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Essays in Behavioral Corporate Finance

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Abstract

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This dissertation explores the extent to which managerial overconfidence affects corporate decisions. This analysis includes three essays, which address a wide range of corporate decisions including financing, investment, acquisition, innovation, liquidity management and advertising decisions.

The first essay introduces a fine-tuned test of the relationship between managerial overconfidence and corporate decisions by taking the chief financial officer (CFO) overconfidence effect into account. Ex-ante, I identify financial policies and non-financial policies such as investment, innovation and acquisition as the primary managerial duties of CFOs and chief executive officers (CEOs) respectively. I construct overconfidence measures for both CEOs and CFOs and test the impact of CEO and CFO overconfidence, both on financial decisions and on nonfinancial decisions. Based on a sample of 1,173 S&P 1500 firms, I find that financial policies are primarily affected by CFO overconfidence while only CEO overconfidence affects nonfinancial decisions. My findings demonstrate that managerial biases affect corporate decisions and managerial duties shape the ways in which top managers influence corporate policies.

The second essay investigates how overconfident CEOs allocate resources toward innovation activities. It argues that overconfident CEOs tend to have greater innovation input. To finance innovation, they save more cash out of the cash flow and spend more on innovation when the cash flow is high. Results from an empirical analysis of 1,015 S&P 1500 firms support this argument. Moreover, based on a series of financial constraint measurements, the effect of CEO overconfidence on liquidity management is found to be more pronounced in financially constrained firms and in highly innovative firms, but not in firms without financial constraints. With regards to innovation performance, overconfident CEOs tend to have more patents, but the overall quality of their patents is not significantly better than that of rational CEOs.

The third essay introduces a simple model of firm advertising behavior in monopolistic competition industries and applies it to the situation of managerial overconfidence. The model shows that the optimal advertising to sales ratio is determined by both firm advertising competency and consumer preference. Overconfident CEOs are more willing to use advertising as a means to convey the quality of their firms and products. Such overestimation of the effects of advertising by overconfident CEOs will result in overspending on advertising. When

financially constrained, an overconfident CEO's tendency to overspend will be curbed to some extent, but his amount of advertising will increase with cash flows. An empirical analysis of 654 S&P 1500 firms supports these predictions. The distorted effect of managerial overconfidence is more prominent when firms are financially constrained and when the overconfidence measure is continuous.

Contents

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Chapter 1: CEOs Versus CFOs: Overconfidence and Managerial Duties

Do managerial biases have a significant impact on corporate decisions? Previous literature indicates chief executive officer (CEO) overconfidence plays an important role in investment, innovation, acquisition and financial decisions (Malmendier and Tate (2005, 2008); Galasso and Simcoe (2011); Hirshleifer, Low and Teoh (2012); Malmendier, Tate and Yan (2011); Ben-David, Graham and Harvey (2007)). However, corporate decisions are not made by the CEO alone but also through the judgment and participation of other top managers, such as the chief financial officer (CFO) or the chief operating officer (COO). Companies confer business titles on top managers to identify their functions within the organization. Managers with different business titles have different business expertise and managerial duties. Therefore, if the impact of managerial biases on corporate decisions is as important as what have been found in the literature, the impact of biases of managers with different business titles can be expected to vary across different corporate decisions.

In this paper, I test the impact of CEO and CFO overconfidence both on financing decisions and on non-financing decisions such as investment, innovation and acquisition. My analysis extends the empirical evidence on managerial overconfidence in two ways. First, if the effect of managerial overconfidence is significant, we should observe not only the managerial confidence effects of CEOs, but also that of other C-level managers, but only in their respective areas of decision-making. For example, we would expect the CFO, and hence CFO overconfidence, to affect financial decisions, but generally not non-financial decisions. Second, I construct a clean and consistent overconfidence measure for both CEOs and CFOs for a larger and updated sample. I also test the robustness of previous results on CEO overconfidence after including measures of CFO overconfidence.

I focus on the managerial duties of both CEOs and CFOs because they each play a major role in corporate decision making and their roles are roughly standardized across U.S. firms.[1] While CEOs affect all major corporate decisions, CFOs are primarily responsible for financial policies. I explore this ex-ante difference between the managerial duties of CEOs and those of CFOs, to identify the effect of managerial overconfidence for both CEOs and CFOs. I test how CEO overconfidence and CFO overconfidence, separately and jointly, affect variables for financial, investment, innovation and acquisition decisions. Another merit of this methodological approach is that it allows a comparison to be drawn between the relative importance of the CEO overconfidence effect and the CFO overconfidence effect.

Previous literature provides guidelines on when we might expect CEO overconfidence or CFO overconfidence to have a significant impact on financial decisions. For example, Malmendier, Tate and Yan (2011) argue an overconfident manager has a more pronounced pecking-order preference for financing, which should apply to both the CEO and the CFO. However, in this case CFO overconfidence might dominate because making financial decisions is the primary managerial duty of the CFO. With regards to investment policies, Malmendier and Tate (2005) predict that managerial overconfidence increases investment-cash flow sensitivity, which should apply only to CEOs, since CFOs have less influence on corporate investment decisions. Similarly, one could also derive a prediction that managerial overconfidence increases R&D expenditure-cash flow sensitivity, which should apply to CEOs, but not CFOs. For

[1] For other managerial positions, there is variation in titles across industries. For example, high-tech companies tend to have a chief technology officer (CTO) while pharmaceutical companies tend to have a chief medical officer (CMO).

acquisitions, the prediction of Malmendier and Tate (2008) of a higher volume of acquisitions when firms are rich in internal sources should also apply to CEOs, not CFOs.

To identify the effect of managerial overconfidence, a majority of existing literature (Malmendier and Tate (2005, 2008); Galasso and Simcoe (2011); Malmendier, Tate and Yan (2011)) uses the same sample, a panel of large firms with a constructed CEO overconfidence measure from 1980 to 1994. Following Malmendier, Tate and Yan (2011), I update and extend the data using the Thomson Reuters insider filing dataset, which covers the years 1996 to present. This allows me to reconstruct the option-based "Longholder" measure developed by Malmendier and Tate (2005) for both the CEO and the CFO. Specifically, the "Longholder" measure is derived by solving a personal portfolio choice model. It identifies a manager as overconfident if the manager holds a fully-vested option sufficiently in-the-money until the year of expiration. I also conduct tests to explicitly address several alternative interpretations of the "Longholder" measure, for example, procrastination, insider information, signaling and risk tolerance. The test results rule out these competing explanations. Combining the Thomson Reuters insider filing dataset with Compustat, Execucomp and CRSP, I construct a panel of 1,173 firms from the S&P 1500 index with measures for both CEO and CFO overconfidence from 1996 to 2010.

My findings strongly support the insight that managerial overconfidence impacts corporate decisions. Further, this influence varies by position and type of decision. Based on the sample, I find both overconfident CEOs and CFOs are significantly more likely to issue debt when accessing external capital market. I also find that both overconfident CEOs and overconfident CFOs use significantly more debt financing when the financial deficit of the firm is high. At the same time, only overconfident CFOs are significantly less likely to issue equity when using external capital, while the same is not true for overconfident CEOs. Additionally, only firms with overconfident CFOs use less equity financing to cover their financial deficits.

As for investment decisions, I do not find any significant impact of CFO overconfidence on investment-cash flow sensitivity, R&D expenditure-cash flow sensitivity or acquisition expenditures. In contrast, I find CEO overconfidence significantly increases investment-cash flow sensitivity and R&D expenditure-cash flow sensitivity. Overconfident CEOs in firms with abundant cash or low book leverage spend significantly more on acquisitions (normalized by asset). For all results, the estimated coefficients of CEO and CFO overconfidence are quite robust, regardless of whether they are estimated separately or jointly.

My findings contribute to the overconfidence literature in several respects. My findings provide new evidence that top manager behavior matters for corporate decisions and that managerial overconfidence has a significant impact on a broad range of corporate decisions. My out-of-sample test of the effects of CEO overconfidence confirms that the empirical findings in the existing overconfidence literature are quite robust. The results suggest the CEO is the most influential person who significantly affects a wide range of corporate decisions.

Furthermore, my findings also indicate the CFO is no less important than the CEO when considering financing decisions. In the case of equity financing, the role of the CFO even outweighs that of the CEO. Hence, the impact of CFO behavior or CFO characteristics should not be ignored by researchers when studying financial policies. My findings suggest the appropriate test for the effect of managerial traits on financial policies is to test the effect of CEO traits and CFO traits on financial policies both jointly and separately (when possible), as the relative importance of the CEO versus that of the CFO on making financial policies is indeterminate ex-ante.

One caveat to my results lies in the issue of endogeneity. Boards choose CEOs based on their business expertise and personal traits, which may take self-confidence into account. For example, Hirshleifer, Low and Teoh (2012) find that overconfident CEOs achieve greater innovative outputs in innovative industries. This helps to explain why so many overconfident CEOs are hired by growth firms. At the same time, CEOs might also self-select into firms given observable firm-level characteristics. However, endogeneity does not affect my main conclusion. If the CEO is chosen because of his overconfidence, the board should be aware that overconfidence might result in varied corporate decisions such as distorted investment behavior, overspending on acquisitions as well as better innovation output. They should take actions which curtail the negative aspects and maximize the benefits of managerial overconfidence. Nevertheless, I address these endogeneity concerns by including additional control variables. I show my results are not driven by year effects, industry effects, firm effects (where possible), observable firm characteristics as well as their interacted effects with year effects or industry effects (where possible).

My results point to the important role of managerial duties when studying the impact of top managers on corporate decisions. However, my results cannot rule out the possibility that a manager might indirectly affect decisions on which he or she has little influence through daily interaction with the manager, such as the CEO, who has the dominant influential power over a decision. It is possible the CFO indirectly affects non-financial decisions through daily interaction with the CEO. However, there is no apparent, reliable empirical strategy to disentangle the CFO peer-effect from the estimated CEO overconfidence effect, nor the CEO peer-effect from the estimated CFO overconfident effect. Nevertheless, researchers should be very cautious when analyzing and interpreting the relationship between the behavior of top managers and the corporate decisions on which they have little influence.

It is helpful to clarify the use of the term “overconfidence” in this paper, which is closely related to a well-documented phenomenon, the "better-than-average" effect, common in the psychology literature. Researchers have found that individuals tend to overestimate their ability relative to the average (Larwood and Whittaker (1977); Svenson (1981) and Alicke (1985)). As a result, people are likely to be overly optimistic about outcomes they can control. In the context at hand, we can therefore expect top managers to be overconfident about the outcomes of decisions under their control.

In the field of corporate finance, Heaton (2002) was the first to show distorted corporate investment decisions could be a result of managers overestimating returns to their investments. Since then, the overconfidence literature has found that CEO overconfidence affects a broad set of corporate decisions such as financial policies (Ben-David, Graham and Harvey (2007); Malmendier, Tate and Yan (2011)), capital expenditure (Malmendier and Tate (2005)), innovation (Galasso and Simcoe (2011); Hirshleifer, Low and Teoh (2012)) and mergers and acquisitions (Malmendier and Tate (2008)). Few studies on the effects of CFO overconfidence have been done, while Ben-David, Graham and Harvey (2007) is a notable exception, analyzing how CFO overconfidence affects financial policies. My paper differs from these contributions in testing, jointly and separately, the impact of both CEO and CFO overconfidence on both financial and non-financial corporate policies, with the goal of helping researchers to better assess the impact of the CFO on corporate decisions.

With regards to investment policies, starting with Fazzari, Hubbard and Peterson (1988), investment-cash flow sensitivity has been studied extensively in the field of corporate finance. Distorted investment decisions are attributed to financial constraints, though there is an ongoing

controversy about this interpretation (Kaplan and Zingales (1997, 2000)). Conversely, Jensen's free cash flow theory suggests investment-cash flow sensitivity could be a result of the agency problem. However, following the overconfidence literature (Heaton (2002); Malmenditer and Tate (2005)), my paper offers a complementary explanation: increased investment-cash flow sensitivity could result from managerial overconfidence, even when there is no agency problem or financial constraints.

Meanwhile, due to the fast pace of modern technological development, innovation becomes more and more important for firms. Brown and Peterson (2009) report that the average firm R&D expenditure has become comparable to the average firm capital expenditure. Galasso and Simcoe (2011) find that firms with overconfident CEOs have a higher level of R&D expenditure-cash flow sensitivity, based on a sample of Fortune 500 firms from 1980 to 1994. Hirshleifer, Low and Teoh (2012) identify that CEO overconfidence has a positive impact on innovation output in innovative industries, based on a sample of S&P 1500 firms from 1993 to 2003. Given these new empirical findings, my paper revisits the impact of CEO overconfidence on R&D expenditure-cash flow sensitivity by using a different sample, a panel of S&P 1500 firms from 1996 to 2010, and including measurements of the CFO overconfidence effect.

Finally, a puzzling finding in M&A literature is that a majority of mergers and acquisitions are value destroying, yet firms continue to pursue them. Moeller, Schlingemann, and Stulz (2005) find that acquiring firm shareholders collectively lost more than 220 billion dollars when merger bids were announced from 1980 to 2001. Both practitioners (like Warren Buffett) and researchers (Roll (1986); Malmendier and Tate (2008)) have cited managerial overconfidence as a possible explanation for the large number of value-destroying deals. This paper provides new evidence that managerial overconfidence increases acquisitions expenditures when firms have abundant cash holdings or low leverage levels. However, my paper does not test whether acquisitions conducted by overconfident managers are more likely to be value-destroying.

The remainder of this analysis is organized as follows. Section I lists the empirical predictions. Section II describes the data. Section III presents the empirical findings for financial policies. Section IV presents the empirical findings for investment, innovations and acquisition decisions. Section V concludes.

I. Testable Predictions

The underlying model of managerial overconfidence in this paper follows a series of papers by Malmendier and Tate which define managerial overconfidence as a biased belief that future returns of investment projects are greater than they actually are.[2] When determining capital budget decisions, overconfident managers must account for both the overestimated future returns of their investment projects and the perceived costs of financing. As a result, financial policies and investment decisions made by overconfident managers deviate from those made by their rational peers.

A. Financial Policies

Internal capital, debt financing and equity financing are three key financing sources for firms. The capital structure predictions for managerial overconfidence tested in this paper are

2 Other examples can be found in Heaton (2002), Hackbarth (2004), Fairchild (2005), Malmendier and Tate (2005, 2008), Cordeiro (2009), Galasso and Simcoe (2011) and Malmendier, Tate and Yan (2011).

based on the formal model presented in the online appendices of Malmendier, Tate and Yan (2011).[3] In their rational benchmark, two kinds of frictions, tax-deductibility of interest payments and financial distress costs, are assumed to assure a single optimal decision on capital structure for the rational manager.

The model predicts overconfident managers will overinvest if they can finance investment with internal capital or risk-free debt. However, when internal capital or risk-free debt is insufficient, overinvestment by overconfident managers is limited to some extent by the perceived cost of external financing, such as the costs of risky debt or equity. The reason being, as rational creditors have unbiased expectations for future firm cash flows, they demand higher interest rates in default states than what overconfident managers perceive as appropriate. Similarly, rational shareholders demand higher returns to their equity capital than what overconfident managers perceive to be appropriate. If the overestimated investment returns are greater than a manager's misperceived cost of external financing, overconfident managers choose to finance the investment with external capital when necessary. Otherwise, overconfident managers will choose to forgo some investment opportunities.

Conditional on a firm seeking external capital, the perceived cost of risky debt financing is generally smaller than that of equity financing. This is because when issuing risky debt, the misperceived cost, resulting from differences in opinions between rational creditors and overconfident managers about future investment returns, only matters for a firm in a state of default. In contrast, when issuing equity, the misperceived cost of equity financing matters for all states. As a result, ceteris paribus, overconfident managers generally prefer risky debt over equity when seeking external capital. The key predictions can be summarized as follows:

Prediction 1: Conditional on accessing an external capital market, overconfident managers are more likely to issue debt than equity.

Prediction 2: Conditional on a given financial deficit, overconfident managers prefer debt financing to equity financing.

B. Investment Decisions

The investment predictions for managerial overconfidence tested in this paper are based on the model of Malmendier and Tate (2005), similar to the model of Malmendier, Tate and Yan (2011). In the benchmark model, rational managers always invest at the first best. Hence their capital expenditures are not correlated with cash flows. In contrast, overconfident managers who overestimate both future returns of their investment projects and the cost of external financing would overinvest if they had sufficient internal capital. Otherwise, overconfident managers choose to forgo some investment projects if it requires external financing and the overestimated future returns are less than the misperceived cost of external financing. Therefore, the investment expenditures made by overconfident managers are predicted to be correlated with cash flows. The same argument could be applied to other investment decisions, such as R&D expenditure decisions. The following two predictions are derived from Malmendier and Tate (2005):

Prediction 3: Overconfident managers have a higher level of investment-cash flow sensitivity than their rational peers.

Prediction 4: Overconfident managers have a higher level of of R&D expenditure-cash flow sensitivity than their rational peers.

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3 I focus on debt financing and equity financing decisions. For other financial policies such as leverage or dividend policies, the theoretically predicted impact of overconfidence is more ambiguous and beyond the scope of this paper.

Turning to acquisition expenditure decisions, managerial overconfidence can be interpreted as an overestimation of the future cash flow, or the "synergy", generated from acquiring other companies. Therefore, similar to the intuition of the models in Malmendier and Tate (2005, 2008), overconfident managers are more acquisitive than their rational peers when they can finance acquisitions with internal capital or riskless debt. However, when acquisitions require external financing and the overestimated acquisition synergy is less than the misperceived external financing costs, overconfident managers choose to forgo some acquisitions. Based on the intuition of Malmendier and Tate (2005, 2008), I test the following prediction:

Prediction 5: Overconfident managers with sufficient internal capital have larger acquisition expenditures than their rational peers.

II. Data

A. Longholder_Thomson Measure

In this paper, managerial overconfidence is defined as the biased belief held by managers that the future returns of their firms are greater than they actually are.[4] Measuring managerial overconfidence is a challenge to empirical researchers. The existing methodologies could be roughly categorized into three categories: the option-based approach, the survey-based approach and press-based approach.[5] I follow the revealed-belief-based approach and replicate the "Longholder_Thomson" measure in Malmendier, Tate and Yan (2011), which uses the timing of option exercise as a proxy for managerial overconfidence.

It is helpful to highlight the development and major features of the "Longholder_Thomson" measure. Originally, Malmendier and Tate (2005) built a benchmark model of option exercise for managers, where the optimal schedule for option exercise depends on individual wealth, degree of risk aversion and diversification. Given that stock options granted to managers are not tradable and short-selling of company stock is prohibited, managers holding stock and option grants are highly exposed to the idiosyncratic risk of their companies. In the benchmark model, risk-averse managers facing under-diversification problems generally choose to exercise options early. However, overconfident managers with overestimated mean future firm cash flows choose to postpone exercising the in-the-money option in order to tap expected future gains.

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4 In the psychology literature, the term overconfidence has broader interpretations. Even within the field of behavioral finance, the theoretical treatments of overconfidence are different. For example, a paper by Ben-David, Graham, and Harvey (2007) models overconfidence as miscalibration of stock market volatility. Galasso and Simcoe (2011) model overconfidence as underestimation of the probability of failure of innovation.

5 For the option-based approach, examples include the "Longholder" and "Holder 67" measures in Malmendier and Tate (2005), which are derived from the timing of option exercise by the CEO. Malmendier and Tate (2008), Billet and Qian (2008), Liu and Taffler (2008), Campbell et al. (2011) and Malmendier, Tate and Yan (2011) also adopt this measurement approach. Another example is Sen and Tumarkin (2009), in which the overconfidence measure is derived from the share retention rate of stocks obtained from an option exercise. With regards to the survey-based approach, Ben-David, Graham, and Harvey (2007) construct a CFO overconfidence proxy based on the narrowness of individual probability distributions for stock market returns made by each CFO who participated in the Duke/CFO Business Outlook survey. The survey aims to collect quarterly data in a variety of business categories reported by individual CFOs. Details about the survey can be found at http://www.cfosurvey.org. For a media-based approach, Malmendier and Tate (2005) and Hirshleifer, Low and Teoh (2012) construct CEO overconfidence measures based on the characteristics of CEOs reported in the press.

Based on the theoretical model, Malmendier and Tate (2005) define a binary variable called "Longholder" as a proxy for managerial overconfidence, where 1 signifies the overconfident manager at some point of his tenure held an option until the last year before expiration, given the option was at least 40% in-the-money. Empirically, Malmendier and Tate (2005) use CEO option-package-level data from a sample of 477 large publicly traded U.S. firms from 1980 to 1994 to identify CEO option exercise. An accurate replication of the original Longholder measure requires complete option-package-level data for firm managers, of which the empirical application is constrained. In order to construct overconfidence measures for both the CEO and the CFO, I reconstruct the Longholder_Thomson measure in Malmendier, Tate and Yan (2011) for the years 1996 to 2010, which has the same definition as the original Longholder measure, but uses the Thomson insider trading database to identify the option exercise by managers in public U.S. firms. The control group consists of managers for whom at least one option exercise is observed in the Thomson database but who do not meet the criteria of overconfidence.

The Thomson insider trading database includes forms 3, 4 and 5 reported by insiders to the SEC. Option exercise data is contained in Table II which illustrates reports from form 4 since 1996. I keep only those records with a very high degree of confidence (a cleanse indicator assigned by Thomson of R, H and C) or a reasonably high degree of confidence (a cleanse indicator assigned by Thomson of L and I). I drop those records which are an amendment to previous records. I further drop records with obvious errors where the maturity date of the option is earlier than the exercise date. I also drop records for which the exercise date is missing because the days remaining until maturity cannot be calculated for these cases. To reduce the effect of extreme outliers, I keep only those records for which the exercise price of the option is within the range of 0.1 to 1000. To calculate the in-the-money percentage for each option, I obtain stock price data from CRSP. I use the Execucomp database to identify the tenure information as well as stock and option holdings for CEOs and CFOs in the Thomson database, which essentially limits my firm sample to the intersection of the Execucomp database and the Thomson database, a subset of S&P 1500 U.S. firms including small, medium and large cap firms from 1996 to 2010.

B. Alternative Interpretations

I consider some alternative interpretations of the Longholder_Thomson measure and their implications for the financial policies and investment decisions tested in this paper.

Procrastination. The Longholder_Thomson overconfidence measure captures a persistent tendency of managers to delay option exercise. One might argue managers hold exercisable options until expiration due to their "inertia" or "procrastination". I find, however, that 88% of overconfident CEOs and 87% of overconfident CFOs conduct portfolio transactions one year prior to the year when options expire. Meanwhile, an "inertial" manager should not actively borrow more debt when the financing deficit is high. However, I find the higher the financing deficit, the more debt issued by overconfident CEOs and CFOs, which is difficult to reconcile with an explanation based on procrastination.

Insider Information. The managers may choose to hold exercisable options because they have positive insider information about future stock prices. However, positive information is more likely to be transitory rather than persistent. But managers who are classified as overconfident need to hold exercisable options for about five years, which is a persistent behavior. Another key distinction between overconfidence and information is whether or not the overconfident mangers earn positive abnormal returns from holding options until expiration. I

calculate the actual returns of overconfident CEOs and CFOs from holding options until their expiration, given that these options were at least 40% in-the-money ("Longhold" transactions). Then I calculate hypothetical returns from exercising these options 1, 2, 3 or 4 years earlier and investing in the S&P 500 Index until these options were actually exercised. I find that approximately 45%-49% of the "Longhold" transactions do not earn positive abnormal returns.[6] I also find that overconfident managers on average do not beat the S&P 500 index by holding these in-the-money options until expiration.

Signaling. As I find that overconfident managers do not earn positive abnormal returns from holding options until expiration, one might argue that managers' persistent holding of exercisable options is a costly signal to the capital market indicating their firms have better prospects than other similar firms do. Given that signaling serves to alleviate informational asymmetries and convey the good quality of firms with managers holding their options, the signaling story does not predict heightened investment/R&D expenditure-cash flow sensitivity or positive correlation between acquisition expenditures and cash holdings among the firms in which CEOs hold their options. However, my results of investment, innovation and acquisition decisions are difficult to reconcile with this explanation.

Risk Tolerance. The Longholder_Thomson overconfidence measure also captures a habitual tendency of managers to hold company risk. One might claim that risk-tolerant or risk-seeking managers prefer to hold exercisable options long and therefore appear to be overconfident under the Longholder_Thomson measure. However, risk tolerance does not predict aversion to equity financing. Moreover, risk tolerance does not predict heightened investment/R&D expenditure-cash flow sensitivity or a positive correlation between acquisition expenditure and cash holdings. Thus, my results of equity financing policies and investment, innovation and acquisition decisions help to rule out this interpretation.

C. Sample

To control for firm and industry characteristics, I retrieve firm-level financial variables from Compustat. Financial firms and regulated utilities (SIC codes 6000 - 6999 and 4900 - 4999) are excluded. For financial policy regressions, I construct three key variables: net debt issues, net equity issues and net financing deficit, using the same definitions as Malmendier, Tate and Yan (2011). Net debt issues is long-term debt issues minus long-term debt reductions. Net equity issues is sales of common stock minus stock repurchases. Net financing deficit is cash dividends plus net investment plus the change in working capital minus cash flow after interest and taxes. Net debt issues, net equity issues and net financing deficit are normalized by assets at the beginning of the year.

I also construct standard firm-level control variables including q, profitability, tangibility, size, book leverage and changes in these variables. Q is the ratio of market value of assets to the book value of assets. The market value of assets is measured by the book value of assets plus the market value of equity minus book value of equity and deferred taxes. Profitability is operating income before depreciation normalized by assets at the beginning of the year. Tangibility is property, plants and equipment normalized by assets at the beginning of the year. Size is the natural logarithm of sales. Book leverage is the sum of quantity debt in current liabilities and long term debt divided by the sum of quantity debt in current liabilities, long term debt and common equity.

[6] Abnormal returns are actual returns minus hypothetical returns.

