Journal of Corporate Finance 67 (2021) 101886

Contents lists available at ScienceDirect

Journal of Corporate Finance

journal homepage: www.elsevier.com/locate/jcorpfin

Do CEO beliefs affect corporate cash holdings?

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ARTICLE INFO

JEL:
G40
G31
G32
G35
D82

Keywords:
CEO
Overconfidence
Optimism
Cash holdings
Corporate finance
Behavioral finance

ABSTRACT

We develop a model of corporate cash holdings that incorporates CEO beliefs. An optimistic CEO views external financing as excessively costly but expects this cost to moderate over time. The optimistic CEO thus delays external financing while funding current investments with existing cash and maintaining a lower cash balance than rational CEOs. We find that, relative to rational CEOs, optimistic CEOs hold 24% less cash, hold lower cash to fund the firms' growth opportunities, and save less cash out of incremental cash flow.

1. Introduction

The current literature identifies several firm characteristics that determine corporate cash holdings (Opler et al. 1999, and Bates et al. 2009). Much of the existing work on cash holdings has focused on firm characteristics.[1] However, little is known about how managerial characteristics affect cash holdings in spite of research documenting the effect of managerial characteristics on various corporate policies.[2] Therefore, exploring the relation between managerial characteristics and cash holdings presents a promising

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[1] The early work by Keynes (1936) focuses on the costs and benefits of cash reserves. Kim et al. (1998) develop a trade-off model of cash holdings and find empirical support for many of its predictions. Opler et al. (1999) also examine the determinants of cash holdings and find support for a trade-off model of cash holdings. Recent research analyzes specific aspects of the determinants of cash holdings. For example, Harford (1999) examines the relation between cash holdings and acquisitions; Dittmar et al. (2003) and Harford et al. (2008) examine the role of corporate governance; Acharya et al. (2012) and Harford et al. (2014) examine the interactions between credit risk and cash holdings; Bates et al. (2009) provide a summary of the different motives for firms to hold cash and explore the intertemporal growth in aggregate cash holdings; Duchin (2010) examines the relation between cash holdings and corporate diversification; Fresard (2010) studies the strategic effect of corporate cash policy; and Liu and Mauer (2011) explore the relation between CEO risk-taking incentives and cash holdings.

[2] For example, Bertrand and Schoar (2003) document that the variation in management "styles" of top executives accounts for some of the unexplained variation in a wide range of corporate policies. Cronqvist et al. (2012) find that corporate leverage choices mirror the personal leverage choices of CEOs. Graham et al. (2013) use psychometric tests to identify behavioral traits of CEOs and provide evidence that these traits are related to corporate financial policies.

https://doi.org/10.1016/j.jcorpfin.2021.101886
Received 17 May 2019; Received in revised form 18 December 2020; Accepted 5 January 2021
Available online 19 January 2021

avenue for research, that can deepen our understanding of corporate cash holdings.

We examine the effect of managerial traits on corporate cash holdings. Specifically, we focus on the effect of CEO overconfidence or optimism, a well-documented psychological trait. The finding that people are overconfident is one of the most robust in the psychology of judgment (De Bondt and Thaler 1995; Kahneman et al. 1982, and Russo and Schoemaker 1990). Overconfidence is defined either as an upward bias in expectations of future outcomes, also known as optimism, or as overestimation of the precision of one's information leading to underestimation of risk. As with much of the recent work in behavioral finance, we rely on the first interpretation and use the terms optimism and overconfidence interchangeably.[3]

Prior research is ambiguous about the effect of CEO optimism on cash holdings. Optimistic CEOs behave as if they are financially constrained, given their belief that external financing is overly costly.[4] This finding may imply that optimistic CEOs hold *more* cash than rational CEOs to finance future investments with internal cash, rather than with future external financing, which they expect to be unduly costly. On the other hand, it is possible that optimistic CEOs hold *less* cash than rational CEOs because they use the internal cash to finance current investments, as they avoid current external financing, which they believe is unduly costly. The net effect of CEO optimism on cash holdings thus depends on the CEO's beliefs about the relative costs of current and future external financing.

Resolving this ambiguity requires a model of corporate decision-making (see Gamba and Triantis 2008), which juxtaposes the costs of current and future external financing. The existing literature does not offer such a model of CEO optimism. We fill this gap by developing a model that exploits the tension between the CEO's perceived costs of current and future external financing. We take as a benchmark the cash balance held by a CEO whose beliefs are identical to those of the investors, and is based on a trade-off between the benefits and costs of holding cash. However, the cash balance held by a CEO whose beliefs differ from those of investors, deviates from the benchmark balance based on his/her perception about the cost of external financing. An optimistic CEO believes that the firm's equity is currently underpriced. Moreover, the CEO believes that this underpricing will mitigate over time as investors learn about the profitability of the firm's investments. An optimistic CEO thus expects the cost of external financing to decline and delays raising external financing. Until this anticipated decline in financing costs occurs, the optimistic CEO finances the firm's investments by relying more on internal cash, thus maintaining a lower cash balance than rational CEOs.

Note that an optimistic CEO's perception that external financing is costly does not necessarily imply that an optimistic CEO uses less external financing than a rational CEO. The optimistic CEO's desire to invest more would induce the CEO to raise greater external financing than a rational CEO. On the other hand, an optimistic CEO's perception that costly external financing will result in a wealth transfer from current shareholders to new investors would induce the CEO to reduce reliance on external financing. Depending on the strength of the two effects, the optimistic CEO may raise more external financing or less compared to the rational CEO. We discuss this point in Section 2.2.

Our model and its extensions provide four predictions. The main prediction of the model is that a firm managed by an optimistic CEO maintains a lower cash balance than an otherwise identical firm managed by a rational CEO. The second prediction is that the difference between the cash held by a firm with a rational CEO and the cash held by a firm with an optimistic CEO is smaller if the firms have assets with longer maturity. The third prediction is that the difference in cash holdings between higher-growth and lower-growth firms will be lower in firms managed by optimistic CEOs. The fourth prediction is that the sensitivity of cash holdings to cash flow will be lower in firms managed by optimistic CEOs i.e., optimistic CEOs save less cash out of incremental cash flow than rational CEOs.

We test three of the model's predictions using a sample drawn from the Execucomp database over the period 1992–2012. As in Malmendier and Tate (2005, 2008) and Malmendier et al. (2011), we classify managers as optimistic if they overinvest personal funds in their company. For this classification, we follow Campbell et al. (2011) and use the data on option compensation. We classify CEOs as optimistic if they held options that were more than 100% in the money at least once during their tenure.

We find that CEO optimism, on average, is associated with a 24% reduction in the firm's cash balance. This result is consistent with the main prediction of our theoretical model. We consider several alternative moneyness thresholds, based on existing literature, to identify optimistic CEOs and find that our main finding is robust to these alternative thresholds. Our main finding is also robust to alternative specifications and to alternative measures of cash holdings.

Consistent with the prior literature, we find that higher-growth firms hold more cash than lower-growth firms. However, our results show that the difference in cash holdings between higher-growth and lower-growth firms is smaller in firms managed by optimistic CEOs. This finding is consistent with an empirical prediction of our model. Furthermore, consistent with another prediction, we find that firms managed by optimistic CEOs save less cash out of incremental cash flow than those managed by rational CEOs.

We perform several tests to check the robustness of our results to endogeneity of CEO optimism, to identification concerns, and to simultaneity concerns. For instance, we consider two instruments for temporal variation in CEO optimism and find results supportive of a causal relation between CEO optimism and cash holdings. We also perform a two-stage estimation where we first obtain the component of CEO optimism predicted by firm characteristics. Our results for cash holdings are robust to controlling for this component of CEO optimism. Tests based on time variation in CEO optimism rule out reverse causality from cash holdings to CEO optimism. Adding CEO-firm fixed effects shows that our results are robust to potential endogeneity arising from omitted variables that

[3] The overestimation of future cash flows (optimism) is discussed in Hackbarth (2008), Heaton (2002), Hirshleifer (2001), and Malmendier and Tate (2005). The overestimation of the precision of one's information is discussed in Barberis and Thaler (2003), Ben-David et al. (2013), Bernardo and Welch (2001), Gervais et al. (2011), Hackbarth (2008), Hirshleifer (2001), and Malmendier and Tate (2005). The former is a bias about the first moment of the outcome whereas the latter is a bias about the second moment of the outcome. As Hirshleifer (2001) points out, an overestimation of the precision of one's information may lead to optimism.

[4] See Malmendier and Tate (2005, 2008), Malmendier et al. (2011), and Deshmukh et al. (2013).

impact CEO choice as well as cash holdings.

Since leverage and cash holdings may be determined simultaneously and may be correlated, using leverage as a control variable may introduce a simultaneity bias. We perform a test that shows that the negative relation between cash holdings and CEO optimism continues to hold when we account for a potential simultaneity bias. Finally, as another test to address the endogeneity of CEO choice, we examine news articles to identify unforced CEO turnovers that are less likely to result solely from the board's decision to change corporate policies. We find that our results continue to hold for unforced turnovers.

We repeat our main analyses using an alternative data sample and an alternative measure of CEO optimism calculated by Malmendier and Tate (2005, 2008). This alternative measure of optimism is based on detailed option-compensation data for CEOs of the largest U.S. companies compiled by *Forbes* magazine over the period 1984–1994. The negative relation between CEO optimism and cash holdings is confirmed in this alternative data sample.

The main insight from our results is that optimistic CEOs' concerns about current financing constraints outweigh their concerns about future financing constraints. They behave as if they face temporary financial constraints. They draw down heavily on liquidity reserves to meet contemporaneous investment needs and anticipate more generous external financing in the future after weathering a period of tight financial constraints.

We contribute to the cash holdings literature by developing a model that endogenizes investment, financing/payout, and cash policies. The model provides a framework that can be used to examine how differences in both beliefs and information, between managers and outside investors, impact corporate policies. Specifically, we consider dynamic trade-offs faced by an optimistic CEO in simultaneously determining cash holdings and choosing investment and financing levels to show how CEO optimism affects corporate cash holdings. Our empirical results provide strong evidence that optimistic CEOs hold less cash than rational CEOs. The battery of tests and the various robustness checks we perform indicate that the negative effect of CEO optimism on cash holdings represents an independent and causal effect and is not a proxy for other documented determinants of cash holdings. In other words, CEO optimism has a direct effect on cash holdings beyond any indirect effect on firm characteristics that determine the demand for cash.

In a recent study, Aktas et al. (2019) compare the marginal value of cash holdings across firms led by rational CEOs and firms led by overconfident CEOs. They find that an incremental dollar of cash holdings generates an additional $0.28 value in firms led by overconfident CEOs than in firms led by rational CEOs. While they do not provide a model, their empirical analysis is motivated by the ambiguity arising from the competing hypotheses based on the previous literature. Our model removes this ambiguity to provide predictions that are confirmed by empirical tests. Unlike Aktas et al. (2019), who focus on value of cash, we examine the level of cash. Our theoretical and empirical results that firms led by optimistic CEOs hold a lower cash balance is consistent with the main result in Aktas et al. (2019) that marginal cash creates more value in these firms.[5]

In a related study, Dittmar and Duchin (2016) find that firms led by CEOs who experienced financial distress early in their career hold more cash. There are fundamental differences between their study and ours. First, Dittmar and Duchin (2016) focus on past professional experiences of a CEO. In contrast, we examine CEO's beliefs about the future. Second, the focus in Dittmar and Duchin (2016) is not on the channel through which past experiences affect cash holdings. In contrast, we offer a theoretical model to identify how CEO beliefs affect the trade-offs that determine a firm's cash holdings.

We also contribute to the growing literature on behavioral corporate finance.[6] Our study is more closely related to the literature that explores the effect of CEO overconfidence or CEO optimism on corporate policies. Malmendier and Tate (2005) document that firms managed by overconfident CEOs exhibit a greater sensitivity of investment spending to internal cash flow. Malmendier and Tate (2008) show that overconfident CEOs are more likely to engage in acquisitions that are value-destroying. Malmendier et al. (2011) argue that overconfident managers perceive their firms to be undervalued and are reluctant to raise funds through costly external sources. They find that the reluctance of overconfident CEOs to raise funds through external sources leads to both a pecking order of financing and debt conservatism. Hirshleifer et al. (2012) show that overconfident CEOs exploit innovative growth opportunities by increasing investment in risky projects. Ben-David et al. (2013) find that optimism among top corporate executives is associated with increased corporate investment. Deshmukh et al. (2013) show that firms managed by overconfident CEOs pay lower dividends.

Our results are consistent with the central thesis of this literature that behavioral characteristics of CEOs affect corporate policies. The previous literature has noted the tension between an optimistic CEO's proclivity towards overinvesting and the CEO's belief that external financing is too costly. Our model addresses this issue and shows that optimistic CEOs invest more than rational CEOs but their investment is constrained by the cost of external financing that they view as too high. These results are consistent with empirical findings in Malmendier et al. (2011) who note that overconfident managers use less external finance.

We discuss several implications for future research arising from our results. First, firms that expect cash flow to increase over time should maintain a lower cash balance. Second, younger firms should maintain a lower cash balance. Third, firms with favorable private

[5] Huang-Meier et al. (2015) report that firms with optimistic managers hold more cash when differences in firm characteristics are not controlled for. They do not examine or report how CEO optimism affects cash holdings after controlling for firm characteristics. Instead, they focus on the sensitivity of cash to various determinants.

[6] Baker et al. (2007) survey the literature that examines the relation between corporate policies and behavioral characteristics of corporate managers and investors. See Hirshleifer (2015) for a recent review of behavioral finance. Hackbarth (2008) shows theoretically that overconfident managers tend to choose higher debt levels. Bernardo and Welch (2001), Gervais et al. (2011), and Goel and Thakor (2008) endogenize CEO overconfidence and consider the impact of CEO overconfidence on shareholders. Heaton (2002) examines how managerial optimism affects corporate policies, de Meza and Southey (1996) and Landier and Thesmar (2009) examine financial contracting with optimistic managers, and Bergman and Jenter (2007) link stock option compensation to employee optimism.

information would maintain a lower cash balance. Fourth, the difference between cash holdings of optimistic and rational CEOs will be lower in multidivision firms than in stand-alone firms. Fifth, firms led by optimistic CEOs hold more lines of credit than firms led by rational CEOs.

