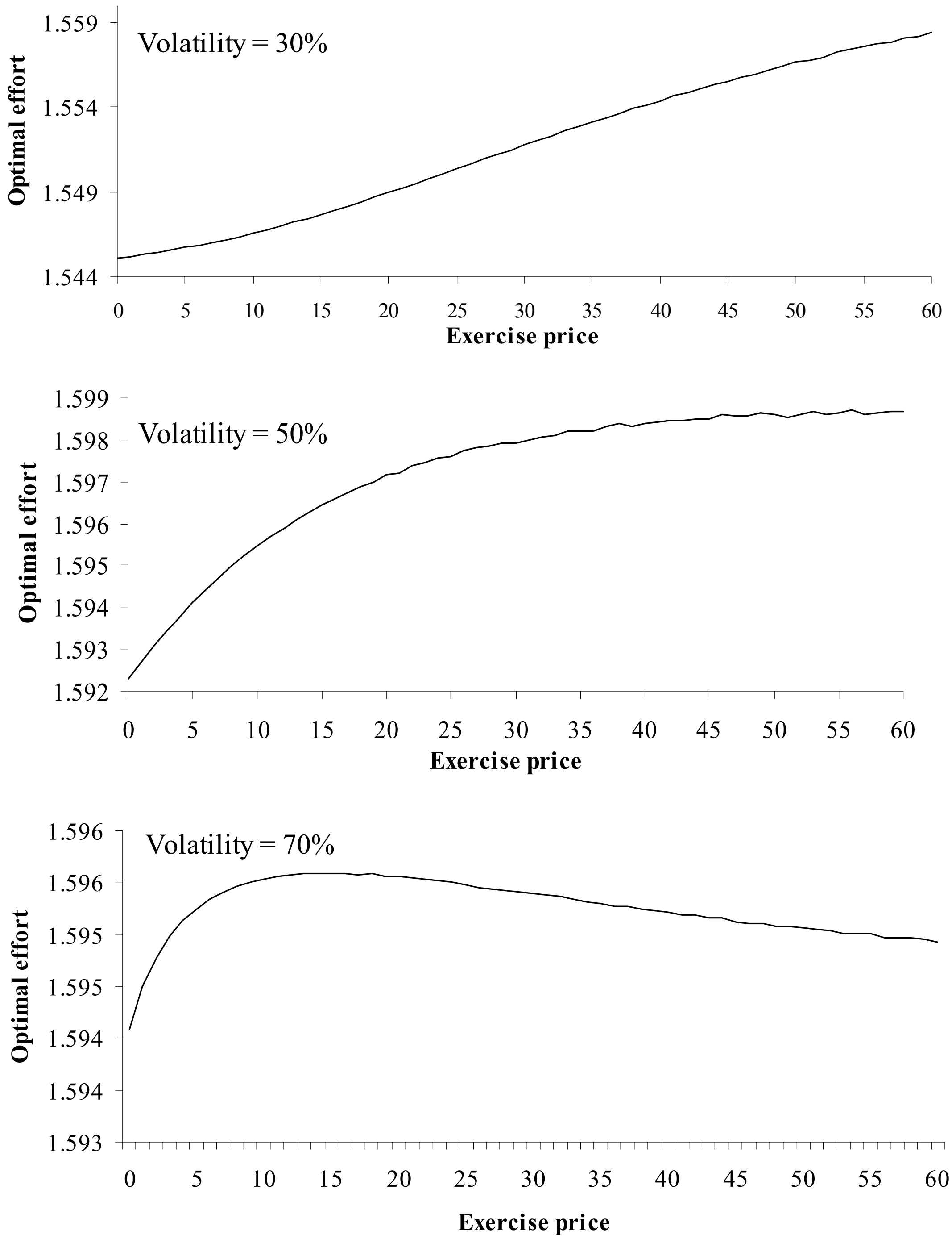

Figure 4: The Relationship between Optimal Effort and Exercise Price

Expected utility is computed under the benchmark assumptions of maturity = 10 years, volatility = 50%, 30%, and 70%, expected market return = 12%, beta = 1, elasticity of stock price = 0.25, non-option wealth = \$4 million, stock-wealth ratio = 40%, and coefficient of absolute risk aversion = 0.0000005. The exercise price changes \$1 at a time from \$0 to \$60. The total Black-Scholes value of these options is \$400,000 under different exercise prices. Therefore, the number of options is generated by using \$400,000 divided by the Black-Scholes value under different exercise prices. The current stock price is \$30.

Feltham and Wu (2001) show that the effort decreases with the exercise price of these options. That is what we observe in the 70% volatility case in Figure 4. There should be a counter effect of higher exercise price on managerial effort. From the 70% volatility case in Figure 4, the highest effort exists at the exercise price of $14 rather than the at-the-money exercise price of $30. In addition, optimal effort increases with exercise prices from $0 to $14, which is the original observed result. When the exercise price exceeds $16, however, effort decreases with the exercise price because the marginal effect of the effort decreases. In this range, the positive effect of wealth reduction on effort is dominated by the negative effect of increasing exercise price on effort. Therefore, the manager exerts less effort if the exercise price is higher than $14. We illustrate the trade-off relationship between both effects on managerial effort in Appendix II.

4.3 Restricted Stock

Restricted stock is stock with a vesting restriction such that it becomes ordinary stock after a specific period of time. Therefore, restricted stock is a special case of stock options. To compare the previous results with those of restricted stock, we perform the same comparative statics analysis for restricted stock, which are the stock options with exercise price of zero.[39] The optimal effort and ratio analyses are reported in Table 6. Except for the three-year maturity in the low volatility case, we find in Panel A that restricted stock induces lower optimal effort compared to options in Table 1. This result is consistent with Lambert and Larcker (2004) who find that option-based contracts dominate restricted stock from the standpoint of the incentive to induce managerial effort. In Panel B, the ratios of executive option values with optimal effort to that without

[39]Because restricted stock is equivalent to an in-the-money option in all cases of positive stock prices, we report only the result for the stock price equal to $30, which is the at-the-money case for stock options.

Table 6: The Optimal Managerial Effort and Value Ratio of Restricted Stocks

We report only the result of the case of a $30 stock price and set the exercise price to zero for restricted stocks. The number of restricted stock shares is calculated by setting the firm cost of restricted stock equal to that of 5,000 stock options. When changing one parameter at a time, we keep all other parameters as their benchmark values. The bold values in Panel C are ratios that are greater than one.

Panel A. Optimal mangerial effort

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty	1.536	2.523	4.901				1.593	2.675	5.288
Elasticity	1.535	2.500	4.806				1.584	2.522	4.553
β	1.596	2.659	5.211				1.575	2.605	5.076
Market return	1.592	2.648	5.182	1.586	2.633	5.144	1.580	2.617	5.105
Non-option wealth	1.675	2.902	6.065				1.506	2.403	4.420
Stock ratio	1.568	2.604	5.109				1.605	2.663	5.183
Number of options	1.592	2.657	5.227				1.581	2.610	5.065
Absolute risk aversion	1.739	3.133	6.884				1.473	2.301	4.114

Panel B. Ratio of executive value with effort to that without effort

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty	1.70	2.10	2.42				1.49	1.66	1.82
Elasticity	1.19	1.26	1.33				2.24	2.86	3.45
β	1.59	1.83	2.05				1.50	1.75	1.99
Market return	1.57	1.81	2.04	1.54	1.79	2.02	1.52	1.77	2.00
Non-option wealth	1.70	2.04	2.37				1.44	1.64	1.81
Stock ratio	1.56	1.83	2.09				1.53	1.76	1.97
Number of options	1.55	1.80	2.02				1.54	1.79	2.02
Absolute risk aversion	1.78	2.15	2.51				1.41	1.61	1.78

Panel C. Ratio of executive value with effort to Black-Scholes value

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty	**1.08**	**1.75**	**2.22**				0.22	0.50	0.80
Elasticity	0.35	0.63	0.85				0.65	**1.42**	**2.21**
β	0.41	0.83	**1.24**				0.50	0.94	**1.35**
Market return	0.42	0.86	**1.26**	0.45	0.89	**1.29**	0.48	0.92	**1.32**
Non-option wealth	0.67	**1.29**	**1.83**				0.34	0.68	**1.01**
Stock ratio	0.52	**1.01**	**1.46**				0.40	0.80	**1.17**
Number of options	0.48	0.92	**1.33**				0.43	0.86	**1.26**
Absolute risk aversion	0.77	**1.44**	**2.01**				0.32	0.65	0.97

optimal effort are in general less than three, except for a three-year maturity in the high elasticity case. Due to the decreasing marginal effect of the effort with respect to wealth, and compared with Table 4, the underestimation of stock options is alleviated when the exercise price equals to zero. It is, however, still substantial for the manager with high elasticity of stock price. In addition, the Black-Scholes values converge to the current stock price when the exercise price is zero. In Panel C, it is still possible that the value of restricted stock is higher than the current market price, especially for the cases with three years maturity. It is straightforward that restricted stock could be worth more for the manager than for ordinary investors when the manager has the ability to influence the firm performance by effort and the current stock price does not reflect this ability.

Interestingly, from the standpoint of efficiency, we compare Panel C in Table 6 with Table 5 and find that restricted stock is more efficient than stock options. It seems to be a puzzle that restricted stock induces less effort but is more efficient than stock options. Comparing the results between Lambert and Larcker (2004) and Hall and Murphy (2001), their different arguments about the incentive effect between restricted stock and stock options are very similar to the puzzle we find. To reconcile both arguments in our result, we find the relationship between option values and exercise prices in Figure 5. From Figure 5, the value of restricted stock is the highest relative to other options with positive exercise prices. That means the restricted stock is the most valuable from the executive's standpoint, which results from the incremental expected utility of the wealth effect on restricted stock. Meanwhile, the wealth effect reduces the marginal effect of the effort and finally decreases the optimal effort. Therefore, we observe higher efficiency but lower managerial effort with restricted stock. Because the results in Tables 5 and 6 are

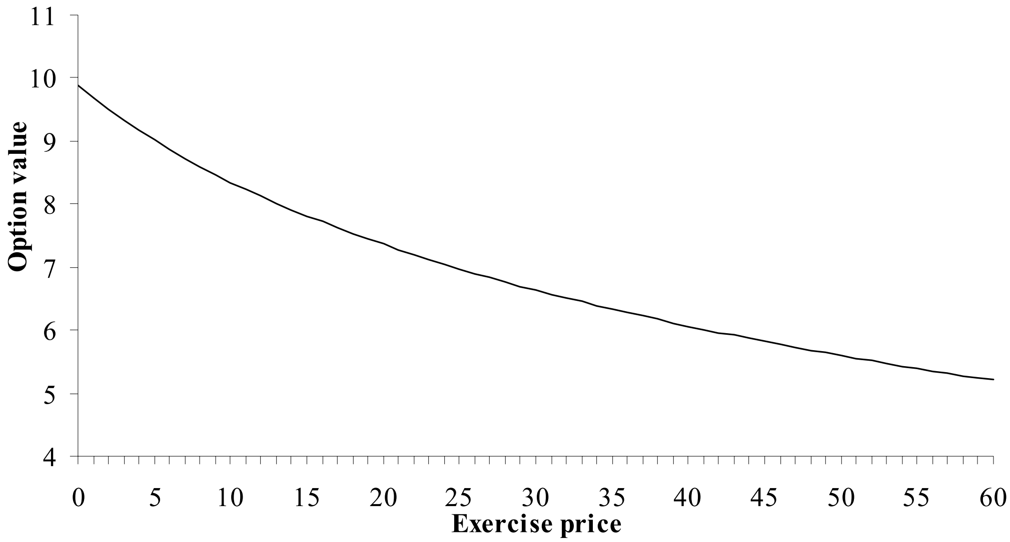

Figure 5: The Relationship between Option Value and Exercise Price

The option values are computed under the benchmark assumptions of maturity = 10 years, volatility = 50%, expected market return = 12%, beta = 1, elasticity of stock price = 0.25, non-option wealth = $4 million, stock-wealth ratio = 40%, and coefficient of absolute risk aversion = 0.0000005. The exercise price changes $1 at a time from $0 to $60. The total Black-Scholes values of these options is $400,000 under different exercise prices. Therefore, the number of options is generated by using $400,000 divided by the Black-Scholes value under different exercise prices. The current stock price is $30.

computed under the same firm cost, we conclude that stock options can induce more effort than restricted stock under the same firm cost.

4.4 Early Exercise

Executive stock options are non-tradable and non-exercisable during the vesting period. The only way to obtain liquidity from these options is to exercise early after the vesting period. Under the assumption that optimal effort does not change with early exercise, we analyze the effect of optimal effort on the behavior of early exercise in this section. Early exercise can meet the manager's demand for liquidity and therefore, it should increase the executive option values. It is difficult to observe the decision to exercise early but it is much easier to observe the decision in a binomial tree. Applying the binomial model, we summarize the values of the options after taking early exercise into account and the ratios of option values with effort to those without effort in Table 7.