To test investment-cash flow sensitivity and R&D expenditure-cash flow sensitivity, I measure cash flow as earnings before extraordinary items and depreciation. Capital expenditure, R&D expenditure and cash flow are normalized by assets at the beginning of the year. I drop one observation which has extreme cash-flow value.[7]

I combine firm-level variables with manager-level variables to form the whole sample, a panel of 1,173 S&P 1500 firms from 1996 to 2010. Compared to the sample of Fortune 500 firms from 1980 to 1994 used in the existing managerial overconfidence literature, my sample differs in two ways.[8] First, it covers a different time period and it considers small and median firms in addition to large firms. Second, it includes overconfidence measures for both the CEO and the CFO, which fills a gap in the existing literature by providing a way to estimate the effects of CEO overconfidence and CFO overconfidence separately and jointly. Table I reports summary statistics for firms, CEOs and CFOs.

III. Overconfidence and Financial Policies

A. Equity Financing versus Debit Financing

To test whether overconfident managers are more likely to issue debt than equity when tapping external capital (Prediction 1), I condition my analysis on accessing external capital to control for the different baseline frequencies of debt and equity issues by overconfident managers and their rational peers. Therefore, the regression sample only includes observations with either positive net long-term debt issues or positive net equity issues. I test whether, conditional on using external financing, overconfident managers prefer debt over equity using the following logit models:

$$\Pr(\mathrm{NDI}_{it}=1|\ \text{external capital}, \mathrm{LTCEO}_{it}, \mathrm{LTCFO}_{it}, \mathrm{X}_{it}) = \mathrm{G}(\beta_1+\beta_2\mathrm{LTCEO}_{it}+\beta_3\mathrm{LTCFO}_{it}+\mathrm{X}_{it}'\mathrm{B}+\varepsilon_{it}) \quad (1)$$

$$\Pr(\mathrm{NEI}_{it}=1|\ \text{external capital}, \mathrm{LTCEO}_{it}, \mathrm{LTCFO}_{it}, \mathrm{X}_{it}) = \mathrm{G}(\beta_1+\beta_2\mathrm{LTCEO}_{it}+\beta_3\mathrm{LTCFO}_{it}+\mathrm{X}_{it}'\mathrm{B}+\varepsilon_{it}) \quad (2)$$

In Specification 1, the dependent variable is NDI, the net debt issues indicator, where 1 signifies the net debt issues is positive and 0 otherwise. In Specification 2, the dependent variable is NEI, the net equity issues indicator, where 1 signifies the net equity issues is positive and 0 otherwise. For both specifications, the regression sample only keeps observations with either NDI equal to 1 or NEI equal to 1, which are firm-years using external capital. LTCEO and LTCFO represent the Longholder_Thomson measure for managerial overconfidence.

For each specification, I start by only including the CEO overconfidence measure to test whether the documented effects of CEO overconfidence are robust. Then I replace the CEO overconfidence measure with the CFO overconfidence measure and run through the same set of regressions. Given that the primary managerial duty of the CFO is making financial decisions, I expect the overconfident CFO has a significant impact on capital structure decisions. Finally, I

[7] I drop an outlier, of which the value of cash flow normalized by assets at the beginning of the year is less than -7.
[8] A detailed description of the sample of Forbes 500 firms can be found in Malmendier and Tate (2005, 2008), Galasso and Simcoe (2011) and Malmendier, Tate and Yan (2011).

jointly add the CEO and CFO overconfidence measures to the regressions to determine which managerial overconfidence leads to a more pronounced pecking-order preference and whether the separately estimated impacts of CEO and CFO overconfidence are robust when estimated jointly. This procedure is applied to all empirical specifications in this paper.

X is a set of standard firm-level and manager-level control variables. Firm-level control variables include book leverage, size, profitability, q and tangibility. Manager-level control variables are option-excluded stock ownership and vested options, which control for the incentive effect. Control variables reflect traditional determinants of capital structure. Year fixed effects and industry fixed effects are included. All standard errors are adjusted for firm-level clustering.

Table II reports the results for Specification 1 with the net debt issues indicator as the dependent variable. Column 1 is a baseline logit regression which only includes the CEO overconfidence proxy and CEO-level control variables. The coefficient of CEO overconfidence is positive and significant at the 1% level (coefficient = 0.410, p-value < 0.001), which means the odds ratio of debt issues for overconfident CEOs is 51% higher than that of rational CEOs.[9] In column 2, to capture the cross-sectional determinants of debt issues I include the standard firm-level control variables from the capital structure literature: q, size, profitability, tangibility and book leverage, all measured at the beginning of the year. I also add industry dummy variables and year dummy variables to remove the industry difference and cyclical effect of debt issues. The estimated coefficient of CEO overconfidence decreases but is still positive and significant at the 5% level (coefficient = 0.217, p-value = 0.009), which indicates the odds ratio of debt issues for overconfident CEOs is 24% higher than that of rational CEOs.

In column 3 and column 4, I replace the CEO overconfidence measure with the CFO overconfidence measure. For the baseline regression, the estimated coefficient of the CFO overconfidence measure is slightly lower than the CEO, significant at the 1% level (coefficient = 0.387, p-value < 0.001). It indicates the odds ratio of debt issues for overconfident CFOs is 47% higher than that of rational CFOs. In column 4, controlling for CFO-level variables, firm-level variables, industry dummies and year dummies, the estimated coefficient of CFO overconfidence decreases but is still significant at the 5% level (coefficient = 0.216, p-value = 0.012). This indicates a 24% increase in odds ratio of debt issues by overconfident CFOs. In column 5 and 6, I include both CEO and CFO overconfidence measures in the baseline regression as well as the regression with the full set of control variables. I find that both estimated coefficients of CEO and CFO overconfidence from column 1 to column 4 remain robust. The results suggest that both the CEO and the CFO have a significant impact on debt financing decisions.

Turning to firm-level control variables, the estimated coefficients are generally similar to what have been found in existing empirical capital structure literature. Profitability, tangibility and firm size significantly increase the likelihood of debt issues as it's easier for firms with stable cash flow (profit) and sufficient collateral (tangible asset and size) to borrow money through bank loans or bond issues. I also find that q is negatively correlated with debt issues. One possible explanation is that a high value of q captures the overvaluation of the firm by the stock market. Hence the firm would time the market by issuing stock at favorable conditions. I do find that q is positively correlated with equity issues in the following tests.

Table III reports the results for Specification 2 with a net equity issues indicator as the dependent variable. The independent variables in regressions from column 1 to column 7 are the

[9] To calculate the percentage change in odds ratio due to CEO overconfidence, I exponentiate the coefficient of CEO overconfidence and subtract 1from it. 51%=exp(0.41)-1.

same as in Table II. As for CEOs, I fail to find a robust effect of CEO overconfidence on equity issues: except for the baseline logit regression in column 1, the coefficients are not significant and the signs are indeterminate. Turning to CFO overconfidence, the estimated coefficients are significantly negative in the regressions controlling for CEO overconfidence, manager-level variables, year fixed effects and industry fixed effects. However, when firm-level control variables are added the estimated coefficient for CFO overconfidence becomes insignificant, though still negative. In the following section regarding net financing deficit, I do find robust effects for CFO overconfidence on the aversion of equity financing.

Firm-level control variables also affect the likelihood of equity issues. I find that q significantly increases the probability of equity issues, which is consistent with market-timing theory. Profitability decreases equity issues as firms with sufficient internal capital or stable cash flows have less incentive to inject capital from the stock market. Size decreases equity issues as large firms can issue bonds at a relatively cheap cost so they use debt financing more frequently than equity financing.

One concern relevant to this approach is that the effects attributed to managerial overconfidence are actually driven by unobserved firm characteristics. I add firm fixed effects to separate the managerial overconfidence effect from time-invariant firm characteristics where possible, but find both the CEO and CFO overconfidence effects become insignificant. Similarly, the tests for Prediction 2 through Prediction 4 also become insignificant. This result could be because adding firm-fixed effects reduces the sample size. It would be interesting to retest Prediction 1 through Prediction 4 using a sample with a larger size and longer time period.

Overall, Table II and Table III suggest the CFO plays an important role in making capital structure decisions, but that the CEO also has significant influence on financial policies, especially on debt financing. Managerial overconfidence leads to a pronounced preference for debt over equity.

B. Net Financing Deficit

I next turn to testing Prediction 2. Given a financial deficit, overconfident managers prefer debt financing over equity financing, I repeat the standard 'financing deficit framework' of Shyam-Sunder and Myers (1999). The financing deficit variable, by construction, measures the amount of financing needed in a given year. As overconfident managers and their rational peers might have a different baseline rate for using debt/equity financing, the appropriate approach when testing Prediction 2 is to examine the impact of managerial overconfidence on the correlation between the net financial deficit and debt/equity financing. Another advantage to this approach is a larger sample size, as the full sample can be used in the regression. The specification for the OLS regression is as follows:

$$D_{it} = \beta_1 + \beta_2 FD_{it} + \beta_3 LTCEO_{it} + \beta_4 LTCFO_{it} + \beta_5 LTCEO_{it} * FD_{it} + \beta_6 LTCFO_{it} * FD_{it} + X_{it}'B + FD_{it} * X_{it}'B + \varepsilon_{it} \quad (3)$$

$$E_{it} = \beta_1 + \beta_2 FD_{it} + \beta_3 LTCEO_{it} + \beta_4 LTCFO_{it} + \beta_5 LTCEO_{it} * FD_{it} + \beta_6 LTCFO_{it} * FD_{it} + X_{it}'B + FD_{it} * X_{it}'B + \varepsilon_{it} \quad (4)$$

D is net debt issues. E is net equity issues. FD is net financing deficit. LTCEO and LTCFO are measures for managerial overconfidence. X is a set of manager-level and firm-level control variables including executive stock and option holdings, changes in q, profitability, tangibility and size.

Table IV and Table V report results for Specification 3 and Specification 4 respectively. The first two columns in Table IV show results for CEO overconfidence. Column 1 is a baseline OLS regression which only includes the CEO overconfidence measure and its interaction with the net financing deficit. Column 2 adds a full set of control variables including CEO stock and option holdings, firm-level variables, year dummies, industry dummies and all their interactions with the net financing deficit. Consistent with Malmendier Tate and Yan (2011), I find a significant positive effect of CEO overconfidence on the sensitivity of debt issues to the net financing deficit (coefficient=0.252, p-value=0.003 without control variables; coefficient=0.184, p-value=0.002 with control variables). Column 3 and column 4 replace the CEO overconfidence measure with the CFO overconfidence measure and run the same regressions as those in column 1 and column 2. I find overconfident CFOs also increase net debt issues significantly when the net financing deficit is large (coefficient=0.310, p-value=0.002 without control variables; coefficient=0.226, p-value<0.001 with control variables). Then I jointly add CEO and CFO overconfidence measures to the regressions in columns 5 through column 7. I find the estimated results remain robust. From the baseline regression to the regression with a full set of control variables, the estimated effects of CFO overconfidence on the sensitivity of net debt issues to net financing deficit are all significant at the 1% level while the effects of CEO overconfidence are significant at the 5% level.

Table V reports the results for net equity issues. Interestingly, I do not find a significant impact of CEO overconfidence on the sensitivity of equity issues to the net financing deficit in all regressions. In contrast, the estimated coefficients of overconfident CFOs interacted with the net financing deficit are significantly negative at the 5% level (coefficient=-0.074, p-value=0.046), robust to controlling for CEO overconfidence, manager-level variables, firm-level variables, year dummies, industry dummies and the interacted effects of all control variables with the net financing deficit.

The results regarding net equity issues (Table III and Table V) suggest that CEOs have a limited impact on equity financing policies while that CFO's influence is significant. The results of Table IV and Table V combined with previous results from Table II and Table III provide strong evidence that CFO traits matter for capital structure decisions and that the CFO is more important than the CEO in the case of equity financing. Hence, it is important to consider all relevant top managers when analyzing how top managers affect corporate decisions.

IV. Overconfidence and Investment Policies

A. Investment and R&D Expenditure – Cash Flow Sensitivity

To test whether overconfident managers have a higher level of investment-cash flow sensitivity (Prediction 3 and Prediction 4), I follow the empirical framework of Malmendier and Tate (2005):

$$I_{it} = \beta_1 + \beta_2 C_{it} + \beta_3 LTCEO_{it} + \beta_4 LTCFO_{it} + \beta_5 LTCEO_{it} * C_{it} + \beta_6 LTCFO_{it} * C_{it} + X_{it}'B + C_{it} * X_{it}'B + \varepsilon_{it} \quad (5)$$

$$R_{it} = \beta_1 + \beta_2 C_{it} + \beta_3 LTCEO_{it} + \beta_4 LTCFO_{it} + \beta_5 LTCEO_{it} * C_{it} + \beta_6 LTCFO_{it} * C_{it} + X_{it}'B + C_{it} * X_{it}'B + \varepsilon_{it} \quad (6)$$

I is capital expenditure. R is R&D expenditure. C is cash flow. They are normalized by assets at the beginning of the year. LTCEO and LTCFO are the managerial overconfidence measures. LTCEO*C and LTCFO*C are the interacted effects of managerial overconfidence and cash flow. X is a set of manager-level and firm-level control variables including managers' stock and vested options holdings, q and the natural logarithm of sales. C*X is the interacted effects of control variables with the cash flow. As capital expenditure decisions are primarily determined by the CEO but not the CFO, I expect that only CEO overconfidence has a significant impact on capital expenditure - cash flow sensitivity but not the CFO overconfidence. However, the CFO might affect capital expenditure decisions indirectly by making financial forecasts for the CEO or helping the CEO prepare a capital budget. The CFO might also influence the CEO's decisions by way of daily interaction. Nevertheless, the effect of CFO overconfidence on capital expenditure decisions, if it exists, should not be more pronounced than the effect of CEO overconfidence. Turning to innovation policies tested in Specification 5, the problem is mitigated as innovation policies are far beyond the managerial duties and business expertise of the CFO. Therefore, I expect that only overconfident CEOs will have a significant impact on R&D expenditure-cash flow sensitivity.

Table VI reports the results for Specification 5. All standard errors are clustered at the firm level. Column 1 and column 3 estimate the impact of CEO overconfidence on capital expenditure-cash flow sensitivity. In the baseline regression in column 1, only controlling for cash flow and manager-level control variables, the estimated coefficient on the interaction of CEO overconfidence measure with cash flow is significantly positive at the 5% level (coefficient=0.075, p-value=0.042). The estimated result is robust to adding a full set of control variables (coefficient=0.074, p-value=0.025) as well as the interacted effects of the full set of control variables with cash flow (coefficient=0.055, p-value=0.040), which is consistent with Malmendier and Tate (2005).

In contrast, the results from column 4 and column 6 show that CFO overconfidence does not increase the sensitivity of investment to cash flow. Column 7 to column 9 estimate the impact of CEO and CFO overconfidence jointly. The results from column 1 to column 6 remain robust: only CEO overconfidence significantly increases the investment-cash flow sensitivity but not CFO overconfidence. The estimated effect of CEO overconfidence (in column 9, coefficient=0.057, p-value=0.053) is robust when controlling for cash flow, CFO overconfidence, managers' stock and vested option holdings, q, size, year dummies, industry dummies and the interacted effects of all control variables with cash flow, though not robust to firm fixed effects.

Table VII estimates Specification 6, which tests how managerial overconfidence affects R&D expenditure-cash flow sensitivity. This analysis follows the same procedures as Table VI, except observations missing a value for R&D expenditure are dropped. The results of Table VII are similar to those in Table VI: only overconfident CEOs increase R&D expenditures more when cash flow increases than their rational peers, but not overconfident CFOs. The estimated coefficient for CEO overconfidence is significantly positive at the 5% level (coefficient=0.127, p-value=0.046), robust when controlling for cash flow, CFO overconfidence, managers' stock and vested option holdings, q, size, year dummies, industry dummies and the interacted effects of all control variables with cash flow, though not robust to firm fixed effects.

Therefore, Table VI and Table VII show that CEO overconfidence affects investment and innovation decisions, which is consistent with existing managerial overconfidence literature. Moreover, I find that CFO overconfidence does not have a significant impact on investment and innovation decisions, which is consistent with the fact that investment and innovation decisions

are not the managerial duties of the CFO. Therefore, these findings provide new evidence for the argument that the impact of the CFO on corporate policies is limited by managerial duties.

As discussed in Section II, testing the impact of managerial overconfidence on investment-cash flow sensitivity and R&D expenditure-cash flow sensitivity also helps to distinguish the managerial overconfidence effect from alternative explanations (like signaling motives or risk tolerance). The findings of Table VI and Table VII cannot be reconciled with a signaling story or risk tolerance story, but are in consistent with the predictions of a managerial overconfidence model.

B. Acquisitions

Overconfident managers are unambiguously more acquisitive only when they have abundant internal capital (Prediction 5). To test Prediction 5 and control for internal capital, I sort the whole sample according to a firm's cash and short-term investments at the beginning of the year. The top 20% are identified as cash-rich firms and the lowest 20% are identified as cash-poor firms.[10]

Alternatively, given that debt financing is a popular financing source of acquisitions and that debt financing is preferred by overconfidence managers who use external financing, I separate firms according to their book leverage at the beginning of the year, assuming that the debt financing capacity decreases with the book leverage. The lowest 20% are identified as firms with high debt financing capacity (low book leverage) and the top 20% are identified as firms with poor debt financing capacity (high book leverage). I confirm that the sample splits generated by these two sorting methods are positively correlated. The empirical specification is:

$$\mathrm{ACQ}_{it} = \beta_1 + \beta_2 \mathrm{C}_{it} + \beta_3 \mathrm{LTCEO}_{it} + \beta_4 \mathrm{LTCFO}_{it} + \mathrm{X}_{it}'\mathrm{B} + \varepsilon_{it} \quad (7)$$

ACQ is acquisition expenditures normalized by assets at the beginning of the year. LTCEO and LTCFO are the managerial overconfidence measures. X is a set of manager-level and firm-level control variables including stock ownership, vested options, q and size. Year fixed effects and firm fixed effects are also included. Standard errors are clustered at the firm level. As M&A decisions are determined by the CEO not the CFO, I expect that only overconfident CEOs in firms with sufficient internal capital or low book leverage have significantly greater acquisition expenditures, but not the CFO.

Table VIII includes the estimated results of Specification 7 within each of the two sample partitions. Panel A's sample partition is based on holdings of cash and short-term investment. Columns 1 to 3 report results for cash-rich firms. In column 3, the estimated coefficient for CEO overconfidence is around 0.077, significant at the 10% level (p-value=0.074), robust to the CFO overconfidence effect, manager-level and firm-level control variables, year fixed effects and firm fixed effects. The estimated coefficient for CFO overconfidence is insignificant. Turning to the results for cash-poor firms shown in columns 4 to column 6, I do not find any significant impact of CEO overconfidence or CFO overconfidence on firm acquisition expenditures. These results are consistent with Prediction 5.

Panel B reports results from regressions using a sample partitioned by book leverage. The results are similar to Panel A. Only overconfident CEOs in firms with low book leverage (thus high debt financing capacity) have a significant impact on acquisition expenditures. In column 3, the estimated coefficient for CEO overconfidence is around 0.029, significant at the 10% level

[10] I confirmed the results are robust when the threshold changes from 20% to either 25% or 30%.

(p-value=0.099), robust to the CFO overconfidence effect, manager-level and firm-level control variables, year fixed effects and firm fixed effects. It is worth noting the estimated effect for CEO overconfidence in low book leverage firms (coefficient=0.028, p-value=0.061) is much less than that in cash rich firm (coefficient=0.077, p-value=0.074). This finding is also consistent with the pecking-order financing preference of overconfident managers: internal capital is preferred to external capital.

With regards to the full sample, column 7 of both Panel A and Panel B estimate the coefficients for CEO and CFO overconfidence jointly using the full sample. The estimated coefficient for CEO overconfidence is still significantly positive at the 5% level (coefficient=0.022 p-value=0.025), which is consistent with Prediction 5. In all regressions, the estimated coefficients for CFO overconfidence are insignificant.

Overall, the findings of Table VIII support Prediction 5: only overconfident CEOs in firms with sufficient internal capital or debt financing capacity spend significantly more on acquisition, but not overconfident CFOs, which is consistent with the theoretical model and empirical findings of Malmendier and Tate (2008) as well as the difference in managerial duties of the CEO and the CFO. That the coefficients of CFO overconfidence are insignificant in all regressions provides additional evidence that a manager's impact on corporate policies is limited by his managerial duties.

For control variables, interestingly, in cash-poor firms q significantly increases acquisition expenditures. This finding is consistent with the q theory of mergers and acquisitions: q captures productivity so that high-productivity firms acquire low-productivity firms. Alternatively, this finding is also consistent with market-timing theory of mergers and acquisitions: q captures the overvaluation of the firm so that overvalued firms use their shares to purchase undervalued firms. To differentiate the two explanations, I look further at specific financing methods. Generally, market timing theory predicts that acquisitions are more likely to be financed by shares. I find that for cash poor firms, q significantly increases net equity issues when acquisition expenditures are high, but not net debt issues. Hence the findings suggest that cash-constrained firms tend to take advantage of market timing when making acquisitions.

There is a concern that over-spending on acquisition expenditures might be caused by the agency problem: entrenched managers with rich internal capital are more likely to make value-destroying investments or acquisitions (Harford, 1999). Fortunately, the presence of empire-building managers will not challenge the robustness of my findings. Note that overconfident managers believe they are in line with the interests of shareholders while empire-building CEOs are aware that they destroy shareholder value. Therefore, an overconfident acquisitive manager would keep holding stock and options of his firm while an empire-building acquisitive manager would reduce his stock and option holdings of the firm. Therefore, the overconfidence measure should be negatively correlated with the empire-building proxy. In the worst case, the presence of empire-building managers will only bias the estimated coefficient of overconfidence downward, which means my estimates are underestimating the true managerial overconfidence effect.

V. Conclusion

By separately and jointly testing the impact of CEO overconfidence and CFO overconfidence on various types of corporate decisions, I find that CFO behavioral traits are crucial for capital structure decisions while CEO behavioral traits are the key to investment, innovation and acquisitions policies as well as partial influential on financial policies. As for

capital structure decisions, the results show that firms with overconfident CFOs are more likely to issue debt and less likely to issue equity when accessing external capital, while overconfident CEOs only affect debt financing decisions. With regards to investment, innovation and acquisitions decisions, which are generally outside the managerial duties of the CFO, I find only CEO overconfidence has a significant impact while CFO overconfidence does not. CEO overconfidence is positively associated with investment-cash flow sensitivity and R&D expenditure-cash flow sensitivity, as well as more acquisition expenditures when internal capital is rich or debt financing capacity is high.

The empirical findings of this paper are largely consistent with the existing managerial overconfidence literature. While the exact mechanism by which the personal traits of top managers affects corporate policies is still in the black box, this paper suggests that managerial duties affect how top managers influence corporate policies. The economic implications of managerial characteristics are richer than what has been previously demonstrated. Future research in this area of inquiry is warranted and necessary.

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Table I. Summary Statistics

Panel A. Firm Variables (Full Sample)

Net financing deficit is cash dividends plus net investment plus change in working capital minus cash flow after interest and taxes, which is identical to that in Malmendier, Tate and Yan (2011). Net investment is capital expenditures plus increase in investments plus acquisitions plus other uses of funds minus sale of property, plants, and equipment minus sale of investment. Change in working capital is change in operating working capital plus change in cash and cash equivalents plus change in current debt. Net debt issues is long term debt minus long term debt reduction. Net equity issues is sales of common stock minus stock repurchases. Cash flow is earnings before extraordinary items plus depreciation. Book leverage is the sum of current liabilities and long term debt divided by the sum of current liabilities, long term debt and book equity. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Profitability is operating income before depreciation divided by assets at the beginning of the year. Tangibility is property, plants and equipment divided by assets at the beginning of the year. The number of firms is 1,173.

Variables	Obs.	Mean	Median	SD
Asset($m)	6361	5118	1258	15029
Capital($m)	6361	1815	260	6519
Net financing deficit($m)	6361	-182	-13	1806
Net investment($m)	6361	206	51	1853
Change in working capital($m)	6361	75	19	625
Cash dividends($m)	6361	96	0	470
Cash flow after interest and taxes ($m)	6361	559	121	1944
Capital expenditure($m)	6361	323	53	1201
R&D expenditure($m)	4261	161	26	524
Acquisition expenditure($m)	6361	127	1	630
Cash flow($m)	6361	562	122	1922
Net financing deficit/assets(t-1)	6361	-0.021	-0.017	0.371
Net debt issuance/assets(t-1)	6361	0.027	0.000	0.159
Net debt issuance indicator	6361	0.329	0.000	0.470
Net equity issuance/assets(t-1)	6361	-0.002	0.000	0.168
Net equity issuance indicator	6361	0.508	1.000	0.500
Capital expenditure /assets(t-1)	6361	0.070	0.046	0.078
R&D expenditure/assets(t-1)	4261	0.061	0.033	0.093
Acquisitions expenditure /assets(t-1)	6361	0.045	0.000	0.139
Cash flow/asset(t-1)	6361	0.122	0.120	0.121
Book leverage	6361	0.280	0.273	0.992
Q	6361	2.290	1.750	2.079
Change in q	6361	-0.058	0.009	1.818
Profitability	6361	0.183	0.172	0.245
Change in profitability	6361	-0.004	0.001	0.219
Tangibility	6361	0.330	0.241	0.448
Change in tangibility	6361	-0.013	-0.004	0.377
ln(Sales)	6361	7.133	7.061	1.572
Change in ln(Sales)	6361	0.106	0.094	0.224

Table I. Summary Statistics

Panel B. CEO Variables

LTCEO is a binary variable where 1 signifies that the CEO at some point during his tenure held exercisable options until the last year before expiration, given that the options were at least 40% in the money entering their last year. Stock Ownership is the option-excluded shares held by CEOs as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by CEOs as a percentage of common shares outstanding.