The paper proceeds as follows. In Section 2, we develop a model of cash holdings and CEO optimism. Section 3 describes the data and the variables. Section 4 presents the empirical results. We discuss the implications of our results for future research and for practice in Section 5. Section 6 concludes with a summary of our findings. The Appendix presents our findings on an alternative sample of firms and an alternative measure of CEO optimism.

2. Model

In this section, we present a model of the effect of CEO optimism on cash holdings.

2.1. Assumptions

Consider a firm that is managed by a CEO who acts in the interest of current shareholders. All agents are risk neutral and the discount rate is zero. The firm starts at time 0 with a cash balance of C_0 and with assets in place that result in cash flow X_0 at maturity M ($0 < M < 1$). The firm pays out cash and/or raises external financing at time 0 and at time M, invests continuously in a new project between time 0 and time 1, and is liquidated after realizing its final cash flow at time 2. Fig. 1 shows the timeline of events.

An investment $I_t dt$ in an infinitesimal time interval dt at time t, $0 < t < 1$, contributes $X_t dt$ to the final cash flow at time 2, where

$$X_t = \begin{cases} 0 & \text{with probability } \pi_l \\ f(I_t) & \text{with probability } \pi_m \\ af(I_t) & \text{with probability } \pi_h, \end{cases}$$

f is an increasing and concave function, $a \geq 1$, and π_l, π_m, and π_h are the probabilities of low, medium, and high project payoffs, respectively.

Firm quality affects both the payoff from assets in place and the cash flow from the new project. The firm quality is unknown at time 0 but is inferred from payoff X_0 from assets in place. A greater X_0 indicates a higher quality and hence a higher X_t. Specifically, $\pi_l(X_0)$ is decreasing in X_0 and $\pi_h(X_0)/\pi_m(X_0)$ is increasing in X_0.

The CEO chooses the investment rate I_t in the new project and the cash balance C at time 0 that is in excess of the investment needs before time M. We call this cash balance excess cash. Excess cash can be used to finance investments after time M, possibly with additional capital raised after time M. Excess cash may also serve transactional or precautionary needs, and may result in agency costs. Without explicitly modeling these factors, we assume that the expected incremental firm value from holding excess cash C, $h(C)$, satisfies $h''(C) < 0$. We define first-best excess cash C^* by $h'(C^*) = 1$.

Since new information is revealed only at time M, the rate of investment changes only at time M. Let $I_t = I$ for $t \leq M$ and $I_t = J$ for $t \geq M$. Without loss of generality, we assume that the financing or payout decisions are taken at time 0 and at time M. The net amount raised by the firm at time 0 is

$$D = C + MI - C_0. \tag{1}$$

If D is positive, the firm raises D though external financing and if D is negative, the firm pays out $-D$ to investors.

Investors have rational beliefs about firm quality. The CEO's beliefs at time 0 about firm quality depend on his optimism p. A value of $p = 0$ indicates a rational CEO, $p > 0$ indicates CEO optimism, and $p < 0$ indicates CEO pessimism. A higher value of p makes higher values of payoff from assets in place (X_0) more likely in the first-order-stochastic-dominance sense. The CEO's optimism p is exogenous to the model, similar to preference parameters such as the degree of risk-aversion or reservation utility. The CEO's optimism may be an inherent trait and/or may result from life experiences (see Dittmar and Duchin (2016) and Stix (2013) for how past experiences affect actions of CEOs and households, respectively). While we focus on the interpretation that the CEO is optimistic relative to rational investors, our results will also apply if the difference in beliefs arises from CEO's private information. In particular, our analysis does not depend on whether the CEO's beliefs are correct or the investors' beliefs are correct.

2.2. Analysis

First, consider the events after time M. The CEO and the investors infer the project quality from the realized cash flow (X_0) and reach the same updated beliefs about the probability distribution of new investment (π_l, π_m, and π_h). Since there is no information asymmetry, external financing is fairly priced and the firm value at time M is independent of future financing policy. The CEO chooses

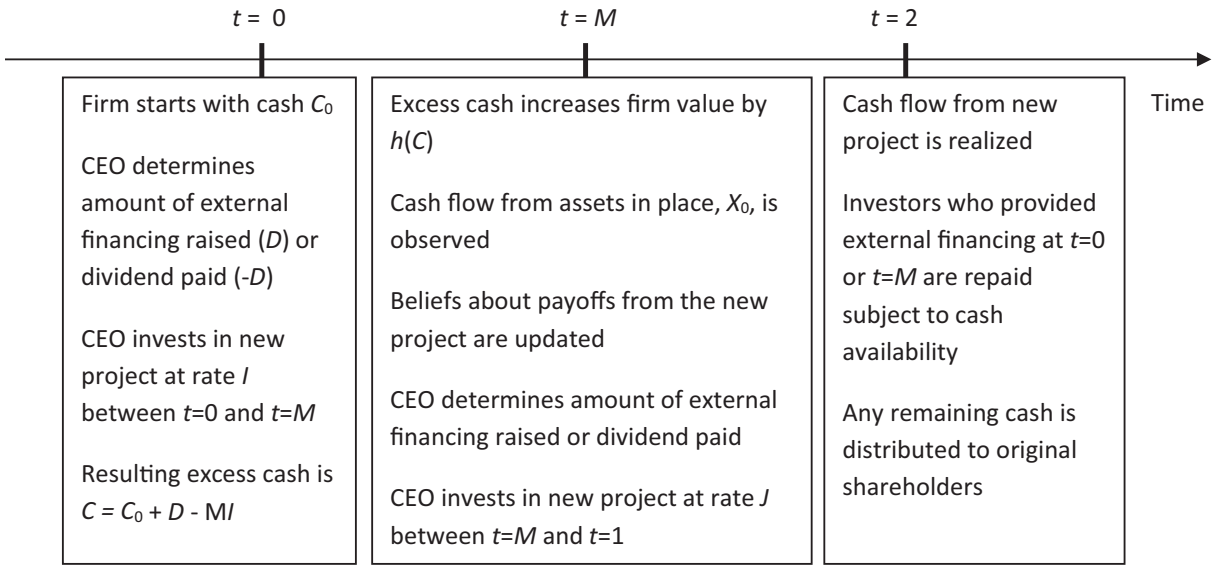

Fig. 1. Timeline.

the NPV-maximizing investment rate.

Now consider the events before time M. Since the CEO is more optimistic than the investors about the prospects of the firm, the CEO prefers debt financing to equity financing, consistent with the finding in Malmendier et al. (2011).[7] The new investors (debtholders) expect to be paid only if the firm realizes medium or high payoffs and accordingly set the face value F of debt such that

$$D = E_0[\pi_m + \pi_h]F. \tag{2}$$

where the subscript 0 in the expectation operator indicates that the expectation is based on investors' beliefs that exhibit zero optimism.

The CEO chooses the investment rate I and the excess cash balance C to maximize his expectation of firm value, given by

$$\begin{aligned} Z(I,C,p) \equiv\ & h(C) + X_0 + E_p[\pi_m + a\pi_h]Mf(I) - (C + MI - C_0)\frac{E_p[\pi_m + \pi_h]}{E_0[\pi_m + \pi_h]} \\ & + (1-M)E_p\left[\max_J\{(\pi_m + a\pi_h)f(J) - J\}\right] \end{aligned} \tag{3}$$

The first term in the objective is the value of the excess cash balance, the second term is the cash flow from assets in place, the third term is the expected cash flow from the investment made before time M, the fourth term is the expected repayment to new investors, and the last term is the NPV of the investment to be made after time M. Note that the last term does not depend on excess cash C because the CEO expects to raise financing at fair terms.

The investment rate I that maximizes the CEO's objective (3) is given by the following first-order condition:

$$E_p[\pi_m + a\pi_h]f'(I) = \frac{E_p[\pi_m + \pi_h]}{E_0[\pi_m + \pi_h]}. \tag{4}$$

Substituting $p = 0$ shows that a rational CEO chooses investment rate I^* to maximize NPV:

$$f'(I^*) = \frac{1}{E_0[\pi_m + a\pi_h]}. \tag{5}$$

An optimistic CEO's investment rate is increasing in his optimism. To see this, we rewrite (4) as

[7] If the ratio of the CEO's probability density to the investors' probability density increases monotonically in quality, then the optimal contract pays investors the entire cash flow proceeds of the firm if the proceeds are below a threshold and nothing otherwise. Under the constraint that investors' payoff is non-decreasing in firm cash flow, the debt contract is optimal. In general, agents prefer positions which promise higher payoffs in states that they consider more likely than other agents. This idea can explain portfolio choice (DeTemple and Murthy 1994), capital structure choice (Yang 2013), and the existence of financial intermediaries (Coval and Thakor 2005).

$$f'(I) = \frac{1}{E_0[\pi_m + \pi_h]}\left(1 - \frac{a-1}{a + E_p[\pi_m]/E_p[\pi_h]}.\right) \tag{6}$$

Consider an increase in p. This makes a higher X_0 more likely and a higher X_0 increases the ratio π_h/π_m.[8] Thus, an increase in p lowers the ratio $E_p[\pi_m]/E_p[\pi_h]$, which lowers the right side of (6). To maintain equality, the left side of (6) must be lowered by increasing I.

To understand this result, consider three effects of CEO optimism. First, a more optimistic CEO estimates a higher probability $\pi_m + \pi_h$ of a positive project payoff and a higher probability π_h of a high project payoff, and hence, a higher NPV of the project. Second, a more optimistic CEO estimates a higher probability $\pi_m + \pi_h$ of repayment to debt investors, but since this is not reflected in investors' pricing of debt (2), the CEO perceives debt to be more underpriced. In the special case of $a = 1$, high and medium payoffs coincide and the overestimation of project NPV is exactly offset by the overestimation of the cost of external financing because both are caused by an overestimation of $\pi_m + \pi_h$, and an optimistic CEO invests the same amount as a rational CEO. However, if $a > 1$, there is a third effect. An optimistic CEO also overestimates the probability of high payoff (π_h) relative to the probability of medium payoff (π_m), which further increases the NPV of the investment without affecting the perceived underpricing of debt. So if $a > 1$, a more optimistic CEO invests more, despite viewing external financing as too costly. Malmendier and Tate (2005) show that optimistic CEOs overinvest if they have sufficient internal funds but curb their investment if they have to raise external financing. We show that despite their reluctance to raise costly external financing, optimistic CEOs overinvest relative to the first-best.

The first-order condition for the excess cash balance C that maximizes (3) is:

$$h'(C) = \frac{E_p[\pi_m + \pi_h]}{E_0[\pi_m + \pi_h]}. \tag{7}$$

For a rational CEO, the above condition is satisfied at the first-best cash balance C^*. The excess cash balance C held by an optimistic CEO is decreasing in his optimism. To see this, consider a value for optimism p and a value for excess cash C that satisfy (7). For a more optimistic CEO, a higher value of p increases the right side of (7). To restore equality in (7), the left side must be increased by lowering C.

To gain an intuition for the above result, consider the effect of a change in excess cash C on the CEO's objective (3). The marginal cost of holding excess cash is the perceived marginal cost of external financing raised before time M. The marginal benefit of holding excess cash is the exogenous marginal benefit $h'(C)$ and the perceived marginal cost of external financing raised after time M. A more optimistic CEO views financing before time M to be more costly and therefore, perceives a higher marginal cost of excess cash. However, a more optimistic CEO does not perceive a higher marginal benefit of excess cash. This is because the exogenous marginal benefit $h'(C)$ is independent of the CEO's optimism and because all CEOs expect to raise financing at fair terms at time M. Facing a higher marginal cost of cash but not a higher marginal benefit of cash, a more optimistic CEO chooses a lower cash balance.

The above rationale leads to the following empirical prediction:

Prediction 1. *Firms led by optimistic CEOs hold less cash than firms led by rational CEOs.*

We now consider the effect of CEO optimism on the level of external financing. The level of external financing is increasing in the investment level and in the cash balance (see (1)). The first effect of CEO optimism on external financing is through the tendency of the optimistic CEO to invest more, which induces the CEO to raise greater external financing than a rational CEO. An alternative to raising external financing is to finance investments partly by drawing down on the cash balance. The reliance on these two sources depends on their relative costs. Believing external financing to be unduly costly, an optimistic CEO uses more cash for investment thereby maintaining a lower cash balance than a rational CEO. This second effect of CEO optimism reduces the external financing raised by the optimistic CEO. The net effect of CEO optimism on external financing depends on the strength of the two effects. If the investment payoff function f is not too concave and the function h for value of cash is sufficiently concave, then the first effect dominates, and an optimistic CEO raises more external financing than a rational CEO. If on the other hand, the investment payoff function f is sufficiently concave and the function h for value of cash is not too concave, then the second effect dominates, and an optimistic CEO raises less external financing than a rational CEO. In both cases, the optimistic CEO's perception of costly external financing constrains his use of external financing. As we note earlier, the empirical evidence (Malmendier et al. 2011) suggests that optimistic CEOs use less external financing, and conditional on raising external financing, they issue less equity.[9]

Next, we discuss how the maturity M of assets in place affects the cash balance. The total cash held by the firm is $C + MI$ where the investment rate I, determined by (6), is (weakly) increasing in CEO optimism, and the excess cash C, determined by (7), is decreasing in CEO optimism.[10] If assets in place have a longer maturity, then investment needs have a greater impact on the cash balance compared to excess cash, and an increase in CEO optimism results in a smaller decline in the total cash balance.[11] We get the following empirical prediction.

[8] Formally, $\frac{E_p[\pi_m]}{E_p[\pi_h]} = \frac{\int \pi_m(x)g(x,p)\mathrm{d}x}{\int \pi_m(x)\{\frac{\pi_h(x)}{\pi_m(x)}\}g(x,p)\mathrm{d}x}$. Since $\pi_h(x)/\pi_m(x)$ is increasing in x and g follows monotone-likelihood-ratio-property, $\frac{E_p[\pi_m]}{E_p[\pi_h]}$ is decreasing in p by Chebyshev's inequality.

[9] We thank a referee for highlighting this issue.

[10] The total cash can be increasing or decreasing in CEO optimism depending on the relative size of cash kept for meeting investment needs and the excess cash retained for other reasons.

[11] $\partial^2(C + MI)/\partial p\partial M = \partial I/\partial p > 0$.

