Forcing Managers to Talk:
CEO Confidence and R&D Opacity

Ping-Sheng Koh
Hong Kong University of Science and Technology
Email: ackoh@ust.hk

David M. Reeb
National University of Singapore
Senior Fellow, *ABFER*
Email: dmreeb@nus.edu.sg

Wanli Zhao
Southern Illinois University
Email: zhaowl@business.siu.edu

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Abstract

We explore the effectiveness of forcing managers to provide financial information by comparing R&D opacity in firms with confident and cautious CEOs. We find that firms with confident CEOs are 25 percent more likely to declare their R&D expenditures relative to cautious-CEO firms. Exploiting state-level regulatory shocks and changes in CEO type we document that cautious-CEO firms provide limited data on R&D. Moreover, we document that R&D opacity significantly influences studies on CEO confidence and corporate innovation, potentially leading to incorrect inferences. These results affect both academics and market participants, implying potential bias in empirical studies on corporate innovation.

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1. Introduction

Beginning with the Securities Act of 1933 financial regulations have expanded to include a wide spectrum of issues, including financial statements, conflicts of interest, and corporate governance (Simon, 1989; Lacko and Papplardo, 2010). Yet the underlying efficiency of these regulations engender substantial debate (e.g., Inderst and Ottaviani, 2012). Legal scholars encourage regulators to compel financial disclosures to reduce agency problems between managers and outside investors. Coffee (1984) argues that financial disclosure regulations facilitate market participation because it creates an affirmative duty to inform investors about corporate activities. Mahoney (1995) observes that financial disclosure rules limit the ability of managers to keep information private to their own personal benefit. Fishman and Hagerty (1990, 2003) discuss how financial disclosure regulations could resolve opacity problems, thereby alleviating investor concerns about missing information. More generally, the role of financial disclosure regulation centers on concerns that managers fail to provide information to outside investors (Admati and Pfleiderer, 2000; Rogerson, 2008). While legal scholars accept the notion that financial regulations mitigate managerial incentives to keep silent (Ferrell, 2004), we lack empirical evidence on financial disclosure regulation efficacy because the activity we wish to evaluate is generally unobservable.

We focus on a specific and important financial disclosure, namely R&D expenditures. Empirical studies in finance routinely rely on R&D expenditure data to measure corporate investments (e.g., McLean and Zhao, 2014). Financial regulations stipulate the reporting of material R&D expenditures by US companies (Barlevy, 2007). Yet, prior research highlights that public firms in the US frequently exhibit missing or incomplete R&D expenditure data (Masulis et al., 2009; Brown et al., 2013). Among the ExecuComp firms in our sample, over one-third of them do not report any information regarding corporate R&D. Studies in economics and finance typically consider firms with missing R&D as zero innovation firms (e.g., Bloom et al., 2013). Yet, Seru (2014) observes that innovative firms tend to disperse their R&D expenditures in different parts of the firm, which potentially obfuscates R&D activities. Turning to R&D outputs, a significant number of these missing R&D firms routinely apply for a substantial number of

patents, corresponding to the bottom 95 percent of positive reporting R&D firms (Koh and Reeb, 2015).

Financial opacity arguably arises because it provides some personal benefit to the manager at a cost to shareholders, suggesting the need to consider managerial traits. Prior research reports that managerial confidence is an important executive trait that influences corporate decisions (Malmandier and Tate, 2005; Ben-David et al., 2013). Exploiting differences in input and output measures of R&D to identify R&D opacity, we investigate whether managerial confidence systematically influences the decision to reveal R&D expenditures. Choosing to label R&D expenditures separately or as part of operating expenses has no effect on reported profits. Firms that fail to report R&D expenditures but engage in patent activity (opaque R&D firms) provide a distinctive setting for investigating whether financial disclosure compliance varies across managers.[1]

Clear arguments arise to suggest that financial disclosure rules produce less influence on confident managers relative to their more cautious counterparts.[2] Facebook's CEO Mark Zuckerberg, for instance, is often described in the business press as highly confident, possessing strong opinions, and fostering corporate secrecy (e.g., Raice, 2012). Bernardo and Welch (2001) advocate that the persistence of confident behavior stems from the limited number of lucky winners viewing their ability as the key to their success. Empirical research in psychology indicates that confident managers often convince themselves that the rules of the game only apply to other participants (Arregle et al., 2007). Others emphasize that confident managers use their prior successes to justify unwarranted decisions today, suggesting confident managers potentially

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[1] Financial disclosure requirements only apply to non-trivial or material items. Materiality has several permutations but centers on whether a failure to reveal influences the assessment of a reasonable investor. In our sample, opaque R&D firms often file large numbers of patents year in and year out. In general, we observe that opaque R&D firms appear similar to the vast majority of positive R&D firms.

	Zero R&D Firms	Opaque R&D Firms	Bottom 95th Percentile of Positive R&D Firms
Patent Applications	*0.030*	*4.69*	*3.92*
Patents Granted	*0.052*	*5.43*	*5.71*

[2] Conceptually these represent more and less confident CEOs. Our analysis sidesteps the source (e.g., miscalibration, risk tolerance, etc.) and social desirability of CEO confidence and uses this managerial trait to investigate systematic non-disclosure. Consequently, labels such as over-confident (non-overconfident), more (less) risk tolerant, or optimistic (pessimistic) also offer alternative descriptions of this managerial trait.

disregard the benefits of revealing R&D (Whyte et al., 1997). Strategy scholars suggest that confident leaders seek to conceal projects and their associated costs to mitigate rival mimicking (Waldman and Yammarino, 1999). Accounting research indicates that confident CEOs are more likely to engage in financial misreporting (Schrand and Zechman, 2012). Thus, popular accounts and prior literature suggest that confident managers potentially refrain from revealing R&D spending.

However, an alternative perspective suggests that confident managers view their R&D expenditures as generating positive outcomes, overestimate the future project cash flows, and/or tolerate risk to a substantive degree. Arguably, these issues increase a confident manager's inclination to disclose their firm's R&D spending. In contrast, cautious CEOs seek to manage market expectations and limit corporate disclosures regarding R&D expenditures. Lev and Sougiannis (1996), for instance, emphasize that investors view R&D expenditures as value-relevant, with greater R&D leading to higher expectations about future performance. Others emphasize that R&D efficiency provides an important component in evaluating managerial performance (Healy et al., 1992). CEOs concerned with limiting external constituents capacity to evaluate or assess their managerial performance seek to limit their R&D disclosures. In this context, cautious managers potentially balance the personal benefits and corporate costs that accrue from not following financial disclosure requirements. If cautious managers put more emphasis on managing the market's expectations regarding this performance attribute, then we expect cautious managers to exhibit a greater tendency relative to confident managers to not disclose R&D expenditures. Overall, persuasive arguments suggest that managerial confidence influences the degree of financial disclosures of R&D spending.

Our empirical analysis begins with an exploration of the cross-sectional relation between CEO confidence and the admission of corporate R&D expenditures. To investigate the role of financial regulations in improving the information environment, we examine the incidence or likelihood of opaque R&D firms based on the CEOs' classification into two categories: confident or less confident (cautious). Our primary measure of managerial confidence uses executives' unexercised in-the-money stock options (Malmendier and Tate, 2005). For comparability with

prior studies, our tabulated results use a binary classification of CEO confidence.[3] We base our analysis on both full and propensity-score matched samples.

Using data from Compustat, ExecuComp, and the US Patent and Trademark Office, our main sample comprises 18,407 firm-year observations from 1992 to 2010. Over one-third (35.5 percent) of our sample firms report no information regarding their R&D expenditures (missing R&D). The remaining firms report either positive or zero R&D spending (80.6 and 19.4 percent, respectively). Approximately 17.5 percent of the missing R&D observations engage in patent activity and we designate them as opaque R&D firms. Classifying CEOs by the option moneyness metric results in roughly 45 percent of the CEOs classified as confident. The incidence of missing R&D expenditure data does appear to differ between confident and cautious CEOs. Firms with missing R&D likely include the ones that do not engage in R&D and those that simply do not separately report their R&D. Consequently, our analysis centers on the subset of missing R&D that exhibit symptoms of positive R&D, namely the opaque R&D firms.

Contrary to the notion that confident CEOs limit corporate disclosures on R&D expenditures, we find lower incidences of opaque R&D in firms with confident CEOs relative to those with cautious CEOs. Based on full samples (propensity-score matched samples) of positive R&D reporting firms and opaque R&D, we find that confident CEOs are associated with a 24 percent (25 percent) lower likelihood of being opaque R&D firms than cautious CEOs. Considerations such as firm size, profitability, volatility, and compensation contract variations do not materially affect these results. To determine if our findings arise by chance, we randomly assign CEO type across the full sample in a falsification test. We find evidence inconsistent with spurious findings. In sum, both the full and matched sample results suggest that confident CEOs are associated with lower R&D spending non-disclosure.

We next use an exogenous legislative shock to the information environment in firms with cautious and confident CEOs to test whether CEO confidence influences the disclosure of R&D spending. The exogenous shock centers on the protection of the firm's human capital and trade

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[3] Dividing CEOs into 3 types using moneyness cut-offs of 30% and 67% provides even more pronounced results (i.e. 300% larger coefficient estimates). Additional tests in Section 5.2 using alternative measures of CEO confidence also give similar inferences.

secrets from employee movement to rival firms. In particular, our examination relies on state-level legislative decisions on Inevitable Disclosure Doctrine (IDD). IDD passage increases the protection of in-state firms' trade secrets by preventing their employees from working in a rival firm, exogenously decreasing a source of information leakage to corporate competitors. We use this exogenous shock to examine the differential response, if any, of disclosures in firms with confident and cautious CEOs. By matching on CEO type prior to the shock, our test provides additional insights into the potential effect of CEO confidence on the disclosure of R&D spending. Specifically, confident CEOs should increase their willingness to disclose R&D spending relative to cautious CEOs after this labor market shock. Intuitively, confident CEO concerns with competitor discovery of corporate innovation should decrease with IDD. The difference-in-differences analysis indicates that confident CEOs, relative to cautious CEOs, are less likely to hide R&D disclosure after the firm's state adopts IDD.

Our next test compares the disclosure choice of firms around dismissals of the CEO. Firms that replace a confident (cautious) CEO with another confident (cautious) CEO do not appear to change their R&D disclosure policy. In contrast, firms changing from confident to cautious CEO are significantly more likely to become opaque R&D firms. Specifically, we find that changing from a confident CEO to a cautious CEO leads to an *eight percent increase* in the incidence of opaque R&D. Likewise, changing from a cautious manager to confident manager results in about *ten percent reduction* in the incidence of opaque R&D. Various difference-in-differences specifications around CEO turnover provide consistent evidence that cautious-CEO firms fail to report corporate R&D expenditures.

We also investigate the role of CEO confidence in R&D opacity after a change in disclosure regime. Both Regulation Fair Disclosure and the Sarbanes-Oxley Act potentially influenced the disclosure of corporate R&D. If CEO confidence influences corporate disclosure policy, then we expect a differential response to this disclosure shift between confident and cautious-CEO firms. Specifically, due to greater limits on selective disclosures, CEO certification requirements, and governance enhancements, we expect a greater impact from the disclosure regime shift on cautious-CEO firms relative to confident-CEO firms. Consequently, we use this

exogenous change in regulatory regime in a difference-in-differences framework to examine its effects on the relation between CEO confidence and R&D opaqueness. While both types of CEO reduce the incidence of opaque R&D after the disclosure reform, the effect is roughly 49 percent larger in cautious-CEO firms relative to confident-CEO firms. Due to the lower incidence of opaque R&D firms in the post-disclosure-reform period (which is associated with a 44%-52% decrease in the relative disclosure bias), tests on the role of CEO confidence on innovation potentially contain less measurement error in the post-disclosure-reform period.