	Full Sample					
	Number of CEOs = 1475					
Variables	Obs.	Mean	Median	SD	Min.	Max.
Stock Ownership (%)	6361	2.08	0.36	5.47	0.00	81.13
Vested Options (%)	6361	0.99	0.61	1.26	0.00	21.00

	LTCEO Sample					
	Number of LTCEOs = 742					
Variables	Obs.	Mean	Median	SD	Min.	Max.
Stock Ownership (%)	3654	2.26	0.45	5.61	0.00	81.13
Vested Options (%)	3654	1.09	0.71	1.33	0.00	18.57

Panel C. CFO Variables

LTCFO is a binary variable where 1 signifies that the CFO at some point during his tenure held exercisable options until the last year before expiration, given that the options were at least 40% in the money entering their last year. Stock Ownership is the option-excluded shares held by CFOs as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by CFOs as a percentage of common shares outstanding.

	Full Sample					
	Number of CFOs = 1484					
Variables	Obs.	Mean	Median	SD	Min.	Max.
Stock Ownership (%)	6361	0.17	0.05	0.76	0.00	22.90
Vested Options (%)	6361	0.25	0.14	0.35	0.00	4.39

	LTCFO Sample					
	Number of LTCFOs = 477					
Variables	Obs.	Mean	Median	SD	Min.	Max.
Stock Ownership (%)	2561	0.23	0.07	1.03	0.00	22.90
Vested Options (%)	2561	0.29	0.18	0.38	0.00	4.16

Table II. Financial Policies: Net Debt Issues

Table II has logit regressions with the Net Debt Issues Indicator as the dependent variable. Coefficients are reported as log odds ratios. The Net Debt Issues Indicator is a binary variable which equals 1 if Net Debt Issues during the year are positive. Net Debt Issues is long term debt minus long term debt reduction. LTCEO/LTCFO is a binary variable where 1 signifies that the CEO/CFO at some point during his tenure held exercisable options until the last year before expiration, given that the options were at least 40% in the money entering their last year. Stock Ownership is option-excluded shares held by the CEO/CFO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO/CFO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Profitability is operating income before depreciation divided by assets at the beginning of the year. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Book Leverage is the sum of current liabilities and long term debt divided by the sum of current liabilities, long term debt and book equity. Stock Ownership, Vested Options, Q, Profitability, Tangibility, ln(Sales), and Book Leverage are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LTCEO	0.410***	0.217***			0.317***	0.281***	0.171**
	(0.081)	(0.083)			(0.084)	(0.087)	(0.085)
Stock Ownership CEO	-0.016	-0.009			-0.014	-0.021*	-0.009
	(0.010)	(0.009)			(0.009)	(0.011)	(0.009)
Vested Options CEO	-0.182***	0.023			-0.098**	-0.048	0.040
	(0.043)	(0.035)			(0.043)	(0.041)	(0.039)
LTCFO			0.387***	0.216**	0.286***	0.252***	0.186**
			(0.083)	(0.086)	(0.086)	(0.091)	(0.089)
Stock Ownership CFO			-0.069	-0.051	-0.063	-0.094	-0.036
			(0.085)	(0.070)	(0.087)	(0.111)	(0.070)
Vested Options CFO			-0.786***	-0.068	-0.605***	-0.520***	-0.111
			(0.158)	(0.130)	(0.171)	(0.156)	(0.142)
Q		-0.071**		-0.072**			-0.070**
		(0.030)		(0.030)			(0.030)
Profitability		1.377***		1.354***			1.378***
		(0.446)		(0.443)			(0.442)
Tangibility		0.531***		0.534***			0.518***
		(0.162)		(0.165)			(0.165)
ln(Sales)		0.388***		0.383***			0.380***
		(0.033)		(0.033)			(0.034)
Book Leverage		-0.028		-0.028			-0.027
		(0.020)		(0.020)			(0.020)
Year Fixed Effects		Yes		Yes		Yes	Yes
Industry Fixed Effects		Yes		Yes		Yes	Yes
Observations	4369	4369	4369	4369	4369	4369	4369

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table III. Financial Policies: Net Equity Issues

Table III contains the results for logit regressions with the Net Equity Issues Indicator as the dependent variable. Coefficients are reported as log odds ratios. The Net Equity Issues Indicator is a binary variable which equals 1 if Net Equity Issues during the year are positive. Net Equity Issues is sales of common stock minus stock repurchases. LTCEO/LTCFO is a binary variable where 1 signifies that the CEO/CFO at some point during his tenure held exercisable options until the last year before expiration, given that the options were at least 40% in the money entering their last year. Stock Ownership is option-excluded shares held by the CEO/CFO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO/CFO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Profitability is operating income before depreciation divided by assets at the beginning of the year. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Book Leverage is the sum of current liabilities and long term debt divided by the sum of current liabilities, long term debt and book equity. Stock Ownership, Vested Options, Q, Profitability, Tangibility, ln(Sales), and Book Leverage are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LTCEO	-0.233**	-0.004			-0.141	-0.091	0.032
	(0.097)	(0.103)			(0.098)	(0.101)	(0.101)
Stock Ownership CEO	0.022	0.010			0.018	0.023	0.009
	(0.014)	(0.012)			(0.013)	(0.014)	(0.012)
Vested Options CEO	0.198***	-0.071*			0.097**	0.035	-0.087*
	(0.050)	(0.041)			(0.049)	(0.047)	(0.045)
LTCFO			-0.328***	-0.120	-0.271**	-0.205*	-0.144
			(0.103)	(0.111)	(0.105)	(0.110)	(0.111)
Stock Ownership CFO			0.279**	0.193*	0.259**	0.347**	0.172
			(0.129)	(0.106)	(0.132)	(0.152)	(0.108)
Vested Options CFO			0.890***	-0.018	0.708***	0.623***	0.096
			(0.220)	(0.162)	(0.232)	(0.217)	(0.181)
Q		0.068**		0.073**			0.071**
		(0.034)		(0.035)			(0.035)
Profitability		-2.809***		-2.791***			-2.817***
		(0.456)		(0.459)			(0.463)
Tangibility		0.329		0.354*			0.345
		(0.212)		(0.213)			(0.214)
ln(Sales)		-0.491***		-0.473***			-0.482***
		(0.044)		(0.044)			(0.045)
Book Leverage		0.073		0.059			0.064
		(0.083)		(0.059)			(0.070)
Year Fixed Effects		Yes		Yes		Yes	Yes
Industry Fixed Effects		Yes		Yes		Yes	Yes
Observations	4369	4369	4369	4369	4369	4369	4369

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table IV. Financial Policies: Financing Deficit and Net Debt Issues

Included here are the results for OLS regressions with Net Equity Issues normalized by assets at the beginning of the year as the dependent variable. Net Debt Issues is long term debt minus long term debt reduction. LTCEO/LTCFO is a binary variable where 1 signifies that the CEO/CFO at some point during his tenure held exercisable options until the last year before expiration, given that the options were at least 40% in the money entering their last year. FD is Net Financing Deficit which is cash dividends plus net investment plus change in working capital minus cash flow after interest and taxes, normalized by assets at the beginning of the year, which is identical to that in Malmendier, Tate and Yan (2011). Manager-level control variables include Stock Ownership and Vested Options. Stock Ownership is option-excluded shares held by the CEO/CFO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO/CFO as a percentage of common shares outstanding. Firm-level control variables include changes in Q, Profitability, Tangibility and ln(Sales). They are identical to those in Frank and Goyal (2003). Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Profitability is operating income before depreciation divided by assets at the beginning of the year. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Manager-level and firm-level control variables are all measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FD	0.072	0.075	0.079	0.078	0.029	0.017	-0.013
	(0.062)	(0.132)	(0.058)	(0.136)	(0.146)	(0.149)	(0.143)
LTCEO	0.006	0.006*			0.001	0.001	0.003
	(0.005)	(0.004)			(0.004)	(0.004)	(0.003)
LTCEO*FD	0.252***	0.184***			0.119**	0.122**	0.126**
	(0.085)	(0.059)			(0.054)	(0.053)	(0.051)
LTCFO			0.005	0.006	0.002	0.003	0.004
			(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
LTCFO* FD			0.310***	0.226***	0.190***	0.179***	0.180***
			(0.098)	(0.061)	(0.060)	(0.058)	(0.053)
Manager Control		Yes		Yes			Yes
Manager Control *FD		Yes		Yes			Yes
FD Control Variables		Yes		Yes			Yes
FD Control Variables *FD		Yes		Yes			Yes
Year Fixed Effects		Yes		Yes		Yes	Yes
Year Fixed Effects *FD		Yes		Yes		Yes	Yes
Industry Fixed Effect		Yes		Yes		Yes	Yes
Industry Fixed Effect *FD		Yes		Yes		Yes	Yes
Observations	6361	6361	6361	6361	6361	6361	6361

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table V. Financial Policies: Financing Deficit and Net Equity Issues

Included below are OLS regression results with Net Equity Issues normalized by assets at the beginning of the year as the dependent variable. Net Equity Issues is sales of common stock minus stock repurchases. LTCEO/LTCFO is a binary variable where 1 signifies that the CEO/CFO at some point during his tenure held exercisable options until the last year before expiration, given that the options were at least 40% in the money entering their last year. FD is Net Financing Deficit which is cash dividends plus net investment plus change in working capital minus cash flow after interest and taxes, normalized by assets at the beginning of the year, which is identical to that in Malmendier, Tate and Yan (2011). Manager-level control variables include Stock Ownership and Vested Options. Stock Ownership is option-excluded shares held by the CEO/CFO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO/CFO as a percentage of common shares outstanding. Firm-level control variables include changes in Q, Profitability, Tangibility and ln(Sales). They are identical to those in Frank and Goyal (2003). Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Profitability is operating income before depreciation divided by assets at the beginning of the year. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Manager-level and firm-level control variables are all measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FD	0.098**	0.222*	0.126**	0.272**	0.342***	0.306**	0.244**
	(0.050)	(0.117)	(0.052)	(0.109)	(0.116)	(0.123)	(0.116)
LTCEO	-0.011*	-0.011*			-0.006	-0.006	-0.006
	(0.007)	(0.006)			(0.006)	(0.006)	(0.006)
LTCEO*FD	0.099	-0.008			0.016	0.011	0.015
	(0.060)	(0.063)			(0.068)	(0.066)	(0.063)
LTCFO			-0.017***	-0.017***	-0.017***	-0.017***	-0.015***
			(0.006)	(0.005)	(0.005)	(0.005)	(0.004)
LTCFO* FD			-0.004	-0.076*	-0.084**	-0.088**	-0.074**
			(0.060)	(0.040)	(0.039)	(0.037)	(0.037)
Manager Control		Yes		Yes			Yes
Manager Control *FD		Yes		Yes			Yes
FD Control Variables		Yes		Yes			Yes
FD Control Variables *FD		Yes		Yes			Yes
Year Fixed Effects		Yes		Yes		Yes	Yes
Year Fixed Effects *FD		Yes		Yes		Yes	Yes
Industry Fixed Effect		Yes		Yes		Yes	Yes
Industry Fixed Effect *FD		Yes		Yes		Yes	Yes
Observations	6361	6361	6361	6361	6361	6361	6361

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table VI. Investment-Cash Flow Sensitivity

Included in Table VI are results for OLS regressions with capital expenditure normalized by assets at the beginning of the year as the dependent variable. CF is Cash Flow, which is earnings before extraordinary items plus depreciation normalized by assets at the beginning of the year. LTCEO/LTCFO is a binary variable where 1 signifies that the CEO/CFO at some point during his tenure held exercisable options until the last year before expiration, given that the options were at least 40% in the money entering their last year. Manager-level control variables include Stock Ownership and Vested Options. Stock Ownership is option-excluded shares held by the CEO/CFO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO/CFO as a percentage of common shares outstanding. Firm-level control variables include Q and ln(Sales). Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Q and ln(Sales) are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cash Flow	0.144***	0.121***	0.249*	0.169***	0.147***	0.241*	0.143***	0.121***	0.233*
	(0.025)	(0.021)	(0.137)	(0.023)	(0.020)	(0.134)	(0.026)	(0.021)	(0.138)
LTCEO	-0.000	0.002	0.005				0.000	0.002	0.004
	(0.005)	(0.004)	(0.003)				(0.005)	(0.005)	(0.004)
LTCEO* CF	0.076**	0.074**	0.055**				0.074*	0.070**	0.057*
	(0.037)	(0.033)	(0.027)				(0.038)	(0.035)	(0.029)
LTCFO				-0.004	0.000	0.005	-0.002	0.001	0.004
				(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
LTCFO* CF				0.038	0.039	0.010	0.006	0.009	-0.007
				(0.041)	(0.037)	(0.036)	(0.043)	(0.040)	(0.038)
Manager Control Variables		Yes	Yes		Yes	Yes		Yes	Yes
Manager Control Variables * CF			Yes			Yes			Yes
Firm Control Variables		Yes	Yes		Yes	Yes		Yes	Yes
Firm Control Variables * CF			Yes			Yes			Yes
Year Fixed Effects		Yes	Yes		Yes	Yes		Yes	Yes
Year Fixed Effects * CF			Yes			Yes			Yes
Industry Fixed Effects		Yes	Yes		Yes	Yes		Yes	Yes
Industry Fixed Effects* CF			Yes			Yes			Yes
Observations	6361	6361	6361	6361	6361	6361	6361	6361	6361

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table VII. R&D Expenditure-Cash Flow Sensitivity

Table VIII includes OLS regressions with R&D expenditure normalized by assets at the beginning of the year as the dependent variable. CF is Cash Flow, which is earnings before extraordinary items plus depreciation normalized by asset at the beginning of the year. LTCEO/LTCFO is a binary variable where 1 signifies that the CEO/CFO at some point during his tenure held exercisable options until the last year before expiration, given that the options were at least 40% in the money entering their last year. Manager-level control variables include Stock Ownership and Vested Options. Stock Ownership is option-excluded shares held by the CEO/CFO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO/CFO as a percentage of common shares outstanding. Firm-level control variables include Q and ln(Sales). Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Q and ln(Sales) are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cash Flow	-0.259***	-0.268***	-0.019	-0.211***	-0.226***	-0.136	-0.260***	-0.269***	-0.222
	(0.082)	(0.074)	(0.203)	(0.070)	(0.064)	(0.198)	(0.085)	(0.076)	(0.206)
LTCEO	-0.025*	-0.014	-0.018*				-0.019	-0.009	-0.011
	(0.015)	(0.012)	(0.010)				(0.014)	(0.011)	(0.009)
LTCEO* CF	0.183*	0.153*	0.153**				0.169*	0.142*	0.127**
	(0.105)	(0.086)	(0.072)				(0.097)	(0.079)	(0.064)
LTCFO				-0.030*	-0.022*	-0.016	-0.020	-0.016	-0.010
				(0.016)	(0.013)	(0.010)	(0.015)	(0.011)	(0.009)
LTCFO* CF				0.102	0.082	0.024	0.023	0.020	-0.028
				(0.109)	(0.087)	(0.069)	(0.098)	(0.076)	(0.063)
Manager Control Variables		Yes	Yes		Yes	Yes		Yes	Yes
Manager Control Variables * CF			Yes			Yes			Yes
Firm Control Variables		Yes	Yes		Yes	Yes		Yes	Yes
Firm Control Variables * CF			Yes			Yes			Yes
Year Fixed Effects		Yes	Yes		Yes	Yes		Yes	Yes
Year Fixed Effects * CF			Yes			Yes			Yes
Industry Fixed Effects		Yes	Yes		Yes	Yes		Yes	Yes
Industry Fixed Effects* CF			Yes			Yes			Yes
Observations	4261	4261	4261	4261	4261	4261	4261	4261	4261

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table VIII. Acquisitions

The results below are for OLS regressions with acquisition expenditures normalized by assets at the beginning of the year as the dependent variable. LTCEO/LTCFO is a binary variable where 1 signifies that the CEO/CFO at some point during his tenure held exercisable options until the last year before expiration, given that the options were at least 40% in the money entering their last year. Manager-level control variables include Stock Ownership and Vested Options. Stock Ownership is option-excluded shares held by the CEO/CFO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO/CFO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Q and ln(Sales) are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

Panel A Split Sample by Cash and Short-Term Investments

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Cash-Rich Firms			Cash-Poor Firms			Full Sample
LTCEO	0.077*		0.077*	0.015		0.009	0.022**
	(0.043)		(0.043)	(0.018)		(0.016)	(0.010)
LTCFO		-0.048	-0.050		0.019	0.021	-0.008
		(0.063)	(0.062)		(0.017)	(0.015)	(0.009)
Q	-0.001	-0.001	-0.001	0.064***	0.062***	0.061***	0.003*
	(0.001)	(0.001)	(0.001)	(0.019)	(0.019)	(0.019)	(0.002)
ln(Sales)	-0.023	-0.017	-0.022	-0.032	-0.043*	-0.040	-0.035***
	(0.020)	(0.018)	(0.019)	(0.026)	(0.026)	(0.026)	(0.010)
Manager Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1257	1257	1257	1256	1256	1256	6281

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Panel B Split Sample by Book Leverage

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Low-Leveraged Firms			High-Leveraged Firms			Full Sample
LTCEO	0.029*		0.028*	0.011		0.009	0.022**
	(0.017)		(0.015)	(0.016)		(0.017)	(0.010)
LTCFO		0.014	0.009		0.029	0.027	-0.008
		(0.021)	(0.020)		(0.027)	(0.025)	(0.009)
Q	0.000	0.000	0.000	-0.002	-0.003	-0.003	0.003*
	(0.001)	(0.001)	(0.001)	(0.013)	(0.013)	(0.013)	(0.002)
ln(Sales)	0.016	0.021*	0.019*	-0.076**	-0.078**	-0.077**	-0.035***
	(0.012)	(0.012)	(0.012)	(0.031)	(0.031)	(0.030)	(0.010)
Manager Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1257	1257	1257	1256	1256	1256	6281

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Chapter 2: CEO Overconfidence, Liquidity Management and Innovation

Do the personal traits of CEOs affect firm innovation? A large number of studies have examined the determinants of firm innovation, most of which focus on the role of firm-level or industry-level characteristics. However, with recent growth in behavioral economics, researchers have begun to explore how the personal traits of CEOs affect innovation. Barker and Mueller (2002) examine the relationship between the experiential and demographic characteristics of CEOs and their firms' R&D expenditures. They find that R&D expenditures are greater in firms with CEOs who are younger, have rich career experience in marketing and/or engineering and advanced science-related degrees. Musteen Barker and Baeten (2006) find the experiential and demographic attributes of CEOs are associated with a CEO's attitude toward change, which suggests that CEO experience and demographics indeed affect CEO attitudes, cognitions, and beliefs, thus influencing the formation of decisions.

This study focuses on a specific behavioral trait of CEOs: CEO overconfidence. It investigates the impact of CEO overconfidence on firm innovation. Though the behavioral approach is often criticized for theoretical weaknesses, a fast-growing literature of managerial overconfidence has explored both the theoretical foundations and empirical evidence for the link between corporate decisions and CEO overconfidence. Many important effects of managerial overconfidence on corporate decisions have been identified. Malmendier and Tate (2005) find that overconfident CEOs have higher investment-cash flow sensitivity, which suggests that CEO overconfidence increases distortions in firm investment. Malmendier and Tate (2008) find that overconfident CEOs are more acquisitive and conduct more value-destroying mergers and acquisitions. Malmendier, Tate and Yan (2011) add that CEO overconfidence leads to a more pronounced pecking-order preference in financing. Ben-David, Graham, and Harvey (2007) find that CFOs who underestimate the variance of cash flows impact a wide range of corporate financial policies. With regards to innovation, Galasso and Simcoe (2011) find that overconfident CEOs have more R&D expenditure, patents and patent citations. This effect is larger in more competitive industries. Hirshleifer, Low and Teoh (2012) find that overconfident CEOs in innovative industries have better innovation performance.

Building on previous contributions, my paper explores the extent to which overconfident CEOs allocate resources to innovation activities both in terms of financing and investment. On the one hand, I examine the financing of innovation investments. Compared to capital investment, innovation investment has certain properties that cause difficulties in financing R&D projects from external capital markets (Hall and Lerner (2009); Hall (2002)). R&D projects frequently entail significant sunk costs and low resale value. Therefore R&D expenditure has little collateral value for debt financing. Moreover, cash flows generated from R&D projects are highly uncertain, usually with a considerable time lag. In addition, R&D projects contain significant firm-specific knowledge. Hence the resulting information asymmetries between investors and managers along with the principal-agent problem further impede external financing conditions for R&D projects. Therefore, external capital like debt or equity are likely to be more expensive for R&D investment than for ordinary capital investment, which implies that cash flows might be more valuable for firms with a greater portion of innovation investment (Hall (1992, 2002); Himmelberg and Petersen (1994)).

Given the relative importance of internal funds for innovation investment, it is important to examine how managerial overconfidence affects firm liquidity management as well as the respective implications for innovation investment. Managerial overconfidence generally results

in a stronger preference for internal capital over external capital (Malmendier and Tate (2005, 2008); Malmendier, Tate and Yan (2011)). Overconfident managers mistakenly believe external capital markets undervalue the present value of their firms and the cost of external financing is (incorrectly) perceived to be higher than what is appropriate. Therefore, the cost of internal capital appears cheaper than the cost of external capital for overconfident managers, which implies overconfident managers have a higher demand for internal funds. I expect that overconfident CEOs generally have a higher propensity to save cash out of cash flows, which is measured by cash flow sensitivity of cash (Almeida, Campello and Weisbach (2004)). This effect will be more prominent in firms with financial constraints. In addition, given the fact that R&D projects rely more on internal capital than ordinary investments do, I expect the impact of managerial overconfidence on liquidity management will also be more prominent in innovative firms.

At the same time, with regards to R&D investment I argue that overconfident CEOs tend to overestimate future returns on R&D projects because of the overestimation of their own ability to generate good outcomes. Similarly, Hirshleifer, Low and Teoh (2012) also argue that people are more likely to be overconfident about their performance on difficult tasks than on easy tasks, which is referred as the 'difficulty effect' in Griffin and Tversky (1992).

Therefore, I expect overconfident CEOs will be more engaged in innovative projects, which is manifested in two ways. First, given an amount of total investment, (defined as the sum of capital expenditure and R&D expenditure) overconfident CEOs tend to choose a higher share of R&D expenditure than their rational peers. Second, overconfident CEOs would like to choose a higher R&D intensity, defined as R&D expenditure normalized by total assets, than their rational peers. In the latter case, given that R&D expenditure relies heavily on internal capital, which is more desirable for overconfident CEOs than their rational peers, I expect CEO overconfidence will lead to higher R&D expenditure-cash flow sensitivity.

To test the impact of managerial overconfidence on firm decisions, a series of papers (Malmendier and Tate (2005, 2008); Galasso and Simcoe (2011); Malmendier, Tate and Yan (2011)) use a panel of large firms with constructed CEO overconfidence measures from 1980 to 1994. Following Malmendier, Tate and Yan (2011), I update and extend the data using the Thomson Reuters Insider Filing dataset, which covers years 1996 to 2010. This allows me to reconstruct the option-based "Longholder_Thomson" measure for CEOs developed by Malmendier and Tate (2005). Originally, the "Longholder_Thomson" measure was derived by solving a personal portfolio choice model. The model identifies a manager as overconfident if the manager holds a fully-vested and sufficiently in-the-money option until the year of expiration. I also conduct tests to explicitly address several alternative interpretations of the "Longholder_Thomson" measure, for example, procrastination, insider information, signaling and risk tolerance. The test results rule out these rival explanations. Combining the Thomson Reuters Insider Filing dataset with Compustat, Execucomp and CRSP, I construct a panel of 1,015 firms from the S&P 1500 index from 1996 to 2010.[11]

[11] My sample and measure for overconfidence are both different from Galasso and Simcoe (2011) and Hirshleifer, Low and Teoh (2012). Galasso and Simcoe (2011) use a panel of Forbes 500 large firms from 1980 to 1994, following the series of papers of Malmendier and Tate (2005, 2008). The overconfidence measure in Galasso and Simcoe (2011) is the Holder67 dummy developed in Malmendier and Tate (2005). Hirshleifer, Low and Teoh (2012) use a panel of S&P 1500 firms from 1993 to 2003. To measure CEO overconfidence, they reconstruct the Holder67 measure in Malmendier and Tate (2005) from Execucomp and the press-based measure in Malmendier and Tate (2005) from Factiva. My sample is a panel of S&P 1500 firms from 1996 to 2010. I reconstruct the Longholder_Thomson measure in Malmendier, Tate and Yan (2011) from the Thomson Insider Trading Database.

For liquidity management and innovation financing, I find evidence that CEO overconfidence increases the cash flow sensitivity of cash. An average firm with an overconfident CEO saves 26% more cash out of cash flows than an average firm with a rational CEO. The impact of overconfident CEOs on firm savings is increased from 26% to more than 38% when firms are identified as having financial constraints.[12] For innovative firms, the CEO overconfidence effect on savings is even more prominent, increasing from 26% to more than 45%.[13] These estimated results are robust when controlling for q, size, tangibility, capital intensity, CEO stock ownership and option holdings, year fixed effects and firm fixed effects. My findings indicate CEO overconfidence leads to a higher propensity to save cash out of cash flows, especially for innovative firms and for firms with financial constraints

With respect to innovation input, on the one hand, I find that without controlling for cash flows, overconfident CEOs only have a greater relative amount of R&D investment (defined as a higher R&D share in total investment) than their rational peers but not a higher absolute amount of R&D expenditure (defined as R&D expenditure normalized by assets at the beginning of the year). The estimated effects are robust when controlling for q, size, tangibility, capital intensity, CEOs' stock ownership, CEOs' vested options, year fixed effects and industry fixed effects, but not firm fixed effects. However, on the other hand, I find that overconfident CEOs have a heightened R&D expenditure-cash flow sensitivity. The estimated results are robust when controlling for q, size, tangibility, capital intensity, CEO stock ownership, CEO vested options, year fixed effects, industry fixed effects and firm fixed effects.