Prediction 2. *The difference between the total cash held by a rational CEO and the total cash held by an optimistic CEO is smaller in a firm with longer maturity of assets (M).*

Our model provides a framework that can be used to examine the effect of differences in beliefs and information between managers and outside investors on corporate policies. For example, the model can accommodate the CEO's private information or a time-varying difference of opinion between the CEO and the investors arising from market sentiment. We discuss some insights about possible extensions in Section 6.

We now consider some alternative interpretations of our results. First, even though optimistic CEOs perceive their firms to be financially constrained, the impact of CEO optimism on cash holdings is not merely an effect of financial constraints. With time-invariant financial constraints, the timing of financing decisions does not matter and the effect of financial constraints on cash holdings is not obvious. Second, our results do not reflect market-timing based on time variation in investment opportunities. The model makes no assumption about whether the CEO considers current or future investment opportunities to be more valuable. Third, we do not assume that optimistic CEOs overestimate the future cash flows of the firm. Even if such a bias exists, it does not affect cash holdings in our model because CEOs prefer to meet future cash needs by raising financing in the future rather than through the current cash balance. Finally, our model does not assume systematic differences in firm characteristics between firms led by optimistic and rational CEOs, even though our empirical analysis controls for various firm characteristics.

2.3. Model extensions

We now extend the model to consider how the effect of CEO optimism on cash holdings depends on growth opportunities and cash flow.

2.3.1. Effect of growth opportunities

We have shown that a firm considers the trade off between financing current investment and financing future investment when determining the cash balance. Growth opportunities, a measure of the future investments relative to the current investments, may influence the trade-off between the current and future financing needs that determines cash holdings.

Let growth g be a measure of investment opportunities available after time M. As noted earlier, in the absence of financing frictions, the firm does not hold additional cash to meet investment needs after time M. However, there is empirical evidence (see Opler et al. 1999) that higher-growth firms hold more cash. Higher-growth firms may hold more cash due to frictions such as transaction costs of external financing. Let K denote the extra cash kept by a firm to meet its growth needs, in addition to the cash kept for investment needs before time M and for transactional and precautionary purposes. We assume that the marginal value of K is increasing in growth g and decreasing in K. Specifically, the marginal value of holding extra cash K is $V(K/K^*(g))$, where K^* is an increasing function, $V(1) = 1$, and V is a decreasing function. The optimal value of K is obtained by equating this marginal value of cash to the marginal cost of cash given by the right side of (7). A rational CEO chooses $K = K^*(g)$ while an optimistic CEO chooses a lower amount $K = K^*(g)V^{-1}\left(\frac{E_p[\pi_m+\pi_h]}{E_0[\pi_m+\pi_h]}\right) < K^*(g)$. Thus, the increase in cash holdings associated with higher growth is decreasing in CEO optimism. The intuition is that the higher cost of financing perceived by the optimistic CEO offsets the benefit of raising cash for future growth needs.

Prediction 3. *The difference between the cash held by higher-growth firms and lower-growth firms is smaller in firms led by optimistic CEOs than in firms led by rational CEOs.*

2.3.2. Effect of cash flow

Malmendier and Tate (2005) show that optimistic CEOs exhibit a higher sensitivity of investment to cash flow. Their result implies that a lower fraction of incremental cash flow is available to add to cash holdings and to reduce external financing because increase in investment, increase in cash holdings, and reduction in external financing are alternative uses of cash flow. However, predicting the sensitivity of cash holdings to cash flow requires modeling the determinants of cash holdings and external financing. We now model how CEO optimism affects the sensitivity of cash holdings to cash flow.

The CEO's objective (3) can be written as

$$Z(I, C, p) \equiv h(C) + R(I) - S(C + MI - C_0) + T, \tag{8}$$

where $R(I)$ is the value of investment, $S(C + MI - C_0)$ is the expected repayment to investors for financing raised before time M, based on CEO's beliefs, and T captures other components in (3) not dependent on I or C. The optimal cash, investment, and financing equate the marginal value of cash, the marginal value of investment, and the marginal cost of financing:

$$h'(C) = R'(I) = S'(C + MI - C_0) \tag{9}$$

The above first-order conditions can be used to determine how I and C change in response to a change in the firm's

contemporaneous cash flow C_0. Totally differentiating (9) with respect to C_0, we get

$$\frac{dC}{dC_0}h'' = \frac{dI}{dC_0}R'' = \left(\frac{dC}{dC_0} + M\frac{dI}{dC_0} - 1\right)S'',$$

which can be simplified to get the cash-flow sensitivity of cash,

$$\frac{dC}{dC_0} = \frac{1}{1 - \frac{h''}{S''} + M\frac{h'''}{R''}}. \tag{10}$$

The cash flow sensitivity of cash in (10) depends on the functional forms for R, S, and h. As specified in the main model, the marginal value of cash is declining ($h'' < 0$) and the marginal value of investment is declining ($R'' < 0$) but the marginal cost of financing (given by the right hand side of (4)) is a constant ($S'' = 0$). In this case, the right hand side of (10) is zero, indicating that cash does not depend on cash flow. The intuition is that any shock to cash flow is absorbed by changing external financing without changing investment or cash from their optimal levels. However, Almeida et al. (2004) show that cash holdings are sensitive to cash flow for an average firm so we assume that there is an additional exogenous convex cost of raising external financing ($S'' > 0$). Then, (10) yields the intuitive result that firms increase cash holdings when there is additional cash flow ($dC/dC_0 > 0$). We also assume that the $h''' \geq 0$ and $R''' \geq 0$. These assumptions are economically plausible and ensure that the marginal values of cash and investment are non-negative for large values of cash and investment.

Optimistic CEOs hold less cash than rational CEOs so the value of h'' is more negative for optimistic CEOs than for rational CEOs. Similarly, optimistic CEOs invest more than rational CEOs so the value of R'' is less negative for optimistic CEOs than for rational CEOs. Substituting these inequalities in (10), it follows that optimistic CEOs save less cash out of cash flow. The intuition is that a rational CEO's investment and financing choices are optimal and changing these can be costly so cash flow shocks are absorbed to a large extent through change in cash holdings. However, an optimistic CEO's investment, financing, and cash holdings are constrained due to his perception of costly financing. That is why, compared to a rational CEO, an optimistic CEO uses a larger fraction of incremental cash flow to invest more or to reduce external financing and saves a smaller fraction as cash. Thus, optimistic CEOs exhibit a lower sensitivity of cash holdings to cash flow.

Prediction 4. *For a given increase in cash flow, the increase in cash holdings in a firm led by an optimistic CEO will be smaller than that in a firm led by a rational CEO.*

In our empirical analysis, we test Predictions 1, 3, and 4.

3. Data and variables

We use option-compensation data for firms from Standard and Poor's Execucomp database over the period 1992–2012. From this initial sample, we eliminate observations for financial firms (SIC 6000–6999), utilities (SIC 4900–4999), and regulated telephone companies (SIC 4813) to get 19,328 firm-year observations for 2172 firms. We supplement the data from Execucomp with various items from the COMPUSTAT database to construct our control variables.

We use the data on option compensation to construct our CEO optimism measures. Options typically represent a large component of CEO compensation packages. CEOs also have their human capital invested in the firm. Taken together, these effects cause CEOs to be underdiversified and highly exposed to company-specific risk. The options issued to CEOs are non-tradeable and the CEOs are typically prohibited from hedging their exposure by short selling their company stock. Underdiversified CEOs should rationally exercise their options early if they are sufficiently deep in-the-money (Hall and Murphy 2002). An optimistic CEO, however, overestimates the expected value of the firm's future payoff and perceives the firm's stock to be undervalued. So, despite being underdiversified, an optimistic CEO is less likely to exercise stock options and thus holds the options longer than his/her rational counterparts. Malmendier and Tate (2005, 2008) use this rationale to derive CEO overconfidence measures based on the option-exercise behavior of CEOs. This rationale also underlies our measures of CEO optimism, *Optimism* and *Post-Optimism*. We now describe these two measures along with the various control variables we use in our empirical analysis.

3.1. Optimism

Malmendier and Tate (2005) classify CEOs as overconfident if they held options that were fully vested five years before expiration and were at least 67% in the money. As in Campbell et al. (2011), we adopt a threshold of 100% moneyness and set *Optimism* equal to one over all the CEO-years if the CEO held an option that was more than 100% in the money at least once during his/her tenure, and zero otherwise. The *Optimism* variable thus represents a fixed effect over all of a CEO's years. Unlike in Campbell et al. (2011), we do not require that the CEO exceed the 100% moneyness threshold at least twice during his/her tenure. The reason is that our focus is on comparing the cash-holdings of optimistic CEOs relative to those of non-optimistic CEOs, whereas, Campbell et al. (2011) compare CEOs with high optimism, low optimism, and those who are moderately optimistic in the context of CEO turnovers. Our requirement that CEOs exceed the 100% moneyness threshold only once in order to be classified as optimistic is consistent with that in Hirshleifer et al. (2012), though they consider a 67% threshold. We show that our results are robust to several alternative criteria for classifying CEOs as optimistic, based on both Campbell et al. (2011) and Hirshleifer et al. (2012). We discuss these results in a later subsection.

Since the Execucomp database does not provide detailed data on the option holdings of a CEO or the exercise price associated with each option grant, we follow Campbell et al. (2011) to calculate the average moneyness of a CEO's option holdings for each year in our

sample period. First, we compute the realizable value per option as the ratio of the total realizable value of exercisable options to the number of exercisable options. Next, we subtract the realizable value per option from the fiscal-year-end stock price to obtain an estimate of the average exercise price of options. Last, to determine the average percentage moneyness of the options, we divide the realizable value per option by the estimated average exercise price.

Our identification of optimistic CEOs may classify some optimistic CEOs as non-optimistic and some non-optimistic CEOs as optimistic. Moreover, if CEO optimism varies over time, this variation is not captured by the *Optimism* variable that takes the same value for a CEO across all years. In this sense, the *Optimism* variable represents a noisy measure of optimism. The goal underlying our classification of CEOs is to ensure that the "optimistic" group is more likely to contain optimistic CEOs than the "rational" group. Any noise in the *Optimism* variable only serves to introduce a bias against finding support for the hypothesized negative relation between cash holdings and CEO optimism.

3.2. Post-optimism

Optimism can be an inherent trait but can also depend on life experiences (Gillham and Reivich 2004). To consider the latter possibility, we construct *Post-Optimism.* This measure, which is also based on the CEO's option-exercise behavior, allows for time variation in CEO optimism over the sample period and eliminates forward-looking information in the classification of a CEO. *Post-Optimism* equals one in all CEO-years following (and including) the first year in which the CEO holds an option that is more than 100% in the money, and zero otherwise. This measure is motivated by the *Post-Longholder* measure in Malmendier and Tate (2005, 2008) and its rationale is similar to that underlying the high-optimism measure in Campbell et al. (2011).

3.3. Control variables

The extant empirical literature indicates that cash holdings are influenced by many factors. In our empirical analysis, we control for factors shown to affect corporate cash holdings in Opler et al. (1999), Harford et al. (2008), and Bates et al. (2009). Specifically, we include growth, cash flow, firm size, leverage, net working capital, R&D expenditures, capital spending, acquisitions, and cash flow volatility.

We also include CEO stock ownership and CEO option ownership to control for agency costs associated with managerial discretion and for any potential incentive effects on cash holdings (Opler et al. 1999; Malmendier and Tate 2008). CEO option ownership also controls for the correlation between the optimism variable and the CEO's option ownership. We control for the degree of financial constraints faced by a firm as optimistic CEOs behave as if they are financially constrained. Following Almeida et al. (2004), we use a bond-rating indicator variable - a value of zero for this variable identifies constrained firms while a value of one identifies unconstrained firms. We include firm size as another control variable for the degree of financial constraints following Almeida et al. (2004). We include year fixed effects to account for any time trends in cash holdings (Bates et al. 2009). We include firm fixed effects and cluster standard errors by firm.

We calculate *Growth* as the ratio of the market value of assets to net assets, where the market value of assets equals the market value of equity plus the book value of total liabilities and net assets equals the book value of total assets minus cash and short-term investments; *Cash Flow* as the ratio of operating income before depreciation less interest expense less income taxes less common and preferred dividends to net assets; *Leverage* as the ratio of the sum of long-term debt and debt in current liabilities to net assets; *NWC to Assets* as the ratio of net working capital (net of cash and short-term investments) to net assets; *RD to Assets* as the ratio of R&D expenditures to net assets (and set equal to zero if R&D is missing); *Capex to Assets* as the ratio of capital expenditures to net assets; *Acquisitions to Assets* as the ratio of acquisition expenditures to net assets; and *Cash Flow Volatility* as the standard deviation of the firm's cash flow over the prior ten-year period. *Bond Rating* is an indicator variable that equals one if the firm has a long-term debt rating and zero otherwise. We use the natural logarithm of sales, termed *Log of Sales,* as a proxy for firm size. For robustness, we use the natural logarithm of the book value of net assets as an alternative proxy for firm size. The CEO's stock ownership, termed *Stock Ownership*, equals the company stock (excluding options) owned by the CEO as a fraction of common shares outstanding. The CEO's option ownership, termed *Vested Options*, equals the ratio of the CEO's holdings of exercisable options to common shares outstanding.

3.4. Dependent variable

Following Opler et al. (1999), we use *Cash Holdings*, the ratio of cash and short-term investments to net assets, as our main dependent variable. However, Bates et al. (2009) argue that this measure of cash holdings can generate large outliers if firms hold most of their assets in cash. To reduce the potential problem of large outliers, we follow Foley et al. (2007) and use an alternative measure, *Log Cash Holdings*, which equals the natural logarithm of *One plus Cash Holdings*. For robustness, we also estimate our main models using *Cash to Assets*, the main measure of cash holdings in Bates et al. (2009), and calculated as the ratio of cash and short-term investments to the book value of total assets.

Our treatment of data outliers is as follows. We trim *Cash Flow* at the 0.5 percentile to ensure that our results are not affected by outliers (Malmendier and Tate 2005, 2008). We also trim *Growth* and *Cash Flow Volatility* at the 99.5 percentile, owing to the extremely large outliers. In addition, we remove about 1% of the observations for which the value of *Leverage* exceeds one. While all tabulated results reflect this treatment of the data, our main result regarding the negative relation between cash holdings and measures of CEO optimism is robust to including all the observations after winsorizing these four variables (at the respective levels at which we trim the observations).