Table 7: Executive Option Values with Consideration of Early Exercise

The numbers in each cell are the option values when the current stock price is $30, which is an at-the-money option. When changing one parameter at a time, we keep all other parameters as their benchmark values. We use the optimal effort in the binomial model without consideration of early exercise to compute the option values in Panel A. We assume the options are exercisable after they are granted and use a monthly time step in the binomial model.

Panel A. Value of exercisable options with managerial effort (1)

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty	$16.00	$24.47	$34.76	$11.59	$12.71	$15.18	$11.86	$11.50	$11.77
Elasticity	$9.75	$8.99	$8.71				$15.30	$21.57	$34.18
β	$10.78	$11.89	$14.29				$12.49	$13.52	$16.06
Market return	$11.13	$12.24	$14.67				$12.13	$13.17	$15.69
Non-option wealth	$15.13	$18.84	$24.87				$9.89	$9.89	$10.82
Stock ratio	$12.71	$14.49	$17.96				$10.84	$11.43	$13.21
Number of options	$13.41	$14.26	$17.01				$10.34	$11.56	$13.82
Absolute risk aversion	$18.57	$23.23	$31.26				$8.84	$9.00	$9.84

Panel B. Value of exercisable options without managerial effort (2)

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty	$8.62	$7.08	$5.87	$8.78	$7.26	$6.18	$9.88	$8.32	$7.01
Elasticity	$8.78	$7.26	$6.18				$8.78	$7.26	$6.18
β	$8.12	$6.73	$5.80				$9.45	$7.81	$6.59
Market return	$8.40	$6.96	$5.97				$9.15	$7.58	$6.41
Non-option wealth	$10.25	$8.78	$7.58				$7.98	$6.38	$5.38
Stock ratio	$9.35	$7.92	$6.77				$8.34	$6.76	$5.75
Number of options	$9.93	$7.88	$6.59				$7.96	$6.75	$5.87
Absolute risk aversion	$11.82	$9.74	$8.21				$7.22	$6.03	$5.10

Panel C. Ratio of executive value with effort to that without effort (1)/(2)

	Lower value			Benchmark			Higher value		
	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
Volatilty	1.86	3.45	5.92	1.32	1.75	2.45	1.20	1.38	1.68
Elasticity	1.11	1.24	1.41				1.74	2.97	5.53
β	1.33	1.77	2.46				1.32	1.73	2.44
Market return	1.32	1.76	2.46				1.33	1.74	2.45
Non-option wealth	1.48	2.15	3.28				1.24	1.55	2.01
Stock ratio	1.36	1.83	2.65				1.30	1.69	2.30
Number of options	1.35	1.81	2.58				1.30	1.71	2.35
Absolute risk aversion	1.57	2.39	3.81				1.22	1.49	1.93

As expected, the addition of early exercise increases the executive values of these options with and without consideration of managerial effort. This result is especially true for options with ten years maturity. Interestingly, all numbers in Panel A are greater than those in Panel B. This finding implies that the addition of early exercise alleviates the underestimation of these options but we still find, in Panel C, some option values with consideration of effort more than twice those without effort, such as the cases of low volatility and high elasticity of stock price. From Panel B in Table 7 compared with that in Table 3, we find that the longer the maturity, the more valuable is early exercise. In addition, the negative relation between option values and maturities disappears in Panel B after the consideration of early exercise. This result is consistent with the explanation of the negative relation we provide in Section 4.2. Since the liquidity discount is reduced due to early exercise, the effect of positive time value is recovered in the option value without managerial effort. For the cases with effort, we find the negative relation comes from two factors, the liquidity discount and the managerial effort as in the previous analysis. Because only the effect of the liquidity discount is excluded, there still exists the trade-off relation between the effort and time value effects. Therefore, the negative relation still exists in many cases in Panel A.

From the literature, two important factors that can affect substantially the decision to exercise early are the manager's stock holdings and risk aversion. When managers are more risk averse or have high stock holdings, they may choose to exercise at lower stock prices. Comparing the previous results with effort, we find that the elasticity plays a dominant role in the determination of option values, which can dominate the two factors. We report the changes of option values after consideration of early exercise in Table 8.

Table 8: Liquidity Premium with Respect to Elasticity of Managerial Effort

The numbers in each cell are the option values when the current stock prices are \$20, \$30, and \$40 respectively. When changing one parameter at a time, we keep all other parameters as their benchmark values. The executive values in Panels A and B are computed by using the same optimal effort from the binomial model without consideration of early exercise.

Panel A. Option value with effort consideration (1)

S	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
		δ =0.1			δ =0.25			δ =0.5	
\$20	\$0.99	\$2.04	\$2.84	\$2.07	\$5.28	\$8.09	\$3.84	\$10.54	\$16.66
\$30	\$2.16	\$4.00	\$5.33	\$3.27	\$7.34	\$10.80	\$5.08	\$12.77	\$19.66
\$40	\$3.78	\$6.82	\$9.08	\$4.90	\$10.24	\$14.73	\$6.75	\$15.79	\$23.83

Panel B. Option value with effort and early exercise consideration (2)

S	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
		δ =0.1			δ =0.25			δ =0.5	
\$20	\$5.65	\$4.49	\$4.30	\$6.83	\$8.25	\$10.67	\$8.83	\$14.75	\$22.35
\$30	\$11.54	\$9.60	\$8.90	\$12.62	\$13.14	\$15.33	\$14.48	\$19.60	\$27.63
\$40	\$18.47	\$16.21	\$15.30	\$19.45	\$19.40	\$21.43	\$21.13	\$25.59	\$34.34

Panel C. Liquidity premium (2)-(1)

S	T=10	T=5	T=3	T=10	T=5	T=3	T=10	T=5	T=3
		δ =0.1			δ =0.25			δ =0.5	
\$20	\$4.66	\$2.45	\$1.47	\$4.76	\$2.97	\$2.58	\$4.99	\$4.21	\$5.69
\$30	\$9.38	\$5.60	\$3.57	\$9.35	\$5.79	\$4.53	\$9.40	\$6.82	\$7.97
\$40	\$14.69	\$9.39	\$6.22	\$14.55	\$9.16	\$6.70	\$14.39	\$9.80	\$10.50

To observe the change of behavior with early exercise, we must find the effect of managerial effort on the behavior of early exercise without changing these two factors in the first step. One easier way to observe this effect is to compare the behavior of early exercise among managers with different elasticities of stock price. There are three findings in Table 8. First, managers with high elasticity value their options higher than other managers do in all combinations of maturity and moneyness. From Panels A and B, this result is consistent regardless of consideration of early exercise. Even though we find that high quality managers exert less effort than medium quality ones in Table 1, they still place higher value on their options due to their quality.

Second, in Panel C, the liquidity premium increases with moneyness and maturity. Because discount options have a higher probability of expiring in-the-money, the manager has a better chance to capture the intrinsic value through early exercise. Therefore, early exercise is more valuable in discount options than premium options. Following the previous explanation of the liquidity discount, we know that longer maturity has a higher liquidity discount. Therefore the liquidity premium increases with maturity. Finally, liquidity premiums in general increase with the elasticity of stock price. This means that the addition of early exercise is more valuable for managers with high quality, because capable managers may choose to exercise their options after the stock price reflects their effort. Hence, we expect capable managers would exercise at higher stock prices. To verify the relation between the elasticity of stock price and the decision to exercise early, we compute the threshold price, which is the critical stock price for the decision of early exercise. We summarize these threshold prices with respect to the elasticity of stock price that implies different manager's quality in Figure 6.

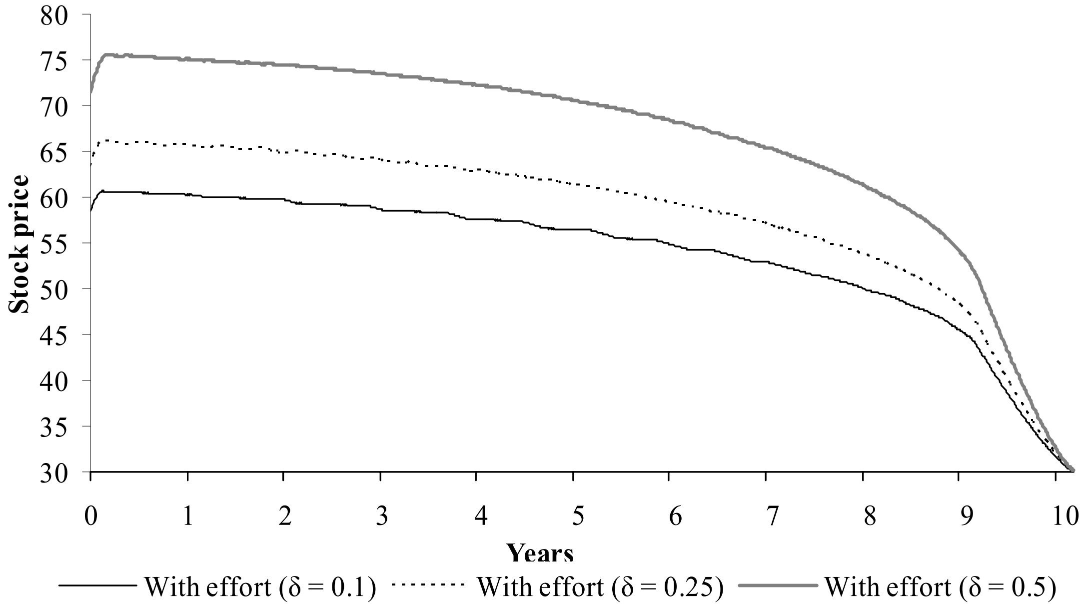

Figure 6: The Threshold Prices for Different Managerial Quality

The threshold price is the critical price for the decision to exercise early. When the stock price is higher than the threshold price, the manager will exercise his options. Otherwise, the manager will hold these options and re-evaluate whether to exercise at the next time step. We change the elasticity of stock price but keep all other parameters as their benchmark values. Because the threshold price is a stepwise function, we smooth the curve by using linear interpolation. In addition, we also increase the number of time steps each year from 12 to 100.

In Figure 6, the threshold prices are positively related to the elasticity of stock price. For example, in year 3, the manager with lowest quality, $\delta = 0.1$, will exercise the options when the stock price is above \$58.58 but the manager with highest quality, $\delta = 0.5$, will wait until the stock price is over \$73.73. This result is consistent with our expectation. Suppose managers know their ability and the effort they exert.[40] Holding the options longer can increase their expected wealth, which also increases their expected utility. Based on the higher expected utility of continuously holding, the threshold prices should be higher for more capable managers. The behavior, however, is not significantly different in the last year. From this result, we expect the manager who

[40]Here we assume managers know their ability with complete accuracy. The case of overconfidence is not an issue in the analysis.

exerts more effort will wait longer to exercise the options. Therefore, the effect of the effort would interact with that of risk aversion or stock holding on the behavior of early exercise, which is examined in the following analysis.

From the results in Section 4.1, we know the manager would exert more effort with his/her stock holdings but less effort with his/her risk aversion. Hence, the decision to exercise early with respect to different risk aversion should be similar with the finding in the literature without consideration of managerial effort. The more risk-averse manager would exercise stock options at lower stock prices, after taking effort into account. We show the change of the threshold price for the early exercise decision with respect to the coefficients of risk aversion and the manager's quality in Figure 7.