My results indicate that the impact of the interaction between cash flows and managerial overconfidence on innovation input is more subtle than it first appears. Overconfident CEOs invest more in innovation when cash flow is high, but reduce the amount of R&D expenditure when cash flow is low. However, overconfident CEOs still maintain a higher relative amount R&D expenditure, which is a higher R&D share in total investment, regardless of the variation of cash flows. Moreover, CEO overconfidence affects innovation investment both directly through investment decisions and indirectly through the management of internal liquidity.

I also examine the outcomes of innovation investments by overconfident managers. Galasso and Simcoe (2011) find that overconfident CEOs have more innovation output both in terms of quantity and quality. Hirshleifer, Low and Teoh (2012) find that overconfident CEOs have better innovation performance in innovative industries. My analysis has produced mixed results. I find that overconfident CEOs have a greater amount of innovation output (the number of patents), yet no discernible difference in quality (the number of citations per patent) than their rational peers.

One caveat of this study is a failure to account explicitly for the self-selection of overconfident CEOs into innovative firms. I do find there are more overconfident CEOs in innovative industries, for example, in the computer and electronic product manufacturing industry. I address this issue by including industry fixed effects and firm fixed effects, which should alleviate this concern to some extent.

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[12] I use five measures (payout rate, assets, sales, tangibility and KZ index) to identify firms with financial constraints.

[13] I measure the innovativeness of firms in three ways. The first measurement is R&D expenditure divided by the sum of R&D expenditure and capital expenditure. The second is R&D expenditure normalized by assets at the beginning of the year. The third is by categorizing firms as innovative if they fall into the computer and electronic product manufacturing industry and the medical and pharmaceutical industry based on the Fama-French 12 industries index. The estimated results are very similar.

Similarly, there might be a concern that R&D performing firms are a self-selected group of firms which do not face liquidity constraints. If this were true, it would inflate the innovation input results but bias the R&D expenditure-cash flow sensitivity results in a downward direction. However, I still find a significant effect of CEO overconfidence on liquidity management in firms with the highest level of innovative input and on R&D expenditure-cash flow sensitivity, which suggests my results are not likely to be driven by self-selection issues.

This paper is closely related to findings in Malmendier, Tate and Yan (2011), Galasso and Simcoe (2011) and Hirshleifer, Low and Teoh (2012). However, it differs from these contributions in several ways. Malmendier, Tate and Yan (2011) empirically test the preference of overconfident CEOs for debt financing versus equity financing, conditional on accessing external capital markets. For their study, they use a panel of Forbes 500 firms from 1980 to 1994 and their findings are consistent with the predicted pecking-order preference for overconfident CEOs. However, the impact of managerial overconfidence on a firm's internal capital management remains untested. This paper advances the literature by testing how managerial overconfidence impacts a firm's internal liquidity management, but not how a firm chooses among external financing means. Galasso and Simcoe (2011) and Hirshleifer, Low and Teoh (2012) focus on the innovation performance of overconfident CEOs. My paper explores the impact of managerial overconfidence on internal financing and addresses the concern that CEO overconfidence will increase the dependence of innovation input on internal capital. In addition, when analyzing firm innovation input, I take account of a firm's choice between alternative uses of funds. I construct a ratio defined as R&D expenditure divided by the sum of R&D expenditure and capital expenditure and examine how managerial overconfidence affects the composition of firm investment.

The remainder of this paper is organized as follows. Section I lists the empirical predictions. Section II describes the data. Section III presents the empirical findings for financial policies. Section IV presents the empirical findings for investment, innovations and acquisition decisions. Section V concludes.

I. Empirical Predictions

Previous literature provides a theoretical foundation for how managerial overconfidence might affect corporate financial policies. Malmendier, Tate and Yan (2011) develop a formal model in their online appendices which predicts that overconfident CEOs have more pronounced pecking-order preferences for financing. Overconfident managers overestimate the future payoffs of their investments. Therefore, they mistakenly believe external capital markets undervalue the present value of their firms. The cost of external financing is incorrectly perceived to be higher than what is appropriate and the cost of internal financing is relatively cheaper than that of external financing. Malmendier, Tate and Yan (2011) empirically find that, conditional on accessing external capital markets, overconfident CEOs prefer debt financing to equity financing.[14] However, the theoretical and empirical implications of an overconfident manager's desire for internal capital have not been tested.

It is logical to expect the preference for internal capital by an overconfident CEO will affect firm liquidity management. Almeida, Campello and Weisbach (2004) find that financial

[14] Since differing evaluations of firm value between overconfident managers and the market affects all states in the case of equity financing but only default states for debt financing, conditional on access to external markets, overconfident managers tend to prefer debt financing to equity financing (Malmendier, Tate and Yan (2011)).

constraints are associated with a firm's propensity to save cash out of cash flows, which is referred to as the cash flow sensitivity of cash. Firms anticipating financing constraints in the future will hoard cash today, though holding cash is costly because saving more today reduces current valuable investments. Almeida, Campello and Weisbach (2004) produce a model which finds that financially constrained firms tend to have a positive cash flow sensitivity of cash. In contrast, an unconstrained firm's changes in cash holdings should depend neither on current cash flows nor on future investment opportunities and thus should not exhibit a systematic propensity to save. When one observes that a firm's cash flow sensitivity of cash varies systematically with proxies for financial constraints, it indicates the existence of financial constraints.

Given that overconfident managers have a higher demand for internal capital, ceteris paribus, they are more likely to perceive liquidity constraints than their rational peers. When anticipating future liquidity constraints, overconfident managers will respond to the potential constraints by saving cash out of cash flows today, though it reduces part of firm investment today. In contrast, rational managers are more willing to fund valuable investments with external capital and will not exhibit systematic saving behavior if there is no financial constraint. Therefore, managerial overconfidence will increase the cash flow sensitivity of cash. The relevant predictions are as follows:

Prediction 1: Overconfident managers have a higher level of cash flow sensitivity of cash than their rational peers.

In addition, it is logical to expect that the more important the liquidity constraint, the greater the effect. The cash flow sensitivity of cash caused by overconfident managers should vary with firm liquidity constraints.

Prediction 2: The impact of managerial overconfidence on cash flow sensitivity of cash is more significant in firms with liquidity constraints but not in firms without liquidity constraints.

At the same time, given that firm R&D expenditures rely more on internal capital, I also expect that investment compositions will play a role: in highly innovative firms, the impact of overconfident managers on cash flow sensitivity of cash should be more prominent.

Prediction 3: The impact of managerial overconfidence on cash flow sensitivity of cash is more significant in innovative firms.

For innovation input, overconfident managers overestimate future payoffs from investment projects (Malmendier and Tate (2005); Galasso and Simcoe (2011); Hirshleifer, Low and Teoh (2012)). This effect is larger when outcomes of investment projects are more risky and require more personal effort by CEOs (Hirshleifer, Low and Teoh (2012)). Therefore, overconfident managers tend to have greater R&D expenditure in their investment composition. Conditional on an amount of total investment, I expect overconfident managers will choose a higher share of R&D expenditure.

Prediction 4: Overconfident managers have a higher R&D share of total investment than their rational peers.

However, given that R&D projects rely heavily on internal capital or equity financing (Hall (2002); Hall and Lerner (2010)), overconfident managers are more reluctant to fund innovation with external financing as they mistakenly believe the cost of external financing is inappropriately high (Malmendier and Tate (2005, 2008); Malmendier, Tate and Yan (2011)). They tend to forgo some innovation projects when internal capital is not sufficient. Therefore, the R&D expenditure of overconfident managers will vary with cash flows. In contrast, rational managers always invest at the first best. The R&D expenditure of rational managers will not

systematically depend on cash flows. Similar to the model of Malmendier and Tate (2005), I derive the following prediction:

Prediction 5: Overconfident managers have a higher level of R&D expenditure-cash flow sensitivity than their rational peers.

II. Data

A. Longholder_Thomson Measure

To measure CEO overconfidence, I follow Malmendier, Tate and Yan (2011) by replicating their "Longholder_Thomson" measure, which is based on the timing of option exercise. It originates from a benchmark model produced by Malmendier and Tate (2005) which analyzes the option exercise behavior of managers. Based on the model, the optimal timing for option exercise depends on individual wealth, degree of risk aversion and diversification. In general, risk-averse rational managers facing under-diversification problems generally choose to exercise options early when possible. For CEOs and other top managers, trading of granted options and short-selling of company stock are prohibited. Holding stock and option grants will leave CEOs highly exposed to idiosyncratic firm risks. However, overconfident managers overestimate the future performance of their firms. Therefore, they tend to postpone the exercise of in-the-money options to tap future profit.

Based on the benchmark model, Malmendier and Tate (2005) construct a dummy variable called "Longholder" as a proxy for managerial overconfidence, where 1 signifies the overconfident manager at some point of his tenure held an option until the last year before expiration, given the option was at least 40% in-the-money, and 0 otherwise. They use CEO option-package-level data from a panel of 477 Forbes 500 firms from 1980 to 1994 to identify CEO option exercise. The Longholder_Thomson measure in Malmendier, Tate and Yan (2011) has the same definition as the Longholder measure but uses the Thomson Insider Trading database to identify CEO option exercise for the years 1992 to 2007. I follow Malmendier, Tate and Yan (2011) in constructing the Longholder_Thomson measure for the years 1996 to 2010. The control group consists of managers for whom at least one option exercise is observed in the Thomson database but who do not meet the criteria of overconfidence.

The Thomson Insider Trading database contains forms 3, 4 and 5 reported by insiders to the SEC. Table II of the Thomson Insider Trading database reports derivative data including option exercise records, which illustrates reports from SEC Form 4 since 1996. I drop those records which are an amendment to previous records and keep only those records with a very high degree of confidence (a cleanse indicator assigned by Thomson of R, H or C) or a reasonably high degree of confidence (a cleanse indicator assigned by Thomson of L or I). I further drop records where the maturity date of the option is earlier than the exercise date, which is an obvious error. I also drop records with missing exercise dates as I cannot calculate the days remaining until maturity for these cases. To exclude extreme outliers, I keep only those records for which the exercise price of the option is within the range of 0.1 to 1000. I retrieve stock price data from CRSP to calculate the in-the-moneyness for each option. I use the Execucomp database to identify the tenure information, stock ownership and option holdings for CEOs in the Thomson database. Therefore, my firm sample is contained in the intersection of the Execucomp database and the Thomson database, which is a subset of S&P 1500 U.S. firms including small, medium and large cap firms from 1996 to 2010.

B. Alternative Interpretations

I address some alternative interpretations of the Longholder_Thomson measure and their implications for the predictions tested in this paper.

Procrastination. Since the Longholder_Thomson overconfidence measure reflects a systematic tendency of managers to delay option exercise, there might be concern that managers hold exercisable options until expiration due to "inertia" or "procrastination". However, I find that 80% of overconfident CEOs have stock and derivative transaction records for the year prior to the year when options expire. In addition, a truly "inertial" manager should not allocate more resources to risky and innovative projects. However, I find that overconfident CEOs have a higher R&D share of total investment. They also systematically generate more patents.

Insider Information. Managers who delay option exercise might seek to profit from these option holdings through insider information about future stock prices. Only positive insider information about stock price will make managers hold options until expiration. However, positive insider information is more likely to be transitory than persistent. Overconfident CEOs are those people who hold exercisable options for about five years. The persistency of this behavior is not consistent with the transitory nature of positive insider information. Whether overconfident mangers earn positive abnormal returns from "Longhold" transactions should help draw a distinction between overconfidence and insider information. Therefore, I check whether overconfident CEOs indeed profit from holding options until expiration ("Longhold" transactions). I calculate the actual returns of those "Longhold" transactions. Then I calculate hypothetical returns from exercising these options 1, 2, 3, or 4 years earlier and investing in the S&P 500 Index until these options were actually exercised. I find that 45%-47% of the "Longhold" transactions do not earn positive abnormal returns.[15] Therefore, overconfident managers on average do not beat the S&P 500 index by holding in-the-money options until expiration.

Signaling. Though overconfident managers do not make abnormal returns from holding options until expiration, which rules out the insider information story, another concern remains. A manager might use the holding of exercisable options until expiration as a costly signal to outside investors that the prospects of a firm are more promising than that of other firms. However, under the signaling story, the problem of informational asymmetries between a firm and outside investors should be alleviated. By conveying the good quality of firms to capital markets, managers who wait to exercise in-the-money options until expiration should not have a heightened R&D expenditure-cash flow sensitivity or a heightened cash flow sensitivity of cash. However, the results of this paper are difficult to reconcile with this explanation.

Risk Tolerance. One might argue that the Longholder_Thomson overconfidence measure reflects a persistent tendency of managers to hold company risk because they have greater risk tolerance. It is natural to expect that a risk-seeking manager would allocate more resources to innovation projects and have greater innovation performance. However, risk tolerance does not predict aversion to external markets and thus a heightened cash flow sensitivity of cash or a heightened R&D expenditure-cash flow sensitivity. My results are also difficult to reconcile with this interpretation.

C. Sample

For firm variables, I obtain financial data from Compustat. I drop financial firms and regulated utilities (SIC codes 6000 - 6999 and 4900 - 4999) and use changes in cash and cash equivalents to measure savings out of cash flow. Cash flow is earnings before extraordinary

[15] Abnormal returns are actual returns minus hypothetical returns.

items plus depreciation. The innovation input is measured in two ways. The first is R&D share, which is defined as R&D expenditure divided by the sum of R&D expenditure and capital expenditure. The second is R&D intensity, which is defined as R&D expenditure divided by assets at the beginning of the year. The set of firm-level control variables are similar to previous innovation literature, which include q, size, intensity and tangibility. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Size is the natural logarithm of sales. Intensity is the natural logarithm of one plus assets divided by the number of employees. Tangibility is property, plants and equipment divided by assets at the beginning of the year. I keep firms with available R&D data. I drop one observation which has an extreme cash-flow value.[16]

After combining firm-level variables and manager-level variables, I obtain a panel of 1,015 S&P 1500 firms from 1996 to 2010. In an extension test that examines innovation performance, I retrieve patent counts and citation data from the NBER patent database from 1996 to 2006. Compared to the sample of Forbes 500 firms from 1980 to 1994 used in Galasso and Simcoe (2011), my sample covers a different time period and includes small and medium firms in addition to large firms. My sample also differs from Hirshleifer, Low and Teoh (2012). The main purpose of Hirshleifer, Low and Teoh (2012) is to test the innovation performance of overconfident CEOs. Their sample period is from 1993 to 2003 due to the availability and potential truncation problems of NBER patent database. In addition, my overconfidence measure, Longholder_Thomson, is different from the Holder67 measure used in both of Galasso and Simcoe (2011) and Hirshleifer, Low and Teoh (2012), even though these two measures are both constructed by Malmendier and Tate (2005). Hence my tests also serve to check the robustness of existing empirical findings and overconfidence measures. Table I reports summary statistics for firms and CEOs.

III. Overconfidence and Innovation Financing

A. Cash Flow Sensitivity of Cash

Following the empirical framework of Almeida, Campello and Weisbach (2004), I use the following specification to test whether overconfident CEOs have a higher propensity to save cash out of cash flow (Prediction 1):

$$\Delta \text{Cash}_{it} = \beta_1 + \beta_2 \text{CF}_{it} + \beta_3 \text{LTCEO}_{it} + \beta_4 \text{LTCEO}_{it} * \text{CF}_{it} + \text{X}_{it}\text{'B} + \varepsilon_{it} \quad (1)$$

ΔCash is changes in cash and cash equivalents normalized by assets at the beginning of the year. CF is cash flow (earnings before extraordinary items plus depreciation) normalized by assets at the beginning of the year. LTCEO is the Longholder_Thomson measure for CEO overconfidence. X is a set of control variables. At the CEO-level, I control for stock ownership and vested options, both as a percentage of common shares outstanding. The firm-level control variables include q, size, capital intensity and tangibility. A major concern in the related investment–cash flow literature is that cash flow might contain unobservable information of investment opportunities of the firm. If not controlling for the investment opportunity, a positive relationship between investment expenditure and cash flow will arise even without financial constraints. However, my specification is less likely to be affected by this concern. If there were no financial constraints, changes in cash holdings of firms would not depend on current cash

[16] I drop an outlier, of which the value of cash flow normalized by assets at the beginning of the year is less than -7.

flows or future investment opportunities (Almeida, Campello and Weisbach (2004)). I also include year fixed effects and firm fixed effects. The firm fixed effects help to remove the time-invariant firm effects.

Table II reports the results of Specification 1. Column 1 is a baseline regression which only includes cash flow, the CEO overconfidence measure and its interacted effect with cash flow. The coefficient of the interaction of CEO overconfidence and cash flow is positive and significant at the 5% level (coefficient=0.317, p-value=0.039), which suggests that overconfident CEOs will save around 32% more than their rational peers out of each unit of additional cash flow (normalized by assets at the beginning of the year). From columns 2 to 4, I gradually add firm-level control variables, CEO-level control variables, year fixed effects and industry fixed effects to the baseline regression. The estimated results are largely robust. In column 4, after adding firm-level control variables, CEO-level control variables, year fixed effects and industry fixed effects, the coefficient of the interaction of CEO overconfidence and cash flow is reduced to 0.267 (p-value=0.04) but is still significant at the 5% level. For the regressions from column 5 to column 8, I control for firm fixed effects. Adding firm fixed effects helps differentiate the time-invariant CEO overconfidence effect from the time-invariant firm effects. After controlling for firm fixed effects, the estimated effect of managerial overconfidence on cash flow sensitivity of cash becomes more prominent. Column 5 is the baseline regression with firm fixed effects, which only includes cash flow, the CEO overconfidence measure and its interacted effect as well as firm fixed effects. The coefficient of the interaction of CEO overconfidence and cash flow increases to 0.430, significant at the 5% level (p-value=0.036). In column 8, where firm-level control variables, CEO-level control variables, year fixed effects and firm fixed effects are included, the coefficient of the CEO overconfidence measure interacted with cash flow is 0.349, significant at the 5% level (p-value=0.037). Overall, the estimated effects of CEO overconfidence on cash flow sensitivity of cash vary between 0.267 and 0.430 and are all significant at the 5% level, which implies that overconfident CEOs will save around 27% to 43% more than their rational peers out of each unit of additional cash flow (normalized by assets at the beginning of the year).

B. Extension One: Liquidity Constrained Firms

To test whether the effect of managerial overconfidence on cash flow sensitivity of cash will be amplified by liquidity constraints (Prediction 2), I separate firms according to priori measures of liquidity constraints traditionally used in the literature. However, given the ongoing debate concerning the validity of particular measures, it is difficult to claim which measure is most preferable. To avoid sample selection problems, I use the following five alternative approaches to split sample and present all results. First, I sort firms according to their annual dividend payout ratio, defined as cash dividend normalized by sales at the beginning of the year. Firms in the bottom (top) two deciles are classified as liquidity constrained (unconstrained). This approach is based on the empirical findings of Fazzari, Hubbard and Petersen (1988). Next, following Gilchrist and Himmelberg (1995), I relate liquidity constrains with firm size. Hence in the second and third approach, I sort firms based on the natural logarithm of assets and the natural logarithm of sales respectively. Firms in the bottom (top) two deciles are classified as liquidity constrained (unconstrained). Then, I sort firms according to their tangibility of assets (defined as property, plants and equipment divided by assets at the beginning of the year). Firms in the bottom (top) two deciles are classified as liquidity constrained (unconstrained). Finally, I reconstruct the KZ index found in Kaplan and Zingales (1997) using the following equation:

$$\text{KZ Index} = -1.002 * \text{Cash Flow} + 0.283 * \text{Q} + 3.139 * \text{Leverage} - 39.368 * \text{Dividends} - 1.315 * \text{Cash Holdings}$$

I sort firms according to their annual KZ index. Firms in the top (bottom) two deciles are classified as liquidity constrained (unconstrained).

The following table summarizes the construction of measures.

No.	Measure	Definition	Constrained	Unconstrained
1	**Payout Ratio**	cash dividends normalized by sales at the beginning of the year	bottom 20%	top 20%
2	**Assets**	natural logarithm of assets	bottom 20%	top 20%
3	**Sales**	natural logarithm of sales	bottom 20%	top 20%
4	**Tangibility**	property plants and equipment divided by assets at the beginning of the year	bottom 20%	top 20%
5	**KZ Index**	see above equation	top 20%	bottom 20%

Panel A to Panel E of Table III display results of estimations of Specification 1 with firm-fixed-effects within each of the above five sample splits. The left hand side of each panel show results for firms classified as liquidity constrained while the right-hand side displays results for unconstrained firms. Overall, the results are consistent with Prediction 2. I find that in each of the five approaches, only overconfident CEOs in firms with liquidity constraints have significantly positive cash flow sensitivity of cash, yet not in firms without liquidity constraints. The size of the estimated effect based on the constrained sample becomes greater than that based on the full sample. Compared to the estimated effect of CEO overconfidence on internal saving using the full sample (coefficient=0.349, p-value=0.037, controlling for CEO-level variables, firm-level variables, year fixed effects and firm fixed effects), the estimated effect of CEO overconfidence on internal saving using constrained firms based on payout ratio increases the most (coefficient=0.733, p-value=0.013, controlling for CEO-level variables, firm-level variables, year fixed effects and firm fixed effects). But the estimated effect of CEO overconfidence using constrained firms based on the KZ index only increase a little (coefficient =0.377, p-value= 0.053, controlling for CEO-level variables, firm-level variables, year fixed effects and firm fixed effects). For the remaining three approaches, based on firm size and tangibility, the estimated coefficients of CEO overconfidence interacted with cash flow are also significantly positive, with coefficients varying between 0.508 and 0.567. They are robust when controlling for CEO-level variables, firm-level variables, year fixed effects and firm fixed effects. Turning to firms classified as unconstrained, I do not find a positive cash flow sensitivity of cash for overconfident CEOs or rational CEOs, which is consistent with findings by Almeida, Campello and Weisbach (2004). The results of Table III suggest that in firms with liquidity constraints, overconfident CEOs will save 38% to 73% more than their rational peers out of each unit of additional cash flow (normalized by assets at the beginning of the year).

C. Extension Two: Innovative Firms

To test whether overconfident CEOs in innovative firms have a more prominent cash flow sensitivity of cash (Prediction 3), I use three methods to identify innovative firms. The first method is based on industry classification. I construct the Fama-French 12 industries index for the full sample. Given that my sample excludes the utility and financial service industries, I sort

the remaining 10 industries according to their average R&D expenditure (normalized by assets at the beginning of the year). The top two industries are the computer and electronic production manufacturing industry and the medical and pharmaceutical industry. Therefore, I classify firms in these two industries as innovative firms. Next, I sort firms based on their R&D intensity (defined as R&D expenditure normalized by assets at the beginning of the year) and classify the top two deciles as innovative firms. Finally, I sort firms based on their R&D share, defined as R&D expenditure divided by the sum of R&D expenditure and capital expenditure. The top two deciles are classified as innovative firms.

Table IV contains the results for estimations of Specification 1 with firm-fixed-effects using subsamples of innovative firms. The results confirm that overconfident CEOs in innovative firms have a significantly positive cash flow sensitivity of cash. The coefficients of the CEO overconfidence measure interacted with cash flow vary between 0.451 and 0.579, which are greater than the coefficient estimated from the full sample (coefficient =0.317, p-value=0.039). These estimated coefficients are all significant at the 5% level, robust when controlling for CEO-level control variables, firm-level control variables, year fixed effects and firm fixed effects. It suggests that overconfident CEOs in innovative firms have a higher propensity to save than average overconfident CEOs.

IV. Overconfidence and Innovation Investment

A. R&D Shares and CEO Overconfidence

To test whether overconfident CEOs have a higher R&D share of total investment than their rational peers (Prediction 4), I use the following specification:

$$\text{RD Share}_{it} = \beta_1 + \beta_2 \text{LTCEO}_{it} + X_{it}'B + \varepsilon_{it} \quad (2)$$

RD Share is defined as R&D expenditure divided by the sum of R&D expenditure and capital expenditure. It measures the innovativeness of firm investment. LTCEO is the overconfidence measure for CEOs. X is a set of control variables including CEO stock ownership, CEO vested options, q, size, capital intensity, tangibility, year fixed effects, industry fixed and firm fixed effects.

Table V contains the estimation results for Specification 2. I find that overconfident CEOs have more innovative investment compositions. Overall, overconfident CEOs have approximately two percent more R&D shares than rational CEOs. The effect is robust when controlling for CEO stock ownership, CEO vested options, q, size, capital intensity, tangibility, year fixed effects and industry fixed effects. However, the estimated coefficient of CEO overconfidence becomes insignificant (column 5) when adding firm fixed effects. With regards to control variables, firms with high values of q have more innovative investment compositions. Small firms also have a higher share of R&D expenditure.

Alternatively, I replace the dependent variable of Specification 2 with R&D expenditure normalized by assets at the beginning the year and test whether CEO overconfidence increases firm R&D expenditure. But I fail to find this result. The results for the innovativeness of investment suggest that overconfident CEOs would like to invest more in R&D projects than their rational peers. However, results for the R&D expenditure suggest that overconfident CEOs are not free to choose a high level of R&D expenditure. One possible explanation is that overconfident CEOs perceive a larger gap between internal capital and external capital. In contrast, R&D share is less affected by the availability of funding. Overconfident CEOs might

allocate resources from capital expenditure to R&D expenditure when constrained. Therefore, we do not observe a greater amount of R&D investment for overconfident CEOs, but a more innovative composition of total investment. To further examine this explanation, the following section tests the relationship between CEO overconfidence and R&D expenditure-cash flow sensitivity.