4. Empirical results

We begin our empirical analysis with univariate comparisons between subsamples with *Optimism* = 1 (optimistic CEOs) and *Optimism* = 0 (rational CEOs). Next, we perform multivariate analyses by estimating a regression model of cash holdings as a function of CEO optimism and the control variables discussed in the previous section. In all of the regression models, we control for both firm and year fixed-effects and cluster standard errors by firm unless stated otherwise. We estimate each model using those observations for which data are available on all variables for that model.

The summary statistics in Panel A of Table 1 show that optimistic-CEO observations represent about 56% of the total firm-year observations. The mean and median values of cash holdings, our main variable of interest, are slightly higher for firms with optimistic CEOs. In addition, firms with optimistic CEOs have relatively higher CEO option ownership (as measured by vested options), higher growth, higher cash flow, higher R&D, higher capital expenditures, and higher CEO Tenure (tenure of the CEO with the firm in years). These differences suggest the need for multivariate analysis to investigate the marginal impact of CEO optimism on corporate cash holdings while controlling for the differences in the various attributes of firms led by optimistic and non-optimistic CEOs.

Since we control for firm fixed-effects, the impact of CEO optimism on cash holdings reflects within-firm variation rather than cross-sectional variation. Therefore, we need variation in CEO optimism within a given firm to determine how cash holdings differ between firms led by optimistic and rational CEOs. This variation is missing in those firms in our sample that have only optimistic CEOs *or* only non-optimistic CEOs. For these firms, the value of the optimism variable is either always one or always zero. Therefore, our estimate of the effect of CEO optimism on cash holdings is determined by observations for firms that have an optimistic CEO in at least one year and a non-optimistic CEO in at least one year, i.e., firms in which the optimism variable is time-varying.

In Panel B of Table 1, we exclude firms where the optimism variable is either always one or zero and report summary statistics for the 854 firms in our sample that have an optimistic CEO in at least one year and a non-optimistic CEO in at least one year. There are 5664 firm-year observations for optimistic CEOs and 4414 firm-year observations for non-optimistic CEOs. These two subsets of observations have similar mean values for cash holdings while the median value for cash holdings is now *lower* for optimistic CEOs. The other firm attributes differ notably between the two subsamples and we control for these differences in multivariate regressions. All of our reported results are based on regressions that use the entire data set (summarized in Panel A) in order to estimate the coefficients of control variables more precisely. However, our main results continue to hold if we instead restrict data to observations summarized in Panel B.

4.1. Optimism and the cash level

We estimate a regression model of cash holdings on the panel data for our sample firms. The independent variable of interest is (CEO) optimism. We also include various control variables. The results from Model 1 in Table 2 indicate that the level of cash holdings is negatively related to optimism and the coefficient is statistically significant at the 1% level. The results also indicate that the level of cash holdings is positively related to growth, cash flow, leverage, and R&D expenditures, and negatively related to firm size (as measured by the logarithm of sales), NWC, capital expenditures, acquisition expenditures, and the CEO's stock ownership. The coefficients on all of these control variables are statistically significant at either the 1% level or the 5% level and the results are generally consistent with the previous literature (Opler et al. 1999; Harford et al. 2008, and Bates et al. 2009). Finally, the coefficients on bond rating, cash flow volatility, and vested options are not statistically significant at conventional levels.

The negative coefficient on optimism indicates that the level of cash holdings is negatively related to the level of CEO optimism and is consistent with our main testable prediction (Prediction 1). The magnitude of the coefficient on optimism, which represents the incremental effect of CEO optimism on cash holdings, is 0.0208. This value is about 24% of the median level of cash holdings (of about 8.5%) and about 10% of the mean level of cash holdings for the overall sample. As an illustration of the economic significance of this coefficient, consider the median cash holdings of 6.99% for the sub-sample of non-optimistic CEOs. The cash holdings of a similar firm managed by an optimistic CEO will be about 30% lower, on average, at 4.91%.

In Model 2, we use post-optimism in place of the optimism variable. The overall results are qualitatively similar to those in Model 1. The coefficient on post-optimism is comparable to that on optimism and economically significant - its magnitude is roughly 24% of the median level of cash holdings (of about 8.5%) for the overall sample.

In Models 3 and 4, we use *Log Cash Holdings* as the dependent variable. In Model 3, we estimate the model with optimism and in Model 4, we replace optimism with post-optimism. The coefficients on both optimism and post-optimism continue to be negative and statistically significant at the 1% level. These coefficients cannot be interpreted as the percentage change in cash holdings across optimistic and non-optimistic CEOs because the dependent variable is log of one plus cash holdings rather than log of cash holdings. The coefficient on vested options is now negative and statistically significant at the 10% level or better. The rest of the results are qualitatively similar to those in Models 1 and 2.

Additional tests of our predictions based on an alternative sample of firms and an alternative measure of CEO optimism, discussed in Appendix, replicate the finding that the level of cash holdings is negatively related to the level of CEO optimism.

4.2. Endogeneity concerns

Our interpretation of the empirical results treats CEO optimism as exogenous. If CEO optimism is endogenously determined, then our results may be consistent with alternative explanations. We now address identification concerns and potential effects of endogeneity arising from CEO selection, reverse causality, omitted variables, and simultaneity concerns. The results from the following

Table 1
Summary Statistics: Optimistic CEOs vs. Non-Optimistic CEOs

Panel A: All Observations

Variable	Optimistic CEOs			Non-Optimistic CEOs			Optimistic vs. Non-Optimistic CEOs	
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	*p*-value for Difference (in Means)	*p*-value for Difference (in Medians)
Cash Holdings	0.2386	0.0859	0.42	0.1852	0.0699	0.36	0.00	0.00
Growth	2.7889	1.9530	2.46	1.9703	1.5631	1.45	0.00	0.00
Cash Flow	0.1161	0.1076	0.12	0.0842	0.0842	0.11	0.00	0.00
Book Value of Assets (in $ millions)	4464.89	1113.53	13,240.58	5763.63	1368.40	15,750.75	0.00	0.00
Net Sales (in $ millions)	4523.66	1160.25	16,381.23	5541.12	1464.64	14,480.21	0.00	0.00
Leverage	0.2331	0.2191	0.18	0.2549	0.2471	0.18	0.00	0.00
NWC to Assets	0.0934	0.0884	0.18	0.0961	0.0901	0.19	0.31	0.28
RD to Assets	0.0517	0.0021	0.11	0.0412	0.0031	0.10	0.00	0.00
Capex to Assets	0.0756	0.0551	0.07	0.0596	0.0443	0.05	0.00	0.00
Acquisitions to Assets	0.0386	0.0018	0.08	0.0313	0.0005	0.07	0.00	0.00
Bond Rating	0.5031	1.0000	0.50	0.5614	1.0000	0.50	0.00	0.00
Cash Flow Volatility	0.0840	0.0372	0.17	0.0667	0.0321	0.12	0.00	0.00
Stock Ownership	0.0264	0.0052	0.06	0.0143	0.0022	0.04	0.00	0.00
Vested Options	0.0099	0.0060	0.01	0.0067	0.0038	0.01	0.00	0.00
CEO Tenure (years)	8.4441	7.0000	7.90	5.0183	3.0000	5.94	0.00	0.00
Observations		11257			8701			

Panel B: Firms with Time-Varying Optimism Only (firms with no time variation in optimism are excluded)

Variable	Optimistic CEOs			Non-Optimistic CEOs		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
Cash Holdings	0.2045	0.0756	0.40	0.2042	0.0853	0.39
Growth	2.6835	1.9225	2.31	2.0203	1.6043	1.43
Cash Flow	0.1125	0.1052	0.11	0.0883	0.0877	0.12
Book Value of Assets (in $ millions)	5807.18	1453.35	16,707.19	7419.74	1689.40	19,992.40
Net Sales (in $ millions)	6264.88	1472.10	21,921.60	7007.72	1753.07	18,254.37
Leverage	0.2435	0.2270	0.18	0.2511	0.2397	0.18
NWC to Assets	0.0910	0.0846	0.17	0.0779	0.0813	0.19
RD to Assets	0.0504	0.0060	0.11	0.0486	0.0065	0.10
Capex to Assets	0.0743	0.0564	0.06	0.0599	0.0438	0.05
Acquisitions to Assets	0.0361	0.0019	0.08	0.0313	0.0016	0.07
Bond Rating	0.5772	1.0000	0.49	0.5843	1.0000	0.49
Cash Flow Volatility	0.0708	0.0353	0.14	0.0699	0.0332	0.13
Stock Ownership	0.0196	0.0035	0.05	0.0076	0.0017	0.02
Vested Options	0.0082	0.0048	0.01	0.0059	0.0033	0.01
CEO Tenure (years)	6.6484	5.0000	7.06	3.7650	3.0000	4.24
Observations		5664			4414	

Cash Holdings equals the ratio of cash and short-term investments to net assets. *Log of Cash Holdings* equals the natural logarithm of one plus *Cash Holdings*. *Growth* equals the ratio of the market value of assets to book value of *net* assets, where the market value of assets equals the market value of equity plus the book value of total liabilities. Net assets equals the difference between total assets and cash & short-term investments. *Cash Flow* equals the ratio of operating income before depreciation *less* interest expense *less* income taxes *less* common and preferred dividends *to* book value of net assets. *Leverage* equals the ratio of the sum of long-term debt and debt in current liabilities to net assets. *NWC to Assets* equals the ratio of net working capital (net of cash and short-term investments) to net assets. *RD to Assets* equals the ratio of R&D expenditures to net assets. *Capex to Assets* equals the ratio of capital expenditures to net assets; *Acquisitions to Assets* equals the ratio of acquisitions to net assets. *Cash Flow Volatility* equals the standard deviation of the firm's cash flow over the prior ten-year period. *Bond Rating* is an indicator variable that equals one if the firm has a long-term debt rating and zero otherwise. *Stock Ownership* equals the fraction of the company stock owned by the CEO (excluding options) as a fraction of common shares outstanding. *Vested Options* equals the ratio of the CEO's holdings of exercisable options as a fraction of common shares outstanding. *CEO Tenure* is the tenure of the CEO with the firm in years.

Table 2
CEO Optimism and Cash Holdings.

	Dependent Variable			
	Cash Holdings (Model 1)	Cash Holdings (Model 2)	Log Cash Holdings (Model 3)	Log Cash Holdings (Model 4)
Optimism	−0.0208***		−0.0104***	
	(−3.32)		(−2.92)	
Post-Optimism		−0.0203***		−0.0088***
		(−3.53)		(−2.81)
Growth	0.0609***	0.0618***	0.0325***	0.0328***
	(11.39)	(11.03)	(15.88)	(15.45)
Cash Flow	0.2343***	0.2363***	0.1623***	0.1606***
	(3.17)	(3.00)	(5.71)	(5.35)
Log of Sales	−0.0522***	−0.0493***	−0.0353***	−0.0345***
	(−6.02)	(−5.64)	(−7.42)	(−7.17)
Leverage	0.0774**	0.0826**	0.0443***	0.0475***
	(2.48)	(2.55)	(2.69)	(2.80)
NWC to Assets	−0.2979***	−0.2811***	−0.1471***	−0.1417***
	(−3.75)	(−3.50)	(−4.92)	(−4.67)
RD to Assets	1.5121***	1.5095***	0.6021***	0.6128***
	(7.38)	(7.09)	(8.13)	(7.72)
Capex to Assets	−0.1693**	−0.1639**	−0.0638*	−0.0634*
	(−2.55)	(−2.40)	(−1.92)	(−1.85)
Acquisitions to Assets	−0.2205***	−0.2035***	−0.1527***	−0.1479***
	(−7.56)	(−6.94)	(−11.11)	(−10.61)
Bond Rating	0.0062	0.0043	−0.0005	−0.0016
	(0.63)	(0.43)	(−0.08)	(−0.28)
Cash Flow Volatility	0.0575	0.0608	0.0324	0.0305
	(1.01)	(1.03)	(1.16)	(1.06)
Stock Ownership	−0.1417**	−0.1382**	−0.0796**	−0.0746**
	(−2.29)	(−2.25)	(−2.17)	(−2.01)
Vested Options	−0.1980	−0.0911	−0.3932**	−0.3588*
	(−0.41)	(−0.18)	(−2.16)	(−1.85)
Firm-Year Observations	19,877	18,808	19,877	18,808
Adjusted R^2	0.7774	0.7826	0.8265	0.8296

This table provides estimates from a regression model, which is estimated on the pooled data over the period 1992–2012. *Cash Holdings* equals the ratio of cash and short-term investments to net assets. *Log Cash Holdings* equals the natural logarithm of *One plus Cash Holdings*. *Optimism* equals one over all the CEO-years if the CEO held an option that was more than 100% in the money at least once during his/her tenure, and zero otherwise. *Post-Optimism* equals one in all CEO-years following (and including) the first year in which the CEO holds an option that is more than 100% in the money, and zero otherwise. *Growth* equals the ratio of the market value of assets to book value of *net* assets, where the market value of assets equals the market value of equity plus the book value of total liabilities. Net assets equals the difference between total assets and cash & short-term investments. *Cash Flow* equals the ratio of operating income before depreciation *less* interest expense *less* income taxes *less* common and preferred dividends *to* book value of net assets. *Log of Sales* equals the natural logarithm of net sales. *Leverage* equals the ratio of the sum of long-term debt and debt in current liabilities to net assets. *NWC to Assets* equals the ratio of net working capital (net of cash and short-term investments) to net assets. *RD to Assets* equals the ratio of R&D expenditures to net assets. *Capex to Assets* equals the ratio of capital expenditures to net assets. *Acquisitions to Assets* equals the ratio of acquisitions to net assets. *Cash Flow Volatility* equals the standard deviation of the firm's cash flow over the prior ten-year period. *Bond Rating* is an indicator variable that equals one if the firm has a long-term debt rating and zero otherwise. *Stock Ownership* equals the fraction of the company stock owned by the CEO (excluding options) as a fraction of common shares outstanding. *Vested Options* equals the ratio of the CEO's holdings of exercisable options as a fraction of common shares outstanding. All models include firm and year fixed effects and the standard errors are clustered by firm.
*** Significant at the 0.01 level; ** Significant at the 0.05 level; * Significant at the 0.10 level.

endogeneity checks suggest a causal effect of CEO optimism on cash holdings.

