Optimism or Over-Precision? What Drives the Role of Overconfidence in Managerial Investment Decisions?

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Abstract

Overconfidence can be viewed as having two dimensions: optimism and over-precision. Extant empirical studies focus mostly on the former due to the difficulty in measuring the latter. This study develops accessible empirical measures to disentangle these two dimensions through a novel application of earnings forecasts issued by firm managers. These measures capture different aspects of the link between overconfidence and managerial investment decisions. Specifically, CEOs displaying excess precision are more likely to scale up investment in real assets (especially via M&A); firms with more optimistic CEOs display no such proclivity. Furthermore, overly precise CEOs are also shown to be more likely to acquire private and geographically distant targets in different industries.

Keywords: Overconfidence, Optimism, Over-Precision, Miscalibration, Corporate Investment, Merger and Acquisition

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1. Introduction

Overconfidence is a common behavioral bias, and its significance to the conduct of human affairs is difficult to overstate (Griffin and Tversky, 1992). The psychology literature describes overconfidence as manifested in two main flavors: (1) positive illusion (or optimism) and (2) over-precision of beliefs (Skala, 2008). In a nutshell, optimism is a 'better than average' effect, whereas over-precision bias is "an unwarranted belief in the correctness of one's answers" (Koriat, Lichtenstein, and Fischhoff, 1980). The former can be thought of as overconfidence regarding the mean (i.e., the first moment), and the latter as overconfidence regarding the precision (i.e., the second moment – variance effect).[1]

Broadly speaking, the finance literature on managerial overconfidence has examined the optimism aspect carefully but has developed relatively little understanding about the role of *precision bias*.[2] For example, CEO overconfidence is frequently examined as a potential driver behind a wide range of corporate finance policies (e.g., Malmendier and Tate 2008; Hirshleifer, Low, and Teoh 2012; Ben-David, Graham, and Harvey 2013). However, this literature primarily focuses on optimism, while largely remaining silent on the role of *precision bias*. In this paper, we put under the microscope the relative importance of this largely neglected aspect of overconfidence in the context of corporate investment decision making.

A precision bias arises when economic agents' subjective probability distributions are too narrow relative to the actual distribution of outcomes. They either overestimate the precision of

[1] Positive illusion refers to the better-than-average effect and unrealistic optimism. Many experimental studies in the psychology literature have shown that individuals have a tendency to consider themselves "above average" and are too optimistic about their own future prospects (Alicke et al. 1995; Svenson 1981; Weinstein 1980).

[2] As noted by Skala (2008), overconfidence and optimism are often used interchangeably for this type of overconfidence in the behavioral corporate finance literature. For example, Malmendier and Tate (2005, 2008) refer to the overestimation of future firm performance as overconfidence, while Otto (2014) refers to it as optimism. Throughout this study, we use optimism to refer to the mean (or first moment) effect of overconfidence.

their information or underestimate the variance of random events. For example, Fischhoff, Slovic, and Lichtenstein (1977) show that when answering questions, experiment participants generally assign a much higher accuracy rate than the actual probability. Similarly, Ben-David, Graham, and Harvey (2013) show that CFOs provide forecast intervals for future S&P 500 returns that seem too narrow. Throughout this study, we use the term "over-precision" to represent this second moment type of overconfidence.

It is important to understand the relative importance of precision bias versus optimism in corporate finance for at least two reasons. First, in surveying the literature on overconfidence, Moore and Healy (2008) observe that "*[t]here are three notable problems with research on overconfidence. The first is that the most popular research paradigm confounds overestimation with overprecision" (p. 503).*[3] As they point out, this issue permeates beyond the psychology literature, including the empirical research in behavioral finance, accounting, and economics. Second, Moore and Healy (2008) find that over-precision is more persistent than optimism. Moreover, over-precision reduces the effect of optimism in an experimental setting, suggesting that over-precision has a first order importance in decision making processes.

Theoretical models in the behavioral corporate finance literature generally differentiate between optimism and over-precision. The former is often modelled as an overestimation of the firm's cash flows (e.g., Heaton, 2002; Malmendier and Tate 2005; Hackbarth 2008). Over-precision is usually defined as an underestimation of risk (e.g., Hackbarth 2008; Ben-David, Graham, and Harvey 2013).[4] While defining theoretical constructs of managerial overconfidence

[3] The other two (out of three) problems with research on overconfidence are (1) the prevalence of underconfidence, and (2) the inconsistency between overestimation and overplacement. In this study, we only focus on the first problem identified in Moore and Healy (2008).

[4] Online Appendix A provides a summary of various definitions of overconfidence used in both psychology and behavioral finance literatures.

and its distinct components is relatively simple, identifying reliable proxies for such constructs is a major challenge in empirical studies.

In the existing empirical literature, the most widely used proxy for managerial overconfidence is an option-based measure developed by Malmendier and Tate (2005, 2008). Corporate managers who hold on to deeply in-the-money options beyond a reasonable threshold are classified as overconfident because they are over-*optimistic* about future firm performance. However, Malmendier and Tate (2005, p.2671) also discuss how this proxy can have the opposite relation with the second aspect of overconfidence: over-precision. Managers who overestimate the precision of their signals are likely to have lower estimates of the firm's stock volatility and therefore place lower values on the firm's stock options. Nevertheless, this option-based proxy is sometimes also used to measure over-precision given the difficulty in capturing precision bias using other available measures. In this study, we confront this empirical challenge by examining earnings forecasts issued by management, which allows us to develop two accessible empirical measures that disentangle over-precision from optimism. This provides an avenue to directly examine the effects of precision bias on corporate policies, and how they can be distinct from the effects of optimism.

Management earnings forecasts are useful in this context for three reasons. First, if executives are optimistic – i.e., they believe that the firm's future performance will be better than its later actual realization, they would issue forecasts that are more optimistic than behaviorally neutral forecasts. Second, the vast majority of management earnings forecasts are presented in the form of a range, which provides sufficient information to simultaneously deduce a measure of precision bias. Our intuition is simple: executives who underestimate the distribution of potential

future outcomes would be more likely to provide narrower forecast ranges relative to the actual distribution.[5]

Third, we are aware of at least two empirical studies that have established a link between earnings forecasts and CEO overconfidence, which encourage a deeper dive into this fruitful setting. In an experimental setting, Libby and Rennekamp (2012) find that overconfident participants are more likely to forecast better subsequent performance (when compared to less confident participants). Using both option-based and press-based measures of CEO overconfidence, Hribar and Yang (2016) find that overconfident CEOs are more likely to issue more optimistic earnings forecasts. They also find that CEOs who hold on to deep-in-the-money options also provide narrower forecast ranges. The latter result is inconsistent with the motivation for the option-based measure as discussed in Malmendier and Tate (2005).

The closest related study to ours is Ben-David, Graham, and Harvey (2013).[6] They utilize confidence intervals on S&P 500 return predictions provided in CFO surveys to differentiate between optimism and over-precision. They find the CFOs participating in their survey to be severely 'miscalibrated', as only 36.3% of one-year S&P 500 returns fall within the CFOs' 80% confidence interval.[7] Ben-David, Graham, and Harvey (2013) also provide some preliminary results suggesting that miscalibrated managers invest more and tolerate higher financial leverage.

[5] Corporate executives have some incentives to provide reasonably wide forecast ranges, as CEOs who miss their biased forecasts face a higher forced turnover rate (Lee, Matsunaga and Park, 2012). In Section 3.1, we discuss how we mitigate CEOs' potential incentives to issue positively biased earnings forecasts during major corporate events.

[6] We consider the empirical results from Ben-David, Graham, and Harvey (2007) to be superseded by Ben-David, Graham, and Harvey (2013). However, we also refer to Ben-David, Graham, and Harvey (2007) for the theoretical model and the empirical predictions on miscalibration, which is their preferred term for over-precision. While we use both terms interchangeably in this paper, we lay out our hypotheses and empirical results using "over-precision". We use the miscalibration term as appropriate when discussing existing studies.

[7] Although in our setting of management earnings forecasts, there are no clear defined confidence ranges given by each manager, we argue that managers are incentivized to issue appropriately wide forecast ranges. Lee, Matsunaga and Parks (2012) show that CEOs are more likely to get fired by either issuing *overly pessimistic forecasts* or *overly optimistic forecasts* that result in less forecasting accuracy.

While our study extends the analysis in Ben-David, Graham, and Harvey (2013), the studies differ in the following five respects. *First*, as opposed to the private nature of their surveys, our measure of overconfidence – coming from earnings forecasts issued by the firm – can be publicly observed by market participants as well as by researchers, and therefore can be more easily adopted by future empirical studies. *Second*, our measure of overconfidence is derived from the firm's internal forecasts and therefore is more specific about the firm's own future performance, for which the managers are more likely to have superior information relative to the forecasts of S&P 500 returns used in Ben-David, Graham and Harvey (2013). *Third*, our study covers a considerably larger sample of firms, which allows us to develop more robust inferences. *Fourth*, the larger sample also enables us to examine the investment decisions of overconfident CEOs in greater detail and to identify the channels through which overconfidence is related to firm investment decisions. *Fifth*, we provide further evidence on the impact of both optimism and precision bias on different types of merger and acquisition decisions (e.g., diversifying and private M&As vs. non-diversifying and public M&As).

In this study, we collect annual management earnings forecast data from the IBES *Guidance* database. Our sample covers the period from 2001 to 2014. Qualitative and open-ended forecasts are excluded, as they are not amenable to the measure we propose. In total, we have 15,303 management earnings forecasts to derive the overconfidence measures. These managerial earnings forecasts can be affected by various firm characteristics and managerial incentives. To control for these variations, we partial out a range of possible confounding effects through a regression design. For example, managers might (appropriately) issue earnings forecast ranges that are wider when the firm's earnings are simply more difficult to forecast. We attempt to control for this particular variation by including the forecast dispersion of equity analysts in the regression

models. We also include industry and year effects to capture potential variations across industries and over time. As a result, the residuals from the regression models provide reasonable measures of the two facets of overconfidence, instead of just variations in optimism and precision due to the variation in firm and industry characteristics. Following Cheng and Lo (2006) who argue that the firm's CEO has the greatest influence over a wide range of corporate decisions, including earnings disclosure decisions, we attribute our measures of overconfidence to CEOs rather than firms.[8]

Generally, we find that the CEOs in our sample are overly precise in their earnings forecasts. CEOs are expected to provide a range of earnings forecasts with a relatively high confidence level as this is an important channel for management to distribute new price-sensitive information to the market (Gong, Li, and Xie, 2009). However, contrary to this expectation, 69.8% of actual earnings fall *outside* the forecast range. In other words, the typical confidence interval is only around 30%, suggesting that CEOs generally underestimate the distribution of potential outcomes. This point estimate is in the same ballpark as the accuracy rate (i.e., 36.3%) of CFOs' predictions of S&P 500 returns in the Ben-David, Graham, and Harvey (2013) study. For CEOs who are classified as overly precise based on the residuals from the regression models, the percentage of actual earnings that fall outside of the range is even higher: 73.0%, suggesting that our identification of over-precision successfully captures the underestimation of risk rather than better forecasting skills.[9]

We then turn to examine how optimistic and overly precise CEOs are different in their corporate investment decisions. We hypothesize that both optimistic and overly precise CEOs

[8] Consistent with modeling overconfidence as a personal fixed effect, we observe that the overconfidence measures we develop display persistence over time. Attributing overconfidence at the CEO level is also consistent with the finding in Bertrand and Schoar (2003) that managerial style matters even after controlling for firm heterogeneity. In unreported results, our over-precision measure is positively correlated with male CEO indicator, indicating that male CEOs are more overconfident relative to other CEOs, consistent with the evidence in prior literature, e.g., Barber and Odean (2001).

[9] Our finding that managers tend to be overly precise in general is consistent with Goel and Thakor (2008). They argue that overconfident managers who underestimate risk and take on excessive risk that results in overrepresentation of the right-tail winners are more likely to be promoted.

would invest more, as they either overestimate project cash flows or use a lower discount rate (because they underestimate risk) that can turn potential projects with negative NPVs into seemingly positive ones. We find that CEOs who provide abnormally precise earnings forecasts invest more in real assets, while optimistic CEOs do not display such pattern. We further document that the increase in investment by overly precise CEOs is mainly driven by external acquisitions. This finding remains after controlling for industry trends and potential sample selection issues. It is also affirmed using merger and acquisition (M&A) transaction data from the Thomson SDC database.

We posit that the impact of CEO over-precision should be more pronounced in more complicated acquisitions. The psychology literature has documented a robust pattern of 'hard-easy' effect of precision bias in which agents overestimate the precision of their knowledge mostly in difficult task (e.g., Fischhoff et al. 1977, Lichtenstein et al. 1982, and Soll 1996). In line with this argument, we predict that overly precise CEOs are more likely to undertake more challenging acquisitions. Consistent with this argument, we find that overly precise CEOs are more likely to engage in acquisitions with private targets, targets in different industries, and targets located further away. On the other hand, there is no clear ex-ante prediction regarding CEO optimism because agents are more likely to *overestimate* their performance in difficult tasks (e.g., Lichtenstein and Fischhoff, 1977), but at the same time *underrate* their ability to complete those tasks relative to their peers (e.g., Kruger, 1999 and Windschitl, Kruger, and Simms, 2003). We do not observe any significant link between CEO optimism and these acquisition decisions.

