Stocking Up: Executive Optimism and Share Retention

Rik Sen & Robert Tumarkin *

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Abstract

We rigorously model the option exercise and portfolio choice problem of optimistic executives. Our analysis motivates two novel indicators of optimism, which can be easily inferred using standard data sets: (i) the retention of a significant proportion of stocks obtained from option exercise and (ii) the voluntary holding of shares. Theory suggests these are superior to alternative indicators based on exercise behavior. In a large cross-section, our measures of CEO optimism explain investment intensity and leverage better than those used previously. We confirm the following implications of the model empirically: optimistic executives delay option exercise and also capture a higher proportion of the American option value.

*Leonard Stern School of Business, New York University, 44 West Fourth Street, New York, NY 10012. We thank Jennifer Carpenter, Xavier Gabaix, Jeffrey Wurgler, and David Yermack for helpful comments.

1 Introduction

Recent work has established that optimistic and overconfident CEOs use more aggressive investment and financing strategies than their peers. As CEO personality traits are not directly observable, researchers, including Malmendier and Tate(2005a, 2005b), have inferred innovative and intuitive measures of optimism from information about an executive's personal portfolio decisions. We rigorously model the optimistic agent's investment and option exercise problem. Our theory suggests an improved way to measure the executive's outlook on the stock, while also providing a theoretical justification for previously used indicators. Empirically, our measures of CEO optimism are more related to firm investment and leverage decisions than those used before in the literature.

This paper builds on two branches of recent financial research: executive stock option exercise policy and the impact of managerial biases on corporate decisions. The models of Carpenter (1998) and Hall and Murphy (2002) fix the outside wealth portfolio exogenously when solving for the optimal exercise policy. The setting used in Carpenter, Stanton and Wallace (2008) implies that it is not optimal to hold stock in the outside portfolio. We extend these modes by allowing for executive beliefs to differ from market beliefs about future stock returns and endogenize the outside portfolio choice. Seminal work by Malmendier and Tate (2005a, 2005b, 2008) and Malmendier, Tate, and Yan (2007) infer managerial biases from their portfolio choice and option exercise behavior and link them with corporate decisions. Our theory provides justification for the measures of managerial biases used in these studies and motivates two new measures of managerial optimism. These can be computed for a large cross section of CEOs using commonly available data sets and show a stronger relation with investment and leverage decisions.

Both "optimism" and "overconfidence" have been applied inconsistently in the literature. Like Baker, Ruback, and Wurgler (2006), we use the term optimism specifically to mean that the executive has higher return expectations for her company's stock than those held by the market. She correctly assesses all other market parameters, such as market returns, volatilities, and correlations. Optimism in this paper is a belief. It is not necessarily a personality trait, an overestimation of ability, or a general market outlook. By contrast, Malmendier and Tate consider an overconfident CEO to be one who overestimates her skill, believing she has a strong ability to influence returns. Such overconfident CEOs are a subset of our optimistic CEOs, which, for example, also includes executives that overestimate returns but accurately evaluate their own skill. To Ben-David, Graham, and Harvey (2007), overconfident executives underestimate volatility, while optimistic ones overestimate expected returns. These traits are surveyed with respect to their beliefs about future market returns for most of their sample, although recent surveys correlate market sentiment with firm-specific beliefs. In our model, optimism is specific to beliefs about the firm. We do not capture underestimation of volatility by the executive.

We analyze the problem of portfolio choice and exercise of a non-transferable stock option for a risk-averse, optimistic executive. The executive is allowed to take unrestricted long positions in the stock, but not permitted to go short. In this regard, our paper enriches the literature on optimal exercise policy, which generally has assumed an exogenously fixed level of stock ownership. Optimistic executives tend to exercise later than their less optimistic peers. However, irrespective of the level of optimism, the executive always exercises early when compared to the optimal exercise policy of a non-optimistic unconstrained agent. We also analyze how the effect of optimism on optimal option exercise behavior changes with observable stock parameters, like dividend yield, volatility, and beta, and unobservables characteristics of the executive, such as wealth and risk aversion.

Given that optimism shows up as such a pervasive and powerful psychological bias in controlled experiments, it is important to derive theoretically grounded measures of it for use in empirical settings. Our analysis suggests two indicators of executive optimism: (i) the retention of a significant proportion of stocks obtained from option exercise and (ii) the voluntary holding of shares. The proportion of stock retained on exercise is always zero for non-optimistic executives. Similarly, a non-optimistic executive will choose to hold the minimum permissible number of shares. Finally, these measures of optimism have the virtue of being readily computable for a large cross section of executives using widely available data sets.

Previous researchers have argued that the tendency of an executive to hold onto the option for longer indicates optimism. Our theory supports this intuition. However, it may be optimal for an optimistic executive to exercise well before maturity or at seemingly low prices if the stock has a high dividend yield. On the other hand, a non-optimistic executive with a low risk aversion would tend not to exercise an option on a non-dividend paying stock too early. Such a risk-neutral executive might hold the option beyond seemingly reasonable price barriers.

Empirically, it is desirable to have measures of optimism that are independent of the stock's parameters and the agent's wealth and risk aversion. Optimism measures that focus on exercise time or critical strike prices implicitly assume that the tendency to delay exercise from optimism dominates the effects of stock parameters and unobservable executive characteristics. However, our analysis suggests this may not be true. By contrast, our two measures are always zero for non-optimistic executives. They are are thereby relatively independent of the shape of the optimal option exercise boundary and parameters of the problem.

Baker, Ruback, and Wurgler (2006) show that optimistic CEOs overinvest and tend to choose higher leverage. Empirically, we find that our measures of optimism for the CEO are positively related to the propensity of investment and firm leverage, after controlling for other factors. We also find that optimistic executives (according to our measures) tend to hold on to options for longer and sacrifice a lower proportion of the American option value when they exercise.

This paper contributes to the growing literature on executive optimism and its corporate finance implications. Our analysis also has implications for the literature on option exercise behavior of executives and its impact on cost of the option to the firm, the value of the option to the executive, and incentive effects of stock options.

The remainder of this paper is organized as follows. In section 2, we present a two-period model in which an optimistic executive with general utility maximizes the portfolio value from a pseudo-American option. Section 3 extends the model into continuous time. Numerical results from solving the continuous time model with an explicit finite difference scheme are explored in section 4. In section 5, we show empirically that our measures of optimism are positively related to investment intensity and leverage. Section 6 concludes.

2 Two-Period Two-State Model

We begin by modeling the portfolio choice and optimal exercise problem of a risk-averse executive who holds a non-transferable option on company stock. For simplicity, we use a two-period, two-state problem in this section. This simplification does not sufficiently capture the dynamics between the optimal exercise policy and portfolio choice, which are considered in the continuous time model of section 3. However the basic intuition for several of our results are easily seen in this setup.

The executive maximizes expected terminal utility from wealth, under a general concave increasing utility function. The executive can invest in the company stock and a riskless asset. Our executive can be optimistic about the returns on the company stock. In this section we show two main theoretical results. First, as executive optimism increases, the tendency for the executive to delay exercising options increases. Second, the executive will not hold the option beyond the optimal early exercise boundary for an unconstrained non-optimistic agent. Allowing an optimistic executive to take unrestricted long positions in her company stock is important for the second result. These two results have important empirical implications for measures of executive optimism based on exercise policy.

2.1 Model

The economy exists for two periods, $t = 0$ and $t = 1$. The executive is endowed with outside wealth W which she can invest in company stock, subject to a short sale constraint, and in a riskless asset, whose gross period return is assumed, for convenience, to be 1. The executive also has a pseudo-American option on the company stock with strike price K, which can be exercised at either time. The option is non-transferable and non-divisible.

Assume that the stock pays a dividend $S\delta \geq 0$ at $t = 0$, such that its ex-dividend price is S. If the option is exercised at $t = 0$, the executive holds the stock instantaneously, receives the dividend, and can then trade the stock in the market. At $t = 1$, the stock will be worth either uS or dS, $u > 1 > d$. q is the executive's level of optimism over the company's returns, which manifests in the belief that the high state return u occurs with probability q, $1 > q > 0$. The executive maximizes expected terminal utility from wealth, where $U(\cdot)$ is an increasing, concave, and twice differentiable utility function.

Let p be such that $pu + (1-p)d = 1$. The market is assumed to be risk neutral and believes that the probability of the up-state is p. Therefore, the stock has an expected gross return of 1, which is the same as the risk-free rate. This implies that a risk averse agent who shares the market beliefs about future stock returns would not want to invest in the stock.

Define the agent's expected utility from exercising the option at $t = 0$ and investing I in the stock as $U_E(q, I)$, for optimism level q. Similarly call the expected utility from holding the stock options and investing I in the stock as $U_N(q, I)$. Clearly, these values satisfy:

$$U_N(q,I) = qU\left(W + I(u-1) + [uS-K]^+\right) + (1-q)U\left(W + I(d-1) + [dS-K]^+\right) \tag{1}$$

$$U_E(q,I) = qU\left(W + (S + S\delta - K) + I(u-1)\right) + (1-q)U\left(W + (S + S\delta - K) + I(d-1)\right) \tag{2}$$

For each case, define the optimal investment strategy $I^*(q)$ as

$$I_N^*(q) = \text{argmax}_{I \geq 0} U_N(q, I)$$
$$I_E^*(q) = \text{argmax}_{I \geq 0} U_E(q, I)$$

The optimal utilities $U^*(q)$ are given by

$$U_N^*(q) = U_N(q, I_N^*(q))$$
$$U_E^*(q) = U_E(q, I_E^*(q))$$

The executive chooses an exercise policy $X \in \{0, 1\}$ to solve

$$\max_{X \in \{0,1\}} XU_E^*(q) + (1 - X)U_N^*(q)$$

2.2 Constraints on the exercise boundary

Consider the value maximization problem of an unconstrained agent that owns an option on the stock. The agent can hedge all unwanted risk in the stock created by holding the option. In some cases, early exercise will be optimal to maximize total value. In general, early exercise arises because of a dividend capture incentive.[1]

An important result from this model is that the short-sale constrained executive will exercise the option early whenever it would be optimal for an unconstrained agent to do so. This result is stated in the following proposition.

Proposition 2.1. *Define the risk-neutral boundary as the minimum $\bar{S}$ at which a unconstrained agent would prefer to exercise the option; $\bar{S} = \frac{(1-p)K}{1+\delta-up}$.[2] For all stock prices above the boundary price, $S > \bar{S}$, it is optimal for a risk-averse executive who is not allowed to go*

[1] In this discrete time model, the unconstrained agent is indifferent between early and delayed exercise even if the stock does not pay a dividend ($\delta = 0$) provided that the option pays off when state d is realized.

[2] The unconstrained agent will exercise immediately for all $S \geq \bar{S}$.

short on the stock to exercise the option early. This holds for all $q \in (0,1)$.

Proof. Appendix B. □

The intuition behind the proposition lies in the outside portfolio choice problem for the constrained executive. As optimism increases, the executive has a weakly increasing desire to hold company stock. However, when it is optimal to exercise the option early, the constrained executive can do so and replace the option holding with stock. Such behavior maximizes value, allowing the constrained executive to capture dividends. This result also holds in continuous time as shown later.