4.2.1.

CEO optimism may impact firm leverage, which, in turn, may impact cash holdings. Since leverage is included as a control variable in the regressions reported in Table 2, our results show that CEO optimism has an effect on cash holdings that is independent of its effect through firm leverage. However, if leverage is determined simultaneously with cash holdings and is correlated with cash holdings, then a simultaneity bias may affect estimates from an ordinary least-squares regression model. To eliminate a potential

Table 3
Endogeneity checks.

	Dependent Variable					
	Cash Holdings (Model 1-2SLS)	Cash Holdings (Model 2)	Cash Holdings (Model 3)	Cash Holdings (Model 4)	Cash Holdings (Model 5)	Cash Holdings (Model 6)
Instrumented Optimism		−0.1102***				
		(−4.88)				
Instrumented Post-Optimism			−0.5232**			
			(−2.49)			
Optimism	−0.0216**			−0.0212***		
	(−2.44)			(−3.38)		
Pre-Optimism					−0.0050	
					(−0.66)	
Post-Optimism					−0.0221***	−0.0202**
					(−3.27)	(−2.17)
Probability of Choosing an Optimistic CEO				−0.0076		
				(−0.09)		
Growth	0.0524***	0.0606***	0.0328***	0.0623***	0.0618***	0.0605***
	(5.75)	(11.34)	(5.59)	(10.66)	(11.03)	(9.78)
Cash Flow	0.1910	0.2057***	0.3729***	0.2625***	0.2367***	0.3307***
	(0.97)	(2.85)	(5.12)	(3.60)	(3.01)	(3.94)
Log of Sales	−0.0508***	−0.0257***	−0.0048	−0.0484***	−0.0496***	−0.0612***
	(−3.68)	(−3.38)	(−0.43)	(−5.49)	(−5.65)	(−4.88)
Leverage	−0.7218	0.0507	0.1301**	0.0927***	0.0828**	0.1579***
	(−0.71)	(1.62)	(2.37)	(2.88)	(2.56)	(4.34)
NWC to Assets	−0.5504**	−0.3586***	−0.3910***	−0.2850***	−0.2811***	−0.3270***
	(−2.35)	(−4.46)	(−5.20)	(−3.35)	(−3.50)	(−3.31)
RD to Assets	1.4330***	1.5018***	1.6544***	1.5581***	1.5097***	1.6473***
	(6.10)	(6.99)	(6.04)	(6.91)	(7.09)	(6.07)
Capex to Assets	−0.3603	−0.3312***	−0.0307	−0.2068***	−0.1646**	−0.1170
	(−1.64)	(−4.78)	(−0.18)	(−3.02)	(−2.41)	(−1.43)
Acquisitions to Assets	−0.1230	−0.2582***	−0.3253***	−0.2144***	−0.2036***	−0.2371***
	(−0.67)	(−8.99)	(−8.85)	(−6.45)	(−6.94)	(−8.80)
Bond Rating		0.0168*	0.0246	0.0067	0.0044	0.0138
		(1.68)	(1.11)	(0.65)	(0.43)	(1.01)
Cash Flow Volatility	0.1448	0.0575	0.1113	0.0708	0.0606	0.0643
	(1.24)	(1.05)	(0.87)	(1.12)	(1.03)	(0.85)
Stock Ownership	−0.0953	−0.1117	−0.1890*	−0.1522**	−0.1372**	−0.1897**
	(−0.57)	(−1.37)	(−1.87)	(−2.50)	(−2.24)	(−2.01)
Vested Options	0.1783	0.0863	−0.3945	−0.4237	−0.0920	−0.2847
	(0.23)	(0.17)	(−0.85)	(−0.88)	(−0.18)	(−0.53)
Year Fixed Effects	Yes	No	No	Yes	Yes	Yes
Fixed Effects	Firm	Firm	Firm	Firm	Firm	CEO-Firm
Standard Errors Clustered	By Firm	By Firm	By Firm	By Firm	By Firm	CEO-Firm
Firm-Year Observations	13,151	20,349	4806	18,656	18,808	18,808
Adjusted R^2	.	0.7598	0.8344	0.7837	0.7826	0.8204

The estimates are from a regression model, estimated on the pooled data over the period 1992–2012. *Cash Holdings* equals the ratio of cash and short-term investments to net assets. *Instrumented Optimism* equals the predicted probability of a positive outcome based on a logit model of Optimism on the instrument, fraction of optimistic CEOs. *Instrumented Post-Optimism* equals the predicted probability of a positive outcome based on a logit model of Post-Optimism on the instrument, percentage change in house value. *Optimism* equals one over all the CEO-years if the CEO held an option that was more than 100% in the money at least once during his/her tenure, and zero otherwise. *Post-Optimism* equals one in all CEO-years following (and including) the first year in which the CEO holds an option that is more than 100% in the money, and zero otherwise. *Pre-Optimism* equals one for those CEO years where Optimism equals one and Post-Optimism equals zero, and zero otherwise. *Probability of Choosing an Optimistic CEO* equals the probability of choosing an optimistic CEO and is calculated from a first-stage logit model of Optimism. *Growth* equals the ratio of the market value of assets to book value of *net* assets, where the market value of assets equals the market value of equity plus the book value of total liabilities. Net assets equals the difference between total assets and cash & short-term investments. *Cash Flow* equals the ratio of operating income before depreciation *less* interest expense *less* income taxes *less* common and preferred dividends *to* book value of net assets. *Log of Sales* equals the natural logarithm of net sales. *Leverage* equals the ratio of the sum of long-term debt and debt in current liabilities to net assets. *NWC to Assets* equals the ratio of net working capital (net of cash and short-term investments) to net assets. *RD to Assets* equals the ratio of R&D expenditures to net assets. *Capex to Assets* equals the ratio of capital expenditures to net assets. *Acquisitions to Assets* equals the ratio of acquisitions to net assets. *Cash Flow Volatility* equals the standard deviation of the firm's cash flow over the prior ten-year period. *Bond Rating* is an indicator variable that equals one if the firm has a long-term debt rating and zero otherwise. *Stock Ownership* equals the fraction of the company stock owned by the CEO (excluding options) as a fraction of common shares outstanding. *Vested Options* equals the ratio of the CEO's holdings of exercisable options as a fraction of common shares outstanding.
*** Significant at the 0.01 level; ** Significant at the 0.05 level; * Significant at the 0.10 level.

simultaneity bias, we instrument for leverage and estimate a two-stage least squares regression model. Following Molina (2005), we use the marginal corporate tax rate as an instrument for leverage.[12] We exclude the bond rating variable from the control variables as bond rating is likely to be correlated with leverage. The results reported in Model 1 in Table 3, which control for potential simultaneity, show that firms led by optimistic CEOs hold significantly less cash.

4.2.2.

Several studies employ managerial fixed effects to analyze the effect of managerial style on corporate policies. Bertrand and Schoar (2003) show that manager fixed effects are empirically important determinants of investment, financial, and organizational practices of firms. Graham et al. (2012) document that manager and firm fixed-effects explain a substantial portion of the variation in executive compensation and that manager fixed effects are more important than firm fixed-effects in explaining executive compensation. Coles and Li (2020) find that manager fixed-effects explain a large fraction of the variation in managerial incentives.

Fee et al. (2013) argue that managerial style inferred from management changes may not represent causation as boards may simultaneously change the firm's leadership and corporate policies. Their criticism is focused on the determination of managerial style with manager fixed-effects, which may be capturing the effect of the board's policy changes. This criticism is inapplicable in our case because our measure of CEO optimism is not derived from data on corporate policies and is not a time-invariant CEO fixed effect. Our CEO optimism measure is determined solely by the CEO's option-exercise behavior, which is unlikely to be controlled by the board. Moreover, the relation between CEO optimism and cash holdings is unlikely to be driven by endogeneity of board's CEO choice as there is no economic rationale for why boards that want to lower cash holdings also choose optimistic CEOs.

4.2.3.

We now consider the possibility that some firm characteristics that cause boards to hire optimistic CEOs also cause these CEOs to hold lower cash. We address this concern using an instrumental variable (IV) approach. The use of the IV approach to identify a causal relation requires instruments that affect CEO optimism but not cash holdings other than possibly through the effect on CEO optimism. Firm characteristics are not good candidates for instruments because they may have an independent effect on cash holdings. CEO personality characteristics, such as CEO gender, may impact CEO optimism but cannot be considered exogenous because the board may base its CEO choice on these characteristics. For example, while CEO gender is exogenous to the CEO, it is not exogenous for the firm because the board can choose the CEO based on gender.

With these qualifications in mind, we consider two instruments. To establish causality of CEO optimism, we draw on the general idea underlying the IV approach (see Roberts and Whited 2012). We first check the relevance of the instrument by estimating a logit model of CEO optimism on the instrument. Next, we use the predicted value of CEO optimism (i.e., the probability of a positive outcome) from this first-stage logit model as an explanatory variable in the second stage, where we regress cash holdings on this variable along with other control variables. The predicted value of CEO optimism from the first stage captures the variation in CEO optimism caused by the variation in the instrument and uses only this variation to estimate the slope estimate (of optimism) in the second stage.

Our first instrument measures the incidence of optimism in the candidate pool from which the board chooses a CEO. If a higher fraction of these candidates is optimistic, then the CEO chosen by the board is more likely to be optimistic even if the board did not specifically opt for an optimistic CEO. Importantly, the incidence of optimism among candidates is exogenous to the firm and is unlikely to have a direct effect on the cash holdings of the firm, satisfying the exclusion condition for an instrument. We assume that the incidence of optimism among the CEOs hired in a given month is representative of the incidence of optimism in the population of candidates considered by a board for the CEO position. For each CEO-firm pair in our data, we determine the month in which the CEO is appointed and calculate the fraction of optimistic CEOs, among all other CEOs in our data, appointed in the same month.

To establish relevance, we examine whether a CEO is more likely to exhibit optimism when there is a greater fraction of optimistic CEOs among CEOs hired in the month that the CEO was hired. Since the instrument varies across time but not cross-sectionally, we do not include year fixed-effects in either stage of estimation. We estimate a logit model of optimism on the fraction of optimistic CEOs (the instrument) and cluster standard errors by CEO. Our untabulated results indicate that the coefficient on the fraction of optimistic CEOs is positive and statistically significant at the 1% level. We use the estimates from the logit model to calculate the probability that optimism equals one - we term this predicted variable as *Instrumented Optimism*. We regress cash holdings on *Instrumented Optimism* along with the other independent variables from Model 1 of Table 2. Our results in Model 2, Table 3 indicate that the coefficient on *Instrumented Optimism* is negative and statistically significant at the 1% level, indicating a causal effect of optimism on cash holdings.

The second instrument we consider is the change in a CEO's house value over the previous two years. A common behavioral bias documented in the psychology literature is attribution bias, which results in a biased updating of beliefs from past experiences.[13] For example, CEOs who experience a good outcome, such as an increase in their real-estate wealth, may become more optimistic. We test this hypothesis when establishing the relevance condition for the instrument. Note that this instrument is exogenous because at the time of choosing a CEO, the board does not know how the value of the CEO's house will change and it is unlikely that there is an omitted factor that affects both the CEO's house value and the firm's cash holdings. Further, the exclusion condition is satisfied as there is no economic rationale for the CEO's house value to directly affect a firm's cash holdings.

[12] We thank John Graham for making his estimates of marginal corporate tax rate based on Graham (1996) available through his website (https://faculty.fuqua.duke.edu/jgraham/read.html).

[13] See Billett and Qian (2008) for references and for evidence that self-attribution bias leads to managerial overconfidence.

Since we do not directly observe the CEO's house value, we determine the zip code of the CEO's residence from the data on political contributions (Beau Page 2015) and calculate the percentage change in house values in that zip code over the previous two years based on data from the real estate data provider Zillow. Since the instrument value can change every year, we use it to instrument the post-optimism variable which can vary over time for a CEO. We estimate a logit model of post-optimism on the percentage change in house value and cluster standard errors by CEO. Again, we do not include year fixed effects in either stage of estimation. Our untabulated results indicate that the coefficient on the change in house value is positive and statistically significant at the 10% level. Next, we use the estimates from the logit model to calculate the probability that post-optimism equals one - we term this predicted variable as *Instrumented Post-Optimism*. We now regress cash holdings on *Instrumented Post-Optimism* along with the other independent variables from Model 2 of Table 2. Our results in Model 3, Table 3 indicate that the coefficient on *Instrumented Post-Optimism* is negative and statistically significant at the 1% level, indicating a causal effect of optimism on cash holdings.

The two instruments we consider vary across time and may reflect changing macroeconomic conditions. If so, these instruments would not be effective in addressing an endogeneity problem arising from time-varying macroeconomic conditions that affect both CEO optimism and cash holdings. However, time-varying macroeconomic conditions cannot explain our findings because our main regression models in Table 2 include year fixed-effects.

4.2.4.

As an alternative to the IV approach, we now consider observed factors that may affect both CEO optimism and cash holdings. Suppose CEO optimism varies as

$$Optimism_{i,t} = Control_{i,t-1} + v_{i,t}, \tag{11}$$

where CEO optimism depends on $Control_{i,\,t-1}$, the lagged firm characteristics observed by the board in determining whether to keep an optimistic CEO. Further, suppose these characteristics also influence cash holdings, determined by the following relation:

$$CashHoldings_{i,t} = \beta_0 + \beta_1 Optimism_{i,t} + \beta_2 Control_{i,t} + \gamma Control_{i,t-1} + u_{i,t}. \tag{12}$$

Our regression models in Table 2 do not control for $Control_{i,t-1}$. So, if the composite error term $\gamma Control_{i,t-1} + u_{i,t}$ is correlated with $Optimism_{i,t}$, then regression coefficients may be biased. To address this issue, we perform a two-step estimation of cash holdings. In the first stage, we estimate a logit model of CEO optimism on lagged values of all firm characteristics included as independent variables in Model 1 in Table 2. Using the regression coefficients, we calculate the predicted probability of choosing an optimistic CEO for every firm-year in our data. We include this probability as an additional explanatory variable in the second stage along with all the variables from Model 1 in Table 2 and estimate a regression model of cash holdings. The error term in this regression, $u_{i,t}$, should now be uncorrelated with $Optimism_{i,t}$, eliminating any bias in the regression coefficient. The results from Model 4 in Table 3 indicate that the coefficient on optimism is negative and statistically significant at the 1% level and its magnitude is virtually identical to that in Model 1, Table 2. This result shows that CEO optimism has an incremental effect on cash holdings beyond any effect of the firm characteristics that determine both CEO optimism and cash holdings.