Our study provides three contributions to the existing behavioral corporate finance literature. First, and most importantly, we develop a new set of proxies for overconfidence based on management earnings forecasts that distinguish precision bias from optimism. This approach

should advance empirical analysis on managerial precision bias, which is linked to a wide range of corporate decisions in various existing theoretical models (e.g., Hackbarth 2008; Gervais, Heaton, and Odean 2011). Second, supplementing existing findings that CEO optimism plays an important role in investment decisions (e.g., Malmendier and Tate 2005, 2008), we document that precision bias plays (at least) an equally important role, especially in acquisition decisions. Our findings suggest that ignoring the distinction between these two facets of overconfidence may lead to inaccurate conclusions. Third, this study provides empirical evidence for the role of precision bias in more uncertain merger and acquisition decisions. Specifically, firms with overly precise CEOs are more likely to acquire private targets, targets in different industries and in further locations.

The remainder of this study proceeds as follows. We develop the hypotheses in Section 2. In Section 3, we detail the process of measuring CEO optimism versus over-precision using management earnings forecasts. Section 4 reports our empirical analysis on the link between the two overconfidence measures and managerial decisions. Section 5 concludes the study.

2. Hypotheses Development

Much of the extant empirical literature on CEO overconfidence has focused on how optimism affects corporate investment decisions. For example, Malmendier and Tate (2005) find supporting evidence that firms with optimistic CEOs invest more, especially when the firm is less financially constrained. Hirshleifer, Low, and Teoh (2012) find that optimistic CEOs invest more in innovation. Both of these results are consistent with Heaton (2002), who argues that optimistic CEOs tend to over-invest because they overestimate future project *cash flows* and therefore perceive some (marginally) negative NPV projects to be positive.

Focusing on the effect of precision bias, Ben-David, Graham, and Harvey (2007) argue that miscalibrated managers underestimate the potential *risk* associated with investments and, therefore, apply a lower discount rate. Even assuming that their expectation of future cash flows is not impacted by their over precision, overly precise managers could perceive some marginally negative NPV projects as enhancing shareholder wealth and, thus, end up investing more. In the empirical literature, the impact of managerial precision bias on corporate investment decisions has received relatively less attention. One clear exception is the survey-based study of Ben-David, Graham, and Harvey (2013), who provide some preliminary empirical results showing that firms with miscalibrated CFOs tend to invest more.

Theoretically, Hackbarth (2009) examines the investment behavior of optimistic and miscalibrated managers using a real option framework. He argues that firms with optimistic CEOs would invest early because a higher perceived growth rate in earnings raises the opportunity cost of waiting to invest. Miscalibrated CEOs would also invest early because they view projects as less uncertain, which reduce the option value of waiting for new information. As a result, both optimistic and miscalibrated CEOs would invest early and engage in more investment.

Accordingly, we hypothesize that firms with optimistic CEOs are more likely to invest more because they overestimate the expected investment return. Moreover, firms with overly precise CEOs are also hypothesized to invest more because they underestimate the investment risk. More formally:

H1a: *Optimistic CEOs invest more in comparison to other CEOs.*

H1b: *Overly precise CEOs invest more in comparison to other CEOs.*

It is important to note that, while both hypotheses make predictions in the same direction, it is unlikely that they will enter with the same intensity and it might even be the case that one effect dominates the other. These are empirical questions. Accordingly, our experimental design aims to tease out the marginal contribution of each aspect of overconfidence, reflected in H1a and H1b. Indeed, our empirical tests are akin to a horse race between these two dimensions in which the goal is to identify the distinctive role each plays within the broader construct of CEO overconfidence.

One important aspect of corporate investment, mergers and acquisitions, has received extensive attention in the behavioral corporate finance literature. Starting with the seminal work of Roll (1986), "hubris" theory suggests that managers could be too confident about the benefits of mergers and acquisitions, and consequently bid excessively for the target. Malmendier and Tate (2008) also find that firms with optimistic CEOs undertake more acquisitions, and especially diversifying acquisitions, i.e., acquisitions of firms in industries that are different from the industries in which the acquirers are currently operating.

Overconfident managers are more likely to engage in acquisitions for two distinct reasons. *First*, optimistic CEOs are likely to overestimate the potential synergies derived from mergers and acquisitions. Therefore, they would be more willing to engage in mergers and acquisitions. *Second*, overly precise managers may perceive acquisitions to be less risky and apply a lower discount rate to determine the NPV of their acquisitions. As a result, they may perceive more acquisition opportunities to have sufficiently high NPVs to undertake. Therefore, we predict that both dimensions of overconfident will lead CEOs to be more likely to engage in acquisitions.

H2a: *Optimistic CEOs are more likely to engage in acquisitions in comparison to other CEOs.*

H2b: *Overly precise CEOs are more likely to engage in acquisitions in comparison to other CEOs.*

Psychology literature has documented a robust pattern of 'hard-easy' effect of precision bias (e.g., Fischhoff et al., 1977, Lichtenstein et al., 1982 and Soll, 1996). That is, people overestimate the precision of their knowledge mostly in difficult tasks. Moore and Healy (2008) also find that over-precision is significantly more pronounced when there is greater level of information uncertainty. In their experiment, the hit rate (answers fell within the confidence intervals) were lowest when participants have the least information available.

In our setting, when the outcome is more uncertain, there is more room for overly precise CEOs to underestimate the risk. As a result, we would expect the effect of CEO over-precision bias to be more pronounced in more challenging mergers and acquisitions. More precisely, we predict that overly precise CEOs would be more likely to acquire targets in industries in which the acquiring firms have not operated before because estimating synergies and discount rates is even more subjective and difficult in these situations.

We also expect a stronger effect of CEO over-precision bias in acquisitions that involve private and geographically distant targets. Acquisitions involving private targets have higher degrees of uncertainty, because there is less information available for private targets both in terms of quantity and quality (Capron and Shen, 2007). There is substantially more information asymmetry around the valuation of private targets when compared to a public target (Officer, Poulsen, and Stegemoller, 2008). The level of uncertainty is also significantly higher for geographically distant acquisitions due to higher information asymmetry (e.g., Kang and Kim, 2008). In addition, international cross-border acquisitions are associated with additional

uncertainty in the form of frictions arising from cultural and geographic differences (Erel, Liao and Weisbach, 2012). Accordingly, we expect the impact of CEO precision bias to be more pronounced in diversifying, private, and geographically distant mergers and acquisitions.

On the other hand, the 'hard-easy' effect of optimism is less clear. Optimism, defined as overestimation of cash flows in this study, can stem from both overestimation and over-placement (better-than-average) biases referred to in Healy and Moore (2008). That is, CEOs can be too confident in his/her skills either in absolute term (i.e., overestimation) or relative to other CEOs (i.e., over-placement). On one hand, psychology literature has shown that overestimation of performance is more prevalent in hard tasks (e.g., Lichtenstein and Fischhoff, 1977, and Lichtenstein et al., 1982). On the other hand, agents seem to rate themselves below average for hard tasks (Kruger, 1999) – i.e., under-placement. For example, contestants in difficult competitions are often pessimistic about winning (Windschitl, Kruger, and Simms, 2003). As summarized in Moore and Healy (2008), easy (hard) tasks produce the most underestimation (overestimation), but also produce the most over-placement (under-placement). As a result, we do not have a clear ex-ante prediction regarding CEO optimism in acquisition decisions with different level of difficulties.

H3: *Overly precise CEOs are more likely to engage in diversifying, private and geographically distant acquisitions in comparison to other CEOs.*

3. Measuring Overconfidence

Managerial overconfidence is very challenging to measure as it is not directly observable. The most widely used measure for managerial overconfidence in the finance literature is one developed by Malmendier and Tate (2005, 2008) that is based on managers' option exercise behaviors. Executives generally receive a significant proportion of their remuneration package in the form of stock and option grants.[10] In addition, their human capital and future employment prospects are highly dependent on firm outcomes. Therefore, executives should seek to diversify by exercising their deep-in-the-money option holdings early to reduce their exposure to firm-specific risks. Nevertheless, some executives hold on to their option holdings for a long period, even until the year of expiration. Hall and Murphy (2002) show that the timing and threshold to exercise options depends on individual wealth, risk aversion, and diversification. Nevertheless, given reasonable calibrations of these parameters, Malmendier and Tate (2005 & 2008) conclude that such late exercise behavior is inconsistent with optimal decision making by executives. As a result, Malmendier and Tate (2005, 2008) classify executives who exhibit such late exercise behavior as overconfident. They argue that these executives are too optimistic about firm future performance, which induces them to hold on to their options beyond the optimal exercise point. Strictly speaking, the option-based measure is designed to measure optimism, the first facet of overconfidence.

However, the option-based measure of overconfidence could also capture the over-precision effect. If executives underestimate the risk of under diversification, they will be more

[10] Notably, stock options are required to be expensed after the implementation of accounting standard FAS 123R in 2005. Hayes, Lemmon and Qiu (2012) report that on average (median), the percentage of stock options as part of CEO compensation has substantially dropped by approximately 44% (65%) in the three years following FAS 123R. Therefore, the adoption of FAS 123R may potentially reduce the apparent economic importance of an options-based overconfidence measure such as Malmendier and Tate (2005) after 2005.

willing to hold on to the unexercised options longer. Therefore, it is not readily apparent which facet of overconfidence is captured by the option-based measure – and most likely it represents some indeterminate blend of the two. Indeed, in untabulated results, the *longholder* measure of overconfidence as developed in Malmendier and Tate (2005), is positively (although statistically insignificant) correlated with optimism (correlation of 0.02) and over-precision (correlation of 0.03).

In empirical work, studies do not usually clearly distinguish between optimism and over-precision. For example, Hribar and Yang (2016) use the option-based measure to examine the impacts of both optimism and miscalibration on management earnings forecasts. Hirshleifer, Low, and Teoh (2012) also use the option-based measure to empirically test the risk-taking of overconfident CEOs. They document that firms with overconfident CEOs are associated with higher stock return volatility. These findings suggest that the option-based measure of overconfidence at least captures some of the over-precision element. It is therefore unclear which facet of overconfidence plays a more important role when the option-based measure is used.

Recognizing the confusion embedded in existing empirical studies of overconfidence, Ben-David, Graham, and Harvey (2013) provide the first attempt to examine optimism and miscalibration separately. In their surveys, Ben-David, Graham, and Harvey (2013) ask CFOs to predict one-year and ten-year S&P 500 future returns. Using the survey responses, they construct (1) a measure of CFO optimism using CFOs' return forecast errors and (2) a measure of CFO miscalibration using the narrowness of their return forecast intervals. The two measures are arguably more closely aligned with the definition of two aspects of overconfidence employed in the behavioral corporate finance models: optimism is often modelled as overestimation of the mean, while miscalibration is usually defined as the underestimation of risk.

In practice, researchers are severely limited in their ability to capture such a distinction across a wider sample of executives. Management earnings forecasts provide us with a unique setting in which alternative overconfident measures can be derived from a broader cross-section of executives. In particular, the vast majority of earnings forecasts issued by management (i.e., 90%, on average) are in the form of a range forecast rather than a point estimate. These range forecasts allow us to separately measure optimism and over-precision. We classify executives who over-forecast earnings as optimistic. Motivated by Ben-David, Graham, and Harvey (2013), we classify executives who issue earnings forecasts with narrower intervals as overly precise.

3.1 Determinants of Management Earnings Forecasts

Cheng and Lo (2006) argue that the CEO of a firm has the greatest influence over a wide range of corporate decisions, including earnings disclosure decisions. They find that managers increase the number of negative earnings forecasts before share purchases, and this effect is stronger for insider trades initiated by CEOs, which suggests that CEOs have the greatest influence over earnings forecasts. Similarly, using the option-based measure of CEO overconfidence, Hribar and Yang (2016) find that CEO overconfidence affects the propriety of management earnings forecasts, which also suggests that CEOs play an important role in earnings disclosure decisions. Therefore, in this study, we attribute the two facets of managerial overconfidence derived from management earnings forecasts to the firms' CEOs. This approach is consistent with Otto (2014), who uses over-forecasts of earnings to identify optimistic CEOs. Attributing the overconfidence measures at the CEO level is also consistent with the finding reported by Bertrand and Schoar (2003) that managerial style matters.

Management earnings forecasts provide a similar setting to the measurement of overconfidence in Ben-David, Graham, and Harvey (2013). The main difference is that they ask

CEOs to predict an exogenous event (e.g., next year's S&P 500 returns) that is not affected by individual firm managers' decisions. Management forecasts can be affected by different firm characteristics and managerial incentives. For example, it might be more difficult to forecast earnings for firms with more volatile earnings, which may result in a larger forecast range that does not necessarily reflect CEO over-precision. To attenuate the effect of these firm and managerial characteristics, we use a regression approach to partial out a range of confounding effects. We subsequently use the residuals to measure the two facets of CEO overconfidence.

Following the prior literature on management earnings forecasts, we use Equation (1) to control for a range of confounding effects:

$$\begin{aligned} &\boldsymbol{MFE_t \text{ or } Precision_t} \\ &\quad = \boldsymbol{\alpha_0} + \sum_{\boldsymbol{i}} \boldsymbol{\beta_i Firm\ Characteristics_{i,t-1}} + \boldsymbol{Industry} \\ &\quad * \boldsymbol{Year\ dummies} + \boldsymbol{PE\ Quintile\ dummies} + \boldsymbol{\varepsilon_t} \end{aligned} \quad (1)$$

Depending on which hypothesis is being tested – either relating to optimism or to over-precision – the dependent variable takes one of two forms. First, with regard to optimism, MFE_t is management forecast error computed as the difference between the mid-point of the forecast range and the actual earnings for year t scaled by the share price at the end of year t-1.[11] Second, with regard to over-precision, $Precision_t$ is defined as the earnings forecast interval for year t scaled by the share price at the end of year t-1, and multiplied by negative one (i.e., -1 for ease of interpretation). That is, a higher value of *Precision* (i.e. a less negative value), the more precise is

[11] Actual earnings are obtained from the IBES Guidance database to ensure consistency with the earnings forecasts.

the forecast and the more overly precise is the CEO.[12] A larger ε_t in each of the two regressions indicates a higher level of optimism or over-precision, respectively.