If CEO confidence influences the disclosure of R&D expenditures, then making comparisons of the inputs and outputs of R&D by CEO type becomes especially challenging. Empirical studies typically rely on R&D expenditures as an input measure of innovation and patents as an output measure of R&D activity. Yet the incentives to patent successful innovations, rather than simply keeping them as trade secrets, differ across industries and firms (Scotchmer, 1991). Arguably, the decision to patent or keep successful innovation secret is also potentially related to CEO confidence. If the incentives to patent successful innovation are positively related to the incentives to report R&D spending, then the post-disclosure-reform period provides a good laboratory for studying the relation between managerial confidence and innovation (both inputs and outputs). Consequently, we examine the relationship differential between CEO confidence and reported R&D in periods with high and low R&D disclosure bias (*viz.*, pre- and post–disclosure-reform periods respectively).

As cautious CEOs exhibit a lower propensity to disclose their R&D expenditures, the standard approach of excluding missing R&D firms or coding them as zero will lead to biased results. In simple univariate analysis of the high R&D disclosure bias period, we find that the confident-CEO firms appear about 6.6 percent more likely to report positive R&D relative to cautious-CEO firms. In contrast, in the low R&D disclosure bias period, the proportion of positive R&D reporting firms is about 7.2 percent lower in confident-CEO firms than in cautious-CEO firms. Our multivariate results also indicate that confident-CEO firms exhibit approximately 15 percent higher reported R&D in the high R&D disclosure bias period relative to cautious-CEO firms. However, in the post disclosure reform period, we find no difference or (roughly 10

percent) lower R&D in confident-CEO firms relative to cautious-CEO firms. Thus, in an environment with more restrictions on selective disclosure and greater accountability (i.e., fewer opaque R&D firms), we find either lower or no differences in R&D spending in confident-CEO firms relative to cautious-CEO firms.

Next, we explicitly examine the implication of disclosure bias on innovation outcomes between confident and cautious-CEO firms. In the high R&D disclosure bias period, we find the proportion of confident CEOs with patent activity is greater than that found in firms with cautious CEOs. Specifically, the proportion of confident-CEO firms with patent activity is about *seven percent greater* than in cautious-CEO firms. In contrast, this relation reverses in the low R&D disclosure bias period, where we find confident-CEO firms have about *10 percent lower* likelihood of having patent activity relative to cautious CEOs. In the multivariate tests we similarly find that confident-CEO firms exhibit fewer (more) patents and lower (more) citations in the low (high) disclosure bias period after controlling for R&D investment amount and potential disclosure bias. We interpret this evidence to suggest that managerial confidence influences both the disclosure and outcome of corporate R&D, and that their relations are further affected by overall financial regulatory environment.

Our study makes several contributions. First, we show that a managerial trait potentially influences corporate decisions to remain silent on activities that constitute a required financial disclosure. Theories of financial disclosure often center on differences in silence versus misrepresentation, emphasizing that required disclosures help overcome problems with managers failing to inform investors about corporate activities (Easterbrook and Fischel, 1984). Our evidence suggests the role of financial disclosures in overcoming corporate silence systematically varies with managerial confidence.

Second, our findings provide evidence that less confident or cautious CEOs engender greater R&D opacity. Regulatory requirements on managerial certification of financial statements and labor market shocks influence R&D opacity differently in firms with confident and cautious CEOs. Supplementary evidence indicates that CFO confidence appears unrelated to this disclosure decision. In this context, a cautious CEO's failure to provide a financial disclosure

potentially creates substantial label confusion (Harbaugh et al., 2011). Intuitively, failure to provide a required financial disclosure creates greater confusion among investors relative to a limited voluntary disclosure. Moreover, it is imperative for studies that investigate the role of firm or managerial attributes on R&D expenditures to incorporate how these attributes influence the disclosure of R&D. For instance, considering firms with missing R&D expenditure data as zero R&D firms can produce substantial bias into the analysis.

Finally, we document that after a change in the disclosure regulatory regime, confident-CEO firms appear to engage in fewer innovation activities using both input and output measures of R&D. These results are in stark contrast to recent research suggesting that firms with confident CEOs engage in more innovation than cautious CEO firms prior to the regime change (e.g., Galasso and Simcoe, 2011; Hirshleifer et al., 2012). One interpretation is that problems in measuring innovation using input measures, such as R&D expenditures, also influence output measures such as patents. In this context, favoring output measures over input measures of innovation replaces one noisy measure with another noisy measure. Moreover, this evidence implies that disclosure rules potentially influences real investment activity. Overall, our analysis suggests that the precision or reliability of financial corporate disclosures fluctuates with CEO confidence.

2. Data and Sample

2.1 Data Source

Our sample firms are constructed within the cross-section of multiple data sources. First, we use the ExecuComp database, which provides the executive compensation information for us to construct the confidence measure. Second, we require firms to have financial information from Compustat with a threshold of total assets and sales of $1 million. Third, we exclude firms in utilities (SIC between 4000 and 4099) and financial services (SIC between 6000 and 6099) due to their different operating and reporting environment. To gauge the influence of R&D investment, we obtain the patent data from the USPTO. We also exclude observations without sufficient

information to construct our variables, leading to an overall sample with 18,407 firm-year observations between 1992 and 2010 inclusively.

2.2 Managerial Confidence

We measure managerial confidence using executives' unexercised in-the-money stock options (Malmendier and Tate, 2005; Armstrong et al., 2015).[4] More specifically, we identify CEOs as confident if their in-the-money exercisable options exhibit greater than 67 percent moneyness. We classify CEOs without sufficient compensation information to determine their moneyness as cautious CEOs. We note that our results continue to hold if we drop these executives from our tests.

2.3 Opaque R&D

A large proportion of firms do not disclose any R&D expenditures in their financial statements, leading to blank or missing R&D expenditures in Compustat. We identify firms with positive patent activity that fail to disclose their R&D expenditures as opaque R&D firms. Specifically, these are firms with missing or blank R&D expenditure data that seek or receive patent applications each year. We also measure reported R&D investment by firms' disclosed R&D expenditures divided by total assets.

2.4 Matched Sample

Research in financial economics suggests that managerial confidence leads to miscalibration in the riskiness of investments, influences capital expenditures, and decreases information production (Malmendier and Tate, 2005; Goel and Thakor, 2008; Ben-David et al., 2013). Others emphasize that CEO confidence potentially influences the decision to engage in

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[4] We use moneyness of exercisable options as our main instrument to determine confident CEO (Hirshleifer et al., 2012). Malmendier and Tate (2005, 2008) suggest this measure captures managerial confidence, arguing CEOs do not exercise them because they overestimate the future success and underestimate the potential risk. In contrast, Armstrong et al. (2015) suggest this measure captures managerial risk tolerance. In the robustness check section, we discuss results using two alternative confidence measures: *Longholder* and *Netbuyer*.

R&D activities (Galasso and Simcoe, 2011; Hirshleifer et al., 2012). Graham et al. (2013) report that CEOs exhibit substantial optimism and risk-tolerance and that these traits influence corporate policies. Consequently, we also employ a propensity-score matching method (without replacement using a caliper of 0.1 percent) to generate a matched sample between firms with confident and cautious CEOs. We match firms based on their size, market-to-book, leverage, ROA, volatility, institutional ownership, CEO age, CEO gender, CEO tenure, CEO delta, CEO vega, industry average R&D, and industry (two-digit SIC) and year dummies. We match on CEO age, gender, and tenure to control for the possibility that these personal traits influence the firm's R&D investment and disclosure decisions. We match on CEO delta and vega to filter out the variation in compensation policy between confident and cautious CEOs. For our main test, the matching process yields a sample of 12,260 firm-year observations with equal numbers of observations with confident/cautious CEOs.

2.5 *Control Variables*

We also control for several firm characteristics that potentially influence a firm's R&D investment and disclosure decision. We control for *Firm Size*, measured as log of book value of total assets. *Leverage* is measured by total liabilities scaled by total assets. *ROA* is measured by earnings before extraordinary items divided by total assets. Market-to-book is the market value of equity divided by the book value of equity. *Volatility* is measured as the standard deviation of daily stock return in the prior year. *Inst_own* is measured by the common equity proportion owned by institutional investors. Bushee (1998) has shown that institutional ownership influences firms' R&D decisions. *Delta* (*Vega*) measures CEO wealth change in dollars to a one percent change in stock price (annualized standard deviation of stock return). Extant research has suggested that variations in delta and vega lead to different CEO risk-taking behavior (Coles et al., 2006), while Hirshleifer et al. (2012) document that delta and vega are related to firms' R&D

investments. Moreover, Armstrong et al. (2013) observe that both delta and vega need to be considered concurrently when examining equity incentives on financial reporting.[5]

2.6 Summary Statistics

Table 1 Panel A presents summary statistics of firm variables of the full sample and the matched sample. For the full sample (Columns 1-3), we find that 45.3 percent of observations in the sample are classified as a confident CEO. Around 36 percent of our sample observations do not report their R&D expenditure. Opaque R&D firms represent about 6.2 percent of our overall sample and comprise about 17.5 percent of missing R&D firms. Average firm size is roughly $1,163 million and average reported R&D investment is 3.4 percent of total assets (assume missing R&D as zeros). Firms have approximately 52 percent of total liabilities in their total assets. The mean (median) ROA is 3.4 percent (5.2 percent). On average, the market-to-book ratio is 3.2 and stock volatility is 12.1 percent. Institutional investors own about 55 percent of the equity. In the full sample, the average CEO age is 55 years and only 1.8 percent of them are female. Average CEO tenure in the sample is seven years. Based on reported R&D, industry level R&D is 3.6 percent of firms' total assets. Finally, the average (log) delta is 5.366 and (log) vega has a mean value of 3.645.

Columns 4-6 report the matched sample statistics. Compared to the full sample, the matched sample exhibits roughly the same average firm size, R&D investment, market-to-book ratio, volatility, CEO age, CEO tenure, and industry level R&D. In contrast, the matched sample firms display higher ROA, higher institutional ownership, fewer female CEOs, and higher *Delta* and *Vega* than in the full sample.

In Panel B, we present the univariate test results comparing firms with confident and cautious CEOs. In Columns 1-3, we observe that both types of firms are similar in their size and CEO age but differ in all other firm characteristics. More specifically, firms with confident CEOs tend to have more R&D investment, less leverage, better financial performance, higher market-to-book ratio, higher volatility and institutional ownership, less likelihood to be female, longer

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[5] We obtain delta and vega from http://sites.temple.edu/lnaveen/data/.

tenure, operate in industries with more R&D, and have higher *Delta* and *Vega* than firms with cautious CEOs (*t-statistics* > 5.50). We observe that firms with confident CEO are more likely to report R&D and less likely to be opaque R&D firms (*t-statistics* > 4.00).

For the propensity-score matched sample (Columns 4-6), firms with confident CEOs no longer differ from firms with cautious CEOs across all the matching dimensions (*t-statistics* < 1.35). This suggests that we have achieved covariate balancing in our matching process and the resulting matched sample firms are comparable across the two types of CEOs. However, among the matched sample, R&D disclosure choices between firms with confident CEOs differ from those with cautious CEOs: the former are more likely to have missing R&D expenditure but are less likely to be opaque R&D firms (*t-statistics* = 2.32 and 3.60 respectively). Taken together, our univariate results provide preliminary evidence consistent with the idea that confident CEOs are more likely to report rather than to hide their R&D expenditure.