4.2.5.

A specific case of endogeneity of CEO optimism arises if the direction of causality is the opposite of our interpretation - that is, cash holdings determine CEO optimism. However, the absence of any prior theory or evidence to support this effect of cash holdings on CEO optimism makes this possibility unlikely. Moreover, if firms with low cash holdings attract optimistic CEOs, then this effect should remain cross-sectional. Harford et al. (2008) address a similar problem by estimating a regression model of the change in cash holdings using the lagged value of their main explanatory variable. We repeat the tests in Table 2 using change in cash holdings as the dependent variable. Our untabulated results indicate that the change in cash holdings is negatively related to post-optimism and the coefficient is statistically significant at the 1% level. Following a logic similar to Harford et al. (2008), the negative relation that we find between post-optimism and the subsequent temporal change in cash holdings suggests that reverse causality is unlikely to explain our findings.

4.2.6.

For another test to rule out reverse causality, we create a variable, *Pre-Optimism*, which equals one for those CEO years where *Optimism* equals one and *Post-Optimism* equals zero, and zero otherwise. As explained earlier, *Post-Optimism* equals one in all those CEO-years that follow (and include) the year in which the CEO, for the first time, holds an option that exceeds the 100% moneyness threshold. The split of the optimism indicator variable into pre-optimism and post-optimism variables captures the time variation in CEO option-exercise behavior (Malmendier and Tate 2008).

We estimate Model 1 from Table 2 after replacing the optimism variable with both pre- and post-optimism variables. The results from Model 5 in Table 3 indicate that the coefficient on post-optimism is negative and statistically significant while the coefficient on pre-optimism is not statistically significant. This finding from the refinement in our model specification suggests that the impact of

optimism on cash holdings is stronger after the CEO has exhibited optimism by delaying option exercise. If the option-exercise behavior of CEOs is driven by the cash holdings of a firm, then there should not be such a systematic difference in the relation between optimism and cash holdings in the pre- and post-optimism years.

4.2.7.

Model 4 in Table 3 controls for observable firm characteristics that may impact both CEO optimism and cash holdings and the results show that this joint effect is not responsible for the impact of CEO optimism on cash holdings that we document. However, there may be omitted factors that are not observed by us that determine both CEO choice and cash holdings. Suppose the CEO's optimism varies as

$$Optimism_{i,t} = CEO_i + v_{i,t}, \tag{13}$$

where CEO_i is a time-invariant characteristic of the CEO chosen by the board of firm i and $v_{i,t}$ is the time-varying component of CEO optimism. The board's choice of the CEO and hence, of CEO characteristic CEO_i, may depend on an omitted variable $w_{i,0}$ observed by the board at the time the CEO is hired:

$$CEO_i = \delta w_{i,0}. \tag{14}$$

The omitted variable $w_{i,0}$ may affect the firm's cash holdings which vary as

$$CashHoldings_{i,t} = \beta_0 + \beta_1 Optimism_{i,t} + \beta_2 Control_{i,t} + \gamma w_{i,0} + u_{i,t}. \tag{15}$$

where $w_{i,0}$ and $u_{i,t}$ are uncorrelated. The regressions in Table 2 do not control for the omitted variable $w_{i,0}$, so the composite error term $\gamma w_{i,0} + u_{i,t}$ may be correlated with $Optimism_{i,t}$, which depends on $w_{i,0}$. This correlation may bias the regression coefficients in an OLS estimation of (15). To address this issue, we can rewrite (15) as

$$CashHoldings_{i,t} = \beta_0 + \beta_1 Optimism_{i,t} + \beta_2 Control_{i,t} + \frac{\gamma}{\delta} CEO_i + u_{i,t}. \tag{16}$$

If the variable CEO_i is included as an additional control variable, then the error term $u_{i,t}$ is uncorrelated with $Optimism_{i,t}$ and the OLS estimation is unbiased. The variable CEO_i is fixed across time for each CEO hired by firm i and can, therefore, be modeled as a CEO-firm fixed effect. CEO-firm fixed effects have been used to control for endogenous matching of CEOs and firms by Graham et al. (2012) and by Bennedsen et al. (2020). We estimate Model 2 in Table 2 by including fixed effects based on the CEO-firm combination and by clustering standard errors by the CEO-firm combination. Note that the firm fixed effects that we use in all the other models remain the same for all observations of a firm regardless of the CEO. In contrast, the CEO-firm fixed effects change for a firm with a switch in the CEO. We do not use the variable optimism as a dependent variable because it is completely determined by the CEO-firm fixed effect. Instead, we use the post-optimism variable which varies for a CEO over time. The results from Model 6 in Table 3 indicate that the coefficient on post-optimism is negative and statistically significant at the 5% level and its magnitude is virtually identical to that in Model 2, Table 2. To the extent that CEO optimism is higher in years where post-optimism equals one, this result shows that the impact of CEO optimism on cash holdings is not driven by omitted variables.

4.2.8.

As another test to address the endogeneity of CEO choice, we follow an approach similar to that in Fracassi and Tate (2012) to isolate CEO transitions that are plausibly unrelated to firm performance. Specifically, we examine news articles to determine the cause for CEO transitions in our sample. We identify unforced CEO turnovers that are less likely to result merely from the board's decision to change corporate policies. We create a variable *unforced1* that equals one for a CEO appointed as a result of a turnover that we determine to be a result of death, health problem, or retirement that is not considered a sudden retirement. The variable *unforced1* equals zero for a CEO appointed as a result of a transition where we could identify a different cause. We create an additional variable *unforced2* that equals one for a CEO appointed as a result of a turnover that we determine to be a result of death, health problem, retirement that is not considered a sudden retirement, or orderly transition. This reduces our sample size as we perform this classification only for CEOs whose predecessor is also in our sample.

We repeat our main regression (Model 1 in Table 2) by including the interaction of optimism with *unforced1* in Model 1 in Table 4 and the interaction of optimism with *unforced2* in Model 2 in Table 4. The coefficient on optimism continues to be negative even though the statistical significance drops due to a smaller sample size (the p-value = 0.103 in Model 1). Moreover, the coefficient on the interaction term is not statistically significant suggesting that our results are not driven by forced CEO transitions. Models 3 and 4 in Table 4 show similar results when we use post-optimism as a measure of CEO optimism. The coefficient on post-optimism is statistically significant at the 1% level in both models while the coefficient on the interaction term is not statistically significant in either model.

Table 4
CEO Optimism and Cash Holdings: Effect of Unforced CEO Turnovers.

	Dependent Variable			
	Cash Holdings (Model 1)	Cash Holdings (Model 2)	Cash Holdings (Model 3)	Cash Holdings (Model 4)
Optimism	−0.0169	−0.0182*		
	(−1.63)	(−1.69)		
Unforced1*Optimism	−0.0043			
	(−0.36)			
Unforced2*Optimism		−0.0011		
		(−0.09)		
Post-Optimism			−0.0232***	−0.0251***
			(−2.59)	(−2.73)
Unforced1*Post-Optimism			0.0077	
			(0.74)	
Unforced2*Post-Optimism				0.0116
				(1.05)
Growth	0.0666***	0.0666***	0.0656***	0.0656***
	(7.30)	(7.30)	(6.88)	(6.89)
Cash Flow	0.2361**	0.2362**	0.2453**	0.2449**
	(2.16)	(2.16)	(2.05)	(2.05)
Log of Sales	−0.0728***	−0.0728***	−0.0610***	−0.0610***
	(−4.52)	(−4.51)	(−3.87)	(−3.87)
Leverage	0.0792*	0.0791*	0.0896**	0.0892**
	(1.89)	(1.88)	(2.08)	(2.07)
NWC to Assets	−0.2759***	−0.2760***	−0.2143***	−0.2145***
	(−3.01)	(−3.01)	(−2.88)	(−2.88)
RD to Assets	1.5134***	1.5132***	1.6125***	1.6116***
	(6.06)	(6.06)	(6.18)	(6.18)
Capex to Assets	−0.2593**	−0.2591**	−0.2403**	−0.2405**
	(−2.39)	(−2.38)	(−2.27)	(−2.28)
Acquisitions to Assets	−0.1911***	−0.1909***	−0.1742***	−0.1744***
	(−4.45)	(−4.45)	(−4.00)	(−4.00)
Bond Rating	0.0138	0.0138	0.0069	0.0068
	(0.75)	(0.75)	(0.36)	(0.36)
Cash Flow Volatility	0.2470*	0.2473*	0.2726*	0.2730*
	(1.84)	(1.85)	(1.66)	(1.66)
Stock Ownership	−0.1296	−0.1290	−0.0669	−0.0667
	(−1.28)	(−1.28)	(−0.99)	(−0.99)
Vested Options	−0.0536	−0.0495	0.0551	0.0644
	(−0.05)	(−0.05)	(0.05)	(0.05)
Firm-Year Observations	9959	9959	9354	9354
Adjusted R^2	0.7588	0.7588	0.7704	0.7705

This table provides estimates from a regression model, which is estimated on the pooled data over the period 1992–2012. *Cash Holdings* equals the ratio of cash and short-term investments to net assets. *Optimism* equals one over all the CEO-years if the CEO held an option that was more than 100% in the money at least once during his/her tenure, and zero otherwise. *Post-Optimism* equals one in all CEO-years following (and including) the first year in which the CEO holds an option that is more than 100% in the money, and zero otherwise. *Unforced1* equals one for a CEO appointed as the result of a CEO turnover stemming from death, health problem, or retirement (not sudden retirement). *Unforced2* equals one for a CEO appointed as the result of a CEO turnover stemming from death, health problem, retirement (not sudden retirement), or orderly transition. *Growth* equals the ratio of the market value of assets to book value of *net* assets, where the market value of assets equals the market value of equity plus the book value of total liabilities. Net assets equals the difference between total assets and cash & short-term investments. *Cash Flow* equals the ratio of operating income before depreciation *less* interest expense *less* income taxes *less* common and preferred dividends *to* book value of net assets. *Log of Sales* equals the natural logarithm of net sales. *Leverage* equals the ratio of the sum of long-term debt and debt in current liabilities to net assets. *NWC to Assets* equals the ratio of net working capital (net of cash and short-term investments) to net assets. *RD to Assets* equals the ratio of R&D expenditures to net assets. *Capex to Assets* equals the ratio of capital expenditures to net assets. *Acquisitions to Assets* equals the ratio of acquisitions to net assets. *Cash Flow Volatility* equals the standard deviation of the firm's cash flow over the prior ten-year period. *Bond Rating* is an indicator variable that equals one if the firm has a long-term debt rating and zero otherwise. *Stock Ownership* equals the fraction of the company stock owned by the CEO (excluding options) as a fraction of common shares outstanding. *Vested Options* equals the ratio of the CEO's holdings of exercisable options as a fraction of common shares outstanding. All models include firm and year fixed effects and the standard errors are clustered by firm.
*** Significant at the 0.01 level; ** Significant at the 0.05 level; * Significant at the 0.10 level.

4.3. Robustness checks

We perform several tests to check the robustness of our main findings.

1. Observations for firms that have only optimistic CEOs in all years and for firms that have only non-optimistic CEOs in all years do not directly contribute to the determination of the impact of CEO optimism on cash holdings in regressions with firm fixed-effects. As a robustness check, we estimate Models 1 and 2 in Table 2 using only those firms that had an optimistic CEO in at least one year and a non-optimistic CEO in at least one year (i.e., observations summarized in Panel B in Table 1). The results are similar to those in Models

1 and 2, and confirm that optimistic CEOs hold statistically and economically significantly less cash than non-optimistic CEOs.

2. As another robustness check, we estimate a simple regression model on the pooled data. We do not include any fixed effects and do not cluster the standard errors. The results from Model 1 in Table 5 indicate that the level of cash holdings is negatively related to CEO optimism and the coefficient is statistically significant at the 1% level. Next, we estimate a regression model by including year fixed-effects, industry fixed-effects (in contrast to firm fixed-effects in Table 2), and by clustering the standard errors by firm. The results from Model 2 in Table 5 indicate that the level of cash holdings is again negatively related to CEO optimism and the coefficient is statistically significant at the 1% level. However, with this model specification, there is only a marginal improvement in explanatory power relative to that for Model 1 - the adjusted R^2 increases from 0.5473 to 0.5717. In contrast, the adjusted R^2 increases to 0.7774 in

Table 5
CEO Optimism and Cash Holdings: Alternative Model Specifications.