2.3 Effect of optimism on the exercise boundary and stock holdings

The executive's outlook q on the stock's returns impacts the range of prices at which it is optimal for the executive to exercise the option at $t = 0$. When the executive is more (less) optimistic, the executive requires a higher (lower) price for early exercise.

Proposition 2.2. *If it optimal for the executive to exercise the option at $t = 0$ for optimism level q_1, then it is optimal to exercise the option at t=0 for all lower levels of optimism. Mathematically, if $U^*_E(q_1) > U^*_N(q_1)$ then $U^*_E(q_2) > U^*_N(q_2)$ for all $q_2 < q_1$.*

Proof. Appendix B. □

The economic intuition behind Proposition 2.2 is straightforward. The risk-averse executive cannot short stock against the option exposure. Therefore, the extra return from holding the option versus early exercise must be weighed against an increase in risk. As the executive becomes less optimistic, this trade off becomes more onerous for a given stock level. So, if it is optimal for an executive to exercise early at a stock price, then it is not worth holding on to the option due to added risk. An executive with lower optimism will have a worse risk-return tradeoff and also exercise the option early.

Proposition 2.3. *Conditional on it being optimal for the executive not to exercise the option early, the number of stocks held in her portfolio is weakly increasing with optimism. Mathematically,* $I_N^*(q_1) \geq I_N^*(q_2)$ *for all* $q_1 > q_2$*.*

Proof. Appendix B □

As the stock becomes a more attractive investment, the executive would want a higher exposure to the stock. Consequently, a more optimistic executive would hold a higher amount of stock in her portfolio.

3 Continuous Time

We now consider a continuous time, partial equilibrium version of the problem in which a risk-averse executive maximizes terminal utility of wealth. The investment opportunity set consists of a stock, a market, and a risk free asset. These are governed by exogenously specified security price processes. The executive can take long positions on the stock, but no short positions.[3] She can take both long and short positions on the market. The stock and market may be correlated, allowing the executive to hedge some systematic risk in the non-transferable option. We show that a critical result of the discrete time model holds in continuous time; the executive will not hold the option beyond the optimal early exercise boundary for an unconstrained agent. This holds for general concave utility functions. In section 4, we examine the numerical implications of the model for an executive with constant relative risk aversion.

The executive's optimism is modeled by an additional drift term on the stock price process. Optimism is constant ex ante, past returns do not affect the executive's outlook on the stock. Throughout the description of the model, we allow for the stock to follow two related stochastic processes. The physical measure is denoted by dS_t^P, while the optimistic executive

[3]In practice, Section 16(b) insiders are subject to short swing profit rules that prevent them from trading in opposite directions within a six month period and making a net profit. However, this should not have a significant impact on the main theoretical results.

believes the stock follows a process denoted by dS_t^E. The stock price is observable, so this difference only affects the expected process followed by the stock. The executive's trading in the stock does not affect prices.

3.1 Model

The model in this section extends the rigorous model developed by Carpenter, Stanton, and Wallace (2008), hereafter CSW. Our extension allows for executive optimism, which is modeled as an additional subjective drift on the company stock. The executive in CSW is equivalent to our executive without optimism. CSW conduct an exhaustive study of option exercise policy and its implications on option cost, term, valuation, and FASB regulation. Our analysis, by contrast, focuses on the implications of option exercise policy on empirical measures of optimism. In the context of the model, the executive only wants to hold company stock when she is optimistic. As such, we enrich the literature by considering the implications of the model when the optimal portfolio includes company stock.

The executive has outside wealth W and at time $t = 0$ receives n non-transferable options with strike price K, time to expiration T and vesting period t_v. The executive's investment opportunity set consists of three securities: a risk-free asset B, a market security M, and the firm's stock S. The risk-free asset grows exponentially at the constant rate r. The market and stock securities are geometric Itō diffusions which satisfy the stochastic differential equations under the physical measure

$$dM_t/M_t = \mu dt + \sigma_m dW_{1,t} \tag{3}$$

$$dS_t^P/S_t = (\lambda - \delta)dt + \sigma_s dW_{2,t} \tag{4}$$

$W_{1,t}$ and $W_{2,t}$ are standard Brownian motions with instantaneous correlation ρ. The stock yields instantaneous dividend δ[4]. We impose the CAPM and assume that $\lambda = \beta(\mu - r) + r$, where $\beta = \rho\sigma_s/\sigma_m$.

The executive is optimistic about the expected return of the company's stock. In addition to the appropriate market compensation for systematic risk, the executives believes that the stock has an additional instantaneous drift of ηdt.

$$dS_t^E/S_t = (\lambda - \delta + \eta)dt + \sigma_s dW_{2,t} \tag{5}$$

We assume that the n options must be simultaneously exercised and that the executive faces short sales restrictions on the company stock. The executive solves the problem of maximizing terminal utility by choosing a time τ to exercise the options and portfolio weights in the market and stock $\omega_t = (\omega_t^m, \omega_t^s)$[5].

$$f(W_t, S_t, t) = \max_{t_v \leq \tau \leq T, \omega_t^M, \omega_t^S \geq 0} V(W_\tau^\omega + n(S_\tau - K)^+, \tau) \tag{6}$$

where W_τ^ω is the wealth obtained by following the investment process ω_t.

$$dW_t^\omega/W_t = \left[r + \omega_t^M(\mu - r) + \omega_t^S(\lambda + \eta - r)\right] dt + \omega_t^M \sigma_m dW_{1,t} + \omega_t^S \sigma_S dW_{2,t} \tag{7}$$

The manager has terminal utility function $U : W \to \mathbb{R}$, which is strictly increasing and concave. $V(\cdot,\cdot)$ is the indirect utility function representing the solution to the managers portfolio choice problem after option exercise.

$$V(W, \tau) = \max_{\theta_t^M, \theta_t^S \geq 0} \mathbb{E}\left[U\left(W_T^\theta\right)\right] \tag{8}$$

[4]Without loss of generality and to simplify notation, we assume that the market does not pay dividends. Dividends paid by the market do not enter into the executive's portfolio choice or option exercise decisions.

[5]These portfolio weights satisfy the technical condition $\mathbb{E}\left[\int_0^\tau ||\omega||\right] < \infty$ and other standard regularity conditions.

where W_τ^θ is the wealth obtained by following the investment process θ_t.

$$dW_t^\theta / W_t = \left[r + \theta_t^M(\mu - r) + \theta_t^S(\lambda + \eta - r) \right] dt + \theta_t^M \sigma_m dW_{1,t} + \theta_t^S \sigma_S dW_{2,t} \tag{9}$$

The continuation region D is the set of values (W, S, t) for which the executive does not exercise the options. It is defined by

$$D = \left\{ (W, S, t) : t < t_v \text{ or } f(W, S, t) > V(W + n(S - K)^+, t) \right\} \tag{10}$$

3.2 Constraints on the exercise boundary

In continuous time, the continuation region for a constrained executive lies within the continuation region for an unconstrained executive. Whenever it would be optimal for an unconstrained executive to exercise the option before expiration, it is also optimal for a constrained executive to do so. Such incentives often arise with American options on dividend paying stocks.

Consider the parallel problem for an unconstrained agent, who is able to short company stock. As before, the agent has a non-divisible, non-transferable option on the company stock. Let f^u and V^u be the unrestricted forms of problems (6) and (8), respectively. For precise definitions, see Appendix C. Define the continuation region D^u, in which the unconstrained agent does not exercise the options as

$$D^u = \left\{ (W, S, t) : t < t_v \text{ or } f^u(W, S, t) > V^u(W + (S - K)^+, t) \right\} \tag{11}$$

Proposition 3.1. *The continuation region of the constrained, optimistic executive lies within* *the continuation region of an unconstrained agent.*

$$D \subseteq D^u$$

Proof. Appendix C. □

Proposition 3.1 has important implications for empirical measures of optimism. The continuation region of the unconstrained CEO contains the continuation regions of all optimistic executives. When D^u is finite, early exercise may be optimal even if the executive is very optimistic. On the other, when D^u is infinite, a non-optimistic executive may optimally delay option exercise. Such delay can occur when the utility function exhibits decreasing absolute risk aversion and the CEO has large outside wealth.

3.3 Conditional expectations

Our objective is to understand how empirical measures of optimism are related to observable parameters of the stock price process and unobservable characteristics of the executive. For much of the data set we use, only option exercises are our observable; options that are vested but unexercised are not seen. As such, we consider three measures of executive optimism conditional on option exercise.

Our primary measure $PROE$ is the percentage of shares retained by the executive on exercise of the option: $PROE(\tau) = (\theta^S_\tau - \omega^S_\tau)/(n \cdot S)$. Intuition suggests that this is a clean measure of optimism. A non-optimistic executive will generally choose not to hold shares in the stock, which, given the short-sale constraint, implies $PROE$ is 0. On the other hand, an optimistic executive will generally want to hold shares in the stock. As the option represents exposure to the stock, one expects that the total number of shares held by the executive increases on exercise.

We also consider the conditional expected time to observed option exercise: $\tilde{\tau}$. This measure is analogous to any measure of optimism that has fixed time and strike thresholds. It is, in spirit, similar to several measures commonly used in the optimism and overconfidence literature. Intuitive arguments imply that optimistic executives delay exercising their option. However, while an executive may delay exercising the option due to optimism, the interrelationship between unobservable characteristics of the executive, such as risk aversion and wealth, and stock price parameters may also result in delayed exercise.

Finally, we consider the fraction of the value of the option received by the executive at exercise $VR(\tau) = (S_\tau - K)^+/P(S, \tau)$, where $P(S, t)$ is the market price of an American option with the same characteristics of the executive's option. As the American option is a freely traded and redundant security, it is not a function of the executive's wealth. Intuition suggests that optimistic executives will receive a higher fraction of option value at exercise.

Let X be a variable of interest: $PROE, \tilde{\tau}$, or VR. Let X_c be the expectation of X, conditional on option exercise. Define the time-t operator $\mathbb{E}_t^P$ as the expectation under the physical probability measure and ∂D as the boundary of the continuation region. To compute X_c.

$$X_c = \mathbb{E}_t^P \left[X | (W_\tau, S_\tau, \tau) \in \partial D \right] \tag{12}$$

$$= \mathbb{E}_t^P \left[X \cdot 1_{(W_\tau, S_\tau, \tau) \in \partial D} \right] / \mathbb{E}_t^P \left[1_{(W_\tau, S_\tau, \tau) \in \partial D} \right] \tag{13}$$

where 1_a is the indicator function of event a.

4 Numerical Results

We solve for the indirect utility function, optimal portfolio allocations, and optimal option exercise policy for a manager with constant relative risk aversion. The manger's risk aversion is indexed by γ where her preference over terminal payouts are given by $U(W, T) = \frac{1}{1-\gamma} W^{1-\gamma}$. Given this, the indirect utility function after the options are exercised has the well known solution to Merton's problem, $V(W,\tau) = \frac{1}{1-\gamma} W^{1-\gamma} e^{(T-\tau)\epsilon}$, where ϵ is a constant.