Five commonly used firm-level control variables are drawn from the prior literature on earnings forecasts (e.g., Gong, Li, and Wang 2011; Hribar and Yang 2016): (1) firm size (*Firmsize*); (2) market-to-book ratio (*MB*); (3) return on assets (*ROA*); (4) change in earnings *(*Δ*Earnings*); and (5) accounting accruals (*Accruals*). We also control for three other groups of firm-level factors that have been found to be important in determining management earnings forecasts, namely: (1) the forecasting environment; (2) managerial incentives; and (3) the forecast horizon. We provide detailed definitions and calculations of these control variables in Appendix A.

First, to control for the variation in forecasting environments that managers face when making their earnings forecasts, we include two sets of variables. First, we include variables that are intended to capture the volatility of firm fundamentals directly: earnings volatility (*Earnings Vol*) and a dummy variable for a loss-making firms (*Loss*). Second, we include a variable that is intended to capture the difficulty in forecasting the firm's earnings: analyst dispersion (*Analyst Dispersion*). When the firm's earnings is difficult to estimate, analyst forecasts are likely to be more dispersed, and managerial forecasts are also likely to be less precise. Indeed, these two variables have substantial correlation: higher analyst dispersion is associated with wider managerial forecast ranges. Including this variable is therefore quite useful in facilitating our objective to capture the variation in managerial forecast ranges that cannot be explained by firm fundamentals.

As documented by Ajinkya, Bhojraj, and Sengupta (2005), firms with more outside directors and higher institutional ownership are more likely to issue more specific and less

[12] We assign missing values to *Precision* for all point estimates (about 10% of our sample).

optimistic earnings forecasts. We therefore control for the proportion of independent directors (*Independent*) and institutional ownership (*Inst. Ownership*). As argued by Rogers and Stocken (2005), firms are more likely to issue less optimistic forecasts if the litigation risk is high and when the market is more concentrated in order to discourage new entrants. Bamber and Cheon (1998) also find that when proprietary information costs are high, managers are less willing to reveal information, which results in lower forecast precision. Therefore, we include the Hirfindahl-Hirschman index (*HHI*) to control for the level of industry competition and a dummy variable for industries with high litigation risk (*Litigation*). All these control variables are measured as of fiscal year t-1.

Second, to control for managerial incentives in providing biased positive earnings forecasts during M&A and financing activities, we include firms' M&A (*MA*) and financing activities (*Net Equity Issue*) during year t in our regression models, following Gong, Li, and Wang (2011) and Hribar and Yang (2016). These variables are important for in this context because we examine the impact of overconfidence on firms' investment behavior, and in particular the merger and acquisition activities. If firms tend to over-forecast earnings prior to engaging in M&As, we could potentially wrongly attribute a positive relation between earnings forecast errors and M&A activities to CEO overconfidence if we do not control for this biased incentive effect. Having said that, there are nontrivial incentives to provide accurate estimates as CEOs bear a cost for issuing biased estimates and then subsequently miss their earnings forecasts. For example, Lee, Matsunaga and Park (2012) find that CEOs are more likely to get fired if they provide a larger magnitude of absolute forecast errors (positive or negative) when firm performance is poor.

Third, to control for the information available when a forecast is made, we include the forecast horizon (*Horizon*), which is the number of days between the management forecast date

and the fiscal period end date (Bamber and Cheon 1998; Johnson, Kasznik, and Nelson 2001). To further control for information availability, we control for the number of analysts following the firm (*Number of Analysts*). In the earnings forecasts regression, we also include the industry-by-year fixed effects using the interactions between the Fama-French 48 industries and year dummies. These variables are used to capture the effects of time-varying industry characteristics and macroeconomic conditions on management earnings forecasts.

In addition to the variables from prior literature on management earnings forecasts, we also include dummy variables for the Price-to-Earnings (PE) ratio quintiles in each year to avoid any potential mechanical relation inadvertently introduced by the use of share price as the "scaling factor". The PE ratio is defined as the ratio of the share price, which is used as a deflator for MFE and Precision, to the mid-point of the earnings forecasts.[13]

We obtain the optimism and over-precision residuals from the forecast error and forecast precision regressions, respectively. The higher are the optimism (over-precision) residuals, the more optimistic (overly precise) are the CEOs. To reduce the noise contained in these residuals, we aggregate them at the CEO's personal level. That is, we average the residuals from all the earnings forecasts issued by a particular CEO. We then compare this average residual value to the median of that variable for all CEOs – specifically, we form dummy variables based on classifying a CEO as optimistic (overly precise) if the average residual from the forecast error (precision) regression is greater than the median value.

[13] For example, suppose two firms issue identical earnings forecasts of \$0.9 to \$1.1 per share, with actual earnings per share realized being \$0.9. The share prices of firms A and B are \$10 and \$20, respectively. Accordingly, firm A has a PE ratio of 10 based on the forecast mid-point of \$1 per share, while firm B has a PE ratio of 20. All else being equal, in this case, firm A will have a higher forecast error and a lower (i.e., more negative) forecast precision than its counterpart firm B. However, this misleading conclusion is driven by the lower PE ratio of firm A. As a result, if we do not control for the difference in PE ratios, our overconfidence measure derived from the regression will be mechanically correlated with the PE ratio when we use share price as the scaling factor and will bias the results of our subsequent tests. Notably, our results are qualitatively similar if we exclude the PE ratio quintile dummies and only include the Fama-French 48 industries by year fixed effects.

Our decision to employ dummy variables reflects a challenging research design tradeoff. Using dummy variables can result in the loss of some information content in each individual earnings forecast.[14] However, the measurement of overconfidence is inherently difficult as the proxies are plagued by substantial noise, so much so that the noise component of a continuous variable design might easily swamp the underlying economic signal. Accordingly, we choose to adopt a cautious and conservative dummy variable method to measure CEO overconfidence – one in which we argue that the cost of any lost information is more than outweighed by the gain in reduced noise.[15]

Our measures of optimism and over-precision should be viewed as *relative* measures among CEOs, as we are not comparing them to theoretically unbiased forecasts. However, this approach is sufficient for our task because we are interested in how the relative variation in the level of optimism and over-precision is related to the relative outcome of firm policies.

3.2 Descriptive Statistics

3.2.1 Sample Selection and Data Sources

We retrieve all management earnings forecasts data in the period from 2001 to 2014 from the IBES Guidance database. This database provides relatively comprehensive coverage starting from 1995. However, we restrict our sample to start from 2001, because only a limited number of management earnings forecasts are available before the passage of the Regulation Fair Disclosure on October 23, 2000. This sample restriction is also employed in Hribar and Yang (2016). We also obtain analyst forecast data from the IBES unadjusted file.

[14] The dummy variable classification approach assumes that CEO overconfidence is a personal fixed effect; hence, it is not time-varying. We address the issue of overconfidence persistence in Section 3.5.

[15] The percentage of CEOs classified as optimistic or overly precise can be slightly different from 50% in the main tests, as the sample of CEOs used might differ due to the availability of data for each regression.

Qualitative and open-ended forecasts are excluded because they are not specific enough to define forecast errors and ranges. As argued by Hribar and Yang (2016), management overconfidence is more likely to manifest itself in annual earnings forecasts where the earnings are most likely to be uncertain. Accordingly, we only retain annual earnings forecasts to identify overconfident managers. Following the prior literature (e.g., Cheng, Luo, and Yue 2013; Gong, Li, and Wang 2011), we exclude pre-announcement forecasts (i.e., forecasts made after fiscal period end) and forecasts made in previous fiscal years, as the information available to managers for such forecasts could be materially different from other forecasts made during the year. To maximize the observations of management earnings forecasts and, hence, reduce the noise in the overconfidence measure, we retain all forecasts made during the fiscal year.

To identify the CEO in each year, we merge our earnings forecast data with data from Execucomp. The main limitation of our analysis is that Execucomp only covers S&P 1500 firms. However, this restriction is necessary as various CEO-level control variables in our main tests, such as stock and option ownership, are derived from Execucomp.[16] We then match our sample of earnings forecasts to the CRSP/Compustat Merged (CCM) database to obtain firm-level control variables. Board information and institutional ownership are derived from RiskMetrics and Thomson Reuters, respectively. Lastly, to be consistent with our main tests, we exclude financial firms (SIC codes between 6000 and 6999) and utilities (SIC 4000 – 4999).

In the investment analyses, we also use stock returns data from CRSP. In the "investment sample", we have 5,244 observations with non-missing CEO optimism, CEO over-precision and firm-level control variables.

[16] This restriction also applies to other studies such as Hirshleifer et al. (2012), who rely on Execucomp stock options data to measure CEO overconfidence.

3.2.2 Descriptive Statistics for Management Earnings Forecasts

Table 1 reports the sample selection procedure and the distribution of the management earnings forecasts. Panel A shows that there are 15,303 management earnings forecasts with non-missing control variables. Panel B presents the time-series distribution and the percentage of range forecasts for each year. Generally, the number of earnings forecasts within our sample has increased over time. In recent years, the number of managerial earnings forecasts captured by our sampling has been quite stable at approximately 1,100 to 1,400 per year. Among the 15,303 forecasts, in unreported statistics, 13,764 (89.94%) of them are in the form of a range, and the remaining 1,539 (10.06%) are point estimates. The very high percentage of range estimates in our sample is consistent with the findings documented by Hribar and Yang (2016) who report 85.59% range forecasts between 2001 and 2010.

[Table 1 about here]

In unreported statistics, approximately 38.8% of the firm-year observations and 48.8% of the CEOs in our sample have at least one earnings forecast. As a consequence, the management earnings forecast-based overconfidence measure is available for a large portion of the CEOs in our sample. Of those CEOs that issue earnings forecasts, on average, fourteen sampled earnings forecast estimates are available throughout the sample period.

Table 2 reports the summary statistics of variables in the management earnings forecast regressions. Notably, there are more observations for variables related to management earnings guidance and analyst earnings forecasts because there are multiple guidance and forecasts for each firm-year. However, we conduct our analyses of investment decisions at the firm-year level. All variables are winsorized at 1% and 99% to eliminate the effect of outliers. On average, CEOs

negligibly under-forecast relative to the actual earnings in our sample, as evidenced by the slightly negative *MFE*. The average range forecasts provided by CEOs are approximately 0.4% of the share price, and the average gap between earnings forecasts and the fiscal year end is approximately 194 days. The firm-level control variables are generally in line with Gong, Li, and Xie (2009) and Hribar and Yang (2016). More specifically, on average, 6.5% of the firm-year observations in our sample represent loss-making firms, while 25.1% engage in M&A activity and 3.1% issue equity that is greater than 5% of total firm assets (i.e., *Net Equity Issue*). In our sample, a typical firm has a market-to-book value of 3.5, and a rate of return on assets is 7.6%. Moreover, the majority of directors are independent directors (74.9%). The sample average institutional investor ownership is approximately 79.8%.

[Table 2 about here]

3.3 Estimation Results for CEO Overconfidence Measures

Table 3 presents the results for the management earnings forecast error and precision regressions in columns (1) and (2), respectively. Column (1) indicates that larger, more profitable firms, and firms with more analyst dispersion tend to over-forecast their earnings, while growth firms and firms with better analyst coverage under-forecast their earnings. We do not find any evidence that independent directors and institutional ownership reduce forecast optimism, in contrast to the findings in Ajinkya, Bhojraj, and Sengupta (2005). Moreover, industry concentration and litigation do not seem to have the effect of reducing managerial forecast errors in our sample, consistent with the findings in Gong, Li, and Wang (2011). Notably, we do not find

support for either higher accruals or a longer horizon forecast being associated with higher forecast errors when we control for analyst dispersion and the number of analysts.[17]

[Table 3 about here]

Turning to the forecast precision regression in column (2), firms with larger size, higher growth and higher profitability provide more precise earnings forecasts. Similar to Cheng, Luo, and Yue (2013), our results indicate that firms reduce their forecast precision when facing higher earnings uncertainty. This result is shown by the negative relation between earnings forecast precision and earnings volatility, analyst dispersion, and forecast horizon. Our findings do not support those of Ajinkya, Bhojraj, and Sengupta (2005) that firms with higher institutional ownership are associated with narrower forecast intervals. Firms in our sample issue more precise earnings forecasts when the litigation risk is high and when they are about to engage in M&A transactions. On the other hand, firms with higher accruals and larger proportion of independent directors are more likely to issue less precise forecasts.

As described in Section 3.1, we classify CEOs as optimistic and overly precise using residuals from the respective regressions in Table 3. We present the distribution of the residuals from the earnings forecast error (precision) regressions in Panel A (Panel B) in Figure 1. Both series are centered at approximately 0 and are close to a normal distribution. As discussed earlier, we average the residuals of the earnings forecast errors (precision) by each CEO and classify each CEO as optimistic (overly precise) if their average residuals from the earnings forecast error (precision) regression are greater than the median of their counterpart CEOs' average residuals. Our measures of optimism and over-precision have a negative correlation of 12.1% (p-value of

[17] However, if we do not control for analyst dispersion and the number of analysts, we find that firms with higher accruals are associated with higher forecast errors, consistent to the results in Gong, Li, and Xie (2009).

less than 1%), which is consistent with Moore and Healy (2008)'s finding that over-precision seems to reduce the effect of optimism.