3. Multivariate Tests

3.1 CEO Confidence and R&D Disclosure

Table 2 presents logit regression results on the relation between CEO confidence and R&D disclosure using the following specifications:

Prob(Y) = f(Confident, Firm Size, Leverage, ROA, Market-to-book, Volatility,

Institutional Ownership, Delta, Vega, Industry and Year fixed effects)   (1)

where Y is either firms reporting missing R&D or being an opaque R&D firm. All other variables are as defined earlier.

Columns 1 and 2 show results based on full-sample while Columns 3 and 4 show matched sample results. In Columns 1 and 3, we find that, after controlling for other firm characteristics, confident CEOs are not significantly related to missing R&D in both full sample and matched-sample tests (*z-statistics* < 1.60). Similarly, we find that confident CEOs are less likely to hide their R&D investment information by being an opaque R&D firm (see Columns 2 and 4; *z-statistics* = -2.08 and -2.21 for full- and matched-sample tests respectively). Economically, the coefficients indicate that confident-CEO firms are 24 percent (25 percent) less

likely to be an opaque R&D firm in the full (matched) sample tests.[6] One potential interpretation is that confident CEOs are less concerned about the negative effect of disclosing R&D investment to the competitors.

Focusing on other firm characteristics, we find that more levered and/or better-performing firms tend to report missing R&D (*z-statistics* > 3.80). On the other hand, higher market-to-book ratio and volatility are negatively associated with the likelihood of reporting missing R&D (|*z-statistics*| > 4.00). We also find that larger firms are more likely to be opaque R&D firms (*z-statistics* > 1.65), while more volatile firms are less likely to be opaque R&D firms (|*z-statistics*| > 3.25). Finally, *Vega* is negatively related to reporting missing R&D as well as being an opaque R&D firm (|*z-statistics*| > 1.75).

To ensure our findings in Table 2 are not an artifact of the confidence measure or driven by chance, we perform a falsification test where we randomly assign the CEO type (confident or cautious) to our sample firms while keeping the relative proportion of confident CEO constant, and use the randomly assigned CEO type to rerun the analysis. We repeat this process 1,000 times and present the frequency distribution of the estimated coefficients for *Confident* in Figure 1A and 1B. The first histogram in Figure 1A indicates that average estimated coefficients for *Confident* are not significantly different from zero for the missing R&D test (*p*-value = 0.83). Further tests suggest that the estimated coefficient in Table 2 (0.143) is significantly different from the mean estimated coefficients from the simulations (*p*-value = 1.00). Similarly, the second graph in Figure 1B shows that the mean estimated coefficients for *Confident* from the simulations is insignificantly different from zero for the opaque R&D test (*p*-value = 0.35). Further tests suggest that the estimated coefficient in Table 2 (-0.166) is significantly different from the mean estimated coefficients from simulated results (*p*-value = 1.00). Moreover, the estimated coefficient for *Confident* in Table 2 is outside the left-tail of the estimated coefficient distribution

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[6] This is computed as the likelihood of firms with confident CEOs being an opaque R&D firm as 9.8% (8.6%) compared with that of cautious CEOs 12.9% (11.4%) in the full sample (matched sample), respectively (assuming control variables at sample average). We also perform additional analysis by including all the matching dimensions to Equation (1) yielding qualitative consistent evidence. Specifically, we continue to find CEO *Confident* is not associated with reporting missing R&D (*z-statistics* <1.38) while negatively associated with being an opaque R&D firms (|*z-statistics*| > 2.15).

from the simulation (-0.156). The latter findings provide evidence consistent with the notion that our main findings reported in Table 2 are unlikely to be an artifact of the confidence measure or driven by chance.

3.2 State Adoptions of Inevitable Disclosure Doctrine

The correlations we document in the panel regressions provide interesting evidence. Next, we explore an exogenous variation in the costs of disclosing R&D expenditures to develop a causal test. Specifically, we use the US state courts' verdict on the Inevitable Disclosure Doctrine (IDD) as the exogenous shock to the protection of the firm's human capital and trade secrets from employee movement to rival firms. Adoption of IDD by a state implies that the trade secrets of the firms residing in that state become better protected as employees of the firm face limitations in working for competitors.[7] IDD passage exogenously decreases a source of information leakage to corporate competitors, providing identification in testing the differential response of confident and cautious-CEO firms.

We expect IDD to affect confident CEOs differently from cautious CEOs. Managers concerned about rival discovery (confident CEOs) are now likely to have fewer incentives to hide their R&D (i.e., being an opaque R&D firm) because the IDD provides another layer of protection from rivals. In contrast, cautious CEOs presumably center less attention on rival discovery and instead focus on market perceptions of their project success. Consequently, we expect that after IDD adoption by a state court, confident CEOs in that state will have even fewer incentives to hide their R&D (i.e., being an opaque R&D firm) while the effects of IDD on cautious CEOs are likely to be muted.

We first provide univariate evidence of the relation between opaque R&D firms and CEO type around the years of IDD adoption based on our matched sample.[8] Figure 2A shows the

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[7] We identify states that have IDD protections based on Klasa et al. (2014).
[8] We develop the matched sample based on the year prior to the IDD adoption and require these control firms to not experience an IDD event in a three-year period before and after the matching year. We match on the following variables: firm size, leverage, ROA, market-to-book, volatility, industry average R&D, institutional ownership, CEO age, CEO gender, CEO tenure, CEO delta, CEO vega, industry and year dummy, without replacement using a caliper of 0.1%.

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percentage of opaque R&D firms among confident CEOs that operate in states that adopted IDD versus states that did not. We observe that the adoption of IDD has greater impact on R&D disclosure of confident CEOs operating in IDD adopting states (dashed line) in comparison to confident CEOs operating in states without IDD adoption (dotted line). Specifically, we observe a sharp decrease in the proportion of opaque R&D firms with confident CEOs in the year of IDD adoption (Year 0). Such decline continues until two years after the IDD adoption (Year 2). In contrast, while there is an initial decline in Year 0 for confident CEOs operating in states without IDD adoption, the magnitude is smaller and little change in the proportion of opaque R&D is observed in subsequent years.

In Figure 2B, we present the graphical representation of the univariate difference-in-differences results by CEO type. In particular, we obtain the first difference dimension by taking the difference in the proportion of opaque R&D firms with confident CEOs between states with and without IDD adoption (that is, dashed line less dotted line in Figure 2A). This gives the dashed line in Figure 2B. The pre-/post-IDD adoption represents the second difference dimension. For comparison, we similarly present the outcomes for cautious CEOs (see dotted line). For firms with confident CEOs (dashed line), we continue to observe a sharp drop in the proportion of opaque R&D firms in the first year of IDD adoption (Year 0). This decline continues until two years after the IDD adoption. The proportion of opaque R&D firms is lower in the post-IDD period relative to the pre-IDD adoption period.

In contrast, for cautious CEOs (dotted line), the proportion of opaque R&D firms exhibit no obvious pattern and are range-bound in their changes in the years surrounding IDD adoption. Moreover, we observe confident and cautious CEOs do not differ much in the years prior to the IDD adoption (see Years -2 to -1). However, divergence emerges from the year of IDD adoption (Year 0) until three years after the IDD adoption with an increasing gap. Collectively, our univariate evidence is consistent with the notion that after the IDD adoption, confident CEOs are less likely to hide their R&D expenditure. These findings from graphical illustrations are consistent with the univariate test results we present in Table 3 Panel A. We find once again that opaque R&D firms decrease more among confident-CEO firms after IDD adoption than among

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cautious-CEO firms (*t-statistics* for the difference-in-differences > 2.00 in both full and matched samples).

Next, we adopt the following difference-in-differences design for our regression analysis:

Prob(Y) = f(Confident, IDD, Confident*IDD, Firm Size, Leverage, ROA, Market-to-

book, Volatility, Institutional Ownership, Delta, Vega, Industry and Year

fixed effects)   (2)

where Y is 1 indicating an opaque R&D firm; *IDD* equals 1 if the state has IDD in effect during that year.[9] All other variables are as defined earlier. Our emphasis is on the interaction term, *Confident*IDD*. We present the relevant test results in Table 3 Panel B.[10]

In Columns 1 and 2, we present the results based on our full sample, focusing on whether firms choose to be opaque R&D firms. Consistent with our findings in Table 2, we find that CEO confidence is negatively associated with being opaque R&D firms (|*z-statistics*| > 1.99). We find IDD has no significant effect on being opaque R&D firms (|*z-statistics*| < 1.18). For our variable of interest, *Confident*IDD*, it is negative and significant (Column 2; *z-statistics* = -2.38), indicating that in states with IDD protection, a confident CEO is less likely to hide their R&D expenditures (by being an opaque R&D firm) than in firms with cautious CEOs (and the difference is larger than in states without IDD).

In Columns 3 and 4, we repeat the tests using the matched sample between firms in states that experience IDD adoption and firms that do not. We match firm-pairs based on the year prior to IDD adoption and we ensure that for the matched control firms they do not experience IDD event in a three-year period before and after the matched year. The result in Column 3 again indicates that CEO confidence is negatively related to being an opaque R&D firms (|*z-statistics*| =

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[9] In this analysis, we drop the year of the court decision (year 0) from the sample. Given the sharp drop observed in Figures 2A and 2B, our test design provides a conservative setting for finding evidence supporting the role of confident CEOs in IDD adopting states.

[10] We also examine the effect of IDD with an alternative difference-in-differences specification, where we focus on the effects of CEO confidence pre and post IDD adoptions among firms that experience IDD shock. Using a 1-year pre and post IDD window, Appendix B Panel A results suggest a qualitatively similar inference to our findings in Table 3. Specifically, we find confident CEOs are less likely to be in opaque firms in the post-IDD period than pre-IDD period and their cautious counterparts (*Confident*IDD* in Columns 2 and 4; |*z-statistics*| > 2.07). These findings are robust if we extend our event windows to 2- or 3-year windows. In addition, we continue to find consistent evidence when we exclude firms with CEO turnover from our test samples.

2.13). Economically, we find that CEO confidence is associated with 16 percent lower probability of being an opaque R&D firm. Further, on average, firms are more likely to be opaque R&D firms after the state adopts IDD protection of trade secrets (*z-statistics* = 2.17), consistent with the notion that preventing competitors from hiring employees with trade secret knowledge heightens competition, prompting firms to be more discretionary in their R&D activity disclosure; or fostering more innovative R&D project investments that firms want to conceal from competitors. In Column 4, we find similar inferences. Economically, CEO confidence is associated with 12 percent lower probability of the firm being an opaque R&D firm. Finally, we find that the interaction term, *Confident*IDD*, is significantly negative (Column 4; |*z-statistics*| = 2.07), suggesting that relative to cautious CEOs, confident CEOs are less likely to hide R&D disclosure (20 percent lower in probability) after the state adopts IDD, either because they are more confident about the inability of competitors to follow their innovation and/or with delivering their expected future performance due to the added intellectual property protection.