Define $\mathbb{E}^O$ as the expectation under the executive's optimistic probability measure. In the continuation region D, the value function f satisfies $\mathbb{E}^O[df] = 0$. To simplify notation, define the operator $\mathcal{L}^{\alpha,\beta}$

$$\mathcal{L}^{\alpha,\beta} = f_t + f_S S(\beta - \delta) + f_W W\left(r + \omega_t^M(\alpha - r) + \omega_t^S(\beta - r)\right) + \frac{1}{2} f_{SS} S^2 \left(\omega_t^S \sigma_S\right)^2 + \frac{1}{2} f_{WW} W^2 \left((\omega_t^M \sigma_M)^2 + 2\rho\omega_t^M \omega_t^S \sigma_M \sigma_S + (\omega_t^S \sigma_S)^2\right) + f_{SW} WS\left(\omega_t^M \rho \sigma_M \sigma_S + \omega_t^S \sigma_S^2\right) \tag{14}$$

Assuming that the indirect utility function f is sufficiently smooth, then in the continuation region it satisfies

$$\mathcal{L}^{\mu,\lambda+\eta} f = 0. \tag{15}$$

The first order conditions for this p.d.e. and the executive's short sale constraints imply the optimal holdings in the stock and market securities. Comparison of the continuation indirect utility and the indirect utility on option exercise gives the optimal exercise policy. Once the executive's strategy is known, it is possible to solve for the conditional expected values: proportion of stocks retained on exercise, time to exercise and value ratio. These all satisfy the partial differential equation:

$$\mathcal{L}^{\mu,\lambda} \mathbb{E}_t^P \left[X \cdot 1_{(W_\tau, S_\tau, \tau) \in d}\right] = 0 \tag{16}$$

The freely traded American option value does not depend on the portfolio choice, exercise policy, or wealth of the executive. Instead, in its continuation region, the market value $P(S,t)$ is governed by

$$\mathcal{L}^{r,r}P|_{W=\omega_t^M=\omega_t^S=0} - Pr = 0 \tag{17}$$

4.1 The impact of optimism

We solve equations (15), (16), and (17) simultaneously using a Leapfrog Du Fort-Frankel scheme, an explicit finite difference method. The errors of this scheme Δu are second order in both space and time; $\Delta u = O(\Delta x^2) + O(\Delta t^2)$. This is an improvement of one order in time over a traditional Euler Explicit finite diference scheme. For details on the solution method see Appendix D. Note that we are solving multiple versions of equation (16), each with unique boundary conditions, to compute the measures of optimism and the probability of option exercise.

We use univariate modifications of our base case to study the impact of beta, volatility, correlation, dividends, risk aversion, and executive outside wealth on the executive's behavior. We look at the evolution of the early exercise boundary, the expected proportion of stocks retained on exercise, the expected time to option exercise, and the expected value ratio conditional on exercise. In our baseline case, the executive has relative risk aversion of $\gamma = 3$ and initial outside wealth of 1. Additionally, the stock price, strike price, and number of options are all initialized to 1 at $t = 0$. The risk free rate is 5%, the market risk premium is 8%, and the market has instantaneous standard deviation 20%. The stock has standard deviation 40%, beta 1.2, and pays a dividend of 3%.

Figure 1 plots the smoothed early exercise boundary for different levels of optimism and outside wealth. For each wealth level, as optimism increases, the exercise boundary moves outward to higher stock prices. This confirms both the intuition from the discrete time model and the reasoning used in Malmendier and Tate (2005a, 2005b, 2008): optimism and overconfidence affects the executive's decision to exercise the option. The effect is greater for higher levels of outside wealth. However, as can be seen, unobservable parameters, such as outside executive wealth, greatly affect the optimal exercise boundary and its relationship with optimism.

Table 2 shows how the number of stocks retained on option exercise relates to executive optimism. The most important result is that a non-optimistic executive $\eta = 0\%$ will sell all the shares received from exercise. Optimistic executives choose to hold onto shares at exercise. This result suggests that whether or not the executive retains shares at exercise is a function purely of optimism. While stock parameters and characteristics of the executive affect how many shares are retained, only optimistic executives will chose to retain shares. Neutral and pessimistic executives should sell all their shares irrespective of observable and unobservable parameters.

The number of shares retained on exercise increases with optimism, as expected. This increase is more sensitive for higher beta, lower volatility, and higher dividend stocks. Additionally, the sensitivity is more pronounced when the executive has lower risk aversion and higher wealth. Together, these results imply that the executive's holding in the stock after exercise is generally related to her ability to hedge the shares. When the market is a better hedge, the executive chooses to hold more stock. This occurs in the model by reducing idiosyncratic risk, such as incresing beta or lowering volatility. Risk neutral and wealthy executives are more able to bear stock hedging costs and hold more the shares receives from option exercise.

Table 3 examines the expected time to option exercise. Time to exercise increases with executive optimism. Early exercise can be optimal even for an optimistic executive if the stock pays a dividend. As such, time to exercise decreases with increasing dividends. Hedging costs have a critical role in determining the length of time the executive holds the option; the impact of optimism is greatest when hedging costs are low. When the idiosyncratic part of the stock return is low (high beta or low volatility, Panels 2, and 3), the option is held longer. Relatively risk-neutral and wealthy executives hold the option longer than other executives because they can more readily bear the hedging costs.

Unlike stocks retained on exercise, the non-optimistic executive does not exercise at a consistent baseline time, which is independent of model parameters. A non-optimistic executive may exercise early due to risk-aversion and dividend capture. Or, she can exercise late because of high outside wealth and lack of stock dividends. For example, in our base case $W_0 = 1.0$, an executive with $\eta = 4\%$ holds the option for an expected 5.026 years. However, a very wealthy executive $W_0 = 3.0$ with a neutral outlook on the stock, $\eta = 0\%$ will hold the option for 5.299 years. As such, it is not clear the a measure of optimism based on a time to maturity is a clean measure of optimism.

Exercise timing and critical price thresholds are complicated functions of model parameters. This suggests that a multidimensional exercise boundary may successfully classify optimistic executives. However, while it may be possible to calibrate a complicated model that makes predictions about the exercise boundary given observable parameters, such a calibration would be difficult and still omit unobservable parameters. By contrast, our measures, proportion of shares retained on exercise and voluntary holdings, are relatively simply to compute and are relatively immune to reasonable variation in unobservable traits of the executive.

Empirical literature studying optimality of executive stock option exercise, for example Bettis et al. (2005), has looked at value ratio in addition to expected time to exercise. Table 4 shows how the expected value ratio changes with parameters in the model. Optimistic executives receive more of the option value on exercise. Options that are more easily hedged result in the executive receiving a higher percent of the option value at exercise. However, the impact of optimism is greatest when the stock cannot be hedged. If the option represents a substantial risk, a non-optimistic executive will exercise early and sub-optimally. This occurs when the stock has low beta and high volatility. Additionally, when the executive has low risk aversion or high outside wealth, optimism matters very little. Exercise is close to optimal in both cases.

The value ratio increases with dividends. This is intuitively sensible; dividends destroy the optional value for an American option. The American option on a dividend paying stock has more of its total value represented by its intrinsic value. As such, the value ratio is a mechanical function of the dividend. While options on dividend paying stocks are less likely to be exercised, because the dividend lowers the stock drift, the executive receives a higher percent value of the option total value conditional on exercise.

The results in Tables 3 and 4 show that optimism can have large effects on stock option exercise behavior. This could affect studies of the cost of the option to the firm and incentive to the executive.

Empirically, it is desirable to have a bounded indicator of optimism, which is primarily sensitive to changes in the optimism parameter. Of the measures presented, proportion of stocks retained on exercise has those properties. It is bounded between 0 and 1. 0 represents a non-optimistic or pessimistic CEO; 1 is the limiting value as optimism increases irrespective of other model parameters. Shares retained is sensitive to optimism, suggesting that it can be converted into indicator variables with fewer misclassification errors than other measures. $PROE$ will always correctly classify the extremes of executive optimism, which includes highly optimistic, non-optimistic, and pessimistic executives. Other measures can misclassify a non-optimistic executive as optimistic. For example, if the stock does not pay dividends and outside wealth is high, the executive delays exercise and also receives a high value ratio on exercise. All empirical measures have the potential to misclassify executives when optimism is in a normal range. However, the sensitivity of PROE to optimism suggests that this measure will have fewer misclassification errors than alternatives.

5 Empirical Results

5.1 Data

For the empirical analysis we match option exercise data from Thomson Financial with Compustat's Executive Compensation database[6]. We obtain financial statement related variables from Compustat's Annual file and stock prices from CRSP. Option exercise data is available in Thomson Financial only after January 1996. Therefore our sample runs from 1996 to 2006.

Thomson Financial Insider trading database compiles information from forms 3, 4 and 5 reported by insiders to the SEC. Option exercise data is obtained from table 2 of form 4 reports. For our study, we keep only those records with a cleanse indicator (assigned by Thomson) of R, H, C, L or I. R, H or C indicates that the data is accurate with a very high degree of confidence. L and I indicate that Thomson either cleaned or improved the data, but could not verify the data from secondary sources. Around a third of all exercise data have an indicator of either L or I. Hence we chose not to drop this data even though some other researchers have dropped these observations.[7] Our cleaning procedures described later should correct for most of the errors. We drop all records that are an amendment to a previous report.

We clean the data as follows before using it. We drop all exercises where the exercise price of the option is less than \$0.10, since the exercise price in these cases could either be erroneous or these options are essentially equivalent to restricted stock. We also drop exercises with exercise price greater than \$2,000. We drop exercises for which the maturity date of the option is before the exercise date or the exercise date is missing, since in these cases the time remaining to maturity cannot be calculated. For exercises which are exercised with more than 8,000 days remaining to maturity, we set the time remaining to maturity

[6] See Appendix E for details on our matching procedure.
[7] Our basic results remain unchanged even if we drop these observations.

to be 8,000 days. This reduces the effect of extreme outliers on the results. We also drop data for those CEO-years for which the total number of options exercises obtained from the Thomson Financial Insider Trading database is not close to the total number of option exercised during the year as reported in the Executive Compensation database. Specifically, we drop those data points where the number from Thomson Financial is less than half or more than double the number from Executive Compensation.

The stock price on the exercise date is obtained from CRSP. If the date of the exercise is not a trading day, then we obtain the price on the previous trading day.

At each option exercise we calculate the value ratio at exercise. This is calculated as the ratio of the payoff from exercise to the American option value under optimal exercise policy from that point on. To obtain the American option value, we use a binomial tree model, averaging the prices from a 250 and a 251 node tree. We use the past 3-year average dividend yield and volatility calculated using monthly returns over the previous 36 months. We use a 2-year or 1-year average of dividend yield when it is not possible to calculate 3-year averages. Since we are trying to estimate the expected future dividend yield and volatility of the stock, extreme volatility and dividend yields, which are unlikely to repeat in the future, are winsorized by year. Volatility values are winsorized at the 5th and 95th percentiles. Dividend yields which are larger than the 95th percentile are set to be equal to the 95th percentile. For the interest rate, we first obtain the zero curves for each day derived from BBA LIBOR rates and settlement prices of CME Eurodollar futures. For a given option, the appropriate interest rate input corresponds to the zero-coupon rate that has a maturity equal to the option's expiration, and is obtained by linearly interpolating between the two closest zero-coupon rates.

We obtain total stock holdings, restricted stock holdings, option holdings, and salary data from Executive Compensation database of Compustat. We define total stock holdings (not including options) which is in excess of restricted stock holdings as "voluntarily held stock".