B. R&D Expenditure-Cash Flow Sensitivity and CEO Overconfidence

To test whether overconfident CEOs have a significantly positive R&D expenditure-cash flow sensitivity (Prediction 5), I use the following specification, which is similar to that used by Malmendier and Tate (2005):

$$\text{RD Intensity}_{it} = \beta_1 + \beta_2 CF_{it} + \beta_3 LTCEO_{it} + \beta_4 LTCEO_{it} * CF_{it} + X_{it}'B + C_{it} * X_{it}'B + \varepsilon_{it} \quad (3)$$

RD Intensity is R&D expenditure normalized by assets at the beginning of the year. CF is cash flows (earnings before extraordinary items plus depreciation) normalized by assets at the beginning of the year. LTCEO is the Longholder_Thomson measure for CEO overconfidence. X is a set of control variables similar to the literature, which includes CEO stock ownership, CEO vested options, q, size, year fixed effects and firm fixed effects. Ideally, to identify the effects of cash flows on overconfident CEOs' R&D expenditure requires exogenous cash flow shocks. Such exogenous cash flow shocks allow us to observe whether overconfident CEOs use more of the additional cash for R&D investment than their rational peers. However, due to the lack of exogenous experiments of this type, I use lagged CEO-level and firm-level control variables as instrumental variables. I also add firm fixed effects to control for endogeneity. However, this approach still suffers from the same difficulties and critiques in the related investment-cash flow sensitivity literature originated by Fazzari, Hubbard, and Petersen (1988).[17] The tendency of firms to smooth R&D spending over time might further confound the results.

Table VI contains the results when estimating Specification 3. I find that overconfident CEOs have a more pronounced R&D expenditure-cash flow sensitivity. Column 1 is a baseline regression, which only includes cash flow, the overconfidence measure and its interaction with cash flow. The coefficient for CEO overconfidence interacted with cash flow is 0.172 and significant at the 5% level (p-value=0.024). This indicates that for one unit increase in cash flow, overconfident CEOs will spend 17% more on R&D expenditure than their rational peers. Column 2 adds firm level control variables, q and size, to the baseline regression. Column 3 shows the results when CEO-level control variables are added. The results remain robust. Column 4 introduces a full set of control variables including CEO stock ownership, CEO vested options, q, size, year fixed effects and industry fixed effects. The estimated effect of managerial overconfidence on sensitivity is quite robust (coefficient = 0.130, p-value=0.036). In columns 5 through 8, I control for firm fixed effects and gradually add a series of control variables. Compared to the results from column 1 to column 4, the firm-fixed-effects estimations are similar in size and are all significant. The firm fixed effects estimator for CEO overconfidence interacted with cash flow is 0.124 (Table V, Column 8) and significant at the 10% level (p-value=0.078). These results are robust when controlling for CEO stock ownership, CEO vested options, q, size, year fixed effects and firm fixed effects. This suggests that with one unit

[17] See the critiques by Kaplan and Zingales (1997) and the corresponding response by Fazzari, Hubbard, and Petersen (2000).

increase in cash flow, overconfident CEOs spend 12% more on R&D expenditure than their rational peers. Overall, the results confirm that overconfident CEOs have a significantly positive R&D expenditure-cash flow sensitivity, which is consistent with Prediction 5 and the findings of Galasso and Simcoe (2011).

C. Innovation Performance and CEO Overconfidence

Whether managerial overconfidence increases or destroys firm value is ultimately an empirical question rather than a theoretical one. Researchers have expressed concern with regards to the negative repercussions of managerial overconfidence. Malmendier and Tate (2005) find that CEO overconfidence increases investment distortions. Additionally, Malmednier and Tate (2008) find overconfident CEOs tend to conduct more value-destroying mergers and acquisitions. However, in the context of innovation, Galasso and Simcoe (2011) and Hirshleifer, Low and Teoh (2012) find that overconfident managers have better innovation performance in certain industry groups. I use the following specification to test the impact of CEO overconfidence on innovation output.

$$\text{Innovation Performance}_{it} = \beta_1 + \beta_2 \text{LTCEO}_{it} + X_{it}'B + \varepsilon_{it} \quad (4)$$

I use patent counts and the average citations per patent to measure the quantitative dimension and qualitative dimension of innovation performance respectively. Given the truncation bias of the patent citation data, the raw number of citations for each patent is multiplied by an adjusted weight from Hall, Jaffe, and Trajtenberg (2001, 2005). To calculate the average citations, the adjusted number of citations for each patent is averaged at firm-year level. To account for the non-negative and highly skewed nature of dependent variables, the natural logarithm of the patent counts and average citations are used as dependent variables. LTCEO is the CEO overconfidence measure. X is a set of control variables including stock ownership, CEO vested options, size, capital intensity, year fixed effects and industry fixed effects.

Table VII includes the results of poisson estimators for Specification 4. On the one hand, I find that overconfident CEOs produce more patents than their rational peers. The dependent variable used in columns 1 to 3 is the number of patents. Column 1 is a baseline regression which only includes the CEO overconfidence measure, the year fixed effects and the industry fixed effects. The estimated coefficient is 0.127 and is significant at the 10% level. The exponential indicates that firms with overconfident CEOs have approximately 14% more patents than firms with non-overconfident CEOs. Column 3 adds CEO-level and firm-level control variables to the baseline regression. The estimated effect is reduced to 0.095, but is still significant at the 10% level. This suggests that overconfident CEOs produce an estimated 10% more patents than their rational peers. This finding is consistent with that of Galasso and Simcoe (2011) and Hirshleifer, Low and Teoh (2012).

On the other hand, turning to the quality of patents, the evidence that CEO overconfidence increases innovation performance is less clear. The dependent variable used in columns 4 to 6 is the average number of citations per patent for each firm-year. I do not find that firms with overconfident CEOs have a higher average number of citations per patent, which is not consistent with Galasso and Simcoe (2011). A possible explanation is that my sample differs from the sample used in Galasso and Simcoe (2011). My sample for Specification 4 covers small, medium and large cap firms from 1996 to 2006 while their sample covers large firms from 1980 to 1994.

To sum up, evidence on the relationship between CEO overconfidence and innovation performance is mixed. Firms with overconfident CEOs have a larger number of patents, but their average number of citations per patent is not statistically distinguishable from that of firms with rational CEOs.

V. Conclusion

This paper examines how overconfident CEOs allocate resources to innovation activities. It first analyzes how overconfident CEOs manage internal liquidity and how internal liquidity affects innovation input. With respect to liquidity management, CEO overconfidence is positively associated with cash flow sensitivity. The effect is larger when firms have financial constraints or when firms have a more innovative composition of investment. I also find that CEO overconfidence increases R&D expenditure-cash flow sensitivity. Firms with overconfident CEOs do not have a greater R&D intensity regardless of cash flows, but I do find that, conditional on an amount of total investment, firms with overconfident CEOs have a higher R&D share of total investment. These empirical findings are largely consistent with the existing literature of managerial overconfidence. Additionally, this paper also fills a gap in the existing literature by determining that the impact of managerial overconfidence on innovation input varies subtly with firm liquidity constraints: In order to innovate more, overconfident CEOs tend to save more out of cash flow and adjust R&D expenditure with variations in cash flow. However, whether CEO overconfidence improves firm innovation performance is still in question. On the one hand, overconfident CEOs have higher patent output volumes. On the other hand, the average number of patent citations produced by overconfident CEOs is not significantly different from those of rational CEOs, which suggests that the quality of patents applied by overconfident CEOs is similar to those applied by their rational peers. Nevertheless, the findings of this paper confirm that managerial overconfidence has an important impact on firm innovation activities in terms of financing, investment and performance.

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Table I. Summary Statistics

R&D shares is defined as R&D expenditure divided by the sum of R&D expenditure and capital expenditure. Cash flow is earnings before extraordinary items plus depreciation. Q is the book value of assets plus market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Capital intensity is the natural logarithm of one plus assets divided by the number of employees. Tangibility is property, plants and equipment divided by assets at the beginning of the year. The number of firms is 1,015.

Panel A. Firm Variables (Full Sample)

Variables	Obs.	Mean	Median	SD
Asset($m)	6754	6042.44	1104.31	29761.65
Sales($m)	6754	5150.78	1104.94	15576.37
Capital($m)	6754	1466.97	224.37	5719.19
Capital expenditure($m)	6754	261.26	46.81	1001.68
Capital expenditure/assets(t-1)	6754	0.06	0.04	0.06
R&D expenditure($m)	6754	182.32	27.69	628.63
R&D expenditure/assets(t-1)	6754	0.06	0.03	0.09
R&D shares	6754	0.42	0.42	0.32
Cash flow($m)	6754	582.07	107.54	2206.88
Cash flow/assets(t-1)	6754	0.11	0.12	0.14
Changes in cash and cash equivalents($m)	6754	52.08	5.68	690.24
Changes in cash and cash equivalents/assets(t-1)	6754	0.02	0.01	0.14
Q	6754	2.47	1.85	2.68
ln(Sales)	6754	7.03	6.92	1.67
Capital intensity	6754	5.44	5.46	0.94
Tangibility	6754	0.28	0.23	0.22

Table I. Summary Statistics

R&D shares is defined as R&D expenditure divided by the sum of R&D expenditure and capital expenditure. Cash flow is earnings before extraordinary items plus depreciation. Q is the book value of assets plus market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Capital intensity is the natural logarithm of one plus assets divided by the number of employees. Tangibility is property, plants and equipment divided by assets at the beginning of the year. The number of firms with overconfident CEOs is 546. The number of firms with non-overconfident CEOs is 594.

Panel B. Firms with Overconfident CEOs

Variables	Obs.	Mean	Median	SD
Asset($m)	3659	7140.98	1230.85	37220.78
Sales($m)	3659	5856.28	1254.89	16110.90
Capital($m)	3659	1556.82	291.95	5743.72
Capital expenditure($m)	3659	296.07	56.60	1052.57
Capital expenditure/assets(t-1)	3659	0.06	0.04	0.06
R&D expenditure($m)	3659	229.87	27.70	765.87
R&D expenditure/assets(t-1)	3659	0.06	0.03	0.08
R&D shares	3659	0.41	0.41	0.31
Cash flow($m)	3659	725.59	129.89	2345.33
Cash flow/assets(t-1)	3659	0.12	0.12	0.11
Changes in cash and cash equivalents($m)	3659	68.42	5.39	883.95
Changes in cash and cash equivalents/assets(t-1)	3659	0.02	0.01	0.13
Q	3659	2.46	1.93	2.05
ln(Sales)	3659	7.16	7.04	1.66
Capital intensity	3659	5.39	5.42	0.97
Tangibility	3659	0.30	0.24	0.23

Panel C. Firms with Non-Overconfident CEOs

Variables	Obs.	Mean	Median	SD
Asset($m)	3095	4743.70	957.29	17094.46
Sales($m)	3095	4316.72	956.83	14879.23
Capital($m)	3095	1360.73	174.23	5689.16
Capital expenditure($m)	3095	220.11	38.28	936.46
Capital expenditure/assets(t-1)	3095	0.06	0.04	0.06
R&D expenditure($m)	3095	126.10	27.68	403.96
R&D expenditure/assets(t-1)	3095	0.07	0.03	0.10
R&D shares	3095	0.43	0.44	0.32
Cash flow($m)	3095	412.39	85.44	2018.30
Cash flow/assets(t-1)	3095	0.10	0.11	0.18
Changes in cash and cash equivalents($m)	3095	32.76	6.09	339.67
Changes in cash and cash equivalents/assets(t-1)	3095	0.03	0.01	0.16
Q	3095	2.49	1.75	3.28
ln(Sales)	3095	6.87	6.79	1.67
Capital intensity	3095	5.50	5.51	0.89
Tangibility	3095	0.26	0.21	0.21

Table I. Summary Statistics

Stock Ownership is the option-excluded shares held by CEOs as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by CEOs as a percentage of common shares outstanding. Overconfident CEOs are CEOs who at some point during their tenure held exercisable options until the last year before expiration, given that these options were at least 40% in the money upon entering their last year.

Panel D. CEO Variables

	Full Sample			
	Number of CEOs = 1337			
Variables	Obs.	Mean	Median	SD
Stock Ownership (%)	6754	2.002	0.326	5.428
Vested Options (%)	6754	1.015	0.636	1.360
	Overconfident CEOs			
	Number of Overconfident CEOs = 628			
Variables	Obs.	Mean	Median	SD
Stock Ownership (%)	3659	1.898	0.404	4.391
Vested Options (%)	3659	1.088	0.703	1.336
	Non-Overconfident CEOs			
	Number of Non-Overconfident CEOs = 711			
Variables	Obs.	Mean	Median	SD
Stock Ownership (%)	3095	2.125	0.263	6.441
Vested Options (%)	3095	0.928	0.556	1.382

Table II Cash Flow Sensitivity of Cash and CEO Overconfidence

The dependent variable is change in cash and cash equivalents normalized by assets at the beginning of the year. Cash Flow is earnings before extraordinary items plus depreciation. LTCEO is the Longholder_Thomson overconfidence measure, which is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in the money upon entering their last year. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Capital Intensity is the natural logarithm of one plus assets divided by the number of employees. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Stock Ownership, Vested Options, Q, ln(Sales), Capital Intensity and Tangibility are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash Flow	0.317**	0.271**	0.270**	0.267**	0.430**	0.290**	0.349**	0.349**
	(0.153)	(0.131)	(0.131)	(0.130)	(0.205)	(0.138)	(0.173)	(0.168)
LTCEO	-0.041**	-0.034**	-0.034**	-0.033**	-0.060**	-0.036**	-0.054**	-0.048**
	(0.016)	(0.014)	(0.014)	(0.014)	(0.027)	(0.015)	(0.023)	(0.021)
LTCEO*Cash Flow	-0.117	-0.106	-0.106	-0.106	-0.073	-0.102	-0.088	-0.086
	(0.141)	(0.131)	(0.131)	(0.132)	(0.188)	(0.136)	(0.167)	(0.163)
Q		0.012***	0.012***	0.012***		0.012***	0.014***	0.013***
		(0.003)	(0.003)	(0.003)		(0.003)	(0.004)	(0.003)
ln(Sales)		-0.005***	-0.005***	-0.005***		-0.005***	0.004	-0.021
		(0.001)	(0.001)	(0.001)		(0.001)	(0.009)	(0.014)
Capital Intensity		-0.004	-0.004	-0.005		-0.006	-0.068***	-0.093***
		(0.004)	(0.004)	(0.004)		(0.004)	(0.013)	(0.018)
Tangibility		-0.030***	-0.030***	-0.027**		-0.033**	-0.052	-0.023
		(0.012)	(0.012)	(0.013)		(0.014)	(0.032)	(0.034)
Stock Ownership			0.000	0.000			0.001	0.001
			(0.000)	(0.000)			(0.001)	(0.001)
Vested Options			0.001	0.001			0.004	0.002
			(0.001)	(0.001)			(0.003)	(0.003)
Year Fixed Effects	No	No	No	Yes	No	No	No	Yes
Industry Fixed Effects	No	No	No	Yes	No	No	No	No
Firm Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	6754	6754	6754	6754	6754	6754	6754	6754

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table III Liquidity Constraints, Cash Flow Sensitivity of Cash and CEO Overconfidence

The dependent variable is change in cash and cash equivalents normalized by assets at the beginning of the year. The sample is sorted by cash dividend normalized by assets at the beginning of the year, of which the lowest (highest) 20% are identified as constrained (unconstrained) firms. Cash flow is earnings before extraordinary items plus depreciation. LTCEO is the Longholder_Thomson overconfidence measure, which is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in the money upon entering their last year. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Capital Intensity is the natural logarithm of one plus assets divided by the number of employees. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Stock Ownership, Vested Options, Q, ln(Sales), Capital Intensity and Tangibility are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

Panel A	**Identify Liquidity Constraints by Dividend Payout Ratio**							
	Constrained Firms				**Unconstrained Firms**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash Flow	-0.327	-0.216	-0.243	-0.242	0.098	-0.021	0.033	0.027
	(0.317)	(0.219)	(0.258)	(0.243)	(0.088)	(0.070)	(0.078)	(0.078)
LTCEO	-0.099	-0.035*	-0.071	-0.064	-0.051	-0.043**	-0.047	-0.036
	(0.062)	(0.019)	(0.053)	(0.050)	(0.037)	(0.018)	(0.037)	(0.036)
LTCEO*Cash Flow	0.957**	0.516**	0.764**	0.733**	0.280	0.194	0.210	0.212
	(0.388)	(0.229)	(0.313)	(0.295)	(0.217)	(0.133)	(0.207)	(0.209)
Q		0.013**	0.021***	0.018**		0.013***	0.012***	0.011***
		(0.005)	(0.008)	(0.008)		(0.003)	(0.004)	(0.004)
ln(Sales)		-0.005	-0.012	-0.039		-0.009***	0.018	-0.019
		(0.004)	(0.024)	(0.038)		(0.003)	(0.013)	(0.015)
Capital Intensity		-0.012	-0.119***	-0.145***		-0.006	-0.101***	-0.142***
		(0.008)	(0.033)	(0.043)		(0.004)	(0.028)	(0.032)
Tangibility		-0.114***	-0.164**	-0.140*		0.003	-0.013	0.047
		(0.028)	(0.074)	(0.075)		(0.029)	(0.069)	(0.083)
Stock Ownership			-0.001	0.000			0.005***	0.005***
			(0.002)	(0.002)			(0.002)	(0.002)
Vested Options			0.001	-0.006			0.012	0.006
			(0.006)	(0.008)			(0.009)	(0.009)
Year Fixed Effects	No	No	No	Yes	No	No	No	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1511	1511	1511	1511	1766	1766	1766	1766

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table III Liquidity Constraints, Cash-Cash Flow Sensitivity and CEO Overconfidence

The dependent variable is change in cash and cash equivalents normalized by assets at the beginning of the year. The sample is sorted by ln(1+assets) at the beginning of the year, of which the lowest (highest) 20% are identified as constrained (unconstrained) firms. Cash flow is earnings before extraordinary items plus depreciation. LTCEO is the Longholder_Thomson overconfidence measure, which is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in the money upon entering their last year. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Capital Intensity is the natural logarithm of one plus assets divided by the number of employees. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Stock Ownership, Vested Options, Q, ln(Sales), Capital Intensity and Tangibility are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

Panel B	**Identify Liquidity Constraints by Assets**							
	Constrained Firms				**Unconstrained Firms**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash Flow	-0.247	-0.190	-0.221	-0.210	0.096	0.067	0.098	0.109
	(0.264)	(0.188)	(0.208)	(0.197)	(0.064)	(0.041)	(0.070)	(0.076)
LTCEO	-0.085	-0.067**	-0.103*	-0.097	-0.018	-0.014	-0.021	-0.023
	(0.055)	(0.029)	(0.060)	(0.059)	(0.025)	(0.015)	(0.026)	(0.025)
LTCEO*Cash Flow	0.667*	0.670***	0.565**	0.508*	0.156	0.114	0.167	0.175
	(0.342)	(0.249)	(0.281)	(0.271)	(0.186)	(0.127)	(0.186)	(0.176)
Q		0.018***	0.018*	0.016*		-0.001	-0.004	-0.004
		(0.005)	(0.010)	(0.009)		(0.003)	(0.005)	(0.005)
ln(Sales)		-0.010	0.007	-0.012		-0.002	0.005	-0.000
		(0.017)	(0.044)	(0.059)		(0.002)	(0.005)	(0.006)
Capital Intensity		-0.027	-0.127***	-0.139**		-0.000	-0.026***	-0.036***
		(0.023)	(0.048)	(0.055)		(0.002)	(0.009)	(0.012)
Tangibility		-0.151**	-0.122	-0.128		-0.009	0.006	0.010
		(0.064)	(0.100)	(0.092)		(0.007)	(0.007)	(0.009)
Stock Ownership			0.005**	0.005**			-0.002*	-0.002**
			(0.002)	(0.002)			(0.001)	(0.001)
Vested Options			0.007	0.004			0.006	0.005
			(0.006)	(0.005)			(0.005)	(0.005)
Year	No	Yes	No	Yes	No	Yes	No	Yes
Industry	No	Yes	No	No	No	Yes	No	No
Firm Fixed Effect	No	No	Yes	Yes	No	No	Yes	Yes
Observations	1351	1351	1351	1351	1350	1350	1350	1350

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table III Liquidity Constraints, Cash-Cash Flow Sensitivity and CEO Overconfidence

The dependent variable is change in cash and cash equivalents normalized by assets at the beginning of the year. The sample is sorted by ln(Sales+1) at the beginning of the year, of which the lowest (highest) 20% are identified as constrained (unconstrained) firms. Cash flow is earnings before extraordinary items plus depreciation. LTCEO is the Longholder_Thomson overconfidence measure, which is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in the money upon entering their last year. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Capital Intensity is the natural logarithm of one plus assets divided by the number of employees. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Stock Ownership, Vested Options, Q, ln(Sales), Capital Intensity and Tangibility are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

Panel C	**Identify Liquidity Constraints by Sales**							
	Constrained Firms				**Unconstrained Firms**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash Flow	-0.194	-0.193	-0.177	-0.157	0.066	0.111*	0.094	0.117
	(0.249)	(0.157)	(0.195)	(0.184)	(0.080)	(0.064)	(0.085)	(0.093)
LTCEO	-0.065	-0.020	-0.071	-0.050	-0.032	-0.015	-0.035	-0.037
	(0.054)	(0.016)	(0.052)	(0.049)	(0.028)	(0.016)	(0.028)	(0.027)
LTCEO*Cash Flow	0.731**	0.410**	0.585**	0.533**	0.210	0.117	0.227	0.227
	(0.334)	(0.177)	(0.276)	(0.263)	(0.195)	(0.132)	(0.195)	(0.185)
Q		0.016***	0.020***	0.019***		-0.004	-0.008	-0.008
		(0.004)	(0.006)	(0.005)		(0.004)	(0.006)	(0.006)
ln(Sales)		-0.011	-0.023	-0.049		-0.003*	0.015***	0.008
		(0.012)	(0.033)	(0.040)		(0.001)	(0.005)	(0.006)
Capital Intensity		-0.022*	-0.165***	-0.184***		0.001	-0.031***	-0.037***
		(0.011)	(0.042)	(0.047)		(0.002)	(0.008)	(0.010)
Tangibility		-0.127**	-0.183**	-0.185**		-0.015	0.015	0.020
		(0.050)	(0.076)	(0.081)		(0.009)	(0.014)	(0.014)
Stock Ownership			0.005**	0.005**			-0.001	-0.001
			(0.002)	(0.002)			(0.001)	(0.001)
Vested Options			0.012*	0.007			0.008	0.008
			(0.007)	(0.006)			(0.006)	(0.006)
Year	No	Yes	No	Yes	No	Yes	No	Yes
Industry	No	Yes	No	No	No	Yes	No	No
Firm Fixed Effect	No	No	Yes	Yes	No	No	Yes	Yes
Observations	1351	1351	1351	1351	1350	1350	1350	1350

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table III Liquidity Constraints, Cash-Cash Flow Sensitivity and CEO Overconfidence

The dependent variable is change in cash and cash equivalents normalized by assets at the beginning of the year. The sample is sorted by Tangibility at the beginning of the year, of which the lowest (highest) 20% are identified as constrained (unconstrained) firms. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Cash flow is earnings before extraordinary items plus depreciation. LTCEO is the Longholder_Thomson overconfidence measure, which is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in the money upon entering their last year. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Capital Intensity is the natural logarithm of one plus assets divided by the number of employees. Stock Ownership, Vested Options, Q, ln(Sales), Capital Intensity and Tangibility are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

Panel D	**Identify Liquidity Constraints by Tangibility**							
	Constrained Firms				**Unconstrained Firms**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash Flow	-0.283	-0.284	-0.271	-0.270	0.077	-0.103	-0.048	-0.042
	(0.295)	(0.190)	(0.214)	(0.197)	(0.225)	(0.149)	(0.197)	(0.201)
LTCEO	-0.112**	-0.051***	-0.081**	-0.065*	-0.009	-0.023	-0.005	-0.002
	(0.048)	(0.016)	(0.037)	(0.034)	(0.033)	(0.023)	(0.029)	(0.030)
LTCEO*Cash Flow	0.697**	0.496**	0.528**	0.532**	0.086	0.158	0.053	0.055
	(0.352)	(0.207)	(0.250)	(0.245)	(0.231)	(0.158)	(0.206)	(0.208)
Q		0.017**	0.024*	0.025**		0.013**	0.016***	0.016***
		(0.008)	(0.012)	(0.012)		(0.006)	(0.005)	(0.005)
ln(Sales)		-0.001	-0.001	-0.028		-0.001	-0.003	-0.017
		(0.004)	(0.016)	(0.021)		(0.004)	(0.009)	(0.012)
Capital Intensity		-0.018**	-0.172***	-0.186***		-0.008*	-0.008	-0.018
		(0.008)	(0.036)	(0.040)		(0.004)	(0.013)	(0.016)
Tangibility		-0.316	-1.209***	-0.826**		-0.062	-0.061	-0.058
		(0.194)	(0.400)	(0.388)		(0.042)	(0.045)	(0.048)
Stock Ownership			0.005**	0.005***			0.002	0.001
			(0.002)	(0.002)			(0.001)	(0.001)
Vested Options			0.007	0.002			-0.001	-0.002
			(0.007)	(0.008)			(0.003)	(0.003)
Year	No	Yes	No	Yes	No	Yes	No	Yes
Industry	No	Yes	No	No	No	Yes	No	No
Firm Fixed Effect	No	No	Yes	Yes	No	No	Yes	Yes
Observations	1351	1351	1351	1351	1350	1350	1350	1350

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table III Liquidity Constraints, Cash-Cash Flow Sensitivity and CEO Overconfidence

The dependent variable is change in cash and cash equivalents normalized by assets at the beginning of the year. The sample is sorted by KZ index at the beginning of the year, of which the highest (lowest) 20% are identified as constrained (unconstrained) firms. Cash flow is earnings before extraordinary items plus depreciation. LTCEO is the Longholder_Thomson overconfidence measure, which is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in the money upon entering their last year. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Capital Intensity is the natural logarithm of one plus assets divided by the number of employees. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Stock Ownership, Vested Options, Q, ln(Sales), Capital Intensity and Tangibility are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