[Figure 1 about here]

3.4 Are CEOs Overly Precise?

We have so far attributed narrower earnings forecast ranges to CEO over-precision. However, such behavior might not necessarily reflect over-precision, but rather superior forecasting skill. With this alternative explanation, we would expect the probability of actual earnings falling within overly precise CEOs' narrower earnings forecast ranges to be at least as high as that for other CEOs, reflecting their superior earnings forecasting skills. Therefore, we examine whether our over-precision measure is merely a reflection of better forecasting skills.

Earnings forecasts provide price-sensitive information to the market, and they are an important channel for management to distribute new information (Gong, Li, and Xie 2009). As a consequence, managers are expected to provide a forecast range in which they have high confidence. Although we do not have a specific threshold for such a confidence interval and it probably varies across time and managers, a relatively high value is expected. For example, if the distribution of earnings is approximately normal and managers' forecast range reflects one standard deviation each below and above the mean, we would expect 67% of the actual earnings to fall within the forecast range.

Table 4 reports the distribution of actual earnings when compared to the earnings forecast ranges. Specifically, we are interested in the proportion of actual earnings that fall outside of the forecast range. As shown in Table 4, out of the 13,764 managerial guidance that are issued as ranges, approximately 30.2% of the actual earnings fall inside of the corresponding managerial

forecast range. Notably, this estimate is conservative, as we have excluded point forecasts, i.e., forecasts with a range of zero. This result is strongly suggestive that managers are generally too confident in their ability to forecast earnings accurately. This result is consistent with Goel and Thakor (2008), who model firms' internal promotion processes as a tournament where overconfident CEOs have a better chance of being promoted to CEO. Given this observation, it is important to re-emphasize that our measure of over-precision is a relative measure, as most CEOs could be classified as overly precise by most reasonable benchmarks.

[Table 4 about here]

Table 4 further reports the distribution of actual earnings compared to the earnings forecasts issued by two groups of CEOs based on their over-precision. For CEOs with higher precision measures, 27% of actual earnings are inside of their forecast range, in comparison to only 33.2% for other CEOs. The decrease of 6.2% of meeting forecast range for overly precise CEOs is economically significant, when we compare with the unconditional probability of 30.2% of actual earnings are inside of the forecast range. That is because, conditional on actual earnings meeting forecast range, overly precise CEOs are 20.5% (6.2%/30.2%) less likely to meet their tight forecast ranges relative to other CEOs. This indicates that our over-precision measure indeed captures behavioral bias rather than better forecasting skills.[18]

[18] Notably, it is not obvious that managers who provide a tight range should mechanically lead to a higher probability of forecasting error. The null hypothesis we are rejecting is that managers provide the appropriate forecast range depending on the firm's condition and their ability to predict earnings. Therefore, the tighter forecast ranges should not lead to a higher likelihood of missing the range.

3.5 Verifying the Overconfidence Measures

Our main empirical analysis starts with a verification procedure, in which we show that our measures meaningfully capture optimism and over-precision, respectively. To this end, we define two dependent variables: (1) *OUT*, a dummy variable that takes the value of one if the actual earnings falls outside of the forecast range and zero otherwise, and (2) *OUT Low*, a dummy variable that takes a value of one if the actual earnings fall below the lower bound of the earnings forecasts, and zero otherwise. The former is a non-directional variable indicating earnings falling outside the *low* or *high* range, while the latter is a directional variable indicating earnings falling below the *low* range.

Our verification procedure rides on the following intuition. When we use the non-directional dependent variable *OUT*, we expect to find a strong positive correlation between OUT and Over-precision, which represents a non-directional aspect (i.e., the second moment) of overconfidence. Such a finding would also help us more formally rule out the possibility that our over-precision measure captures superior forecasting skill. In contrast, when we use the directional dependent variable *OUT Low*, we expect a strong positive correlation between *OUT Low* and Optimism, which represents a directional aspect of overconfidence.

We first estimate a logistic regression to model the likelihood of actual earnings falling outside of the forecast range (*OUT*). We include the same set of control variables as in the earnings forecast precision regression. The main variable of interest is our measure of over-precision. If this measure captures forecasting skill, we would expect a negative (or non-significant) sign. In contrast, a positive sign would indicate that the measure captures over-precision bias.

[Table 5 about here]

Table 5 presents the results of the logistic regression. Confirming our univariate findings in Table 4, CEOs classified as overly precise are more likely to issue earnings forecast ranges that are too narrow, i.e., the actual earnings frequently fall outside of the forecast ranges. Optimism, on the other hand, is *not statistically* correlated with the probability of earnings falling outside of the forecast range. When we change our dependent variable to the directional variable *OUT Low*, the results indicate that CEOs that we identify as optimistic have a much higher probability (18.5% higher in unreported results) of having the actual earnings fall lower than the forecast range, consistent with these CEOs being overly optimistic in their earnings forecasts. In sum, our verification analysis confirms that our two measures (optimism and over-precision) are useful in capturing the two different aspects of CEO overconfidence.

3.6 Persistence in Overconfidence

We treat CEO optimism and over-precision as a personal fixed effect, which is consistent with studies that use the option-based measure of overconfidence (e.g., Malmendier and Tate 2005, 2008). In this section, we analyze whether the assumption that overconfidence is persistent is statistically valid.

Instead of aggregating the residuals at the CEO level across all years, we classify CEOs as optimistic or overly precise year by year as long as they have a valid earnings forecast during any given year. Specifically, we average the residuals from the earnings forecast regressions for a CEO each year and classify the CEO as optimistic or overly precise if the average value is greater than the associated median value for all CEOs for that year. If CEO overconfidence is persistent over time, we would observe that prior-year optimism or over-precision has predictive power for an optimism or over-precision classification in the current year, respectively.

[Table 6 about here]

Table 6 reports the logistic regressions modeling the likelihood of being classified as optimistic (overly precise) using past one-year and/or two-year optimism (over-precision) as independent variables. The results show that a past-year classification is significantly positively correlated with the likelihood of being classified as optimistic or overly precise again in the current year. Consistent with Moore and Healy (2008), we find that over-precision is quite persistent, and more so than over-optimism. Specifically, in unreported results, the probability or proportion of a CEO classified as overly precise in this year increases from 29.8% to 69.4% if he/she was classified as overly precise last year.[19] The corresponding increase is from 38.7% to 61.4% for optimism. It is important to note that we include industry effects in the first stage regressions; as such, this persistence is independent from the mechanical persistence of industry classification. In sum, this analysis verifies that our assumption of overconfidence persistence appears to be reasonable and justified.

4 CEO Overconfidence and Corporate Investment Decisions

Our Hypothesis 1 and Hypothesis 2 predict that both optimistic and overly precise CEOs invest more and engage in more M&As in comparison to other CEOs, while Hypothesis 3 predicts that overly precise CEOs are more likely to acquire diversifying, private and geographically distant targets.

4.1 Research Design and Model Specification

We use Equation (2) to test our Hypotheses 1 and 2 on corporate investment and M&A activities.

[19] The increase reflects the marginal effect of the coefficient on *Over-Precision*$_{t-1}$ in Column (2) of Table 6.

$$Investment\ Measure_t$$

$$= \alpha_0 + \alpha_1 OverOptimism + \alpha_2 OverPrecision$$

$$+ \sum_i \beta_i Firm\ Characteristics_{i,t-1} + \gamma_1 CEO\ Delta_{\ i,t-1}$$

$$+ \gamma_2 CEO\ Vega_{\ i,t-1} + Industry\ dummies + year\ dummies + \varepsilon_t \qquad (2)$$

Our main variables of interest are CEO *Optimism* and *Over-Precision*, which are defined using management earnings forecast data, as described in Section 3. As predicted by Hypotheses 1 and 2, optimistic and overly precise CEOs would both invest more and engage in more M&As, i.e., the respective coefficients are predicted to take positive signs:

H1a & H2a: $\alpha_1 > 0$

H1b & H2b: $\alpha_2 > 0$.

The investment analysis employs the following six alternative measures of investment: (1) *Total Corporate Investment*; (2) *Total Real Investment*; (3) *Total Capex*; (4) *Acquisition*; (5) *Expansion Capex;* and (6) *R&D*. *Total Corporate Investment* is the sum of *Total Real Investment* and research and development expenditure. *Total Real Investment* is defined as capital expenditures (*capx*, Compustat acronym) plus acquisitions (*aqc*) less sales of property, plant and equipment (*sppe*). This definition is slightly different from that used by Ben-David, Graham, and Harvey (2013), who also include increases and sales of investments (*inch*, *siv*) in the calculation of total investment.[20] However, their measure could potentially include financial investments such as investments in securities, whereas we are more interested in investments in real assets. We then

[20] Our results are qualitatively similar when using the total investment measure in Ben-David, Graham, and Harvey (2013).

separate *Total Real Investment* into *Total Capex* and *Acquisition.* Our definition of *Total Capex* is consistent with Coles, Daniel, and Naveen (2006), who define it as capital expenditures less sales of property, plant and equipment. We then further divide *Total Capex* into *Expansion Capex* and Sustaining Capex (proxied by depreciation and amortization, *dp*). Moreover, we are also interested in the impact of overconfidence on R&D spending, and we use *R&D* (*rdx*) as one of the investment dependent variables.[21] The relations among various measures of investment are summarized in Figure 2.

[Figure 2 about here]

All control variables are consistent with the prior literature (Ben-David, Graham, and Harvey 2013; Coles, Daniel, and Naveen 2006; Hirshleifer, Low, and Teoh 2012). Specifically, our set of control variables comprise: *Sales*, capital intensity measured as property, plant and equipment per employee (*PPE/Emp*), *Stock Return, Tobin's Q, Sales Growth, Profitability, Book Leverage, Cash, Vega and Delta*. Coles, Daniel, and Naveen (2006) find that CEOs with higher sensitivity of wealth to stock volatility (*Vega*) invest more in R&D but less in property, plant and equipment (PPE). On the other hand, CEOs with higher sensitivity of wealth to share price (*Delta*) invest less in R&D but more in PPE. As a result, we have also included *Delta* and *Vega* of the CEO as additional control variables. The calculation of *Delta* and *Vega* follows Core and Guay (2002). All control variables are defined in Appendix A.

[21] In the reported specification, missing R&D values are replaced with zero. However, our results are not sensitive to including a dummy variable to denote missing R&D values, as suggested by Koh and Reeb (2015).

4.2 Descriptive Statistics for the Investment Sample

Table 7 reports the summary statistics of our investment sample for both the dependent and independent variables. Approximately half of our firm-year observations are classified as optimistic or overly precise CEOs, respectively. This percentage may vary slightly because we have to drop some observations with missing information for the investment measures.

[Table 7 about here]

The total corporate investment in our investment sample is around 13.1% of the total assets. Firms invest approximately 9.6% of their total assets in real assets on average per year, and this amount is broken down into total capital expenditures (4.4%) and acquisitions (4.9%).[22] The average R&D expenditure is around 3.2% of total assets. We further break the total capital expenditure of 4.4% into expansion capex and sustaining capex. Interestingly, the average firm in our sample seems to spend very little on expansion capex, as all of the 4.4% of total capital expenditures is used for sustaining capital expenditures. Similarly, when comparing expansion capex to acquisitions of 4.9%, our sample firms tend to invest in external acquisitions rather than internal growth. All the other control variables are comparable to Coles, Daniel, and Naveen (2006) and Hirshleifer, Low, and Teoh (2012).

Panel B of Table 7 further separates our investment sample into firm-year observations with optimistic versus other CEOs. We classify 502 CEOs as optimistic, out of 1,006 CEOs in our sample. Generally, there are no significant differences between optimistic and other CEOs in terms of the five investment measures used in this study. Surprisingly, firms with non-optimistic CEOs appear to invest more in the R&D expenditures in a univariate setting, which leads to higher total

[22] The numbers may not add up due to different number of observations for different investment measures.

corporate investment by non-optimistic CEOs. For the control variables, firms with optimistic CEOs tend to be smaller, have lower capital intensity, have lower stock returns, have lower growth opportunities (indicated by a lower *Tobin's Q)*, have lower sales growth, and hold lower cash positions, but they have higher leverage. CEOs who are classified as optimistic also have lower *Delta* and *Vega* values than non-optimistic CEOs.

Panel C of Table 7 partitions the investment sample based on a different dimension, namely over-precision. Approximately 504 CEOs out of 1,006 CEOs are classified as overly precise. In contrast to the sample split based on the measure of optimism, firms with overly precise CEOs invest more in real assets – mainly driven by higher amount of acquisitions. They also have higher level of R&D expenditure. Firms with overly precise CEOs are smaller, have lower capital intensity and a lower cash position, but they have higher stock returns and higher sales growth rates. Overly precise CEOs are found to have higher *Delta*, but lower *Vega* values than other CEOs.

4.3 Corporate Investment Decisions

To formally test our predictions in Hypotheses 1 and 2 which predict that optimistic and overly precise CEOs invest more and engage in more M&As, we empirically estimate Equation (2). The regression results of various corporate investment decisions are reported in Table 8. The detail construction of each corporate investment variable is defined in Figure 1.

[Table 8 about here]

Column (1) in Table 8 estimates the relation between the two facets of CEO overconfidence and total corporate investment. The results show that neither firms with optimistic CEOs nor overly precise CEOs invest more in all types of corporate investment. However, when we break the total corporate investment into total real investment in Column (2), we see a difference. Specifically,

firms with overly precise CEOs generally invest more in real assets. Given that the sample average of total real asset investment is approximately 9.6 percent of total assets, being overly precise increases it to 10.5 percent, which, in the context of our sample, reflects an approximately 9.4% (or $70 million) increase in average real asset investment. However, we do not find that CEO optimism has a significant impact on total real asset investment decisions. Our overall results are consistent with Ben-David, Graham, and Harvey (2007), who find that overly precise CFOs invest more, while optimistic CFOs do not.