3.3 CEO Turnover, CEO Confidence, and R&D Disclosure

Next, we use CEO turnover to examine the effect of CEO confidence on R&D disclosure. We generate a matched sample between confident CEO turnovers and cautious CEO turnovers based on the year prior to their dismissal. We match on firm size, ROA, leverage, market-to-book, volatility, CEO age, CEO gender, CEO tenure, CEO delta, CEO vega, and industry and year dummy, using a caliper of 0.1 percent without replacement. We identify 304 cases of confident CEO dismissals and 304 cautious CEO dismissals for the test.[11] We include a three-year window prior to and post the turnover in our regression. Our empirical approach adopts a change specification as follows:

$$\Delta Y = f(\text{Confi-Confi, Confi-Cautious, Cautious-Confi, }\Delta\text{Firm Size, }\Delta\text{Leverage, }\Delta\text{ROA,}$$
$$\Delta\text{Market-to-book, }\Delta\text{Volatility, }\Delta\text{Institutional Ownership, }\Delta\text{Delta, }\Delta\text{Vega,}$$
$$\text{Industry fixed effects)} \qquad (3)$$

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[11] Among the 608 CEO turnovers, we identify the following breakdown: 20% cautious to cautious, 30% cautious to confident, 15% confident to cautious, and 35% confident to confident.

where ΔY is the change in opaque R&D disclosure in pre versus post CEO turnover periods. *Confi-Confi* represents confident CEOs in both pre and post turnover; *Confi-Cautious* (*Cautious-Confi*) indicates a change in CEO type from confident (cautious) in pre-turnover to cautious (confident) CEOs in post-turnover period. All other variables are measured as change between pre and post CEO turnover period and as defined earlier. We perform two sets of difference-in-differences tests. First, we compare firms with changes in the type of CEO to firms that just change to CEOs of the same type. Second, we compare firms with CEO turnover (either confident or cautious outgoing CEOs) against those without CEO turnover.[12]

We present the results in Table 4. Panel A shows univariate test results covering pre and post turnover with various CEO type changes. In Columns 1-3, we focus on firms that experience CEO turnover. We find that when the incoming CEOs are of the same type as the outgoing CEOs, there is no significant change in the incidence of opaque R&D firms between pre vs. post turnover (*t-statistics* < 0.50). Difference-in-differences tests indicate that the incidence of opaque R&D in firms with the same type of CEO pre and post turnover remains unchanged (*t-statistics* = 0.39). In contrast, firms that changes from a confident CEO to cautious CEO results in a significant increase in the incidence of opaque R&D (*t-statistics* = 2.02), while a change from cautious to confident CEOs results in a significant decline in incidence of the opaque R&D (*t-statistics* = 2.27).[13] In Columns 4-6, we show that among firms that have a confident CEO before the turnover, firms that change to cautious CEO observes greater incidence of opaque R&D firms than those that have a new CEO that is confident (*t-statistics* for difference-in-differences = 2.08). Finally, in Columns 7-9, we find that firms that have cautious CEOs before turnover experience lower incidence of opaque R&D firms if they change to confident CEO than if they hire the same type of CEO (*t-statistics* for difference-in-differences = 2.05).

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[12] In this latter approach, we match confident (cautious) CEO turnover to firms that do not experience CEO turnover. Specifically, we match 248 confident CEO turnovers to 248 no-turnover firms and 316 cautious-CEO turnovers to 316 no-turnover firms.

[13] Multiple difference-in-differences tests, using firms without changes in the CEO type as the non-treatment group all indicate that CEO changes from confident to cautious CEO, these treated firms experience significantly more incidence of opaque disclosure (*t-statistics* > 2.08), while a change from cautious to confident CEO is associated with a significant decline in incidence of opaque R&D disclosure (*t-statistics* > 2.02).

Panel B presents the regression results. Corresponding to the univariate test in Panel A, in Column 1 we find that relative to firms with cautious CEOs before and after CEO turnover (*Cautious-Cautious*), firms that have confident CEOs before and after CEO turnover (*Confi-Confi*) are not less likely to be opaque R&D firms post CEO turnover (*t-statistics* = -1.43). Moreover, firms with CEO type change from confident to cautious (*Confi-Cautious*) are more likely to be opaque R&D firms post turnover than in the pre turnover period (*t-statistics* = 2.10). Finally, firms with CEO type change from cautious to confident (*Cautious-Confi*) are less likely to be opaque R&D firms post turnover than pre turnover period (*t-statistics* = -2.01).

We next conduct *F*-tests to compare the effect between the different types of CEO change. More specifically, we find that a change in CEO type from confident to cautious (*Confi-Cautious*) is more likely to be a opaque R&D firm post turnover than in the pre-turnover period and those that have confident CEO before and after CEO turnover (*Confi-Confi*; *F-statistics* = 4.45). In contrast, firms that have CEO type change from cautious to confident (*Cautious-Confi*) are less likely to be opaque after turnover than before turnover and those that change from confident to cautious (*Confi-Cautious*) after the CEO turnover (*F-statistics* = 8.22). Collectively, our difference-in-differences results indicate that a change in CEO type is associated with R&D disclosure choice where a confident (cautious) CEO that replaces a cautious (confident) CEO is less (more) likely to be an opaque R&D firm than a cautious (confident) CEO replacing a cautious (confident) CEO.

In Columns 2 and 3, we present results of alternative difference-in-differences specifications that contrast firms with CEO turnover against those without. Column 2 reports results on firms with CEO turnover that has a confident CEO as the outgoing CEO. We find that when cautious CEOs replace confident CEOs, they are more likely to change to hiding their R&D expenditure (i.e., more likely to be opaque R&D firms) in comparison to their confident predecessors and to firms without CEO turnover (Column 2; *t-statistics* = 1.83). This relation holds even when we compare to firms that replace a confident CEO with another confident CEO (*F-statistics* = 4.33). For the latter, we also find no evidence that their choice of being opaque firms changed as compared with firms without CEO turnover (*t-statistics* = -1.05).

In Column 3, we focus on firms that replace a cautious CEO. Similar to our univariate results, we find firms that replace a cautious CEO with a confident CEO are more likely to change to reporting positive R&D rather than continuing to hide their R&D expenditure by being opaque R&D firms. This is true irrespective of whether it is compared with firms without CEO turnover (*t-statistics* = -2.18) or with firms that replace a cautious CEO with another cautious CEO (*F-statistics* = 5.88). Finally, the opaque choice for firms that replace a cautious CEO with the same CEO type remains the same and does not differ from firms without CEO turnover (*t-statistics* = 1.10).

In sum, various difference-in-differences specifications using CEO turnover provide consistent evidence that firms with confident CEO are more likely to report R&D rather than hide their R&D by being opaque R&D firms.

3.4 Disclosure Reform Shocks: Regulation Fair Disclosure & Sarbanes-Oxley

In the early 2000s, two major reforms potentially influenced corporate disclosures of financial information to outside investors, including corporate R&D. First, Regulation Fair Disclosure (Reg FD) facilitated information dissimilation to the outside market and limited managers' ability to selectively disclose sensitive information (e.g., Bushee et al., 2004). Second, the Sarbanes-Oxley Act created greater accountability *via* CEO and CFO certification of financial reports and improved corporate governance (Chang et al., 2006). Due to these limits on selective disclosure in the post-disclosure environment, failing to report R&D expenditures became more costly. Similarly, greater CEO liability and improved governance should also act to facilitate corporate disclosures. Consequently, we expect the proportion of opaque R&D firms should decrease after these disclosure reforms. Moreover, the effect should differ between confident and cautious CEOs if managerial confidence influences this disclosure choice. Intuitively, limiting managerial discretion for private disclosures and improved corporate governance increases the costs of concealing R&D to the CEO, generating a differential response between confident and cautious CEOs.

We compare firms' disclosure of R&D between pre-disclosure and post-disclosure reform periods in Table 5. To capture effects from both the Regulation FD in 2000 and Sarbanes-Oxley Act in 2002, we treat years 2000 through 2002 as transition years and drop them from our test. In Panel A, we present univariate test results for full and matched samples. Generally, we find in both samples that 1) consistent with Table 2 results, confident CEOs are less likely to be opaque firms than cautious CEOs in both pre and post-disclosure era (*t-statistics* > 2.07); and 2) despite both confident and cautious-CEO firms being less likely to be opaque R&D firms after regulatory change (*t-statistics* > 1.90), confident CEOs experience smaller change in their R&D opaqueness than cautious CEOs (*t-statistics* for the difference-in-differences > 1.99), where on average the effects on cautious-CEO firms are about 49% greater than that for confident-CEO firms.

Panel B reports the multivariate tests where we modify Equation (2) using a dummy variable, *Post-disclosure*, to indicate the period after the disclosure regime shift. Consistent with the univariate results reported in Panel A, we find that confident CEOs are less likely to be opaque R&D firms than cautious CEOs in the pre-disclosure era (*z-statistics* > 1.78), but are insignificantly different from the latter in the post-disclosure era (*F-statistics* < 2.62). Moreover, the interaction term, *Confident*Post-disclosure*, is positive and significant (*z-statistics* > 1.80), suggesting that the impact of disclosure reform on R&D disclosure is smaller for confident CEOs than for cautious CEOs after regulatory change. Overall, our findings suggest that the macro information environment affects firms' financial disclosure compliance and the extent of this influence varies by CEO confidence.

4. Declining Disclosure Bias

4.1 CEO Confidence and R&D Expenditure

Our next test centers on examining how CEO confidence relates to the level of R&D expenditure and how the R&D disclosure choice may play a role in the relationship. The results in Table 5 indicate a 17%-33% decrease in R&D disclosure bias (*viz.*, the proportion of opaque R&D firms in the market) in the post-2002 period. Moreover, the relative differences in

disclosure bias between confident and cautious CEOs decline by 44%-52% in the post-reform period. We use these high (pre-disclosure reform) and low (post-disclosure reform) periods of R&D disclosure bias to evaluate the role of disclosure bias on R&D investment between confident and cautious-CEO firms.

First, we examine the proportion of positive R&D firms in confident and cautious-CEO firms in the high and low R&D disclosure bias periods. Table 6, Panel A shows that 1) confident CEOs exhibit a higher proportion of positive R&D firms than cautious CEOs (*t-statistics* > 4.70) in both full and matched sample tests during the high R&D disclosure bias period; 2) confident-CEO firms exhibit a lower proportion of positive R&D firms than cautious-CEO firms (*t-statistics* > 5.50) in both full and matched sample tests during the low R&D disclosure bias period. Thus, the univariate results imply that differences in the propensity to engage in positive R&D differ among confident and cautious CEOs based on the disclosure regime.

In Panels B and C, we present multivariate test using R&D expenditure as the dependent variable. Here in order to mitigate or control for the bias in R&D disclosure, we replace the missing R&D values with zero, industry-average value, or 0.5% of sales.[14] As such, we control for the effects of R&D disclosure choice on the relation between reported R&D level and CEO confidence. Panel B presents results for the high R&D disclosure bias period where we find CEO confidence is positively related to R&D expenditure (*t-statistics* > 2.82), consistent with Hirshleifer et al. (2012) that uses a sample largely comprising the same time period. In contrast, Panel C shows that after the regulatory change, confident CEO is negatively associated with R&D expenditure in three of the five models (|*t-statistics*| > 1.95).

Interestingly, we find that missing R&D denotation is negatively associated with R&D when missing R&D is replaced by zero and a small amount (see Columns 2 and 4 in Panels A and B); and positively associated with R&D when industry averages are used to replace missing R&D (Columns 3 and 5 in Panels A and B). These seem to suggest the true R&D of missing R&D firms is on average between 0.5 percent of sales and their industry average. The relative

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[14] We choose this figure because it is the mid-point between zero and 1%, a common threshold for mandatory R&D disclosure. Alternative approaches to mean substitution include modeling the missing R&D with either single or multiple imputations (Koh et al., 2015).

magnitude of the coefficients further suggest the average true R&D of missing R&D firms is closer to the industry average than to 0.5 percent of sales.