Panel E	**Identify Liquidity Constraints by KZ Index**							
	Constrained Firms				**Unconstrained Firms**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash Flow	-0.211	-0.154	-0.156	-0.149	0.253**	0.013	0.163	0.121
	(0.234)	(0.155)	(0.179)	(0.164)	(0.118)	(0.166)	(0.119)	(0.121)
LTCEO	-0.055	-0.034**	-0.013	0.017	-0.075	-0.052*	-0.088	-0.087
	(0.048)	(0.013)	(0.045)	(0.041)	(0.056)	(0.031)	(0.055)	(0.057)
LTCEO*Cash Flow	0.590**	0.367**	0.428**	0.377*	0.469	0.469*	0.490	0.531
	(0.269)	(0.172)	(0.213)	(0.194)	(0.352)	(0.257)	(0.346)	(0.349)
Q		0.021***	0.021**	0.017**		0.003	0.003	0.002
		(0.004)	(0.010)	(0.009)		(0.003)	(0.004)	(0.004)
ln(Sales)		-0.009*	-0.016	-0.067**		-0.007**	-0.003	-0.018
		(0.005)	(0.026)	(0.030)		(0.003)	(0.017)	(0.028)
Capital Intensity		-0.020*	-0.114***	-0.168***		-0.003	-0.067**	-0.087**
		(0.011)	(0.035)	(0.043)		(0.006)	(0.027)	(0.041)
Tangibility		-0.097**	-0.206*	-0.093		-0.010	-0.064	-0.026
		(0.048)	(0.118)	(0.089)		(0.032)	(0.085)	(0.079)
Stock Ownership			0.004*	0.005***			0.002	0.002
			(0.002)	(0.002)			(0.002)	(0.002)
Vested Options			-0.004	-0.011			0.012	0.011
			(0.008)	(0.008)			(0.008)	(0.008)
Year	No	Yes	No	Yes	No	Yes	No	Yes
Industry	No	Yes	No	No	No	Yes	No	No
Firm Fixed Effect	No	No	Yes	Yes	No	No	Yes	Yes
Observations	1351	1351	1351	1351	1327	1327	1327	1327

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table IV Innovativeness of Firm Investment, Cash-Cash Flow Sensitivity and CEO Overconfidence

The dependent variable is change in cash and cash equivalents normalized by assets at the beginning of the year. Cash Flow is earnings before extraordinary items plus depreciation. LTCEO is the Longholder_Thomson overconfidence measure, which is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in the money upon entering their last year. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Capital Intensity is the natural logarithm of one plus assets divided by the number of employees. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Stock Ownership, Vested Options, Q, ln(Sales), Capital Intensity and Tangibility are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	Firms with High R&D Expenditure			**Firms with High R&D Shares**			**Electronic Manufacturing and Pharmaceutical Industries**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cash Flow	-0.199	-0.187	-0.150	-0.177	-0.158	-0.148	-0.101	-0.115	-0.111
	(0.246)	(0.169)	(0.167)	(0.235)	(0.159)	(0.179)	(0.206)	(0.146)	(0.170)
LTCEO	-0.093*	-0.026	-0.026	-0.104**	-0.029*	-0.043	-0.072**	-0.039**	-0.057**
	(0.053)	(0.016)	(0.047)	(0.047)	(0.016)	(0.041)	(0.034)	(0.015)	(0.028)
LTCEO*Cash Flow	0.794**	0.453**	0.579**	0.761**	0.426**	0.567**	0.556**	0.368**	0.451**
	(0.335)	(0.202)	(0.242)	(0.303)	(0.177)	(0.239)	(0.241)	(0.158)	(0.197)
Q		0.019***	0.025**		0.014***	0.014***		0.014***	0.014***
		(0.006)	(0.010)		(0.004)	(0.005)		(0.003)	(0.004)
ln(Sales)		-0.010*	-0.048		-0.015**	-0.066**		-0.010***	-0.034*
		(0.005)	(0.033)		(0.006)	(0.031)		(0.003)	(0.020)
Capital Intensity		-0.016	-0.125***		-0.023*	-0.206***		-0.013*	-0.129***
		(0.011)	(0.045)		(0.012)	(0.051)		(0.007)	(0.026)
Tangibility		-0.051	-0.030		-0.110*	-0.108		-0.065**	-0.059
		(0.068)	(0.134)		(0.062)	(0.132)		(0.027)	(0.059)
Stock Ownership			0.005**			0.005			0.003*
			(0.002)			(0.003)			(0.002)
Vested Options			0.002			-0.002			0.002
			(0.007)			(0.009)			(0.005)
Year	No	Yes	No	Yes		No	Yes	No	Yes
Industry	No	Yes	No	No		No	Yes	No	No
Firm Fixed Effect	No	No	Yes	Yes		No	No	Yes	Yes
Observations	1414	1414	1414	1401	1401	1401	3087	3087	3087

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table V. R&D Shares and CEO Overconfidence

The dependent variable is R&D shares which is defined as R&D expenditure divided by the sum of R&D expenditure and capital expenditure. LTCEO is the Longholder_Thomson overconfidence measure, which is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in the money upon entering their last year. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Capital Intensity is the natural logarithm of one plus assets divided by the number of employees. Tangibility is property, plants and equipment divided by assets at the beginning of the year. Q, ln(Sales), Capital Intensity, Tangibility, Stock Ownership and Vested Options are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	(1)	(2)	(3)	(4)	(5)
LTCEO	0.021*	0.021*	0.023**	0.023**	0.006
	(0.012)	(0.013)	(0.010)	(0.010)	(0.007)
Q	0.010***	0.010***	0.005**	0.005**	-0.005***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.001)
ln(Sales)	-0.046***	-0.047***	-0.024***	-0.023***	-0.026***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)
Capital Intensity	0.130***	0.129***	0.078***	0.078***	0.013*
	(0.008)	(0.008)	(0.008)	(0.009)	(0.008)
Tangibility	-0.578***	-0.578***	-0.385***	-0.386***	-0.039*
	(0.036)	(0.036)	(0.031)	(0.031)	(0.021)
Stock Ownership		-0.000	-0.000	-0.000	0.000
		(0.001)	(0.001)	(0.001)	(0.000)
Vested Options		-0.001	0.001	0.001	0.002
		(0.004)	(0.004)	(0.004)	(0.002)
Year Fixed Effects	No	No	No	Yes	Yes
Industry Fixed Effects	No	No	No	Yes	No
Firm Fixed Effects	No	No	No	No	Yes
Observations	6754	6754	6754	6754	6754

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table VI R&D Expenditure-Cash Flow Sensitivity and CEO Overconfidence

The dependent variable is R&D expenditure normalized by assets at the beginning of the year. Cash Flow is earnings before extraordinary items plus depreciation. Payout Cash Flow (CF) is earnings before extraordinary items plus depreciation. LTCEO is the Longholder_Thomson overconfidence measure, which is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in the money upon entering their last year. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Stock Ownership, Vested Options, Q and ln(Sales) are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash Flow	-0.277***	-0.252***	-0.251***	-0.246***	-0.222***	-0.223***	-0.223***	-0.227***
	(0.058)	(0.048)	(0.048)	(0.050)	(0.072)	(0.065)	(0.065)	(0.064)
LTCEO	-0.023**	-0.014*	-0.014*	-0.012	-0.021*	-0.017*	-0.017*	-0.015
	(0.010)	(0.008)	(0.008)	(0.008)	(0.011)	(0.010)	(0.010)	(0.010)
LTCEO *Cash Flow	0.172**	0.130**	0.132**	0.130**	0.163**	0.129*	0.129*	0.124*
	(0.076)	(0.063)	(0.063)	(0.062)	(0.081)	(0.072)	(0.072)	(0.071)
Q		0.011***	0.011***	0.009***		0.006***	0.006***	0.006***
		(0.003)	(0.003)	(0.002)		(0.002)	(0.002)	(0.002)
ln(Sales)		-0.014***	-0.015***	-0.008***		-0.020***	-0.019***	-0.024***
		(0.001)	(0.001)	(0.001)		(0.004)	(0.004)	(0.005)
Stock Ownership			-0.001**	-0.001***			0.000	0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Vested Options			-0.002	-0.001			0.001	0.001
			(0.001)	(0.001)			(0.001)	(0.001)
Year Fixed Effects	No	No	No	Yes	No	No	No	Yes
Industry Fixed Effects	No	No	No	Yes	No	No	No	No
Firm Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	6754	6754	6754	6754	6754	6754	6754	6754

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table VII Innovation Performance and CEO Overconfidence

The dependent variable of columns 1 to 3 is log(1+Patent). Patent is the number of patents applied for during the year. The dependent variable of columns 4 to 6 is log(1+ Citation/Patent). Citation is the total number of citations of all patents applied for during the year. LTCEO is the Longholder_Thomson overconfidence measure, which is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in the money upon entering their last year. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Capital Intensity is the natural logarithm of one plus assets divided by the number of employees. Stock Ownership, Vested Options, ln(Sales) and Capital Intensity are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	Dependent Variable=log(1+Patent)			Dependent Variable=log(1+Citation/Patent)		
	(1)	(2)	(3)	(4)	(5)	(6)
LTCEO	0.127*	0.144**	0.095*	0.066	0.067	0.074
	(0.073)	(0.069)	(0.058)	(0.055)	(0.054)	(0.052)
Stock Ownership		-0.038***	-0.011		-0.018**	-0.008
		(0.014)	(0.008)		(0.008)	(0.007)
Vested Options		-0.347***	-0.124***		-0.106***	-0.057*
		(0.055)	(0.037)		(0.036)	(0.032)
ln(Sales)			0.288***			0.085***
			(0.019)			(0.017)
Capital Intensity			0.256***			0.206***
			(0.046)			(0.042)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4852	4852	4852	4852	4852	4852

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Chapter 3: A Model of Managerial Overconfidence and Advertising

Advertising is one of the most visible economic activities. Firms use advertising to promote their products and services to consumers. The classic paper of Dorfman and Steiner (1954) offers one of the earliest formal models of optimal monopoly advertising, capturing the key structural factors that monopoly advertising depends on endogenously. Since then, a voluminous literature has investigated the determinants of advertising such as concentration, profit, entry and price at the industry, firm and even brand levels. However, few of these determinants take behavioral features into account. This paper extends the existing literature by investigating the impact of managerial overconfidence on advertising decisions.

To better understand the rationale behind advertising decisions and the key assumptions of this paper, it is helpful to review varying viewpoints of advertising. In the early work of Marshall (1890, 1905, 1919), advertising is depicted as a constructive (or informative) way to convey useful information to consumers. However, this approach also notes that advertising at times plays a combative (or persuasive) role as it fortifies consumers' responses through providing repetitive information. This distinction between the informative roles and persuasive roles of advertising has stimulated an extensive literature.[18] Others have argued that advertising directly enters consumers' preferences in a way complementary to the consumption of the advertised product (Telser (1964); Stigler and Becker (1977)). Though it is widely recognized that advertising can influence consumer behavior for different reasons, this paper focuses on the informative role of advertising, which is when a firm uses advertising as a tool to inform consumers about the quality of the product and/or the firm.

In the context of informative advertising, this paper studies how managerial overconfidence distorts firm advertising decisions. Managerial overconfidence is a phenomenon well-documented by social psychology. There is a fast-growing literature investigating the impact of managerial overconfidence on firm decisions and firm performance (Malmendier and Tate (2005, 2008); Malmendier, Tate and Yan (2011); Ben-David, Graham, and Harvey (2007); Galasso and Simcoe (2011); Hirshleifer, Low and Teoh (2012)). This paper defines managerial overconfidence as a biased belief held by a CEO that the quality of products produced by his firm is better than average but that, at the same time, the quality of the firm's products are undervalued by consumers and markets. Therefore, overconfident CEOs will be more willing to use advertising as a means to reduce asymmetric information problems and promote sales.

To illustrate the above intuition, I first present a basic model of optimal advertising for firms in monopolistic competition industries using a framework previously employed by Dorfman and Steiner (1954). This model proposes that firm advertising should decrease with the price elasticity of demand and increase with the advertising elasticity of sales, the firm advertising competency. I next add managerial overconfidence to the model, which is included as an overestimation of advertising competency.

The model predicts that overconfident CEOs will overspend on advertising and have a greater ratio of advertising to sales. When taking financing issues into account, the model shows the degree of overspending will be curbed to some extent if there is not sufficient internal capital. As a result, the model predicts that advertising expenditures by overconfident CEOs are more

[18] The advocates of the informative view of advertising include Braithwaite (1928), Ozga (1960), Stigler (1961) and Nelson (1970). The persuasive view includes Chamberlin (1933), Kaldor (1950), Comanor and Wilson (1967, 1974).

sensitive to cash flows than the advertising expenditures of non-overconfident CEOs in firms with financial constraints.

The model demonstrates that when managerial overconfidence exists, the Dorfman and Steiner theorem will be violated in two different ways, contingent on the firm's financial position. First, when an overconfident CEO has sufficient internal capital, he will set his advertising to sales ratio equal to the ratio of the (incorrectly) perceived advertising elasticity to the price elasticity. This means the overconfident CEO will still follow the Dorfman and Steiner rule, but will apply an overconfident parameter. Therefore, those with a correct perception of firm advertising competency would observe that firms with overconfident CEOs violate the Dorfman and Steiner rule. Second, when an overconfident CEO is financially constrained and has to utilize external capital, his advertising behavior will not only violate the Dorfman and Steiner condition with the correct parameter but also the Dorfman and Steiner condition with the overconfident parameter.

To test these predictions, I use a large sample of 654 S&P 1500 firms from 1996 to 2010. To measure CEO overconfidence, I reconstruct the Longholder_Thomson measure used by Malmendier, Tate and Yan (2011), which is compiled from the Thomson Insider Trading Database. The Longholder_Thomson measure is based on the timing of option exercise by CEOs. It identifies a CEO as overconfident if at any point during his tenure a CEO held an option until its expiration (longhold behavior). Alternatively, I construct a continuous measure of CEO overconfidence based on the Longholder_Thomson measure, which is defined as the number of years a CEO exhibited a longhold behavior divided by the total number of years of his tenure.

The empirical results support the predictions of the model. I find that having an overconfident CEO increases advertising expenditures by 23.1% to 56.3%. In the presence of managerial overconfidence, the ratio of advertising to sales is also increased by 20.7% to 46.2%. Additionally, I find that firms with overconfident CEOs are associated with more pronounced advertising expenditure-cash flow sensitivity. The effect is larger if the overconfident CEOs are financially constrained and the measure of CEO overconfidence is continuous. Overall, these findings are consistent with the predictions of the model.

One caveat of this paper is that the model only considers advertising decisions and does not take into account additional decisions such as capital expenditure and innovation decisions. Whether adding other firm decisions will change the main results of the model depends on the specification of the decision making process. Another caveat of the model is that it does not provide a theoretical justification for whether or not the continuous measure of CEO overconfidence is better than the dummy measure of CEO overconfidence. Again, the answer depends on the model's specification of CEO overconfidence.

The remainder of this paper is organized as follows. Section I presents the model. Section II describes the data. Section III presents the empirical specifications and results. Section IV concludes.

I. The Model

A. Intuition

Based on the Dorfman and Steiner optimal advertising theorem (Dorfman and Steiner (1954)), I build a simple two-period model of advertising decisions for firms in monopolistic competition industries. I then analyze how managerial overconfidence distorts the amount of advertising expenditures and the advertising to sales ratio.

Dorfman and Steiner (1954) show that a rational profit-maximizing monopolist will set an optimal level of advertising such that the marginal revenue of advertising will be equal to the marginal cost of advertising, which includes not only the marginal expenditures of advertising but also the marginal cost of additional output due to the increased demand created by advertising. This allows them to derive an optimal advertising rule stating that the advertising to sales ratio should be equal to the ratio of advertising elasticity to price elasticity. The Dorfman and Steiner theorem intuitively acknowledges that a firm's level of advertising is jointly determined by both consumer preference and firm-specific advertising competence.

The Dorfman and Steiner theorem assumes that CEOs are fully rational. My model relaxes this assumption and takes into account situations where a CEO is overconfident, in that he overestimates the effect of advertising on promoting sales. The model shows that when the CEO has an overly optimistic perception of his firm's advertising competence, he will make distorted advertising decisions: advertising expenditures and the advertising to sales ratio set by the overconfident CEO are larger than those of the rational CEO. Moreover, when financially constrained, an overconfident CEO will have positive advertising expenditure-cash flow sensitivity.

The subtle results outlined above are attributable to the overconfident CEO's belief that external capital markets have underestimated the present value of his firm. Because the overconfident CEO is overly optimistic about his firm's advertising competency, he overestimates the firm's future profit and thus the present firm value. To avoid diluting the share value of existing shareholders, the overconfident CEO will spend less on advertising than what is (incorrectly) perceived to be the first best, but still more than the advertising level of a rational CEO. Hence, both the perceived and the true Dorfman and Steiner conditions are violated.

B. Setup

Consider a firm in a monopolistically competitive industry. At period 0, the firm has assets A_0 and s shares outstanding. The firm has a constant marginal cost of production, denoted as c. The amount of products sold in period 1 is $q(a, p, \phi)$. a, p, ϕ represent advertising expenditures, price and managerial overconfidence respectively. One can think of advertising competency as how advertising serves to increase firm sales. Hence, the advertising elasticity of sales, denoted as $\varepsilon_q^a(a, p, \phi)$, is a natural measure for advertising competency.

Because the goal of the model is to demonstrate the distorted advertising behavior of overconfident CEOs, to simplify the calculation I assume that advertising competency is a positive constant independent of advertising expenditures. However, perceived advertising competency will increase only with the degree of managerial overconfidence. I also assume that price elasticity depends on price alone. I therefore assume the sales function has the form $q(a, p, \phi) = G(a, \phi)H(p) + \theta$. θ is a stochastic error term with a mean of 0. The structure of $q(a, p, \phi)$ ensures the existence of a unique optimal solution (a^*, p^*) such that $a^* > 0$ and $p^* > 0$. ϕ is the degree of managerial overconfidence where $\phi = 0$ for rational CEOs while $\phi > 0$ for overconfident CEOs. $G(a, \phi)$ satisfies that $G'_\phi > 0$, $G'_a > 0$, $G''_a < 0$ and $\varepsilon_G^a(\phi) = aG'_a(a, \phi)/G(a, \phi)$ is a positive constant independent of a but monotonically increasing with ϕ for $\phi \geq 0$. $H(p)$ has a form similar to a standard demand curve. The price elasticity, $\varepsilon_q^p = -pq_p/q = \varepsilon_H^p(p)$ is a non-increasing function of p.

With regards to available financing sources, in period 0, a free cash flow F_0, which excludes the required investment expenditures and change in net working capital, is realized and

available for financing advertising. The firm could also borrow riskless debt up to an exogenous limit with its assets as collateral. However, after excluding the portion used for an exogenous level of investment expenditure, the remaining portion, denoted as D_0 , is available for advertising expenditures. I also assume the external capital markets are efficient and that a firm can issue new shares to raise funds. Therefore, the optimization problem of the CEO is

$$\max_{a,p,f,d,s'} \frac{s}{s+s'}\{A_0 + F_0 + \Pi(a,p,\phi) - f - d\}$$

$$\text{s.t.} \quad \frac{s'}{s+s'}\{A_0 + F_0 + \Pi(a,p,0)Q - f - d\} = a - f - d$$

$$0 \le s', 0 \le f \le F_0, 0 \le d \le D_0, 0 \le f + d \le a$$

where $\Pi(a,p,\phi) = (p-c)q(a,p,\phi)$ is expected profit which will be realized in period 1, s' is new shares issued, f is the amount of cash financing and d is the amount of debt financing. Note that new shareholders assess firm value based on the correct expected firm profit $\Pi(a,p,0)$.

C. Solutions

Case 1: rational CEOs $\phi = 0$

Let (a^{fb}, p^{fb}) be the (first best) solution of rational CEOs. (a^{fb}, p^{fb}) satisfies that

$$\frac{p^{fb} - c}{p^{fb}} = \frac{1}{\varepsilon_H^p(\ p^{fb})}$$

$$\frac{a^{fb}}{p^{fb}q(a^{fb}, p^{fb}, 0)} = \frac{\varepsilon_G^a(0)}{\varepsilon_H^p(\ p^{fb})}$$

where $\varepsilon_H^p(p) = -pq_p/q = \varepsilon_q^p(a,p,0)$ is the price elasticity and $\varepsilon_G^a(0) = aq_a/q = \varepsilon_q^a(a,p,0)$ is the advertising elasticity.

Proof: see appendices.

Therefore, the price set by a rational CEO is a level such that the gross profit margin equals the inverse of the price elasticity. The advertising expenditures of a rational CEO follows the Dorfman and Steiner rule that the advertising to sales ratio equals the ratio of advertising elasticity to price elasticity, which can also be expressed as

Advertising to Sales Ratio= Advertising Competency/ Price Elasticity

The first best solution (a^{fb}, p^{fb}) only depends on consumer preference and firm advertising competency $\varepsilon_G^a(0)$, but does not vary with financing sources.

Case 2: overconfident CEOs with sufficient internal capital $\phi > 0$

Let $(\hat{a}, \hat{p})$ be the solution of overconfident CEOs with sufficient internal capital, which means the desired level of advertising expenditures by overconfident CEOs can be funded by the cash flow and riskless debt such that $\hat{a} < F_0 + D_0$. $(\hat{a}, \hat{p})$ satisfies that

$$\frac{\hat{p}-c}{\hat{p}}=\frac{1}{\varepsilon_H^p(\hat{p})}$$

$$\frac{\hat{a}}{\hat{p}q(\hat{a},\hat{p},\phi)}=\frac{\varepsilon_G^a(\phi)}{\varepsilon_H^p(\hat{p})}$$

Overconfident CEOs also follow the Dorfman and Steiner rule that the ratio of advertising expenditure to sales equals the ratio of advertising elasticity of demand to price elasticity of demand, however, at the same time using an incorrect parameter.

Compared to (a^{fb}, p^{fb}), the (first best) solution of rational CEOs is

$$\hat{p}=p^{fb}$$

$$\hat{a}>a^{fb}$$

$$\frac{\hat{a}}{\hat{p}q(\hat{a},\hat{p},0)}>\frac{a^{fb}}{p^{fb}q(a^{fb},p^{fb},0)}$$

Proof: see appendices.

Therefore, although overconfident CEOs set the same price level as rational CEOs, overconfident CEOs overspend on advertising. They have a higher level of advertising expenditures. Their advertising to realized sales ratio is also greater than that of rational CEOs. Since $\hat{a}$ depends only on managerial overconfidence, advertising competency and consumer preference, the advertising expenditures of overconfident CEOs do not vary with financing sources.

Case 3: overconfident CEOs with insufficient internal capital $\phi>0$

Consider the case when $\hat{a}>F_0+D_0$, and the desirable advertising level for overconfident CEOs cannot be covered by available internal capital. Let (a^*, p^*) be the solution for overconfident CEOs with insufficient internal capital. (a^*, p^*) satisfies

$$\frac{p^*-c}{p^*}=\frac{1}{\varepsilon_H^p(\ p^*)}$$

$$\frac{a^*}{p^*q(a^*,p^*,\phi)}=\frac{\varepsilon_G^a(\phi)}{\varepsilon_H^p(p^*)\Pi_a'(a^*,p^*,\phi)}$$

where $\Pi_a'(a^*,p^*,\phi)>1$ and depends on A_0, F_0, D_0 and ϕ.

Therefore, when overconfident CEOs are financially constrained, they violate Dorfman and Steiner's rule.

Overconfident CEOs might or might not issue new shares. However, in both cases, compared to (a^{fb}, p^{fb}) and $(\hat{a}, \hat{p})$,

$$p^{fb}=p^*=\hat{p}$$

$$a^{fb}<a^*<\hat{a}$$

$$\frac{a^{fb}}{p^{fb}q(a^{fb},p^{fb},0)} < \frac{a^{*}}{p^{*}q(a^{*},p^{*},0)} < \frac{\hat{a}}{\hat{p}q(\hat{a},\hat{p},0)}$$

$$\frac{\partial a^{*}}{\partial F_0} > 0$$

Proof: see appendices.

Therefore, the advertising expenditures of overconfident CEOs increase with cash flows when internal financing sources are insufficient.

D. Implications

The model shows that advertising decisions made by overconfident CEOs differ from those made by rational CEOs. The following propositions summarize the main results of the model.

Proposition 1: If the CEO is rational ($\phi = 0$), advertising expenditures are independent of cash flow, regardless of firm financing position. The advertising to sales ratio equals the ratio of advertising elasticity to price elasticity.

Proposition 2: If the CEO is overconfident ($\phi > 0$) and internal capital is sufficient, advertising expenditures are greater than that of the rational CEO but independent of cash flow. The advertising to sales ratio equals the ratio of (incorrectly) perceived advertising elasticity to price elasticity.

Proposition 3: If the CEO is overconfident ($\phi > 0$) and internal capital is insufficient, advertising expenditures are greater than that of the rational CEO but less than that of the overconfident CEO with sufficient internal capital. Further, advertising expenditures will increase with cash flow. The resulting advertising to sales ratio is greater than the ratio of advertising elasticity to price elasticity but less than the ratio of (incorrectly) perceived advertising elasticity to price elasticity.

Proof: see appendices.

Therefore, from Proposition 2 and Proposition 3 I find that overconfident CEOs deviate from the first best in two ways. Each deviation has different implications for overspending on advertising and advertising expenditure-cash flow sensitivity, contingent on the sufficiency of internal capital.

Assuming other factors which influence advertising expenditure-cash flow sensitivity do not vary systematically with CEO overconfidence and that the CEO is not overconfident about other firm decisions or exogenous variables, I derive the following testable predictions:

Prediction 1: Overconfident CEOs spend more on advertising than their rational peers.

Prediction 2: Overconfident CEOs have a higher advertising to sales ratio than their rational peers.

Prediction 3: The advertising-cash flow sensitivity of overconfident CEOs is more pronounced than that of rational CEOs.

Prediction 4: The advertising-cash flow sensitivity of overconfident CEOs is more pronounced in financially constrained firms.

The following section empirically tests these predictions.