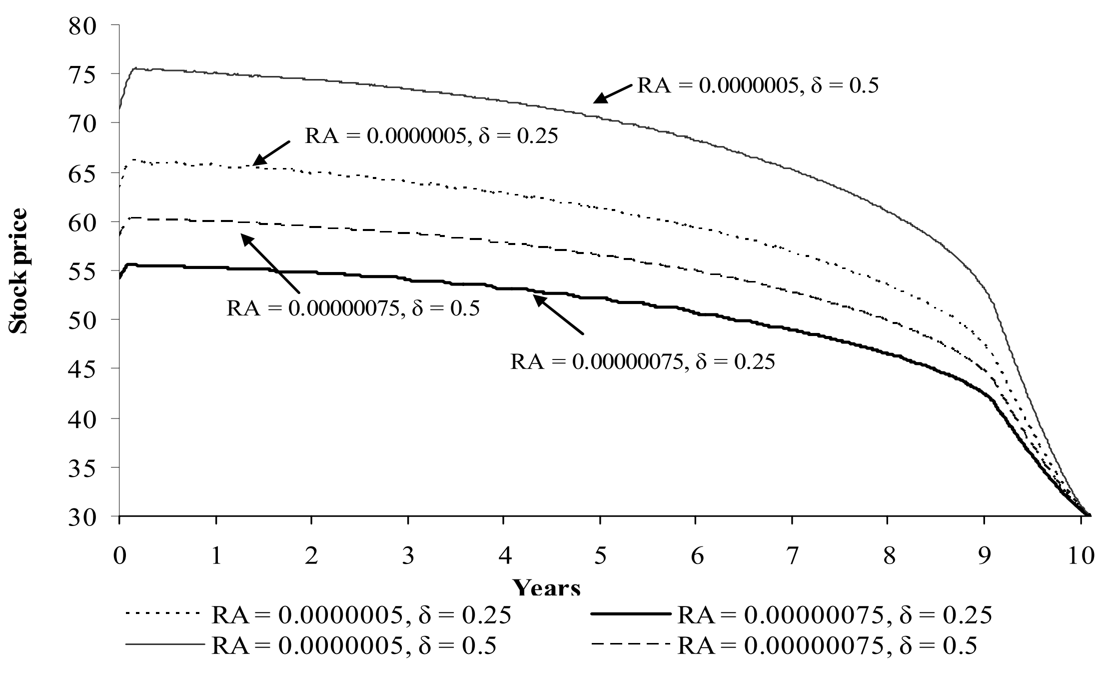

Figure 7: The Threshold Prices for Different Risk Aversion

The threshold price is the critical price for the decision to exercise early. When the stock price is higher than the threshold price, the manager will exercise his options. Otherwise, the manager will hold these options and re-evaluate whether to exercise at the next time step. We change the coefficient of absolute risk aversion and the elasticity of stock price but keep all other parameters as their benchmark values. Because the threshold price is a stepwise function, we smooth the curve by using linear interpolation. In addition, we also increase the number of time steps each year from 12 to 100.

From Figure 7, we find the expected relation between the threshold stock prices and the coefficient of risk aversion regardless of the manager's quality. The most risk averse and medium quality manager exercises the options with the stock price below $56. The threshold stock price for the less risk-averse medium quality manager is above $64 within the first three years. The managerial effort resulting from risk aversion has a similar effect as risk aversion on the behavior of early exercise. Therefore, we find that managerial effort enhances the effect of risk aversion on the decision to exercise early. It is worth noting that the manager's quality can increase the threshold price. The original result, however, still holds when we allow managers to improve their quality.[41] Hence, consideration of the manager's quality does not change the pattern of the effect of risk aversion on early exercise.

An existing result in the literature states that less diversified managers would exercise at a lower stock price compared with ordinary diversified investors. Because managers can reduce firm specific risk by early exercise, they would do it as soon as the options are vested. This is the result without consideration of managerial ability. From the previous analysis, we know that there is a counteracting effect between stock wealth and managerial effort resulting from the stock-wealth ratio on the behavior of early exercise. The change in the threshold stock price with respect to the stock-wealth ratio is shown in Figure 8. In Figure 8, the decision to exercise early with respect to the stock-wealth ratio is consistent with that in the literature after we consider the effect of the effort in different stock holdings. Managers want to exercise their options at a lower

[41]A learning process would improve the manager's quality. In the model, we hold the manager's quality constant within the maturity of options when we analyze the effect of other parameters. Managers, however, may have better quality in different option grants or in different companies due to the accumulation of management experience.

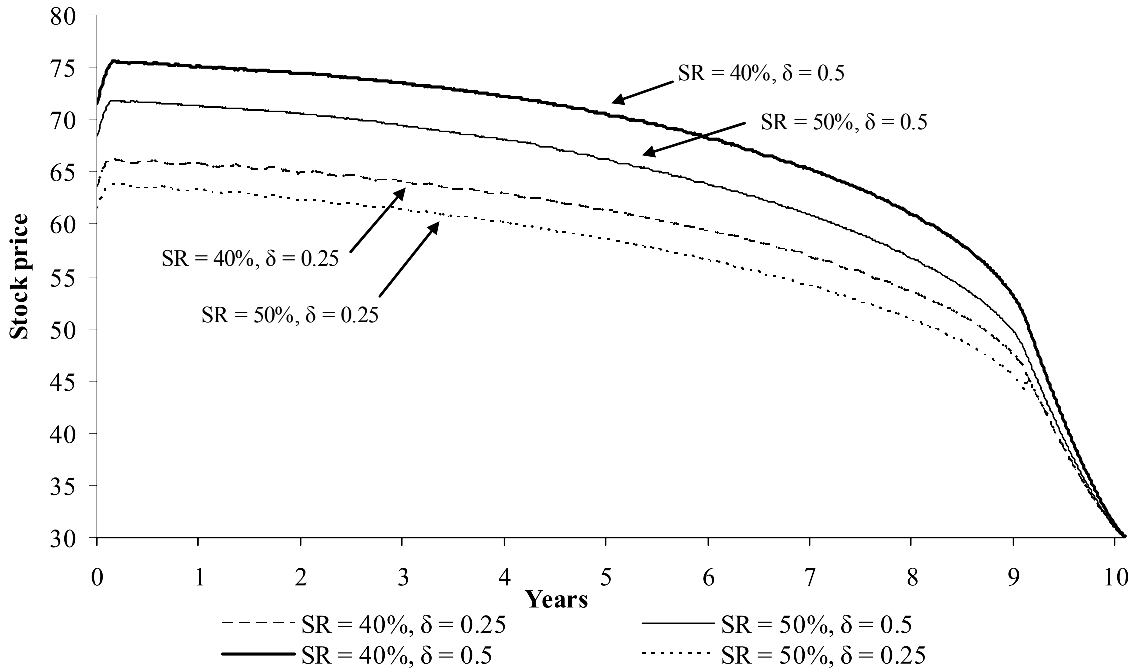

Figure 8: The Threshold Price for Different Stock-Wealth Ratios

The threshold price is the critical price for the decision to exercise early. When the stock price is higher than the threshold price, the manager will exercise his options. Otherwise, the manager will hold these options and re-evaluate whether to exercise at the next time step. We change the stock-wealth ratio but keep all other parameters as their benchmark values. Because the threshold price is a stepwise function, we smooth the curve by using linear interpolation. In addition, we also increase the number of time steps each year from 12 to 100.

stock price when they have a higher stock wealth. For example, the manager with 50% stock wealth exercises the options at a lower threshold stock price than the one with 40% stock wealth before the expiration date. The threshold price of early exercise changes when their quality is improved. When managers with a 50% stock-wealth ratio improve their quality from 0.25 to 0.5, they choose to exercise their options at a higher price than the threshold prices of medium quality managers with a 40% stock wealth. Hence, the effect of managerial effort upon the manager's quality could dominate that of stock wealth in some cases of high elasticity of stock price.

CHAPTER 5 IMPLICATIONS AND EMPIRICAL TESTS

To summarize the finding so far, we conclude that managerial ability to influence the stock price is important in the valuation of executive stock options. It is optimal for managers to exert different degrees of effort under different situations. Therefore, option values under these situations are also affected substantially by effort exerted. Ignoring this effect could cause underestimation of not only the option values but also the efficiency of these options. For example, all option values with optimal effort are higher than those without effort. In addition, managers may value these options higher than their market counterparts, which are the Black-Scholes values. These results show that the effect of managerial ability can dominate that of undiversification, illiquidity, and/or risk aversion.

5.1 Testable Implications and Hypotheses

From the analysis above, we find that managerial ability can have a substantial effect on the values of executive stock options. The solution of the manager's problem shows that it is optimal for the manager to exert extra effort when the elasticity of stock price is positive. These option values and managerial effort, however, cannot be observed in the market. We cannot directly test the relationship between option value and managerial effort. Instead, because we connect the incremental expected returns with managerial effort, we can test the implications of the incremental expected returns in our model. Due to the positive relationship between managerial effort and the incremental expected return, all other things being equal, the increase in the incremental expected return implies that the manager exerts more effort. We summarize the testable implications as follows.

First, in Section 3, we connected managerial effort with incremental expected stock return. Therefore, the incremental expected return should be related to the parameters we use in the simulations. For example, the incremental expected return should be positively related to the quality of the manager, the stock-wealth ratio, the number of stock options, and the stock return volatility. It should be negatively related to beta, market return, the manager's non-option wealth, and absolute risk aversion. Whether these relationships hold is an empirical question and we will test them in the next section.

Hypothesis 1: Based on the result of managerial ability, incremental expected return driven by managerial effort should be positively related to managerial ownership, stock volatility, and the manager's quality and negatively related to the manager's wealth.

Hall (2003) argues that one of the challenges of stock-based compensation is to avoid excessive pay to top executives. We get the second implication from the result relating to the values of stock options. Stock options are more efficient when executives value these options higher. Therefore, we expect that firms should use stock options to compensate their executives when they are more capable, have lower non-option wealth, more stock holdings, or less risk aversion.

Hypothesis 2: Based on the result of more effort from stock options than cash compensation, we expect that managers who receive more stock options exert more effort. Alternatively, firms that grant more stock options have higher incremental expected returns.

Third, the pay-for-performance relationship is another stream in the literature of executive compensation. Hall and Liebman (1998) mention that most people believe that CEOs are paid like bureaucrats.[42] There is no unanimous conclusion about this issue, especially for stock-based compensation. From our analysis, we get the second implication about pay-for-performance sensitivity after taking managerial ability into account. Based on the result of optimal effort, we expect a stronger pay-for-performance sensitivity when managers have low non-option wealth, or high managerial ownership. The same relation should also be observed when top executives are more capable or have low absolute risk aversion. Hall and Liebman (1998) use the data of the largest public U.S. firms to test the pay-for-performance relationship and find a strong relationship for these large firms. In addition, Baker and Hall (2004) show that marginal productivity of effort, which is a proxy for the manager's quality, increases significantly with firm size. Combining both findings, it seems consistent with our implication that the more capable the managers, the stronger the pay-for-performance relationship would be.

Hypothesis 3: If stock-based compensation is used efficiently, then pay-for-performance sensitivity should be stronger for those firms whose managers exert more effort. Those firms should have high incremental expected returns or managers in those firms have high ownership or low wealth.

Finally, we find that the behavior of early exercise is affected by the manager's risk aversion and his stock ownership. Managerial effort, however, can change this

[42] The argument is first stated in Jensen and Murphy (1990a): " In most publicly held companies, the compensation of top executives is virtually independent of performance. On average, corporate America pays its most important leaders like bureaucrats." They address the question of whether executive pay is related to firm performance.

behavior and have a dominant role, compared with the previous literature. The final implication suggests that there exist a trade-off relationship of the manager's ownership in the decision to exercise early. When managers have more stock holdings, the marginal effect of effort can dominate the effect of suboptimal stock holdings. Managers can hold these stock options longer than they suppose to do. They would like to exercise their options after the effort is reflected in the stock price and it can take more time in most cases.

5.2 Empirical Analysis

Managerial effort is a key factor in our model but an unobservable variable in the real world. Based on the inference of the model, we expect a positive relationship between managerial effort and incremental expected return. Because managerial effort is private information and its effect should be reflected in the stock price gradually through accounting or other public resources, we expect that the majority of the stock return attributed to managerial effort should be reflected in the abnormal stock return, which is independent of market or industry performance.

Following Garvey and Milbourn (2006), we use a simple market model to decompose the stock return into two components, luck and skill. The luck portion comes from the co-movement of the stock price with the market or industry index and the skill portion comes from managerial ability, which includes managerial effort and quality.[43] The skill portion is similar to the abnormal stock return from the market perspective. Therefore, the information on managerial ability can be observed in the abnormal return.

[43] Garvey and Milbourn (2006) mention the possibility of measurement error in this method that can blur the expected relationship between abnormal return and firm- and executive-specific variables in our empirical tests.

To test the three hypotheses mentioned in the last section, we collect the data at different time points for different tests explained as follows.

In the time line above, managers have all information about firm characteristics and their own properties at t = -1 and then they exert optimal effort during this time period. We expect that the effect of effort would be reflected in the abnormal return at t = 0. After the board of directors observes the effect, it determines new compensation based on the firm's performance, which is measured by the expected and abnormal returns, at t = 0. To test the relationship between incremental expected return and firm- and executive-specific variables mentioned in *Hypothesis 1*, we collect all data as of t = -1 and estimate the abnormal return at t = 0. Then we run the regression of abnormal return on these variables. To test *Hypothesis 2*, we collect the changes in executive compensation from t = -1 to t = 0 and then test the differences in these variables. For the test of pay-for-performance sensitivity in *Hypothesis 3*, we collect all data and estimate the abnormal return at t = 0. Then, we estimate the pay-for-performance sensitivity for total, cash-based, and stock-based compensations.

5.2.1 Data Description

All variables in the tests come from two data sources. We calculate stock and market index returns and stock volatility using the data from the Center for Research in Security Prices (CRSP). The executive compensation data come from Standard and Poor's ExecuComp database. Because the executive compensation data are annual data, we calculate the raw stock return and volatility on an annual basis. The raw stock returns, a proxy for expected return with effort, are calculated by monthly compounding of holding period returns from CRSP. To calculate stock volatility, we use the monthly stock return over the past 60 months to estimate the standard deviation. In addition, we convert the stock return and volatility into dollar terms to be consistent with the variable unit in the model. Therefore we multiply the raw stock return and volatility by market capitalization at the beginning of each sample year.