4.2 CEO Confidence and R&D Performance

Our last set of examinations focuses on the innovative performance or outcome of R&D investment in terms of patents and patent citations. In Table 7 Panels A-C we present univariate results on the proportion of firms that have patents, the number of patents and citations they garner respectively. In Panel A, we find that the proportion of firms with patents decreases among confident CEOs while it increases among cautious CEOs from the high to low R&D disclosure bias periods. More interestingly, the evidence shows that while confident CEOs are generally more likely than their cautious counterparts to have patent activity in the high R&D disclosure bias period, the situation reverses in the low R&D disclosure bias era (*t-statistics* > 3.20). The difference-in-differences is significant in full sample and matched sample (*t-statistics* > 6.70), suggesting cautious CEOs are more likely to have patent activities in the low R&D disclosure bias period than high R&D disclosure bias period as compared to their confident counterparts. Panels B and C show similar inferences where we examine the number of patents and citations. Generally speaking, we find that cautious-CEO firms experience no significant change in patents and citations before and after the regulatory change (*t-statistics* < 1.73). In contrast, confident CEOs' patents and citations decreased drastically after the regulatory change (*t-statistics* > 5.25), where they ended up having significantly fewer patents and citations than their cautious counterparts (*t-statistics* > 3.55). We find the difference-in-differences are all significant (*t-statistics* > 6.12).

In Table 8, we present multivariate regression results on the effects of CEO confidence on firms' innovation outputs (patent applications and citations), after taking into consideration innovation inputs and potential for R&D disclosure bias. More specifically, we contrast between confident and cautious CEOs and examine the effect before and after the regulatory change. As

Table 6's evidence indicates that the average true R&D of missing R&D firms are closer to their industry averages, we replace missing R&D with their industry averages for our tests here.[15]

We find no evidence that confident CEO is associated with patent applications in both high and low R&D disclosure bias periods (Columns 1 and 3; |*t-statistics*| < 1.00). For patent citations, we find no evidence suggesting confident CEO is associated with more patent citations during high disclosure bias period (Column 2; *t-statistics* = 0.25) but a negative association is found in the low disclosure bias period (Columns 4; *t-statistics* = -3.29). Last, we find evidence consistent with the notion that R&D of confident CEOs are positively associated with patent applications and citations in the high disclosure bias era (*Confident*R&D* in Columns 1 and 2; *t-statistics* > 1.83) but become negative in the low disclosure bias era (*Confident*R&D* in Columns 3 and 4; |*t-statistics*| > 1.83).

Thus, our evidence indicates that R&D disclosures are influenced by CEO traits and information environment shock has differential impacts on their relations. Moreover, patent activity and characteristics also differ by CEO traits before and after the information environment shock. Taken together, they suggest that it is difficult to infer the influence of CEO confidence on corporate R&D decisions using financial statements without considering the effect of disclosure differences.

5. Robustness Checks

5.1 Degree of CEO Confidence

To the extent CEO confidence is associated with R&D disclosure choice according to our findings thus far, we expect more prominent results when focusing on more confident CEOs. To investigate this, we increase the threshold of moneyness of unexercised options in the confidence measure to 100 percent and 150 percent. We find that results using these higher thresholds for CEO confidence are associated with stronger results; that is, we find that confident CEOs are even less likely to be in an opaque R&D firm than cautious CEOs when measuring confidence using these more stringent thresholds. For instance, we find that CEO confidence measure using

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[15] We note that we obtain similar results if we replace missing R&D with zero or 0.5% of sales.

100 percent moneyness threshold is associated with 30 percent (35 percent) lower probability of being a opaque R&D firm in the full (matched) sample tests.

5.2 Alternative Measures of CEO Confidence

We also use two alternative proxies for CEO confidence (Malmendier and Tate, 2005; Hobson et al., 2012). The first one is *Longholder*, which indicates that if a CEO during our sample period still holds option in the year of expiration which is at least 40 percent in-the-money, then we designate this CEO as confident. The second measure, *Netbuyer*, is calibrated as follows: First, we require the CEO maintains the title for at least 14 years in our sample. Second, during the first five years of CEO tenure, if the CEO buys more shares than they sell in net terms in at least three years during that period, then we designate the CEO as confident. In our regression analysis, we drop the first five years for these CEOs. As pointed out by Malmendier and Tate (2005), this measure yields a much smaller sample for multivariate test. We yield 230 unique CEOs in our sample, 140 of which are confident CEOs.

Untabulated results indicate that both alternative measures for CEO confidence generate inferences similar to our main measure. More specifically, we find that CEO confidence is not associated with missing R&D reporting while negatively associated with being opaque R&D firms than cautious CEO. Economically for instance, we find that *Netbuyer* CEO is associated with a 51 percent lower probability of being an opaque R&D firm than non-*Netbuyer* CEO.

5.3 Prior Stock Performance

CEO confidence is likely to be influenced by prior firm performance. Hirshleifer et al. (2012) find that moneyness is significantly associated with contemporaneous stock returns and up to six years of lagged stock returns. As such, we control for the cumulative stock return over the lesser of the CEO's tenure or seven years. Alternatively, we add additional controls of annual stock return for the prior five years. Using either approach, we continue to find evidence that is qualitatively and quantitatively similar to our main results reported earlier.

5.4 Chief Financial Officer Confidence and R&D Disclosure

We also investigate the effect of CFO confidence on R&D disclosure as recent studies indicate that the CFO plays a prominent role in firms' financial reporting decisions (e.g., Ge et al., 2011). It follows that CFO confidence may also play an important role in the R&D disclosure decision. We identify confident CFOs following the same procedure as for CEOs. In Appendix C, we show results based on IDD shock with both full sample and matched sample tests, we find no stand-alone effect of CFO confidence on R&D disclosure ($|z\text{-}statistics| < 1.25$). Further, we observe no incremental effect of CFO confidence between states that adopt IDD vs. states that do not ($|z\text{-}statistics| < 0.51$).[16] Collectively, our evidence suggests R&D disclosure decisions are more affected by CEOs' traits than CFOs' traits.

5.5 Variation in Enforcement on Financial Reporting

We also investigate whether our results are driven by variations in enforcement attention from the SEC/DOJ. We repeat our tests controlling for proxies in enforcement attention from government agencies. For instance, Kedia and Rajgopal (2011) find that the firm's distance to a SEC divisional office is associated with the attention from the SEC. We also include auditor tenure (number of years the auditor auditing the firm) and whether the auditor is one of the Big 4 (i.e., PWC, Ernst & Young, Deloitte, KPMG). Further, we control for the effect from prior regulatory actions or legal cases against the firm within the previous 10 years. Presumably, those firms are more prone to regulatory attention.[17] Our results are robust to these additional factors that may explain regulatory enforcement variations across firms.

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[16] Using an alternative difference-in-differences specification that focuses only on firms operating in states with IDD, we continue to find no evidence of CFO confidence is associated with being opaque R&D firms (see Appendix B Panel B; $|z\text{-}statistics| < 0.40$).
[17] We rely on Accounting and Auditing Enforcement Releases (AAER), legal actions from the Securities and Exchange Commission and Department of Justice (SEC/DOJ), as well as class action lawsuits to capture regulatory attention. We use the Audit Analytics legal case database to identify if the firm is involved in legal actions related to accounting malpractice, mergers & acquisitions, securities law, financial reporting, fraud, AAER, class action, stockholder suits, and initial public offerings (IPOs).

6. Conclusion and Policy Implications

In this study, we explore how CEO characteristics influence firms' financial R&D disclosure practices. R&D is a major investment for a firm and involves a long-term horizon, substantive uncertainty and risk, and presumably influences the firm's competitive advantage. Even though accounting rules mandate disclosure of R&D activity, in practice, managers have significant discretion to disguise R&D in their reporting choice. Yet a significant number of firms fail to report any R&D spending even though they regularly seek patents (Koh and Reeb, 2015). Consequently, R&D disclosures provide an ideal test environment for investigating the role of financial disclosure mandates in reducing non-disclosure.

We find that confident CEOs, relative to cautious CEOs, are less likely to hide their R&D expenditures by being an opaque R&D firm (i.e., report missing R&D while seeking patents). Exploiting state-level regulatory shocks, changes in CEO type, and an exogenous deviation in regulatory regime, we document that cautious-CEO firms significantly under-report their corporate R&D. Taking into account temporal differences in the prevalence of opaque R&D firms, we illustrate that firms with confident CEOs display lower likelihoods of R&D activity, exhibit lower R&D expenditures, and obtain fewer patents per dollar spent during the low R&D disclosure bias period.

These results provide important insights in three specific areas. First, the analysis indicates that financial regulations influence firms differently depending on the degree of managerial confidence. In this context, the ability of financial disclosure rules to solve non-disclosure problems systematically vary across manager-firm type. If financial disclosure rules are aimed at solving agency induced non-disclosures, then our findings suggest this solution appears ineffective. Second, the results suggest that cautious CEOs engage in more corporate R&D relative to their more confident counterparts in period with a lower incidence of R&D opacity. One plausible interpretation is that confident-CEOs tend to engage in lower innovation activity. Third, our analysis implies that output measures of R&D, such as patents, are also systematically affected by financial disclosure choice. Overall, our study provides evidence that

CEO confidence has a significant influence on the precision of the financial disclosure of R&D activity.

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Table 1 Summary Statistics and Univariate Test

Panel A presents mean, median, and standard deviations of firm characteristics for both full and matched samples. The matched sample is based on propensity-score on the following firm characteristics: firm size, market-to-book, leverage, ROA, volatility, institutional ownership, CEO age, CEO gender, CEO tenure, CEO delta, CEO vega, industry average R&D, and industry (2-digit SIC) and year dummies. Panel B shows univariate mean test results.

Panel A: Summary Statistics

	Full Sample			Matched Sample		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
	(1)	(2)	(3)	(4)	(5)	(6)
Confident	0.453	0.000	0.497	0.500	0.500	0.500
Missing R&D	0.355	0.000	0.478	0.359	0.000	0.480
Opaque R&D	0.062	0.000	0.241	0.062	0.000	0.241
Firm Size	7.059	6.899	1.536	7.111	6.946	1.532
R&D	0.034	0.003	0.058	0.034	0.003	0.059
Leverage	0.516	0.519	0.226	0.508	0.517	0.212
ROA	0.034	0.052	0.120	0.041	0.054	0.107
Market-to-book	3.185	2.351	3.508	3.160	2.403	3.254
Volatility	0.121	0.104	0.068	0.119	0.103	0.065
Inst_own	0.547	0.616	0.310	0.572	0.640	0.300
CEO Age	55.369	55.000	7.684	55.288	55.000	7.571
CEO Female	0.018	0.000	0.131	0.016	0.000	0.125
CEO Tenure	7.041	5.000	7.441	7.147	5.000	7.370
Industry R&D	0.036	0.016	0.036	0.036	0.016	0.036
Delta	5.366	5.340	1.544	5.464	5.383	1.349
Vega	3.645	3.778	1.660	3.728	3.847	1.588
N	18,407			12,260		

Panel B: Univariate Test

	Full Sample			Matched Sample		
CEO type:	Confident	Cautious	t-test	Confident	Cautious	t-test
	(1)	(2)	(3)	(4)	(5)	(6)
Missing R&D	0.341	0.368	4.04***	0.369	0.348	2.32**
Opaque R&D	**0.048**	**0.074**	**7.77*****	**0.053**	**0.070**	**3.60*****
Firm Size	7.077	7.045	1.46	7.096	7.125	1.02
R&D	0.038	0.031	8.26***	0.033	0.034	0.85
Leverage	0.486	0.540	17.28***	0.509	0.507	0.39
ROA	0.051	0.019	18.88***	0.040	0.042	0.99
Market-to-book	3.740	2.723	20.86***	3.153	3.168	0.25
Volatility	0.124	0.119	5.56***	0.119	0.119	0.51
Inst_own	0.601	0.503	22.71***	0.570	0.574	0.65
CEO Age	55.460	55.293	1.58	55.327	55.249	0.55
CEO Female	0.011	0.023	6.26***	0.016	0.016	0.15
CEO Tenure	8.468	5.837	25.22***	7.186	7.108	0.56
Industry R&D	0.038	0.034	8.62***	0.036	0.036	0.15
Delta	5.852	4.937	42.06***	5.449	5.478	1.14
Vega	3.992	3.343	27.68***	3.708	3.748	1.35
N	8,344	10,063		6,130	6,130	

Table 2 CEO Overconfidence and R&D Disclosure

This table presents results of the effect of CEO confidence on R&D disclosure choice. All variables are defined in Appendix A. The z-statistics provided in parentheses are adjusted for heteroskedasticity using the Huber-White Sandwich estimator and are corrected for clustering of firm effects. ***, **, and * indicates significance at the 1%, 5%, and 10% level using two-tailed tests, respectively.