There are two reasons why this measure is noisy. Firstly, the restricted stock holdings are measures as of the fiscal year end date, while the total stock holdings are measured as of a date between the fiscal year end date and the proxy filing date. Vesting of restricted stocks and the effect of transactions between the fiscal year end date and the date on which the stock holding is recorded may not be appropriately reflected in the measure. The second source of measurement error arises from the fact that many firms have minimum stock holding requirements (Core and Larcker (2002)). To account for this noise, we use Core and Larcker's stock ownership minimum as a multiple of salary. They find a mean and median multiple of 4.0. We compute this implicit restricted stock holding level as of fiscal year end. We then take the maximum of this value and that reported in Executive Compensation plus one thousand. As Executive Compensation has a large number of missing restricted holding observations, this method partially corrects for erroneous use of zero restricted holdings. Our sample has a mean ownership to salary ratio of 2.8 for non-missing observations. Using this value instead of 4.0 does not change the results. To the extent that measurement errors are systematically related to the variables of interest, our empirical results should be interpreted with caution.

5.2 Optimism and suboptimality of exercise

Our theory implies that more optimistic CEOs hold on to a larger proportion of shares obtained from exercising the option. Motivated by this observation, we compute PROE as the proportion of stocks retained by the CEO on option exercise. It is averaged across option exercises by every CEOs during each fiscal year. Our second measure for optimism is motivated by the observation that voluntary holding of stock weakly increases with optimism. We create an indicator variable that attempts to capture whether the CEO holds stocks voluntarily. CEOs are required to report total stock holdings in proxy statement. However these holdings may not be voluntary. Some of these might be unvested restricted stocks, which the CEO is not free to sell. Core and Larcker (2002) find that firms often have minimum stock holding requirements for their top executives. This requirement is often stated in terms of a multple of their salary. In their data they find that the mean and median salary multiple is 4. If the value of a CEO's total stock holding is more than 4 times her salary and also exceeds her unvested restricted stock holding by 1000, we take this as an indication that she holds stocks voluntarily and the variable VoluntaryHolder is defined to be one. For all our empirical results, VoluntaryHolder is measured as of the beginning of the fiscal year i.e. using data from the previous year.

Our numerical results show that more optimistic executives tend to exercise their options later. Also, when they do exercise, the value ratio, that is the ratio of the intrinsic value to the American option value, is higher for more optimistic executives. In this section, we test these implications of our model.

Results are presented in Table 5. We categorize every CEO-year into either a high optimism or low optimism group based on our measures of optimism. We then compare the means and medians of time remaining to maturity at exercise and ValueRatio across the two groups. When classified based on PROE, on an average, more optimistic CEOs exercise around 0.8 years later than less optimistic ones. When classified based on voluntary stock holdings, more optimistic CEOs exercise around 0.9 years later than less optimistic ones. These differences are significant at 0.1% significance level. The differences in medians between the two groups are even larger, more than 1.5 years, for both kinds of classification and are also statistically significant at the 0.1% level. Similarly ValueRatio also changes significantly across more and less optimistic CEOs. These results show that optimism seems to have a significant impact on option exercise behavior of executives.

5.3 Impact of optimism on investments and leverage

Optimistic CEOs would overestimate the returns to available projects and therefore choose to invest more aggressively. We test this hypothesis by regressing investment intensity variables on optimism measures and controls. The investment intensity variables are capital expenditures intensity, computed as capital expenditures scaled by assets, and acquisitions intensity, computed as acquisitions scaled by assets. Optimistic CEOs would feel that the equity of the firm is undervalued relative to debt and therefore choose a higher leverage ratio.To test this, we regress leverage ratio on optimism variables and controls. Our controls for the above regressions include collateral, size, asset market-to-book, profitability, 12-month past returns, a dividend-payer dummy, industry and time fixed effects. Our control variables are chosen based on Frank and Goyal (2007b) and Ben-David, Graham and Harvey (2007). In all our regressions, the t-statistics are computed by clustering standard errors by firm or by 48 Fama-French industries.

We use the tendency of an executive to habitually hold on to a non-trivial portion of the shares after exercise as our first measure of optimism in the regressions. Since we observe share retention behavior only for the years in which there is at least one exercise, we use all observations across years for the same CEO and create a variable that takes the same value for each CEO for the entire sample period. The variable ShareRetainer is calculated as follows. For every option exercise, we calculate an indicator Retainer_25 which is 1 if the executive sold less than 75% of the shares obtanied from exercise within a week of exercise. Then, for every executive-year in which there is at least one exercise, we calculate the weighted (by the number of options exercised) average of Retainer_25. Finally, these executive-year observations are averaged for to each executive to obtain ShareRetainer. To address the statistical issues arising out of the variable taking the same value for each CEO for all years, standard errors are clustered at the firm level. Our second measure of optimism is VoluntaryHolder, which was described in the previous section and captures whether the

CEO voluntarily holds stock. This variable can take a different value for each CEO year.

We create a third measure of optimism following Malmendier and Tate (2005). Malmandier and Tate (2005) create their measures using option grants and aggregate exercise data reported in annual proxy statements. They classify a CEO as overconfident (for all of her years in the sample) if she ever holds an option until the last fiscal year of its duration. We use option exercises reported to the SEC on form 4 to create this measure. For each exercise, the CEO reports the expiration date of the option. If a CEO exercises an option within 6 months of expiration in two different fiscal years, we classify her as optimistic (for all the years in the sample) and set the indicator variable LongHolder to one. This is done to reduce the noise in the classification and reduce the chances of misclassifying a CEO as optimistic due to an error in reporting the expiration date in form 4. Classifying CEOs as optimistic based on exercising an option within 6 months of expiration just once (instead of in two different fiscal years) gives virtually identical results.

The results for investment intensity are presented in Tables 6 and 7. Overall the results show that investment intensity increases with our optimism measures. Our optimism measure based on shares retained on exericise is highly significantly related to capex intensity and acquisition intensity. The optimism measure based on voluntary holding of stock is significantly related to capex intensity and marginally significantly related to acquisition intensity. In contrast, our LongHolder indicator seems to be negatively related to both acquisition intensity and capex intensity, though the relation is only marginally significant.

The results for the effect of optimism on book leverage are presented in Table 8. Our measures are marginally positively related to book leverage, while LongHolder is negatively related, but this relation is not statistically significant.

Following Malmendier and Tate, we examine whether investment-cashflow sensitivity is affected by optimism. Note that our sample is from a different time period and the cross section is larger than that used by Malmendier and Tate, so our results are not directly comparable with theirs. The results are presented in Table 9. Although all the measures are positively related to investment-cashflow sensitivity, none of the relations are statistically significant. However, both our measures are more strongly related to investment-cashflow sensitivity when comapared to LongHolder. If we define the LongHolder measure based on exercising an option within 6 months of expiration just once (instead of in two different fiscal years), it performs slightly better in the regression, but the coefficient is still not statistically significant.

Overall, the results demonstrate that our measures perform reasonably well empirically predicting the behavior of optimistic CEOs.

6 Conclusion

This paper conducts a rigourous theoretical analysis of the optimal exercise and portfolio policy of an executive when her beliefs about future stock returns differ from market beliefs. Specifically, we focus on an optimistic executive who believes that the expected stock returns are higher than what is assumed by the market. Intuitive measures based on delayed exercise of options by executives have been used to infer executive's optimism and overconfidence of her own ability in pervious literature. While our theory provides some justification for such measures, our analysis shows that they can often misclassify executives depending on dividend yield, volatility, executive wealth and risk aversion. Our theory motives two novel indicators of executive optimism: (i) the retention of a significant proportion of stocks obtained from option exercise and (ii) the voluntary holding of shares. Theoretically, non-optimisitic executives will not meet the criteria for these indicators irrespective of the values of observable and unobservable parameters. Additionally, they can be computed for a large cross section of executives using widely available data sets.

Our paper contributes to the growing literature on the relation between beliefs of the executive (optimism, overconfidence, etc.) and corporate finance implications. Our measures of CEO optimism are positively and significantly related to propensity of investment and firm leverage.

Our theoretical and empirical analysis show that executive optimism has a large effect on option exercise behavior. This suggests that executive optimism might affect the cost of the option to the firm, its incentive effects and its value to the executive. Therefore, executive optimism might be an important factor for future researchers to consider from the perspective of optimal compensation policy.

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A Variable definitions

Variables of executive optimism	
Share Retainer	For every option exercise we calculate an indicator Retainer_25 which is 1 if the executive sold less than 75% of the shares obtanied from exercise within a week of exercise. Then, for every executive-year in which there is at least one exercise, we calculate the weighted (by the number of options exercised) average of Retainer_25. Finally these are averaged for to each executive to obtain ShareRetainer.
Voluntary Holder	This is an indicator variable which is one if the stock holdings of the executive at the end of the fiscal year exceeds the greater of four times the executive salary in the previous year and the reported number of restricted shares plus one thousand.
Long Holder	We follow Malmendier and Tate (2005) in the creation of this variable. This is an indicator variable which operates at the level of each CEO. If a CEO exercises options within 6 months of maturity in two different fiscal years during our sample period, the variable is one.
Variables from Compustat Annual File	
Acquisition Intensity	Acquisitions(item 129) / lag(toal assets (item 6)).
Assets	Assets (item 6)

Asset Market-to-Book	Total assets at market values / total assets at book values = (share price (item 199) * #shares (item 54) + debt in current liabilities (item 34) + long-term debt (item 9) + preferredliquidation value (item 10) - deferred taxes and investment tax credit (item 35)) / total assets (item 6).
Book Leverage	Total debt / total assets at book values = (long-term debt (item 9) + debt in current liabilities (item 34)) / total assets at book value (item 6).
Cash Flow	Earnings before extraordinary items (item 18) plus depreciation (item 14)
Capex Intensity	Net investments / lag(total assets at book values) = (capital expenditures (item 128) + increase in investments (item 113) + acquisitions (item 129) - sales of property, plant and equipment (item 107) - sale of investments (item 109)) / lag(total assets (item 6)).
Collateral	Tangible assets / total assets at book values = (plant property & equipment (item 8) + inventory (item 3)) / total assets (item 6).
Dividends	1 if declared dividends (item 21), and 0 otherwise
Investment	capital expenditures (item 128)
Profitability	Operating profit (item 13) / lag(total assets (item 6))
Sales	Annual sales in millions of USD (item 12).
Variables from Compustat's Executive Compensation Database	
1 year Return	TRS1YR (one year total return)
Dividend yield	bs_yield (average dividend yield over previous 3 years)

Volatility	bs_volatility (volatility computed using monthly returns over previous 5 years)

B Discrete Time Proofs

Let p be the risk-neutral pricing probability of the stock returning u, $p = \frac{1-d}{u-d}$. Then, $(1-p) = \frac{u-1}{u-d}$. Define the option's delta equivalent as $\Delta = \frac{[uS-K]^{+}-[dS-K]^{+}}{u-d}$.

Lemma B.1. *For a ll stock prices above the price at which a risk-neutral agent would exercise the option, the payoffs are greater in exercising the option and replicating the option payoffs than in holding the option. Mathematically,* $S + S\delta - K + \Delta(u-1) \geq [uS-K]^{+}$ *and* $S + S\delta - K + \Delta(u-1) \geq [dS-K]^{+}$.