	Dependent Variable		
	Cash Holdings (Model 1)	Cash Holdings (Model 2)	Cash Holdings (Model 3)
Optimism	−0.0303***	−0.0309***	−0.0177***
	(−7.54)	(−3.97)	(−2.83)
Growth	0.0629***	0.0664***	0.0621***
	(53.02)	(14.18)	(10.62)
Cash Flow	0.1856***	0.1744**	0.2272***
	(9.85)	(2.47)	(3.62)
Log of Sales	−0.0321***	−0.0408***	−0.0482***
	(−18.76)	(−9.05)	(−5.04)
Leverage	−0.1076***	−0.0819***	0.0854**
	(−9.02)	(−2.71)	(2.51)
NWC to Assets	−0.1927***	−0.2178***	−0.2987***
	(−16.80)	(−4.43)	(−3.77)
RD to Assets	1.5135***	1.5065***	1.5899***
	(65.40)	(11.65)	(8.18)
Capex to Assets	−0.3901***	−0.3310***	−0.2296***
	(−12.30)	(−4.69)	(−3.82)
Acquisitions to Assets	−0.2471***	−0.2099***	−0.2170***
	(−9.98)	(−4.58)	(−6.23)
Bond Rating	0.0023	0.0138	0.0009
	(0.44)	(1.64)	(0.08)
Cash Flow Volatility	0.1713***	0.1324**	0.0544
	(11.90)	(2.39)	(0.88)
Stock Ownership	0.1026***	0.1529	−0.0993
	(2.93)	(1.21)	(−1.54)
Vested Options	0.8222***	0.6260	−0.3906
	(5.02)	(1.41)	(−1.01)
Year Fixed Effects	No	Yes	Yes
Industry Fixed Effects	No	Yes	No
Firm Fixed Effects	No	No	Yes
Standard Errors Clustered	No	By Firm	By Firm
Five Lags of Annual Stock Returns	No	No	Yes
Firm-Year Observations	19,877	19,877	16,966
Adjusted R^2	0.5473	0.5717	0.7833

This table provides estimates from regression models, which are estimated on the pooled data over the period 1992–2012. *Cash Holdings* equals the ratio of cash and short-term investments to net assets. *Optimism* equals one over all the CEO-years if the CEO held an option that was more than 100% in the money at least once during his/her tenure, and zero otherwise. *Post-Optimism* equals one in all CEO-years following (and including) the first year in which the CEO holds an option that is more than 100% in the money, and zero otherwise. *Growth* equals the ratio of the market value of assets to book value of *net* assets, where the market value of assets equals the market value of equity plus the book value of total liabilities. Net assets equals the difference between total assets and cash & short-term investments. *Cash Flow* equals the ratio of operating income before depreciation *less* interest expense *less* income taxes *less* common and preferred dividends *to* book value of net assets. *Log of Sales* equals the natural logarithm of net sales. *Leverage* equals the ratio of the sum of long-term debt and debt in current liabilities to net assets. *NWC to Assets* equals the ratio of net working capital (net of cash and short-term investments) to net assets. *RD to Assets* equals the ratio of R&D expenditures to net assets. *Capex to Assets* equals the ratio of capital expenditures to net assets. *Acquisitions to Assets* equals the ratio of acquisitions to net assets. *Cash Flow Volatility* equals the standard deviation of the firm's cash flow over the prior ten-year period. *Bond Rating* is an indicator variable that equals one if the firm has a long-term debt rating and zero otherwise. *Stock Ownership* equals the fraction of the company stock owned by the CEO (excluding options) as a fraction of common shares outstanding. *Vested Options* equals the ratio of the CEO's holdings of exercisable options as a fraction of common shares outstanding.
*** Significant at the 0.01 level; ** Significant at the 0.05 level; * Significant at the 0.10 level.

Table 6
Interactive Effect of CEO Optimism and Growth on Cash Holdings.

	Dependent Variable	
	Cash Holdings (Model 1)	Cash Holdings (Model 2)
Optimism	0.0407*	
	(1.94)	
Post-Optimism		0.0338*
		(1.93)
Growth	0.0873***	0.0839***
	(7.83)	(8.86)
Optimism * Growth	−0.0299***	
	(−2.79)	
Post-Optimism * Growth		−0.0255***
		(−2.90)
Cash Flow	0.2198***	0.2182***
	(3.02)	(2.81)
Log of Sales	−0.0526***	−0.0488***
	(−6.12)	(−5.70)
Leverage	0.0803***	0.0865***
	(2.59)	(2.69)
NWC to Assets	−0.2763***	−0.2583***
	(−3.38)	(−3.09)
RD to Assets	1.4800***	1.4636***
	(7.33)	(6.80)
Capex to Assets	−0.1697**	−0.1682**
	(−2.56)	(−2.44)
Acquisitions to Assets	−0.2184***	−0.2030***
	(−7.56)	(−6.99)
Bond Rating	0.0078	0.0047
	(0.79)	(0.46)
Cash Flow Volatility	0.0525	0.0602
	(0.93)	(1.02)
Stock Ownership	−0.1501**	−0.1514**
	(−2.45)	(−2.17)
Vested Options	−0.1400	−0.0565
	(−0.29)	(−0.11)
Firm-Year Observations	19,877	18,808
Adjusted R^2	0.7794	0.7845

This table provides estimates from a regression model, which is estimated on the pooled data over the period 1992–2012. *Cash Holdings* equals the ratio of cash and short-term investments to net assets. *Optimism* equals one over all the CEO-years if the CEO held an option that was more than 100% in the money at least once during his/her tenure, and zero otherwise. *Post-Optimism* equals one in all CEO-years following (and including) the first year in which the CEO holds an option that is more than 100% in the money, and zero otherwise. *Growth* equals the ratio of the market value of assets to book value of *net* assets, where the market value of assets equals the market value of equity plus the book value of total liabilities. Net assets equals the difference between total assets and cash & short-term investments. *Cash Flow* equals the ratio of operating income before depreciation *less* interest expense *less* income taxes *less* common and preferred dividends *to* book value of net assets. *Log of Sales* equals the natural logarithm of net sales. *Leverage* equals the ratio of the sum of long-term debt and debt in current liabilities to net assets. *NWC to Assets* equals the ratio of net working capital (net of cash and short-term investments) to net assets. *RD to Assets* equals the ratio of R&D expenditures to net assets. *Capex to Assets* equals the ratio of capital expenditures to net assets. *Acquisitions to Assets* equals the ratio of acquisitions to net assets. *Cash Flow Volatility* equals the standard deviation of the firm's cash flow over the prior ten-year period. *Bond Rating* is an indicator variable that equals one if the firm has a long-term debt rating and zero otherwise. *Stock Ownership* equals the fraction of the company stock owned by the CEO (excluding options) as a fraction of common shares outstanding. *Vested Options* equals the ratio of the CEO's holdings of exercisable options as a fraction of common shares outstanding. All models include firm and year fixed effects and the standard errors are clustered by firm. *** Significant at the 0.01 level; ** Significant at the 0.05 level; * Significant at the 0.10 level.

Model 1 in Table 2 based on a regression model that includes year fixed-effects, firm fixed-effects, and the clustering of standard errors by firm. Therefore, we report all of our results using a model specification that includes year fixed-effects, firm fixed-effects, and the clustering of standard errors by firm.[14]

3. Our optimism measures, based on the CEO's option-exercise behavior, may be correlated with the firm's past stock returns. Malmendier et al. (2011) use a similar measure of optimism, based on Execucomp data and calculated the way we do, and control for past stock return. Similarly, our proxy for growth may be affected by the firm's past stock returns. To ensure that the optimism measure and growth are not simply proxies for high past stock returns, we estimate Model 1 from Table 2 after including five lags of annual stock return and find that the negative relation between cash holdings and optimism is robust to the inclusion of past stock return. We report the results in Model 3 in Table 5.

4. We consider alternative moneyness thresholds to identify optimistic CEOs. First, as in Malmendier and Tate (2005) and in Hirshleifer et al. (2012), we adopt a moneyness threshold of 67% and create *Optimism67*, which equals one over all the CEO-years if the CEO held an option that was more than 67% in the money at least once during his/her tenure and zero otherwise. We construct two more measures, *OptimismTwice* and *Post-OptimismTwice*. For these two measures, we follow Campbell et al. (2011) and focus on those CEOs who fail to exercise their options at least *twice* when the options are at least 100% in the money. We set *OptimismTwice* equal to one over all the years of a CEO if the CEO held an option, that was more than 100% in the money, at least twice during his/her tenure, and zero otherwise. *Post-OptimismTwice* equals one in all CEO-years following (and including) the first year in which the CEO holds an option, that is more than 100% in the money, at least twice during his/her tenure, and zero otherwise. We estimate Model 1 and Model 3 from Table 2 by successively replacing optimism with each of the three alternative measures: *Optimism67*, *OptimismTwice*, and *Post-OptimismTwice*. For both models and for each of these three optimism measures, we find that the coefficient on the optimism measure is negative and statistically significant at the 5% level.

5. The summary statistics in Table 1 indicate that optimistic CEOs have a longer CEO tenure. A positive association between optimism and CEO tenure is likely to arise mechanically given the way we construct CEO optimism. While there is no theoretical rationale for a relation between cash holdings and CEO tenure, we perform a robustness check to examine whether such a relation leads to the relation we find between cash holdings and CEO optimism. We find that the relation between cash holdings and optimism remains negative and statistically significant after controlling for CEO tenure.

6. Our main result with respect to the negative relation between cash holdings and optimism continues to hold qualitatively in robustness checks which consist of replacing the natural logarithm of sales with the natural logarithm of the book value of net assets, replacing bond rating with a dividend-payout indicator variable, clustering standard errors by CEO instead of by firm, and using *Cash to Assets* as the dependent variable.[15]

4.4. Interactive effects

We now test the two empirical predictions regarding the interactive effects of both growth and cash flow with optimism on a firm's cash policy.

4.4.1. Interactive effect of optimism and growth

Prediction 3 states that the difference between the cash holdings of higher-growth firms and lower-growth firms is smaller in firms led by optimistic CEOs than in firms led by rational CEOs. We estimate the regression model of cash holdings in Model 1, Table 2 by including the interaction between optimism and growth. The results in Model 1, Table 6 indicate that the coefficient on growth is positive while the coefficient on the interaction between growth and optimism is negative. Both of these coefficients are significantly different from zero at the 1% level.

The positive coefficient on growth indicates that a rational CEO in a higher-growth firm holds more cash than a similar CEO in a lower-growth firm. The negative coefficient on the interaction term, however, shows that the increase in cash holdings for higher growth is lower in firms managed by optimistic CEOs. This result is consistent with Prediction 3. The coefficient on the interaction term is also economically significant in that the marginal impact of growth on cash holdings is about 34% lower in firms managed by optimistic CEOs. Since optimistic CEOs expect the terms of financing to improve over time, they prefer to finance the greater future investment needs through external financing in the future rather than by raising external financing earlier to accumulate internal cash. We obtain qualitatively similar results when we use post-optimism (Model 2) in place of optimism.

[14] In Models 1 and 2 of Table 5, the coefficients on the standard controls such as growth, cash flow, firm size, leverage, net working capital, R&D expenditures, capital spending, acquisitions, and cash flow volatility accord well with those in Opler et al. (1999), Harford et al. (2008), and Bates et al. (2009). However, once we include firm fixed-effects, some of the coefficients lose their significance while the coefficient on leverage flips sign.

[15] The precautionary motive for holding cash is that a cash buffer can protect a firm against adverse cash flow shocks (Bates et al. 2009). Based on this motive, both less risk-averse CEOs and CEOs who estimate higher future cash flows may hold lower cash. Our control variables, such as the CEO's stock and option ownership and the firm's cash flow volatility, are likely to be correlated with the CEO's risk aversion, suggesting that differences in CEO risk aversion do not explain our results. Our model explains why the CEO's expectations about future cash flow do not impact cash (see the discussion on page). We cannot empirically rule out that differences in expectations of future cash flow between optimistic and non-optimistic CEOs contribute to differences in their cash holdings. However, Malmendier and Tate (2005, 2008) show that the option-exercise-based optimism measure does not capture private information about future cash flows.

Table 7
Interactive Effect of CEO Optimism and Cash Flow on Change in Cash Holdings: Cash-Flow Sensitivity of Cash.

	Dependent Variable	
	Change in Cash Holdings (Model 1)	Change in Cash Holdings (Model 2)
Optimism	0.0266***	
	(2.56)	
Post-Optimism		0.0249***
		(3.04)
Cash Flow	0.6029***	0.5415***
	(11.56)	(13.90)
Cash Flow * Optimism	−0.3009***	
	(−5.10)	
Cash Flow * Post-Optimism		−0.2085***
		(−4.65)
Growth	0.0325***	0.0284***
	(8.92)	(9.53)
Size	0.0594***	0.0142
	(3.74)	(1.24)
Capex to Assets	−1.2014	−1.6480***
	(−1.53)	(−2.56)
Acquisitions to Assets	−1.6989***	−1.9354***
	(−4.28)	(−6.33)
Change in NWC	−1.5241***	−1.5093***
	(−12.17)	(−13.82)
Change in Short-Term Debt	−0.9826***	−0.9240***
	(−6.61)	(−7.40)
Firm-Year Observations	19,106	18,077
χ^2	732.20***	1141.74***

This table provides estimates from a firm-fixed-effect IV estimation of a regression model, which is estimated on the pooled data over the period 1992–2012. *Cash Holdings* equals the ratio of cash and short-term investments to net assets. *Optimism* equals one over all the CEO-years if the CEO held an option that was more than 100% in the money at least once during his/her tenure, and zero otherwise. *Post-Optimism* equals one in all CEO-years following (and including) the first year in which the CEO holds an option that is more than 100% in the money, and zero otherwise. *Cash Flow* equals the ratio of operating income before depreciation *less* interest expense *less* income taxes *less* common and preferred dividends *to* book value of net assets. *Growth* equals the ratio of the market value of assets to book value of *net* assets, where the market value of assets equals the market value of equity plus the book value of total liabilities. Net assets equals the difference between total assets and cash & short-term investments. *Size* equals the natural logarithm of the book value of net assets. *Capex to Assets* equals the ratio of capital expenditures to net assets. *Acquisitions to Assets* equals the ratio of acquisitions to net assets. *Change in NWC* equals the change in net working capital (net of cash and short-term investments) over the fiscal year divided by net assets. *Change in Short-Term Debt* equals the change in debt in current liabilities over the fiscal year divided by net assets. Both models include year fixed effects and the standard errors are based on the conventionally-derived variance estimator for generalized least-squares regression.
*** Significant at the 0.01 level; ** Significant at the 0.05 level; * Significant at the 0.10 level.

4.4.2. Interactive effect of optimism and cash flow: cash-flow sensitivity of cash

Prediction 4 states that for a given increase in cash flow, cash holdings increase less in a firm led by an optimistic CEO than in a firm led by a rational CEO. We examine the interactive effect of optimism and cash flow on a firm's cash holdings by using the empirical framework in Almeida et al. (2004), who examine the effect of financial constraints on the relation between the change in cash holdings and cash flow. Specifically, they estimate the cash flow sensitivity of cash, which measures the change in cash holdings for a one-dollar increase in cash flow.

We follow Almeida et al. (2004) and estimate a regression model with the change in cash holdings as the dependent variable. The explanatory variables are optimism, cash flow, cash flow interacted with optimism, growth, the logarithm of the book value of net assets as a proxy for firm size, capital expenditures, acquisition expenditures, change in net working capital, and change in short-term debt. The change in cash holdings represents the net effect of several investment and financial decisions. Therefore, as in Almeida et al. (2004), we use an instrumental-variable (IV) approach to control for the potential endogeneity of investment and financial decisions. We use the same set of instruments as in Almeida et al. (2004): two lags of the level of fixed capital (net property, plant, and equipment (PPE) to net assets), lagged acquisitions to net assets, lagged net working capital to net assets, lagged short-term debt to net assets, twice lagged sales growth, and two-digit SIC indicators. We estimate a fixed-effects IV model, controlling for year effects.