	Full Sample		*Matched Sample*	
Dependent variable:	Missing R&D	Opaque R&D	Missing R&D	Opaque R&D
	(1)	(2)	(3)	(4)
Constant	-2.066***	-4.988***	-2.015**	-5.307***
	(-2.62)	(-3.96)	(-2.37)	(-3.97)
Confident	**0.143**	**-0.166****	**0.183**	**-0.198****
	(1.50)	**(-2.08)**	**(1.55)**	**(-2.21)**
Firm Size	-0.082	0.124*	-0.071	0.267***
	(-1.47)	(1.65)	(-1.13)	(3.14)
Leverage	1.162***	0.496	1.399***	0.164
	(4.08)	(1.23)	(4.30)	(0.35)
ROA	1.832***	2.107***	1.905***	1.580
	(4.61)	(2.78)	(3.84)	(1.45)
Market-to-book	-0.064***	-0.061***	-0.082***	-0.038*
	(-4.83)	(-3.20)	(-4.81)	(-1.65)
Volatility	-3.895***	-5.421***	-3.201***	-6.253***
	(-5.58)	(-3.85)	(-4.02)	(-3.26)
Inst own	-0.287	0.062	-0.182	0.232
	(-1.47)	(0.20)	(-0.88)	(0.66)
Delta	0.012	0.041	0.030	-0.057
	(0.31)	(0.60)	(0.67)	(-0.64)
Vega	-0.187***	-0.117**	-0.179***	-0.117*
	(-5.32)	(-1.97)	(-4.52)	(-1.76)
Industry, Year	*Yes*	*Yes*	*Yes*	*Yes*
Observations	*18,407*	*13,094*	*12,260*	*8,022*
Pseudo R^2	0.349	0.264	0.358	0.242

Table 3 IDD Restrictions, CEO Confidence, and R&D Disclosure
This table presents results examining the incremental effect of CEO confidence on R&D disclosure, comparing the difference before and after states adopting IDD vs. states that keep the same legislation. IDD is a dummy variable equals 1 when the IDD is adopted in the state. We match firms that experience legislation change with firms that do not by the year prior to the IDD adoption, based on propensity-score on firm size, leverage, ROA, market-to-book, volatility, industry average R&D, institutional ownership, CEO age, CEO gender, CEO tenure, CEO delta, CEO vega, industry and year dummy. The z-statistics provided in parentheses are adjusted for heteroskedasticity using the Huber-White Sandwich estimator and are corrected for clustering of firm effects. Statistical significance at 1%, 5%, and 10% is represented by ***, **, *, respectively.

Panel A: Proportion of Opaque R&D Firms

CEO Type	Full Sample			Matched Sample		
	Confident	Cautious	t-test	Confident	Cautious	t-test
	(1)	(2)	(3)	(4)	(5)	(6)
No IDD	0.048	0.078	3.10***	0.049	0.080	3.20***
IDD	0.038	0.077	3.91***	0.041	0.078	3.37***
t-test	2.10**	0.20	2.50**	2.00**	0.30	2.02**

Panel B: IDD Restrictions, CEO Confidence and Opaque R&D

Dependent variable:	Opaque R&D			
	Full Sample		Matched Sample	
	(1)	(2)	(3)	(4)
Constant	-4.991***	-4.986***	-13.271***	-14.211***
	(-3.96)	(-3.96)	(-6.00)	(-6.34)
Confident	-0.167**	-0.153**	-0.273**	-0.193**
	(-2.08)	(-1.99)	(-2.13)	(-2.14)
IDD	0.046	0.011	0.888**	0.724**
	(1.18)	(1.04)	(2.17)	(2.36)
Confident * IDD	-	**-0.190****	-	**-0.453****
		(-2.38)		**(-2.07)**
Firm Size	0.125*	0.124*	0.325*	0.317
	(1.66)	(1.65)	(1.67)	(1.62)
Leverage	0.496	0.499	0.255	0.269
	(1.23)	(1.23)	(0.22)	(0.24)
ROA	2.106***	2.105***	-0.221	-0.157
	(2.78)	(2.77)	(-0.11)	(-0.08)
Market-to-book	-0.061***	-0.061***	-0.147*	-0.147*
	(-3.19)	(-3.20)	(-1.88)	(-1.90)
Volatility	-5.425***	-5.437***	-9.857**	-9.856**
	(-3.85)	(-3.86)	(-2.50)	(-2.50)
Inst own	0.061	0.065	-0.267	-0.260
	(0.20)	(0.21)	(-0.37)	(-0.36)
Delta	0.041	0.041	-0.098	-0.100
	(0.60)	(0.60)	(-0.69)	(-0.71)
Vega	-0.117**	-0.116*	-0.332**	-0.332**
	(-1.98)	(-1.95)	(-2.14)	(-2.15)
Industry and Year Dummy	Yes	Yes	Yes	Yes
Observations	13,094	13,094	1,026	1,026
Pseudo R^2	0.264	0.264	0.301	0.302

Table 4 CEO Turnover, CEO Confidence, and R&D Disclosure: Tobit Regression
We present results based on propensity-score matched sample of confident and cautious CEO before their turnover. We match on the following firm characteristics: firm size, ROA, leverage, market-to-book, volatility, CEO age, CEO gender, CEO tenure, CEO delta, CEO vega, and industry and year dummies. In Panel A, the sample represents 304 cases of confident CEO turnover and 304 cautious CEO turnovers for our test. In Panel B (C), we match firms with confident (cautious) CEO that experience turnover vs. those that do not. The z-statistics provided in parentheses are adjusted for heteroskedasticity using the Huber-White Sandwich estimator and are corrected for clustering of firm effects. Statistical significance at 1%, 5%, and 10% is represented by ***, **, *, respectively.

Panel A: Proportion of Opaque R&D Firms

	Confident vs. Cautious CEO Turnover			Confident CEO Turnover vs. Non-Turnover			Cautious CEO Turnover vs. Non-Turnover		
	Pre	Post	t-test	Pre	Post	t-test	Pre	Post	t-test
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Confi-Confi	0.052	0.051	0.50	0.052	0.053	0.49	-	-	-
Confi-Cautious	0.051	0.055	2.02**	0.052	0.056	2.11**	-	-	-
Cautious-Confi	0.058	0.053	2.27**	-	-	-	0.058	0.052	2.29**
Cautious-Cautious	0.059	0.059	0.23	-	-	-	0.059	0.058	0.27
Tests of Differences									
Confi-Confi vs. Confi-Cautious	0.42	2.11**	2.19**	0.30	1.90*	2.08**	-	-	-
Confi-Confi vs. Cautious-Confi	2.20**	1.02	2.02**	-	-	-	-	-	-
Confi-Confi vs. Cautious-Cautious	2.51**	2.73***	0.39	-	-	-	-	-	-
Confi-Cautious vs. Cautious-Confi	2.48**	1.15	3.06***	-	-	-	-	-	-
Confi-Cautious vs. Cautious-Cautious	3.25***	1.98**	2.08**	-	-	-	-	-	-
Cautious-Confi vs. Cautious-Cautious	0.31	2.88***	2.46**	-	-	-	0.20	2.22**	2.05**

Table 4 (cont'd)

Panel B: Multivariate Test

Dependent Variable:	ΔOpaque R&D		
	Confident CEO vs Cautious CEO Turnover	*Confident CEO Turnover vs. Non-Turnover*	*Cautious CEO Turnover vs. Non-Turnover*
	(1)	(2)	(3)
Constant	0.027	0.037	0.026
	(0.47)	(0.65)	(1.05)
Confi-Confi (β_1)	**-0.045**	**-0.050**	**-**
	(-1.43)	**(-1.05)**	
Confi-Cautious (β_2)	**0.026****	**0.045***	**-**
	(2.10)	**(1.83)**	
Cautious-Confi (β_3)	**-0.020****	**-**	**-0.021****
	(-2.01)		**(-2.18)**
Cautious-Cautious (β_4)	**-**	**-**	**0.008**
			(1.10)
ΔFirm Size	-0.020	-0.025	-0.018
	(-1.55)	(-1.44)	(-1.50)
ΔLeverage	0.028	0.035	0.033
	(0.68)	(0.89)	(0.98)
ΔROA	0.025	0.025	0.019
	(0.41)	(0.50)	(0.61)
ΔMarket-to-book	-0.003	-0.006	-0.005
	(-1.50)	(-1.39)	(-1.20)
ΔVolatility	0.131	0.122	0.117
	(1.53)	(1.30)	(1.28)
ΔInst_own	0.035	0.029	0.044
	(1.16)	(1.32)	(1.50)
ΔDelta	0.003	0.001	0.001
	(0.64)	(0.29)	(0.55)
ΔVega	-0.003	-0.007	-0.005
	(-0.68)	(-0.55)	(-0.70)
Industry Dummy	*Yes*	*Yes*	*Yes*
Observations	*608*	*496*	*632*
Chi-Squared	67.13	72.67	100.6
F-test:			
Confi-Confi vs. Confi-Cautious ($\beta_1=\beta_2$)	*4.45***	*4.33***	*-*
Confi-Confi vs. Cautious-Confi ($\beta_1=\beta_3$)	*1.50*	*-*	*-*
Confi-Cautious vs. Cautious-Confi ($\beta_2=\beta_3$)	*8.22****	*-*	*-*
Cautious-Cautious vs. Cautious-Confi ($\beta_3=\beta_4$)	*-*	*-*	*5.88***

Table 5 CEO Confidence and R&D Opacity: Effects of Disclosure Reform
This table presents results of the effect of CEO confidence on R&D disclosure choice. Low Bias is a dummy variable equals 1 indicating time period after 2002, and zero for the period before 2000. Panel A presents univariate test. Panel B shows regression result. The z-statistics provided in parentheses are adjusted for heteroskedasticity using the Huber-White Sandwich estimator and are corrected for clustering of firm effects. ***, **, and * indicates significance at the 1%, 5%, and 10% level using two-tailed tests, respectively.