Proof. Define the critical exercise price for a risk neutral agent as $\bar{S} = \frac{(1-p)K}{1+\delta-up}$. Clearly, for all $S \geq \bar{S}$, $S + S\delta - K \geq p\,[uS-K]^{+} + (1-p)\,[dS-K]^{+}$. Let $S \geq \bar{S}$. Then,

$$\begin{aligned} S + S\delta - K + \Delta(u-1) &\geq [uS-K]^{+} + (1-p)\,[dS-K]^{+} + \Delta(u-1) \\ &= [uS-K]^{+} \end{aligned}$$

Similarly,

$$\begin{aligned} S + S\delta - K + \Delta(u-1) &\geq [uS-K]^{+} + (1-p)\,[dS-K]^{+} + \Delta(d-1) \\ &= [dS-K]^{+} \end{aligned}$$

□

Proof of 2.1: Assume that instead of investing optimally with exercise, the executive invests in the non-exercise portfolio and replicates the option payoff by buying Δ shares of the stock.

Then, by the inequalities in the Appendix Lemma B.1:

$$\begin{aligned}
U_E^*(q) &\geq U_E(q, I_N^* + \Delta) \\
&= qU\left(W + S + S\delta - K + (I_N^* + \Delta)(u-1)\right) + \\
&\qquad (1-q)U\left(W + S + S\delta - K + (I_N^* + \Delta)(d-1)\right) + \\
&\geq qU\big(W + (uS - K)^+ + I_N^*(u-1)\big) + \\
&\qquad (1-q)U\big(W + (dS - K)^+ + I_N^*(d-1)\big) \\
&= U_N^*(q)
\end{aligned}$$

□

The proof of 2.2 requires two lemmas.

Lemma B.2. *The expected pay-off from holding the option exceeds its intrinsic value.*

$$p[uS - K]^+ + (1-p)[dS - K]^+ \geq [S - K]^+$$

Proof:

$$\begin{aligned}
&pu + (1-p)d = 1 \\
&p(uS - K) + (1-p)(dS - K) = S - K \\
&[p(uS - K) + (1-p)(dS - K)]^+ = [S - K]^+ \\
&p[(uS - K)]^+ + (1-p)[(dS - K)]^+ \geq [S - K]^+
\end{aligned}$$

□

Lemma B.3. *If it is optimal for the executive to exercise the option immediately, then the executive holds less of the stock than the option's delta equivalent. Additionally, if the* *executive were to hold the option until $t = 1$, then it would be optimal to have no outside investment in the stock.*

If $U_E^*(q) > U_N^*(q)$, then

1. $I_E^*(q) \leq \Delta$

2. $I_N^*(q) = 0$

Proof of (i): Assume that the agent chooses not to exercise the option, but instead invests in the post-exercise optimal portfolio and delta hedges the option, then

$$\begin{aligned}
U_N\left(q, I_E^*(q) - \Delta\right) &= qU\left(W + [uS - K]^+ - \Delta(u - r) + I_E^*(q)(u - r)\right) + \\
&\qquad (1 - q)U\left(W + [dS - K]^+ - \Delta(d - r) + I_E^*(q)(d - r)\right) \\
&= qU\left(W + p[uS - K]^+ + (1 - p)[dS - K]^+ + I_E^*(q)(u - r)\right) + \\
&\qquad (1 - q)U\left(W + p[uS - K]^+ + (1 - p)[dS - K]^+ + I_E^*(q)(d - r)\right) \\
&\geq qU\left(W + [S - K]^+ + I_E^*(q)(u - r)\right) + \\
&\qquad (1 - q)U\left(W + [S - K]^+ + I_E^*(q)(d - r)\right) \\
&= U_E^*(q)
\end{aligned}$$

From the concavity of $U(\cdot)$, it follows that $\frac{\partial^2 U_N(q,I)}{\partial I^2} < 0$ for all I. Therefore, if $I_N^*(q) > 0$, then $I_N^*(q)$ is the unconstrained maximizer of $\text{argmax}_I U_N(q, I)$. This then implies that $U_N^*(q) = U_N(q, I_N^*(q)) \geq U_N(q, I_E^*(q) - \Delta) \geq U_E^*(q)$. This contradicts $U_E^*(q) > U_N^*(q)$. Therefore, $I_N^*(q) = 0$. $\square$

Proof of (ii): Suppose $I_E^*(q) \geq \Delta$. Then, $I_E^*(q) - \Delta$ is a feasible investment for the agent if the option is not exercised. As above,

$$U_N^*(q) = U_N(q, I_N^*(q)) \geq U_N(q, I_E^*(q) - \Delta) \geq U_E^*(q)$$

This contradicts $U_E^*(q) > U_N^*(q)$, so $I_E^* < \Delta$. $\square$

Proof 2.2: From lemma B.3, if option exercise at $t = 0$ is optimal for optimism q_1, then $I_N^*(q_1) = 0$. Since $\frac{\partial^2 U_N(q,I)}{\partial q \partial I} > 0$ and $\frac{\partial^2 U_N(q,I)}{\partial^2 I} < 0$, then for $q_2 < q_1$, $I_N^*(q_2) = 0$. Intuitively, the short sale constraint binds for q_1. This constraint binds more strongly for $q_2 < q_1$, so it must be that the executive would hold no stock if they were to decide to not exercise the option.

Consider the difference between exercise utilities:

$$\begin{aligned} U_E^*(q_2) - U_E^*(q_1) &\geq U_E(q_2, I_E^*(q_1)) - U_E^*(q_1) \\ &= -(q_1 - q_2)U\left(W + [S-K]^+ + I_E^*(q_1)(u-1)\right) + \\ &\qquad (q_1 - q_2)U\left(W + [S-K]^+ + I_E^*(q_1)(d-1)\right) \end{aligned}$$

Now, by B.3, $I_E^*(q_1) < \Delta$, so

$$\begin{aligned} [S-K]^+ + I_E^*(q_1)(u-1) &\leq [S-K]^+ + \Delta(u-1) \\ &= [S-K]^+ + [uS-K]^+(1-p) - [dS-K]^+(1-p) \\ &= [S-K]^- \left(p[uS-K]^+ + (1-p)[dS-K]^+\right) + [uS-K]^+ \\ &\leq [uS-K]^+ \end{aligned}$$

where the last line comes from Lemma B.2. So, $U\left(W + [S-K]^+ + I_E^*(q_1)(u-1)\right) \leq U\left(W + [uS-K]^+\right)$. If $U\left(W + [S-K]^+ + I_E^*(q_1)(d-1)\right) \leq U\left(W + [dS-K]^+\right)$, then $U_E^*(q_1) \leq U_N^*(q_1)$. Since we are given that $U_E^*(q_1) > U_N^*(q_1)$, it follows that $U\left(W + [S-K]^+ + I_E^*(q_1)(d-1)\right) \geq U\left(W + [dS-K]^+\right)$. Therefore, by exercising the option early, the executive gets a weakly lower payoff when the stock return is u and a weakly higher payoff when the stock returns d. Then,

$$U_E^*(q_2) - U_E^*(q_1) \geq -(q_1 - q_2)U\left(W + [uS - K]^+\right) + (q_1 - q_2)U\left(W + [dS - K]^+\right)$$
$$= U_N^*(q_2) - U_N^*(q_1)$$

Therefore, since $U_E^*(q_1) \geq U_N^*(q_1)$ it must be that $U_E^*(q_2) \geq U_N^*(q_2)$. □

C Continuous Time Proofs

Proof of 3.1. Define f^u and V^u as the indirect utility functions representing the solution for an unconstrained agent's portfolio choice problem as:

$$f^u(W_t, S_t, t) = \max_{t_v \leq \tau \leq T, \omega_t^M, \omega_t^S} V(W_\tau^\omega + n(S_\tau - K)^+, \tau)$$
$$V^u(W, \tau) = \max_{\omega_t^M, \omega_t^S} \mathbb{E}\left[U\left(W_T^\omega\right)\right] s.t.(7)$$

The unconstrained agent synthetically sells the option in the market and invests optimally. Hence, their exercise policy will reflect the market valuation maximization exercise policy for the option. Therefore, without loss of generality, assume that the unconstrained agent has an optimism level equal to that of the executive. Then, assume that $(W, S, t) \ni D^u$. Then, $f^u(W, S, t) \leq V^u(W + (S - K)^+, t)$. By definition, it must be that $f^u(W, S, t) \geq f(W, S, t)$.

Assume that V^u and V are sufficiently smooth, increasing in wealth, and strictly concave in wealth. Then, given that the executive is optimistic about stock returns, the short-sale constraint does not bind after exercise.[8] Therefore, $V^u(W + (S - K)^+, t) = V(W + (S - K)^+, t)$. So, $f(W, S, t) \leq V(W + (S - K)^+, t)$. Therefore, $(W, S, t) \ni D$.

□

[8] The well known result is that optimal, unconstrained portfolio holdings are given by $\Phi = \frac{-f_W}{wf_{WW}}\left[\sigma\sigma^T\right]^{-1}\lambda$. The portfolio choice term, $\left[\sigma\sigma^T\right]^{-1}\lambda$, has non-negative stock holdings for an optimistic executive. The leverage term $\frac{-f_W}{wf_{WW}} > 0$ given the assumptions.

D Numerical Methodology

We solve partial differential equations (15), (16), and (17) simultaneously using a Du Fort-Frankel leapfrog finite difference scheme. The scheme operates over a transformed state space, which is configured to efficiently use computing resources. To enforce convergence, the portfolio choice set is restricted. Instead of solving a partial differential equation to compute the indirect utility function (8), we use the well known solution to the problem for a constant relative risk averse investor.[9] Note that solving the equations simultaneously is not necessary as (15) can be solved directly and (16) only depends on the optimal policy implied by (15). However, simultaneously solution eliminates the need to store value function results for (15) at each time step. Details about the solution method and boundary conditions follow.

As a first step, we bound the model's state space to Θ where:

$$\Theta = \{(W, S, t) : (W, S, t) \in [W_{min}, W_{max}] \times [S_{min}, S_{max}] \times [0, T]\}.$$

where $W_{min}, W_{max}, S_{min}$, and S_{max} are selected to represent a range of probable values given the market environment. Θ is a subset of the model's actual state space $\mathbb{R}_+ \times \mathbb{R}_+ \times [0, T]$. In practice, we choose $W_{min} = S_{min} = 0.1$ and $W_{max} = S_{max} = 10.0$ for most configurations of the model.

The state spaces of the executive's wealth and stock price Θ are transformed to efficiently use computational power. The transformed state space $\hat{\Theta}$ is

$$\hat{\Theta} = \left\{(\hat{W}, \hat{S}, t) : (\hat{W}, \hat{S}, t) \in [0, 1] \times [0, 1] \times [0, T]\right\}$$

Specifically, for an untransformed variable x, we use the transformation

$$f(x) = (x - x_{min})/(A_x + D_x x) \tag{18}$$

[9] Using a numerical method to solve the agent's optimal investment problem without options provides similar results but slows the computation.

where A_x, D_x, and x_{min} and free constants. These constants are selected so that, for a minimal value of x_{min}, $f(x_{min}) = 0$ and, for a maximum state value x_{max}, $f(x_{max}) = 1$. We pick parameter values to center the transformed grid around an area of interest. This is accomplished by solving the equations so that, for an initial state value x_0, $f(x_0)$ is exactly on the grid. By placing the initial state on the grid, we eliminate the need to interpolate values at our point of interest. Qualitatively, if $f(x_0) < 0.5$, the grid is configured so that we have higher accuracy in states when $x_t > x_0$. We generally set $f(x_0) = 0.5$.