In terms of R&D expenditures, using the option-based measure of overconfidence, Hirshleifer, Low, and Teoh (2012) provide evidence that optimistic CEOs spend more on R&D expenditures because they overestimate the probability of success. However, as shown by Koh, Reeb and Zhao (2017), the positive relation could be biased by the fact that overconfident CEOs are more likely to disclose R&D expenditures than non-overconfident CEOs. Koh, Reeb and Zhao (2017) do not find a significant relation between CEO overconfidence and R&D expenditure in the post Regulation Fair Disclosure and Sarbanes-Oxley Act period which is consistent with our sample period. Similar to Koh, Reeb and Zhao (2017), in Column (6), we do not find evidence that either optimism or over-precision has significant influence over R&D expenditure in our sample.

We further partition total real asset investment into total capital expenditures in column (3) and acquisitions in column (4). We find that the increase in total real asset investment is mainly driven by the higher number of acquisitions associated with overly precise CEOs. The economic magnitude is also large. Overly precise CEOs spend 0.7% more on acquisitions than other CEOs, which suggests that overly precise CEOs have a strong preference for external acquisitions. Given the average firm spends about 4.9% of total assets in acquisition, this represents an increase of 14% in acquisition spending. We also further partition total capital expenditures into sustaining and

expanding capital expenditures in column (5). We find that overly precise CEOs are not associated with expanding capital expenditures. Again, CEO optimism is not observed to have any impact on investment decisions.

With regard to the control variables, larger firms generally invest less in terms of the proportion of total assets. Firms with higher capital intensity spend more on internal capital expenditure, but less in acquisitions. Firms with higher growth opportunities prefer to grow internally rather than by making acquisitions. We also observe that strong stock performance generally increases investment but decreases R&D expenditures. Firms with higher sales growth invest more in acquisitions, expansion capex and R&D expenditures. Not surprisingly, more profitable firms invest more in both total capex and acquisition expenditures. However, profitable firms invest less in R&D. On the other hand, higher leveraged firms reduce real investments and R&D expenditures. Consistent with Harford (1999), firms with high cash positions tend to invest more in acquisitions. Our estimates are also consistent with Coles, Daniel, and Naveen (2006), who show that CEOs with higher *Vega (Delta)* values invest more (less) in R&D expenditures but higher *Vega* reduces capital expenditures.

Overall, our results show that overly precise CEOs prefer external growth via acquisitions more than other CEOs, which provides support for the predictions of H1b and H2b. There is no discernible difference for other forms of investment such as sustaining or expanding capital expenditures, or investing in R&D. On the other hand, optimistic CEOs do not seem to differ in capital expenditure decisions relative to other CEOs. As such, there is no support for either H1a or H2a.

4.4 Mergers & Acquisitions

Our results in Section 4.3 suggest that overly precise CEOs invest more than other CEOs in M&A activities. This result is consistent with Malmendier and Tate's (2008) finding of a positive relation between CEO optimism and M&A activities. They also indicate that the relation is stronger for diversifying M&As. In this section, we aim to provide a counterpart analysis for our two overconfidence measures using an alternative source of data that allows us to identify different types of M&As: the Thomson SDC database. In addition, we will also empirically test our Hypotheses H3 regarding the effect on overconfidence on acquisitions involving private and geographical distant targets.

We collect all M&A transaction data from the Thomson SDC database from 2001 to 2014. Deals where the acquirer already holds more than 51% of the target are removed from the sample. In addition, we only retain deals where an acquirer owns more than 51% of the target after the deal and, hence, have the controlling stake. Following Malmendier and Tate (2008), we exclude deals in which the acquisitions are worth less than 5% of the acquirer's equity value.[23]

We then match the M&A transaction data to our main investment sample. We create a dummy variable, *MA*, that takes a value of 1 if a firm engages in at least one M&A transaction during the year and zero otherwise. To test Hypotheses H3, we also create dummy variables, *MA_DIV, MA_WITHIN, MA_PRI, MA_PUB, MA_OS, MA_IS, MA_F* and *MA_D,* which takes a value of one if the firm completes at least one M&A transaction during the year which involves a target in a different industry (*MA_DIV*) (according to Fama-French 48 industry classification), a target within the same industry (*MA_WITHIN*), a private target (*MA_PRI*), a public target

[23] Malmendier and Tate (2008) consider this criterion to be important because acquisitions of small units of another company might not have much CEO involvement. Notably, our results are not sensitive to this 5% restriction. Furthermore, our results are robust to another alternative criterion, which is to retain all transactions with values of over $1 million (Moeller, Schlingemann, and Stulz 2004).

(*MA_PUB*), a target outside the acquirer state (*MA_OS*), a target within the acquirer state (*MA_IS)*, a foreign target (*MA_F*) and a domestic target (*MA_D*), and zero otherwise.

$$\begin{aligned}\Pr(MA_{it} = 1) &= \alpha_0 + \alpha_1 OverOptimism + \alpha_2 OverPrecision \\ &+ \sum_i \beta_i Firm\ Characteristics_{i,t-1} + \gamma_1 CEO\ Delta_{\ i,t-1} \\ &+ \gamma_2 CEO\ Vega_{\ i,t-1} + Industry\ dummies + year\ dummies + \varepsilon_t \end{aligned} \quad (3)$$

We use Equation (3) to model the likelihood of firms engaging in different types of M&A transactions using a logistic regression. The dependent variable takes one of the following dummy variables: *MA, MA_DIV, MA_WITHIN, MA_PRI, MA_PUB, MA_OS, MA_IS, MA_F* and *MA_D.* Following H2a and H2b, we predict that both α_1 and α_2 to be positive when the dependent variable is *MA.* According to H3, we would expect α_2 to be positive when the dependent variable is *MA_DIV, MA_PRI, MA_OS* or *MA_F*, while we do not have a prediction for α_1. All control variables are identical to the control variables used in the investment regressions in Section 4.3, and they are defined in Appendix A. Fama-French 48 industries and year dummies are also included.

Table 9 reports the estimates from the logistic regressions of M&A decisions. Consistent with our findings in Section 4.3, only firms with overly precise CEOs are more likely to engage in corporate acquisitions, i.e., again supporting H2b. Given the unconditional probability of M&A transaction is 15.1% in our sample, having an overly precise CEO increases the probability by 3.0%, which represents an increase of 19.8%. In contrast, CEO optimism does not have any significant link with M&A activities, i.e., H2a is again not supported. As such, our results are quite distinct from Malmendier and Tate (2008), who find that CEO optimism is an important

determinant of M&A activities. Instead, our results indicate that precision bias is the more dominant aspect of overconfidence with regard to corporate acquisitions.

Table 9 also further separates the sample into diversifying and non-diversifying M&As. Consistent with H3, overly precise CEOs are more likely to target firms in industries different from the firms' own industry, while the result is not statistically significant for targets within the same acquirer industry. Given the unconditional probability of diversifying M&A transaction is 6.6% in our sample, having an overly precise CEO increases the probability by 1.7%, which represents an increase of 25.8%. The result of diversifying M&A is consistent with Malmendier and Tate (2008). However, our rational differs from Malmendier and Tate (2008) who use diversifying acquisitions as a proxy for deal quality, while we argue that CEO over-precision is more pronounced in more uncertain/difficult acquisitions due to the 'hard-easy' effect of overconfidence. Table 9 also shows insignificant results for CEO optimism regardless of the subsamples tested.

[Table 9 about here]

With regard to the control variables, we find that larger firms are less likely to acquire in our sample. Firms with a lower Tobin's Q are more acquisitive, which suggests that those firms substitute external acquisitions for internal growth (Malmendier and Tate 2008). Firms with higher past stock returns and higher profitability are more likely to acquire. Consistent with Harford (1999), firms are more likely to acquire when positive cash is high, supporting the managerial empire-building hypothesis. Consistent with Coles, Daniel, and Naveen (2006), CEOs with higher *Vega* are more acquisitive.

In Table 10, we further separate the sample into private and public M&As. According to H3, we predict CEO over-precision to have stronger impact in private acquisitions where there is more uncertainty due to lack of information available in private firms. Consistent with our prediction, we find that the positive relation between CEO over-precision and M&A decisions is concentrated in transactions involving a private target. Given the unconditional probability of private M&A transaction is 11.4% in our sample, having an overly precise CEO increases the probability by 3.3%, which represents an increase of 29.0%. On the other hand, overly precise CEOs are not more likely to conduct an acquisition of public target. CEO optimism continues to be insignificant in both of the subsample regressions, which supports the dominant effect of precision bias in the merger and acquisition decisions.

[Table 10 about here]

In a similar fashion, Table 11 presents the parameter estimates of merger and acquisition regressions using three different subsamples categorized by the target's geographic location. H3 predicts a stronger effect of CEO precision bias on merger and acquisition decisions when the target is geographically distant from the acquirer. The first two columns of Table 11 examine the likelihood of acquiring domestic targets outside the acquirer's state and domestic targets within the acquirer's state. Consistent with H3, we find that overly precise CEOs are more likely to acquire targets located outside the acquirer states, but not targets within the same states. Given the unconditional probability of M&A transactions involving domestic targets in a different state is 10.8% in our sample, having an overly precise CEO increases the probability by 2.1%, which represents an increase of 19.4%.

[Table 11 about here]

Column (3) of Table 11 presents the results on the acquisition of foreign targets. Based on H3, we would expect CEO over-precision to have greater impacts in the more challenging foreign acquisitions. As shown in Table 11, CEO over-precision is positively correlated with the probability of conducting a foreign acquisition, although the p-value is slightly above the conventional 10% significance level. This is likely due to the fact that we only have about 3.5% of our sample involving the acquisition of a foreign targets, which significantly reduces the power of the test. Therefore, we only treat these are suggestive evidence. Nevertheless, the economic significance is large. Having an overly precise CEO increases the probability of foreign acquisition by 0.9%, which represents an increase of nearly 26%. CEO optimism continues to be insignificant in any of the M&A regressions.

In summary, we have documented a robust finding that overly precise CEOs are more likely to conduct merger and acquisitions, especially acquisitions involving targets in different industries, private targets and targets that are geographically distant. On the other hand, we do not find CEO optimism to play a significant role in the merger and acquisition decisions.

4.5 Robustness Checks for Optimism and Over-Precision Measures

A potential concern with our earnings forecast-based measure of overconfidence is a sample selection issue. To be able to calculate CEO optimism or over-precision in Section 3.1, we first need the firms to provide earnings forecasts, and do so as a range. As a result, a firm-year combination can only enter into our final sample if there is at least one earnings forecast made by the CEO during the sample period. If the determinants of issuing management earnings forecasts are correlated with the determinants of corporate investment and merger and acquisition decisions, then a sample selection bias concern can arise. In this section, we employ Heckman's two-step sample selection model to address this issue.

In the first step, we follow Otto (2014) and model the selection indicator on the CEO level as a function of the average values of the following variables: (1) number of analysts following (obtained from the IBES database); (2) earnings volatility; (3) institutional ownership; (4) net debt issuance; and (5) net equity issuance during the sample period. We use the average value of these five determinants because our two CEO overconfidence measures rely on the average earnings forecast errors or precision from all forecasts made by a particular CEO. In this first step, we also further include the control variables used in our corporate investment and merger and acquisition regressions in Tables 8 to 11, Fama-French 48 industry fixed effects and year fixed effects. In the second step, we rerun all our corporate investment and merger and acquisition regressions after including an Inverse Mills ratio (IMR). The untabulated results are qualitatively similar to the results reported in the earlier sections.

5 Conclusion

In this study, we construct new measures of distinct aspects of CEO overconfidence using management earnings forecasts. These forecasts are typically issued in the form of a range, providing us with an opportunity to separately measure optimism and over-precision. We measure optimism using the (signed) earnings forecast error, while over-precision is measured using the narrowness of the forecast range, after controlling for a range of likely determinants. Compared to existing measures of overconfidence, such as the option-based measure proposed by Malmendier and Tate (2005, 2008), our measure is more directly tied to the basic constructs in theoretical models analyzing the effects of managerial overconfidence (e.g., Hackbarth, 2008).

Our measures indicate that CEOs are generally overly precise. A little less than one third of actual earnings fall *inside* the management earnings forecast ranges. More importantly, our

measure of over-precision is associated with a higher probability of actual earnings falling outside of the range, suggesting that our measure captures behavioral bias rather than superior forecasting skills.

We then provide evidence regarding how managerial optimism and over-precision are related to corporate investment and merger and acquisition decisions. CEOs with over precision are associated with a higher level of investment, which is mainly driven by higher acquisition spending. Overly precise CEOs are more likely to acquire private firms, firms in different industries and firms that are geographically distant. Conversely, optimistic CEOs do not seem to invest more in real assets. Neither optimistic nor overly precise CEOs spend more on R&D expenditures. Overall, the relatively stronger results for over-precision, taken together with non-results for optimism, suggest that managers' confidence is driven by their ability to control or manage risk rather than their confidence regarding the firm's operations.

This study shows that managerial over-precision and optimism have distinct impacts on corporate investment decisions. Therefore, it is important for future empirical studies to distinguish between these two manifestations of overconfidence, potentially using the accessible empirical measures of over-precision and optimism developed in this study.