Panel A: Proportion of Opaque R&D Firms

CEO Type	Full Sample			Matched Sample		
	Confident	Cautious	*t-test*	Confident	Cautious	*t-test*
	(1)	(2)	(3)	(4)	(5)	(6)
Pre-disclosure	0.054	0.085	5.39***	0.058	0.083	2.59***
Post-disclosure	0.042	0.057	3.00***	0.048	0.062	2.07**
t-test	*2.32***	*5.22****	*2.28***	*1.90**	*2.20***	*1.99***

Panel B: Regression Result

Dependent variable:	Opaque R&D	
	Full Sample	*Matched Sample*
	(1)	(2)
Constant	-4.931***	-5.729***
	(-3.91)	(-4.39)
Confidence (β_1)	-0.241*	-0.383*
	(-1.78)	(-1.95)
Post-disclosure (β_2)	-0.101	-1.357***
	(-1.31)	(-3.45)
Confident * Post-disclosure (β_3)	**0.140***	**0.107***
	(1.81)	**(1.88)**
Firm Size	0.132*	0.434***
	(1.73)	(5.47)
Leverage	0.640	-0.166
	(1.48)	(-0.37)
ROA	1.574*	0.865
	(1.82)	(0.73)
Market-to-book	-0.057***	-0.010
	(-2.98)	(-0.47)
Volatility	-5.616***	-1.952
	(-3.50)	(-1.16)
Inst own	0.157	0.249
	(0.51)	(0.84)
Delta	0.044	-0.090
	(0.63)	(-1.21)
Vega	-0.115*	-0.043
	(-1.82)	(-0.72)
Industry and Year Dummy	Yes	Yes
Observations	10,192	8,748
Pseudo R^2	0.254	0.153
F-test:		
Post-disclosure (Confi – Cautious) ($\beta_1+\beta_3=0$)	*1.30*	*2.62*
Confi (Post-disclosure – Pre-disclosure) ($\beta_2+\beta_3=0$)	*0.92*	*6.45***

Table 6 CEO Confidence and R&D Expenditures

This table presents results of CEO confidence on firms' R&D investment. The dependent variable is R&D expenditure divided by total assets. We show results based on the time period of High Bias (before 2000) and Low Bias (after 2002), respectively. Panel A includes firms with positive R&D expenditure. In Panel B, we replace missing R&D with zero, industry average, or 0.5% of sales, respectively. The t-statistics provided in parentheses are adjusted for heteroskedasticity using the Huber-White Sandwich estimator and are corrected for clustering of firm effects. Statistical significance at 1%, 5%, and 10% is represented by ***, **, *, respectively.

Panel A: Proportion of Positive R&D Firms (among reporting firms)

CEO Type	Full Sample			Matched Sample		
	Confident	Cautious	*t-test*	Confident	Cautious	*t-test*
High Bias	0.835	0.783	*4.70***	0.847	0.759	*5.84***
Low Bias	0.773	0.833	*5.50***	0.757	0.840	*5.54**
t-test	*5.28***	*4.90***	*9.28***	*5.91***	*5.46***	*9.18***

Panel B: High R&D Disclosure Bias

	Dependent Variable = R&D Expenditures/TA				
	(1)	(2)	(3)	(4)	(5)
Constant	0.094***	0.110***	0.137***	0.110***	0.137***
	(5.34)	(7.54)	(9.47)	(7.67)	(9.44)
Confident	**0.006*****	**0.007*****	**0.005*****	**0.007*****	**0.005*****
	(3.00)	**(3.69)**	**(2.82)**	**(3.77)**	**(2.84)**
Missing R&D	-	-0.031***	0.006***	-0.024***	0.006***
		(-15.56)	(4.09)	(-12.16)	(3.62)
Opaque R&D	-	-	-	-	0.002
					(0.92)
Controls, Industry and Year Dummy	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	7,520	7,520	7,520	7,520	7,520
Adjusted R^2	0.530	0.565	0.591	0.547	0.591
Replacing Missing R&D with:	*Zero*	*Zero*	*Ind. Avg.*	*0.5% of Sales*	*Ind. Avg.*

Panel C: Low R&D Disclosure Bias

	Dependent Variable = R&D Expenditures/TA				
	(1)	(2)	(3)	(4)	(5)
Constant	0.066***	0.080***	0.095***	0.080***	0.095***
	(3.03)	(6.09)	(10.77)	(6.39)	(10.79)
Confident	**-0.004****	**-0.003***	**-0.003**	**-0.003****	**-0.003**
	(-2.19)	**(-1.95)**	**(-1.55)**	**(-2.01)**	**(-1.52)**
Missing R&D	-	-0.033***	0.006***	-0.026***	0.006***
		(-14.85)	(3.82)	(-11.84)	(3.22)
Opaque R&D	-	-	-	-	0.004**
					(2.27)
Controls, Industry and Year Dummy	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	6,911	6,911	6,911	6,911	6,911
Adjusted R^2	0.465	0.509	0.526	0.498	0.527
Replacing Missing R&D with:	*Zero*	*Zero*	*Ind. Avg.*	*0.5% of Sales*	*Ind. Avg.*

Table 7 CEO Confidence and Patent Activity

The table presents univariate results regarding patents and citations by CEO type. High Bias (Low Bias) indicates time period before 2000 (after 2002). All variables are defined in Appendix A. Statistical significance at 1%, 5%, and 10% is denoted by ***, **, and *, respectively.

Panel A: Proportion of Firms with Patents

CEO Type	Full Sample			Matched Sample		
	Confident	Cautious	*t-test*	Confident	Cautious	*t-test*
	(1)	(2)	(3)	(4)	(5)	(6)
High Bias	0.448	0.418	*2.62***	0.443	0.425	*1.20*
Low Bias	0.410	0.454	*3.20***	0.387	0.485	*5.30***
t-test	*2.84***	*3.02***	*6.77***	*3.26***	*3.61***	*7.55***

Panel B: Number of Patents per Firm

CEO Type	Full Sample			Matched Sample		
	Confident	Cautious	*t-test*	Confident	Cautious	*t-test*
	(1)	(2)	(3)	(4)	(5)	(6)
High Bias	14.670	8.998	*4.16***	14.329	9.579	*2.18**
Low Bias	5.625	11.019	*4.51***	4.305	12.657	*5.30***
t-test	*6.40***	*1.73*	*8.22***	*5.26***	*1.63*	*7.06***

Panel C: Citations per Firm

CEO Type	Full Sample			Matched Sample		
	Confident	Cautious	*t-test*	Confident	Cautious	*t-test*
	(1)	(2)	(3)	(4)	(5)	(6)
High Bias	277.230	156.960	*4.20***	243.997	190.642	*1.26*
Low Bias	67.746	151.485	*3.55***	44.051	182.730	*4.57***
t-test	*8.07***	*0.21*	*6.97***	*6.60***	*0.18*	*6.12***

Table 8 CEO Confidence and Corporate Patent Applications and Citations
The table presents OLS regression results on the effect of R&D investment on R&D performance by the CEO type. We replace the missing R&D with industry-average R&D. High Bias (Low Bias) indicates years before 2000 (after 2002). All variables are defined in Appendix A. The t-statistics provided in parentheses are adjusted for heteroskedasticity using the Huber-White Sandwich estimator and are corrected for clustering of firm effects. Statistical significance at 1%, 5%, and 10% is denoted by ***, **, and *, respectively.

Dependent Variable:	High R&D Disclosure Bias		Low R&D Disclosure Bias	
	Log(1+Patent App.)	Log(1+Citations)	Log(1+Patent App.)	Log(1+Citations)
	(1)	(2)	(3)	(4)
Confidence	0.034	0.022	-0.045	-0.280***
	(0.59)	(0.25)	(-0.99)	(-3.29)
R&D	3.620***	6.612***	2.233***	2.117
	(4.13)	(4.86)	(3.23)	(1.54)
Confident * R&D	**1.546***	**1.379***	**-1.022***	**-1.444***
	(1.86)	**(1.83)**	**(-1.83)**	**(-1.90)**
Missing R&D	-0.685***	-0.923***	-0.326***	-0.614***
	(-9.80)	(-7.81)	(-6.83)	(-5.75)
Firm Size	0.531***	0.408***	0.294***	0.368***
	(14.85)	(9.11)	(10.73)	(8.41)
Leverage	-0.436***	-0.728***	-0.101	0.498**
	(-3.01)	(-3.05)	(-0.88)	(2.14)
ROA	0.234	0.188	-0.182	0.789**
	(0.91)	(0.45)	(-0.97)	(2.43)
Market-to-book	0.022***	0.025**	0.011**	0.014
	(3.61)	(2.35)	(2.19)	(1.39)
Volatility	-0.050	0.449	0.227	-1.132*
	(-0.12)	(0.62)	(0.62)	(-1.78)
Inst own	-0.396**	-0.201	-0.307***	-0.760***
	(-2.42)	(-0.81)	(-2.92)	(-3.62)
Delta	-0.025	-0.025	-0.021	-0.051
	(-1.24)	(-0.81)	(-1.21)	(-1.58)
Vega	0.012	0.076**	0.010	0.032
	(0.59)	(2.54)	(0.60)	(1.19)
Industry and Year Dummy	*Yes*	*Yes*	*Yes*	*Yes*
Observations	7,520	7,520	6,911	6,911
Adjusted R^2	0.554	0.424	0.420	0.277

Appendix A: Variable Definitions

Confident: a dummy variable equals 1 if the CEO is confident. Confident is defined as follows: during the sample period, if the CEO who at least twice had vested options that were valued above the 67% moneyness, then this CEO is identified as confident for the sample period.

Opaque R&D: a dummy variable indicating a firm with blank R&D reporting while has patents.

Firm Size: log of book value of total assets.

Leverage: total liabilities divided by total assets.

ROA: income before extraordinary items divided by total assets.

Market-to-book: market value of common equity divided by book value of common equity.

Volatility: standard deviation of daily stock return in the prior year.

Inst_own: proportion of common equity ownership by institutional investors.

Delta: measures CEO wealth change in dollars to a 1% change in stock price.

Vega: measures CEO wealth change in dollars to a 1% change in annualized standard deviation of stock return.

Longholder: a dummy variable equals to 1 if the CEO is confidence, and cautious otherwise (Malmendier, Tate, and Yan, 2011; Hobson, Mayew, and Venkatachalam, 2012). During the CEO's tenure at the firm, if the CEO holds an option until the year of expiration which is at least 40% in the money, then we designate the CEO confident. Option holdings are obtained from Execucomp's Outstanding Equity Awards database.

Netbuyer: a dummy variable equals to 1 if the CEO is a net equity buyer in 3 or more years during the first 5 years being CEO, and zero otherwise (Malmendier and Tate, 2005). We drop the first 5 years of CEO tenure in regression analysis.

IDD: a dummy variable indicating firms in the state that adopts IDD and zero otherwise.

Patent Application: number of patent applications by the firm during the year.

Patents Granted: number of patents granted to the firm during the year.

Citations: number of citations for all the patents that the firms has during the year, truncated by the methodology in Hall et al. (2001).

Pre-disclosure/High Bias: a dummy variable indicating the period prior to 2000.

Post-disclosure/Low Bias: a dummy variable indicating the period after 2002.

Appendix B: IDD Shock and R&D Opacity: Alternative Specification Comparing among Firms Operating in States with IDD Adoption.