To focus on the effect of the CEO on the firm performance, we use every executive in ExecuComp who is the CEO of a firm for at least two consecutive years. The data range is from 1992 to 2005. Due to the requirement of two years of CEO data, we use the first two years of each CEO as the screening years. This is, each CEO in our sample is in at least the third year as the CEO in the same firm. To measure the stock-wealth ratio, which is the percentage of the manager's wealth that is invested in firm stock, we estimate the total wealth by using total compensation in ExecuComp. Following Hall and Knox (2004) and Garvey and Milbourn (2003), we estimate the CEO's total wealth as the greater of six times CEO compensation and $3 million.[44] The results, however, are not sensitive to the factor we use in the estimation. The qualitative results do not change if we simply change the factor. We also estimate stock wealth as the product of the percentage of the firm's stock owned by the CEO and the market capitalization of the firm at the end of the sample year. Finally, the stock-wealth ratio of each CEO is the ratio of stock wealth to total wealth. The summary statistics for these variables are presented in Table 9. From the executive compensation data, we find that

[44]The CEO compensation we use for estimation of total wealth is the sum of salary, bonus, other annual compensation, long-term incentive payouts, the total value of restricted stock, the net value of stock option exercised, and all other total, which is the same as Garvey and Milbourn (2003). The factors of six times and $3 million are the same as Hall and Knox (2004).

the median and mean of cash-based compensation, which is the sum of salary and bonus, are $989,000 and $1,357,000 respectively. The median restricted stock is zero, which is not uncommon in executive compensation. Carter, Lynch and Tuna (2006) show that approximately 80% of the ExecuComp firms were granting options to CEOs from 1995 to 2001 and only about 20% of these firms were granting restricted stock. For stock options, we report the Black-Scholes values of these options in ExecuComp. The median stock option is $521,000 and the mean and the 75th percentile are around $1,790,000. The result shows that the distribution of stock options is highly skewed. The total compensation includes salary, bonus, restricted stock, stock options valued by the Black-Scholes formula, long-term incentive payouts, and all other total. We calculate CEO tenure by finding the difference between the current sample year and the year in which the executive became CEO.

The median and mean of the estimated manager's total wealth are $9 and $21 million. Because the stock wealth could be greater than the manager's wealth in the sample, we need the upper and lower bounds for the stock-wealth ratio. Following Hall and Knox (2004), we set the ratio equal to 90% when the estimated ratio is greater than 90% and 10% when it is less than 10%. Our result is not sensitive to the factors in this assumption. The median and mean stock-wealth ratio is 64.96% and 58.74% respectively, which are close to the estimation in Hall and Knox (2004).[45] We also find that the percentages of firm stock owned by the CEO do not change substantially in our sample.

[45]Hall and Knox (2004) show that the median and mean percentage of stock and option holding in the executive's wealth are 52.5% and 50.9% respectively.

Table 9: Summary Statistics of Firm- and Executive-Specific Variables

All data include every CEO and firm in ExecuComp from 1994 to 2005. Each CEO holds the CEO title in the firm for at least two years. All firms in the sample have the fiscal year ending in December. Cash-based compensation, *CB*, includes the CEO's annual salary and bonus. Stock-based compensation, *SB*, includes restricted stock, *RS*, and the Black-Scholes value of all options, *OPT*. Total compensation, Total Comp., is the sum of cash- and stock-based compensation, long term incentive payouts, and other cash and annual payouts. Total wealth is the greater of six times CEO compensation and $3 million. CEO compensation is the sum of salary, bonus, other annual compensation, long-term incentive payouts, the total value of restricted stock, the net value of stock options exercised, and all other total. Stock-wealth ratio is the ratio of the manager's stock wealth to the total wealth defined above. The percentage of firm stock owned by the CEO is the percentage of outstanding shares hold by the CEO at the end of the fiscal year. CEO tenure is calculated as the difference between the current sample year and the year in which the executive became CEO. The stock return and volatility are calculated by using five years of holding period returns before each sample year. Volatility is the standard deviation of the monthly stock return over the past 60 months of each firm-year. Market capitalization is the firm's market value at the end of each sample year. Book-to-market ratio is the ratio of book value of total assets to market capitalization. Total assets are the book value of assets at the end of the fiscal year. The number of observations is 9,363 firm-years.

Variable	Mean	25%	Median	75%	Min	Max	Std
Executive compensation							
Salary + Bonus, *CB* ($,000)	1,357	575	989	1,670	0	34,050	1,471
Restricted stock, *RS* ($,000)	429	0	0	19	0	38,250	1,687
Stock option, *OPT* (Black-Scholes value, $,000)	1,798	0	521	1,789	0	290,595	5,336
Total compensation ($,000)	4,123	1,068	2,175	4,719	0	293,097	6,892
Tenure (Years)	10	5	8	13	3	56	7
Total wealth, *TW* ($,000)	21,149	4,667	9,124	19,778	3,000	1,047,679	43,737
Stock-wealth ratio, *SWR* (%)	58.74	27.40	64.96	90.00	10.00	90.00	31.47
Percentage of firm stock owned by CEO (%)	2.79	0.18	0.50	1.78	0.00	54.70	6.34
Firm characteristic							
Annual stock return (%)	17.78	-11.98	10.69	35.83	-96.82	1,494.00	58.47
Stock price volatility, *Vol* (%)	40.94	26.10	35.10	49.60	10.40	186.00	21.77
Market capitalization ($ m)	6,063	597	1,652	4,987	5	349,510	16,179
Book-to-Market ratio, BV/MV (%)	214.19	63.47	117.33	233.64	2.21	14,004.30	345.37
Total assets ($ m)	11,122	517	1,747	6,666	3	1,484,100	47,054

The 25th and 75th percentiles are 0.18% and 1.78% respectively. Compared with market capitalization, the percentile cannot provide relative information about the manager's stock wealth. The 0.18% of a large firm could be substantially larger amount than the 1.78% of a small firm. This is the main reason why we convert these variables into dollar terms. Because of the two-year CEO requirement, these firms are more likely to be established firms that have had stable performance. For example, the mean and median stock returns are 17.78% and 10.69% and the mean and median stock volatilities are 40.94% and 35.10%, which are lower than the average stock volatility used in ExecuComp database to estimate the Black-Scholes values.

Before performing the regression analysis, it is important to check the correlation among these variables. To observe how these variables are correlated, we summarize the simple correlation among these variables in Table 10. First, we find that total compensation is highly correlated with the cash- and stock-based components, especially the stock option component, in executive compensation. For example, its correlation coefficient with cash-based compensation is 0.52 and with stock options is 0.86. Managers who receive higher cash pay also have higher stock-based compensation.

Second, not surprisingly, firm size is also highly correlated with cash-based and total compensation. Large firms have the ability to pay a higher compensation package. In addition, the longer the CEO stays in the firm, the higher is the percentage of his wealth invested in the firm stock. The correlation between tenure and percentage of stock owned by the CEO is 0.35. Finally, the correlation between total compensation and stock-wealth ratio is -0.05. This means that the method we used to estimate manager's total wealth does not cause a problem of high correlation between these two variables.

Table 10: Correlation Matrix

Simple correlations are calculated for each firm-year in the sample. All data include every CEO and firm in ExecuComp from 1994 to 2005. Each CEO holds the CEO title in the firm for at least two years. All firms in the sample have the fiscal year ending in December. Cash-based compensation, *CB*, includes the CEO's annual salary and bonus. Stock-based compensation, *SB*, includes restricted stock, *RS*, and the Black-Scholes value of all options, *OPT*. Total compensation, Total Comp., is the sum of cash- and stock-based compensation, long term incentive payouts, and other cash and annual payouts. Stock-wealth ratio is the ratio of the manager's stock wealth to the total wealth. Total wealth is the greater of six times CEO compensation and $3 million. CEO compensation is the sum of salary, bonus, other annual compensation, long-term incentive payouts, the total value of restricted stock, the net value of stock options exercised, and all other total. The percentage of firm stock owned by the CEO is the percentage of outstanding shares hold by the CEO at the end of the fiscal year. CEO tenure is calculated as the difference between the current sample year and the year in which the executive became CEO. The stock return and volatility are calculated by using five years of holding period returns before each sample year. Volatility is the standard deviation of the monthly stock return over the past 60 months of each firm-year. Market capitalization is the firm's market value at the end of each sample year. Book-to-market ratio is the ratio of book value of total assets to market capitalization. Total assets are the book value of assets at the end of the fiscal year. The number of observations is 9,363 firm-years.

	Cash-based	Restricted stock	Stock options	Total comp.	Tenure	SWR	% Share own	Stock return	Stock volatility	BV/ MV	Market cap.	Assets
Cash-based	1.00											
Restricted stock	0.31	1.00										
Stock opions	0.22	0.12	1.00									
Total comp.	0.52	0.42	0.86	1.00								
Tenure	-0.01	-0.03	-0.03	-0.04	1.00							
SWR	-0.06	-0.04	0.02	-0.05	0.26	1.00						
% Share own	-0.11	-0.05	-0.04	-0.09	0.35	0.36	1.00					
Stock return	0.05	0.05	0.04	0.05	0.01	0.01	0.04	1.00				
Stock volatility	-0.13	-0.03	0.06	-0.02	0.03	0.01	0.12	0.09	1.00			
BV/MV	0.08	0.03	-0.04	0.00	-0.01	-0.02	-0.02	0.07	-0.09	1.00		
Market cap.	0.42	0.27	0.21	0.37	-0.03	0.00	-0.07	0.04	-0.16	0.00	1.00	
Assets	0.35	0.22	0.08	0.22	-0.03	0.00	-0.06	-0.02	-0.11	0.27	0.54	1.00

5.2.2 Regression of Abnormal Return

To estimate the abnormal stock return for each firm, we apply a simple market model by using the monthly holding period return in CRSP. We consider the market index return as the source of luck.[46] We estimate the constant term and factor loading, or beta coefficient, of the market return, which are used to project the expected or normal return. The regression model for the decomposition is the following,

$$r_{it} = \alpha_i + \beta_i r_{mt} + \varepsilon_{it} ,$$

where r_{it} is the raw stock return of firm *i* in year *t*, and r_{mt} is the market index return. $\alpha_i + \beta_i r_{mt+1}$ is the expected return of firm *i* in year *t+1*. ε_{it+1} is the residual term in the regression and represents the abnormal return that includes the incremental expected return from the manager's ability. We use five years of historical raw stock returns and the market return from CRSP to estimate α_i and β_i for each firm year.

The first empirical test is to regress ε_{it} on firm-specific and executive-specific variables of firm *i* in year *t-1*. The regression model for this test is the following,

$$\varepsilon_{it} = a + b_1\gamma_{it-1} + b_2 SWR_{it-1} + b_3 TW_{it-1} + b_4 CB_{it-1} + b_5 OPT_{jt-1} + b_6 VOL_{it-1} + b_7 X_{it-1} + b_8 D + \xi_{it} , \tag{11}$$

where

γ : manager's quality,

SWR: stock-wealth ratio,

TW: manager's total wealth,

CB: cash-based compensation or sum of salary and bonus,

[46] We also use equal-weighted and value-weighted industry returns as market factors and the results are qualitatively indifferent from what we report here.

OPT: total value of option grant valued by the Black-Scholes method,

VOL: stock volatility, σ,

X: control variables including book-to-market ratio, market capitalization, and tenure,

D: year and/or industry dummy,

ξ: residual term.

Among all variables, the manager's quality is unobservable. Therefore, we need a proxy variable to capture the effect of the manager's quality. Baker and Hall (2004) derive a formula to estimate the marginal product of CEO effort, which is,

$$\gamma_{it-1} = \sqrt{\frac{2\theta^*_{it-1}\sigma^2_{it-1} \times RRA_i}{TW_{it-1}\left(1-\theta^*_{it-1}\right)}}, \tag{12}$$

where θ^*_{it-1} is the CEO's effective ownership percentage in firm *i* at time *t-1*. Following their assumption, we assume all managers have the same coefficient of relative risk aversion, *RRA*, of 2.5. We have the data for all other variables in this formula so we use this variable as a proxy for the manager's quality.

The regression results are summarized in Table 11. We find supportive evidence for our implication. In Regression (1), the stock-wealth ratio is positively related to the abnormal return and is significant at the 1% level. The significant relationship implies that a higher stock-wealth ratio induces a higher abnormal return, a finding consistent with the convergence of interest hypothesis in the management ownership literature.[47] Because there is a substantial positive relationship between management ownership and the stock-wealth ratio in Table 10, this evidence supports our implication that a high

[47]Interested readers can refer to Morck, Shleifer, and Vishney (1988), McConnell and Servaes (1990), Mehran (1995), and Core and Larcker (2002).