As an example, consider the stock price variable. Assume that the transformed space uses an equally spaced 100 point grid and that we want to ensure accuracy for stock prices greater than the initial value S_0. This requires setting $f(S_0) < \frac{1}{2}$. Throughout the paper, we normalize the initial stock price $S_0 = 1$. For most computation runs, we set $S_{min} = 0.1$ and $S_{max} = 10$. Then, for example, we want $f(S_0) = 40/100$, it is straightforward to solve the resulting equations to see that $x_{min} = 0.1$, $A_x = 1.4$, and $D_x = 0.85$. In some cases, for example when the stock has a high dividend rate, we may change the minimum and maximum untransformed state values and recenter the grid to have a greater focus on low stock prices.

The executive's portfolio choice problem is non-trival when the agent is optimistic. Without the option, the executive wishes to hold a positive amount of the stock. However, the portfolio choice opportunity set must be bounded to ensure that the numerical scheme converges. Per the short sale constraints, we enforce $\omega_t^S \geq 0$. In addition, we assume that the executive cannot have a position greater than two times wealth in both the stock and the market. Together, these constraints require $0 \leq \omega_t^S \leq 2$ and $-2 \leq \omega_t^M \leq 2$. These constraints can be interpreted as leverage constraints imposed on the executive by a broker. Use of both more or less stringent constraints does not impact the results presented in the paper. Similarly, we experimented with different shaped constraint sets and these do not change the results. For example, a gross leverage constraint on the total portfolio, $|\omega_t^S + \omega_t^M| \leq C$, generates results similar to those presented here.

To find the optimal portfolio choice, we consider nine points in (ω^S, ω^M) for each point in the continuation set. Our approach considers internal and corner solutions, thereby accounting for the fact that the objective function may be concave in certain locations. For the first point, we assume that the objective function is globally concave and compute the unconstrained first order conditions. Four more points are found by examining the boundary of the constrained portfolio choice set. We alternatively assume that the solution has $\omega_t^S = 0, \omega_t^S = 2, \omega_t^M = -2$, and $\omega_t^M = 2$. We plug each of these assumptions individually into the p.d.e. (15) and derive appropriate first order conditions for the other variable. Finally, we consider the four corner points $(\omega^S, \omega^M) \in \{(0, -2), (2, -2), (0, 2), (2, 2)\}$. We reject any potential solution arising from first order conditions if they imply a solution outside the constrained opportunity set. We select the optimal portfolio choice from the remaining candidates as the argument that maximizes the objective function.

The partial differential equation requires selecting terminal and boundary conditions. For the executive problem 15, we use the intuition from Carpenter, Stanton, and Wallace (2008) for when either the stock or wealth values hit an upper boundary. For these high values, Carpenter, Stanton, and Wallace show that the executive follows a nearly optimal policy yielding a present value of the options nearly equal to the American option value. We use the American option value for the lower boundaries of stock price and wealth. This choice, while incorrect theoretically, represents an upper bound on the value and does not qualitatively impact the results. A lower bound value of 0 provides similar results. Terminal conditions for all p.d.e.s are provided by the theoretical model.

The appropriate American option value represents optimal exercise under a risk-neutral measure. This value must reflect the executive's exercise restriction, i.e. the option can not be exercised for $t < t_v$. These computations can be done using a binomial tree approach. However, that method is quite slow. For a moderately sized grid, 100 point grid in the stock space and a 10,000 point grid in time, a pure binomial tree approach would require computing 1,000,000 binomial trees. So, to improve computational time, we use hybrid binomial tree-finite difference approach to value the American option. First, we compute the option value using a binomial tree for S_{max} and S_{min} at each point in time[10]. These provide the boundary conditions for the standard option pricing p.d.e. We then evaluate this p.d.e. using the Du Fort-Frankel method and take the maximum of the p.d.e. continuation value and the immediate exercise value. This hybrid scheme seems to provide a high degree of accuracy without significantly increasing computational time.

The Du Fort-Frankel scheme is generally more stable and accurate than a standard Euler explicit finite difference scheme. For a $h_1 \times h_2$ grid in a two dimensional state space, let $h = \max(h_1, h_2)$. Leapfrog schemes, such as the Du Fort-Frankel, generally require $O(h)$ steps in time for stability while Euler explicit schemes require $O(h^2)$. Compared to a traditional leapfrog scheme, the Du Fort-Frankel scheme is more stable by using information contained in the time evolution of second derivatives. This stability is often helpful for solving non-linear partial differential equations. We find that this is especially true for this problem.

As with all leapfrog schemes, Du Fort-Frankel uses values at time steps $t+1$ and $t+2$ to compute values at t. The model here only has information at the terminal value. Therefore, in order to seed the leapfrog method, we use an Euler Explicit method. However, as these two methods have different convergence rates, we initially use an Euler explicit method with $\propto h^2$ time steps before switching over to the Du Fort-Frankel scheme with $\propto h$ steps. Explicitly, assume that time period T is equally divided into $N \propto h$ steps for a leapfrog scheme. The terminal conditions are used to set portfolio values at step N. We then add N additional steps between time step t_{N-1} and t_N and use an Euler Explicit method to solve for portfolio values at t_{N-1}. Then, using the Euler Explicit solution at t_{N-1} and the terminal condition at t_N we can use a leapfrog method to solve the p.d.e.

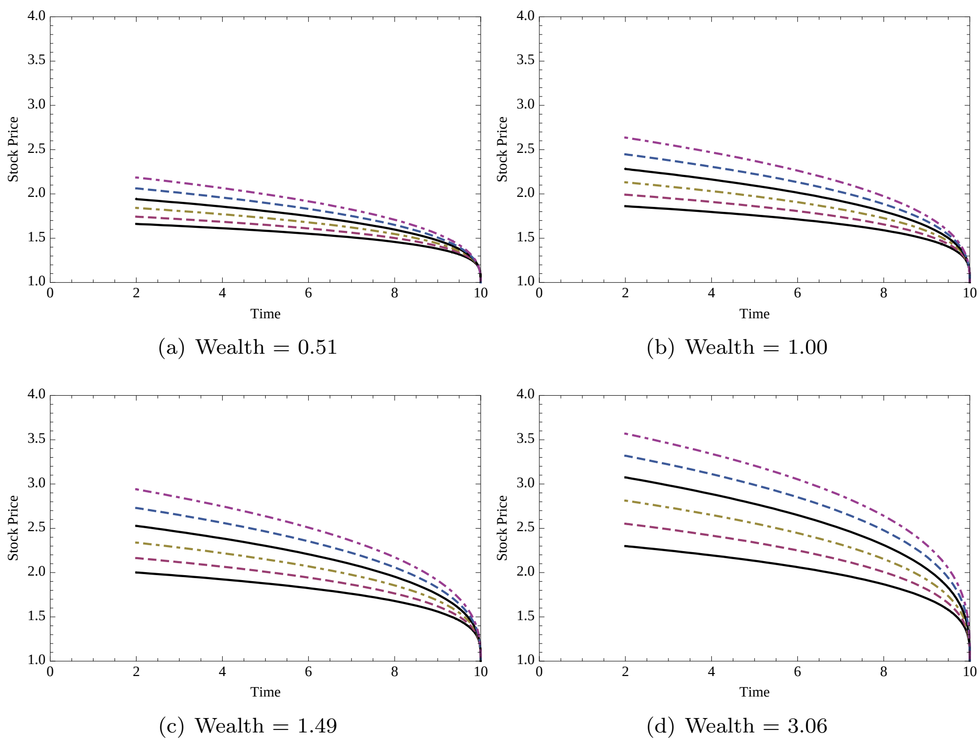
[10] Other studies have shown that averaging over an even and odd step binomial tree is an accurate approach. To that end, we average the values from a 200 step and 201 step binomial tree for each stock price.

Finally, we must comment on the timing of the portfolio choice problem. During the Euler Explicit seed steps, the timing of the portfolio choice decisions is slightly incorrect. Derivatives at $t+1$ are used to compute optimal portfolio choices at t. These then allow the solver to find functional values at t. Under the leapfrog Du Fort-Frankel method, the portfolio choice timing is correct. The function values at $t+1$ are used to compute derivatives and optimal portfolio choice positions at $t+1$. These, combined with the function values at $t+2$, inform the value of the time derivative and provide functional values at t.

E Compustat Executive Compensation/Thomson Financial Matching Procedure

We merge Execucomp with Thomson, which allows us to gather information on both compensation structure and option exercise behavior. To combine these data sets, we must find each executive's Execucomp and Thompson internal identifier numbers. We do this with a matching algorithm, using Execucomp as the key database. For each Execucomp executive, we find the CRSP permno that corresponds with the company 6 digit cusip. We then find executives in the matching firm in Execucomp for which the field lastname is contained in Thompson field ownername. We take the remaining fields and look for matches that contain one of the following: the first and middle names, the first name and middle initial, the first initial and middle name, the first name, the middle name and first name, the middle name and first initial, and the middle initial and first name. All matches are output to a datafile. Execucomp executives with Jr., Sr., etc... are matched manually.

Figure 1: Early Exercise Boundary Evolution with Optimism, Time, and Outside Wealth



(a) Wealth = 0.51

(b) Wealth = 1.00

(c) Wealth = 1.49

(d) Wealth = 3.06

The graphs show the impact of optimism on the executive's early exercise boundary for the option. Optimism level η is 0.0 for the low solid line, 0.02 for the low dashed line, 0.04 for the low dotted-dashed line, 0.06 for the high solid line, 0.08 for the high dashed line, and 0.10 for the high dotted-dashed line. Panels (a), (b), (c), and (d) represent different amounts of outside wealth. The model parameters are $S_0 = 1$, $K = 1$, $\beta = 1.2$, $\delta = 0.03$, $\sigma_m = 0.2$, $\sigma_s = 0.4$, $r_f = 0.05$, $\mu = 0.13$, $t_v = 2$, and $T = 10$.