Appendix A Variable Measurement

Panel A: Management Earnings Forecast Regression Variables

Variable	Measurement
Dependent Variable	
MFE	Management forecast error, computed as the difference between the mid-point of the forecast and the actual earnings for year t, scaled by the share price at the end of year t-1.
Precision	Management forecast precision, defined as the earnings forecast intervals for year t, scaled by the share price at the end of year t-1 and multiplied by negative one (i.e., -1).
Independent Variables	
Firmsize	The natural log of the firm's total assets in year t.
MB	Market-to-book ratio, calculated as the ratio of the market value of equity to the book value of equity in year t.
ROA	Return on assets, calculated as income before extraordinary items divided by total assets in year t-1.
Δ*Earnings*	Change in earnings, calculated as the change in earnings before extraordinary items from year t-1 to year t, scaled by the year-end market value of equity.
Accrual	The difference between income before extraordinary items and operating cash flows in year t, scaled by lagged total assets.
Earnings Vol	Earnings volatility, calculated as the standard deviation of income before extraordinary items scaled by average total assets over the past 5 years including year t.
Loss	An indicator that equals one if the firm reports an earnings loss in year t.
Independent	The percentage of independent directors on the board in year t.
Inst Ownership	The percentage of institutional ownership in year t.
HHI	The industry concentration index, measured as the Herfindahl-Hirschman index on sales revenue calculated based on the 4-digit SIC code.
Litigation Risk	An indicator that equals one for litigious industries, including Biotech (SIC 2833 to 2836), Computer Hardware (SIC 3570 to 3577), Electronics (SIC 3600 to 3674), Retailing (SIC 5200 to 5961), and Computer Software (SIC 7371 to 7379), and zero otherwise.
MA	An indicator that equals one if the firm's acquisition costs exceed 5% of its total assets for year t and zero otherwise.
Net Equity Issue	An indicator that equals one if the firm's net share issuance exceeds 5% of its total assets for year t and zero otherwise.
Horizon	The number of days between the management forecast day and the fiscal year end day.
Number of Analysts	The number of analysts following the firm within 90 days of each management earnings forecast for the fiscal year t.

Analyst Dispersion	Analyst Dispersion, defined as the standard deviation of the latest analyst earnings forecast from each analyst within past 90 days of each management earnings forecast for year t, scaled by the share price at the end of year t-1.

Panel B: Investment and Merger and Acquisition Regression Variables

Variable	Measurement
Dependent Variable	
Total Corporate Investment	Measured as capital expenditures plus acquisition costs and research and development expenditures, minus the sales of property, plant and equipment in year t.
Total Real Investment	Measured as capital expenditures plus acquisition costs minus the sales of property, plant and equipment in year t.
Total Capex	Measured as capital expenditures minus the sales of property, plant and equipment in year t.
Acquisition	Acquisition costs in year t.
Exp. Capex	Measured as capital expenditures minus the sales of property, plant and equipment minus depreciation and amortization in year t.
R&D	Research and development expenditures in year t. Missing values are replaced with 0.
MA	An indicator that equals one if the firm has at least one acquisition during year t and zero otherwise.
MA_DIV	An indicator that equals one if the firm has at least one diversifying acquisition (target in a different Fama-French 48 industry) during year t and zero otherwise.
MA_WITHIN	An indicator that equals one if the firm has at least one acquisition where the target is in the same Fama-French 48 industry during year t and zero otherwise.
MA_PRI	An indicator that equals one if the firm has at least one acquisition of private target during year t and zero otherwise.
MA_PUB	An indicator that equals one if the firm has at least one acquisition of public target during year t and zero otherwise.
MA_OS	An indicator that equals one if the firm has at least one acquisition where the target is outside the acquirer state but within the country during year t and zero otherwise.
MA_IS	An indicator that equals one if the firm has at least one acquisition where the target is inside the acquirer state during year t and zero otherwise.
MA_F	An indicator that equals one if the firm has at least one acquisition of foreign target during year t and zero otherwise.
Independent Variables	
Optimism	An indicator that equals one if the CEO is classified as optimistic according to the process described in Section 3 and zero otherwise.
Over-Precision	An indicator that equals one if the CEO is classified as over-precise according to the process described in Section 3 and zero otherwise.

Sales	Sales revenue in $mil in year t.
PPE/Emp	Ratio of net property, plant and equipment to the number of employees in year t.
Tangibility	Net property, plant and equipment scaled by total assets in year t.
Stock Return	The buy-and-hold stock return during fiscal year t.
Tobin's Q	Ratio of market value to book value of assets in year t.
Sales Growth	Log transformation of sales in year t divided by sales in year t-1.
Profitability	Ratio of operating income before depreciation in year t to total assets in year t-1.
Book Leverage	Ratio of the sum of long-term debt and short-term debt to total assets in year t.
Cash	Ratio of cash holdings to total assets in year t.
Delta	Dollar change ($000) in CEO stock and option holdings corresponding to a 1% change in the stock price in year t.
Vega	Dollar change ($000) in CEO option holdings corresponding to a 1% change in stock volatility in year t.

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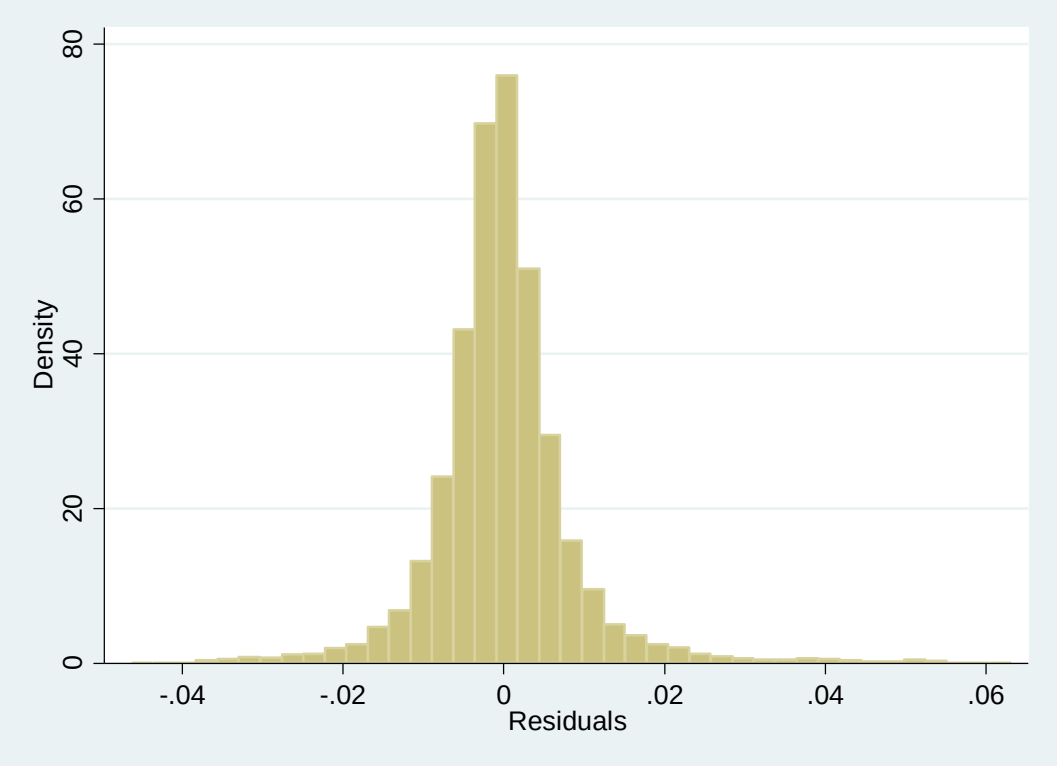
Figure 1. Distribution of Residuals from the Management Earnings Forecast Regressions

Panel A. Forecast Error Residuals



Panel B. Forecast Precision Residuals

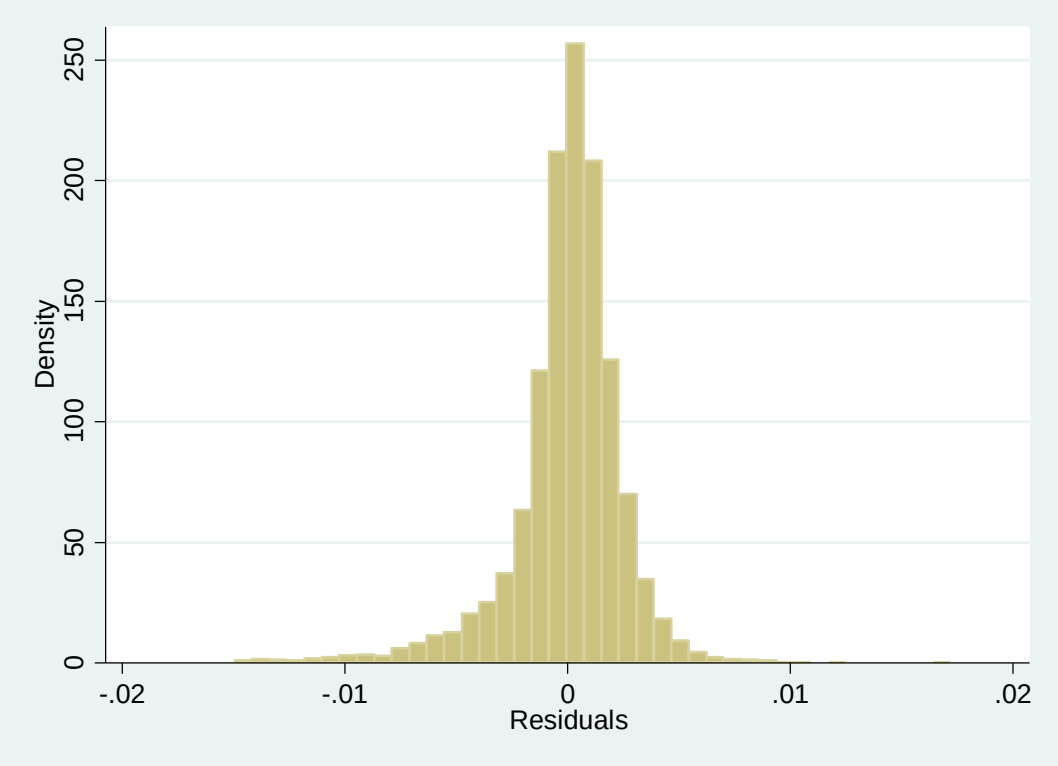


Figure 2. Measures of Investment and their Relationships

(Compustat acronym is shown in square brackets. The number in parentheses corresponds to the column number in Table 8 the corporate investment decision regression results.)

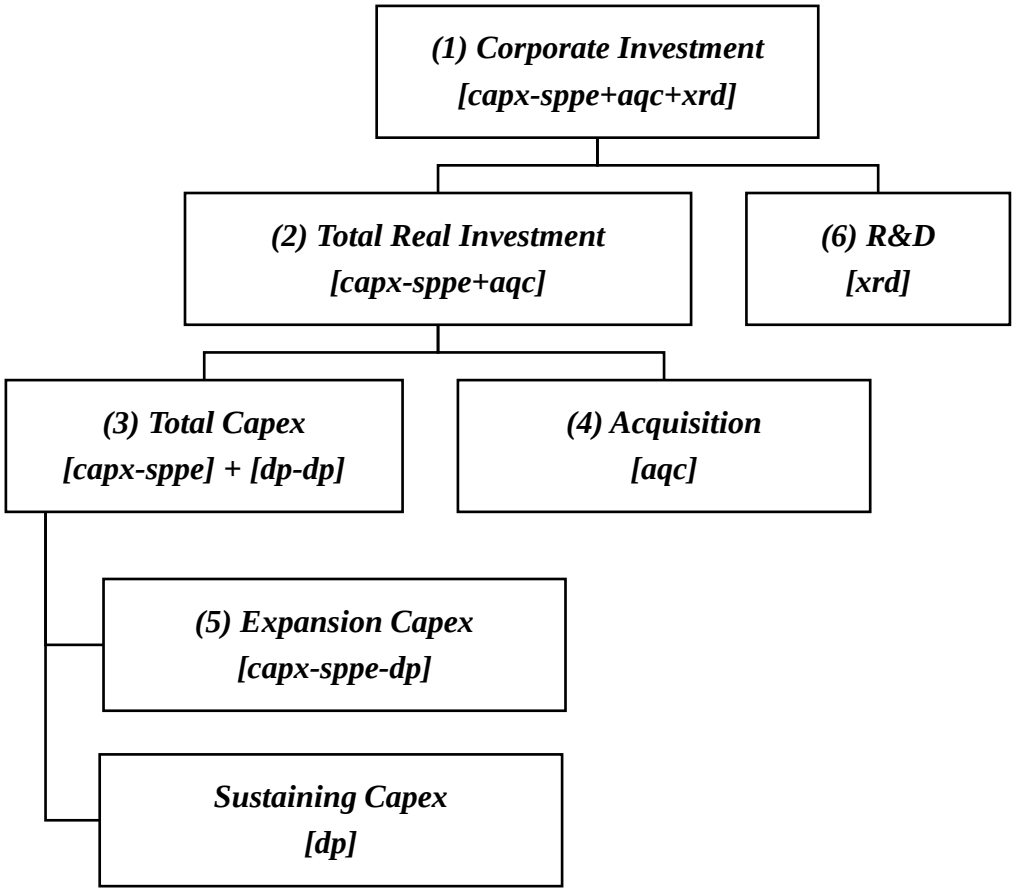


Table 1
Management Earnings Forecasts Sample Selection and Distribution

Panel A. Sample Selection Criteria	
Annual management earnings forecasts for fiscal year 2001 to 2014	66,453
Less: Forecasts that are not point or range estimates	(3,757)
Less: Forecasts not issued within fiscal year t	(6,235)
Total point and range earnings forecasts issued in fiscal year t	56,461
Less: Forecasts unmatched to CRSP-Compustat Merged (CCM) and Execucomp databases	(21,213)
Less: Financial Industry (SIC 6000 – 6999) and Utilities (SIC 4000 – 4999)	(7,189)
Less: Forecasts with missing control variables	(12,756)
Final Sample	15,303

Panel B. Sample Distribution

Forecast Year	Number of Forecasts	Percentage of Yearly Total Forecasts (%)	Proportion of Range Forecasts to Total Forecasts by Year (%)
2001	429	2.80	81.35
2002	734	4.80	77.79
2003	793	5.18	85.62
2004	980	6.40	89.08
2005	1,043	6.82	91.37
2006	1,186	7.75	91.32
2007	975	6.37	89.54
2008	1,181	7.72	88.40
2009	1,171	7.65	90.52
2010	1,399	9.14	93.57
2011	1,334	8.72	94.53
2012	1,435	9.38	90.10
2013	1,373	8.97	91.04
2014	1,270	8.30	91.81
Total	15,303	100.00	89.94

Table 2
Management Earnings Forecasts and Firm Characteristics Summary Statistics

This table shows the summary statistics for our dependent variables and firm-level control variables in the management earnings forecast regression. Panel A contains 15,303 (13,764) observations for point (range) forecasts; while Panel B contains 3,651 firm-year observations. The sample period covers 2001 to 2014. Details of all variable measurements are provided in Appendix A.