Panel A: IDD Restrictions, CEO Confidence, and R&D Opacity

Dependent variable:	Opaque R&D			
	Full Sample		*Matched Sample*	
	(1)	(2)	(3)	(4)
Constant	-12.562***	-13.851***	-11.299***	-12.015***
	(-6.11)	(-6.40)	(-4.49)	(-5.20)
Confident CEO	-0.927**	-0.675**	-1.230**	-0.882**
	(-2.22)	(-2.25)	(-2.50)	(-2.20)
IDD	0.169	0.295	0.55	0.195
	(0.90)	(0.71)	(1.11)	(1.20)
Confident CEO * IDD	-	-0.504**	-	-0.612**
		(-2.07)		(-2.18)
Controls, Industry and Year Dummy	*Yes*	*Yes*	*Yes*	*Yes*
Observations	*624*	*624*	*508*	*508*
Pseudo R^2	0.263	0.264	0.272	0.272

Panel B: IDD Restrictions, CFO Confidence, and R&D Opacity

Dependent variable:	Opaque R&D			
	Full Sample		*Matched Sample*	
	(1)	(2)	(3)	(4)
Constant	-11.877***	-12.989***	-10.092***	-11.133***
	(-5.67)	(-6.20)	(-4.29)	(-4.55)
Confident CFO	-0.391	-0.436	-0.376	-0.437
	(-1.31)	(-1.33)	(-1.22)	(-1.42)
IDD	0.274	0.270	0.309	0.311
	(0.85)	(0.84)	(1.20)	(1.23)
Confident CFO * IDD	-	0.077	-	0.082
		(0.24)		(0.39)
Controls, Industry and Year Dummy	*Yes*	*Yes*	*Yes*	*Yes*
Observations	*624*	*624*	*508*	*508*
Pseudo R^2	0.263	0.263	0.267	0.267

Appendix C: IDD Restrictions, CFO Confidence, and R&D Disclosure

This table presents results based on full and matched samples for the incremental effect of CFO confidence on R&D disclosure, comparing the difference before and after states adopting IDD vs. states that keep the same legislation. We match firms that experience legislation change with firms that do not, based on propensity-score on the following variables: firm size, leverage, ROA, market-to-book, volatility, industry average R&D, institutional ownership, CEO delta, CEO vega, industry and year dummy. The z-statistics provided in parentheses are adjusted for heteroskedasticity using the Huber-White Sandwich estimator and are corrected for clustering of firm effects. Statistical significance at 1%, 5%, and 10% is represented by ***, **, *, respectively.

Panel A: Univariate Test

	Full Sample			Matched Sample		
	Confident CFO	Cautious CFO	t-test	Confident CFO	Cautious CFO	t-test
	(1)	(2)	(3)	(4)	(5)	(6)
No IDD	0.047	0.048	0.88	0.055	0.057	0.67
IDD	0.098	0.101	0.96	0.098	0.099	0.20
t-test	3.80***	4.02***	0.33	3.30***	2.70***	0.30

Panel B: Multivariate Test

| Dependent variable:	Opaque R&D			
	Full Sample		Matched Sample	
	(1)	(2)	(3)	(4)
Constant	-5.018***	-5.016***	-13.674***	-15.648***
	(-3.98)	(-3.98)	(-6.16)	(-6.93)
Confident CFO	-0.108	-0.087	-0.209	-0.224
	(-0.69)	(-0.53)	(-1.24)	(-0.43)
IDD	0.035**	0.020**	0.893***	0.953***
	(2.14)	(2.07)	(2.77)	(2.86)
Confident CFO * IDD	-	**-0.253**	-	**-0.046**
		(-0.51)		**(-0.48)**
Firm Size	0.130*	0.129*	0.282	0.306*
	(1.74)	(1.73)	(1.57)	(1.67)
Leverage	0.514	0.519	0.486	0.392
	(1.27)	(1.28)	(0.45)	(0.35)
ROA	2.084***	2.088***	0.224	0.114
	(2.75)	(2.75)	(0.11)	(0.06)
Market-to-book	-0.062***	-0.062***	-0.139*	-0.147*
	(-3.23)	(-3.23)	(-1.82)	(-1.86)
Volatility	-5.492***	-5.515***	-9.336**	-9.584**
	(-3.88)	(-3.90)	(-2.25)	(-2.33)
Inst own	0.041	0.044	-0.050	-0.073
	(0.13)	(0.14)	(-0.07)	(-0.10)
Delta	0.031	0.031	-0.076	-0.074
	(0.46)	(0.46)	(-0.52)	(-0.51)
Vega	-0.122**	-0.121**	-0.325**	-0.336**
	(-2.06)	(-2.05)	(-2.19)	(-2.34)
Industry and Year Dummy	Yes	Yes	Yes	Yes
Observations	13,094	13,094	1,026	1,026
Pseudo R^2	0.264	0.264	0.304	0.307

Figure 1A: Simulation Result on Missing R&D Test
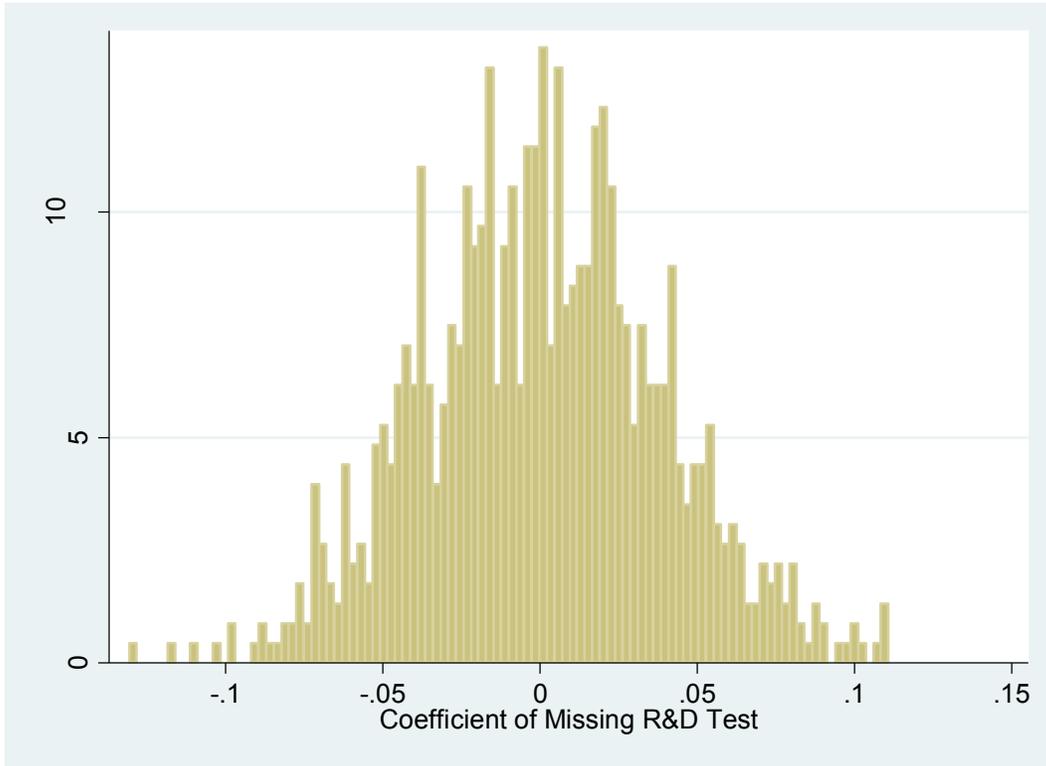
Figure 1B: Simulation Results on Opaque R&D
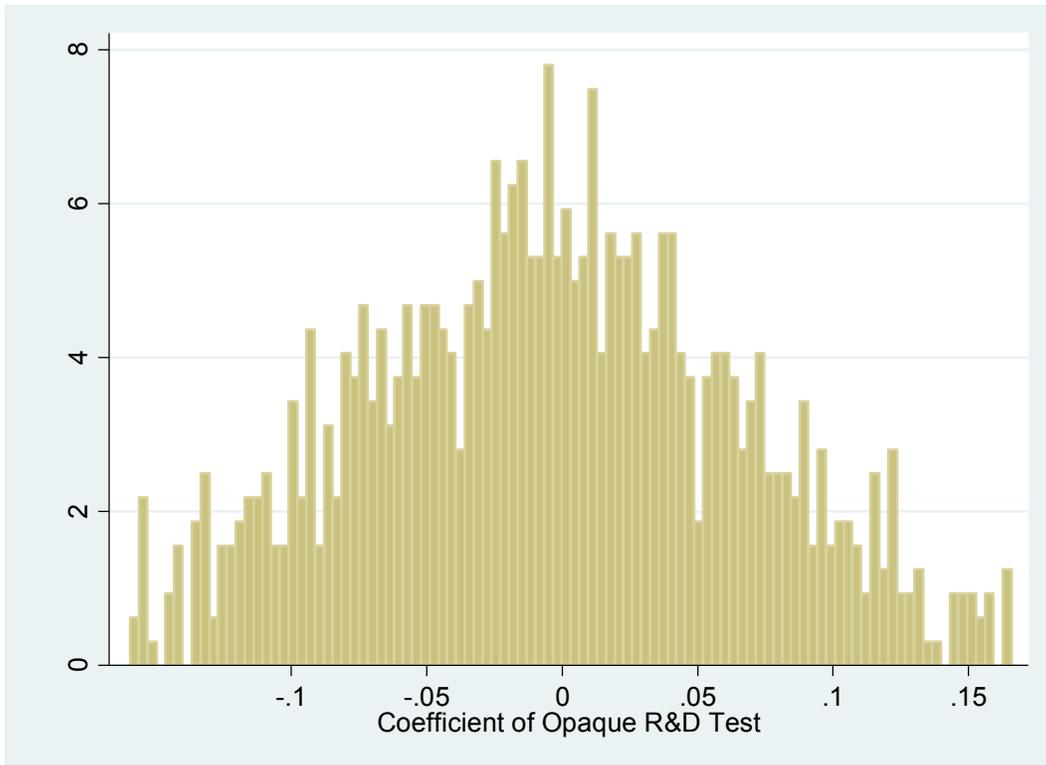
Figure 2A Confident CEO and Opaque R&D Firms: Pre and Post IDD Shock

- - - - Confident CEO with IDD Shock ••••••• Confident CEO without IDD Shock
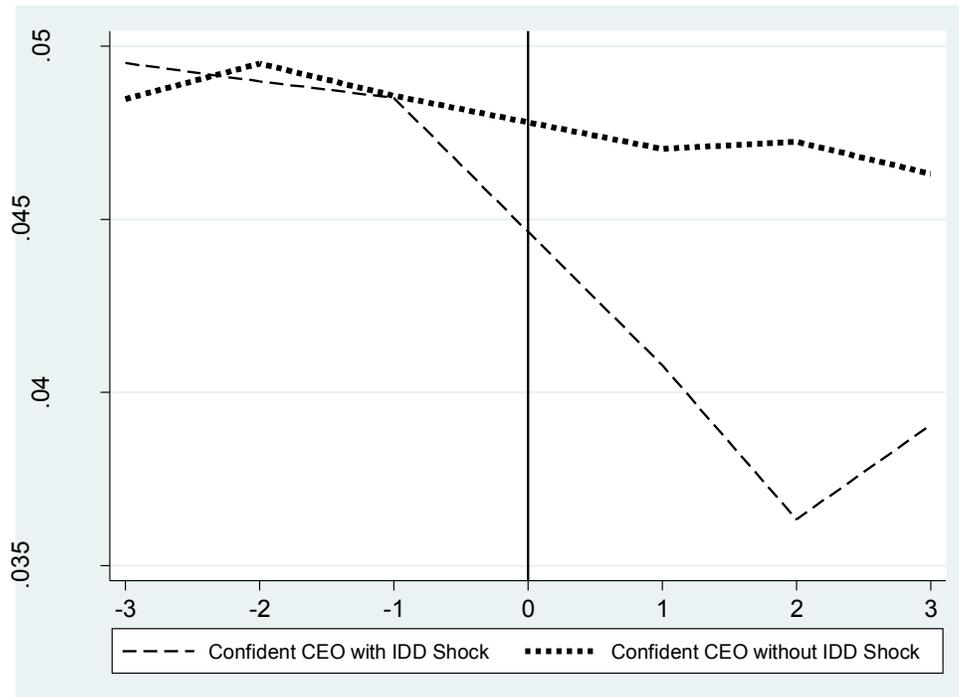
Figure 2B CEO Type and Opaque R&D Firms: Pre and Post IDD Shock (Difference-in-differences)

- - - - Confident CEO DID ••••••• Non-confident CEO DID