Table 2: Expected Proportion of Stocks Retained on Exercised ($PROE$)

	Optimism					
Changing Parameter	η =0%	2%	4%	6%	8%	10%
Panel 1: Dividend Effects						
0.0	0.000	0.082	0.156	0.218	0.267	0.300
0.01	0.000	0.084	0.162	0.230	0.286	0.330
0.02	0.000	0.085	0.167	0.242	0.305	0.359
0.03	0.000	0.086	0.171	0.252	0.325	0.389
0.04	0.000	0.087	0.174	0.260	0.344	0.422
Panel 2: Beta Effects						
0.6	0.000	0.064	0.128	0.191	0.252	0.308
0.8	0.000	0.068	0.137	0.204	0.268	0.327
1.0	0.000	0.075	0.150	0.223	0.291	0.353
1.2	0.000	0.086	0.171	0.252	0.325	0.389
1.4	0.000	0.105	0.206	0.296	0.374	0.445
Panel 3: Volatility Effects Holding Correlation Constant						
0.3	0.000	0.158	0.299	0.416	0.523	0.638
0.35	0.000	0.114	0.225	0.322	0.407	0.484
0.4	0.000	0.086	0.171	0.252	0.325	0.389
0.5	0.000	0.053	0.106	0.159	0.211	0.261
0.6	0.000	0.036	0.072	0.107	0.143	0.178
Panel 4: Risk Aversion Effects						
1.1	0.000	0.290	0.548	0.730	0.815	0.833
2.0	0.000	0.144	0.275	0.393	0.505	0.615
3.0	0.000	0.086	0.171	0.252	0.325	0.389
4.0	0.000	0.061	0.121	0.181	0.241	0.297
5.0	0.000	0.047	0.094	0.141	0.187	0.233
Panel 5: Initial Wealth Effects						
0.5	0.000	0.054	0.109	0.164	0.221	0.277
0.75	0.000	0.071	0.142	0.212	0.281	0.344
1.0	0.000	0.086	0.171	0.252	0.325	0.389
1.5	0.000	0.115	0.221	0.312	0.394	0.473
3.0	0.000	0.184	0.334	0.474	0.605	0.711

Numerical solution of the executive's terminal utility maximization problem using an explicit finite difference scheme. The executive optimally exercises the compensation option, with partial exercise excluded, and invests outside wealth optimally in the company stock and the market security. The executive has initial wealth 1.0 and constant relative risk aversion of 3. At time 0, the company stock has price one and the executive receives one at-the-money option on the stock, which vests in two years. The risk free rate is 5%. The market follows a geometric Brownian motion with instantaneous mean 13% and instantaneous volatility 20%.The stock also follows a geometric Brownian motion, for which the base case has instantaneous volatility 40%, pays a dividend of 3%, and has a beta of 1.2. Under the physical probability measure, the stock's instantaneous mean is equal to its CAPM market adjustment for risk. The executive uses an optimistic probability measure, believing that the stock has instantaneous mean with drift of the CAPM market adjustment plus their optimism level. All executive portfolio and option exercise decisions are made under the optimistic probability measure. The table shows the expected proportion of the stock shares received on option exercise that instantaneously continue to be held in the executive's optimal portfolio. This conditional expectation is taken under the physical probability measure.

Table 3: Expected Time to Exercise ($\tilde{\tau}$)

Changing Parameter	Optimism η =0%	2%	4%	6%	8%	10%
Panel 1: Dividend Effects						
0.0	4.846	5.140	5.468	5.822	6.185	6.566
0.01	4.753	5.025	5.306	5.614	5.937	6.278
0.02	4.661	4.909	5.166	5.429	5.701	5.992
0.03	4.582	4.805	5.026	5.269	5.501	5.749
0.04	4.504	4.707	4.910	5.113	5.316	5.525
Panel 2: Beta Effects						
0.6	4.367	4.543	4.714	4.904	5.100	5.311
0.8	4.409	4.592	4.776	4.979	5.182	5.398
1.0	4.480	4.673	4.881	5.094	5.314	5.538
1.2	4.582	4.805	5.026	5.269	5.501	5.749
1.4	4.729	4.992	5.248	5.504	5.771	6.001
Panel 3: Volatility Effects Holding Correlation Constant						
0.3	4.861	5.299	5.749	6.191	6.604	6.915
0.35	4.703	5.006	5.319	5.636	5.964	6.280
0.4	4.582	4.805	5.026	5.269	5.501	5.749
0.5	4.414	4.542	4.675	4.800	4.931	5.062
0.6	4.238	4.320	4.390	4.461	4.535	4.602
Panel 4: Risk Aversion Effects						
1.1	5.422	5.959	6.415	6.740	6.923	6.999
2.0	4.966	5.317	5.682	6.040	6.377	6.661
3.0	4.582	4.805	5.026	5.269	5.501	5.749
4.0	4.349	4.507	4.675	4.838	5.000	5.175
5.0	4.199	4.321	4.444	4.566	4.692	4.816
Panel 5: Initial Wealth Effects						
0.5	4.284	4.417	4.536	4.666	4.798	4.932
0.75	4.459	4.644	4.834	5.026	5.223	5.412
1.0	4.582	4.805	5.026	5.269	5.501	5.749
1.5	4.816	5.103	5.392	5.682	5.973	6.243
3.0	5.299	5.726	6.123	6.463	6.722	6.886

Numerical solution of the executive's terminal utility maximization problem using an explicit finite difference scheme. The executive optimally exercises the compensation option, with partial exercise excluded, and invests outside wealth optimally in the company stock and the market security. The executive has initial wealth 1.0 and constant relative risk aversion of 3. At time 0, the company stock has price one and the executive receives one at-the-money option on the stock, which vests in two years. The risk free rate is 5%. The market follows a geometric Brownian motion with instantaneous mean 13% and instantaneous volatility 20%.The stock also follows a geometric Brownian motion, for which the base case has instantaneous volatility 40%, pays a dividend of 3%, and has a beta of 1.2. Under the physical probability measure, the stock's instantaneous mean is equal to its CAPM market adjustment for risk. The executive uses an optimistic probability measure, believing that the stock has instantaneous mean with drift of the CAPM market adjustment plus their optimism level. All executive portfolio and option exercise decisions are made under the optimistic probability measure. Expected time to exercise is a conditional expectation, computed under the physical probability measure. Options that expire worthless do not get included in this computation.

Table 4: Expected Value Ratio on Exercise (VR)

	Optimism					
Changing Parameter	η =0%	2%	4%	6%	8%	10%
Panel 1: Dividend Effects						
0.0	0.805	0.840	0.870	0.896	0.917	0.935
0.01	0.841	0.873	0.901	0.924	0.943	0.958
0.02	0.867	0.898	0.923	0.943	0.959	0.972
0.03	0.887	0.915	0.938	0.956	0.970	0.980
0.04	0.902	0.928	0.949	0.964	0.976	0.985
Panel 2: Beta Effects						
0.6	0.843	0.872	0.896	0.917	0.935	0.950
0.8	0.854	0.883	0.907	0.928	0.945	0.959
1.0	0.869	0.897	0.921	0.940	0.956	0.969
1.2	0.887	0.915	0.938	0.956	0.970	0.980
1.4	0.909	0.937	0.958	0.973	0.983	0.989
Panel 3: Volatility Effects Holding Correlation Constant						
0.3	0.921	0.956	0.978	0.991	0.997	1.000
0.35	0.904	0.936	0.959	0.975	0.987	0.994
0.4	0.887	0.915	0.938	0.956	0.970	0.980
0.5	0.852	0.875	0.895	0.912	0.927	0.939
0.6	0.818	0.836	0.853	0.867	0.880	0.892
Panel 4: Risk Aversion Effects						
1.1	0.972	0.990	0.997	1.000	1.000	1.000
2.0	0.935	0.961	0.978	0.989	0.996	0.999
3.0	0.887	0.915	0.938	0.956	0.970	0.980
4.0	0.843	0.871	0.895	0.916	0.933	0.948
5.0	0.806	0.833	0.857	0.878	0.896	0.913
Panel 5: Initial Wealth Effects						
.5	0.813	0.841	0.865	0.886	0.904	0.920
0.75	0.859	0.888	0.913	0.933	0.949	0.962
1.0	0.887	0.915	0.938	0.956	0.970	0.980
1.5	0.920	0.946	0.965	0.979	0.988	0.994
3.0	0.960	0.981	0.992	0.997	0.999	1.000

Numerical solution of the executive's terminal utility maximization problem using an explicit finite difference scheme. The executive optimally exercises the compensation option, with partial exercise excluded, and invests outside wealth optimally in the company stock and the market security. The executive has initial wealth 1.0 and constant relative risk aversion of 3. At time 0, the company stock has price one and the executive receives one at-the-money option on the stock, which vests in two years. The risk free rate is 5%. The market follows a geometric Brownian motion with instantaneous mean 13% and instantaneous volatility 20%.The stock also follows a geometric Brownian motion, for which the base case has instantaneous volatility 40%, pays a dividend of 3%, and has a beta of 1.2. Under the physical probability measure, the stock's instantaneous mean is equal to its CAPM market adjustment for risk. The executive uses an optimistic probability measure, believing that the stock has instantaneous mean with drift of the CAPM market adjustment plus their optimism level. All executive portfolio and option exercise decisions are made under the optimistic probability measure. At option exercise, the value ratio is computed as the ratio of the intrinsic value to the value of a freely traded american option. Expected value ratio is the expectation of this ratio computed under the physical measure, conditional on option exercise.

Table 5: CEO optimism and early option exercise behavior

Panel A: By Proportion Retained on Exercise

Variable		Low PROE	High PROE
Time to maturity (years)	Mean	3.61	2.83
	Median	3.50	1.96
	N	2189	2531
Value Ratio	Mean	89.4%	92.4%
	Median	96.1%	99.0%
	N	2154	2459

Panel B: By Voluntary Holder

Variable		Voluntary Holder = 0	Voluntary Holder = 1
Time to maturity (years)	Mean	3.82	2.93
	Median	3.99	2.32
	N	1340	3372
Value Ratio	Mean	87.8%	92.3%
	Median	93.7%	98.8%
	N	1304	3304

PROE is the proportion of stocks retained by the CEO on option exercise. It is averaged across option exercises during each fiscal year. Those CEOs who have an average PROE that exceeds the median value for a year are categorized in the high PROE group. Voluntary holder is one if the stock holdings of the executive exceeds the greater of four times the executive salary in the previous year and the reported number of restricted shares plus one thousand. Value ratio is the ratio of the intrinsic value of the option to the American option value at exercise. Time to maturity is the number of years remaining for the option to expire when it was exercised. Value ratio and time to maturity are averaged to each CEO for each fiscal year and weighted by the number of stocks exercised. The table presents means and medians of the average value ratio and average time to maturity for different types of CEOs. All differences in means based on a t-test and differences in medians based on a Wilcoxon Rank Sum test are significant at the 0.1% level.