II Data

The CEO overconfidence measurement used here is based on the Longholder measure developed by Malmendier and Tate (2005). The Longholder measure uses the timing of option exercise to identify CEO overconfidence. According to the benchmark model of CEO option exercise in Malmendier and Tate (2005), the optimal timing of option exercise for the CEO depends on individual wealth, degree of risk aversion, and diversification. In general, risk-averse rational CEOs choose to exercise options early when possible, because CEOs are prohibited from trading granted options and short-selling of company stock. Holding stock and options too long will expose CEOs to idiosyncratic firm risks unnecessarily. However, overconfident CEOs overestimate the future return of their firms. Therefore, hoping to benefit from the future profit, overconfident CEOs tend to postpone exercising the in-the-money option.

Malmendier and Tate (2005) use CEO option-package-level data from a panel of 477 Forbes 500 firms from 1980 to 1994 to construct the Longholder measure, a dummy where 1 signifies the overconfident manager at some point of his tenure held an option until the last year before expiration, given the option was at least 40% in-the-money, and 0 otherwise (longhold behavior). In order to test the robustness of the original Longholder measure, Malmendier, Tate and Yan (2011) use the Thomson Insider Trading database to reconstruct the Longholder measure for the years 1992 to 2007. In this paper, I follow Malmendier, Tate and Yan (2011) by constructing a Longholder_Thomson measure for the years 1996 to 2010. The control group is managers whose option exercise is observed in the Thomson database, but who do not meet the criteria of overconfidence. I also construct a continuous measure of CEO overconfidence, AV_ Longholder_Thomson. This measurement is defined as the number of years during a CEO's tenure that the CEO exhibits longhold behavior divided by the number of years in his tenure. I attempt to test whether the impact of overconfident CEOs increases with the degree of CEO overconfidence, though the theoretical explanation depends on the model's specification of CEO overconfidence.

The Thomson Insider Trading database collects data of insider trading from forms 3, 4 and 5 reported by insiders to the SEC. The option trading data are contained in Table II of the Thomson Insider Trading database, which is based on reports from SEC form 4 starting from 1996. I drop those records which are an amendment to previous records and keep only those records with a very high degree of confidence (a cleanse indicator assigned by Thomson of R, H, C) or a reasonably high degree of confidence (a cleanse indicator assigned by Thomson of L or I). I further drop records with obvious errors such that the maturity date of the option is earlier than the exercise date. I also exclude observations which are missing the date of option exercise, as I cannot calculate the days remaining until maturity for these cases. Further, I drop extreme outliers where the exercise price of the option is less than 0.1 or greater than 1000. I use stock price data from CRSP to calculate the in-the-moneyness for each option. I use the Execucomp database to obtain the tenure, stock ownership and option holdings for CEOs in the Thomson database. Therefore my firm sample is at the intersection of the Execucomp database and the Thomson database, which is a subset of S&P 1500 U.S. firms including small, medium and large cap firms from 1996 to 2010.

For financial variables, I obtain data from Compustat. I drop financial firms and regulated utilities (SIC codes 6000 - 6999 and 4900 - 4999). I keep observations for which advertising expenditures are not missing. I use advertising expenditures normalized by assets at the beginning of the year to measure advertising level. The ratio of advertising to sales is measured by advertising expenditures divided by sales. The set of firm-level control variables include q, size and Lerner index. I include Lerner index, which is the gross profit margin, because the

advertising level and advertising intensity are both predicted to increase with the price elasticity, which is the inverse of the gross profit.[19] Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Size is the natural logarithm of sales. After combining firm-level variables with CEO-level variables, the sample consists of 654 S&P 1500 firms from 1996 to 2010. Table I presents the summary statistics.

III. Empirical Results

A. CEO Overconfidence and Advertising Expenditure

I use the following specification to test whether overconfident CEOs have a higher level of advertising expenditures (Prediction 1):

$$AD_{it} = \beta_1 + \beta_2 LTCEO_{it} + X_{it}'B + \varepsilon_{it} \quad (2)$$

AD is advertising expenditures normalized by assets at the beginning of the year. LTCEO is the Longholder_Thomson measure. Alternatively, I also use the continuous AV_LTCEO measure to test whether the prediction holds. X is a set of control variables including Q, ln(Sales) and Lerner index, CEO stock ownership as a percentage of total shares outstanding, CEO vested options holding a percentage of total shares outstanding, year fixed effects and firm fixed effects. Firm fixed effects helps to remove the time-invariant firm effects. All standard errors are adjusted for clustering at the firm level.

Table II reports the results of Specification 1. The coefficient of the Thomson_Longholder measure is approximately 0.009 (p-value=0.044) in the regression results displayed in columns 1 to 3, and these results are robust when controlling for q, ln(Sales) and Lerner index, CEO stock ownership and CEO vested options, year fixed effects and firm fixed effects. Taking the ratio of the coefficient of CEO overconfidence to mean advertising expenditures for non-overconfident CEOs (0.039) (normalized by assets at the beginning of the year) shows that having an overconfident CEO increases advertising expenditures (normalized by assets at the beginning of the year) by 23.1%. When compared to the median advertising expenditure for non-overconfident CEOs (0.016) normalized by assets at the beginning of the year), the estimated coefficient of 0.009 implies that CEO overconfidence increases advertising expenditures (normalized by assets at the beginning of the year) by 56.3%. This represents a substantial effect.

Regressions in columns 4 to 6 are based on the continuous AV_LTCEO measure. The estimated results are very similar. The coefficient of AV_LTCEO is approximately 0.007, but still significant at the 10% level (p-value=0.085) and robust when controlling for Q, ln(Sales) and Lerner index, CEO stock ownership and CEO vested options, year fixed effects and firm fixed effects. This implies that CEO overconfidence increases advertising expenditures (normalized by assets at the beginning of the year) by 17.9%, based on the mean level for non-overconfident CEOs and by 43.8% when using the median level for non-overconfident CEOs.

[19] There are some extreme values for gross profit margin. Observations are trimmed at the 1% level. However, I ensure that these extreme values will not change the main results. I also ensure that including measures for industry structure like the four-firm concentration ratio does not change the results

These results support Prediction 1 by providing evidence that overconfident CEOs spend more on advertising than their rational peers spend. Turning to the control variables, I also find that the coefficient for Lerner Index, which measures market power, is approximately 0.045 and significant at the 1% level throughout the regressions reported in columns 1 to 6. This finding is consistent with the predictions of the model and the existing empirical literature. Q also increases advertising expenditures significantly, but I do not find evidence of any significant impact by firm size on advertising expenditure.

B. **CEO Overconfidence and Advertising Intensity**

To test whether overconfident CEOs have a greater advertising to sales ratio (Prediction 2), I use the following specification:

$$\text{AD\_Sales}_{it} = \beta_1 + \beta_2 \text{LTCEO}_{it} + \text{X}_{it}'\text{B} + \varepsilon_{it} \quad (2)$$

AD_Sales is advertising expenditures divided by sales. LTCEO is the Longholder_Thomson measure. I also use the continuous AV_LTCEO measure to test whether the prediction holds. X is a set of control variables including Q, ln(Sales) and Lerner index, CEO stock ownership as a percentage of total shares outstanding, CEO vested options holding a percentage of total shares outstanding, year fixed effects and firm fixed effects. All standard errors are adjusted for clustering at the firm level.

Table III reports the results of Specification 2. The regressions reported in columns 1 to 3 use the Longholder_Thomson measure. For the regression in column 1, which only controls for firm-level variables and firm fixed effects, the coefficient of the Longholder_Thomson measure is approximately 0.006 and significant at the 5% level (p-value=0.035). Column 2 adds CEO control variables to the baseline regression. The estimated results are very similar. Column 3 further includes year-fixed effect. The coefficient of the Longholder_Thomson measure is unchanged. These results imply that, relative to the mean (0.029) and median (0.0130) advertising to sales ratio of non-overconfident CEOs, having an overconfident CEO increases the advertising to sales ratio by 20.7% and 46.2%, respectively. The regressions reported in columns 4, 5 and 6 are based on the continuous AV_LTCEO measurement. The estimated effect for the overconfidence measure is very similar (coefficient=0.005, significant at 10% level). Again, I find that Lerner Index and q substantially increase the advertising to sales ratio.

C. CEO Overconfidence and Advertising Expenditure-Cash Flow Sensitivity

To test whether overconfident CEOs have a more pronounced advertising expenditure-cash flow sensitivity than their rational peers (Prediction 3), I use the following specification:

$$\text{AD}_{it} = \beta_1 + \beta_2 \text{CF}_{it} + \beta_3 \text{LTCEO}_{it} + \beta_4 \text{LTCEO}_{it} * \text{CF}_{it} + \text{X}_{it}'\text{B} + \varepsilon_{it} \quad (3)$$

AD is advertising expenditure normalized by assets at the beginning of the year. LTCEO is the Longholder_Thomson Measure. Alternatively, I also use the continuous AV_LTCEO measurement to test whether the prediction holds. X is a set of control variables including Q, ln(Sales), CEO stock ownership as a percentage of total shares outstanding, CEO vested options holding a percentage of total shares outstanding, year fixed effects and firm fixed effects. The firm fixed effects help to remove time-invariant firm characteristics. All standard errors are adjusted for clustering at the firm level.

Table IV reports the regression results for Specification 3 using the full sample. Column 1 is a baseline regression which only includes the firm fixed effects, cash flow, the Longholder_Thomson measure and their interaction effect. The positive and significant coefficient (coefficient=0.041, p-value= 0.005) of the interaction term implies that cash flow has a significant impact on advertising expenditure (normalized by assets at the beginning of the year) for overconfident CEOs. From columns 2 to 4, I gradually add firm-level control variables, CEO control variables and year fixed effects. The coefficient remains significant at the 10% level but the size of the effect is reduced to 0.022 with the full set of control variables in column 4. When the Longholder_Thomson measure is replaced with the continuous AV_LTCEO measure, the effect of CEO overconfidence becomes more pronounced. In column 8, the coefficient for AV_LTCEO interacted with cash flow is increased to 0.035 and significant at the 10% level (p-value=0.089). This result is robust when controlling for firm-level control variables, CEO control variables, year fixed effects and firm fixed effects. Further, these results suggest the advertising expenditures of overconfident CEOs are more sensitive to cash flow, which is consistent with Prediction 3 and the findings of Malmendier and Tate (2005) and Galasso and Simcoe (2011).

Alternatively, to test Prediction 4, which states that financial constraints will amplify the advertising expenditure-cash flow sensitivity of overconfident CEOs, I split the sample into constrained firms and unconstrained firms based on the payout ratio, which is defined as cash dividends divided by sales. I classify the bottom three deciles as constrained firms and the top three deciles as unconstrained firms. I next test whether the impact of CEO overconfidence on advertising expenditure-cash flow sensitivity is stronger when there are financial constraints using the constrained subsample and unconstrained subsample respectively.

Table V reports the results of the robustness test. Panel A reports the results for regressions using the constrained subsample. Throughout the regressions reported from column 1 to column 4, the estimated coefficients for the Longholder_Thomson measure interacted with cash flow are similar to the estimated coefficient based on the full sample. However, the regressions reported in columns 5 to 8, which use the AV_LTCEO measure, indicate the estimated effect of CEO overconfidence becomes substantially greater when firms are classified as financially constrained. The coefficient for AV_LTCEO interacted with cash flow is 0.077 and significant at the 10% level (p-value=0.082), which more than doubled than the estimated coefficient of 0.035 based on the full sample. In contrast, I do not find any significant impact of cash flow on the advertising expenditures of non-overconfident CEOs. A possible explanation is that non-overconfident CEOs are willing and able to tap external capital when internal capital is insufficient.

Panel B of Table V reports the results for regressions using the unconstrained sample. I do not find any significant effect of cash flow on advertising expenditures for overconfident CEOs in those firms classified as financially unconstrained, regardless of whether CEO overconfidence is measured by the Longholder_Thomson measure or the continuous AV_LTCEO measure. The results in Table V confirm that the sufficiency of internal capital affects the overconfident CEO's advertising decisions, which is consistent with Prediction 4.

IV. Conclusion

In this paper I investigate the impact of CEO overconfidence on advertising. I argue that overconfident CEOs, who tend to believe the quality of their products is better than average, are more willing to use advertising as a way to convey information about their products to consumers. I present a model of optimal adverting, which predicts that CEO overconfidence can

increase firm advertising expenditure and the ratio of advertising to sales. When there are financial constraints, the advertising levels of overconfident CEOs will increase with cash flows. The results of empirical tests using 654 S&P 1500 firms support the predictions of the model.

My findings suggest CEO overconfidence will cause distortions in advertising decisions. Overconfident CEOs are more likely to overspend on advertising. Yet financial constraints will curb to some extent the degree to which CEO overconfidence distorts advertising decisions. These findings indicate overconfident CEOs are more likely to engage in advertising battles, which is complementary to the existing advertising literature as well as the managerial overconfidence literature.

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Table I. Summary Statistics

Cash flow is earnings before extraordinary items plus depreciation. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Lerner index is gross profit divided by sales. Payout ratio is cash dividends divided by sales. Overconfident CEOs are CEOs who at some point during their tenure held exercisable options until the last year before expiration, given the options were at least 40% in-the-money upon entering their last year. The total number of firms is 654.

Panel A. Firm Variables (Full Sample)

Variables	Obs.	Mean	Median	SD
Asset($m)	3914	7365.72	1288.34	22741.06
Capital($m)	3914	2265.23	253.44	8107.82
Gross profit($m)	3914	2694.74	538.50	6974.53
Sales($m)	3914	6745.78	1433.62	18352.82
Advertising expenditure($m)	3914	192.88	26.12	531.21
Advertising expenditure/asset(t-1)	3914	0.0405	0.0200	0.0594
Ratio of advertising to sales	3914	0.0299	0.0157	0.0373
Cash flow($m)	3914	825.70	124.16	2873.99
Cash flow /asset(t-1)	3914	0.1258	0.1248	0.1217
Q	3914	2.4204	1.8536	2.7563
ln(Sale)	3914	7.3519	7.1943	1.6298
Lerner index	3914	0.4428	0.4179	0.1955
Payout ratio	3694	0.0629	0.0274	0.1029

Panel B. Firms with Overconfident CEOs

Variables	Obs.	Mean	Median	SD
Asset($m)	2173	8305.48	1482.85	22592.36
Capital($m)	2173	2551.99	330.36	8256.53
Gross profit($m)	2173	3201.24	640.39	7389.27
Sales($m)	2173	7742.12	1699.06	17692.65
Advertising expenditure($m)	2173	221.91	34.99	576.92
Advertising expenditure/asset(t-1)	2173	0.0419	0.0240	0.0580
Ratio of advertising to sales	2173	0.0308	0.0192	0.0349
Cash flow($m)	2173	1017.16	148.98	2885.20
Cash flow /asset(t-1)	2173	0.1323	0.1295	0.1021
Q	2173	2.3501	1.8749	1.8508
ln(Sale)	2173	7.5304	7.3717	1.6450
Lerner index	2173	0.4332	0.4030	0.1922
Payout ratio	2076	0.0652	0.0299	0.1013

Panel C. Firms with Non-Overconfident CEOs

Variables	Obs.	Mean	Median	SD
Asset($m)	1741	6192.77	1027.44	22877.69
Capital($m)	1741	1907.31	183.99	7906.07
Gross profit($m)	1741	2062.56	446.24	6365.19
Sales($m)	1741	5502.21	1141.89	19077.12
Advertising expenditure($m)	1741	156.65	16.70	465.57
Advertising expenditure/asset(t-1)	1741	0.0388	0.0158	0.0610
Ratio of advertising to sales	1741	0.0289	0.0127	0.0401
Cash flow($m)	1741	586.73	98.40	2842.72
Cash flow /asset(t-1)	1741	0.1177	0.1179	0.1420
Q	1741	2.5080	1.8151	3.5771
ln(Sale)	1741	7.1290	6.9509	1.5830
Lerner index	1741	0.4547	0.4351	0.1988
Payout ratio	1618	0.0599	0.0247	0.1049

Table I. Summary Statistics

Panel D. CEO Variables

Stock Ownership is the option-excluded shares held by CEOs as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by CEOs as a percentage of common shares outstanding. Overconfident CEOs are CEOs who at some point during their tenure held exercisable options until the last year before expiration, given that the options were at least 40% in-the-money upon entering their last year.

	Full Sample			
	Number of CEOs = 828			
Variables	Obs.	Mean	Median	SD
Stock Ownership (%)	3914	2.788	0.373	7.181
Vested Options (%)	3914	1.096	0.659	1.488
	Overconfident CEOs			
	Number of Overconfident CEOs = 402			
Variables	Obs.	Mean	Median	SD
Stock Ownership (%)	2173	2.701	0.446	6.262
Vested Options (%)	2173	1.272	0.765	1.744
	Non-Overconfident CEOs			
	Number of Non-Overconfident CEOs = 426			
Variables	Obs.	Mean	Median	SD
Stock Ownership (%)	1741	2.897	0.318	8.185
Vested Options (%)	1741	0.877	0.537	1.047

Table II Advertising Expenditure and CEO Overconfidence

The dependent variable is advertising expenditures normalized by assets at the beginning of the year. LTCEO is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in-the-money upon entering their last year. AV_LTCEO is the number of years during a CEO's tenure that he longheld an option until expiration, divided by the number of years in his tenure. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Lerner Index is gross profit divided by sales. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Stock Ownership, Vested Options, Lerner Index, Q and ln(Sales) are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	Dependent Variable=Advertising Expenditure / Assets (t-1)					
	(1)	(2)	(3)	(4)	(5)	(6)
LTCEO	0.009*	0.009**	0.009**			
	(0.004)	(0.004)	(0.004)			
AV_LTCEO				0.008*	0.008*	0.007*
				(0.005)	(0.005)	(0.004)
Lerner Index	0.044***	0.044***	0.046***	0.043***	0.043***	0.045***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Q	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Sales)	-0.009***	-0.009***	-0.004	-0.009***	-0.009***	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Stock Ownership		0.000	0.000		0.000	0.000
		(0.000)	(0.000)		(0.000)	(0.000)
Vested Options		-0.001	-0.000		-0.001	-0.000
		(0.001)	(0.001)		(0.001)	(0.001)
Year Fixed Effects	No	No	Yes	No	No	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3914	3914	3914	3914	3914	3914

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table III Advertising Intensity and CEO Overconfidence

The dependent variable is advertising expenditures divided by sales (advertising intensity). LTCEO is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in-the-money entering their last year. AV_LTCEO is the number of years during a CEO's tenure that he longheld an option until expiration, divided by the number of years in his tenure. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Lerner Index is gross profit divided by sales. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Stock Ownership, Vested Options, Lerner Index, Q and ln(Sales) are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	Dependent Variable=Advertising Expenditure / Sales					
	(1)	(2)	(3)	(4)	(5)	(6)
LTCEO	0.006**	0.006**	0.006**			
	(0.003)	(0.003)	(0.003)			
AV_LTCEO				0.005*	0.005*	0.005*
				(0.003)	(0.003)	(0.003)
Lerner Index	0.049***	0.048***	0.049***	0.048***	0.048***	0.049***
	(0.012)	(0.011)	(0.011)	(0.012)	(0.011)	(0.011)
Q	0.001***	0.000***	0.000***	0.001***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(Sales)	-0.003**	-0.003**	-0.001	-0.003**	-0.003**	-0.000
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Stock Ownership		0.000	0.000		0.000	0.000
		(0.000)	(0.000)		(0.000)	(0.000)
Vested Options		-0.001	-0.001		-0.001	-0.001
		(0.001)	(0.001)		(0.001)	(0.001)
Year Fixed Effects	No	No	Yes	No	No	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3914	3914	3914	3914	3914	3914

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table IV Advertising Expenditure-Cash Flow Sensitivity and CEO Overconfidence

The dependent variable is advertising expenditures normalized by assets at the beginning of the year. Cash flow is earnings before extraordinary items plus depreciation normalized by assets at the beginning of the year. LTCEO is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in-the-money entering their last year. AV_LTCEO is the number of years during a CEO's tenure that he longheld an option until expiration, divided by the number of years in his tenure. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Stock Ownership, Vested Options, Q and ln(Sales) are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

	Dependent Variable=Advertising Expenditure / Assets(t-1)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash Flow	0.020*	0.016**	0.013*	0.013*	0.023**	0.018**	0.015**	0.015**
	(0.011)	(0.008)	(0.007)	(0.007)	(0.010)	(0.007)	(0.007)	(0.007)
LTCEO	0.002	0.004	0.005	0.005				
	(0.004)	(0.004)	(0.004)	(0.004)				
LTCEO*Cash Flow	0.041***	0.026**	0.023*	0.022*				
	(0.015)	(0.012)	(0.012)	(0.012)				
AV_LTCEO					-0.001	0.002	0.003	0.003
					(0.005)	(0.004)	(0.005)	(0.005)
AV_LTCEO*Cash Flow					0.061***	0.041**	0.039*	0.035*
					(0.023)	(0.020)	(0.021)	(0.020)
Q		0.003***	0.003***	0.003***		0.003***	0.003***	0.003***
		(0.001)	(0.001)	(0.001)		(0.001)	(0.001)	(0.001)
ln(Sales)		-0.005***	-0.007***	-0.003		-0.005***	-0.007***	-0.003
		(0.001)	(0.002)	(0.002)		(0.001)	(0.002)	(0.002)
Stock Ownership			0.000	0.000			0.000	0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Vested Options			-0.001	-0.000			-0.001	-0.000
			(0.001)	(0.001)			(0.001)	(0.001)
Year Fixed Effects	No	No	No	Yes	No	No	No	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3914	3914	3914	3914	3914	3914	3914	3914

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table V Financing Constraints, Advertising Expenditure-Cash Flow Sensitivity and CEO Overconfidence

The dependent variable is advertising expenditures normalized by assets at the beginning of the year. Cash flow is earnings before extraordinary items plus depreciation normalized by assets at the beginning of the year. LTCEO is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in-the-money entering their last year. AV_LTCEO is the number of years during a CEO's tenure that he longheld an option until expiration, divided by the number of years in his tenure. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Stock Ownership, Vested Options, Q and ln(Sales) are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

Panel A	Dependent Variable=Advertising Expenditure / Assets(t-1)							
Constrained Sample	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash Flow	-0.000	0.003	0.001	0.001	-0.001	0.002	-0.001	-0.001
	(0.005)	(0.003)	(0.003)	(0.003)	(0.005)	(0.004)	(0.004)	(0.004)
LTCEO	-0.004	-0.003	-0.004	-0.005				
	(0.004)	(0.004)	(0.004)	(0.005)				
LTCEO*Cash Flow	0.034**	0.025*	0.025*	0.025*				
	(0.015)	(0.014)	(0.014)	(0.014)				
AV_LTCEO					-0.008	-0.007	-0.008	-0.010
					(0.006)	(0.006)	(0.006)	(0.007)
AV_LTCEO*Cash Flow					0.086*	0.071*	0.078*	0.077*
					(0.046)	(0.042)	(0.045)	(0.044)
Q		0.001***	0.001***	0.001***		0.001***	0.001***	0.001***
		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
ln(Sales)		-0.004***	-0.005**	-0.003		-0.004***	-0.005**	-0.003
		(0.001)	(0.002)	(0.002)		(0.002)	(0.002)	(0.002)
Stock Ownership			0.000	0.000			0.000	0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Vested Options			0.000	0.001			0.001	0.001
			(0.001)	(0.001)			(0.001)	(0.001)
Year Fixed Effects	No	No	No	Yes	No	No	No	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1109	1109	1109	1109	1109	1109	1109	1109

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table V Financing Constraints, Advertising Expenditure-Cash Flow Sensitivity and CEO Overconfidence

The dependent variable is advertising expenditures normalized by assets at the beginning of the year. Cash flow is earnings before extraordinary items plus depreciation normalized by assets at the beginning of the year. LTCEO is a binary variable where 1 signifies the CEO at some point during his tenure held exercisable options until the last year before expiration, given the options were at least 40% in-the-money entering their last year. AV_LTCEO is the number of years during a CEO's tenure that he longheld an option until expiration, divided by the number of years in his tenure. Stock Ownership is option-excluded shares held by the CEO as a percentage of common shares outstanding. Vested Options is the number of exercisable options held by the CEO as a percentage of common shares outstanding. Q is the book value of assets plus the market value of equity minus the book value of equity minus deferred tax, divided by the book value of assets. Stock Ownership, Vested Options, Q and ln(Sales) are measured at the beginning of the year. All standard errors are adjusted for clustering at the firm level.

Panel B	Dependent Variable=Advertising Expenditure / Assets(t-1)							
Unconstrained Sample	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cash Flow	0.076**	0.043*	0.037	0.036	0.077**	0.050**	0.041*	0.040*
	(0.036)	(0.023)	(0.024)	(0.024)	(0.030)	(0.020)	(0.021)	(0.021)
LTCEO	0.012	0.010	0.013	0.013*				
	(0.010)	(0.007)	(0.009)	(0.007)				
LTCEO*Cash Flow	0.004	0.012	0.002	-0.000				
	(0.039)	(0.026)	(0.027)	(0.027)				
AV_LTCEO					0.012	0.012	0.014	0.012
					(0.012)	(0.008)	(0.010)	(0.010)
AV_LTCEO*Cash Flow					0.004	-0.004	-0.015	-0.017
					(0.057)	(0.043)	(0.044)	(0.045)
Q		0.004***	0.003***	0.003***		0.004***	0.003***	0.003***
		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
ln(Sales)		-0.003	-0.009***	-0.003		-0.002	-0.009**	-0.002
		(0.002)	(0.004)	(0.005)		(0.002)	(0.004)	(0.005)
Stock Ownership			-0.000	-0.000			-0.000	-0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Vested Options			-0.000	0.000			-0.000	0.000
			(0.001)	(0.001)			(0.001)	(0.001)
Year Fixed Effects	No	No	No	Yes	No	No	No	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1328	1328	1328	1328	1328	1328	1328	1328

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Appendices

Part I: Solving the Optimization Problem

The financing condition implies that

$$s' = s\frac{a - f - d}{A_0 + F_0 + (p - c)q(a, p, 0) - a}$$

Denote $(p - c)q(a, p, \phi)$ as $\Pi(a, p, \phi)$

The maximization problem is equal to

$$\max_{a,p,f,d} \; A_0 + F_0 + \Pi(a, p, \phi) - f - d - (a - f - d)\frac{A_0 + F_0 + \Pi(a, p, \phi) - f - d}{A_0 + F_0 + \Pi(a, p, 0) - f - d}$$

$$s.t. \quad 0 \le f \le F_0, 0 \le d \le D_0, 0 \le f + d \le a$$

Given that the structure of $q(a, p, \phi)$ ensures the optimal solution $a^* > 0$ and $p^* > 0$, to solve the problem, I ignore the non-negativity constraints $0 \le f$ and $0 \le d$. Then I show that the optimal solutions to the unconstrained problem, f^* and d^*, satisfies them.