Table 11: Regression of Abnormal Return

The dependent variable in regressions (1) to (3) is the abnormal return from the market model. The market return is the return to the S&P 500 index over the past 60 months of each sample year. The elasticity of stock price, γ, is calculated by using Equation (2). The stock-wealth ratio is the ratio of the manager's stock wealth to his total wealth. Total wealth is the greater of six times CEO compensation and $3 million. CEO compensation is the sum of salary, bonus, other annual compensation, long-term incentive payouts, the total value of restricted stock, the net value of stock options exercised, and all other total. Cash-based compensation, *CB*, includes the CEO's annual salary and bonus. Stock options, *OPT*, are the Black-Scholes values of annual option grants. Volatility is the standard deviation of the monthly stock return over the past 60 months of each firm-year. All abnormal returns and volatilities are dollar return and volatility. The hypothesis, *Hypothesis I*, tested in the regressions is that managerial effort reflected in abnormal returns should be positively correlated to the stock-wealth ratio, stock volatility, and the manager's quality and negatively correlated to the manager's total wealth. In each regression, we control for the book-to-market ratio, market size, and tenure. In addition, we also control for year in Regression (2) and year and industry in Regression (3). The industry dummy is constructed by using 2-digit SIC codes for each firm. The numbers in parentheses are t-statistics based on robust standard errors. The symbols *, **, and *** indicate that the coefficient is different from zero at the 10%, 5%, and 1% significance levels respectively.

	(1)	(2)	(3)
Elasticity	0.0302	0.0287	0.0220
(γ)	(0.12)	(0.12)	(0.09)
Stock-wealth ratio	175.09	144.42	181.38
(*SWR)*	(2.78)***	(2.31)**	(2.7)***
Total wealth	-0.0036	-0.0036	-0.0033
(*TW*)	(-2.96)***	(-2.99)***	(2.77)***
Salary+Bonus	0.1032	0.1056	0.1113
(*CB*)	(4.45)***	(4.51)***	(4.47)***
Stock options	-0.0140	-0.0158	-0.0123
(*OPT*)	(-1.48)	(-1.60)	(-1.25)
Volatility	-0.0460	-0.0468	-0.0448
(*VOL*)	(-3.59)***	(-3.65)***	(-3.51)***
Book-to-Market	15.42	10.90	11.32
(*BV/MV*)	(2.98)***	(2.15)**	(1.86)*
Market Cap.	-251.99	-241.18	-263.69
	(-11.00)***	(-10.52)***	(-10.5)***
Tenure	-2.61	-2.29	-0.9215
	(-1.09)	(-0.96)	(-0.37)
Constant	1450.02	1364.09	2119.21
	(10.20)***	(8.26)***	(3.14)***
Year dummy	No	Yes	Yes
Industry dummy	No	No	Yes
Adj-R^2	0.097	0.113	0.120

stock-wealth ratio induces more effort that is reflected in a higher abnormal return. In addition, the manager's total wealth has a significantly negative impact on abnormal return. Both results hold regardless of the controls for year and industry. This evidence implies that firms are more likely to perform better than market expectations when their CEOs have lower wealth. Because CEOs have more incentives to create firm value when the marginal effect of their effort is relatively higher in low wealth case, this evidence supports our prediction about the negative relationship between abnormal return and the manager's wealth.

There are two significant relationships different from those of our simulation results. First, stock volatility has a negative effect on abnormal return. Originally we find that the marginal effect of effort increases with volatility in Equation (9), and therefore, managers exert more effort with volatility that is reflected in a high abnormal return. When stock volatility increases, however, the probability that managerial effort leads to a bad outcome also increases. Therefore, managers would exert less effort in some high volatility cases. The simulation does not capture this negative effect but it does capture the high probability of a bad outcome from low expected terminal wealth. The empirical evidence seems to capture the negative effect in the regression. Therefore, there is no consistent relationship between stock volatility and abnormal return.[48] It depends on firm and executives characteristics, such as the magnitude of stock volatility, the stock-wealth ratio, and the composition of compensation. We take these factors into account in the

[48] In the asset pricing literature, some researchers find a negative relationship between idiosyncratic volatility and stock return. There is, however, no unanimous conclusion about the relationship between idiosyncratic volatility and expected return. For example, Ang, Hodrick, Xing, and Zhang (2005) find that the average returns of portfolios with high idiosyncratic volatility have a significant difference of -1.06% per month relative to those of portfolio with low idiosyncratic volatility. In contrast, Barberis and Huang (2001) find a positive relationship between higher idiosyncratic volatility and expected return from a behavioral standpoint.

next step and run similar regressions under different conditions represented by the abnormal return. Interestingly, the relationship between stock volatility and the abnormal return is different after we control for these conditions.

Second, we also find that cash-based compensation has a positive effect on abnormal returns and it is persistent under year and industry controls in Table 11. The result shows that an increase in cash-based compensation also provides incentives to improve firm performance. There is no risk-sharing effect from cash-based compensation. Therefore, the positive relationship is not consistent with the trade-off relationship between incentives and risk mentioned in agency theory. Murphy (1999) summarizes the structure of each component in executive compensation. He mentions that managers prefer a one dollar increase in base salary to one dollar in another component of compensation because base salary is a fixed component and it is normally a benchmark for other compensation components. In addition, almost every for-profit firm has an annual bonus plan for top executives whose performance beats a benchmark or threshold performance. Therefore, combining those with our findings, we expect that CEOs who had an increase in cash-based compensation due to better performance the previous year tend to have better market performance in the following year.[49] From this expectation, firms with different abnormal returns should have different magnitudes of change in their cash-based compensation.

For the manager's quality, the coefficient is not significantly different from zero at the 10% significant level. One possible reason is because the proxy for the manager's

[49]This effect is similar to the first-order autotcorrelation, or momentum effect, of the stock return in the investment literature. Jedageesh and Titman (1993) show the evidence that the momentum effect is the price reaction to firm-specific information. We find, however, that base salary has a positive impact on abnormal return but annual bonus has a negative impact. Both coefficients are significant at the 1% level.

quality is computed under relatively restrictive assumptions. The insignificance may result from the discrepancy between the characteristics of empirical data and the underlying assumptions.[50] Finally, stock options have a negative but insignificant impact on abnormal return. As we mentioned in the introduction, many firms broadly use stock options in their compensation package and options still account for 40% of median executive pay in the U.S. market. From our model, we find that stock options induce more effort relative to cash and restricted stock compensation. Therefore, we expect the effect of stock options on managerial effort should interact with other factors, such as the stock-wealth ratio, total wealth, or other factors not included in the model.

Even though we model some variables that affect managerial effort, it is possible that we ignore other important factors. Those factors could be important for managers when they determine optimal effort. For example, we find in the simulation result that the moneyness of these options also influences managerial effort. Therefore, managerial effort might change due to repricing the existing stock options. Chance, Kumar, and Todd (2000) find that firms with greater agency problems and insider-dominated boards tend to reprice their executive stock options. In addition, highly regulated firms or firms whose performance is highly dependent on factors that out of the manager's control, such as oil prices in the airline industry, have different overall conditions that we do not capture in the regression analysis. Moreover, the change in accounting regulation can affect the use of different components in compensation. Hall and Murphy (2003) argue that fewer

[50] To compute γ, we assume that CEO's effective ownership percentage, θ^*, observed in the data is the optimal level of management ownership with respect to firm size. In addition, we also assume all managers have the same coefficient of relative risk aversion. Moreover, γ is sensitive to the multiplier we use to estimate the manager's wealth. Therefore, this measure might not effectively capture the effect of the manager's quality.

options will be granted when firms must expense these options. We do not include these factors in our model but they do affect the optimal effort decision.

These missing variables, however, should be correlated with managerial effort that is represented by the abnormal return. To capture the difference in overall conditions for managers to exert effort, we use the abnormal return as a proxy for these conditions. In the model, we expect that firms have higher incremental expected return when managers exert more effort. This implies that high abnormal return in general is an indicator for the preferable conditions, either from the firm's or the manager's standpoint, for managers to exert effort.[51] The indicator is used to capture these overall conditions. In addition, when a market random shock that is independent of the firm's expected return, on average, has a similar impact market-wide, firms with positive abnormal return are more likely to have the preferable conditions. Therefore, we create a dummy variable, D_{AR}, as the indicator. $D_{AR} = 1$ when firms have a positive abnormal return and $D_{AR} = 0$ otherwise. We use three interaction terms $CB_t \times D_{AR}$, $OPT_t \times D_{AR}$, and $VOL_t \times D_{AR}$ to capture the effect of cash-based or stock options compensation, or stock volatility in different overall conditions. The regression results are summarized in Table 12. Interestingly, all interaction terms are positive and significantly different from zero at the 1% significant level in Table 12. The significant impact still exists even though we control for year and industry. The evidence shows asymmetric sensitivity of the abnormal return to cash-based and stock options compensation, and stock volatility between firms with positive abnormal returns and those with negative abnormal returns. For example,

[51] When we mention preferable conditions, we mean overall conditions that are preferred by firms or managers and encourage managers to exert more effort. For example, repricing existing stock options can induce more effort from the manager's standpoint. Or, firms can reduce the use of stock options when they must expense these options, which is unpreferable from the firm's standpoint.

Table 12: Regression of Abnormal Return with Different Overall Conditions

The dependent variable in regressions (1) to (3) is the abnormal return from the market model. The market return is the return to the S&P 500 index over the past 60 months of each sample year. D_{AR} is a dummy variable and equals to 1 when the abnormal return is positive, 0 otherwise. The elasticity of stock price, γ, is calculated by using Equation (2). The stock-wealth ratio is the ratio of the manager's stock wealth to his total wealth. Total wealth is the greater of six times CEO compensation and $3 million. CEO compensation is the sum of salary, bonus, other annual compensation, long-term incentive payouts, the total value of restricted stock, the net value of stock options exercised, and all other total. Cash-based compensation, *CB*, includes the CEO's annual salary and bonus. Stock options, *OPT*, are the Black-Scholes values of annual option grants. Volatility is the standard deviation of the monthly stock return over the past 60 months of each firm-year. All abnormal returns and volatilities are dollar return and volatility. The hypothesis, *Hypothesis I*, tested in the regressions is that managerial effort reflected in abnormal returns should be positively correlated to the stock-wealth ratio, stock volatility, and the manager's quality and negatively correlated to the manager's total wealth. In each regression, we control for the book-to-market ratio, market size, and tenure. The industry dummy is constructed by using 2-digit SIC codes for each firm. The numbers in parentheses are t-statistics based on robust standard errors. The symbols *, **, and *** indicate that the coefficient is different from zero at the 10%, 5%, and 1% significance levels respectively.

	(1)	(2)	(3)
Elasticity	0.019	0.0019	0.0147
(γ)	(0.32)	(0.03)	(0.24)
Stock-wealth ratio	84.90	76.03	98.15
(*SWR*)	(1.56)	(1.41)	(1.71)*
Total wealth	-0.0035	-0.0035	-0.0033
(*TW*)	(-3.47)***	(-3.49)***	(-3.34)***
Salary+Bonus	-0.0684	-0.064	-0.0552
(*CB*)	(-2.73)***	(-2.60)***	(-2.25)**
Stock options	-0.0475	-0.0474	-0.0452
(*OPT*)	(-2.76)***	(-2.73)***	(-2.71)***
Volatility	-0.1233	-0.1239	-0.1215
(*VOL*)	(-4.93)***	(-4.91)***	(-4.08)***
	0.3243	0.314	0.3076
$CB * D_{AR}$	(6.48)***	(6.33)***	(6.24)***
	0.127	0.1266	0.1327
$OPT * D_{AR}$	(4.72)***	(4.79)***	(5.62)***
	0.2467	0.2464	0.2459
$VOL * D_{AR}$	(6.53)***	(6.53)***	(6.48)***
Book-to-Market	7.46	4.61	2.34
(*BV/MV*)	(1.64)	(1.02)	(0.45)
Market Cap.	-247.90	-242.30	-257.14
	(-8.75)***	(-8.47)***	(-8.41)***
	-0.9752	-0.7845	0.1437
Tenure	(-0.46)	(-0.38)	(0.07)
	1479.28	1475.98	1544.33
Constant	(8.40)***	(7.81)***	(7.75)***
Year dummy	No	Yes	Yes
Industry dummy	No	No	Yes
Adj-R^2	0.375	0.382	0.383

the cash-based compensation has a negative impact of -0.0684 on abnormal return when firms have a negative abnormal return but it has positive impact of 0.2559 for firms with a positive abnormal return. In addition, both stock options and volatility have significantly negative effects on abnormal return in firms with a negative abnormal returns but a positive effect on firms with a positive abnormal return.