	N	Mean	Std. Dev.	Min.	Median	Max.
Panel A. Management Guidance Level Variables						
MFE	15,303	-0.000	0.011	-0.039	-0.001	0.065
Precision	13,764	-0.004	0.003	-0.020	-0.003	0.000
Horizon	15,303	194.149	99.216	0	196	365
Analyst Dispersion	15,303	0.002	0.003	0.000	0.001	0.019
Number of Analyst	15,303	9.787	6.116	2	8	29
Panel B. Firm-Level Control Variables						
Firmsize	3,651	7.750	1.410	4.660	7.659	12.491
MB	3,651	3.549	3.043	0.306	2.714	19.435
ROA	3,651	0.076	0.065	-0.311	0.071	0.299
Δ*Earnings*	3,651	0.001	0.075	-0.944	0.006	0.407
Accruals	3,651	-0.057	0.062	-0.348	-0.051	0.134
Earnings Vol	3,651	0.034	0.040	0.001	0.022	0.306
Loss	3,651	0.065	0.247	0	0	1
Independent	3,651	0.749	0.144	0.222	0.778	0.923
Inst. Ownership	3,651	0.798	0.141	0.242	0.812	1.000
HHI	3,651	0.295	0.213	0.054	0.235	1.000
Litigation	3,651	0.299	0.458	0	0	1
MA	3,651	0.251	0.433	0	0	1
Net Equity Issue	3,651	0.031	0.174	0	0	1

Table 3
Management Earnings Forecast and Precision Regressions

This table presents the management earnings forecast and precision regression results. The models estimated are discussed in Section 3.1. The sample contains 15,303 (13,764) observations for forecast error (precision) regressions and covers 2001 to 2014. The dependent variables are *MFE* and *Precision*. All control variables are measured at the last fiscal year-end (except for *MA* and *Net Equity Issue*), and details of their measurements are presented in Appendix A. Fama-French 48 Industries by year fixed effects are included. Standard errors are clustered at the firm level. The p-value is reported in parentheses, and ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Constants are not reported.

Independent Variables	Dependent Variables	
	MFE_t	$Precision_t$
$Firmsize_{t-1}$	0.001***	0.000***
	(0.000)	(0.000)
MB_{t-1}	-0.000***	0.000***
	(0.000)	(0.000)
ROA_{t-1}	0.007**	0.007***
	(0.042)	(0.000)
$\Delta Earnings_{t-1}$	0.004	0.001*
	(0.318)	(0.080)
$Accruals_{t-1}$	0.005	-0.004***
	(0.146)	(0.003)
$Earnings\ Vol_{t-1}$	0.000	-0.003*
	(0.929)	(0.087)
$Loss_{t-1}$	-0.001	-0.000
	(0.112)	(0.244)
$Independent_{t-1}$	-0.000	-0.001**
	(0.819)	(0.040)
$Inst.\ Ownership_{t-1}$	0.002	0.000
	(0.249)	(0.662)
HHI_{t-1}	0.001	-0.001
	(0.305)	(0.154)
$Litigation_{t-1}$	-0.000	0.001***
	(0.372)	(0.002)
MA_t	-0.000	0.000***
	(0.975)	(0.000)
$Net\ Equity\ Issue_t$	-0.004***	0.000
	(0.000)	(0.127)
Horizon	0.000	-0.000***
	(0.148)	(0.000)
Analyst Dispersion	0.394***	-0.460***
	(0.000)	(0.000)
Number of Analysts	-0.000***	0.000
	(0.000)	(0.222)
Industries by Year Fixed Effect	Yes	Yes
PE Quintiles Fixed Effect	Yes	Yes
Observations	15,303	13,764
Adjusted R^2	0.234	0.449

Table 4
Actual Earnings versus Earnings Forecast Range

This table reports the distribution of actual earnings that fall outside and inside of the earnings forecast range on the full earnings forecasts sample. It further provides breakdowns for earnings forecasts issued by overly precise CEOs and other CEOs. The percentage of the sample total is reported in parentheses. A t-test is conducted to test the difference between the two subsamples. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	Full Sample	Overly Precise CEOs	Other CEOs
Outside Range	9,611 (69.8%)	4,950 (73.0%***)	4,661 (66.8%)
Inside Range	4,153 (30.2%)	1,831 (27.0%***)	2,322 (33.2%)
Total	13,764 (100%)	6,781 (100%)	6,983 (100%)

Table 5
Modelling the Likelihood of Actual Earnings Falling Outside or Lower Bound of the Forecast Range made by Optimistic and Overly Precise CEOs

This table presents the logistic regression examining the effect of *optimism* and *over-precision* on the probability of actual earnings falling outside of the forecast range. The sample covers 2001 to 2014. The dependent variables are *OUT* and *OUT Low*. *OUT* is a dummy variable that takes a value of one if the actual earnings fall outside of the forecast range and zero otherwise. *OUT Low* is a dummy variable that takes a value of one if the actual earnings fall below the forecast range and zero otherwise. For brevity, control variables are not reported. All control variables are measured at the last fiscal year-end (except for *MA* and *Net Equity Issue*), and details of their measurements are presented in Appendix A. Fama-French 48 Industry fixed effects and year fixed effects are included. Standard errors are clustered at the firm level. The p-value is reported in parentheses, and ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Constants are not reported.

Independent Variables	Dependent Variables	
	OUT	*OUT Low*
Optimism	-0.113	1.204***
	(0.183)	(0.000)
Over-Precision	0.320***	-0.161*
	(0.000)	(0.060)
Firm-level Control Variables	Yes	Yes
Industry Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Observations	13,688	13,736
Pseudo R^2	0.052	0.138

Table 6
Regression Results for Persistence of Overconfidence Measures

This table presents the logistic regressions examining the effect of past one- and/or two-year *optimism* and *over-precision* on the current year optimism and over-precision classification. The sample covers 2001 to 2014. The dependent variables are *optimism* and *over-precision* classification in the current year. The independent variables are *optimism* and *over-precision* in year t-1 and/or t-2. Standard errors are clustered at the CEO level. The p-value is reported in parentheses, and ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Constants are not reported.

Independent Variables	Dependent Variables			
	Optimism$_{(t)}$	*Optimism*$_{(t)}$	*Over-Precision*$_{(t)}$	*Over-Precision*$_{(t)}$
Optimism$_{t-1}$	0.928***	0.973***		
	(0.000)	(0.000)		
Optimism$_{t-2}$		0.117		
		(0.251)		
Over-Precision$_{t-1}$			1.676***	1.577***
			(0.000)	(0.000)
Over-Precision$_{t-2}$				0.772***
				(0.000)
Observations	2,515	1,711	2,281	1,525
Pseudo R^2	0.038	0.044	0.116	0.156

Table 7
CEO Overconfidence and Corporate Investment -- Summary Statistics

This table shows the summary statistics for our dependent variables and control variables in the CEO Overconfidence and Corporate Investment regressions. Panel A summarizes the entire investment sample. Panel B (Panel C) further partitions the sample into optimistic CEO and non-optimistic CEO (overly precise CEO and others) subsamples. A CEO is deemed to be optimistic (overly precise) if the average residuals from the management earnings forecast error (precision) regression are above its corresponding median value. For more details on the classification of optimism and over-precision, refer to Section 3.1. Details of all variable measurements are provided in Appendix A. t-tests are conducted to test for differences between the means for the optimistic and non-optimistic (overly precise and others) subsamples. *, **, *** indicate significance at the 10%, 5%, and 1% level, respectively.

Panel A. Pooled sample

	N	Mean	Std. Dev.	Min.	Median	Max.
Dependent Variable						
Total Corporate Investment	3,633	0.131	0.132	0.002	0.091	0.746
Total Real Investment	3,633	0.096	0.117	-0.102	0.055	0.746
Total Capex	3,763	0.044	0.045	-0.001	0.031	0.313
Acquisition	5,048	0.049	0.101	-0.002	0.008	0.585
Exp. Capex	3,762	-0.001	0.045	-0.718	-0.004	0.264
R&D	5,244	0.032	0.047	0.000	0.013	0.264
Independent Variables						
Optimism	5,244	0.469	0.499	0.000	0.000	1.000
Over-Precision	5,244	0.505	0.500	0.000	1.000	1.000
Sales ($m)	5,244	5606.2	11390.5	67.8	1872.8	82559.0
PPE/Emp	5,244	70.8	170.9	2.3	36.3	3840.2
Stock Return	5,244	0.150	0.411	-0.760	0.121	1.749
Tobin's Q	5,244	1.995	1.092	0.739	1.670	7.311
Sales Growth	5,244	0.078	0.160	-0.608	0.076	0.706
Profitability	5,244	0.169	0.088	-0.124	0.157	0.507
Book Leverage	5,244	0.212	0.159	0.000	0.206	0.739
Cash	5,244	0.151	0.167	0.001	0.089	0.847
Delta ($,000)	5,244	664.8	1198.6	6.7	301.4	10631.1
Vega ($,000)	5,244	189.1	247.4	0.0	97.4	1488.4

Table 7
CEO Overconfidence and Corporate Investment Summary Statistics
(Continued)

Panel B: Optimistic versus Non-Optimistic Subsamples

	Optimistic CEOs (502 CEOs)				Non-Optimistic CEOs (504 CEOs)			
Variables	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.
Dependent Variable								
Total Corporate Investment	1,730	0.124***	0.083	0.132	1,903	0.138	0.100	0.131
Total Real Investment	1,730	0.095	0.053	0.120	1,903	0.096	0.057	0.115
Total Capex	1,775	0.045	0.032	0.045	1,988	0.043	0.029	0.045
Acquisition	2,389	0.048	0.007	0.104	2,659	0.049	0.009	0.098
Exp. Capex	1,774	-0.001	-0.004	0.043	1,988	0.000	-0.004	0.047
R&D	2,461	0.027***	0.007	0.043	2,783	0.037	0.017	0.050
Independent Variables								
Sales ($m)	2,461	5254.4**	1855.8	10368.3	2,783	5917.3	1890.5	12216.9
PPE/Emp	2,461	63.1***	34.7	104.8	2,783	77.6	38.5	212.7
Stock Return	2,461	0.132***	0.098	0.402	2,783	0.166	0.138	0.419
Tobin's Q	2,461	1.863***	1.554	1.009	2,783	2.113	1.785	1.148
Sales Growth	2,461	0.066***	0.064	0.161	2,783	0.089	0.086	0.159
Profitability	2,461	0.171*	0.155	0.090	2,783	0.166	0.159	0.086
Book Leverage	2,461	0.237***	0.237	0.161	2,783	0.190	0.181	0.153
Cash	2,461	0.126***	0.068	0.149	2,783	0.174	0.111	0.179
Delta ($,000)	2,461	580.2***	264.3	1066.5	2,783	739.6	353.0	1299.9
Vega ($,000)	2,461	170.7***	88.3	228.9	2,783	205.4	107.1	261.7

Table 7
CEO Overconfidence and Corporate Investment Summary Statistics
(Continued)

Panel C: Overly Precise versus the Remaining Subsamples

	Overly Precise CEOs (504 CEOs)				Non Overly Precise CEOs (502 CEOs)			
Variables	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.
Dependent Variable								
Total Corporate Investment	1,852	0.138***	0.101	0.137	1,781	0.124	0.083	0.125
Total Real Investment	1,852	0.101***	0.059	0.122	1,781	0.090	0.052	0.112
Total Capex	1,928	0.043*	0.030	0.042	1,835	0.045	0.031	0.047
Acquisition	2,536	0.054***	0.011	0.105	2,512	0.043	0.006	0.096
Exp. Capex	1,928	0.000	-0.004	0.040	1,834	-0.002	-0.004	0.050
R&D	2,649	0.034**	0.014	0.048	2,595	0.031	0.011	0.046
Independent Variables								
Sales ($m)	2,649	4987.1***	1700.7	10967.7	2,595	6238.2	2095.9	11775.1
PPE/Emp	2,649	57.3***	36.6	82.0	2,595	84.5	36.0	227.6
Stock Return	2,649	0.165***	0.139	0.398	2,595	0.135	0.096	0.423
Tobin's Q	2,649	2.017	1.719	1.050	2,595	1.973	1.625	1.133
Sales Growth	2,649	0.088***	0.083	0.153	2,595	0.068	0.071	0.167
Profitability	2,649	0.168	0.161	0.078	2,595	0.169	0.154	0.098
Book Leverage	2,649	0.209	0.204	0.156	2,595	0.215	0.208	0.162
Cash	2,649	0.147*	0.085	0.163	2,595	0.156	0.094	0.172
Delta ($,000)	2,649	715.9***	327.3	1271.4	2,595	612.6	284.9	1117.2
Vega ($,000)	2,649	181.9**	97.8	232.3	2,595	196.5	97.2	261.8

Table 8
CEO Overconfidence and Corporate Investment Decisions

This table presents the CEO overconfidence and corporate investment regression results. The models estimated are discussed in Section 4.1.2. The sample covers 2001 to 2014. The dependent variables are *Total Corporate Investment*, *Total Real Investment*, *Total Capex*, *Acquisition*, *Expansion Capex*, and *R&D*. A CEO is deemed to be optimistic (overly precise) if the average residuals from the management earnings forecast error (precision) regression are above its corresponding median value. For more details on the classification of optimism and over-precision, refer to Section 3.1. All control variables are measured at the last fiscal year-end, and details of their measurements are presented in Appendix A. Fama-French 48 Industry fixed effects and year fixed effects are included. Standard errors are clustered at the firm level. The p-value is reported in parentheses, and ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Constants are not reported.