Table 6: Acquisition Intensity

	(1)	(2)	(3)	(4)	(5)	(6)
Share Retainer	1.271**	1.271**				
	(2.509)	(2.362)				
Voluntary Holder			0.750	0.750*		
			(1.604)	(1.766)		
Long Holder					-0.720*	-0.720*
					(-1.732)	(-1.669)
Book Leverage	0.166***	0.166***	0.143***	0.143***	0.167***	0.167***
	(9.133)	(7.357)	(6.275)	(6.575)	(9.006)	(7.279)
Collateral	-11.93***	-11.93***	-11.12***	-11.12***	-11.72***	-11.72***
	(-9.281)	(-7.977)	(-8.495)	(-7.522)	(-8.927)	(-7.776)
Log(Sales)	-0.770***	-0.770***	-0.600***	-0.600***	-0.806***	-0.806***
	(-4.771)	(-5.093)	(-3.808)	(-3.902)	(-4.962)	(-5.341)
Log(Asset Market-to-Book)	-2.871***	-2.871***	-2.937***	-2.937***	-2.931***	-2.931***
	(-6.596)	(-6.098)	(-5.257)	(-5.428)	(-6.570)	(-6.207)
Profitability	17.20***	17.20***	15.98***	15.98***	17.13***	17.13***
	(4.987)	(5.855)	(4.955)	(4.660)	(4.952)	(5.814)
Dividends	-0.597	-0.597	-0.712	-0.712	-0.455	-0.455
	(-0.883)	(-1.061)	(-1.012)	(-1.224)	(-0.729)	(-0.803)
Log(1 yr return)	0.587***	0.587***	0.550***	0.550***	0.576***	0.576***
	(3.480)	(3.614)	(3.028)	(3.214)	(3.436)	(3.540)
Dividend Yield	-1.101***	-1.101***	-0.895***	-0.895***	-1.150***	-1.150***
	(-4.499)	(-4.344)	(-3.978)	(-3.459)	(-4.588)	(-4.492)
Volatility	-7.868***	-7.868***	-6.587***	-6.587***	-8.398***	-8.398***
	(-4.705)	(-4.247)	(-3.628)	(-3.601)	(-5.070)	(-4.495)
Constant	12.78***	12.78***	10.14***	10.14***	13.20***	13.20***
	(7.962)	(4.944)	(5.130)	(2.876)	(7.610)	(5.124)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Industry	Firm	Industry	Firm	Industry	Firm
Observations	4084	4084	3094	3094	4084	4084
R^2	0.154	0.154	0.140	0.140	0.152	0.152

Robust t statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table shows results of regression of acquisition intensity on CEO optimism measures and controls. All variables are defined in Appendix A. The t-statistics in columns (1), (3), and (5) are based on standard errors clustered by Fama-French 48 industries. T-statistics in columns (2), (4), and (6) are derived from standard errors clustered by firm.

Table 7: Capital Expenditure Intensity

	(1)	(2)	(3)	(4)	(5)	(6)
Share Retainer	2.008***	2.008***				
	(3.227)	(2.710)				
Voluntary Holder			1.356**	1.356**		
			(2.370)	(2.216)		
Long Holder					-0.767	-0.767
					(-1.647)	(-1.393)
Book Leverage	0.182***	0.182***	0.163***	0.163***	0.184***	0.184***
	(7.483)	(5.694)	(5.762)	(5.052)	(7.529)	(5.674)
Collateral	-2.321	-2.321	-1.612	-1.612	-2.017	-2.017
	(-1.151)	(-1.157)	(-0.618)	(-0.755)	(-1.001)	(-1.001)
Log(Sales)	-1.193***	-1.193***	-1.002***	-1.002***	-1.255***	-1.255***
	(-5.324)	(-5.735)	(-4.151)	(-4.597)	(-5.764)	(-6.058)
Log(Asset Market-to-Book)	0.164	0.164	0.255	0.255	0.0730	0.0730
	(0.149)	(0.203)	(0.177)	(0.267)	(0.0648)	(0.0900)
Profitability	34.41***	34.41***	32.48***	32.48***	34.34***	34.34***
	(5.356)	(6.932)	(4.449)	(5.252)	(5.328)	(6.893)
Dividends	-1.551	-1.551**	-1.557	-1.557*	-1.330	-1.330*
	(-1.630)	(-2.032)	(-1.527)	(-1.891)	(-1.511)	(-1.721)
Log(1 yr return)	0.869***	0.869***	0.913***	0.913***	0.853***	0.853***
	(4.107)	(3.788)	(4.023)	(3.684)	(4.074)	(3.717)
Dividend Yield	-1.215***	-1.215***	-0.953**	-0.953***	-1.295***	-1.295***
	(-4.010)	(-3.783)	(-2.586)	(-2.745)	(-4.219)	(-4.004)
Volatility	0.837	0.837	2.293	2.293	0.100	0.100
	(0.337)	(0.312)	(0.822)	(0.832)	(0.0399)	(0.0373)
Constant	8.654***	8.654**	2.602	2.602	9.168***	9.168***
	(3.020)	(2.543)	(0.830)	(0.550)	(3.016)	(2.671)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Industry	Firm	Industry	Firm	Industry	Firm
Observations	4084	4084	3094	3094	4084	4084
R^2	0.192	0.192	0.180	0.180	0.190	0.190

*** p<0.01, ** p<0.05, * p<0.1

Robust t statistics in parentheses

The table shows results of regression of capital expenditure intensity on CEO optimism measures and controls. All variables are defined in Appendix A. The t-statistics in columns (1), (3), and (5) are based on standard errors clustered by Fama-French 48 industries. T-statistics in columns (2), (4), and (6) are derived from standard errors clustered by firm.

Table 8: Book Leverage

	(1)	(2)	(3)	(4)	(5)	(6)
Share Retainer	1.657*	1.657*				
	(1.960)	(1.684)				
Voluntary Holder			1.135*	1.135		
			(1.897)	(1.503)		
Long Holder					-1.400	-1.400
					(-1.283)	(-1.444)
Collateral	3.742	3.742	3.527	3.527	4.075	4.075
	(0.817)	(1.415)	(0.745)	(1.198)	(0.883)	(1.539)
Log(Sales)	1.622***	1.622***	1.264**	1.264***	1.587***	1.587***
	(3.297)	(5.030)	(2.497)	(3.570)	(3.290)	(4.998)
Log(Asset Market-to-Book)	-5.205***	-5.205***	-5.459***	-5.459***	-5.290***	-5.290***
	(-4.716)	(-6.171)	(-4.634)	(-5.501)	(-4.837)	(-6.260)
Profitability	-13.71	-13.71**	-16.95	-16.95**	-13.90	-13.90**
	(-1.482)	(-2.501)	(-1.483)	(-2.464)	(-1.525)	(-2.542)
Dividends	-1.558	-1.558	-1.195	-1.195	-1.365	-1.365
	(-1.242)	(-1.350)	(-0.960)	(-0.963)	(-1.100)	(-1.170)
Log(1 yr return)	-0.115	-0.115	0.138	0.138	-0.136	-0.136
	(-0.459)	(-0.515)	(0.517)	(0.536)	(-0.546)	(-0.609)
Repurchases	-0.225	-0.225	0.336	0.336	-0.251	-0.251
	(-0.281)	(-0.360)	(0.407)	(0.493)	(-0.296)	(-0.401)
Capital Expenditure Intensity	0.162***	0.162***	0.158***	0.158***	0.164***	0.164***
	(7.470)	(6.747)	(6.358)	(5.743)	(7.573)	(6.704)
Dividend Yield	1.011	1.011*	0.939	0.939	0.952	0.952*
	(1.371)	(1.808)	(1.191)	(1.543)	(1.311)	(1.700)
Volatility	-1.553	-1.553	-2.803	-2.803	-2.377	-2.377
	(-0.399)	(-0.472)	(-0.724)	(-0.769)	(-0.638)	(-0.725)
Constant	11.42**	11.42***	11.06**	11.06***	12.16***	12.16***
	(2.531)	(3.304)	(2.496)	(2.942)	(2.785)	(3.542)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Industry	Firm	Industry	Firm	Industry	Firm
Observations	4084	4084	3094	3094	4084	4084
R^2	0.301	0.301	0.302	0.302	0.300	0.300

Robust t statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table shows results of regression of book leverage on CEO optimism measures and controls. All variables are defined in Appendix A. The t-statistics in columns (1), (3), and (5) are based on standard errors clustered by Fama-French 48 industries. T-statistics in columns (2), (4), and (6) are derived from standard errors clustered by firm.

Table 9: Investment to Cashflow Sensitivity (Normalized by assets)

	(1)	(2)	(3)	(4)	(5)	(6)
Cashflow	-0.0468	-0.0468	0.00237	0.00237	-0.0523	-0.0523
	(-0.365)	(-0.472)	(0.0129)	(0.0202)	(-0.391)	(-0.520)
Share Retainer	1.36e-05	1.36e-05				
	(0.00299)	(0.00261)				
Share Retainer * Cashflow	0.0248	0.0248				
	(0.688)	(0.640)				
Voluntary Holder			-0.00121	-0.00121		
			(-0.363)	(-0.314)		
Voluntary Holder * Cashflow			0.0297	0.0297		
			(1.518)	(1.059)		
Long Holder					-0.00186	-0.00186
					(-0.477)	(-0.413)
Long Holder * Cashflow					0.0134	0.0134
					(0.407)	(0.404)
Book Leverage	0.000268	0.000268*	0.000228	0.000228	0.000270	0.000270*
Collateral	0.0392***	0.0392***	0.0299*	0.0299**	0.0392**	0.0392***
Log(Sales)	-0.000681	-0.000681	0.00101	0.00101	-0.000578	-0.000578
Log(Asset Market-to-Book)	0.0188***	0.0188***	0.0174***	0.0174***	0.0189***	0.0189***
Profitability	-0.0397	-0.0397	-0.0216	-0.0216	-0.0394	-0.0394
Dividends	0.00293	0.00293	-0.000200	-0.000200	0.00288	0.00288
Log(1 yr return)	-0.00182	-0.00182	-0.00208	-0.00208	-0.00189	-0.00189
Repurchases	-0.00295	-0.00295	-0.00283	-0.00283	-0.00275	-0.00275
Dividend Yield	0.000495	0.000495	0.00193	0.00193	0.000430	0.000430
Volatility	0.00706	0.00706	0.00999	0.00999	0.00690	0.00690
Book Leverage * Cashflow	-0.00110	-0.00110	-0.000433	-0.000433	-0.00110	-0.00110
Collateral * Cashflow	0.512***	0.512***	0.548***	0.548***	0.516***	0.516***
Log(Sales) * Cashflow	0.00129	0.00129	-0.0102	-0.0102	-0.000311	-0.000311
Log(Asset Market-to-Book) * Cashflow	-0.0608**	-0.0608**	-0.0514*	-0.0514**	-0.0617**	-0.0617**
Profitability * Cashflow	0.432***	0.432***	0.246**	0.246**	0.431***	0.431***
Dividends * Cashflow	-0.0406	-0.0406	-0.0128	-0.0128	-0.0373	-0.0373
Log(1 yr return) * Cashflow	0.00658	0.00658	0.0109	0.0109	0.00702	0.00702
Repurchases * Cashflow	-0.0526*	-0.0526*	-0.0518*	-0.0518*	-0.0552*	-0.0552*
Dividend Yield * Cashflow	-0.0419**	-0.0419**	-0.0526**	-0.0526***	-0.0423**	-0.0423**
Volatility * Cashflow	0.0938	0.0938	0.0881	0.0881	0.0884	0.0884
Constant	0.0219	0.0219	-0.0118	-0.0118	0.0225*	0.0225
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Industry	Firm	Industry	Firm	Industry	Firm
Observations	4084	4084	3094	3094	4084	4084
R^2	0.562	0.562	0.569	0.569	0.562	0.562

*** p<0.01, ** p<0.05, * p<0.1

Robust t statistics in parentheses

The table shows results of regression of investment normalized by assets on cashflow normalized by assets, CEO optimism measures, interaction of optimism measures with (normalized) cashflow. The usual controls and their interaction with (normalized) cashflow are included in the regressions. All variables are defined in Appendix A. The t-statistics in columns (1), (3), and (5) are based on standard errors clustered by Fama-French 48 industries. T-statistics in columns (2), (4), and (6) are derived from standard errors clustered by firm. The t-statistic values for the controls are dropped for brevity.