From the result in Table 12, we have an interesting inference. When overall conditions are preferable for CEOs to exert effort, both cash-based and stock options compensations can induce more effort that is reflected in abnormal returns. In addition, stock volatility has a positive impact on managerial effort, which is consistent with our simulation result. Because the overall conditions are preferable, the marginal effect of effort increases with volatility. Therefore, higher volatility induces more effort and further increases the abnormal return. In contrast, when the overall conditions are not preferable, both cash-based and stock options compensation have a negative impact on abnormal return. Or, neither form of compensation can provide useful incentives for managers to exert more effort.[52] In this case, reducing stock volatility or the firm's risk level would improve performance.

5.2.3 Summary of the Issues Related to Executive Compensation

From the results of asymmetric sensitivity of abnormal return above, we find that executive compensation and stock volatility interact with the overall conditions and therefore, have a different effect on managerial effort. This is an ex-ante analysis because

[52]The banking industry is an example of this situation. Before deregulation, the banking industry had a relatively smaller agency problem. Therefore, stock-based compensation could not be utilized in the way it should be to align the interests of managers and shareholders. After deregulation, however, banks increasingly use stock-based compensation to align interests when they face more opportunity sets and a more highly competitive environment. See Becher, Campbell, and Frye (2005), Houston and James (1995), and Hubbard and Palia (1995) for reference.

all factors are collected before observing managerial effort, where $t = -1$. When we move one step further, that is, when the board of directors observes managerial effort gradually through the abnormal return or other means, it is interesting to see how these firms compensate their executives for their effort. We summarize the change in total compensation and in the stock- and cash-based components of executive compensation from $t = -1$ to $t = 0$ in Table 13. Not surprisingly, both total compensation and stock- and cash-based components have significantly greater means in firms with positive abnormal returns. Because the managers of these firms have better performance than market expectations, it is reasonable and consistent with pay-for-performance mechanisms to increase their total compensation. Interestingly, the mean and the median of total and cash-based compensations increase, but the mean of stock-based and option compensation decreases in those firms with a negative abnormal return. This result implies that many firms still increase their cash-based compensation when managers perform worse than market expectations. The penalty for worse performance results from stock-based compensation. The mean of the change in restricted stock and options in these firms is $-38,480 and the median is $0.

This result shows that the executive compensation contracts in these firms are relatively inefficient relative to those contracts in firms with positive abnormal returns. For example, from the analysis in the last section the increase in either cash-based or stock option compensation cannot induce managerial effort effectively when overall conditions are not preferable. More than 50% of these firms, however, still increase their cash-based compensation and more than 25% of these firms increase the stock-based compensation. We must, however, interpret this result with caution. Because we compare

Table 13: Summary of Change in Executive Compensation

The change, Δ, in compensation is the difference in compensation between *t = -1* and *t = 0*. The summary statistics include mean, standard deviation, 25th percentile, median, and 75th percentile dollar value for the change in total compensation and cash- and stock-based compensation. AR is the abnormal return from the simple market model where the market return is the return to the S&P 500 index over the past 60 months of each sample year. We separate the sample into two groups, one with positive AR and the other with negative AR. Total compensation is the sum of cash- and stock-based compensation, long term incentive payouts, and other cash and annual payouts. Cash-based compensation includes the CEO's annual salary and bonus. Stock-based compensation includes restricted stock and the Black-Scholes value of all stock options. The hypothesis, *Hypothesis II*, is that managers who receive more stock options exert more effort. Alternatively, firms that grant more stock options have higher abnormal returns. The null hypothesis for t-statistics is that the mean compensation of positive AR firms ≤ the mean compensation of negative AR firms. The null hypothesis for f-statistics is that the standard deviation of positive AR firms ≤ the standard deviation of negative AR firms. The null hypothesis for nonparametric χ^2-statistics is that both groups have the same median compensation. The symbols *, **, and *** indicate that the coefficient is different from zero at the 10%, 5%, and 1% significance levels respectively.

Δ Total compensation	Positive AR	Negative AR	Positive AR - Negative AR
Mean	681.66	78.53	t = 4.38***
Std	6,081.28	7,010.38	f = 1.33***
25th	-200.38	-529.91	
Median	252.07	38.66	$\chi^2(1)$= 113.12***
75th	1116.96	764.97	

Δ (Salary + bonus)	Positive AR	Negative AR	
Mean	202.76	9.24	t = 9.82***
Std	903.15	956.82	f = 1.12***
25th	-0.24	-137.81	
Median	106.06	20	$\chi^2(1)$= 248.31***
75th	355.53	180	

Δ (Restricted stock + stock options)	Positive AR	Negative AR	
Mean	212.3	-38.48	t = 1.99**
Std	5,511.41	6,543.57	f = 1.41***
25th	-239.72	-386	
Median	0.06	0	$\chi^2(1)$= 16.95***
75th	556.79	454.38	

Δ Stock options	Positive AR	Negative AR	
Mean	103.01	-64.75	t = 1.44*
Std	4,973.88	6,167.27	f = 1.53***
25th	-212.21	-316.38	
Median	0	0	$\chi^2(1)$= 3.94**
75th	369.54	354.34	

executive compensation and performance contemporaneously, it is possible that the change in compensation results from past performance. If this is the case, then the result still supports that the change in compensation among firms with negative abnormal returns cannot induce managerial effort at $t = 0$ efficiently.

Based on the results in this and the last section, we find supportive evidence for *Hypothesis 2*. Firms with preferable overall conditions grant more stock options and these options have a positive impact on abnormal returns. Therefore, we expect that these firms should have more efficient executive compensation than other firms in the sample. One common measure used to analyze the efficiency of executive compensation is the pay-for-performance sensitivity. Hence, these firms with a positive abnormal return should have stronger pay-for-performance sensitivity than other firms. This expectation is *Hypothesis 3* from the implication in Section 5.1. We perform this test in the next section.

5.2.4 Pay-for-Performance Sensitivity

Jensen and Murphy (1990) define and perform empirical tests for pay-for-performance sensitivity, which is the dollar change in the CEO's wealth associated with a dollar change in shareholder wealth. Later, Aggarwal and Samwick (1999) point out that ignoring the effect of the variance of firm performance would cause substantial underestimation of the pay-for-performance effect. Therefore, in the test, we follow the method in Aggarwal and Samwick (1999) and take the stock return variance into account through the cumulative distribution function (CDF) of the variance of the stock return when we estimate pay-for-performance sensitivity.[53]

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[53]We explain the intuition of the use of CDF and use a simple example to show how to generate the CDF of the stock return variance in Appendix III.

We examine pay-for-performance sensitivity under two different overall conditions classified by the sign of abnormal return, If firms grant their executive compensation efficiently, then we expect to see managers who exert more effort receive higher pay especially through stock-based compensation. The regression model for pay-for-performance sensitivity is the following,

$$Comp_{it} = \alpha_1 + \beta_1 R_{it} + \beta_2 F\left(\sigma_{it}^2\right) + \beta_3 \left(R_{it} \times F\left(\sigma_{it}^2\right)\right) + \beta_4 X_{it} + \varepsilon_{it} ,$$

where $Comp_{it}$ is the dollar amount of executive compensation, either total or each component of compensation for firm *i* at time *t*, R_{it} is the dollar return for firm *i*, $F\left(\sigma_{it}^2\right)$ is the CDF of stock return variance, and X_{it} includes the same control variables as in Regression (1). The pay-for-performance sensitivity for a firm with median risk level is $\beta_1 + 0.5\beta_3$. We run the regression by using total compensation and stock- and cash-based compensation separately and summarize the results in Table 14. From Table 14, we find that the pay-for-performance sensitivities resulting from total compensation are significantly different from zero for both types of firms. For median risk firms with a positive abnormal return, the manager's total compensation increases \$640 when shareholder's wealth increases by \$1 million. For median risk level firms with a negative abnormal return, it increases \$1,030. Comparing pay-for-performance sensitivities from cash- and stock-based compensations, we find the significant sensitivity in negative abnormal return firms is driven by cash-based compensation. For firms with a positive abnormal return, it is driven by stock-based compensation and mainly from stock options. This result implies that cash-based compensation is more sensitive to firm performance than stock-based compensation in negative abnormal return firms. Combined with the evidence in Table 12, the pay-for-performance sensitivity in negative abnormal return

Table 14: Pay-for-Performance Sensitivity between Positive AR and Negative AR Firms

The pay-for-performance sensitivity, *PPS*, is the sum of the coefficients of the change in shareholder wealth, ΔSW, and the product of ΔSW and CDF(σ^2) in the regression of executive compensation when shareholder wealth increases by $1 million. We separate the sample into two groups with different signs of the abnormal return. Total compensation is the sum of cash- and stock-based compensation, long term incentive payouts, and other cash and annual payouts. Cash-based compensation includes the CEO's annual salary and bonus. Stock-based compensation includes restricted stock and the Black-Scholes value of all stock options. The 25th, 50th, or 75th percentile risk is defined by the CDF of stock variance. The numbers in parentheses are t-statistics based on robust standard errors. In each regression, we control for the book-to-market ratio, market size, tenure, CDF(σ^2), and year and industry dummies. The symbols *, **, and *** indicate that the coefficient is different from zero at the 10%, 5%, and 1% significance levels respectively.

Dependent variable		Positive AR	Negative AR
Δ Total compensation	Δshareholder wealth,	1.1945	1.8129
	ΔSW	(2.16)**	(2.26)**
		-1.1043	-1.5644
	ΔSW*CDF(σ^2)	(-1.98)**	(-1.90)*
	PPS ($1M ΔSW)		
	25th percentile risk	920	1,420
	50th percentile risk	640	1,030
	75th percentile risk	370	640
	Adj-R^2	0.05	0.027
Δ (Salary + bonus)	Δshareholder wealth, *SW*	0.0859	0.2
		(1.62)	(2.44)**
		-0.0833	-0.1475
	ΔSW*CDF(σ^2)	(-1.50)	(-1.52)
	PPS ($1M ΔSW)		
	25th percentile risk	70	160
	50th percentile risk	40	130
	75th percentile risk	20	90
	Adj-R^2	0.052	0.05
Δ (Restricted stock + stock options)	Δshareholder wealth, *SW*	1.1601	1.2703
		(2.19)**	(1.55)
		-1.0589	-1.0828
	ΔSW*CDF(σ^2)	(-1.98)**	(-1.28)
	PPS ($1M ΔSW)		
	25th percentile risk	900	1,000
	50th percentile risk	630	730
	75th percentile risk	370	460
	Adj-R^2	0.068	0.02
Δ Stock options	Δshareholder wealth, *SW*	1.1493	1.3163
		(2.24)**	(1.61)
		-1.1060	-1.2154
	ΔSW*CDF(σ^2)	(-2.04)**	(-1.45)
	PPS ($1M ΔSW)		
	25th percentile risk	870	1,010
	50th percentile risk	600	710
	75th percentile risk	320	400
	Adj-R^2	0.078	0.015

firms shows that these firms seem to have inefficient compensation. Because the increase in either cash- or stock-based compensation has a negative impact on managerial effort among these firms, significant pay-for-performance from cash-based compensation cannot improve firm performance by much.

The significant pay-for-performance sensitivity from stock-based compensation in positive abnormal return firms implies that stock-based compensation provides significant incentives to exert effort and is efficiently used under preferable overall conditions. This result is consistent with the evidence in Table 12. Even though both results in positive and negative abnormal return firms support our predictions, we need to interpret these results with caution. We separate the sample by the sign of abnormal returns and find that the pay-for-performance sensitivity from cash compensation is relatively stronger than that from stock-based compensation in negative abnormal return firms. This result can be driven by the effect of the abnormal return itself rather than by the overall conditions proxied by the abnormal return. Stock-based compensation shows a weak pay-for-performance sensitivity because of negative abnormal returns while cash-based compensation shows a relatively stronger sensitivity. To observe pay-for-performance sensitivity from different angle and alleviate the problem of the classification criterion of abnormal return, we test pay-for-performance sensitivity within the groups classified by factors in the theoretical model. In doing so, we can connect the empirical test of pay-for-performance with the implication from our model.

From the previous regression analysis, we find two factors that have a significant impact on abnormal return or managerial effort: the stock-wealth ratio and the manager's total wealth. On the one hand, from the simulation result, we know that a higher stock-wealth ratio induces more effort and higher non-option wealth reduces effort. On the other hand, from the empirical evidence, the stock-wealth ratio has a significantly positive effect on abnormal return but total wealth has a significantly negative impact on abnormal return. Based on these results, we separate the whole sample into four equal-size groups with respect to stock-wealth ratio and total wealth. Managers in the group with the higher stock-wealth ratio and lower total wealth exert the most effort and those in the group with the lower stock-wealth ratio and higher total wealth exert the least effort. If executive compensation is efficiently used, then we expect that the group with the higher stock-wealth ratio and lower total wealth should have the stronger pay-for-performance and the group with the lower stock-wealth ratio and higher total wealth should have the weaker pay-for-performance sensitivity. First, we test this hypothesis for total compensation and summarize the result in Table 15.