Independent Variables	Dependent Variables					
	(1) Total Corporate Investment	*(2) Total Real Investment*	*(3) Total Capex*	*(4) Acquisitions*	*(5) Expansion Capex*	*(6) R&D*
Optimism	-0.000	-0.002	-0.000	0.001	-0.001	0.001
	(0.983)	(0.721)	(0.886)	(0.738)	(0.685)	(0.802)
Over-Precision	0.008	0.009**	-0.001	0.007**	0.003	-0.001
	(0.125)	(0.033)	(0.502)	(0.035)	(0.253)	(0.748)
$Log(sales)_{t-1}$	-0.014***	-0.010***	-0.003***	-0.007***	0.001	-0.004***
	(0.000)	(0.000)	(0.005)	(0.000)	(0.460)	(0.001)
$Log(PPE/Emp)_{t-1}$	0.012***	0.003	0.011***	-0.008***	0.002	0.007***
	(0.002)	(0.271)	(0.000)	(0.000)	(0.279)	(0.000)
$Stock\ Return_{t-1}$	0.014**	0.017***	0.005***	0.012***	0.000	-0.003**
	(0.025)	(0.003)	(0.004)	(0.003)	(0.950)	(0.028)
$Tobin's\ Q_{t-1}$	0.009*	-0.001	0.003*	-0.005	0.008***	0.010***
	(0.055)	(0.689)	(0.052)	(0.103)	(0.007)	(0.000)
$Sales\ Growth_{t-1}$	0.036**	0.025*	0.004	0.025**	0.022***	0.008*
	(0.026)	(0.097)	(0.457)	(0.026)	(0.005)	(0.088)
$Profitability_{t-1}$	0.126***	0.216***	0.112***	0.097***	-0.034	-0.082***
	(0.005)	(0.000)	(0.000)	(0.001)	(0.453)	(0.000)
$Book\ Leverage_{t-1}$	-0.066***	-0.035**	-0.046***	-0.000	-0.022***	-0.028***
	(0.001)	(0.034)	(0.000)	(0.971)	(0.002)	(0.000)
$Cash_{t-1}$	0.067***	0.010	-0.025***	0.029*	-0.003	0.057***
	(0.004)	(0.608)	(0.000)	(0.072)	(0.739)	(0.000)
$Log(1+delta)_{t-1}$	-0.003	-0.001	0.000	-0.001	0.000	-0.003**
	(0.219)	(0.700)	(0.988)	(0.748)	(0.956)	(0.015)
$Log(1+vega)_{t-1}$	0.005**	0.001	-0.002**	0.002*	-0.001	0.004***
	(0.015)	(0.582)	(0.047)	(0.093)	(0.260)	(0.000)
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,633	3,633	3,763	5,048	3,762	5,244
Adjusted R^2	0.186	0.116	0.466	0.066	0.198	0.494

Table 9
CEO Overconfidence and Diversifying Mergers & Acquisitions

This table presents the logistic regression results on CEO overconfidence and diversifying versus within M&A activities. The models estimated are discussed in Section 4.4. The sample covers 2001 to 2014. The dependent variables are *MA, MA_DIV* and *MA_WITHIN*. *MA, MA_DIV and MA_WITHIN* is a dummy variable that takes a value of one if the firm conducts at least one M&A, one diversifying M&A or one M&A within the same industry during the year and zero otherwise, respectively. A CEO is deemed to be optimistic (overly precise) if the average residuals from the management earnings forecast error (precision) regression are above its corresponding median value. For more details on the classification of optimism and over-precision, refer to Section 3.1. All control variables are measured at the last fiscal year-end, and details of their measurements are presented in Appendix A. Fama-French 48 Industry fixed effects and year fixed effects are included. Standard errors are clustered at the firm level. The p-value is reported in parentheses, and ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Constants are not reported.

Independent Variables	Dependent Variables		
	MA	*MA_DIV*	*MA_WITHIN*
Optimism	0.083	-0.036	0.160
	(0.363)	(0.790)	(0.144)
Over-Precision	0.243**	0.292**	0.183
	(0.011)	(0.036)	(0.125)
$Log(sales)_{t-1}$	-0.126***	-0.130**	-0.097*
	(0.006)	(0.049)	(0.084)
$Log(PPE/Emp)_{t-1}$	-0.091	-0.169**	-0.050
	(0.106)	(0.044)	(0.466)
$Stock\ Return_{t-1}$	0.301***	0.247*	0.303**
	(0.002)	(0.085)	(0.014)
$Tobin's\ Q_{t-1}$	-0.366***	-0.613***	-0.245***
	(0.000)	(0.000)	(0.002)
$Sales\ Growth_{t-1}$	0.770***	0.156	0.992***
	(0.005)	(0.709)	(0.003)
$Profitability_{t-1}$	1.019	3.072***	0.130
	(0.102)	(0.001)	(0.857)
$Book\ Leverage_{t-1}$	-0.041	-0.493	0.236
	(0.902)	(0.321)	(0.539)
$Cash_{t-1}$	0.797**	0.547	0.836**
	(0.012)	(0.226)	(0.032)
$Log(1+delta)_{t-1}$	-0.024	0.080	-0.094*
	(0.617)	(0.315)	(0.095)
$Log(1+vega)_{t-1}$	0.111**	0.081	0.093*
	(0.011)	(0.187)	(0.084)
Industry Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	5,244	5,143	5,173
Pseudo R^2	0.052	0.088	0.067

Table 10
CEO Overconfidence and Private Mergers & Acquisitions

This table presents the logistic regression results on CEO overconfidence and private versus public M&A activities. The models estimated are discussed in Section 4.4. The sample covers 2001 to 2014. The dependent variables are *MA_PRI* and *MA_PUB*. *MA_PRI* and *MA_PUB* is a dummy variable that takes a value of one if the firm conducts at least one private M&A or one public M&A transaction during the year and zero otherwise, respectively. A CEO is deemed to be optimistic (overly precise) if the average residuals from the management earnings forecast error (precision) regression are above its corresponding median value. For more details on the classification of optimism and over-precision, refer to Section 3.1. All control variables are measured at the last fiscal year-end, and details of their measurements are presented in Appendix A. Fama-French 48 Industry fixed effects and year fixed effects are included. Standard errors are clustered at the firm level. The p-value is reported in parentheses, and ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Constants are not reported.

Independent Variables	Dependent Variables	
	MA_PRI	*MA_PUB*
Optimism	0.101	0.084
	(0.337)	(0.587)
Over-Precision	0.346***	-0.041
	(0.002)	(0.780)
$Log(sales)_{t-1}$	-0.280***	0.223***
	(0.000)	(0.002)
$Log(PPE/Emp)_{t-1}$	-0.119*	-0.046
	(0.065)	(0.619)
$Stock\ Return_{t-1}$	0.277**	0.362**
	(0.012)	(0.042)
$Tobin's\ Q_{t-1}$	-0.451***	-0.169
	(0.000)	(0.112)
$Sales\ Growth_{t-1}$	0.663**	0.883*
	(0.034)	(0.065)
$Profitability_{t-1}$	1.100	0.812
	(0.147)	(0.432)
$Book\ Leverage_{t-1}$	0.147	-0.041
	(0.683)	(0.948)
$Cash_{t-1}$	0.979**	0.070
	(0.011)	(0.905)
$Log(1+delta)_{t-1}$	-0.029	0.020
	(0.605)	(0.816)
$Log(1+vega)_{t-1}$	0.093**	0.103
	(0.045)	(0.161)
Industry Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Observations	5,217	4,876
Pseudo R^2	0.072	0.061

Table 11
CEO Overconfidence and Geographically Distant Mergers & Acquisitions

This table presents the logistic regression results on CEO overconfidence and geographically distant M&A activities. The models estimated are discussed in Section 4.4. The sample covers 2001 to 2014. The dependent variables are *MA_IS, MA_OS, and MA_F*. *MA_IS, MA_OS,* and *MA_F* is a dummy variable that takes a value of one if the firm conducts at least one M&A transaction than involves a target in the same state, in a different domestic state and in a foreign country during the year and zero otherwise, respectively. A CEO is deemed to be optimistic (overly precise) if the average residuals from the management earnings forecast error (precision) regression are above its corresponding median value. For more details on the classification of optimism and over-precision, refer to Section 3.1. All control variables are measured at the last fiscal year-end, and details of their measurements are presented in Appendix A. Fama-French 48 Industry fixed effects and year fixed effects are included. Standard errors are clustered at the firm level. The p-value is reported in parentheses, and ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Constants are not reported.

Independent Variables	Dependent Variables		
	MA_IS	*MA_OS*	*MA_F*
Optimism	0.092	0.110	0.046
	(0.696)	(0.314)	(0.788)
Over-Precision	0.031	0.229**	0.287
	(0.898)	(0.048)	(0.105)
$Log(sales)_{t-1}$	-0.085	-0.144**	-0.052
	(0.436)	(0.012)	(0.518)
$Log(PPE/Emp)_{t-1}$	0.199	-0.143**	-0.045
	(0.165)	(0.036)	(0.660)
$Stock\ Return_{t-1}$	0.205	0.366***	0.070
	(0.464)	(0.001)	(0.710)
$Tobin's\ Q_{t-1}$	-0.323**	-0.396***	-0.224
	(0.014)	(0.000)	(0.104)
$Sales\ Growth_{t-1}$	1.807**	0.302	1.155**
	(0.010)	(0.364)	(0.010)
$Profitability_{t-1}$	0.795	1.553**	-0.994
	(0.527)	(0.037)	(0.460)
$Book\ Leverage_{t-1}$	-0.199	-0.083	0.003
	(0.786)	(0.841)	(0.996)
$Cash_{t-1}$	0.574	0.671*	1.041*
	(0.454)	(0.065)	(0.094)
$Log(1+delta)_{t-1}$	0.021	-0.012	-0.073
	(0.876)	(0.842)	(0.391)
$Log(1+vega)_{t-1}$	0.081	0.123**	-0.008
	(0.516)	(0.025)	(0.913)
Industry Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	4,265	5,238	4,783
Pseudo R^2	0.075	0.057	0.080

Internet Appendix A:
Definition of Managerial Optimism and Over-Precision

In the behavioral finance literature, the extant definition of overconfidence is somewhat confusing (Skala 2008). Studies generally focus on two types of overconfidence effects, namely overestimation of the mean and underestimation of the variance.

Overestimation of the mean could arise from overconfidence or optimism, which the psychology literature treats as two different concepts. However, in the behavioral corporate finance literature, they are generally treated the same, given that both overconfidence and optimism lead to overestimation of the mean. For example, Malmendier and Tate (2005) use overconfidence, while Heaton (2002) uses optimism for overestimation of the mean.

Underestimation of the variance stems from another particular type of overconfidence, namely over-precision as defined by Moore and Healy (2008). In the behavioral finance literature, this type of bias is generally referred to as overconfidence (e.g., Gervais, Heaton, and Odean 2011; Goel and Thakor 2008) or miscalibration (Ben-David, Graham, and Harvey 2013). We provide a summary of the definitions that have been used in the table below.

<table>
<tr><th colspan="5">Optimism and Overconfidence in Psychology and Behavioral Finance</th></tr>
<tr><th colspan="2">Psychology</th><th></th><th colspan="2">Behavioral Finance</th></tr>
<tr><td rowspan="3">Optimism
(Larsen and Buss, 2002)</td><td>Dispositional Optimism</td><td rowspan="5">]</td><td rowspan="3">Overestimation of the Mean
(Optimism in this study)</td><td>Overconfidence
(e.g., Malmendier and Tate 2005)</td></tr>
<tr><td>Self-efficacy</td><td rowspan="3">Optimism
(e.g., Heaton 2002)</td></tr>
<tr><td>Optimistic Bias</td></tr>
<tr><td rowspan="3">Overconfidence
(Moore and Healy, 2008)</td><td>Overestimation</td></tr>
<tr><td>Overplacement</td></tr>
<tr><td>Over-precision</td><td>→</td><td rowspan="2">Underestimation of the Variance
(Over-precision in this study)</td><td>Overconfidence
(e.g., Goel and Thakor 2008)</td></tr>
<tr><td></td><td></td><td>Miscalibration
(e.g., Ben-David, Graham, and Harvey 2013)</td></tr>
</table>

Overconfidence in the behavioral corporate finance literature could refer to either overestimation of the mean or underestimation of the variance effects. As a result, we use optimism for overestimation of the mean, and over-precision for underestimation of the variance to avoid this confusion.