The results from Model 1 in Table 7 indicate that the average firm in our sample exhibits a positive cash-flow sensitivity of cash. In

other words, firms in our sample, on average, increase their cash holdings when they experience an extra dollar of cash flow. The coefficient on the interaction of optimism and cash flow, however, is negative and statistically significant at the 1% level. This negative sign suggests that firms managed by optimistic CEOs save less cash out of an extra dollar of cash flow than firms managed by rational CEOs. For example, the coefficient of about 0.60 on cash flow suggests that when cash flow increases by $1, rational CEOs save about 60 cents. In contrast, the coefficient on the interactive term (of cash flow and optimism) of -0.30 suggests that when cash flow increases by $1, optimistic CEOs save only about 30 cents. These results are consistent with Prediction 4. We obtain qualitatively similar result (in Model 2) when we use post-optimism in place of optimism. The results in Table 7 also provide an answer to the following question: What do optimistic CEOs do when they receive a cash windfall in the form of an increase in cash flow? The finding that optimistic CEOs save less cash suggests that causality flows from optimism to cash holdings and further allays any endogeneity concerns.

Since optimistic CEOs behave as if they are financially constrained, we want to rule out the possibility that optimism might serve as a proxy for financial constraints. To do so, we estimate Model 1, Table 7 separately for financially constrained and unconstrained firms. We follow Almeida et al. (2004) in using two variables to identify constrained and unconstrained firms: the bond rating dummy and a dividend dummy. For each variable, a value of zero identifies constrained firms while a value of one identifies unconstrained firms. In total, we estimate four models: two for constrained firms (i.e., bond rating dummy = 0 and dividend dummy = 0) and two for unconstrained firms (i.e., bond rating dummy = 1 and dividend dummy = 1). Our untabulated results indicate that the coefficient on cash flow is positive and significant at the 1% level in all four cases while the coefficient on the interaction of cash flow and optimism is negative and significant at the 1% level in three cases. In the fourth case (bond rating dummy = 1), the coefficient on the interaction of cash flow and optimism is negative but not statistically significant ($p = 0.139$). Overall, these findings suggest that optimism does not serve as a proxy for financial constraints and has an independent negative effect on the relation between cash holdings and cash flow.

We also test the interactive effects using the alternate sample and measure of optimism. The results, presented in Appendix, qualitatively match the results discussed in this section.

5. Implications

Our model and empirical results provide several implications for future research and for practice. For instance, the intuition underlying our model can also be used to examine how cash holdings are affected by factors, other than CEO optimism, that influence the timing of investment and financing decisions. First, if using external financing, rather than internally generated cash, entails exogenous costs that are convex in the amount of financing raised, then firms that expect cash flow to increase (decrease) over time should maintain a lower (higher) cash balance. Second, younger firms, in which information asymmetry is expected to decline over time, should also maintain a lower cash balance while expecting to raise external financing at more favorable terms when information asymmetry declines in the future.[16] Third, ignoring the risk of shareholder litigation, firms with favorable (unfavorable) private information that cannot be disclosed to investors in the short term would expect the cost of external financing to decline (rise) over time and would maintain a lower (higher) cash balance.

Another implication is that since the impact of CEO optimism on cash holdings is driven by the CEO's perceived cost of external financing, this impact is likely to be low in firms that rely less on external financing. For example, multidivision firms hold less cash than stand-alone firms because they rely more on internal capital markets (Duchin 2010). Based on our theoretical and empirical results, we predict that the difference between cash holdings of optimistic and rational CEOs will be lower in multidivision firms than in stand-alone firms.

The implications of our results for practice relate to corporate governance. While an optimistic CEO thinks that the low cash balance is in the best interest of shareholders, the shareholders and the board may foresee costs of holding low liquidity such as the cost of foregoing valuable investment opportunities due to lack of liquidity. The board may incentivize the management to take actions that mitigate these costs. For example, a line of credit provides an alternative source of corporate liquidity (Lins et al. 2010; Demiroglu and James 2011). The CEO may be reluctant to avail of lines of credit if his perception of costly external financing extends to the cost of lines of credit. However, since the cost of obtaining and maintaining a line of credit is much smaller than the cost of raising external financing, the CEO may be more amenable to obtaining a line of credit than holding more cash. Thus, boards of firms led by optimistic should require them to hold more lines of credit. We predict that firms led by optimistic CEOs hold more lines of credit than firms led by rational CEOs.

6. Conclusion

The key message of the paper is that CEO beliefs, specifically those characterized as optimism, play a significant role in corporate cash policy. Contrary to the intuitive implications based on extant research, we find that optimistic CEOs hold less cash than their rational counterparts. This reduction in cash holdings resulting from CEO optimism is both statistically and economically significant. Our empirical results show that firms managed by optimistic CEOs hold cash balances that are, on average, 24% lower than those in firms managed by non-optimistic CEOs.

The main prediction of a negative relation between CEO optimism and cash holdings derives from a model that adds managerial beliefs (i.e., optimism) to the traditional trade-off model of costs and benefits of holding cash. The intuition is that an optimistic CEO believes external financing to be excessively costly but expects this cost to decrease over time as investors learn about the profitability

[16] This prediction is consistent with the finding in Gao et al. (2013) that private firms hold less cash than public firms despite higher financing frictions.

of existing investments. As a result, the CEO delays raising external financing, funds current investments with internal cash, and maintains a lower cash balance.

Our results, robustness checks, and several endogeneity checks indicate that CEO optimism affects corporate cash holdings through an independent channel. That is, there is a causal negative effect of CEO optimism on cash holdings that is incremental to any indirect effect through the impact of CEO optimism on other determinants of cash policy.

In addition to maintaining a lower cash balance, firms managed by optimistic CEOs save less cash out of incremental cash flow than firms managed by rational CEOs. We also find that CEO optimism weakens the positive relation between a firm's growth and cash holdings.

We provide additional testable results that are not related to CEO optimism but follow from the intuition of our model. We also offer new testable implications about corporate liquidity that follow from our results.

Acknowledgements

We are grateful to Ulrike Malmendier for providing the data on CEO overconfidence. We thank Irina Krop, Srashti Baheti, and Shuang Wu for research assistance. We gratefully acknowledge the helpful comments of two anonymous referees, the editor, Bart Lambrecht, Fangjhou Liu, Vikram Nanda, the seminar participants at the 2015 Financial Management Association Annual Meeting, the 2016 American Finance Association Annual Meeting, Brandeis University, University of Oklahoma, University of Wisconsin, Milwaukee, Federal Reserve Bank, Richmond, Stevens Institute of Technology, and University of Central Florida. Anand Goel gratefully acknowledges financial support to the Program for Financial Innovation at Stevens Institute of Technology from Dr. Stephen Boswell and the Charles Koch Foundation.

Appendix A: Alternative Sample and Optimism Measure

We confirm our main result using an alternative sample and an alternative measure of optimism. The alternative sample is identical to that in Malmendier and Tate (2005, 2008) and contains 477 firms. It is based on the samples used in Yermack (1995) and in Hall and Liebman (1998) and consists of those firms that appear at least four times in one of the lists of the largest U.S. companies compiled by *Forbes* magazine over the period 1984–1994. This dataset provides detailed information on CEO stock and stock option holdings. Malmendier and Tate (2008) use the data on option holdings to derive their various portfolio-based optimism/overconfidence measures. In our tests below, we use *Longholder*, their main measure of CEO overconfidence.[17] The data cover the period 1980–1994 and we supplement the above data on CEO overconfidence with various items from the COMPUSTAT database to construct our control variables. The data filters result in 2324 firm-year observations for 237 firms for our empirical analysis.

We estimate a regression model of cash holdings with Longholder as the independent variable of interest. The various control variables we include are the same as those in Table 2. The results from Model 1 in Table A indicate that the level of cash holdings is negatively related to Longholder and the coefficient is statistically significant at the 5% level. This result is consistent with our main testable prediction (Prediction 1) and with the findings in Table 2. The magnitude of the coefficient on Longholder is similar to that on optimism in Table 2. The results also indicate that the level of cash holdings is positively related to growth, cash flow volatility, and vested options and negatively related to capital expenditures and acquisition expenditures. The coefficients on all of these control variables, with the exception of vested options, are statistically significant at the 5% level or better and these results are generally consistent with the previous literature. Finally, the coefficients on bond rating, log of sales, NWC to assets, cash flow, leverage, RD to assets, and stock ownership are not statistically significant at conventional levels.

The magnitude of the coefficient on Longholder, which represents the incremental effect of CEO optimism on cash holdings, is 0.0265. This value is about 55% of the median level of cash holdings (of about 4.8%) for the overall sample. As an illustration of the economic significance of this coefficient, consider the median cash holdings of 4.7% for the sub-sample of non-optimistic CEOs. The cash holdings of a similar firm led by an optimistic CEO, on average, will be about 56% lower at 2.05%.

Next, we confirm our results about the interactive effects of growth and cash flow with optimism on a firm's cash policy using the alternative sample and the Longholder measure of optimism. We first estimate the regression model of cash holdings in Model 1, Table 6 by replacing optimism variable with Longholder. The results from Model 2 of Table A are qualitatively similar with respect to both growth and the interactive effect. The negative coefficient on the interaction term between growth and Longholder shows that the increase in cash holdings resulting from higher growth is lower in firms managed by optimistic CEOs and is consistent with Prediction 3. We next estimate the regression model of cash holdings in Model 1, Table 7 by replacing the optimism variable with Longholder. The results from Model 3 of Table A are qualitatively similar. The negative coefficient on the interaction term between cash flow and Longholder shows that optimistic CEOs save less cash out of an extra dollar of cash flow than firms managed by rational CEOs and is consistent with Prediction 4.

[17] Longholder is an indicator variable that identifies CEOs who hold an option until the year of expiration at least once during their tenure even though the option is at least 40% in the money. This variable (akin to our optimism variable) represents a fixed effect over all of a CEO's years.

Table A
CEO Optimism and Cash Holdings, Interactive Effect of CEO Optimism and Growth on Cash Holdings and of CEO Optimism and Cash Flow on Change in Cash Holdings: Alternative Sample and Optimism Measure

	Dependent Variable		
	Cash Holdings (Model 1)	Cash Holdings (Model 2)	Change in Cash Holdings (Model 3)
Longholder	−0.0265**	0.0265	0.0146
	(−2.03)	(0.97)	(0.74)
Growth	0.0658***	0.0743***	0.0428***
	(5.34)	(5.54)	(6.14)
Longholder * Growth		−0.0331**	
		(−2.16)	
Cash Flow	0.0940	0.0870	0.5663***
	(0.55)	(0.51)	(6.26)
Longholder * Cash Flow			−0.3241**
			(−2.05)
Log of Sales	−0.0165	−0.0161	
	(−1.31)	(−1.28)	
Size			−0.0269***
			(−2.56)
Leverage	0.0275	0.0249	
	(0.54)	(0.50)	
NWC to Assets	−0.0631	−0.0630	
	(−1.26)	(−1.25)	
RD to Assets	0.4562	0.4757	
	(1.03)	(1.05)	
Capex to Assets	−0.1631**	−0.1561**	−0.8165*
	(−2.57)	(−2.43)	(−1.84)
Acquisitions to Assets	−0.1094***	−0.1101***	0.0525
	(−3.39)	(−3.41)	(0.13)
Bond Rating	0.0122	0.0113	
	(1.04)	(0.97)	
Cash Flow Volatility	0.9172**	0.9009**	
	(2.58)	(2.56)	
Stock Ownership	−0.1425	−0.1506	
	(−1.23)	(−1.31)	
Vested Options	0.0416*	0.0389*	
	(1.82)	(1.87)	
Change in NWC			−0.8787***
			(−5.52)
Change in Short-Term Debt			−0.8593***
			(−5.22)
Firm-Year Observations	2324	2324	2253
Adjusted R^2	0.6873	0.6899	
χ^2			225.53***

This table provides estimates from a regression model, which is estimated on the pooled data over the period 1980–1994. *Cash Holdings* equals the ratio of cash and short-term investments to net assets. *Longholder* is a binary variable that equals 1 if the CEO held an option package until the last year before expiration at least once during his/her tenure *and* the option package held was at least 40% in the money entering its final year. *Growth* equals the ratio of the market value of assets to book value of *net* assets, where the market value of assets equals the market value of equity plus the book value of total liabilities. Net assets equals the difference between total assets and cash & short-term investments. *Cash Flow* equals the ratio of operating income before depreciation *less* interest expense *less* income taxes *less* common and preferred dividends *to* book value of net assets. *Log of Sales* equals the natural logarithm of net sales. *Leverage* equals the ratio of the sum of long-term debt and debt in current liabilities to net assets. *NWC to Assets* equals the ratio of net working capital (net of cash and short-term investments) to net assets. *RD to Assets* equals the ratio of R&D expenditures to net assets. *Capex to Assets* equals the ratio of capital expenditures to net assets. *Acquisitions to Assets* equals the ratio of acquisitions to net assets. *Cash Flow Volatility* equals the standard deviation of the firm's cash flow over the prior ten-year period. *Bond Rating* is an indicator variable that equals one if the firm has a long-term debt rating and zero otherwise. *Stock Ownership* equals the fraction of the company stock owned by the CEO (excluding options) as a fraction of common shares outstanding. *Vested Options* equals the ratio of the CEO's holdings of exercisable options as a fraction of common shares outstanding. *Change in NWC* equals the change in net working capital (net of cash and short-term investments) over the fiscal year divided by net assets. *Change in Short-Term Debt* equals the change in debt in current liabilities over the fiscal year divided by net assets. Models 1 and 2 includes firm and year fixed effects and the standard errors are clustered by firm. Model 3 provides estimates from a (firm) fixed-effect IV estimation of a regression model and includes year fixed effects. The standard errors in Model 3 are based on the conventionally-derived variance estimator for generalized least-squares regression.
*** Significant at the 0.01 level; ** Significant at the 0.05 level; * Significant at the 0.10 level.

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