As expected, the group with the higher stock-wealth ratio and lower total wealth has the strongest and significant pay-for-performance sensitivity. The pay-for-performance sensitivity in this group is significantly different from zero at the 1% significance level. Median risk firms in this group have their manager's total compensation increase by $670 when shareholder wealth increases $1 million. Compared with other firms with the lower stock-wealth ratio, these firms provide the greatest incentives. The group of firms with the lower stock-wealth ratio and higher total wealth, however, does not have the weakest pay-for-performance sensitivity, which is different from our expectations.

Because we learn from previous analysis that cash-based and stock-based compensations have different effects under different overall conditions, we suspect they

Table 15: Pay-for-Performance Sensitivity from Total Compensation (with Respect to Manager's Wealth and Stock-Wealth Ratio)

The pay-for-performance sensitivity, *PPS*, is the sum of the coefficients of the change in shareholder wealth, ΔSW, and the product of ΔSW and CDF(σ^2) in the regression of executive compensation when shareholder wealth increases by $1 million. We separate the sample into two groups with different signs of the abnormal return. Total compensation is the sum of cash- and stock-based compensation, long term incentive payouts, and other cash and annual payouts. The stock-wealth ratio is the ratio of the manager's stock wealth to his total wealth. Total wealth is the greater of six times CEO compensation and $3 million. CEO compensation is the sum of salary, bonus, other annual compensation, long-term incentive payouts, the total value of restricted stock, the net value of stock optionw exercised, and all other total. Higher (lower) total wealth includes executives with their wealth above (below) the median total wealth. Higher (lower) stock-wealth ratio includes executives with their stock-wealth ratio above (below) the median stock-wealth ratio. The hypothesis, *Hypothesis III*, for *PPS* is that *PPS* is stronger for firms whose managers exert more effort. In addition, these managers tend to have a higher stock-wealth ratio and a lower total wealth. The 25th, 50th, or 75th percentile risk is defined by the CDF of stock variance. The numbers in parentheses are t-statistics based on robust standard errors. In each regression, we control for the book-to-market ratio, market size, tenure, CDF(σ^2), and year and industry dummies. The symbols *, **, and *** indicate that the coefficient is different from zero at the 10%, 5%, and 1% significance levels respectively.

Δ Total compensation		**Higher total wealth**	**Lower total wealth**
Higher stock-wealth ratio	Δshareholder wealth, *SW*	1.1461	1.3685
		(1.30)	(2.99)***
	ΔSW*CDF(σ^2)	-0.9433	-1.3632
		(-1.02)	(-3.00)***
	PPS ($1M ΔSW)		
	25th percentile risk	910	1,030
	50th percentile risk	670	670
	75th percentile risk	440	350
	Adj-R^2	0.023	0.027
Lower stock-wealth ratio	Δshareholder wealth, *SW*	0.9693	0.3641
		(1.89)*	(0.80)
	ΔSW*CDF(σ^2)	-0.8309	-0.1131
		(-1.59)	(-0.15)
	PPS ($1M ΔSW)		
	25th percentile risk	760	340
	50th percentile risk	550	310
	75th percentile risk	350	280
	Adj-R^2	0.041	0.166

Table 16: Pay-for-Performance Sensitivity from Cash-Based Compensation (with Respect to Manager's Wealth and Stock-Wealth Ratio)

The pay-for-performance sensitivity, *PPS*, is the sum of the coefficients of the change in shareholder wealth, ΔSW, and the product of ΔSW and CDF(σ^2) in the regression of executive compensation when shareholder wealth increases \$1 million. We separate the sample into two groups with different signs of the abnormal return. Cash-based compensation, *CB*, includes the CEO's annual salary and bonus. Stock options, *OPT*, are the Black-Scholes values of annual option grants. Stock-wealth ratio is the ratio of the manager's stock wealth to the total wealth. Total wealth is the greater of six times CEO compensation and \$3 million. The CEO compensation is the sum of salary, bonus, other annual compensation, long-term incentive payouts, the total value of restricted stock, the net value of stock options exercised, and all other total. Higher (lower) total wealth includes executives with their wealth above (below) the median total wealth. Higher (lower) stock-wealth ratio includes executives with their stock-wealth ratio above (below) the median stock-wealth ratio. The hypothesis, *Hypothesis III*, for *PPS* is that *PPS* is stronger for firms whose managers exert more effort. In addition, these managers tend to have a higher stock-wealth ratio and a lower total wealth. The 25th, 50th, and 75th percentile risk is defined by the CDF of stock variance. The numbers in parentheses are t-statistics based on robust standard errors. In each regression, we control for the book-to-market ratio, market size, tenure, CDF(σ^2), and year and industry dummies. The symbols *, **, and *** indicate that the coefficient is different from zero at the 10%, 5%, and 1% significance levels respectively.

Δ (Salary + bonus)		**Higher total wealth**	**Lower total wealth**
Higher stock-wealth ratio	Δshareholder wealth, *SW*	0.1051	0.0661
		(1.54)	(1.96)*
	ΔSW*CDF(σ^2)	-0.0607	-0.0621
		(-0.72)	(-1.62)
	PPS (\$1M ΔSW)		
	25th percentile risk	90	50
	50th percentile risk	70	40
	75th percentile risk	60	20
	Adj-R^2	0.029	0.068
Lower stock-wealth ratio	Δshareholder wealth, *SW*	0.4004	0.1765
		(4.47)***	(3.33)***
	ΔSW*CDF(σ^2)	-0.3811	-0.1341
		(-4.04)***	(-1.71)*
	PPS (\$1M ΔSW)		
	25th percentile risk	310	140
	50th percentile risk	210	110
	75th percentile risk	110	80
	Adj-R^2	0.057	0.107

also have different effects under the classification with respect to stock-wealth ratio and manager's total wealth. Therefore, we perform the same tests of pay-for-performance sensitivity from cash- and stock-based compensations and summarize the results in Tables 16 and 17.

The pay-for-performance sensitivity from cash-based compensation in Table 16 shows that the group of firms with the lower stock-wealth ratio and higher total wealth has the strongest sensitivity. In addition, the manager's wealth increases more when he has a lower stock-wealth ratio. This result is consistent with the previous analysis of cash-based compensation. Cash-based compensation is not used efficiently by firms. There are two previous results that can explain this argument. First, from Table 12, we find that cash-based compensation has a significantly positive impact on the abnormal return in firms with positive abnormal returns. From Table 14, however, these firms do not have significant pay-for-performance sensitivity from cash-based compensation. Second, there exists significant pay-for-performance sensitivity from cash-based compensation in those firms with negative abnormal returns. Cash-based compensation, however, has a negative effect on abnormal returns in Table 12. Based on the evidence, we conclude that cash-based compensation is not efficiently used.

For stock-based compensation in Table 17, the stronger pay-for-performance sensitivity is mainly driven by stock option compensation.[54] The group of firms with the higher stock-wealth ratio and lower total wealth has stronger sensitivity and the group with the lower stock-wealth ratio and higher total wealth has the weakest sensitivity for

[54]We perform the same test for restricted stock and stock options and the results for stock options are similar to those for stock-based compensation.

Table 17: Pay-for-Performance Sensitivity from Stock-Based Compensation (with Respect to Manager's Wealth and Stock-Wealth Ratio)

The pay-for-performance sensitivity, *PPS*, is the sum of the coefficients of the change in shareholder wealth, ΔSW, and the product of ΔSW and CDF(σ^2) in the regression of executive compensation when shareholder wealth increases \$1 million. We separate the sample into two groups with different signs of the abnormal return. Cash-based compensation, *CB*, includes the CEO's annual salary and bonus. Stock options, *OPT*, are the Black-Scholes values of annual option grants. The stock-wealth ratio is the ratio of the manager's stock wealth to his total wealth. Total wealth is the greater of six times CEO compensation and \$3 million. The CEO compensation is the sum of salary, bonus, other annual compensation, long-term incentive payouts, the total value of restricted stock, the net value of stock options exercised, and all other total. Higher (lower) total wealth includes executives with their wealth above (below) the median total wealth. Higher (lower) stock-wealth ratio includes executives with their stock-wealth ratio above (below) the median stock-wealth ratio. The hypothesis, *Hypothesis III*, for *PPS* is that *PPS* is stronger for firms whose managers exert more effort. In addition, these managers tend to have a higher stock-wealth ratio and a lower total wealth. The 25th, 50th, and 75th percentile risk is defined by the CDF of stock variance. The numbers in parentheses are t-statistics based on robust standard errors. In each regression, we control for the book-to-market ratio, market size, tenure, CDF(σ^2), and year and industry dummies. The symbols *, **, and *** indicate that the coefficient is different from zero at the 10%, 5%, and 1% significance levels respectively.

Δ (Restricted stock + stock options)		**Higher total wealth**	**Lower total wealth**
Higher stock-wealth ratio	Δshareholder wealth, *SW*	1.0042	1.2926
		(1.15)	(2.77)***
	ΔSW*CDF(σ^2)	-0.8276	-1.2868
		(-0.90)	(-2.76)***
	PPS (\$1M ΔSW)		
	25th percentile risk	800	970
	50th percentile risk	590	650
	75th percentile risk	380	330
	Adj-R^2	0.02	0.024
Lower stock-wealth ratio	Δshareholder wealth, *SW*	-0.0824	0.0754
		(-0.26)	(0.16)
	ΔSW*CDF(σ^2)	0.1903	-0.1235
		(0.58)	(0.16)
	PPS (\$1M ΔSW)		
	25th percentile risk	-30	40
	50th percentile risk	10	10
	75th percentile risk	60	-10
	Adj-R^2	0.045	0.153

stock-based compensation. For example, for firms with median risk level, the manager's wealth increases $650 in the strongest sensitivity group but only $10 in the weaker sensitivity group. This result supports the previous analysis because it shows that stock-based compensation is efficiently used relative to cash-based compensation.

CHAPTER 6 CONCLUSION AND FUTURE RESEARCH

6.1 Conclusion

Within the past two decades, stock options have been broadly used in the U.S. and many countries around the world. The valuation of executive stock options has drawn substantial attention in academia and in practice. In this paper, we find that managerial ability, or managerial effort specifically, can affect the valuation of the options. We show that if granted options, managers exert optimal effort that is greater than the minimum effort to justify the current stock price. Consequently, managerial effort increases the value of the stock and the options. Therefore, ignoring this factor would underestimate the values of options. This result is consistent with the recent argument that the incentive effect should be taken into account in either the valuation of stock options or the optimal contracts between shareholders and managers.

In addition, we find that certain variables have an impact on managerial effort. For example, managerial effort increases with stock volatility and the executive's stock-wealth ratio. In contrast, it decreases with non-option wealth and absolute risk aversion. Compared with restricted stock, executive stock options induce more effort under the same cost. Therefore, stock options should be relatively cost efficient instruments to serve as incentives for managers to increase shareholder wealth. Moreover, the manager's quality, or talent, is also a key factor in the determination of optimal effort. Managers with high quality can exert less effort but the impact of their effort is greater than that of other managers with medium or low quality. Therefore, we expect that the performance of firms with high quality managers should be better than that of other firms.

We connect firm market performance with managerial effort and show by simulations that there is a positive relationship between incremental expected return and effort, other things being equal. Using empirical data, we find supportive evidence that the manager's total wealth, stock-wealth ratio, cash and options compensation, and stock volatility that affect managerial effort also significantly influence the firm's abnormal return. In addition, we show that there are other factors not in our analysis that also have an impact on the relationship between abnormal return and these variables in our analysis. Finally, the results of pay-for-performance sensitivity show that stock-based compensation is more efficiently used relative to cash-based compensation. We find that this sensitivity is stronger in firms whose mangers have a higher stock-wealth ratio and lower total wealth. From our simulation results, these managers tend to exert more effort.

6.2 Future Research

From the simulation results, we also find that managerial effort can influence early exercise behavior. Managers who exert more effort exercise their options at a higher stock price. This result implies that managers may postpone their decision to exercise their options until their effort is reflected in the stock price, which means a higher option payoff. These managers are naturally less willing to sacrifice time value, so they exercise their options later.

For future research, we want to test the relationship between the holding period of these options and the firm-specific and executive-specific variables analyzed in our model. To perform this test, we need the data on executive stock option exercises that includes exercise date, strike price, time to maturity, and expiration date of the options exercised. Combined with the data we have, we can conduct this empirical test and it will provide further information about how managerial effort affects stock option value and how stock options serve as incentives.