Let λ, μ and ν be the Lagrange multipliers on the constraints $f \le F_0$ and $d \le D_0$, and $f + d \le a$ respectively. Then the first order conditions imply

$$\frac{A_0 + F_0 + \Pi(a^*, p^*, \phi) - f^* - d^*}{A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*} - (a^* - f^* - d^*)\frac{\Pi(a^*, p^*, \phi) - \Pi(a^*, p^*, 0)}{(A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*)^2} - 1 - \lambda - \nu = 0$$

$$\frac{A_0 + F_0 + \Pi(a^*, p^*, \phi) - f^* - d^*}{A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*} - (a^* - f^* - d^*)\frac{\Pi(a^*, p^*, \phi) - \Pi(a^*, p^*, 0)}{(A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*)^2} - 1 - \mu - \nu = 0$$

$$\Pi'_a(a^*, p^*, \phi) - \frac{A_0 + F_0 + \Pi(a^*, p^*, \phi) - f^* - d^*}{A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*} - (a^* - f^* - d^*)\left(\frac{\Pi'_a(a^*, p^*, \phi)(A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*)}{(A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*)^2} - \frac{\Pi'_a(a^*, p^*, 0)(A_0 + F_0 + \Pi(a^*, p^*, \phi) - f^* - d^*)}{(A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*)^2}\right) + \nu = 0$$

$$\Pi'_p(a^*, p^*, \phi) - (a^* - f^* - d^*)\left(\frac{\Pi'_a(a^*, p^*, \phi)(A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*)}{(A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*)^2} - \frac{\Pi'_a(a^*, p^*, 0)(A_0 + F_0 + \Pi(a^*, p^*, \phi) - f^* - d^*)}{(A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*)^2}\right) = 0$$

$$\lambda(f^* - F_0) = 0, \mu(d^* - D_0) = 0, \nu(f^* + d^* - a^*) = 0$$

$$\lambda \ge 0, \mu \ge 0, \nu \ge 0$$

(i) Suppose $\phi = 0$.
Then the first order conditions are simplified to

$$-\lambda - \nu = 0$$

$$-\mu - \nu = 0$$

$$\Pi'_p(a^*, p^*, 0) = 0$$

$$\Pi'_a(a^*, p^*, 0) - 1 + \nu = 0$$

Then the constraints $\lambda \geq 0$, $\mu \geq 0$ and $\nu \geq 0$ imply

$$\lambda = \mu = \nu = 0$$

$$\Pi'_p\left(a^{fb}, p^{fb}, 0\right) = 0$$

$$\Pi'_a\left(a^{fb}, p^{fb}, 0\right) = 1$$

The last two equations imply

$$p^* - c = -\frac{q(a^*, p^*, 0)}{q_p(a^*, p^*, 0)}$$

$$(p^* - c)q_a(a^*, p^*, 0) = 1$$

Applying the price elasticity of market share, $\varepsilon^p_q(a, p, 0) = -pq_p/q = \varepsilon^p_H(p)$, and the advertising elasticity of market share, $\varepsilon^a_q(a, p, 0) = aq_a/q = \varepsilon^a_G(0)$

$$\frac{p^* - c}{p^*} = \frac{1}{\varepsilon^p_q(\ a^*,\ p^*, 0)} = \frac{1}{\varepsilon^p_H(\ p^*)}$$

$$\frac{a^*}{p^* q(a^*,\ p^*, 0)} = \frac{\varepsilon^a_q(\ a^*,\ p^*, 0)}{\varepsilon^p_q(\ a^*,\ p^*, 0)} = \frac{\varepsilon^a_G(0)}{\varepsilon^p_H(\ p^*)}$$

The first best solutions satisfy

$$\frac{a^{fb}}{p^{fb} q(a^{fb}, p^{fb}, 0)} = \frac{\varepsilon^a_G(0)}{\varepsilon^p_H(\ p^{fb})} = \frac{p^{fb} - c}{p^{fb}}\ \varepsilon^a_G(0)$$

Since $p^{fb} q\left(a^{fb}, p^{fb}, 0\right)$ is total sales, $(p^{fb} - c)/p^{fb}$ is gross profit margin and $\varepsilon^a_q(0)$ measures the advertising elasticity of demand, the "advertising competency" perceived by rational managers, so

Advertising Intensity=Gross Profit Ratio * Advertising Competency

(ii) Suppose $\phi > 0$.

Consider two cases $\nu > 0$ and $\nu = 0$.

a. Case 1: If $\nu > 0$, then $f^* + d^* = a^*$ and therefore $s' = 0$. There is no new share issued.

The first order conditions become

$$\lambda = \mu = \frac{A_0 + F_0 + \Pi(a^*, p^*, \phi) - f^* - d^*}{A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*} - 1 - \nu$$

$$\Pi'_p(a^*, p^*, \phi) = 0$$

$$\Pi'_a(a^*, p^*, \phi) - \frac{A_0 + F_0 + \Pi(a^*, p^*, \phi) - f^* - d^*}{A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*} + \nu = 0$$

Given $\Pi'_p(a^*, p^*, \phi) = 0$. Then

$$\frac{p^* - c}{p^*} = \frac{1}{\varepsilon_q^p(\ a^*,\ p^*, 0)} = \frac{1}{\varepsilon_H^p(\ p^*)}$$

$$p^* = p^{fb} = \hat{p}$$

First order conditions imply

$$\Pi'_a(a^*, p^*, \phi) = 1 + \lambda = 1 + \mu$$

If $\lambda = \mu = 0$, then $\Pi'_a(a^*, p^*, \phi) = 1$. Note that $\Pi'_a\left(a^*, p^{fb}, 0\right) = \Pi'_a(a^*, p^*, 0) < \Pi'_a(a^*, p^*, \phi) = 1 = \Pi'_a\left(a^{fb}, p^{fb}, 0\right)$

It implies

$$a^{fb} < a^* = \hat{a}$$

Therefore, when internal capital is sufficient, overconfident CEOs will overspend on advertising expenditures.

Turning to advertising intensity,

$$\frac{\hat{a}}{\hat{p}q(\hat{a}, \hat{p}, \phi)} = \frac{\varepsilon_G^a(\phi)}{\varepsilon_H^p(\hat{p})} = \frac{\varepsilon_G^a(\phi)}{\varepsilon_G^a(0)} \frac{\varepsilon_G^a(0)}{\varepsilon_H^p(p^{fb})} = \frac{\varepsilon_G^a(\phi)}{\varepsilon_G^a(0)} \frac{a^{fb}}{p^{fb} q(a^{fb}, p^{fb}, 0)}$$

$$\frac{\hat{a}}{\hat{p}q(\hat{a}, \hat{p}, 0)} = \frac{G(\hat{a}, \phi)}{G(\hat{a}, 0)} \frac{\hat{a}}{\hat{p}q(\hat{a}, \hat{p}, \phi)} = \frac{G(\hat{a}, \phi)}{G(\hat{a}, 0)} \frac{\varepsilon_G^a(\phi)}{\varepsilon_G^a(0)} \frac{a^{fb}}{p^{fb} q(a^{fb}, p^{fb}, 0)}$$

Therefore

$$\frac{\hat{a}}{\hat{p}q(\hat{a}, \hat{p}, 0)} > \frac{\hat{a}}{\hat{p}q(\hat{a}, \hat{p}, \phi)} > \frac{a^{fb}}{p^{fb} q(a^{fb}, p^{fb}, 0)}$$

This implies overconfident CEOs with abundant internal capital will have a greater advertising intensity.

If $\lambda = \mu > 0$, then $f^* = F_0$, $d^* = D_0$. Given $a^* = d^* + f^* = F_0 + D_0$. Then $\Pi'_p(a^*, p^*, 0) = 0$. Hence $p^* = p^{fb} = \hat{p}$. Therefore

$$\Pi'_a(a^*, \hat{p}, \phi) = \Pi'_a(a^*, p^*, \phi) = 1 + \lambda > 1 = \Pi'_a(\hat{a}, \hat{p}, \phi)$$

So

$$a^* < \hat{a}$$

Given that $\nu > 0$. We have

$$\Pi'_a(a^*, p^*, \phi) < \frac{A_0 + \Pi(a^*, p^*, \phi) - D_0}{A_0 + \Pi(a^*, p^*, 0) - D_0}$$

Since $A_0 - D_0 > 0$ and

$$\frac{\Pi(a^*, p^*, \phi)}{\Pi(a^*, p^*, 0)} = \frac{G(a^*, \phi)}{G(a^*, 0)} > 1$$

Therefore

$$\Pi'_a(a^*, p^*, \phi) < \frac{G(a^*, \phi)}{G(a^*, 0)}$$

Note that

$$\Pi'_a(a^*, p^*, 0) = \frac{\Pi'_a(a^*, p^*, 0)}{\Pi'_a(a^*, p^*, \phi)}\Pi'_a(a^*, p^*, \phi) = \frac{\varepsilon^a_G(0)G(a^*, 0)}{\varepsilon^a_G(\phi)G(a^*, \phi)}\Pi'_a(a^*, p^*, \phi)$$

Hence

$$\Pi'_a(a^*, p^*, 0) < \frac{\varepsilon^a_G(0)}{\varepsilon^a_G(\phi)} < 1$$

Given

$$1 < 1 + \lambda = \Pi'_a(a^*, p^*, \phi)$$

Then

$$\Pi'_a(a^*, p^*, 0) = \frac{\varepsilon^a_G(0)G(a^*, 0)}{\varepsilon^a_G(\phi)G(a^*, \phi)}\Pi'_a(a^*, p^*, \phi) > \frac{\varepsilon^a_G(0)G(a^*, 0)}{\varepsilon^a_G(\phi)G(a^*, \phi)}$$

We have

$$0 < \frac{\varepsilon^a_G(0)G(a^*, 0)}{\varepsilon^a_G(\phi)G(a^*, \phi)} < \Pi'_a(a^*, p^*, 0) < \frac{\varepsilon^a_G(0)}{\varepsilon^a_G(\phi)} < 1$$

$$1 < \Pi'_a(a^*, p^*, \phi) < \frac{G(a^*, \phi)}{G(a^*, 0)}$$

Note that

$$\Pi'_a\left(a^*, p^{fb}, 0\right) = \Pi'_a(a^*, p^*, 0) < 1 = \Pi'_a\left(a^{fb}, p^{fb}, 0\right)$$

$$a^* > a^{fb}.$$

Combining with previous results we have

$$a^{fb} < a^* < \hat{a} \text{ and } p^{fb} = p^* = \hat{p}.$$

When turning to advertising intensity, given $\Pi'_a(a^*, p^*, \phi) > 1$ and $p^* = \hat{p}$

$$\frac{a^*}{p^* q(a^*, p^*, \phi)} = \frac{\varepsilon^a_G(\phi)}{\varepsilon^p_H(p^*)\Pi'_a(a^*, p^*, \phi)} < \frac{\varepsilon^a_G(\phi)}{\varepsilon^p_H(\hat{p})} = \frac{\hat{a}}{\hat{p} q(\hat{a}, \hat{p}, \phi)}$$

Note that $a^* < \hat{a}$ imply

$$\frac{G(a^*, \phi)}{G(a^*, 0)} < \frac{G(\hat{a}, \phi)}{G(\hat{a}, 0)}$$

So

$$\frac{a^*}{p^* q(a^*, p^*, 0)} = \frac{G(a^*, \phi)}{G(a^*, 0)} \frac{a^*}{p^* q(a^*, p^*, \phi)} < \frac{G(\hat{a}, \phi)}{G(\hat{a}, 0)} \frac{\varepsilon^a_G(\phi)}{\varepsilon^p_H(\hat{p})} = \frac{\hat{a}}{\hat{p} q(\hat{a}, \hat{p}, 0)}$$

Given

$$\Pi'_a(a^*, p^*, \phi) < \frac{G(a^*, \phi)}{G(a^*, 0)}$$

So

$$\frac{a^*}{p^* q(a^*, p^*, 0)} = \frac{G(a^*, \phi)}{G(a^*, 0)} \frac{a^*}{p^* q(a^*, p^*, \phi)} = \frac{G(a^*, \phi)}{G(a^*, 0)} \frac{\varepsilon^a_G(\phi)}{\varepsilon^p_H(\hat{p})\Pi'_a(a^*, p^*, \phi)} > \frac{\varepsilon^a_G(\phi)}{\varepsilon^p_H(\hat{p})} = \frac{\hat{a}}{\hat{p} q(\hat{a}, \hat{p}, \phi)}$$

Therefore

$$\frac{a^{fb}}{p^{fb} q(a^{fb}, p^{fb}, 0)} < \frac{\hat{a}}{\hat{p} q(\hat{a}, \hat{p}, \phi)} < \frac{a^*}{p^* q(a^*, p^*, 0) q} < \frac{\hat{a}}{\hat{p} q(\hat{a}, \hat{p}, 0)}$$

Case 2: If $\nu = 0$, then $f + d \leq a$ does not bind at a^*. Hence new shares are issued: $s' > 0$.

$$\lambda = \mu = \frac{(\Pi(a^*, p^*, \phi) - \Pi(a^*, p^*, 0))(A_0 + F_0 + \Pi(a^*, p^*, 0) - a^*)}{(A_0 + F_0 + \Pi(a^*, p^*, 0) - f^* - d^*)^2}$$

Since $A_0 + F_0 + \Pi(a^*, p^*, 0) - a^* > 0$ and $\Pi(a^*, p^*, \phi) > \Pi(a^*, p^*, 0)$, then $\lambda = \mu > 0$. Thus $f^* = F_0$ and $d^* = D_0$.

Therefore, the F.O.C of p is

$$\Pi'_p(a^*, p^*, \phi) - \frac{\Pi'_p(a^*, p^*, \phi)(A_0 + \Pi(a^*, p^*, 0) - D_0) - \Pi'_p(a^*, p^*, 0)(A_0 + \Pi(a^*, p^*, \phi) - D_0)}{(A_0 + \Pi(a^*, p^*, 0) - D_0)^2}(a^* - F_0 - D_0) = 0$$

Suppose $\Pi'_p(a^*, p^*, \phi) \neq 0$

Given

$$\Pi'_p(a^*, p^*, \phi) = \Pi'_p(a^*, p^*, 0)\frac{G(a^*, \phi)}{G(a^*, 0)}$$

$$\Pi(a^*, p^*, \phi) = \Pi(a^*, p^*, 0)\frac{G(a^*, \phi)}{G(a^*, 0)}$$

Let

$$\frac{G(a^*, \phi)}{G(a^*, 0)} = K(\phi) > 1$$

Replacing $\Pi'_p(a^*, p^*, \phi)$ and $\Pi(a^*, p^*, \phi)$ with $\Pi'_p(a^*, p^*, 0)K(\phi)$ and $\Pi(a^*, p^*, 0)K(\phi)$ we can get

$$\Pi'_p(a^*, p^*, 0) = \Pi'_p(a^*, p^*, 0)\frac{(K(\phi) - 1)(a^* - F_0 - D_0)(A_0 - D_0)}{K(\phi)(A_0 + \Pi(a^*, p^*, 0) - D_0)^2}$$

Given $A_0 - D_0 > 0$, $A_0 + \Pi(a^*, p^*, 0) + F_0 - a^* > 0$ and $(a^* - F_0 - D_0) > 0$, this implies

$$0 < \frac{(K(\phi) - 1)(a^* - F_0 - D_0)(A_0 - D_0)}{K(\phi)(A_0 + \Pi(a^*, p^*, 0) - D_0)^2} < 1$$

It contradicts the assumption that $\Pi'_p(a^*, p^*, \phi) \neq 0$.

Therefore

$$\Pi'_p(a^*, p^*, 0) = 0 \text{ and } p^* = p^{fb} = \hat{p}$$

Therefore, the F.O.C of a is

$$\Pi'_a(a^*, p^*, \phi) - \frac{A_0 + \Pi(a^*, p^*, \phi) - D_0}{A_0 + \Pi(a^*, p^*, 0) - D_0} - (a^* - F_0 - D_0)\frac{\Pi'_a(a^*, p^*, \phi)(A_0 + \Pi(a^*, p^*, 0) - D_0) - \Pi'_a(a^*, p^*, 0)(A_0 + \Pi(a^*, p^*, \phi) - D_0)}{(A_0 + \Pi(a^*, p^*, 0) - D_0)^2} = 0$$

Given

$$\Pi'_a(a^*, p^*, \phi)(A_0 + \Pi(a^*, p^*, 0) - D_0) > \Pi'_a(a^*, p^*, 0)(A_0 + \Pi(a^*, p^*, \phi) - D_0)$$

Then

$$\Pi'_a(a^*, p^*, \phi) > \frac{A_0 + \Pi(a^*, p^*, \phi) - D_0}{A_0 + \Pi(a^*, p^*, 0) - D_0} > 1$$

Given $p^* = \hat{p}$. Then

$$\Pi'_a(a^*, \hat{p}, \phi) = \Pi'_a(a^*, p^*, \phi) > 1 = \Pi'_a(\hat{a}, \hat{p}, \phi)$$

So

$$a^* < \hat{a}$$

Let

$$\frac{\varepsilon^a_G(\phi)G(a^*, \phi)}{\varepsilon^a_G(0)G(a^*, 0)} = T(\phi) > 1$$

And we also have

$$\Pi'_a(a^*, p^*, 0) = \frac{\Pi'_a(a^*, p^*, 0)}{\Pi'_a(a^*, p^*, \phi)}\Pi'_a(a^*, p^*, \phi) = \frac{\Pi'_a(a^*, p^*, \phi)}{T(\phi)} > \frac{1}{T(\phi)} > 0$$

Substituting $\Pi'_a(a^*, p^*, \phi)$ with $\Pi'_a(a^*, p^*, 0)T(\phi)$ yields

$$\begin{aligned}\Pi'_a(a^*, p^*, 0)T(\phi) - \frac{A_0 + \Pi(a^*, p^*, \phi) - D_0}{A_0 + \Pi(a^*, p^*, 0) - D_0} \\ - (a^* - F_0 \\ - D_0)(\frac{\Pi'_a(a^*, p^*, 0)T(\phi)(A_0 + \Pi(a^*, p^*, 0) - D_0)}{(A_0 + \Pi(a^*, p^*, 0) - D_0)^2} \\ - \frac{\Pi'_a(a^*, p^*, 0)(A_0 + \Pi(a^*, p^*, \phi) - D_0)}{(A_0 + \Pi(a^*, p^*, 0) - D_0)^2}) = 0\end{aligned}$$

Rearranging the equation yields

$$\Pi'_a(a^*, p^*, 0)$$

$$= \frac{1}{\frac{A_0 + F_0 + \Pi(a^*, p^*, 0) - a^*}{A_0 + \Pi(a^*, p^*, \phi) - D_0}T(\phi) + \frac{a^* - F_0 - D_0}{A_0 + \Pi(a^*, p^*, 0) - D_0}}$$

$$= \frac{1}{\frac{A_0 + F_0 + \Pi(a^*, p^*, 0) - a^*}{A_0 + \Pi(a^*, p^*, \phi) - D_0} T(\phi) + 1 - \frac{A_0 + F_0 + \Pi(a^*, p^*, 0) - a^*}{A_0 + \Pi(a^*, p^*, 0) - D_0}}$$

$$= \frac{1}{1 + (A_0 + F_0 + \Pi(a^*, p^*, 0) - a^*)(\frac{T(\phi)}{A_0 + \Pi(a^*, p^*, \phi) - D_0} - \frac{1}{A_0 + \Pi(a^*, p^*, 0) - D_0})}$$

Since

$$\frac{\Pi(a^*, p^*, \phi)}{\Pi(a^*, p^*, 0)} = \frac{\varepsilon_G^a(0)}{\varepsilon_G^a(\phi)} T(\phi) < T(\phi)$$

Then

$$\frac{T(\phi)}{A_0 + \Pi(a^*, p^*, \phi) - D_0} > \frac{1}{A_0 + \Pi(a^*, p^*, 0) - D_0}$$

So

$$\Pi_a'(a^*, p^*, 0) < 1$$

Given $p^* = p^{fb}$. Then

$$\Pi_a'(a^*, p^*, 0) < 1 = \Pi_a'(a^{fb}, p^{fb}, 1)$$

So

$$a^* > a^{fb}$$

Combined with previous results we have $a^{fb} < a^* < \hat{a}$ and $p^* = p^{fb} = \hat{p}$

When turning to advertising intensity, given $\Pi_a'(a^*, p^*, \phi) > 1$ and $p^* = \hat{p}$

$$\frac{a^*}{p^* q(a^*, p^*, \phi)} = \frac{\varepsilon_G^a(\phi)}{\varepsilon_H^p(p^*) \Pi_a'(a^*, p^*, \phi)} < \frac{\varepsilon_G^a(\phi)}{\varepsilon_H^p(\hat{p})} = \frac{\hat{a}}{\hat{p} q(\hat{a}, \hat{p}, \phi)}$$

Note that $a^* < \hat{a}$ imply

$$\frac{G(a^*, \phi)}{G(a^*, 0)} < \frac{G(\hat{a}, \phi)}{G(\hat{a}, 0)}$$

So

$$\frac{a^*}{p^* q(a^*, p^*, 0)} = \frac{G(a^*, \phi)}{G(a^*, 0)} \frac{a^*}{p^* q(a^*, p^*, \phi)} < \frac{G(\hat{a}, \phi)}{G(\hat{a}, 0)} \frac{\varepsilon_G^a(\phi)}{\varepsilon_H^p(\hat{p})} = \frac{\hat{a}}{\hat{p} q(\hat{a}, \hat{p}, 0)}$$

Given

$$\frac{1}{T(\phi)} < \Pi'_a(a^*, p^*, 0) < 1$$

Then

$$\frac{a^*}{p^* q(a^*, p^*, 0)} = \frac{\varepsilon^a_G(0)}{\varepsilon^p_H(p^*)\Pi'_a(a^*, p^*, 0)} > \frac{\varepsilon^a_G(0)}{\varepsilon^p_H(p^{fb})} = \frac{a^{fb}}{p^{fb} q(a^{fb}, p^{fb}, 0)}$$

Therefore

$$\frac{a^{fb}}{p^{fb} q(a^{fb}, p^{fb}, 0)} < \frac{a^*}{p^* q(a^*, p^*, 0)} < \frac{\hat{a}}{\hat{p} q(\hat{a}, \hat{p}, 0)}$$

Part II: Proof of positive advertising expenditure cash flow sensitivity

If $\phi = 0$, we have $a^* = a^{fb}$. Therefore a^* is independent of F_0.

If $\phi > 0$

Consider two cases $\nu > 0$ and $\nu = 0$.

Case 1: If $\nu > 0$ and $\lambda = \mu = 0$, we have $a^* = \hat{a} < F_0 + D_0$. Therefore a^* is independent of F_0 when internal capital is abundant.

Case 2: If $\nu > 0$ and $\lambda = \mu > 0$, we have $a^* = F_0 + D_0$. Therefore a^* increases with F_0 when internal capital is used up.

Case 3: If $\nu = 0$. $a^* > F_0 + D_0$, which implies the internal capital is insufficient and new shares are issued.

Given the F.O.C.

$$\Pi'_a(a^*, p^*, \phi) - \frac{A_0 + \Pi(a^*, p^*, \phi) - D_0}{A_0 + \Pi(a^*, p^*, 0) - D_0}$$
$$- (a^* - F_0 - D_0)\frac{\Pi'_a(a^*, p^*, \phi)(A_0 + \Pi(a^*, p^*, 0) - D_0) - \Pi'_a(a^*, p^*, 0)(A_0 + \Pi(a^*, p^*, \phi) - D_0)}{(A_0 + \Pi(a^*, p^*, 0) - D_0)^2}$$
$$= 0$$

We have

$$\frac{\partial a^*}{\partial F_0} = \frac{\Pi'_a(a^*, p^*, \phi)(A_0 + \Pi(a^*, p^*, 0) - D_0) - \Pi'_a(a^*, p^*, 0)(A_0 + \Pi(a^*, p^*, \phi) - D_0)}{\Psi}$$

Note that

$$\Pi'_a(a^*, p^*, \phi)(A_0 + \Pi(a^*, p^*, 0) - D_0) - \Pi'_a(a^*, p^*, 0)(A_0 + \Pi(a^*, p^*, \phi) - D_0) > 0$$

$\Psi = -\Pi''_a(a^*, p^*, \phi)(A_0 + \Pi(a^*, p^*, 0) + F_0 - a^*)(A_0 + \Pi(a^*, p^*, 0) - D_0) - \Pi''_a(a^*, p^*, 0)(a^* - F_0 - D_0)(A_0 + \Pi(a^*, p^*, \phi) - D_0) + 2(A_0 + \Pi(a^*, p^*, 0) - D_0)\Pi'_a(a^*, p^*, \phi)(1 - \Pi'_a(a^*, p^*, 0))$

Given $-\Pi''_a(a^*, p^*, \phi) > 0$, $A_0 + \Pi(a^*, p^*, 0) + F_0 - a^* > 0$, $A_0 - D_0 > 0$, $-\Pi''_a(a^*, p^*, 0) > 0$, $a^* - F_0 - D_0 > 0$, $1 - \Pi'_a(a^*, p^*, 0) > 0$, $\Pi'_a(a^*, p^*, \phi) > 0$.

Therefore $\Psi > 0$.

So

$$\frac{\partial a^*}{\partial F_0} > 0$$

So if $\nu = 0$, a^* increases with F_0 when internal capital is insufficient.