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APPENDIX I. THE COMPUTATION OF OPTIMAL EFFORT AND EXECUTIVE OPTION VALUE

There are two steps in our simulations. First, we find optimal managerial effort by solving Equation (5). Second, applying the optimal effort in the first step in the certainty equivalent approach in Equation (8), we find the executive option value. In the comparative statics analysis of optimal effort and option value, we change one parameter at a time and keep all other parameters as benchmark values. All parameters and their benchmark values are list below:

S_0: the current stock price on grant date, \$30,

K: exercise price, \$30,

T: time to maturity, 10 years,

r_f: risk-free rate, 5% per annum,

r_m: market return, 12% per annum,

β: systematic risk, 1,

σ: stock volatility, 50%,

δ: the elasticity of stock price, 0.5,

ρ: absolute risk aversion, 0.0000005,

η: incremental expected return, choice variable,

c: cash wealth, \$2.4 million (\$4 million * 60%),

m: the number of shares of stock, 53,333 shares (\$4 million *40% / \$30)

n: the number of stock options, 40,000 options,

Next, we show the procedure we use to compute optimal effort and option value in detail.

I.A Optional Effort

To find out the optimal effort, which involves solving for η in Equation (5), we must first specify the terminal stock price. Following Hall and Murphy (2002), we assume the distribution of stock prices in T years is lognormal with volatility σ and expected return $\left[r_f + \beta\left(r_m - r_f\right) + \eta - \sigma^2/2\right]T$. Applying the solution for the after-effect stock price on Section 3.1.2.,

$$S_T^* = S_0 e^{\left(\alpha - \frac{1}{2}\sigma^2 + \eta\right)T + \sigma w_T},$$

we construct the distribution of possible terminal stock prices with effort. Plugging the terminal stock price with effort into the terminal wealth, W_T, in Section 3.1., we have the distribution of possible terminal wealth including cash, \$*c*, *m* shares of stock, and *n* stock options. Finally, given the negative exponential utility function with coefficient of absolute risk aversion, ρ, and all necessary parameters, $r_f, r_m, \beta, \sigma, T, S_0, K, c,$ *m, n, δ,* and ρ, we can solve for η in Equation (5) by using the first-order condition, which is

$$\sum_0^\infty U'\left(W_T\right) f\left(S_T^*\right) - \left(e^{\eta T/\delta} - 1\right) e^{\eta T/\delta} \frac{T}{\delta} = 0$$

where $f\left(S_T^*\right)$ is the probability of S_T^*. Because there is no closed-form solution for η in the above condition, we simulate with different values for η until the first-order condition is less than 0.0000001. The first η that meets this criterion is the optimal managerial effort reported in Table 1 under given parameters.

I.B Option Value

To find the option value using the certainty equivalent approach in Equation (8),

$$\int_0^\infty U\left(\left(c+CE\right)\left(1+r_f\right)^T + mS_T^{1*}\right) f\left(S_T^{1*}\right) dS_T^{1*} - \frac{1}{2}\left(e^{\eta_1 T/\delta} - 1\right)^2$$

$$= \int_0^\infty U\left(c\left(1+r_f\right)^T + mS_T^{2*} + nMax\left(S_T^{2*} - K, 0\right)\right) f\left(S_T^{2*}\right) dS_T^{2*} - \frac{1}{2}\left(e^{\eta_2 T/\delta} - 1\right)^2,$$

we need the optimal effort, which is a function of η_2, in the first step. Based on the optimal effort, we find the possible terminal after-effort stock prices, S_T^{2*}, and the expected utility net of the disutility of effort, which is the right-hand side of Equation (8). The certainty equivalent amount, *CE*, is the total value of *n* stock options. We need to solve for *CE/n* that is the value of one option. Applying the same method to find the optimal effort with *m* shares of stock but zero stock options, we find the optimal effort without options, which is a function of η_1. Based on the optimal effort without options, we find the possible terminal after-effort stock prices, S_T^{1*}. Finally, we compute the expected utility on the left-hand side of Equation (8) by changing *CE* until

$$\frac{\int_0^\infty U\left(\left(c+CE\right)\left(1+r_f\right)^T + mS_T^{1*}\right) f\left(S_T^{1*}\right) dS_T^{1*} - \frac{1}{2}\left(e^{\eta_1 T/\delta} - 1\right)^2}{\int_0^\infty U\left(c\left(1+r_f\right)^T + mS_T^{2*} + nMax\left(S_T^{2*} - K, 0\right)\right) f\left(S_T^{2*}\right) dS_T^{2*} - \frac{1}{2}\left(e^{\eta_2 T/\delta} - 1\right)^2} - 1 < 0.00001 .$$

The first *CE* that satisfies this criterion is the total value of *n* options. The value of one option is *CE/n*.

APPENDIX II. ILLUSTRATION OF THE TRADE-OFF BETWEEN EXERCISE PRICE AND THE PROBABILITY OF AN OPTION EXPIRING IN-THE-MONEY

In the expected utility maximization model, we need to know only the terminal wealth to compute the expected utility. Therefore, the executive's expected utility is a linear combination of the utilities from three cases of the option's payoff, in-the-money (ITM), at-the-money (ATM) and out-of-the-money (OTM). Based on the assumptions about the executive's utility and terminal wealth in Section 3, the terminal wealth and utility are follows:

$$W_T = \begin{cases} c\left(1+r_f\right)^T + \left(m+n\right)S_T^* - nK & ITM \\ c\left(1+r_f\right)^T + mS_T^* & ATM\ and\ OTM \end{cases},$$

$$U_T = -\frac{1}{\rho}e^{-\rho W_T} - \frac{1}{2}\left(e^{\eta T/\delta} - 1\right)^2.$$

The partial derivative of the utility with respect to the incremental expected return is

$$\frac{\partial U_T}{\partial \eta} = \begin{cases} e^{-\rho W_T}\left(m+n\right)S_T^* T - \left(e^{\eta T/\delta} - 1\right)e^{\eta T/\delta}\frac{T}{\delta} & ITM \\ e^{-\rho W_T} m S_T^* T - \left(e^{\eta T/\delta} - 1\right)e^{\eta T/\delta}\frac{T}{\delta} & ATM\ and\ OTM \end{cases}.$$

Suppose the stock prices have h possible outcomes ranked in ascending order with probability p_i and the case of at-the-money occurs in the outcome $a < h$ with exercise price $K = K_1$. The expected utility is

$$E\left(U_T^{K_1}\right) = \sum_{i=1}^{a-1} p_i U_{OTM}^{K_1} + \sum_{i=a+1}^{h} p_i U_{ITM}^{K_1} + p_a U_{ATM}^{K_1}.$$

The partial derivative of $E\left(U_T\right)$ with respect to incremental expected return is

$$\frac{\partial E\left(U_T^{K_1}\right)}{\partial \eta} = \sum_{i=1}^{a-1} p_i \frac{\partial U_{OTM}^{K_1}}{\partial \eta} + \sum_{i=a+1}^{h} p_i \frac{\partial U_{ITM}^{K_1}}{\partial \eta} + p_a \frac{\partial U_{ATM}^{K_1}}{\partial \eta}.$$

This is the marginal effect of the managerial effort. The same equation is hold for $K = K_2 > K_1$, which is

$$\frac{\partial E\left(U_T^{K_2}\right)}{\partial \eta} = \sum_{i=1}^{b-1} p_i \frac{\partial U_{OTM}^{K_2}}{\partial \eta} + \sum_{i=b+1}^{h} p_i \frac{\partial U_{ITM}^{K_2}}{\partial \eta} + p_b \frac{\partial U_{ATM}^{K_2}}{\partial \eta}.$$

From the above equation, we know the at-the-money case occurs in the outcome $b < h$, $b > a$. Then, the effect of increasing the exercise price on the marginal expected utility with respect to incremental expected return is

$$\frac{\partial E\left(U_T^{K_2}\right)}{\partial \eta} - \frac{\partial E\left(U_T^{K_1}\right)}{\partial \eta} = \sum_{i=1}^{a-1} p_i \left(\frac{\partial U_{OTM}^{K_2}}{\partial \eta} - \frac{\partial U_{OTM}^{K_1}}{\partial \eta} \right) + p_a \left(\frac{\partial U_{OTM}^{K_2}}{\partial \eta} - \frac{\partial U_{ATM}^{K_1}}{\partial \eta} \right) + \sum_{i=a+1}^{b-1} p_i \left(\frac{\partial U_{OTM}^{K_2}}{\partial \eta} - \frac{\partial U_{ITM}^{K_1}}{\partial \eta} \right)$$
$$+ p_b \left(\frac{\partial U_{ATM}^{K_2}}{\partial \eta} - \frac{\partial U_{ITM}^{K_1}}{\partial \eta} \right) + \sum_{i=b+1}^{h} p_i \left(\frac{\partial U_{ITM}^{K_2}}{\partial \eta} - \frac{\partial U_{ITM}^{K_1}}{\partial \eta} \right)$$

The first two terms on the right hand side are equal to zero. The third and fourth terms are negative under our parameter sets and they result from increasing the exercise price. Therefore, we define that both terms have a negative effect from increasing the exercise price. The last term on the right-hand side is positive, and it results from the reduction of terminal wealth following the increase in exercise price. We define this term as a positive effect from the wealth reduction. When the exercise price is very low, such as $K_1 = 1$ and $K_2 = 2$, a and b are very small. Therefore, the positive effect in the last term dominates the negative effect from increasing the exercise price. When the exercise price, however, is much higher than the current stock price, then the probability of expiring in-the-money is decreasing. This means that the total value of the last term becomes smaller. Hence, the negative effect in the third and fourth terms dominates the positive effect in the last term.

When the marginal effect of managerial effort decreases, the manager would reduce his effort to achieve the maximization of expected utility.

APPENDIX III. THE INTUITION OF THE USE OF CDF OF STOCK RETURN VARIANCE AND AN EXAMPLE

Aggarwal and Samwick (1999) test the sensitivity of executive compensation to firm performance, which is pay-for-performance sensitivity. From the solution of the optimal pay-for-performance sensitivity, they expect that the sensitivity decreases with stock return variance. They point out, however, that there is no explicit prediction of the relationship between the level of compensation and firm stock return variance in a standard principal-agent model. To consider the effect of stock return variance on the sensitivity and alleviate the influence of the relationship between the level of compensation and stock return variance, they add the CDF of stock return variance and the interaction term between CDF of stock return variance and stock return in the regression analysis.

Stock return variance is the relative risk measure within a firm but it cannot provide useful information about the risk level of a firm relative to other firms. Aggarwal and Samwick use the cumulative distribution function to standardize the risk measure and take the relative risk level into account in their estimation of pay-for-performance sensitivity. It is worth noting that they use the variance of dollar return to capture the size effect on the variance in the standardized risk measure. We also follow their method to generate $\mathrm{CDF}\left(\sigma_{it}^{2}\right)$.

We use an example of three firms to show how to generate the CDF of stock return variance for each firm year. Suppose these three firms have annualized stock return variance for three years as follows,

	Firm 1	Firm 2	Firm 3
Year 1	$\sigma_{11}^2 = 0.10$	$\sigma_{21}^2 = 0.30$	$\sigma_{31}^2 = 0.15$
Year 2	$\sigma_{12}^2 = 0.20$	$\sigma_{22}^2 = 0.20$	$\sigma_{32}^2 = 0.15$
Year 3	$\sigma_{13}^2 = 0.15$	$\sigma_{23}^2 = 0.25$	$\sigma_{33}^2 = 0.20$

Where σ_{it}^2 is the stock variance of firm *i* in year *t*. From the definition, the minimum and maximum values of CDF are zero and one respectively and they represent the minimum and maximum stock return variance observed in the sample. To generate $\mathrm{CDF}\left(\sigma_{it}^2\right)$, we first rank all stock variances in ascending order. Then $\mathrm{CDF}\left(\sigma_{it}^2\right)$ is the cumulative probability of the stock return variance of firm *i* in year *t* in the sample. For example,

$$\mathrm{CDF}\left(\sigma_{11}^2\right) = \mathrm{prob}\left(\sigma^2 < 0.10\right) = 0,$$

$$\mathrm{CDF}\left(\sigma_{13}^2\right) = \mathrm{CDF}\left(\sigma_{31}^2\right) = \mathrm{CDF}\left(\sigma_{32}^2\right) = \mathrm{prob}\left(\sigma^2 \le 0.15\right) = \frac{4}{9},$$

$$\mathrm{CDF}\left(\sigma_{12}^2\right) = \mathrm{CDF}\left(\sigma_{33}^2\right) = \mathrm{prob}\left(\sigma^2 \le 0.20\right) = \frac{7}{9},$$

$$\mathrm{CDF}\left(\sigma_{23}^2\right) = \mathrm{prob}\left(\sigma^2 \le 0.25\right) = \frac{8}{9}, \text{ and } \mathrm{CDF}\left(\sigma_{21}^2\right) = \mathrm{prob}\left(\sigma^2 \le 0.30\right) = 1.$$

VITA

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